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FERTILIZER VALUE OF COMPOST AND DENSIFIED FERTILIZERS MADE FROM SWINE AND POULTRY MANURES ON CROPS AND CHEMICAL PROPERTIES OF CLAY SOIL

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ABSTRACT

The risks associated with animal manure when used as fertilizer are complex in nature and when not handled properly can cause damage to humans and environment. This investigation sought to elucidate the requirements when compost with animal manures are processed into densified fertilizer and assess its fertilizer value. Composting of poultry and swine manures were conducted in the demonstration area of Agricultural Systems Institute (ASI) at U.P. Los Baños, Philippines. Nutrient additives (rice bran, rice ash, soya meal, carbonized rice hull, alumino-silicate material, *Gliricidia sepium*) were mixed with poultry and swine manures while concurrent vermicomposting was conducted using fresh *G. sepium* and carabao manure. The composting final by-products were molded into densified fertilizers. The efficacy of these fertilizers was evaluated in pot experiments conducted in sequential cropping from February 03 to May 25, 2014. Corn (*Zea mays* L.) was planted first followed by bush sitao (*Vigna sesquipedalis x Vigna unguiculata*) as second crop. The response of crops and changes in the chemical properties of acidic clay soil (*Typic Tropudalfs)* were examined. The study showed the role of densification technology in the production of organic fertilizers from animal manures. Research findings suggest that the densified manure-based fertilizers with organic additives may be used as alternative to chemical commercial fertilizer when the latter is not available. The form (powder or molded) and chemical constituents of the applied fertilizers affected the crop yield and brought positive changes in the chemical properties (pH and cation exchange capacity) of soil. A longer cropping period is required before significant changes in soil properties can be detected

Key words: pelleted organic fertilizers, densification, compost pathogens, additives

INTRODUCTION

The swine and poultry sub-sectors are among the top economic contributors of the agriculture industry in the Philippines. There are concomitant environmental issues that must be confronted alongside the intensified poultry and livestock production (Briones 2005). The risks associated with animal manure when used as fertilizer are complex in nature and when not handled properly can cause damages to humans and environment. The potential pollutants of concern in animal manures are infectious agents, nutrients, salts, and heavy metals that may either be leached to groundwater or transported to surface waters by runoff. According to Jones and Martin (2003) another danger in the application of compost from animal manures can increase the risk for the occurrence of *Salmonella* and *Escherichia coli* bacterial illnesses, particularly when applied to soils used to grow vegetable crops. But because animal manure contains large amount of nitrogen (N) and phosphorus (P) and micronutrients, they could substantially contribute to meeting the fertilizer requirements of Philippine agriculture, if only these could be recovered as composts/organic fertilizers. Therefore, high quality by-products must be produced consistently to offset these production costs.

Composting is the most widely used eco-friendly approach toward managing the livestock manure and producing valuable organic products (Bernal et al. 2009, He et al. 2011 and Wang et al. 2017). Compost stability is an important aspect of compost quality and it can reduce manure volume and transform it into a more stable nutrient form (Purdue, 1996). Compost made from animal manure is an effective material for improving the physical and chemical properties of soil (Cosico 2006, Ewulo 2008 and Purser 2013). Numerous studies have been conducted on the benefits related to composted animal manure's application on soil quality (Zhu et al 2014), soil fertility (Gil et al. 2008, Alemi et al. 2010, Pampuro et al. 2017), and the environment (Pampuro et al. 2016, Subedi et al. 2016). Flavel and Murphy (2006) reported that the soil benefits greatly from the addition of organic fertilizers by improving its fertility, soil structure, water-holding capacity, bulk density and biological properties. However, the cost of composting relative to utilization of raw manures can be considerably higher (Rynk, 1992).

