INTEGRATION OF CROP-LIVESTOCK-BIOGAS AND THE EFFECT OF DRIED SLUDGE MANURE ON THE GROWTH AND YIELD OF MAIZE ON ULTISOL SOIL

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ABSTRACT

This research was aimed to evaluate the kind and amount of feed consumed by 20 heads of cattle and the amount of manure produced, to evaluate the amount of biogas, sludge and slurry produced by digester and to study the application of manure, dried sludge manure, and NPK fertilization on the growth and yield of hybrid maize of Pioneer 27 (P27). Research was conducted from 2012 to 2013 in Tamanbogo Experimental Farm. Results showed that the total weight of feed consumed in the rainy and the dry season achieved the recommendation of 10% of the body weight of cattle. The average production of manure and urine was 11.25 kg head^{-1} day^{-1} with the biogas production of 3 m^3 day^{-1} sufficient for cooking and lighting for 5 members of family daily. The by-product of biogas production was 8 kg day^{-1} of sludge and 127 L day^{-1} of slurry. The grain yield of P27 with application of dried sludge accompanied with 50 % of NPK fertilizer recommendation dose gave the highest yield of P27 (4.45 t ha^{-1}) with a profit Rp. 3,466,000 ha^{-1} and B/C of 1.5.

Keywords: biogas, by-product, maize, sludge, yields

INTRODUCTION

The availability of land for agriculture in the moment and the future will be in sub-optimal land which has low pH and poor nutrients, such as in Ultisol soil. Ultisol soil in Indonesia reached 45.8 million ha or 25% of the land area in Indonesia, which is a potential sub-optimal soil for agriculture in several major islands outside Java. Ultisol soil in Sumatera is 29 millions ha (28.2%), 2.24 millions ha of which are in the province of Lampung (Subagyo et al., 2004). Conventional agriculture in Ultisol soil has been known to cause soil degradation because it involves intensive tillage, burning of crop residues to make a clean garden.

The increasing pressure on land and the growing demand for livestock products in Indonesia makes it more essential to ensure the effective use of land and feed resources, including crop residues. Integration of livestock in farming systems enables animals to help with farming operations, and transport and sale of animals sometimes provide cash for farming labors and agricultural inputs. Dwiyanto and Haryanto (1999) stated that integration of crop-livestock systems is to integrate all components of farming both horizontally and vertically, so that no waste is wasted. An integrated crop-livestock farming system represents a key solution for increasing soil productivity, enhancing crop and livestock production, and safeguarding the environment through prudent and efficient resource use.

Gupta et al. (2012) mentioned that the integrated farming systems hold special position as in this system; the by-product of one system becomes the input for other. Food crop residues such as straws or other biomass provide a suitable fodder for cattle and other ruminants, while occasionally, the food crop provides supplementary grain feed for productive animals. On the other hand, livestock waste in the form of manure and urine is the source of soil organic matter and fertilizer. Manure is usually applied directly to the soil as a source of organic and inorganic fertilizer to improve soil productivity and crop yields. These systems are environmentally friendly and able to add a source of revenue and reduce the risk of failure (Nitis, 1995; Adnyana, 2005).

All livestock waste can be processed in situ to produce biogas as a source of alternative energy. Biogas can be produced from simple organic raw materials such as cattle dung that

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could be used for electricity and as a fuel for domestic cooking. Alternatively, entering 25 kg of fresh cattle dungs into the digester can produce $0.83 m^3$ to $1 m^3$ of biogas (Amankwah, 2011, and Gupta *et al.*, 2012). Biogas is one of the most important bio-energy which can be used to replace natural gas (Hobson *et al.*, 1981).

The issues of cattle waste disposal, sanitation and environmental problems coupled with the high cost of fossil fuel make biogas production a better choice. The rest of the manure out from the digester in the form of sludge and slurry is ready-made organic fertilizer required by crops, and as soil amendment (Haryanto, 2009). The sludge and slurry are good source of fertilizer for crop production. According to Ames (1976), the sludge and slurry contain excellent nutrients such as N, P, K, Ca, Mg, Fe, S and other trace elements. The rest of the manure out from the digester is a ready-made source of organic material that has anaerobically decomposed. The effectiveness of the two types of organic matter on growth and yield of crops need to be investigated.

