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Full length Research Paper

Effect of basic fertilizer doses and liquid organic fertilizer concentration on soybean yield

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The research aimed at examining the impact of fertilizer doses and concentration of liquid organic fertilizers (LOF) treatment on soybean yield. The hypotheses of this study was that LOF effectively influenced soybean yield. The research was conducted in factorial scheme with two factors randomized. Two different treatments were applied (TA and TB). TA is the treatment with basic fertilizer (urea, triple super phosphate (TSP) and KCl), TA1 - (40 kg Urea/ha, 90 kg TSP/ha, and 90 kg KCl/ha); TA2 - (45 kg Urea/ha, 95 kg TSP/ha, and 95 kg KCl/ha) and TA3 - (50 kg Urea/ha, 100 kg TSP/ha and 100 kg KCl/ha). TB is the treatment with LOF concentration (sugarcane pulp waste and sugarcane skin). TB0 (without LOF, control), TB1, TB2 and TB3 are treatments with concentrations of 7.1, 10.7 and 14.3% of the LOF, respectively. Thus, the experiment presented 12 combined treatments (3 × 4) and each treatment was performed in triplicate, totaling 36 experimental plots. The results showed that basic fertilizer doses treatment had no significant effect on soybean yield, while LOF concentration treatment at 14.3% gave better result on soybean yield. Therefore, it can be concluded that LOF treatment can increase soybeans yield by up to 2.36 Mg/ha.

Key words: Soybean, basic fertilizer, waste, liquid organic fertilizers (LOF).

INTRODUCTION

Soybean is considered as one of the priority food commodities in Indonesia, as its high price volatility might affect the economy. This topic could be very interesting for research, particularly on the issue of food security that focuses on self-sufficiency, which needs to be strengthened and achieved if Indonesia does not want to depend on soybean importation (Adisarwanto, 2008).

Achieving self-sufficiency on soybean is one of the main programs of the Ministry of Agriculture (MoA) of Indonesia. This program should receive supports from all relevant parties in the production process. The national production level of soybean is determined more by its plantation area than by its productivity level. The soybean productivity in Indonesia is quite low, it is around 1.29 Mg/ha, though with the existing production technology the productivity could be increased by 1.7 to 3.2 Mg/ha (Anonymous, 2009).

A modern agriculture production system that focuses more on production has made farmers to use mineral fertilizer, and without sufficient knowledge that improper

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use of mineral fertilizer can reduce the quality of plant production. Moreover, the use of mineral fertilizer continuously and uncontrollably within a long period of time will have negative impact on land fertility as well as on the environment. The use of fertilizer in a proper way should consider its effect toward the environment and the ecosystem balance in the surroundings (Novizan, 2003). Herawati (2003) found that berta Cd metal content exists on some of phosphor (P) mineral fertilizer at the rate of 0.1 to 0.7 mg/kg. The land which is frequently cultivated with mineral fertilizer will become solid and difficult to be processed thus adversely affecting the growth of plant. Therefore, the use of organic fertilizer which can help improve soil structure, increase land permeability and decrease the dependancy of land on the mineral fertilizer is encouraged. Organic fertilizer also serve as source of food for microorganism living on the land and increase the number and activity of those microorganism, and this makes the land fertile (Hadisuwito, 2008). Land preparation is aimed at increasing production.

Organic fertilizer is made from organic material. It can be in various forms like (1) solid organic fertilizer and (2) liquid organic fertilizer (LOF). Organic raw material could be obtained from waste/abandoned organic waste form human activities. In Indonesia for example coconut husk and cane skin garbage are an abondant waste which serve as a resource for LOF. A research by Suryaningsih et al. (2010) concluded that the use of solid organic fertilizer made from bakery waste combined with LOF, and mixed with goat droppings and coconut husk produced more mustard compared to the use of only solid organic fertilizer made from bakery waste.

