Effect of Green Biomasses on Compost Quality

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Abstract- With an increasing trend towards organic agriculture, the use of organic compost is becoming a necessity. Organic compost fertilizer produced from agricultural waste generally contains low nutrient contents essential to plant growth. Improving the quality of organic compost fertilizer will help farmers raise healthier food while promoting safer environment. The study aimed to investigate the effect of green biomass in enhancing the quality of compost from crop residues. The study used experimental research method laid out in Completely Randomized Design (CRD) in three replicates. Treatments were increasing volume of mixture of green biomasses of *Leucaena leucocephala* (Lam.) de Wit, *Tithonia diversifolia* (Hemsl.) A. Gray, and *Moringa oleifera* Lam. added to pre-composted crop residue. Wood ash comprising 1% by weight of dry compost materials was added per treatment. The macro and micronutrient content of finished compost were analyzed. Finished compost quality in terms of Nitrogen, Phosphorous and Potassium were significantly increased by enriching pre-composted crop residue with increasing volume of mixture of green biomasses. The best treatment combinations were mixing pre-composted crop residue and mixture of green biomass at 3:5, 3:4 and 3:3 in that order. The micronutrients particularly Zinc and Iron were also significantly increased while Copper and Manganese were significantly lowered. The organic Carbon content of finished compost was significantly increased while the pH levels were enhanced towards neutral level.

Index Terms- Green biomass, compost quality, compost enrichment, crop residue composting.

I. INTRODUCTION

Compost product which is also referred to as "organic input" or "soil amendments" is an organic fertilizer that is applied to amend soil physical and chemical properties. Compost production is a proven-technology that can be applied on the spot, but there are many aspects that should be improved in the technology. The major problem with the use of compost as organic fertilizer is its low nutrient content and the slow release of such nutrients for the crops being grown. Fening (2010) stated that due to high cost of inorganic fertilizers, farmers used alternative source of nutrient for their crops such as animal manure and compost from household waste and crop residue, but decreasing crop yield suggests that such organic inputs have low nutrient concentration with limited potential to improve crop yield.

One of the major areas for improvement is the enhancement of compost product in terms of its nutrients quality. Studies conducted to improve the quality of compost from rice straw include that of Goyal and Sindhu (2011) who used biogas slurry, consortium of fungi with *Trichoderma*, and cattle dung in the compost mixture, Abdelhamid (2008) who used oil seed cake and poultry manure on composting rice straw, Fening (2010) who studied on improving the fertilizer quality of cattle manure by using *Chromolaena odorata, Stylosanthes guyanensis* and corn stover mixture as source of nutrients; Evangelista (2011) who used wild sunflower, *Tithonia diversifolia*, to accelerate composting of rice hay and to improve the quality of compost product, and, the Department of Agriculture (2010) that promoted the use of compost from crop residues in combination with animal wastes and natural fertilizer materials such as rock phosphate and limestone in producing compost with greater nutrient content. Other studies were conducted on fortified/enriched compost fertilizer using various methods (Godwa, 1996; Harrison, 2005; CTA, 2007; Ndung'u *et al*., 2007; Biswas, 2008; Torkashvand, 2010). Such studies were related to quality improvement of compost from agricultural wastes that focused on the use of animal manure (cow dung, poultry and pig manures), inorganic chemical fertilizers as fortifying substances, natural fertilizer materials such as rock phosphate, mica, and limestone, and microorganism inoculants from various strains of fungi and bacteria. The problem with the use of the above materials in enhancing the quality of compost is the cost, source and availability of such materials which may not be affordable to ordinary farmers. If available, the quantity may not be enough for composting. An ideal material for compost quality improvement is something that farmers can produce or can easily access. The use of green biomass that contains much higher nutrients offers a promising potential in improving compost quality. The study was thus conducted to uncover the effect of mixture of nutrient-rich green biomasses, which are locally available and/or could easily be grown by farmers, on compost quality.