The objective of the study was to evaluate the integration of crop-livestock-biogas and to study the effect of manure (dry decomposition process) and dried sludge (wet decomposition process) on the growth and yield of maize.

MATERIALS AND METHODS

The study was conducted for 2 years (from 2012 to 2013) in Tamanbogo Experimental Farm of the Indonesian Soil Research Institute, located in East Lampung, Lampung Province, Indonesia. There were three activities comprising 1) evaluating of the kind and amount of feed given to cattle and the amount of cattle dung produced each day, 2) manure management consisting of dry decomposition process (normal manure) and wet decomposition process through biogas digester (dried sludge), and 3) evaluating the effect of normal manure, dried sludge and the dose of NPK fertilizers on the growth and yield of maize.

First activity was conducted to observe the kind and amount of feed given to 20 heads of cattle reared in Tamanbogo Experimental Farm. Measurement was done to the weight of feed consumed and the weight of cattle dungs produced by 20 heads of cattle each day, in 30 days. The weight of feed consumed each day was calculated by reducing the weight of feed given by the weight of feed not consumed by cattle.

The activity 2 was to measure the weight of cattle dung by weighing the dung/manure produced by 20 heads of cattle each day in the morning. The cattle dungs were processed to get the normal manure and dried sludge manure. The normal manure was made by mixing the fresh cattle manure with the residues of unconsumed feeds and decomposed at a place protected from direct sunlight. The dry decomposition process of manure can produce ready-made manure after 40 days of decomposition processes. The dry sludge manure was made by building a biogas digester with a volume of $9 m^3$, creating a place to insert the cattle dung into the digester (inlet) and making a reservoir to collect sludge and slurry (outlet). The sludge was wind-dried at a place protected from direct sunlight for 30 days until it was as dry as normal manure.

The weight of manure required to fill the biogas digester ($9 m^3$) was calculated using the ratio of manure and water in the digester of 1:1. Charging the digester with manure and water was conducted after the required amount of animal waste has been collected. The volume of manure was converted into manure weight (in kg) by using the manure bulk density (BD) of 710 kg per m^3 (Alberta, Agriculture and Rural Development, 2005). As much as 3,200 kg manure (equivalent to $4.5 m^3$) was inserted into the digester through the inlet canal until the digester was full with manure and water. When the digester was full, the amount of manure inserted into the digester was 68 kg day^{-1}. The volume of biogas produced by the digester was calculated based on the results of research conducted by Gupta *et al.* (2012), where 25 kg of fresh cattle dung inserted to the digester can produce $1 m^3$ of biogas.

The weight of sludge was calculated based on the research results conducted by Muryanto (2008), where the weight of sludge coming out of the digester is 12% of the weight of manure inserted into the digester. The volume of slurry was calculated using the formula of the weight of slurry = the weight of the manure inserted into the digester + the weight of water required – the weight of sludge sent out from the outlet of the digester.

The activity 3 was to examine the effect of normal manure (dry decomposition process), dried sludge (dry residue of wet decomposition

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process) and NPK fertilizer on the growth and yield of Pioneer 27 (P27) maize hybrid. The study was conducted at Tamanbogo Experimental Farm in 2013 using a randomized block design with four replications. The treatments involved:

T1: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1}

T2: Dried sludge manure (wet decomposition process) at a dose of 5 t ha^{-1}

T3: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1} + 50% of the dose of NPK recommendation

T4: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1} + 75% of the dose of NPK recommendation

T5: Dried sludge manure (wet decomposition process) at a dose of 5 t ha^{-1} + 50% of the dose of NPK recommendation

T6: Dried sludge manure (wet decomposition process) at a dose of 5 t ha^{-1} + 75% of the dose of NPK recommendation

Pioneer 27 maize hybrid was planted with a space of 75 cm x 20 cm, 1 plant hole^{-1} on each plot size of 4 m x 5 m. The normal cattle manure and dried sludge manure required for each plot were calculated based on the dry weight. The water content of normal manure and dried sludge manure was analyzed in the laboratory, each of which was taken as much as 10 g, heated in an oven at 100°C for 48 hours until it reached a constant dry weight. The water content of the samples was determined by the formula of Water content (%) = (wet sample weight-dry sample weight)/wet sample weight × 100.

Observation was conducted on the plant growth, maize dry grain yield, and farming financial analysis. The data of plant growth, yield and biomass were statistically analyzed using the SAS program (Ramon *et al.*, 1991), whereas financial analysis using the B/C ratio.

