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Development of Organic Fertilizer Products and Systems to Improve Soil Fertility of Organic Vegetable Production of Cabbage in Benguet, Philippines

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Abstract

Formulation of organic fertilizers were studied to support organic vegetable production in Benguet, Philippines. The formulated liquid organic fertilizers based on farmers' concoctions showed very low nutrient contents. New formulations using legume seeds were done which resulted to higher nutrient contents. Likewise, solid organic fertilizers were formulated using locally available raw materials. A combination of 50% chicken manure, 20% sawdust, 20% sunflower leaves, 10% Alnus compost and *Trichoderma* gave the highest nutrient contents. The solid and reformulated organic liquid fertilizers and *Trichoderma* were tested on cabbage grown in farm under conversion to organic production. Lower yields were observed during the early part of conversion. However, after three years of conversion, the yields of cabbage had significantly increased which were comparable to the yield in conventional farms. The recommended rates of solid and liquid formulated organic fertilizers found effective for both cabbage are 10t/ha of formulated solid fertilizer and 60 ml/L of liquid fertilizer, respectively. The nutrient management system found effective for organic production of cabbage was the application of *Trichoderma* two weeks before planting and split application of solid organic fertilizers three times during the growing period, that is, before planting, 15 days after planting and 30 days after planting at the rate of 2.5, 2.5 and 5.0 t/ha, respectively. The organic liquid fertilizer was applied at the rate of 60 ml per liter of water 15 days after planting and every two weeks thereafter until cabbage heads have formed. This nutrient management system provided the crops the essential nutrients during the critical growth and reproductive stages which resulted to higher yields comparable to those produced in conventional farms.

KEYWORDS

organic fertilizers
conversion
mineralization
nutrient management

Introduction

In the Philippines, organic agriculture has recently been given focus by the government because of the recognition of the hazards and resources depletion associated with the conventional system of crop production (Melero et al. 2006). With Republic Act 10068, known as Organic Agriculture

Act, government research institutions, POs, and NGOs felt the need to work together to develop and improve organic agriculture practices and systems. This has direct implication to Benguet Province, being the largest producer of semi-temperate vegetables and fruits, supplying these to capital cities in the country. Its major crops are tubers, roots, bulbs, leafy vegetables, stems, and flowers (Lu, 2009). The province is notoriously known for its rampant use of synthetic fertilizers and pesticides and the negative health effects of these were already felt. Cheng (1994) documented that vegetable farmers' most common complaints in the province were allergic reactions both in the skin and the eyes, abdominal pain, dizziness, chest pain, headache, and nose bleed.

Organic farming which is also seen to improve of soil fertility and conditions (Roy et al. 2010) is very much needed since majority of soil series in the locality were found degraded from decades of synthetic inputs under conventional farming (Calubaquib et al. 2016). All major soil series from Luzon (which include Benguet) were found acidic, have a very low organic matter, total N, available P, and low to moderately low exchangeable cations. Hence, it is imperative that proper nutrient management system should be implemented and at the same time making the cost as low as possible. These were the major considerations in this study in determining the ideal liquid and soil organic fertilizer formulations using locally available materials.

Amidst the abovementioned benefits of organic farming, farmers are generally apprehensive particularly on the perceived risks involved during the conversion period. Farmer observed generally lower crop yield during the transition period compared to those grown conventionally (FAO 2007 Initial Report; Mendoza, 2008) which is understandable since the effects of organic farming are generally long-term. This shows the need to develop technologies to sustain the productivity of the farms during the conversion period. Foremost, would be to understand the soil dynamics during the conversion period. Previous studies conducted on this include the work of Clark et al. (1998) and Teasdale et al. (2007) but these were conducted in temperate countries. Both authors agree that soil dynamics differ significantly between sites, thus their result could not accurately explain or account for areas entirely different from their sites, e.g. semi-temperate areas in a tropical country like here in Benguet. This shows the need to understand soils dynamics during conversion periods under local conditions for development of possible intervention to encourage more farmers to shift to organic farming.