The study was based from the theory that variation on the quality of compost depends on compost material used. Tennakoon and Bandara (2003) elucidated that variation in the nutrient content of compost depends upon the nature of the material being composted. Since plant materials vary in their nutrient content and concentration, it is therefore expected that when used in composting, variation in compost quality will exist. The variation in the initial content and concentration of nutrient of compost materials suggests the need to identify the best combination of compost materials that can yield finished compost of with the highest quality. Evaluation of available compost material and determining the best material can lead to successful production and use of high quality compost. In general, green biomass with high nutrient content like is Nitrogen is indicated by having dark green leaves that make a good organic fertilizer. Jama *et al*. (2004) reported that green leaf biomass of *Tithonia* is high in nutrients and Taguiling (2014) reported that Tithonia diversifolia contains NPK values of 24.2, 95 and 160 mg/100g, respectively. Magat *et al*. (2009) reported that *Moringa oleifera* leaves had high macro and micronutrients as source of nutrient for compost. Since the green biomass of the foregoing species contains high nutrient contents, it is logical to expect that when composted, portion of these nutrients will be retained in the compost product. It is thus conceptualized in this study that using the above green biomass with high nutrient content will result to compost with higher nutrient content quality.

This study also conceptualized that increasing the amount of green biomass would correspondingly increase the nutrient quality of finished organic compost product. Misra & Roy (2003) stated that composting requires the inclusion of a higher proportion of sappy green matter with higher nitrogen content (lower Carbon/Nitrogen ratio) such as grass and other plant cuttings. Lickacz (2002) also reported that wood ash is an effective compost material. Thus, it is further conceptualized that addition of ash will further enhance the quality of compost in terms of its P and K contents.

The overall objective of this study was to determine the effect of green biomass and wood ash in enhancing the quality of finished organic compost using crop residue as main composting material.

II. MATERIALS AND METHODS

The study used the experimental method of research laid out in Completely Randomized Design (CRD) in two replicates. Completely Randomized Design is the simplest experimental design in which the subjects are randomly assigned to treatments. The design relies on randomization to control the effects of extraneous variables. The experimenter assumes that, on average, extraneous factors will affect treatment conditions equally, so any significant differences between conditions can fairly be attributed to the independent variable (Stat Trek, 2011).

In this study, the subjects were the crop residue compost materials and the treatments or independent variables were the increasing volume of green biomass with the addition of ash to the compost material. The dependent variables were the compost quality parameters in terms of pH, O.C, N, P, K and micronutrient like Fe, Mn, Zn, and Cu. It was hypothesized that if increasing the volume of green biomass and the addition of wood ash is effective in increasing the compost quality, compost treated with greater volume of green biomass should show significantly higher nutrient contents than the control treatment. The treatments (T) were as follows:

- T_0 Crop residue only or 3:0 ratio - Control treatment
- T_1 Crop residue + Green biomass at 3:1 ratio
- T_2 Crop residue + Green biomass at 3:2 ratio
- T_3 Crop residue + Green biomass at 3:3 ratio
- T_4 Crop residue + Green biomass at 3:4 ratio
- T_5 Crop residue + Green biomass at 3:5 ratio

Crop residues from threshing of rice (*Oryza sativa L.*) and corn (*Zea maize L.*) stalks were mixed at a ratio of 3:1 rice straw - corn stalks ratio, while the green biomass or succulent stems and leaves of (Ipil-ipil (*Leucaena leucocephala* (Lam.) de Wit), Wild sunflower (*Tithonia diversifolia* (Hemsl.) A. Gray) locally known as *Lappao*, and Malungay (*Moringa oleifera Lam.*) were mixed at a ratio of 1:2:1. Wood ash was added to compose about 1% of the dry crop residue compost material.

Composting Procedure

The study used a 2-stage composting process involving pre-composting and compost enrichment. Pre-composting was patterned from Taguiling (2013) and Cuevas (2013) with modification involving the following steps: a) gathering rice straw and corn stalks from threshing sites, weighing and chopping the same to almost uniform sizes and mixing them at 3:1 rice straw-corn stalks ratio; b) soaking the mixture overnight and allowing excess water to drip; c) preparing an elevated platform made of bamboo about 6 inches from the ground with a dimension of about 1.2 x 1.2 x 1 m; d) piling the crop residue mixture on top of the elevated platform to about 15 cm, broadcasting a handful of *Trichoderma harzianum* as activator, and adding about 5 cm layer of green biomass; e) repeating step d until a height of 1 meter is attained and covering the pile with plastic sheets; and, f) allowing the pile to pre-decompose for 15 days, sprinkling water every after 5 days.

