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Biophysical Monitoring on the Effect on Different Composition of Goat and Cow Manure on the Growth Response of Maize to Support Sustainability

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Abstract

Currently Indonesia has targeted to satisfy the national demand of maize by fulfilling its own production. The policy will benefit the social economy of the local farmers and communities and create a variety of jobs. Attempts in fulfilling demand should uphold production sustainability, even then many indication show declining capability of soil to have increased. Reducing the capability of soil may lead to the reducing of productivity. Many well-documented data show that using organic fertilizer such as manure might improve soil's biological properties as well as its nutrition, production and quality of the obtained maize. Nevertheless, these improvements depend on the chemical composition of the green manures applied to the soil. Manures have different varieties in its chemical composition of nutrition, and heavy metal content depending on the diet. Little attention has been given by farmers on the probability of their plants might be contaminated by lead. Lead has been known to have a detrimental effect on plants. Therefore monitoring the effect is needed. The research was dedicated to participate on the effort of increasing productivity by promoting manure usage such as goat and cow manure on growing maize. Different compositions of goat and cow manure were applied on the soil media growth of maize on the glasshouse. The growth was monitored biophysically by measuring the leaves surface electrical difference and area and observing for signs of chlorosis. Result has shown that the addition of manure on soil has increases leaf area and electrical potential difference compared to the maize grown in a mere soil media. It is concluded that renewable fertilizer such as cow and goat manure was important in increasing plant growth. A composition of 2/3 soil and 1/3 goat manure was optimal for the leaves growth followed by composition of 2/3 soil and 1/3 cow manure. No signs of stress symptoms such as chlorosis were found; meaning that on all compositions of manure used in the research might be safe for plant and soil and pose no threat for human safety. Further monitoring is needed to ensure no lead contamination.

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1. Introduction

Currently Indonesia has targeted to satisfy the national demand of maize by fulfilling its own production targeted in around 20.31 million ton in 2015, an increase of 5% from the previous production of 19 million tones, and imported around 3 million tones (Kompas, 2015). The policy will benefit on the reduction of import, and the social economy of the local farmers and communities and create a variety of jobs. Attempts in fulfilling demand should uphold production sustainability, even then, the indication of declining soil capababilities has increased (Tiamiyu et al., 2012; Zingore, 2011; and Bhuiyan et al., 1995) might be due to improper balance using fertilizer (Nurhayati & Hariadi, 2015). Reducing the capability of soil may lead to the reducing of productivity of crop. The research was dedicated to participate on the effort of increasing productivity by promoting manure use such as goat and cow manure on growing maize. Different compositions of goat and cow manure were applied on the soil media growth of maize on the glasshouse. The growth was monitored biophysically by measuring the leaves surface area and electrical difference and also observing for signs of chlorosis.

Many well documented data show that using organic fertilizer such as manure might improve soil's biological properties as well as its nutrition, production, and quality of the obtained crop (Asroh, 2010; Tiamiyu et al., 2012; Eivazi, 2010). Nevertheless, these improvements depend on the chemical composition of the green manures applied to the soil. Manures have different varieties in its chemical composition of nutrition (Pennington et al., 2014) and heavy metal content depending on the diet (Nicholson et al., 1999).

Eventhough plant growth have responded positively to manure, it is yet to become a complete large scale solution for nutrition (Bationo et al, 2004), therefore the effort into a efficient fertilizer management is needed. The lack of knowledge of the farmers on fertilizer dosage has also been reported (Nurhayati & Hariadi, 2015), the need in preserving and improving the result and develop soil management practice for soil quality (Reves, 1997). The application of organic nutrient source such as manure has become a better alternative to prevent food productivity decrease and at the same time repair soil quality. Properly applied manure is a valuable source of plant nutrients that improves the quality and productivity of soils. A nutrient management plan would allow efficient use of nutrients and protect water quality as some application practices could cause problems. Improperly managed waste water could pollute surface or ground water.

Little attention has been given by farmers on the probability of their plants being contaminated by heavy metals (Sherene, 2010; Ntui et al., 2014). Heavy metals such as lead have been known to have a detrimental effect on plants (Nurhayati et al., 2015). Therefore, monitoring the effect on the growth of maize, and heavy metals content on manure is needed to support sustainability and reduce the health risk.