There have been few efforts to document the soil dynamics under organic production in the locality such as the pioneering work of Datic et al. (2015) and Laurean et al. (2015) but these were conducted under one to two cropping only. Thus, the result cannot really elucidate the transformation of soil dynamics during the conversion period. This prompted the conduct of the study, partly, to monitor the changes in different soil parameters during several cropping as part of documenting the soil conditions during the conversion period. Additionally, the study was conducted to design an efficient nutrient management system for farms under conversion to organic farms and in organic farms without abrupt reduction in crop yields under semi-temperate condition of Benguet, Philippines. On-farm raw materials were utilized for organic fertilizer production so that farmers can produce their own organic fertilizers right in their farms. This strategy reduces their dependence on costly commercial organic fertilizers.

Materials and Methods

Preparation and Formulation of Liquid and Solid Organic Liquid Fertilizers

Organic fertilizers, both in liquid and solid forms were formulated. Liquid fertilizers were formulated from fresh sunflower leaves, fresh azolla, fish scraps, molasses, bones of grass-eating animals, seashells, potato tubers, banana peels, coconut vinegar and molasses. The methods of fermentation that were used were those being practiced by the farmers (Jensen et al., 2006). Four formulations were conducted in the study namely farmer's formulation coded as FF1, FF2, FF3, and FF4. These were compared with re-formulated liquid organic fertilizer (RF) with four formulations, as well, coded as RF1, RF2, RF3 and RF4.

On the other hand, solid fertilizers were formulated from locally available materials such as chicken manure, sawdust, and other plant materials. Four formulations were also calibrated in the study namely solid organic fertilizer SF1, SF2, SF3 and SF4 (refer to Table 1). These were composted using *Trichoderma* and indigenous microorganisms to enhance decomposition. Unfortunately, the study

Table 1

Formulation of Solid Organic Fertilizer Used in the Study

Solid Organic Formulation	Organic Materials	% Composition
SF1	Chicken manure	70
	Mushroom compost	20
	Wild sunflower	10
SF2	Chicken manure	60
	Mushroom compost	20
	Wild sunflower	10
	Alnus compost	10
SF3	Chicken manure	50
	Mushroom compost	20
	Wild sunflower	20
	Alnus compost	10
SF4	Chicken manure	40
	Mushroom compost	20
	Wild sunflower	20
	Alnus compost	20

was unable to identify these microorganisms down to species level. The pH and nutrient contents including nitrogen (N), phosphorus (P),potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), zinc (Z), copper (Cu), and organic matter (OM) of these fertilizer formulated were determined at the Bureau of Soils and Water Management, Quezon City, Philippines.

Efficacy Trials of Formulated Organic Fertilizers on Cabbage during Conversion to Organic Farm

Cabbage (*Brassica oleracea* var. Capitata, Lucky Ball cultivar) was used as the test crop to determine the efficacy of the formulated organic fertilizers. The study was conducted in a 1,200 m² area at BSU Experiment Farm from December 2011 to March 2012. The area was divided into five (5) blocks for solid fertilizer and four (4) blocks for liquid fertilizer – one for every treatment. Each block was further subdivided into five plots measuring 1x10 m (10 m²) each. The experimental design used was the Randomized Complete Block Design (RCBD) involving factorial arrangements. RF4 was selected as liquid fertilizer and SF3 for solid organic fertilizer. Five (5) treatments for solid organic fertilizer while four (4) in liquid fertilizer, as detailed in Table 2, were calibrated in the study. Significant difference among these treatments were analyzed using the LSD.

Two trials were conducted to determine the efficacy of the liquid and solid organic fertilizer formulations on the crop yield. The first trial was conducted on December 2011 – March 2012 while the second trial was on April – July 2012. In every trial, solid organic fertilizers were applied three (3) times namely before planting, 15 days after planting and after 30 days. On the other hand, the organic liquid plant supplements were applied 15 days after planting and every two weeks thereafter.

The interaction effect between solid and liquid organic fertilizer on the yield of cabbage were also explored. This was performed on another blocks of plots where every solid fertilizer treatment were paired with each liquid fertilizer treatments. These resulted to creation of 20 blocks (5 solid fertilizer treatments x 4 liquid fertilizer treatments) with 3 replications each using 1x10 m plot.