Compost enrichment using green biomass involved the addition of mixture of green biomass to the pre-composted crop residue following steps of: a) gathering and chopping green biomasses of *Ipil-ipil* (*L. leucocephala*), Wild sunflower (*T. diversifolia*) and *Malungay* (*M. oleifera*), and mixing the said green biomass at a ratio of 1:2:1; b) weighing pre-composted crop residue and mixture of green biomass; c) mixing thoroughly the pre-compost and mixture of green biomasses following the treatment ratios above and adding about 2 handfuls of wood ash during the mixing process; d) putting the mixture in a non perforated sack and allowing the mixture in each treatment to undergo decomposition for 36 days under a shaded area, sprinkling water every 6 days to hasten decomposition.

Finished composts were screened and composts in each replicate were mixed thoroughly. Composite sample of 0.5 kg were subjected to nutrient analysis at the Bureau of Soils and Water Management, Quezon City. Parameters measured in this study included indicators of compost quality such as the major plant nutrients as follows: Macronutrients - total N (%), total P_2O_5 (%), total K_2O_5 (%), O.C. % , pH, and some micronutrients such as Copper (Cu), Zinc (Zn), Iron (Fe), and Manganese (Mn).

III. RESULTS AND DISCUSSIONS

Macronutrient Quality of Finished Compost

Nitrogen Content. Table 1 shows the quality of compost in each treatment based on total Nitrogen content. The treatments labeled T_0 to T_5 represent finished compost derived by composting crop residue and green biomass following the indicated ratio with the addition of ash computed as 1% of the weight of the compost material.

The average total nitrogen content of the finished compost shows increasing trend with T_0 or control treatment showing the lowest total nitrogen content (0.58%) and T_4 showing the highest total nitrogen content (2.51%) on oven-dry weight basis. On weight basis, a total nitrogen content of 2.51% translates to 25100 milligrams of total nitrogen per kilogram of compost or 25100 ppm under T_4 compared to control (T_0) of 5800 ppm. Typically, nitrogen is the most costly and limiting nutrient that is required in greatest quantities by plants according Gerngross et al. (2006). The finding implies that enriching compost with increasing amount of green biomass increases the amount of nitrogen in finished compost.

Total nitrogen (N) includes all forms of nitrogen: organic N, Ammonium N (NH_4-N), and Nitrate N (NO_3-N). Rice straw/corn stalks contain low 0 - 0.5% Nitrogen according to Asaolu et al. (2011), thus the increase in the nitrogen values could be attributed to the effect of green biomass added during compost enrichment. According to Anonymous (2007) most finished composts had total Nitrogen content that generally lie between 0.4 and 3.5. The result of this study is within the upper range except for the control treatment which was on the lower range. The high Nitrogen content as found in this study could be attributed to the high Nitrogen content of *Moringa oleifera* leaves (N-4.74% (Magat *et al*. 2009), *Leucaena* (3.74%) (Gachene and Kimaru, 2003) and *Tithonia* (3.5%) Jama *et al*. (2004) and 5.53% according to Evangelista (2011).

Analysis showed that there was a significant difference on the amount of total Nitrogen between treatments. Total Nitrogen content at treatments T_5, T_4, T_3 and T_2 were significantly higher than T_1 and T_0 treatments but were not significantly different with each other according to Duncan's Multiple Range Test (DMRT). The no significant difference between the treatments implies that increasing the ratio of crop residue and green biomass from 3:2 to 3:5 do not give significantly higher Nitrogen content of compost product although there may be slight differences in the numerical values.

All the composts enriched with green biomass had nitrogen content that were significantly higher than the control treatment and at an increasing trend. This implies that the addition of increasing amount of green biomass significantly increases total nitrogen content of crop residue compost. The amount of Nitrogen present in all the finished composts were from 2.19% to 2.51% and were in agreement with that of Cuevas (1997) who found that Nitrogen (N) content of most compost ranges from 1.5% to 3.0%. The control treatment in this study had a Nitrogen content (0.58%) which was lower than the 0.65% Nitrogen content of paddy straw as found by Kumar *et al*. (2011) but higher than the findings of Koenig and Johnson (1999) stating that rice straw and corn stover contain 0 - 0.5 % Nitrogen. The Nitrogen content of 0.58 to 2.52% as found in this study was higher than the findings of (Taguiling, 2013) in which Nitrogen content of 0.41 to 0.51% was found using only two species as green biomass. The finding was in agreement with that of Evangelista (2011) who found that *Tithonia diversifolia* not only accelerates composting of rice hay but improves the quality of compost product.