Herawati and Indarwati dan Achmadi (2012) proved that application of liquid organic fertilizer made from water-hyacint waste on soyben plant increased soybean yield by 21.6% compared to treatment without application of LOF made from water-hyacint waste.

The aim of this study is to determine the right dose of basic fertilizer and LOF concentration, and their interaction dose toward soybean yield. This research will contribute to the effort made in achieving food self-sufficiency and acceleration of Indonesian food sovereignty. It could also be a solution on handling solid waste in Indonesia.

MATERIALS AND METHODS

Planting location

The research was conducted in the Production Laboratory, Faculty of Agriculture, University of Wijaya Kusuma Surabaya and at the Experimental Garden of Assessment Institute for Agricultural Technology, Mojosari, Mojokerto. The research began in March, 2016 and ended in October, 2016. The experimental site is located at 7°30'26 "S latitude and 112°31'57" E longitude, at an altitude of ±28 m above mean sea leve. The climate is characterized by rainy season and dry season, with an average rainfall of 10.58 mm, while the temperature reaches 220 to 310°C, with air humidity range from 74.3 to 84.8 Mb/day and average wind speed range from 3.88 to 6.88 knots/month. The soil in the study area is Regosol at the Entisol order, which is characterized by imperfect development and only has marginal horizon A with coarse-grained regosol soils, weak structures, low organic compounds; it contains only nutrients of P and K which are still fresh, but less N, with pH range from 6 to 7.

Substances and equipment

There are two types of substances used in this research. Substances used to prepare LOF, such as sugarcane pulp waste and sugarcane skin, carbohydrate source (sugar), coconut water, rice water and well water, and substances used in the field, such as soybean seeds, urea fertilizer, TSP, KCl, manure, LOF, etc.

Research method

The research was conducted in factorial scheme with two factors randomized. Two different treatments were applied (TA and TB).

TA = Doses of Basic Fertilizer, Urea, TSP and KC1;
TA1 = 40 kg Urea/ha; 90 kg TSP/ha and 90 kg KCl/ha;
TA2 = 45 kg Urea/ha; 95 kg TSP/ha and 95 kg KCl/ha;
TA3 = 50 kg Urea/ha; 100 kg TSP/ha and 100 kg KCl/ha;
TB = LOF concentration (sugarcane pulp waste and sugarcane skin);
TB0 = without LOF (control);
TB1 = 7.1 % of LOF;
TB2 = 10.7% of LOF and;
TB3 = 14.3% of LOF.

Thus, the experiment had 12 combined treatments (3 × 4) and each treatment was replicated trice with 36 experimental plots in total.

Research procedures

Preparing liquid organic fertilizer (LOF)

Preparation of LOF from organic sugarcane pulp waste and sugarcane skin was conducted at the Production Laboratory, Faculty of Agriculture, University of Wijaya Kusuma Surabaya, Indonesia. The following steps were applied (1) preparing all necessary substances and equipments used for making liquid organic fertilizer, (2) preparing organic waste (sugarcane pulp and sugarcane skin) by washing and cutting into small parts, (3) place the cut organic waste into the LOF tub, and adding all other materials such as 1 kg of sugar, coconut water, rice water and 50 L well water until it submersed, followed by proper stirring, (4) closing the LOF tub and creating an air hole by inserting a plactic hose which is connected to a plastic bottle waste filled with water, and (5) Leaving the mixture for 15 days (2 weeks) until alcohol smell is perceived.

Collecting of organic fertilizer (LOF)

The collection of LOF was done 15 days from the day of preparation by filtering and filling into jerrycan prior application on the land according to the treatment.

Planting and maintenance of soybean plant

Land preparation

The preparation is normally done if soybean is planted on a dry

land at the beginning of rainy season, since the land surface is hardened. The preparation of the drainage channel is also necessary to accelerate the disposal of excess water and to avoid incidence of errosion due to land processing.

Preparing trial plot for planting

Once the land has been prepared, the land is left for one week to kill pests due to the sun rays. The process is followed by watering to prevent formation of land chunks. The land is then divided into 3 lanes for soybean planting, with a size of 3 m × 5 m^2 = 15 m^2 with each lane having 12 plots.