For comparison, separate plots several blocks away from the experiment area was set up following

Table 2

The Treatments Used to Test the Efficacy of Formulated Organic Fertilizers on Cabbage (Brassica oleracea var. Capitata, Lucky Ball Cultivar)

Treatments for Solid Fertilizer using SF_		Treatments for Liquid Fertilizer using RF_	
Code	Description	Code	Description
A_1	Control	B_1	Control
A_2	2.5 tons/ha	B_2	20 ml/li
A_3	5.0 tons/ha	B_3	40 ml/li
A_4	7.5 tons/ha	B_4	60 ml/li
A_5	10.0 tons/ha		

practices for conventional farming. Three (3) blocks were designated for this with three (3) plot replications. These were fertilized following farmers' practice at a rate of 20 bags/ha complete fertilizer plus 100 sacks/ha chicken manure that was soaked in water for seven days. Mixed fertilizers were drenched equally to the plot in every two weeks with a rate of urea 50 kg/ha and 50 kg of complete fertilizer.

Cultural management. In each plot, cultural management like weeding, hilling-up, pest control and irrigation were uniformly imposed. Plants were irrigated after every two or three days.

Medium-Term Assessment of the Nutrient Management System under Organic Cabbage Production

After the 1st and 2nd trial for efficacy evaluation of the liquid and solid fertilizer, the best formulation with its optimum amount was utilized to observe the effects of continuous organic production on cabbage yield. The same area for organic production was utilized but relatively smaller at 300 m². The same area previously used for conventional farming was also cultivated with the same plant and the same cultural practices (except fertilizer and pesticide) for comparison. Additionally, mineralization study of the formulated solid organic fertilizer was conducted to determine the best time for application to the test plant cabbage. These were conducted from November 2012 to April 2013.

The soil conditions of the organic and conventional farm were also monitored from 2011 (Year 1) to 2013 (Year 3) to determine possible improvement of the soil due to the organic fertilizers. Soil parameters measured include bulk density, pH, organic matter, P, K, heavy metals such as cadmium, mercury, lead and pesticide residue like chlorothalonil, cyhalothrin and cypermethrin. All of these parameters were analyzed at Bureau of Soils and Water Management, Quezon City, Philippines.

Results and Discussion

Formulation of Liquid and Solid Organic Fertilizers

Formulated Liquid Organic Fertilizers. Table 3 shows the result of analysis of the organic liquid fertilizers prepared using farmers' formulation and the re-formulated organic liquid fertilizers using legume seeds. The result showed that the

Table 3

Comparison of the Chemical Composition of Liquid Organic Fertilizers between Farmer's Formulation and the Re-formulated Organic Liquid Fertilizers Using Legume Seeds

Soil chemical components	Farmer's Formulation				Re-formulated organic liquid fertilizers using legume seeds			
	FF1	**FF2**	**FF3**	**FF4**	**RF1**	**RF2**	**RF3**	**RF4**
Total N, %	0.13	0.05	0.04	0.04	0.78	1.00	0.86	1.00
Total P (P_2O_5) , %	0.004	0.07	Trace	Trace	0.004	0.002	Trace	0.004
Total K (K_2O), %	0.17	0.08	0.22	0.14	0.88	1.22	1.26	1.24
Total Ca (CaO), %	0.08	0.99	0.02	0.40	0.06	0.02	0.06	0.06
Total Mg (MgO), %	0.05	0.08	0.03	0.05	0.06	0.08	0.06	0.06
pH	3.4	3.9	3.6	2.9	3.7	4.1	4.1	4.2
Sodium, %	0.006	0.003	0.003	0.0003	0.01	0.001	0.01	0.001
Zinc , ppm	1.48	Trace	Trace	Trace	12.72	11.10	7.49	9.96
Copper, ppm	Trace	Trace	Trace	Trace	1.50	1.91	2.25	3.32
Manganese, ppm	39.07	13.88	5.20	24.31	4.49	5.63	5.62	8.16
Iron, ppm	64.79	16.01	12.30	27.29	8.23	7.25	3.37	Trace
Organic Matter, %	21.16	1.06	21.81	12.63	20.35	27.24	21.79	23.80

where: FF – farmer's formulation; RF – Re-formulated organic liquid fertilizers formulated organic liquid fertilizers contain both the macro- and micro-nutrients important to plant growth and development. However, all of the four farmer's formulations had very low values of N, P and K at less than 1%, while the amount of Fe and Mn is quite high. The high availability of Fe and Mn could be attributed to the mediums' very acidic pH. Very acidic pH are widely known to cause high availability of heavy metals (Taiz & Zeiger, 2002). Comparing these with the nutritional requirements of crops, the nutrient contents of the four farmer's formulations were not sufficient to supply the nutritional needs of organically-grown crops.