Phosphorous Content. Highest phosphorous content (1.74%) was obtained from T_5 when pre-composted crop residue was enriched with green biomass at 3:5 ratio followed by T_4-3:4 and T_3 treatments with a total phosphorus content of 1.73% and 1.55%, respectively. The above treatments were significantly higher than the rest of the treatments except that T_3 was at par with T_2 and T_1 with Phosphorous content of 1.46 and 1.37%, respectively. All crop residue composts treated with green biomass were significantly higher than the T_0 or control treatment. This finding implies that mixing pre-composted crop residue with green biomass at 3:1 to 3:5 significantly increases phosphorous content of finish compost. The significant increase in P content could be attributed to the high P content of the species used and the addition of wood ash during composting.

Potassium Content. The total K content of treatment samples was from 2.46 to 9.28% on oven-dry basis. The compost in the control treatment had the lowest Potassium content at 2.46% percent and was at par with T_1 with potassium content of 2.94%. The composts enriched with green biomass from T_2 to T_5 showed increasing potassium content from 4.31 to 9.28% and were significantly superior over the control and T_1 treatments based on the analysis. This implies that the addition of increasing volume of green biomass with the addition of wood ash significantly increases the potassium content of compost from crop residue. The Potassium content of treatments T_3-5.25%, T_4-6.54% and T_5-(9.28%) were within or higher than the Philippine National Standard (5-7%) for organic fertilizer. The high Potassium content of crop residue enriched with green biomass was probably due to the addition of wood ash with 4-10% potash and the high Potassium content of *Tithonia diversifolia* (2.7-4.8%), *Leucaena leucocephala* (1.3-3.4%) (Jama et al., 2004). The T_4 treatment contains potassium (6.54%) that was significantly higher than T_3, T_2, T_1 and T_0 or control treatments. The T_1 and T_0 treatments were not significantly different from each other.

Micronutrient Quality of Finished Compost

Copper Content. The copper content of the control treatment (122.46 ppm) was significantly higher than the copper content of all the compost treatments enriched with green biomass and wood ash. Increasing the amount of green biomass showed no linear effect on the copper content of finished compost. The copper content of all the treatments enriched with green biomass and ash were found to be lower than the control treatment and were significantly lower than the untreated compost. The finding implies that the addition of green biomass and ash cause a reduction on the copper content of finished compost.

Zinc Content. On ovendry basis, treatment T_4 showed the highest Zinc content (110.7 ppm) and was significantly higher than the rest of the treatments. The Zinc content of treatments T_5, T_3, and T_2 of 77.7, 82.6 and 73.5 ppm, respectively were significantly higher than T_1 and T_0 treatments but were statistically the same by DMRT. Except for T_1 which was statistically at par with T_0, the rest of the treatments were significantly higher than the control treatment implying that the addition of increasing volume of green biomass increases the zinc content of finished compost. Zinc plays a role in protein synthesis as evidenced by the accumulation of soluble nitrogen compounds such as amino acids and amides. The high level of Zinc of finished compost implies that it is suitable in rice paddy areas where Zinc deficiency is limiting crop growth.

Iron Content. Highest iron content (8,593 ppm) was obtained in treatment T_5 when pre-composted crop residue was enriched with green biomass at 3:5 ratio and was significantly higher than the rest of the treatments. This was followed by T_4

treatment with iron content of 6,976 ppm which was also higher than the rest of the treatments. The other composts (T_3,T_2 and T_1) treated with green biomass and wood ash were also significantly higher the T_0 or control treatment implying that green biomass and wood ash increases the iron content of finished compost. According to Davis (1983) Iron is a catalyst to chlorophyll formation, acts as an oxygen carrier, and aids in respiratory enzyme systems.