Planting and fertilization

The soybean planting activity is arranged in a distance of 40 cm × 15 cm (Herawati and Indarwati dan Achmadi, 2012), with continuous fertilizer application. The fertilizer used is Urea, TSP, KC1 and manure. The manure is applied at processing time to loosen the soil, about 3 days before planting, to allow complete mixing with land as the media. After planting, the LOF is applied as liquid fertilizer according to the treatment which is once a week for 6 times. Togther with Urea application, TSP and KC1 are applied by spreading between the lanes according to the treatment.

The care for soybean plant

Taking care of the soybean plant is an important step as it affects production. Watering in dry season is done once a day in the morning or afternoon, from the planting until the harvest. Weeding is done to allow soybean plants receive sufficient water and nutrient from the land. The weeding is done mechanically to remove wild plants (gulma) which could be the source of pest for the soybean plants. During weeding, it is important to remove any existing pest (Sartono dan Wibisono, 2007). Another way of protecting the plant from pest and disease is by using virus-free seeds, sanitation, plants rotation, and by revoking, throwing and burning of the virus-affected plants, collecting and destroying the eggs or caterpillar on the plants, or other natural treatments.

Harvesting

The harvest time of soyben plants is determined by, besides the age which is in line with the variety description, 70% of the leafs turning yellowish and falling down, and the pods becoming hardened and brownish (Purwono and Purnamawati, 2002). It also depends on the number of pods which are already yellowish brown (less than 95% of pods color has changed and the leaves left are just 5 to 10%). Harvesting is done by cutting down the stem of soybean plant close to the base using sharp jagged sickle. After that, the soybean yield is weighed.

Post harvest

After the harvest, yield is weighed in line with observed parameter, followed by sundrying for 3 days.

Parameters

The observation was done one week after the application of LOF in the field, and the observed parameters include:

Table 1. The average number of root nodule per plant with basic fertilizer doses treatments and LOF concentration.

Treatment	Number of root nodule
Basic fertilizer doses	
TA1	17.83
TA2	20.17
TA3	23.83
BNT 5%	TN
LOF concentration	
TB0	13.44[b]
TB1	23.44[a]
TB2	22.44[a]
TB3	23.11[a]
BNT 5%	7.8

Note : Numbers that are followed by the same letter in the same column are not real difference in the BNT test at 5%.

Growth parameter

The growth parameter observed during the research include: (1) the number of root nodules per plant which is the total number of root nodules observed 3 weeks after planting, (2) the number of effective root nodules per plant that is the root nodule showing pink color to brownish in the middle when cut transversly, and observed 3 weeks after planting, and (3) the number of branch per plant which is the number of branch producing soybean pod.

Production parameter

Some of the production parameter observed during the research includes the number of pods per plant and the potential yield. The number of pods per plant is the number of pod containing soybean seed. The potential yield (ton/ha) is the yield per plot converted to hectare

Data processing

The observation data results is obtained by measuring and weighing the soybean yield directly on site field during the research period. The data is processed using the Analysis of Variance of RAK model, to determine if real difference exists from the treatments. In case a real difference exists, the observation is continued with Smallest Real Difference (BNT 5%).

RESULTS AND DISCUSSION

Observation of the parameter

The Number of Root Nodules per Plant

Table 1 and Figure 1 presents data on the effect of different treatments on the average number of root nodule per plant. The table reveals that the application of LOF with a concentration of 7.1% (TB1) produced more