On the other hand, higher nutrient contents were noted for the re-formulated organic liquid fertilizers using legume seeds. Re-formulated organic liquid fertilizer (RF) 2 and 4 have the highest total N contents and high K content. RF3 also have high K content. All four formulations have high amounts of micro-nutrients, although F2 has the highest Zn content while F4 has the highest Mn content. The N, P and K contents of the re-formulated organic liquid fertilizer in the study were superior to those recorded by Phibunwatthanawong and Riddech (2019). In their study, molasses, distillery slop and sugarcane leaves were used for liquid organic fertilizer formulations with N, P and K content ranging from 0.12–0.21%, 0.003–0.015% and 0.80–1.08%.

Formulated Solid Organic Fertilizers. Results of the analysis showed that all four formulations of solid organic fertilizer (SF) contain the essential macro- and micro-nutrient elements required by crops. Among the treatments, SF3 contains the highest amount of macro- and micro-nutrients (Table 4). The Philippine National Standard for organic fertilizers states that organic fertilizers should have a total N, P, and K contents of 7% (BAFPS, 2013). Based from the analysis of the four formulations, SF1, SF2 and SF3 would qualify as organic fertilizer having a total of 5-7% N, P, and K while SF4 would qualify as soil conditioners with less than 5% NPK at moist basis. Higher N, P, and K values are noted when the formulations were analyzed on oven dry basis where SF1, SF2, and SF3 have more than 7% total NPK.

Table 4

Chemical Composition of Formulated Solid Organic Fertilizers

Chemical components	Solid Organic Fertilizer Formulation							
	SF1		SF2		SF3		SF4	
	As Rcvd	Oven Dry	As Rcvd	Oven Dry	As Rcvd	Oven Dry	As Rcvd	Oven Dry
Total N, %	0.97	1.42	0.97	1.37	1.23	1.79	0.97	1.61
Total P (P_2O_5) , %	2.26	3.32	2.67	3.73	2.81	3.88	0.04	0.06
Total K (K_2O), %	2.55	3.74	2.82	4.02	2.96	4.11	0.06	0.09
Total Ca (CaO), %	5.46	8.01	5.81	8.27	6.72	9.77	0.001	0.002
Total Mg (MgO), %	0.88	1.29	0.39	0.56	0.39	0.56	0.002	0.003
pH	7.00		7.6		7.6		7.5	
Sodium, %	0.02	0.03	0.02	0.03	0.02	0.03	0.001	0.002
Zinc , ppm	288.00	422.0	288.00	409.00	313.00	454.00	2.50	4.16
Copper, ppm	0.20	0.43	97.50	139.00	0.35	0.73	Trace	Trace
Manganese, ppm	65.00	138.0	60.10	97.50	41.30	82.50	7.50	12.48
Iron, ppm	24.00	58.0	34.45	68.0	43.67	90.0	22.50	37.43
Organic C, %	7.90	11.59	8.79	12.51	12.98	18.80	10.43	17.35
OM, %	13.58	19.93	15.12	21.51	22.33	32.33	17.94	29.84
% Moisture	31.82		29.74		31.23		39.89	

where: Rcvd - as received with moisture content; SF – solid organic fertilizer formulation

Comparing our results with other studies, the PK in SF2 and SF3 were superior that other formulations recorded by Actena et al. (2008) and Eroa (2015) but N in SF2 and SF3 were generally lower. The study of Actena et al. (2008), P and K of duck manure, cow dung, water hyacinth, municipal water, kajan-oil and neem-oil cake organic fertilizer formulation ranges from 0.25–2.10% and 0.48–1.89%, respectively. On the other hand, Jatropha seed cake in Eroa (2015) had P and K content of 0.72 and 1.89%. These values were much lower compared to the 3.73 – 3.88% P and 4.02–4.11% K recorded in SF2 and SF3 of the study. However, the N content in the SF2 and SF3, at 1.37-1.79%, were much lower than those recorded in duck manure (2.37%), kajan-oil (4%), neem-oil cake (5%) and jatropha seed cake (3.61%); comparable with water hyacinth (1.48%) and municipal waste (1.23%); and higher than in cow manure (0.97%).