Manganese Content. The compost in the control treatment (T_0) had the highest Manganese content at 899.4 ppm based on oven-dry weight. The composts enriched with green biomass and wood ash from treatments T_1 to T_5 showed decreasing manganese content from 892.8 ppm to 698.8 ppm. Except for T_1 which was statistically at par with the control treatment, all the composts enriched with green biomass and wood ash were significantly lower than the control based on the analysis. This implies that the addition of increasing volume of green biomass and ash significantly decreases the manganese content of compost from crop residue. The Manganese content of the T_5, T_4 and T_3 were at par with each other and were significantly lower than the T_2, T_1 and T_0 treatments.

Organic Carbon, and pH Content of Finished Compost

Organic Carbon Content. Table 1 further shows an increasing trend on the amount of organic carbon starting from the control treatment (12.47%) up to the T_5 treatment (31.37%). The organic carbon (OC) content of T_1 to T_5 treatments were significantly higher than the control treatment but were not significantly different from each other. The finding implies that a significant increase in the OC content of compost can be attained by increasing the ratio of compost-green biomass to 3:1 and above. Organic carbon is the measure of carbon based materials in the compost. It is an important source of carbon that improves soil and plant efficiency by improving soil physical properties, providing a source of energy to beneficial organisms, and enhancing the reservoir of soil nutrients. High quality compost will usually have a minimum of 50% organic carbon content based on dry weight (Darlington, 2007).

pH Content. The pH of compost derived in this study was as low as 4.55 to as high as 6.8. Most foreign standards require that pH of compost should not exceed 7.5 which was met by 100% of the treatments. Other national standards suggest excellent pH values between 6 and 8.5 which were met by 50% of finished compost. The control treatment showed acidic pH value (4.55) while the T_1 and T_2 treatments were slightly acidic with pH value of 5.70 and 5.75, respectively. Analysis revealed that all enriched composts were significantly higher than the control. The pH in the T_4 and T_3 treatments were statistically identical and were within the favorable pH for plant growth. The pH value in the T_5 treatment (6.8) almost reached the neutral state and was significantly different with the rest of the treatments.

IV. CONCLUSION

The results of the study indicate that nutrient quality of compost fertilizer from rice straw and corn stalks can be enhanced by pre-composting said crop residues, adding mixture of nutrient-rich green biomasses and small amount of wood ash. Treating pre-composts with increasing amount of green biomass of *Leucaena leucocephala*, *Tithonia diversifolia Moringa oleifera* significantly increases the Nitrogen, Phosphorous, Potassium, Zinc and Iron contents of finished compost but has an inverse effect on the Copper and Manganese contents of the compost product. It also increases the Organic Carbon content of finished compost and improves its pH value to almost neutral state. Further studies need to be conducted to elevate further the nutrient level of the compost to be at par or better than the national or international standards for organic fertilizer.

APPENDIX

Table 1. Mean nutrient quality of finished compost in terms of macro and micronutrients on dry weight basis

Treatments	Total N (%)	(P_2O_5), (%)	K_2O, (%)	Zn, ppm	Fe, ppm	Mn, ppm	Cu, ppm	Organic C., %	pH
T_0 - 3:0-Control	0.58 ^{c}	1.14^c	2.46^e	32.7^c	2373.0^e	899.4^a	122.46^a	12.47^b	4.55^d
T_1 - 3:1 ratio	2.19^b	1.37^b	2.94^e	38.1^c	2927.0^d	892.8^a	86.26^b	24.46^a	5.70^c
T_2 - 3:2 ratio	2.39^a	1.46^b	4.31^d	73.5^b	6006.0^c	828.3^b	92.06^b	25.51^a	5.75^c
T_3 - 3:3 ratio	2.45^a	1.55^{ab}	5.25^c	82.6^b	6126.0^c	713.0^c	82.47^{bc}	26.28^a	6.35^b
T_4 - 3:4 ratio	2.51^a	1.73^a	6.54^b	110.7^a	6976.0^b	698.8^c	70.24^d	27.63^a	6.50^b
T_5 - 3:5 ratio	2.49^a	1.74^a	9.28^a	77.7^b	8593.0^a	711.8^c	74.05^{cd}	31.37^a	6.80^a

Means with the same subscripts in column denotes non significant differences by Duncan's multiple range test (DMRT) (p=0.001)

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