The quality of compost and its varying nutrient composition also limit its efficient use (Gouin 1998, Pangga 2006 and Hepperly et al. 2009). Runoff, hydrolysis and leaching process affect the level of nutrient loss to the environment during composting (De Ceuster and Hoitink, 1999; Fauci et al. 1999). Low density of livestock manure and varying nutrient concentration are two factors that limit the application of composted animal manure. The densification technology is an effective solution for both problems. Densification of biomass material that usually has a low density is good way of increasing density, reducing the cost of transportation, and simplifying the storage and distribution of this material. (Zafari and Kianmehr 2013; Pampuro et al. 2017). Densification or pelletizing technology converts animal manure to a dry, pathogen free, easy to handle, finished product that can be used as a fertilizer, soil amendment, feed additive, or energy fuel (USPEA 1998). Pellet processing can be used as a method for slow-release of N fertilizer that reduces leaching losses and enhanced N uptake, as well as positive effects on both soil and plant health. Molding compost fertilizer into pellets can solve problems such as soil moisture content, high volume per unit weight, and changing nutrient composition (Hara 2001). Pelletized fertilizers can be applied uniformly with better control because of its size and less moisture than manure (UNL 1998). The aims of the present study were to carry out an assessment of the composts and densified fertilizers from animal manures in the context of 1) requirements in producing quality compost by-products, 2) physiological response of corn and soybean, 3) confounding factors affecting the efficiency of densified fertilizers and 4) changes in the chemical properties of acidic clay soil.

MATERIALS AND METHODS

Compost production. Manure collection was conducted between November 2013 to December 2014 from commercial swine and poultry farms in Batangas and Laguna Philippines, respectively. The livestock manures were air-dried and sieved in 2.0 mm mesh and stored for composting. Animal manure samples were analyzed for its nutrient composition at the Agricultural Systems Institute-Analytical Service Laboratory (ASI-ASL), U.P. Los Baños, Philippines. The nutrient additives, (rice bran, rice ash, soybean meal, carbonized rice hull, alumino-silicate material, *Gliricidia sepium*) at different proportions, were mixed with the animal manures to enhance the nutrient composition of the final products. Mixes of swine and poultry manures were composted in separate composter bins up to the time the level of completeness of the composting process were attained. Five (5) batches of compost finished products were made from poultry and swine manures. Concurrent vermicomposting was conducted using fresh *G. sepium* and carabao manure as substrates for African night crawler (*Eudrilus eugeniae*) earthworms. Samples of the final products of decomposition were submitted to the ASI-ASL for nutrient chemical analysis and National Institute of Molecular Biology and Biotechnology

(BIOTECH) laboratory, U.P. Los Baños for the detection of pathogens-*Salmonella spp*. and *Escherichia coli*.

Densification technology. The molding machine is a disk-pelleter roller that has disks with many holes and a roller. Batch 5 of poultry and swine manure-based finished products was selected among the batches. The powder form of compost (batch 5) and vermicompost were wet at 15% moisture content and fed between the disks and roller, and as the disk and roller turns, the compost was forced into the holes, producing the molded form. With its condensed property, this product was referred in this study as densified fertilizer. Similarly the same process was done to powder vermicompost, hereby, referred as densified vermicompost.

Pot experiments. Sequential cropping was conducted at the composting and demonstration area of ASI-U.P. Los Banos, Philippines. The first crop was corn (*Zea mays* L.) sown on 03 February 2014 and followed by planting bush sitao (*Vigna sesquipedalis x Vigna unguiculata*) as second crop immediately following the harvest of corn. The 1st crop was harvested 72 days after germination (16 April 2014) and the bush sitao seeds were planted on 30 April 2014. Vegetable pods were harvested (six harvests) 35-45 days after emergence. Harvesting was done manually at 2-3 days interval to prolong the productive life of the plants. Black polyethylene pots with 30.5 cm internal diameter and 15.1 cm deep were utilized in this experiment. Each pot was filled with 10 kg air-dried soil of Alipit series. Based on the weight of soil/pot, the organic-based fertilizers were applied at 5 tons/ha, the amount approximates the rate of crop residues applied in many farming systems. The soil organic matter (SOM), soil pH and cation exchange capacity (CEC) were measured using Walkley and Black, potentiometric and ammonium acetate methods, respectively. The experimental treatments were as follows: T1- Control, no fertilizer, T2- dried swine manure, T3- dried poultry manure, T4- densified swine manure-based organic fertilizer, T5- densified poultry manure-based organic fertilizer, T6- densified vermicompost, T7- *Gliricidia sepium*, fresh leaves, T8- chemical fertilizer, recommended rate. Fresh leaves of *G. sepium* served as one of the additives in the production of organic fertilizers and also the main substrate used in vermicomposting. Treatments 2 to 7 were applied before planting. Split application for Treatment 8 was done with urea (46-0-0) and complete fertilizer (14-14-14) as sources of nutrients. Recommended rate for corn (90-30-30) and bush sitao (20-45-45) were followed. The experiments were laid out using Completely Randomized Design (CRD) with 3 replications. The data were analyzed using analysis of variance (ANOVA) and the mean separation was conducted using least significant differences (LSD $_{0.05}$).