Efficacy Trials of Formulated Organic Fertilizers on Cabbage during Conversion to Organic Farms

The marketable yield of cabbage during the first and second trial is shown in Table 5 wherein significant differences were observed among treatments. During the first trial of conversion to organic farms, the yield of cabbage ranged from 5.32 – 8.22 t/ha which were very low compared to the 50 t/ha yield under conventional farm. In solid fertilizer, increasing the amount applied resulted to increase in yield compared to the control. Application of 10 t/ha of the formulated solid organic fertilizer significantly increased the yield by 58.67% when compared with the control. However, this trend is not observed in liquid fertilizer where yield applied with 20 to 40 ml/L is even lower than the control. Only those applied with 60 ml/liter is higher than the control, though not statistically significant. The low yield during the first trial is understandable since organic fertilizers need first to undergo the process of mineralization to release essential nutrients to the soil for plant uptake (Sajib et al. 2015; Taiz & Zeiger 2002).

During the second trial, much higher yields were obtained but were still considerably lower compared with yields obtained from conventional farms. Nonetheless, the expected results were now evident wherein higher input of fertilizer resulted to higher yield, in both liquid and solid fertilizer. Much higher increase in yield were

Table 5

Marketable Yield of Cabbage as Affected by the Application of Different Rates of Solid and Liquid Organic Fertilizer during Conversion to Organic Farms (t/ha)

Treatment	Marketable yield of cabbage (t/ha)	
	First trial	Second Trial
Solid Fertilizer		
A1 – Control	5.17^{b}	6.81^{e}
A2 – 2.5 tons/ha	6.11^{ab}	13.91^{d}
A3 – 5.0 tons/ha	7.16^{ab}	18.26^{c}
A4 – 7.5 tons/ha	7.50^{ab}	22.95^{b}
A5 – 10.0 tons/ha	8.20^{a}	27.31^{a}
Liquid Fertilizer		
B1 – Control	7.36^{ab}	15.98^{d}
B2 – 20 ml/li	6.28^{ab}	17.47^{c}
B3 – 40 ml/li	5.32^{b}	18.52^{b}
B4 – 60 60/li	8.22^{a}	19.42^{a}

Means with the same letter were not significantly different at 5% level of significance DMRT

observed under solid fertilizer where 2.5 t/ha resulted to 204% increase in yield, 5 t/ha to 268%, 7.5 t/ha to 337% and 10 t/ha to 401%. On the other hand, lower increase in yield were observed in liquid fertilizer ranging only at 9–21.53%.

Interaction Effect. Statistical analysis shows that there were significant interaction among the different rates of solid and liquid organic fertilizer particularly during the second trial. During the first trial, Figure 1 shows that the application of 5 t/ha of solid organic fertilizer and without organic liquid plant supplements registered the highest yield. It was followed by those applied with 7.5 t/ha of solid organic fertilizers and 60 ml/liter of formulated organic liquid plant supplements. However, there were no evident trend observed under Trial 1.

During the second trial, a linear trend was observed showing increasing yield as both amount of liquid and solid organic fertilizer increases (Figure 2). In fact, the regression equation derived from these were very high ranging from 0.97–0.99 which means that these equations can be used to predict the increased in yield as the liquid and solid fertilizer increases. The highest yield was observed from those applied with 10t/ha of solid fertilizers and 60 ml organic liquid plant