2. Material and Method

2.1. Sample preparation

Cow manure (CM) and goat manure (GM), approximately 6 moths old were collected from farmers and transferred to The University of Jember. The cow and goat were only fed on plant leaves and grasses. Common soil from the local farmer's corn fields were transported and used in glasshouse to grow the corn. Four different treatments of mixture soil and manure were used to compare the maize growth to the soil alone. The treatment were, for each mixture of soil (S) to goat manure (1/4S : ¾ GM); soil to cow manure (1/4S: ¾CM); soil to goat manure (2/3 S : 1/3 GM); soil to cow manure (2/3 S : 1/3 GM) and soil alone as a control.

Maize seeds were purchased from a nursery shop. The healthy and homogen plant were then grown and then selected and planted on different mixtures of soil and manure medium. Every treatment were replicated 5 times. Measurement of plant growth were conducted weekly after the plants had adapted to growing in the medium after a week by measuring leaf area which is calculated by length x width x correction factor.

2.2. Biophysical monitoring

The electrical potential difference were measured by biophysical methods as in Hariadi dan Shabala (2004). The leaf samples were taken from the third position counted from the top leaves. The visual effects of the leaves were observed and photograpped weekly. Data were subjected to analysis of variance (ANOVA) and the mean were compared to in acceptance p< of 0.05

Monitoring was conducted on the collected samples of cow and sheep manure from the Jember- East Java area, three sub district were chosen; Kaliwates, Tanggul and Ajung. Electrical Conductivity, pH, and heavy metal content were measured using atomic absorption spectrometry (AAS).

3. Result and Discussion

3.1. Maize Growth

Figure (1) shows that the plant growth had varied according to ration the of manure to soil composition. Little difference was shown in maize growth during week-1 of application of sheep manure (3/4 CM to ¼S) as in treatment-1 to the control, but a lower composition of sheep manure to 1/3 CM to 2/3 soil had better maize growth. During week-2 and week-3 the response of maize to the application of manure in all compositions were higher than the control plant. This meant that the maize had grown better under application of both manure.

The value of the leaf area of the maize also varied according to the ratio composition of manure to soil (Fig.2). The lowest of leaf area were shown by the control plant, and the highest value of leaf area were for the application of soil to cow manure ratio of: 2/3:1/3 followed by the composition of soil to cow manure: 2/3: 1/3. It means that the plant has responded differently on the aplication of manure. No signs of chlorosis symptoms had appeared on the leaves of all treatments and control during four weeks of experiment (Fig 3). It appears that the application of manure on the soil media has a positive effect to the growth.

No statistically significant difference in leaf area was found between the non application manure on treatment –1 during week-1 to week 4. However, the greatest difference were between control to treatment 3 and to treatment 4 during application of the manure.

3.2. Biophysical monitoring –response on the PD leaves plant

Application of different ratios of manure had varying potential difference (PD) response of maize leave (Fig 3). There was increasing of PD on each treatment compared to control. The treatment-3 (2/3S : 1/3 CM) and treatment-4 (2/3 S: 1/3 GM) had a higher potential difference than others. This indicated that manure application in every treatment had an effect on the growth of plant. The value of electrical PD on the control plant were at 122 mV-158 mV, the highest of electrical PD were 180 mV and the lowest were 124 mV. The result were slightly different to the result of V broadbeans reported by Hariadi & Shabala (2004) on the range of optimal growth at between 120 mV-160 mV, and the Mg stress in 40 mV-60 mV.

Trend increasing of potential difference (PD) on every treatment has shown no indication of the disturbance on the transport process due to application of manure. There is significant differences between PD control to each treatment from week-1 to week-4 except for T1 to control during week-1 and week 2.

The value of the electrical potential difference that is higher than the control may be due to the existence of N, P, K element in the manure. The content of N, P, K, C in sheep, were higher than on the cow manure, each 8 kg/ton, 7 kg/ton, 15 kg/ton and 8 kg/ton, while in cow each were 5 kg/ton, 2 kg/ton, 5 kg/ton, and 3 ton/kg respectively (Pennington et al., 2015), compared to urea that contained 34.75% of N and S (24%), and ZA contain 20.16% of N (Eivazi et al., 2013). Phospor play important role on the transport of ions, and development of cell membrane, while K has effect on the osmotic regulation in the plant cells. The positive response on the potential difference on the plant for every treatment of the manure compare to the control has shown that the media has improved due to aplication of manure. The better quality of media with the presence of manure have the possibility to increase work function of root system to uptake mineral and nutrient (Hendalastuti et al., 2006).