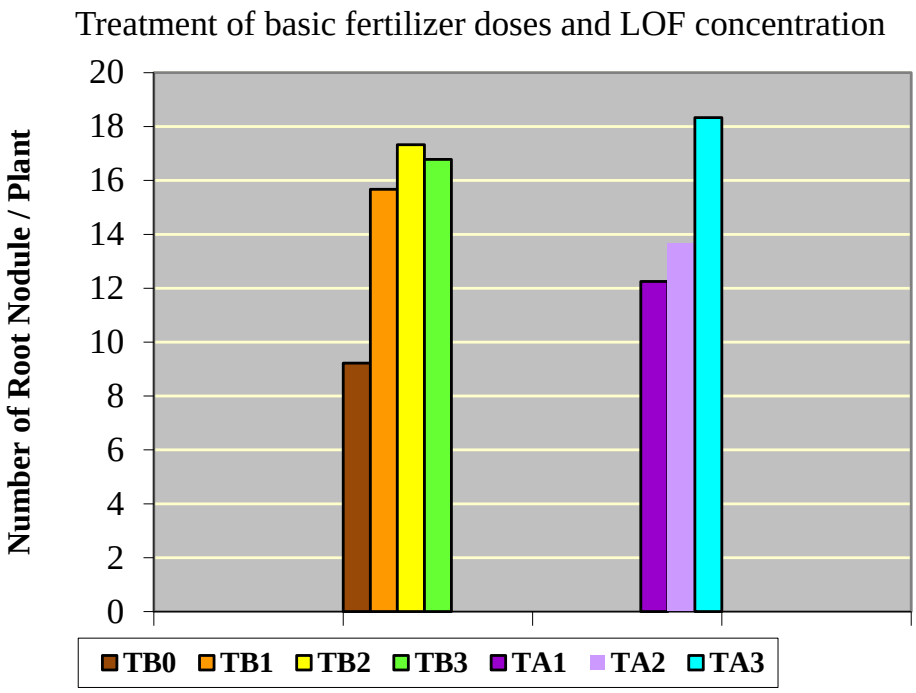

Figure 1. Average number of root nodule per plant (gram) due to treatment of basic fertilizer doses and LOF concentration

Table 2. The average number of effective root nodule / plant with basic fertilizer doses treatment and LOF concentration

Treatment	Number of effective root nodule
Basic fertilizer doses	
TA1	12.25[b]
TA2	13.67[ab]
TA3	18.33[a]
BNT 5%	5.28
LOF Concentration	
TB0	9.22[b]
TB1	15.67[a]
TB2	17.33[a]
TB3	16.78[a]
BNT 5%	6.09

Note: The Numbers that are followed by same letter in the same column are not real difference in the BNT test at 5%.

root nodules per plant compared with the control one, though it is not significantly different with other treatments (TB2 and TB3). While the treatment on the basic fertilizer doses does not show significant difference, there is a tendency that the TA3 treatment can produce more root nodule compared with other treatment.

The number of effective root nodule per plant

Table 2 and Figure 2 presents that data on the observed average number of effective root nodule per plant that resulted from different treatments. The application of TA3 treatment on the soybean plant produced a higher effective root nodule per plant compared with the TA1 treatment, while with the TA2 treatment the difference is not significant. As for the LOF concentration treatment, in which the provision of LOF with a concentration of 10.7% (TB2) result in higher average number of effective root nodule/plant compared with the control, it does not show significant difference with the other treatments (TB1 and TB3).

The number of branches per plant

The observed data on average number of braches per plant affected by different treatments is presented in Table 3 and Figure 3. The table reveals that a significant difference is seen on the LOF concentrate treatment, in which the application of LOF with a concentration of 7.1% (TB1) produces a higher average number of branches per plant compared with control, though it is not significantly different with the other treatments (TB2 and TB3). While basic fertilizer doses treatment does not show a significant difference, though there is a tendency