The whole plant was cut 1 cm above the soil surface at harvest time. The plant samples were cleaned from dirt and air-dried immediately for 3 days and oven-dried at 60ºC until a constant dry weight was achieved. These plant samples were ground (0.5 mm) and stored for chemical analyses. Soil from each pot were laid out in a large plastic tray and roots and the remaining pieces of residues were removed. The soil was carefully removed and washed from the roots. Clean roots were oven-dried at 60ºC for 48 hours or until a constant weight was obtained. The herbage dry matter weight (aboveground parts and roots) of corn plants were recorded. The number and fresh weight of soybean pods were measured. Laboratory samples were taken from the soil and the remaining soil was air-dried, ground (2mm) and returned to corresponding treatment pots for the second cropping. The study was terminated after the harvest of bush sitao pods and the soil was analyzed.

RESULTS AND DISCUSSION

Compost production and densification technology

Animal manure in general should not be treated as waste products as it can be valuable plant nutrient resource. The initial N concentration in swine and poultry manures was 2.13 and 2.10 %, respectively (Table 1). Both manures remained at neutral pH range (7.1 to 7.6) with moderate amount of organic carbon: 16.2% and 17.4% for poultry manure and swine manure, respectively. The P concentration is relatively higher in swine manure (5.60%) compared to poultry manure (3.76%). The concentration of the basic cations like potassium (K), calcium (Ca) and magnesium (Mg) in the poultry manure are far greater than the swine manure. However, the level of acidic cations such as iron (Fe) and copper (Cu) are predominant in the latter. There are many associated factors affecting the nutrient composition of manures. These variations are expected because different farms provide different diet/food supplements and management. The changes in the chemical composition of animal manures depends on many factors such as class of animal, kind of feed consumed, kind of bedding used and the method of handling (Purser 2013 and Bernal et al. 2009).

Table 1. Chemical composition of the air-dried swine and poultry manures used in the experiment.

Materials	pH	OC	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn
		%						ppm			
Poultry manure	7.6	16.16	2.10	3.76	3.74	5.80	0.41	7762	1371	54	571
Swine manure	7.1	17.35	2.13	5.60	0.84	0.53	0.11	10262	442	535	502

The chemical analyses of raw materials added (additives) to livestock manures are presented in Table 2. *Gliricidia sepium* (Jacq. Kunth ex Walph) is one of the important additives utilized in compost production because of its high N, P and K concentration (3.68%, 1.19% and 3.13%, respectively). It is a small to medium-sized tree belonging to the family Leguminosae. In the Philippines, it is locally known as Kakawate or Madre Cacao that has been naturalized everywhere because of its adaptability to any type of soil condition. This tree has been integrated into farming practices as soil amendment (Badayos and Pangga 2000, Villegas-Pangga 2010). *G.sepium* as a green manure minimizes the use of chemical fertilizers that are expensive. As leaf manure, it showed enhancement of soil productivity and increase in crop yields in several rainfed crops attributed to its nutrients (Srinivasa Rao et al. 2011, Beedy et al. 2010).