Figure 1.The growth of maize on the different variation of ratio media soil and manure during week-1 and their individual leaves from week-1 to week-4 measurements, from leftside left side C (control), T1(1/4 S: ¾ GM); T2 (1/4 S:3/4 CM); T3(2/3S:1/3CM); and T4(2/3S: 1/3 GM).

The highest potentials were in treatment-4 that were grown on a ratio of 1/3 goat manure to 2/3 soil media that the manure has positive effect to the growth of the maize. It also has shown that the composition of manure play an important role on the optimal growth on the maize during the stage of their growth. The application of green manures to the soil produced improvement in the soil biological properties as well as in the nutrition, production and quality of the obtained maize. Nevertheless, these improvements depend on the chemical composition of the green manures applied to the soil (Tejada et al., 2008). Cow manure have micronutrients such as Fe, Mn, Zn, Cu, N and N (Indrasari & Syukur, 2006). The optimal production in sweetcorn had an application of manure of 60 tons/ha (300 gr/polybag) (Asroh, 2010).

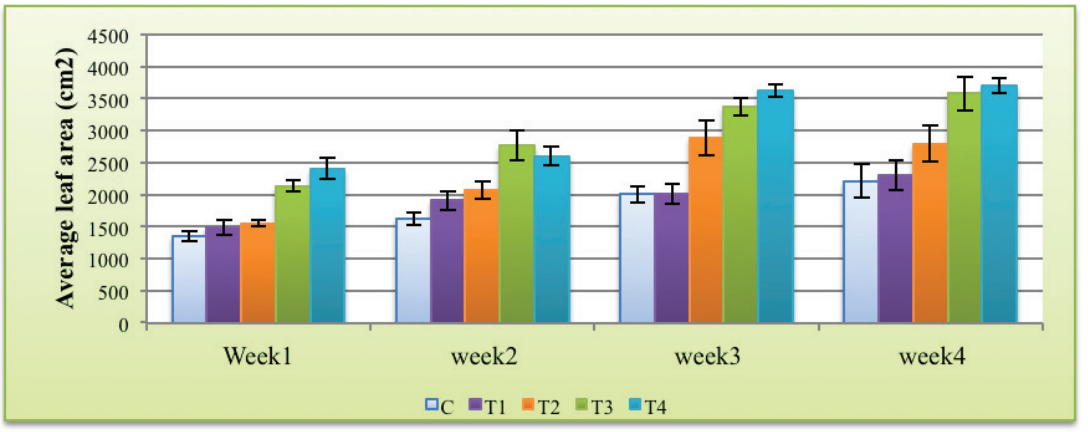

Figure. 2 Average of leaves area of maize grown in different concentration of manure , C(control), T1(1/4 S: ¾ GM); T2 (1/4 S:3/4 CM); T3(2/3S:1/3CM); and T4(2/3S: 1/3 GM).

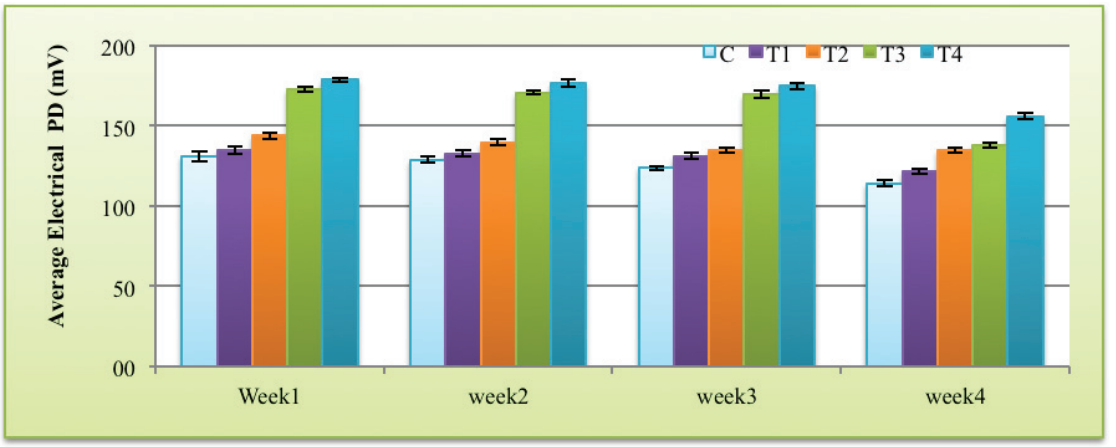

Figure. 3 Electrical Potential PD of the maize under different application of manure on their growing soil media, C(control), T1(1/4 S: ¾ GM); T2 (1/4 S:3/4 CM); T3(2/3S:1/3CM); and T4(2/3S: 1/3 GM).