RESULTS AND DISCUSSION

Type and Amount of Feed Consumed

Integration of 20 heads of cattle with average body weight of 300 kg head^{-1} in crop-livestock integration systems in Tamanbogo Experimental Farm utilized the cheaper cost of animal feeds. Assuming that the need of fresh fodder head^{-1} day^{-1} for cattle was as much as 10% of the body weight, Table 1 shows that the total feed consumed by cattle was 36.35 kg head^{-1} in the wet season and 30.70 kg head^{-1} in the dry season.

Nutritional values of crop residues especially rice straw and other crop residues are generally low in digestibility and protein content. Improving intake and digestibility of crop residues by physical and chemical treatments is technically possible but it is not feasible for poor small farmers because they will require machinery and chemicals that are expensive or not readily available. Table 1 shows that the fresh grasses and cassava dregs (residues of tapioca production) were the largest portion of fodder in a rainy/wet season.

The total consumption of fresh grasses has decreased from 48.4% in the rainy season to 34.2% in the dry season, but the cassava dregs, rice straw, leaves of legumes and concentrate increased. Total feed consumption in the wet season was 36.35 kg head^{-1} (12.11 kg head^{-1} of dry matter) and in the dry season was 30.70 head^{-1} (11.95 kg head^{-1} of dry matter), meaning that the weight of the animal feed consumed has already achieved 10% of the body weight of cattle.

Table 1. Cattle feed supply in crop-livestock integration systems in Tamanbogo Experimental Farm, 2012

Sources of feeds	Fresh Fodder (kg head^{-1})		Dry matter (kg head^{-1})	
	RS	DS	WS	DS
Rice straw	2.50	3.50	2.00	3.01
Elephant Grass	5.00	1.50	1.00	0.30
Setaria Grass	3.34	2.00	0.67	0.40
Panicum maximum Grass	4.47	2.50	0.89	0.50
Wild Grass	4.80	4.50	1.20	1.13
Cassava dregs	9.25	11.00	2.31	2.75
Glyrisidia leaf	0.25	0.70	0.06	0.17
Cassava leaf	3.00	1.00	0.75	0.25
Concentrate	3.75	4.00	3.23	3.44
Total feed consumed (kg head^{-1})	36.35	30.70	12.11	11.95

Remarks: RS: Rainy season, DS: Dry season

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Production of Cattle Dung, Biogas, Sludge and Slurry

Table 2 shows that the weight of manure as a by-product in cattle rearing in Tamanbogo Experimental Farm reached 9.25 kg head^{-1} day^{-1} and urine as much as 2 L head^{-1} day^{-1}. If the BD of cattle urine was considered 1, the total weight of manure and urine was 11.25 kg head^{-1} day^{-1}, which is equivalent to 4.1 t head^{-1} year^{-1}. Cattle manure was used to fill the digester to produce biogas as a renewable energy source to fulfill the need of household energy such as for lighting and cooking.

Pohekara *et al.* (2005), Graminha *et al.* (2008) and Yadvika *et al.* (2004) reported that cattle dung is a good substrate at generating biogas, as it comes from the cattle's digestion system, which contains anaerobic bacteria helpful in producing biogas. Filling the digester with a volume of 9 m^3 required 4.5 m^3 of manure and 4.5 m^3 of water equivalent to 3,200 kg of fresh manure and 4,500 kg of water. The amount of manure needed to fill the digester can be collected within 14 days.

Cattle excretion (dung and urine) has two crucial roles in the overall sustainability of the system; they improve nutrient cycling and provide energy. Excreta contain several nutrients (including nitrogen, phosphorus and potassium) and organic matter, which are important for maintaining soil structure and fertility. Through its use, crop production will increase while the risk of soil degradation will decrease. Excreta are also as the basis for the production of biogas and energy for household use (e.g. cooking, lighting) or for rural industries (e.g. powering mills and water pumps). Fuel in the form of biogas can replace the usual energy sources such as charcoal, wood and liquid petroleum gas (LPG).