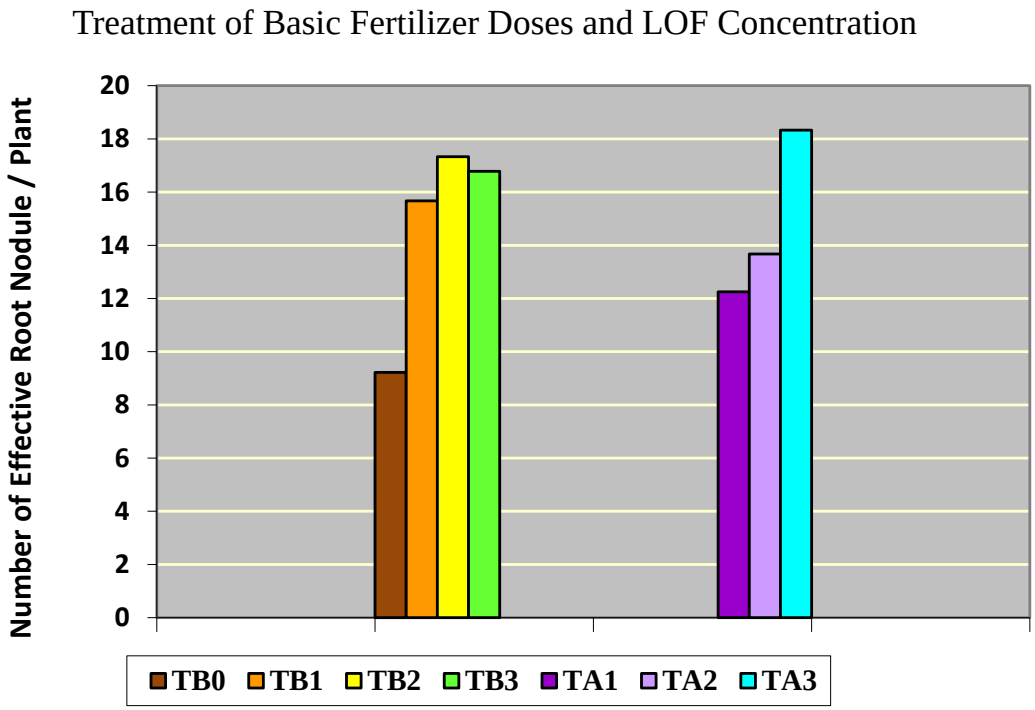

Figure 2. Average number of effective root nodule / plant (gram) due to the treatment of basic fertilizer doses and lof concentration.

Table 3. Average number of branches / plant due to basic fertilizer doses and lof concentration.

Treatment	Number of branches
Basic fertilizer doses	
TA1	19.43
TA2	20.25
TA3	21.27
BNT 5%	TN
LOF concentration	
TB0	17.09[b]
TB1	22.12[a]
TB2	20.82[a]
TB3	21.24[a]
BNT 5%	2.76

Note: The Numbers are followed by the same letter in the same column are not real difference in the BNT test at 5%.

that the TA3 treament produces more branches per plant compared with the other treatment.

The number of filled pod/plant

The observed data on the average number of filled pod per plant is presented in Table 4 and Figure 4. It shows that application of LOF with a concentration of 10.7% (TB2) can produce higher average number of pods per plant compared with control, though it is not significantly different with the other treatments (TB1 and TB3). While basic fertilizer doses treatment does not show a significant difference, though there is a tendency that the TA3 treatment produces more pods per plant compared with the other treatments.

Yield potential/dry weight of soybean seed/ha (ton)

On the yield potential parameter, the research provided evidence that application of LOF with a concentration of 10.7% (TB2) resulted in a higher average of yield potential (Mg/ha) compared with control, though it is notsignificantly different with the other treatments (TB1 and TB3) as presented in Table 5 and Figure 5. While basic fertilizer doses treatment does not show significant difference, though there is a tendency that the TA3 treatment produces more filled pod/plant compared with the other treatments.