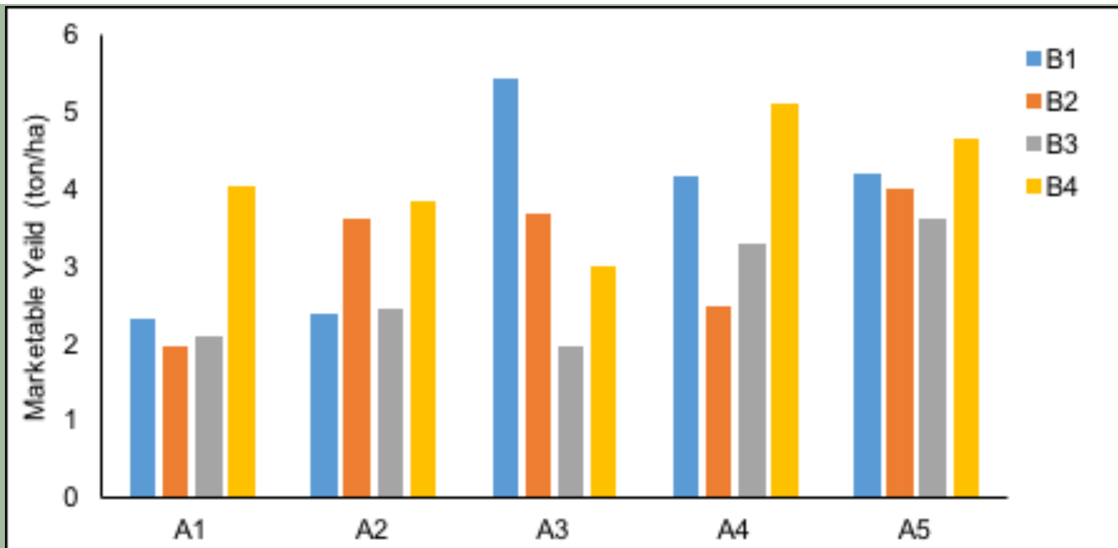

Figure 1. Interaction effect of solid organic fertilizer and liquid organic fertilizer on the marketable yield of cabbage during the first trial (A1 – A5 = solid fertilizer treatments; B1 – B4 = liquid fertilizer treatments)

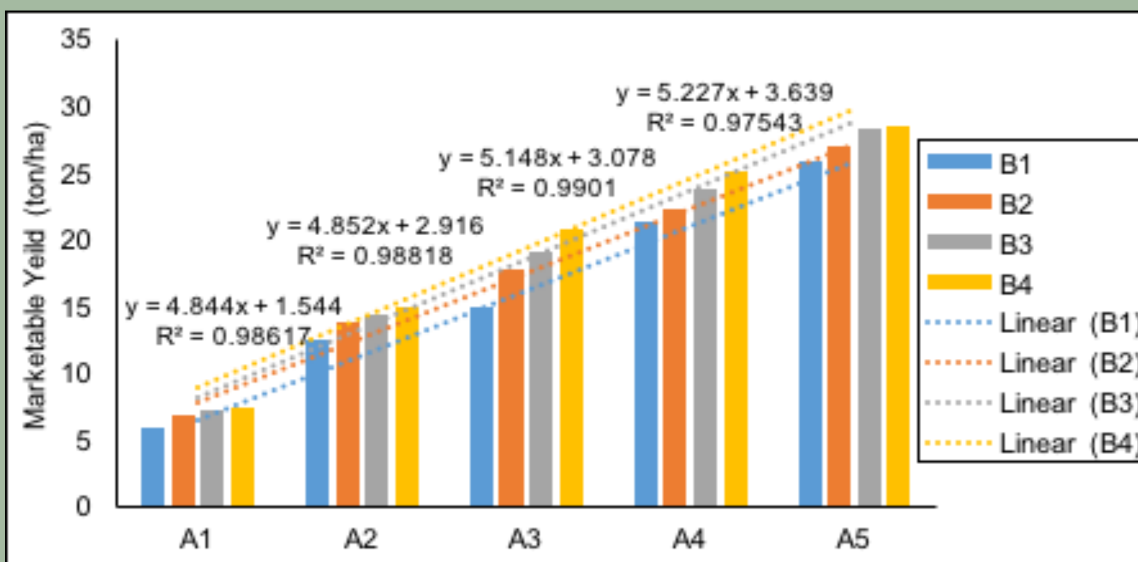

Figure 2. Interaction effect of solid organic fertilizer and liquid organic fertilizer on the marketable yield of cabbage during the second trial (A1 – A5 = solid fertilizer treatments; B1 – B4 = liquid fertilizer treatments)

supplements/liter of water. It was followed by those applied 7.5t/ha of organic solid fertilizers and 60 ml/liter of organic liquid plant supplements. The lowest yield was observed from the control.