Biogas as the main product of the digester is a mixture of various types of gas. Methane (CH_4) is the biggest content with pure methane heating value of 8,900 kcal per m^3 (Liu, 2010). Making biogas from cattle manure obtained calories value between 4800-6700 kcal/m^3 with a composition of 54-70% CH_4, 27-45% CO_2, 0.5 - 3.0% N, 0.1% CO , 0.1% O, and a few of hydrogen sulfide, ammonia, and nitrogen oxides (Karsini, 1981). Gupta *et al.* (2012) suggested that from 25 kg of cattle dung could produce 1 m^3 of biogas, so that one head of cattle in Tamanbogo Experimental Farm with animal dung weight of 11.25 kg cattle^{-1} produced as much as 0.45 m^3 of biogas.

Werner *et al.* (1989) and Massoti (2003) suggest that cooking food for one person needs as much as 0.27 m^3 biogas day^{-1} and for lighting with an electric bulb of 40 watt requires 0.28 m^3 biogas hour^{-1}. Biogas digester with a volume of 9 m^3 can generate as much as 3 m^{3}day^{-1} biogas which can be used for cooking for the family of 5 members (1.35 m^3 day^{-1}), and lighting for 5 hours (1.4 m^3 day^{-1}).

Table 2. Cattle dung and biogas production in crop-livestock integration systems in Tamanbogo Experimental Farm, 2012

Description	Value	Unit	Description
Cattle dung	11.25	kg head^{-1} day^{-1}	
Volume of Biogas Digester	9	m^3	
Cattle dung required to fill the digester	4.5	m^3	
	Equivalent to 3.200	kg	Cattle manure BD was 710 kg per m^3.
Water required to fill the digester	4.5	m^3	
	Equivalent to 4.500	kg	Water BD was 1 kg per m^3.
Manure inserted into the digester (inlet)	68	kg day^{-1}	
Water inserted into the digester (inlet)	68	kg day^{-1}	
Production of Sludge (outlet)	8	kg day^{-1}	12% of the production of manure (Muryanto *et al.*, 2008).
Production of Slurry (outlet)	127	L day^{-1}	Weight of manure produced + weight of water required - weight of sludge produced.
Production of Biogas	3	m^3 day^{-1}	25 kg of cattle manure produced 1 m^3 of biogas (0.45 m^3 head^{-1}).

Livestock manure that was collected and treated in anaerobic digester can protect ammonia and methane from emitting to atmosphere, and reduce the amount of nutrients to rush into groundwater resulting in aquatic system eutrophication. The gas house gas (GHG) emission reduction can be achieved through the reduced use of inorganic fertilizers (N) and fossil fuel in household level. Meanwhile, biogas and sludge and slurry produced from anaerobic digestion process are a renewable energy fuel and organic fertilizer to substitute fossil fuel and industrial fertilizer in agricultural systems. Therefore, biogas is now widely integrated with animal husbandry and becomes an important means of manure treatment in agricultural sector.

Table 3. The results of the analysis of normal manure (dry decomposition) and dried sludge manure (wet decomposition), in Tamanbogo Experimental Farm

Parameter	Normal manure	Dried sludge manure
Water content (%)	18.84	18.10
pH H_2O	8.34	6.57
C (%)	16.00	12.77
N (%)	0.88	0.63
P_2O_5 (%)	0.86	0.71
K_2O (%)	2.42	0.41
Na (%)	0.19	0.11
Ca (%)	1.09	0.61
Mg (%)	0.44	0.24
Fe (mg kg^{-1})	9594	13089
Mn (mg kg^{-1})	1643	1101
Cu (mg^{-1} kg^{-1})	14.36	19.20
Zn (mg kg^{-1})	76.93	71.18

Remarks: analyzed at Soil Chemical Laboratory of Indonesian Soil Research Institute.

The byproduct of biogas production in the form of sludge and slurry is a ready-made material of soil amendment to improve soil quality and crop production. The results of analysis of normal manure (dry decomposition process), sludge and slurry (wet decomposition process) in Table 3 show that the pH of the organic materials was 6.57 to 8.34.

The content of C and nutrient elements in normal manure (dry decomposition process) is higher than dried sludge manure derived from wet decomposition process because the sludge and slurry that comes out from the biogas digester outlet had been decomposed perfectly, so that the C and nutrient content of the manure were lower, except the content of Fe and Cu. The process of anaerobic decomposition in the digester produced CH_4, CO_2, N, CO, O, hydrogen sulfide, ammonia and nitrogen oxides, forming elements of biogas, so that the content of C and other nutrients in the dried sludge manure was lower. Drying process until the water content of the sludge reached 18.10%, causing a reduction in C and nutrient content in the dried sludge.