Among the nutrient additives, rice bran has the highest carbon (37.5%) and K (3.22%) concentration. It has low Ca and Mg concentration that may be attributed to its acidity at pH 5.4. Similar to rice bran, soy bean meal (SBM) is highly acidic (pH 5.9) and has high C concentration (21.2%). All other major elements are at low levels including total N (0.49%). This low total N concentration is not expected from a commercial feed formulation. Soybean meal is the most commonly used vegetable protein source in feed industry (Kim et al. 2016) and most commonly used plant protein in aquaculture (Akiyama 1988). It has high protein and amino acid content (Banaszkiewicz 2011) and contains more digestible protein than animal proteins with 10, 11 and 17% more digestible than fish meal, squid meal and shrimp meal, respectively (Akiyama 1988). SBM is a natural fertilizer with phytotoxic activity (Brown and Davis 2016) and is a good source of N when used as fertilizer in an organic farming system. Carbonized rice hull (CRH) is produced from the incomplete or partial burning of rice hull at <700◦C. When burning reaches to >800◦C, it becomes rice ash. CRH and rice ash pH are 9.5 and 10.2, respectively.

Alumino-silicate clay is used as a natural additive containing high levels of sulfur and iron, at 1555 and 7121 ppm, respectively. Though it has a cation exchange capacity (CEC) of 21.19 cmol(+)/kg soil, it contains low levels of major elements NPK and organic C. With nearly neutral pH 6.5, it has a high concentration of Ca (1356 ppm) and Mg (814ppm). Alumino-silicate clays can be very important as sites for microbial activity and areas where chemicals can adsorb (Dodds and Whiles 2012)

Table 2. Chemical characteristics of raw materials used in organic fertilizer production.

Raw Materials	pH	Organic C	Total N	P	K	Ca	Mg	SO_4^-	Fe	Zn	Cu	Mn
		%				ppm						
Alumino-silicate clay*	6.5	1.94	0.04	0.05	0.06	1356	814	1555	7121	16	5	142
Soybean meal	5.9	21.2	0.49	0.11	0.42	799	206	ND	167	19	ND	171
Rice Bran	5.4	37.49	1.05	0.41	3.22	0.08	0.11	-	122	58	8	222
Carbonized rice hull	9.5	2.08	0.18	0.45	0.90	2415	384	ND	1466	56	5	118
Rice Ash	10.2	0.37	0.03	0.28	0.93	1168	233	139	10	ND	86	ND
Gliricidia sepium++	6.2	-	3.68	1.19	3.13	0.95	1.66	-	-	_	-	-

*CEC: 21.19 cmol(+)/kg soil

++ Organic constituents of *G. sepium*: Digestible organic matter 55%; Acid-detergent fiber 22.2%, Lignin 8.65%, Cellulose 13.6%, Hemicelluloses 11.5%

In general, nitrogen is the most deprived macronutrient observed in all organic-based fertilizers tested (Table 3). The amount of P (P_20_5) is consistently the highest in the composted swine manure compared with K (K_20). However, a different pattern was observed in composted poultry manure, which demonstrated higher concentration of K than P (batch 2 to 4). The amount of organic matter varied from very low 8.56% (Batch 2) to 33.74% (Batch 5). The total NPK concentration from Batch 1 to 5 ranged from 5.1 to 8.34%. On the other hand, the vermicompost showed lower amounts of total NPK with only 2.82%. The nutrient content of compost or organic fertilizer will depend upon the nutrient content of the raw materials, management of the composting system, and the relative "decomposability" of the compost materials (Porter 2015; Pangga 2006).

The Philippine National Standards for Organic Soil Amendment (PNS-OSA) includes all the products within the scope of PNS i.e. organic fertilizers, compost/soil conditioner, microbial inoculants, and organic plant supplements (BAFS 2016). Result findings suggest that the added organic materials (additives) enhanced the quality of the compost by-products by increasing its nutrients to a level that can be categorized as organic fertilizers which is in conformity to the PNS-OSA. Organic fertilizer, defined by PNS-OSA, is any product in solid or liquid form, of plant (except byproducts from petroleum industries) or animal origin, that has undergone substantial decomposition that can supply available nutrients to plants with a total N, P and K of five to ten percent (5-10%). This may be enriched by microbial inoculants and naturally occurring minerals but no chemical or inorganic fertilizer material has been used in the production or added to the finished product to affect the nutrient content. Only the NPK concentration makes it different from compost with 2.5 to <5.0%. (BAFS, 2016). Recognizing the given Standards, Batch 1 to 5 were categorized as organic fertilizers, while soil conditioner/compost for vermicompost. The composition and quality of raw organic materials (physical and chemical), and the rate and efficiency of composting process (temperature, moisture content, aeration rate) are some of the basic factors influencing the properties of these organic fertilizers (Bernal et al. 2009, Pangga, 2006).