The application of 1/3 and ½ cow manure to soil has increased the growth of rose tomatoes and chili by increasing the height and total leave area per plant (Nurhayati & Hariadi, 2015). It has showed that the plant responded better than if grown in soil alone, but the result also has shown that the addition of NPK during the stages on the either 1/3 and 1/3 of cow manure and soil composition did not show significant difference. In this result, the increase of manure (3/4 S: ¼ S) and ¾ GM: ¼ S) did not show better growth of maize. Further research is needed to calculate the maize production due to the effect of both manure, since the combination of organic fertilizer and inorganic fertilizer have higher grain on Boro rice than on organic manure alone (Alim, 2012). Managing soil fertility such as manure will be effective when strategically combined with fertilizer (Zingore, 2011).

It means that the sustainability of production can not be maintained by relying solely on the organic fertilizer alone (Alim, 2012; Zingore, 2011), but at least the result has shown that increasing manure more than 1/3 on the stages might not have much benefit on growth, it will only will inform us to use the manure efficiently. The using of cow and goat manure also reduced the price of fertilizer that at some times may be difficult to access by farmers due to high prices. The combination of inorganic and organic reducing nutrient price, and increasing netto income 11

percent of rice yield (De-ren & Wan-fan,1998). Fertilization strategy are recomended for sustainable agricultural development to sustain high yields economically and provide the opportunity to either build or maintain plant nutrients in the soil.

Table 1. Leaf area and error of maize grown under different composition of manure on the growing media during observation week-1 to week-4

Treatment (soil : manure)	Week-1 (cm^2)	Week-2(cm^2)	Week-3(cm^2)	Week-4(cm^2)
C-control (soil)	1355.81 ± 81.98	1622.79 ± 102.79	2011.55 ± 126.64	2215.74 ±260.61
T-1 (1/4 S + 3/4 SM)	1484.10 ± 114.52	1913.56 ± 146.75	2005.88 ± 159.09	2298.55 ± 231.57
T-2 (1/4 S + 3/4 CM)	1548.35 ± 48.40	2078.13 ± 134.29	2885.59 ± 271.69	2789.81 ± 286.19
T-3 (2/3 S + 1/3 CM)	2135.99 ± 90.89	2773.45 ± 233.79	3370.08 ± 137.04	3588.99 ± 263.19
T-4 (2/3 S + 1/3 SM)	2408.40 ± 166.45	2596.06 ± 148.93	3629.39 ± 104.07	3704.61 ± 122.97

Table 2. Electrical Potential Difference and error of maize grown under different composition of manure on the growing media during observation week-1 to week-4

Treatment (soil : manure)	PD ± s.e (mV)-week-1	PD ± s.e (mV) week-2	PD ± s.e (mV) week-3	PD ± s.e (mV) week-4
C-control (soil)	131.00 ± 3.25	129.00 ± 2.09	124.00 ± 1.12	114.00 ± 2.09
T-1 (1/4 S + 3/4 SM)	135.00 ± 2.50	133.00 ± 2.24	131.00 ± 2.09	122.00 ± 1.37
T-2 (1/4 S + 3/4 CM)	144.00 ± 2.09	140.00 ± 1.77	135.00 ± 1.77	135.00 ± 1.37
T-3 (2/3 S + 1/3 CM)	173.00 ± 1.37	171.00 ± 1.12	170.00 ± 2.50	138.00 ± 1.37
T-4 (2/3 S + 1/3 SM)	179.00 ± 1.12	177.00 ± 2.24	175.00 ± 1.77	156.00 ± 2.09

The increasing trend of leaf area also showed that it may be due to supply of nitrogen from the manure. Nitrogen gave a green colour to the leaves and benefited in enhancing all the development of plant during all the stages. Enough supply of nitrogen also was beneficial on the photosynthesis process. The tendency of reduced electrical potential difference on week-4 in all treatment is possible due to reduced nutrients because of daily continual absorption of nutrients after application of manure.