Idnani and Varadarajan (1974) reported that about 16% of the nitrogen in the digester sludge was present as dissolved ammonia, which evaporated. It is, therefore, suggested that the sludge and slurry should be covered from the direct sunlight in order to preserve its fertilizer quality.

During fermentation of livestock manure, plant pathogen can be killed under anaerobic environment, and biogas residue is a high quality of organic fertilizer produced (Liu, 2010). The chemical forms of N and P in residue are easier to be utilized by plants in short time than those in other manure management system, such as compost/dry decomposition process. Zhang and Wang (2008) mentioned that organic matter content in biogas residue was ca. 28%-50%, humic acid content was ca. 10%-20%, cellulose content was 13%-17%, N content was 0.8%-20% and P content was 0.4%-12%.

Liu (2010) mentioned that slurry was another by product of biogas consisting of three kinds of bioactive substances. All of these elements play an important role in maintaining plant's normal growth. Slurry is different from solid residue, since it can be irrigated in farms to vegetable, fruit and other plants directly (Zhang and Wang, 2008). However, due to N and COD contained in slurry, the amount of it should follow the national regulation of farm irrigation depending on plant categories.

The Effect of Manure, Dried Sludge and NPK Fertilizer on the Growth and Yield of Maize

Growth and Yield of Maize

Table 4 shows that plant height at harvest time and dry grain yield of Pioneer hybrid maize (P 27) in the treatment of normal manure (T1, T3 and T4) and dried sludge manure (T2, T5 and T6)

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were not significantly different. However, the addition of NPK fertilizers at the rates of 50% (T3 and T5) and 75% (T4 and T6) of the recommendation dose (200 kg ha^{-1} of urea, 125 kg ha^{-1} of SP 36 and 50 kg ha^{-1} of KCl) showed significant difference on plant height and dry grain yield compared to that without NPK fertilization (T1 and T2).

Table 4. Plant height at harvest time and dry grain yield of P 27 maize in Tamanbogo Experimental Farm, during Rainy Season 2013

Treatment	Plant Height (cm)		Dry Grain Yield (t ha^{-1})	
T1	138.30	b	1.46	b
T2	130.80	b	1.25	b
T3	195.75	a	4.01	a
T4	191.00	a	4.21	a
T5	177.85	a	4.45	a
T6	181.30	a	4.18	a

Remarks: numbers in the same column followed by the same letters are not significantly different based on Duncan's Multiple Range Test at 5% significance level; T1: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1}; T2: Dried sludge manure (wet decom-position process) at a dose of 5 t ha^{-1}; T3: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1} + 50% of the dose of NPK recommendation; T4: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1} + 75% of the dose of NPK recommendation; T5: Dried sludge manure (wet decom-position process) at a dose of 5 t ha^{-1} + 50% of the dose of NPK recommendation; T6: Dried sludge manure (wet decom-position process) at a dose of 5 t ha^{-1} + 75% of the dose of NPK recommendation

Based on plant height, in 5 weeks after planting, maize in each treatment showed changes from previous week (Figure 1). The treatment of normal manure and dried sludge manure without NPK fertilizer (T1 and T2) gave a significantly lower plant height than that given additional fertilizer NPK (T3, T4, T5 and T6), but no significant differences were shown among T3, T4, T5 and T6.

The use of normal manure or dried sludge manure accompanied with NPK fertilizer at a rate of 50% of the recommended dose did not show any significant differences in plant height and dry grain yield compared to the use of normal manure and dried sludge manure with NPK fertilizer at 75% of the dose of NPK fertilizer recommendation.