Table 3. Nutrient composition of organic soil amendments made from animal manures.

Organic soil amendments	**N**	**P**	**K**	**Organic Matter**	**Total NPK (%)**
	%				
Composted swine manure-with additives					
Batch 1	0.93	3.09	1.32	28.80	5.34
Batch-2	0.60	3.64	0.83	8.56	5.07
Batch-3	0.86	5.13	0.87	10.96	6.86
Batch 4	0.72	3.46	1.38	15.36	5.56
Batch 5	0.89	3.96	1.26	33.74	6.11
Composted poultry manure with additives					
Batch 1	1.44	4.27	1.18	26.38	6.89
Batch 2	0.56	2.60	2.75	7.74	5.91
Batch 3	1.00	3.26	3.36	9.54	7.62
Batch 4	0.71	2.48	4.02	11.28	7.21
Batch 5	1.04	3.99	3.31	19.72	8.34
Vermicompost	1.30	0.83	0.69	26.00	2.82

A promising approach toward increasing the benefits of composted animal manure, as well as to create a potential new market for animal manure-derived fertilizer, is to apply a densification process (Pampuro et al. 2017). The densification or pelletizing of compost is a technology that can improve the quality of a compost by adjusting its nutrient content through the addition of raw materials (Zafari and Kianmehr 2012).

In the present study, the Philippine National Collection of Microorganisms Laboratory of BIOTECH confirmed the absence of coliform bacteria (*E. coli*) and *Salmonella sp.* in the densified fertilizers. Composting is a natural aerobic biological process at high temperature (>60ºC) which kills the pathogens and provides a safe, practical and economically feasible method for stabilizing animal manure (Carr 1994; Cosico 2006). An increase in the quality of the composting products and quality control (absence of pathogenic microorganisms) has been reported to make animal manures more competitive with chemical fertilizers (UNL 2006; De Ceuster and Hoitink 1999; Fauci et al. 1999)

Characteristics of clay soil

Alipit series is classified as very fine clayey, mixed, isohyperthermic *Typic Tropudalfs*. The Alipit clay soil is strongly acidic (pH 5.5) with high amount of exchangeable Fe (107 ppm) and K (2.6 cmol/kg soil), very low level of available P and moderate amount of organic matter (Table 4). The other essential elements (Zn, Cu, Mn, Ca and Mg) are in critical nutrient levels. There are certain soils in the country that were developed from basic volcanic deposits including volcanic ash (Carating et al. 2014). Alipit soils are developed from volcanic tuff which are characterize by the presence of redoximorphic features formed by the reduction-oxidation of Fe and Mn. Such explanation and its clayey texture may contribute to the high cation exchange capacity (CEC) of Alipit soil with 27.3 cmol (+)/kg soil.

Table 4. Chemical properties of Alipit clay soil used in pot experiment.

Soil	pH	OM	N	P	Fe	Zn	Cu	Mn	K	Mg	Ca	CEC
		(%)				(ppm)				(cmol (+)/kg soil)		
Alipit Clay	5.5	2.3	0.2	2.5	107.0	2.4	10.0	31.0	2.6	3.8	8.6	27.3

Response of corn

The fertilizer treatments affected mean herbage dry weight of corn (Table 5). Chemical fertilizer (T8) was found to be significantly different with all manure-based fertilizer treatments including T7. It gave the highest mean with 106.4 g/pot, half the weight (57.5 g/pot) from control no-fertilizer treatment. These are expected because of the readily available nutrients from the applied chemical fertilizers. The densified organic fertilizers (T4 to T6) showed poor herbage yields that can be attributed to their slow-release characteristic. Furthermore, nutrient availability from densified fertilizers for plant uptake was probably affected by the physical and chemical properties of the materials. The pellets expand and their shape becomes distorted when they are soaked in water (Hara 2001). However, the effect on crops of the pellet is relatively different than that of ordinary compost. The shape of the pellet persists in upland soils for a relatively longer time. The breakdown of pellets in upland soils is slower than that of ordinary compost (Lazcano and Dominguez 2011). Most of the benefits of organic fertilizers on soil fertility have mainly been reported to be long-term effects, so that repeated applications over several years are necessary to achieve the desired steady state that will guarantee crop productivity.