Medium-Term Assessment of the Nutrient Management System under Organic Cabbage Production

Nutrient Management for Cabbage in Organic Farm. The computed yield per hectare of cabbage on the second year of conversion to organic farm is 27.45 t/ha (Table 6). This is higher than those recorded during the first year but still much lower than the 50 t/ha yield in conventional plots. This is most likely due to the still improving soil and the relatively slower mineralization of nutrients from the organic fertilizer. Partly, the low yield of cabbage could be also be attributed to the intense heat during the summer when the trial was conducted since the cultivar used, Lucky Ball, is susceptible to intense heat. The soil easily dried up even with irrigation which affected the growth of the plant. Nonetheless, the yield recorded in the study was comparable with those

Table 6

Marketable Yield of Cabbage in Farm Under Organic Conversion and Conventional Farms

Production Type	Feb-May 2012 MEAN YIELD (t/ha)	Nov 2012-Feb, 2013 MEAN YIELD (t/ha)
Farm under conversion to Organic	27.45	54.84
Conventional Farm (t/ha)	50.00	56.18

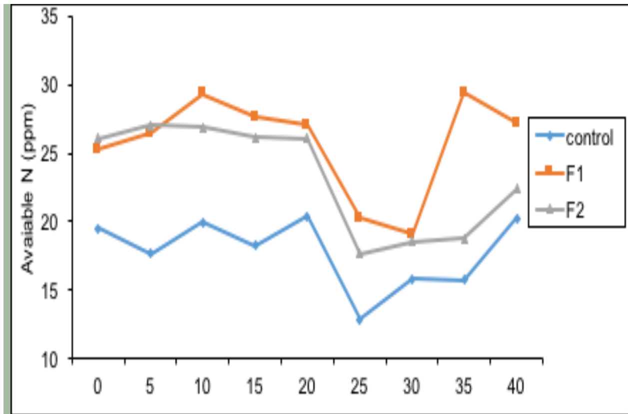

Figure 3. Available N (ppm) released at various days of incubation

recorded by Tad-awan and Basquial (2015) and Tad-awan and Shagol (2016) at 23.27 and 26.26 t/ha, respectively.

Towards the third year of conversion, the computed marketable yield of cabbage per hectare reached 54.84 t/ha which is comparable with the yield of 56.18 t/ha in conventional farm (Table 4). This shows significant improvement as compared with the previous yields. The higher yield could have been attributed to improved soil conditions with the appropriate nutrient management employed such as application of *Trichoderma*, and organic solid and liquid fertilizers. The nutrient management system that was employed may also have provided the plants the necessary nutrients they required during the critical growth and reproductive stages, hence the higher yield. The yield of cabbage under organic production in third year is comparable with 40 – 57.16 tons/ha recorded by Sajib et al. (2015) under organic production in Bangladesh.

According to Clark et al. (1998), organic farming affect changes in nutrient availability to crops either directly by contributing to nutrient pools or indirectly by influencing the soil chemical and physical environment. Soil improvement following the transition to organic management occur slowly, generally taking several years to detect (Wander et al., 1994; Drinkwater et al., 1995; Werner, 1997), yet can have a dramatic effect on long-term productivity (Tiessen et al., 1994). These were consistent with the results of the study. The improvement in yield of cabbage started at second year but the optimum yield was obtained at third year.

Mineralization process. Figure 3 shows that the highest N released was noted in the formulated organic fertilizer (SF1 and SF2) 10 days and 35 days after incubation as compared with the lower available N released for the other formulation using pyrolysis method. In between these incubation days, diminishing amounts of available N were observed. This is most likely due to mineralization of OM releasing N into the supply pool. The result corroborates with Tan (2003) who stated that during decomposition, available N (NH_4^+ and NO_3-) are released thereby increasing the N content of the soil. Brady and Weil (2002) stated that soil organic matter acts as a slow-release nutrient storehouse especially nitrogen. On the other hand, control has the lowest N released in all incubation periods.