Application of normal manure as much as 5 t ha^{-1} accompanied with NPK fertilization at 50% of recommended dose/T3 (Table 4 and Figure 2) increased maize yields by 2.7 times from the yield achieved in the treatment of normal manure without NPK fertilizer (T1). Increasing NPK fertilization to 75% of the recommended dose/T4 (300 kg ha^{-1} of urea, 187.5 kg ha^{-1} of SP 36 and 75 kg ha^{-1} of KCl) increased the dry grain weight by 2.9 times of T1 but only 0.05 times of the T3. The use of dried sludge manure without NPK fertilization gave dry grain yield of P 27 as much as 1.25 t ha^{-1}. Application of dried sludge manure accompanied with NPK fertilization at the doses of 50% (T5) and 75% (T6) of the NPK recommendation dose increased the yield of maize to 4.45 t ha^{-1} and 4.18 t ha^{-1} respectively. Animal manure alone was not enough to support the growth and development of crop, even if it does contain the nutrients needed. The use of manure derived from the normal manure and dried sludge accompanied with NPK fertilization at the rate of 50% of recommended dose on maize farming in acid upland soil gave positive impact both in terms of technical and economical point of views.

Financial Analysis

Table 5 shows that the labor cost was the largest portion in maize farming reaching 56.8 to 67.0% of the total cost. The use of normal manure or dried sludge as much as 5 t ha^{-1} along with NPK fertilization between 50-75% of recommended dose decreased labor cost by 23-27% of the total cost, while the cost of seeds and pesticides reached 10-11% and 2.8-3.2% of the total cost, respectively. Maize farming in upland Ultisol soil by using 5 t ha^{-1} of organic fertilizer derived from the dry decomposition (normal manure) and wet decomposition (dried sludge) without NPK fertilization suffered a loss of Rp. 2,243,000 ha^{-1}-Rp 2,768,000 ha^{-1} with B/C between 0.53 and 0.62The use of both sources of manure on maize farming along with NPK fertilizer at a dose of 50% and 75% of the recommended dose (T3, T4, T5 and T6) gave a profit of Rp. 1,824,000 ha^{-1}-Rp. 3,466,000 ha^{-1} with B/C>1.

Maize farming which gave the greatest amount of profit (Rp. 3,466,000 ha^{-1}) was achieved when dried manure accompanied with NPK fertilization at the doses of 50% of recommended dose (200 kg ha^{-1} urea, 125 kg ha^{-1} of SP 36 and 50 kg ha^{-1} of KCl) with a best B/C of 1.45 was used.
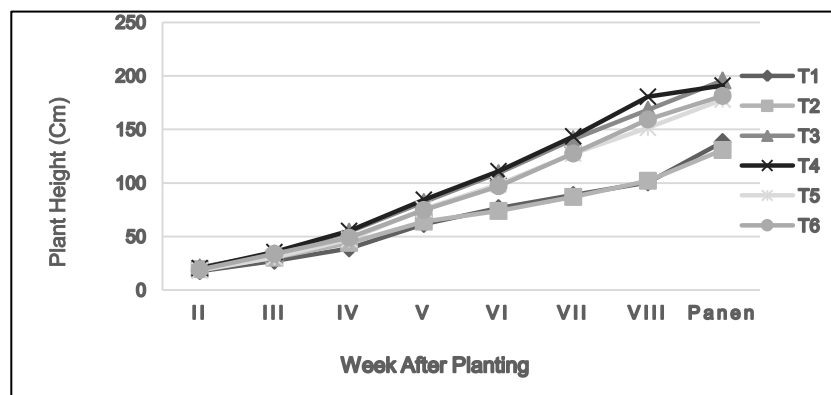
Remarks: T1: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1}; T2: Dried sludge manure (wet decomposition process) at a dose of 5 t ha^{-1}; T3: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1} + 50% of the dose of NPK recommendation; T4: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1} + 75% of the dose of NPK recommendation; T5: Dried sludge manure (wet decomposition process) at a dose of 5 t ha^{-1} + 50% of the dose of NPK recommendation; T6: Dried sludge manure (wet decomposition process) at a dose of 5 t ha^{-1} + 75% of the dose of NPK recommendation