The effects of powder-form dried swine manure (T2) and chicken manure (T3) on the performance of corn were significantly higher than the densified form of fertilizers (T4 to T6). Results of the study suggest that the nutrient release pattern of the powder forms is faster than the densified forms which are slow-release in nature. Such findings are supported by the reports of Alemi et. al. (2010) where the effects of slow-release of nutrients from mixed pellets showed N in densified fertilizers is not as readily available as the N in dried manure.

Although the initial total N concentration of dried *G. sepium* was the highest (3.7%) among the additives, its composition was reduced to more than half (1.3%) after full decomposition at vermicomposting. The slow-release of nutrients that led to poor dry matter yields were attributed to the density and low NPK properties of T7. Hartemink and Sullivan (2001) demonstrated that the use of oven-dried *G. sepium* leaves as the initial biomass resulted in decomposition of only half its biomass in 12 weeks. This close relationship between initial N concentration and N release is consistent with the observation of other workers (Berendse 1987; Fox et al. 1990). Plant materials with high N concentration are considered to be of high resource quality to microorganisms as they decompose and release N quickly (Schofield 1945).

Table 5. Effect of fertilizer treatments on herbage dry matter weight of corn.

Treatments	Herbage dry matter weigh (g/pot)
Control (no fertilizer)	57.51d
Dried swine manure	85.98b
Dried chicken manure	89.40b
Densified swine OF	67.70c
Densified chicken OF	69.97c
Densified vermicompost	65.52c
Fresh *Gliricidia sepium*	67.70c
Chemical fertilizer	106.40a

Response of bush sitao

The fertilizer treatments affected the performance of bush sitao (Table 6). There was no significant difference between the densified (T4 and T5) and chemical fertilizer (T8) together with dried poultry manure (T3) treatments on the number and weight of pods/pot. High yields delivered by swine and poultry densified fertilizers suggest that faster release of nutrients occurred during the 2nd cropping and efficiently taken up by the legume plant. Though there is no significant difference between T2 and T3, the crop responses were related to their original chemical properties. The higher number and weight of pods in poultry manure can be attributed to its higher nutrient concentrations when compared to that of swine manure. Among the densified fertilizers, a poorer performance of bush sitao was observed in pots applied with densified vermicompost. Such observation was related to nutrient deficiencies at maturity period. Pelletized fertilizer is superior to other dry fertilizers as it avoids undesirable growth flushes, more efficiently absorbed by roots and reduces potential plant phytotoxicity (McIver 1990).

Table 6. Effect of fertilizer treatments on the yield of bush sitao

Treatments	Number of Pods	Pods Fresh Weight (g/pot)
T1 Control	25c	144.6c
T2 Dried raw swine manure	37b	206.3b
T3 Dried raw poultry manure	43ab	235.8ab
T4 Densified swine-based OF	46a	244.5a
T5 Densified poultry-based OF	46a	267.4a
T6 Densified vermicompost	36b	206.8b
T7 Fresh *G. sepium*	37b	205.7b
T8 Chemical fertilizer	46a	246.0a

In general, the application of organic-based fertilizers provides greater number and higher weight of vegetable pods when compared to treatments without added nutrients. The cumulative agronomic value of organic fertilizers applied to agricultural soils could be more than 5x greater in the post-application period than the value realized during the year of application (Adenawoola and Adejoro 2005).