The result given has shown that the ratio of soil to goat manure 1/3 to 2/3 volume of the pot gave optimal growth, by number of leaves, plant height and leaf area, and potential difference of the leaves, without any symptom of stress on the plant. It gave the conclusion that sheep manure or the cow manure on the research did not harm the maize during the growth stage. The result has gave the farmers that the manure may be use as a fertilizer alternative during the growth stages at given times.

The smallest response of the control plant than the treatment plant, gave an indication that the manure had a positive impact to the plant. To have a better performance, the maize may be grown under a media mixture with a 2/3 soil and 1/3 cow or goat manure, and with the optimum performance obtained on 2/3 soil and 1/3 goat manure. For a comparison, a recomendation by Gudugi et al. (2012) for optimal growth of swetcorn, around 15 ton/ha of poultry manure is needed to maintain the sustainability of soil. The optimal growth is by using 1/3 of goat manure or alternatively for 1/3 of cow manure to soil media for optimal growth of leaves and maize biomass, can be applied to change the inorganic fertilizer to reduce the cost of the price of Urea or to be substitute for inorganic fertilizer to reduce the dependence to inorganic material. It has been suggested that farmer may use a combination of inorganic and organic material, or enriched manure with the inorganic material to reduce the amount of organics that may be insufficient in the area (Ayoola & Makinde, 2009). The combination of organic and urea dosage of 150kg N/ha and 200 kg N/ha have shown good growth on sweetcorn (Kresnatita et al., 2013). The combination of fertilizers has also contributed in the increase of nutrition concentrations in sun flower (Esmaeilian et al., 2012).

The application of inorganic fertilizer and cow manure increased the growth of Amaranth, but an integrated approach and balancing the inorganic fertilizer and manure needs to be clearly observed in developing countries, because the optimum growth on the mixture of manure of 87.5kg N/ha and 9.0 t/ha cannot be fullfiled by small farmers (Nyankanga et al., 2012). Organic fertilizer when used in sufficient quantity can effectively complement inorganic nutrient input (De-ren & Wan-fan, 1998), but for the sustainable agriculture must not merely be focussed on the increasing of the organic material in the soil, but also on the uptake of residual nutrients to prevent the excess of nutrients leaching into the ground water. The ratio of nutrients in organic material (manure) is different to the

ratio of nutrients to remove, therefore the excess accumulation of nutrients such as P and N can occur from longterm use of manure. Compost may increase N content, save minerals for the next growing season (Diacono & Montemurro, 2010).

The use of manure may also reduce water quality by increasing chemical oxygen demands (Edmeades, 2003). The application of the organic compost also pose a problem to the environment such as volatization of amonia, reducing concentration of oxygen on the soil, produce phytotoxic compounds and immobilizes soil mineral N. The quality of organic fertilizer should be stabilized to reduce potential hazard to soil and environtment. Assessment is needed to indicate the exstence of heavy metals and their accumulation in the soil.

In the long term, it may play an important role on climate change mitigation by carbon sequestration, and in turn reverse soil degradation.

3.3. Monitoring the Heavy Metals Pb, Cd and Cu, Al and Fe

Monitoring Pb from three different areas of Jember-East Java, Kaliwates, Tanggul and Ajung, showed that the cow manure in the area were 0.785 ppm, 0.859 ppm, 1.452 ppm or in the average of (1.032 ± 0.211) ppm; and for goat manure at 0.785 ppm, 0.489 ppm, and 1.007 ppm or in average of (0.7603 ± 0.15)ppm (Fig. 4). This average was higher than Sherene (2010), manure has heavy metal such as Cd, Pb (0.7 µg/g, Cr and Co). Farmer should be aware of the improper use of the manure and the fertilizer, accumulation of heavy metals from manure-as a low cost fertilizer- can have toxic effect on the soil and plant and risk the human safety through the food chain.