Figure 1. The growth of maize based on plant height for each treatment
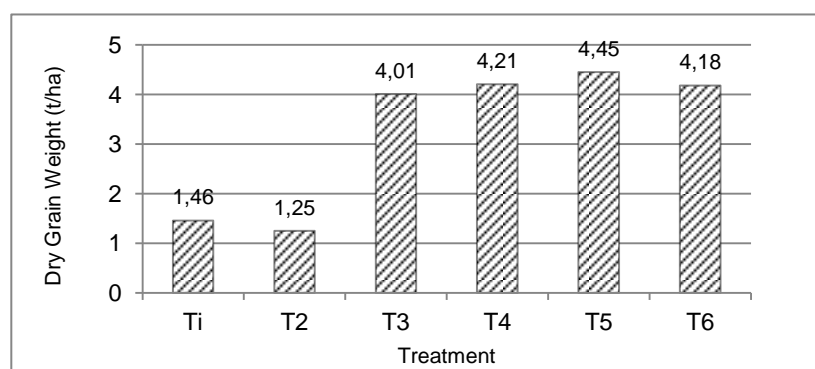
Remarks: T1: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1}; T2: Dried sludge manure (wet decomposition process) at a dose of 5 t ha^{-1}; T3: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1} + 50% of the dose of NPK recommendation; T4: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1} + 75% of the dose of NPK recommendation; T5: Dried sludge manure (wet decomposition process) at a dose of 5 t ha^{-1} + 50% of the dose of NPK recommendation; T6: Dried sludge manure (wet decomposition process) at a dose of 5 t ha^{-1} + 75% of the dose of NPK recommendation

Figure 2. Effect of normal manure and dried sludge on dry grain yield of P27 maize

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Table 5. Financial analysis of P27 maize farming with manure and NPK fertilizers in Tamanbogo Experimental Farm

Variable	Treatment (Rp)					
	T1	T2	T3	T4	T5	T6
Labor force	3,950,000	3,950,000	4,550,000	4,900,000	4,550,000	4,900,000
P27 seeds	945,000	945,000	945,000	945,000	945,000	945,000
Fertilizers						
Urea	-	-	380,000	570,000	380,000	570,000
SP36	-	-	300,000	450,000	300,000	450,000
KCl	-	-	400,000	600,000	400,000	600,000
Normal Manure/Dried Sludge	700,000	700,000	700,000	700,000	700,000	700,000
Insecticides	54,000	54,000	81,000	108,000	81,000	108,000
Herbicides	135,000	135,000	135,000	135,000	135,000	135,000
Plastic bag	100,000	100,000	150,000	150,000	150,000	200,000
Plastic ropes	9,000	9,000	18,000	18,000	18,000	18,000
Total costs	5,893,000	5,893,000	7,659,000	8,576,000	7,659,000	8,626,000
Value of maize yields	3,650,000	3,125,000	10,025,000	10,525,000	11,125,000	10,450,000
Profit	(2,243,000)	(2,768,000)	2,366,000	1,949,000	3,466,000	1,824,000
B/C	0.62	0.53	1.31	1.23	1.45	1.21

Remarks: The price of Urea: Rp.1.900 kg^{-1}, SP 36: Rp.2.400 kg^{-1}, KCl: Rp.8.000 kg^{-1}, P 27 Maize seed: Rp. 63,000 kg^{-1}, wage of labor: Rp. 50.000 person days^{-1}, Dry grain price: Rp. 2500 kg^{-1}; T1: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1}; T2: Dried sludge manure (wet decomposition process) at a dose of 5 t ha^{-1}; T3: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1} + 50% of the dose of NPK recommendation; T4: Normal manure (dry decomposition process) at a dose of 5 t ha^{-1} + 75% of the dose of NPK recommendation; T5: Dried sludge manure (wet decomposition process) at a dose of 5 t ha^{-1} + 50% of the dose of NPK recommendation; T6: Dried sludge manure (wet decomposition process) at a dose of 5 t ha^{-1} + 75% of the dose of NPK recommendation

CONCLUSIONS

The total weight of feed consumed in rainy and dry seasons was 36.35 kg head^{-1} day^{-1} and 30.70 kg head^{-1} day^{-1}, respectively. The average production of manure and urine was as much as 11.25 kg head^{-1} day^{-1}, so that filling the biogas digester with a volume of 9 m^3 requires 3,200 kg of manure for 14 days. Biogas production from the bio digester was 3 m^3 day^{-1} sufficient for cooking for 5 family members and lighting with 40 watt bulbs for 5 hours a day. The by-product of biogas production was 8 kg day^{-1} of sludge and 127 L day^{-1} of slurry. The content of C and nutrients in the dried sludge was lower than that in manure because the anaerobic decomposition in the digester produced biogas containing C and other elements. The grain yield of P27 with application of dried sludge along with NPK fertilizer at a dose of 50% of recommended dose gave the highest yield of P27 (4.45 t ha^{-1}) with a profit of Rp. 3,466,000 ha^{-1} and B/C of 1.5.

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