Physical and Chemical Properties of Soil of Farms under Conversion to Organic. Table 7 shows the soil properties before the start of conversion and during the 3rd year of conversion. The table showed that soil conditions, specifically physical and chemical properties, had improved a lot. The initial pH of the soil is moderately acidic, organic matter is moderately favorable while P and K are considered high. This result of soil analysis required the application of 140-0-0 kg/ha N, P_2O_5 and K_2O for Cabbage and 80-0-0 kg/ha for carrot.

Lead and cadmium were detected in the experimental site in Year 1, though the concentrations were both below the allowable limit for soil. Mercury was not detected. On the other hand, two types of pesticides were detected in the soil. Chlorothalonil, an organochlorine pesticide, was detected at a level that is much higher than the maximum allowable limit. Cyhalothrin and cypermethrin, which are both pyrethroid pesticides were found within the allowable limit.

In year 3, the bulk density of soil has changed from a dense soil (1.65 g/cc) to a more porous soil (1.17 g/cc). Likewise the pH of the soil improved from very acidic to a level that is within the pH requirements of most vegetable crops. The organic matter, phosphorus and potassium were likewise improved. The heavy metals and pesticide residues that were detected during the start of the project were no longer detected during the third year of conversion. This is because synthetic pesticides and fertilizers were no longer applied.

Table 7

Soil Properties of Soil in Year 1 and Year 3

Soil Properties	**Year 1**	**Year 3**
1. Bulk density (g/cc)	1.65	1.17
2. Soil pH	5.12	5.63
3. Organic matter (%)	3.0	3.51
4. Phosphorus (ppm)	86	120.00
5. Potassium (ppm)	372	470.00
Heavy Metals		
1. Cadmium (ppm)	0.0238	negative
2. Mercury (ppm)	negative	negative
3. Lead (ppm)	0.3813	negative
Pesticide Residues		
1. Chlorothalonil (ppm)	0.21	negative
2. Cyhalothrin (ppm)	0.02	negative
3. Cypermethrin (ppm)	0.03	negative

Conclusions

The re-formulated organic liquid fertilizer using legume seeds with fermented fruit, plant juices and fish amino acids as carrier showed much higher nutrient contents than those of the farmers' formulations. On the other hand, the formulated solid organic fertilizers satisfied the Philippine National Standards for Organic Fertilizers having a total NPK of 5-7%. These contain macro- and micro-elements essential for better plant growth and development. During initial conversion to organic farms, yield of cabbage was very low as compared with the yield obtained from conventional farms. However, as the conditions of the soils were improving with the use of organic fertilizer, the yield also correspondingly increased. Mineralization study provided information for the proper nutrient management in organic farms. Split application of the solid organic fertilizers in three occasions and the use of the liquid organic fertilizer as supplement during critical growth stages resulted to increase in cabbage yield which is comparable to yield obtained from conventional farm. Improved soil conditions were observed in farms after three years of conversion as manifested by the improved chemical and physical properties of the soils. The soil pH, OM, P and K were within the levels favorable to crops. Likewise, the heavy metals such as Cd and Pb that were detected during the start of the study were no longer detected after 3 years of conversion.

Recommendations

The formulated solid and liquid organic fertilizers are important inputs for organic production of highland vegetable crops. Application of *Trichoderma* is recommended to be applied two weeks before planting to control soil borne pathogens and to aid in making nutrients available as it is also a decomposer. The formulated compost at the rate of 2.5 tons/ha and 60 ml/l of water of re-formulated organic liquid fertilizer is recommended to be applied before planting, another 2.5 t/ha compost and 60 ml/l of water organic liquid fertilizer to be applied 15 days after planting. The third application of 5.0 t/ha compost and 60 ml/l of water re-formulated organic liquid fertilizer shall be applied 30 days after planting. The organic liquid fertilizer shall be applied every two weeks thereafter until cabbage heads have formed.

Insect-repellant plants/barrier plants like marigold around the farm should also be planted as a way of controlling insect pests. Plant extracts may also be applied to control insect pests and diseases. Multiple cropping should also be practiced in the organic farm to increase biodiversity.

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