Cow manure in Kaliwates, Tanggul and Ajung contained Cd of (0.455, 0.4809 and 0.4300) ppm while goat manure contained (0.4809, 0.5064, and 0.2774) ppm or an average of (0.456 ± 0.015) ppm and 0.422 ± 0.073) ppm of cow and goat manure. It can be seen that the average of Al was around (1.1414 ± 0.2735) ppm for cow manure and (0.2939±0.078) ppm for goat manure; the average of Cu was (0.0784±0.000866) ppm for cow and (0.1588± 0.067) ppm for goat manure, while for Fe was in the range of (1.49-4.039) ppm or average of (2.732 ±0.7366) ppm for cow manure or between (0.706-2.078) ppm or in the average of (1.294 ± 0.408) ppm for goat manure. Animal manure is an important source of heavy metals to the environment in Northeast China (Zhang et al, 2012), here at least two heavy metals were found in the three regions such as Pb and Cd. Ordering in the five elements of metals was Fe>Al.>Pb>Cd>Cu for cow manure, for goat manure the order was Fe>Pb>Cd>Al>Cu. Heavy metals in cow manure has ben investigated and range in contain in manure in Nigeria by order Zn>Mn>Ni>Pb>Cr>Cu (Ntui et al, 2014), that previously been indicated to be related to additions in the diet in England and Wales (Nicholson et al., 1999).

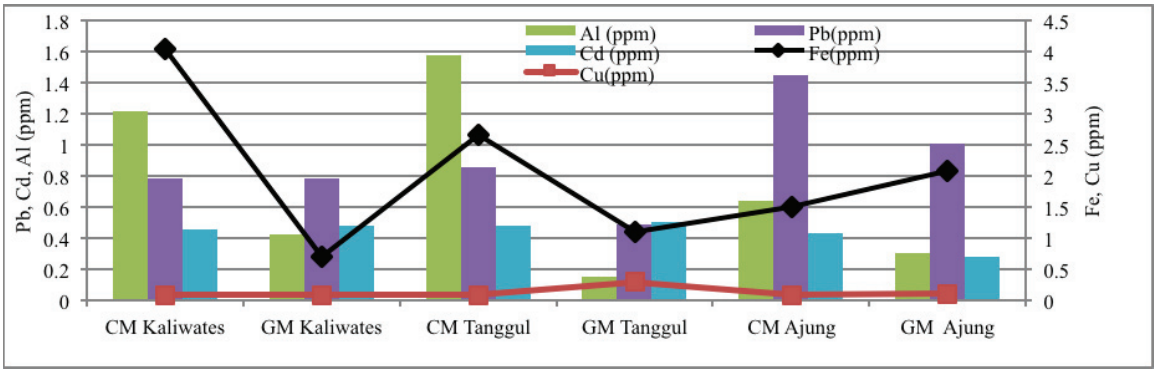

Fig. 4. The lead (Pb), Cadmium (Cd), Alumina (Al), Iron (Fe) and Copper (Cu) on the goat and cow manure of three different region (Kaliwates, Tanggul, and Ajung) of Jember district-East Java Indonesia.

The pH of cow manure (Fig 5) was in a range of 7.59 to 8.10, and goat manure in a range of 7.73-8.38, while the soil media used here was around 6.78, addition of 1/3 cow manure and 1/3 goat manure increased the pH to around 6.91 and 6.88, which lower than addition of ¾ Cow manure and goat manure in around 7.43 and 7.49. Most of the

addition of manure had greater biomass production, with increased height and leaf area of maize. It has showed that most of maize can grow on these pH conditions. Plant productivity of biomass was simply measuring the total of photosynthesis of the plants less respiration, since crop plants grow almost entirely by photosynthesis (Sharma-Natu & Ghildiyal, 2005), that also has been seen by the increase of the leaves PD (Fig. 3).