Soil chemical properties after harvest

The soil pH level improved from its initial pH 5.5 after 2 sequential cropping in all treatments. (Table 7). Although the increase in pH level is not notable, the application of organic-based fertilizers, in long term basis, may increase the pH to a desirable neutral level. It can be noted that soils added with chemical fertilizers in both Crop 1 and Crop 2 were more acidic than the control treatment. On the other hand, the increase in pH on soil amended with organic inputs is in agreement with the results obtained by Magdoff (1998) and Havlin et al. (2005), who attributed the increase in pH to the added basic cations to the soil which in turn raises the soil pH. The cation exchange capacity (CEC) of Alipit clay soil in all treatments increased from its initial level of 27.3 cmol(+)/kg soil. Such findings is expected since soil CEC is determined by the amount of clay and/or humus that is present. Interestingly, only the CEC in T8 dropped after the 2nd cropping. A reduction of CEC by mineral fertilizers was observed in pot experiments over a 7-year period (Jakobsen 1996). Pelletizing promotes the concentration of the nutrients available in the solid fertilizers thus improving its fertilizing and amending properties (Alemi et al. 2010; Pampuro et al. 2017).

Table 7. Organic matter, cation exchange capacity and pH of Alipit clay after corn- bush sitao croppings

Soil Amendment	OM (%)		CEC (cmol(+)/kg soil)		pH	
	Crop 1	Crop 2	Crop 1	Crop 2	Crop 1	Crop 2
T1- Control	2.85	2.80	31.23	32.53	5.80	6.46
T2- Dried swine manure	2.88	2.85	30.04	31.39	5.91	6.52
T3 Dried poultry manure	2.85	2.77	31.33	30.26	5.83	6.54
T4 Densified swine manure-based OF	2.93	2.91	29.31	29.53	5.73	6.60
T5 Densified poultry manure-based OF	3.15	3.07	31.25	32.39	5.67	6.53
T6 Densified vermicompost	2.90	2.88	30.32	32.91	5.73	6.38
T7 Fresh *Gliricidia sepium*	2.87	2.83	33.00	33.23	5.71	6.54
T8 Chemical fertilizer	2.85	2.75	31.34	28.56	5.73	6.43

Considering that Alipit clay soil has moderate amount of organic matter (2.3%) at the start of the experiment, it was observed that its level increased after the 1st crop (corn) was harvested. Interestingly, the OM in soil applied with dried poultry manure (T3) decreased after each cropping and lower than the OM in control pots. The OM in densified fertilizers provides gradual nutrient supply for a long period of time, which improves N fertilizer use efficiency and reduces N leaching losses. These changes in SOM level can be attributed to many factors i.e. added fertilizers, microbial diversity, mineralization rate, plant nutrient uptake (Magdoff 1998; Egball et al. 2002). It may also be presumed that the slight decline in the CEC of other treatments is related to these factors. The continuous application of organic matter as farm compost, farmyard manure, and plant residues is needed to maintain or increase soil organic matter content (Srinivasa Rao et al. 2011). The improvement in soil properties using organic sources like animal manures requires longer period before changes can be observed (Schoenau 2006).

CONCLUSIONS

Substantial effort was made to elucidate the short term effects of organic-based and chemical fertilizers on crop performance and soil properties of an acidic clay soil. The results showed that the response of corn and bush sitao in sequential cropping is affected by the physical and chemical properties of the fertilizer materials. The highest mean dry herbage weight of corn was expected to come from chemical fertilizer treatment because of the readily available nutrients from the material itself. The corn plants applied with powder-form dried manures performed better than densified fertilizers because of the slow-release nature of the latter. Furthermore, it must be highlighted that the densified fertilizers with additives showed significant impact on the 2nd crop. The legume pods number and weight were at their best on pots applied with densified fertilizers. The nutrient efficiency from these fertilizers significantly complemented that of chemical fertilizers. Results such as these suggest that manure-based densified fertilizers, when enhanced with organic additives, may be used as alternative to chemical commercial fertilizers in times when these are not available. The study confirms that the quality of the composting products and quality control (absence of pathogenic microorganisms) would make them more competitive with chemical fertilizers. The fertilizer value of compost and densified fertilizers must be based on high quality standards consistently produced to offset the production costs while balancing the risks associated in handling bulk animal manures and the damage to humans and environment.

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