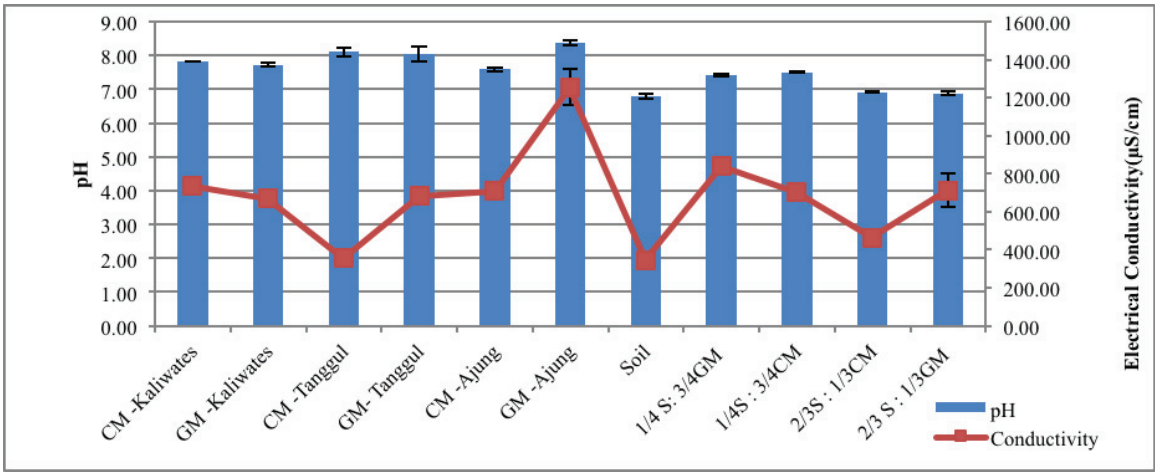

Fig. 5. The pH and conductivity of the goat and cow manure of three different region (Kaliwates, Tanggul, and Ajung) of Jember district-East Java Indonesia, and the variation of soil and manure on different concentration

Addition of 1/3 goat and 1/3 cow manure to ¾ soil media has increased the soil electrical conductivity (EC) from 347.67 µS/cm to 714 µS/cm and 464.67 µS/cm, and increasing to ¾ goat manure and ¾ cow manure to ¼ soil each has increased of the EC to 841 µS/cm and 701.67 µS/cm. The electrical conductivity was involved on the water-holding capacity of the media that effected on the crop yield, thus can be used as measurement of the field productivity (Grisso et al., 2009). Electrical conductivity of nutrition will affect the yield and fruit quality (Tadesse et al., 1999). The EC of manure have different values from different farmers, due to different diet (Fig.5) and different pH, also different heavy metal contents (Fig 4) which gave a recommendation on continual monitoring for using manure as fertilizers.

Table 3. Measurement of Fe, Cu, Al, Pb and Cd Content from different area of Jember

Manure	Fe(ppm)	Cu(ppm)	Al (ppm)	Pb(ppm)	Cd (ppm)
Cow -Kaliwates	4.039	0.0799	1.2121	0.785	0.4555
Goat-Kaliwates	0.706	0.0875	0.4242	0.785	0.4809
Cow-Tanggul	2.667	0.0769	1.5758	0.859	0.4809
Goat-Tanggul	1.098	0.2926	0.1545	0.489	0.5064
Cow -Ajung	1.490	0.0784	0.6364	1.452	0.4300
Goat-Ajung	2.078	0.0965	0.3030	1.007	0.2774

4. Conclusion

The result showed that application of cow manure and sheep manure are useful as an organic fertilizer for yield growth of maize. The optimal growth of maize was on a media of soil that contained 1/3 sheep manure to 2/3 soil. The addition of manure of ¾ cow manure or sheep manure to the ¼ soil media may increase the growth of maize but the effects was not linear dependant. The growth of maize without addition of manure shows the lowest result, that concluded that the application of green manure is considered a good agricultural practice.

The biophysical monitoring showed that the addition of 1/3 of goat manure and 1/3 cow manure to the 2/3 soil has increased of electrical potential difference (PD) from its soil growth at range of 122 mV-158 mV to 124 mV-180

mV, increasing of the electrical conductivity from its control, showed the suitable pH and water holding capacity. No signs of chlorosis had been detected on the leaves due to the presence of heavy metals such as Pb during four weeks of experiments.

The benefits of utilizing manure through land application are noticeable to increase maize productivity. It is concluded that renewable fertilizer such as cow and goat manure was important in increasing plant growth. A composition of 2/3 soil and 1/3 goat manure was optimal for the leaves growth followed by composition of 2/3 soil and 1/3 cow manure. No signs of stress symptoms such as chlorosis were found; meaning that on all compositions of manure used in the research might be safe for plant and soil and pose no threat for human safety. But people should be aware that from the monitoring of three regions of Jember district showed the presence of heavy metals Pb and Cd. Ordering for five elements of metals was Fe>Al.>Pb>Cd>Cu for cow manure, for goat manure the order was Fe>Pb>Cd>Al>Cu. Better management of using manure as a fertilizer is needed to reduce the risk of heavy metal contamination. Further monitoring is needed to ensure no lead contamination.

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