DISCUSSION

The result of analysis of variance (ANOVA) shows that the treatment on LOF concentration influenced the

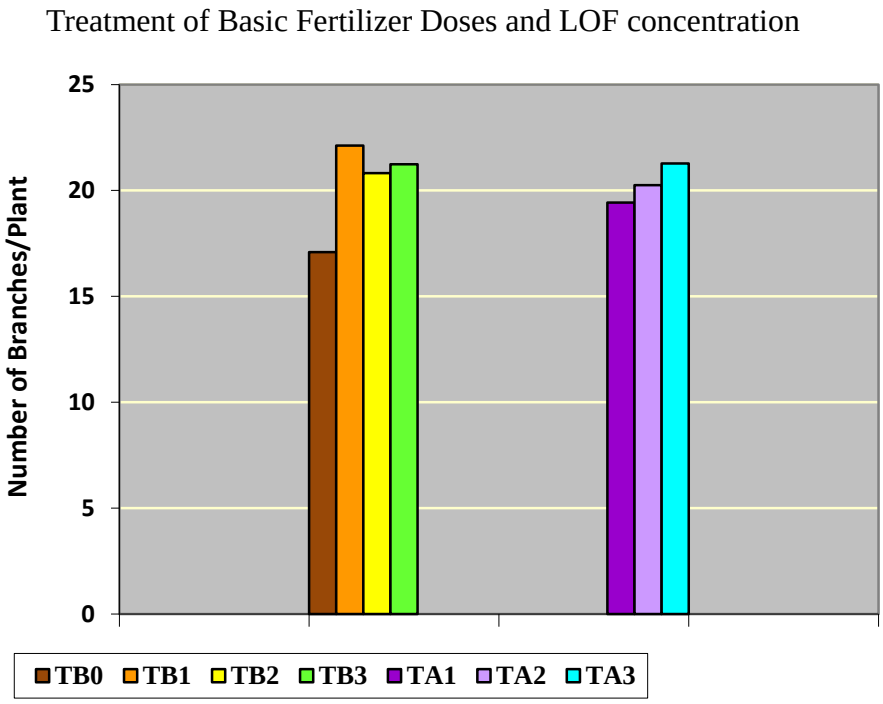

Figure 3. Average Number of Branches / Plant (Gram) due to the treatment of basic fertilizer doses and LOF concentration.

Table 4. Average number of filled pod / plant (gram) due to the treatment of basic fertilizer doses treatment and LOF concentration at harvest time.

Treatment	Number of root nodule
Basic fertilizer doses	
TA1	57.70
TA2	53.52
TA3	58.96
BNT 5%	TN
LOF concentration	
TB0	47.0[b]
TB1	58.38[a]
TB2	61.78[a]
TB3	59.76[a]
BNT 5%	8.94

Note : The numbers that are followed by the same letter in the same column are not real difference in the BNT test at 5%.

number of root nodule and branches parameter. This might be due to organic fertilizers consisting of many nutrients that are useful in maintaining the soil health. It then encourages flourishing of the rhizosphere micro-flora which stimulate growth of plants.

The application of LOF concentration of sugarcane pulp waste and sugarcane skin at 7.1% (TB1) produced more root nodule and branches compared with the control (TB0), though it is not significantly different with the TB2 and TB3 treatments. As for the number of effective root nodule parameters, the application of LOF concentration of sugarcane pulp waste and sugarcane skin of 10.7% (TB2) produced higher number of effective root nodule compared with the control even though it is not significantly different with the TB1 and TB3 treatment. This result is in line with Chauhan et al. (2016) who discovered that application of mixing inorganic and organic fertilizers in certain level could maintain the soil nutrients at levels which allow plant to grow, flourish, and deal with pests, diseases and environmental stresses. He also emphasized that the integrated nutrient management (INM) systems in soil need to be maintained through application of organic fertilizer together with inorganic fertilizers.

The basic fertilizer doses treatment showed better results on the number of effective root nodule, in which the TA2 treatment produced a higher number of effective root nodule, though it is not significantly different with TA3. As expected on the number of root nodule and branches parameter, the treatment of basic fertilizer doses did not have a significant effect, though there is a tendency that the treatment of basic fertilizer doses of TA3 on the average produced more root nodule and branches. This implies that nutrient provided by basic fertilizer doses could not be able to encourage the

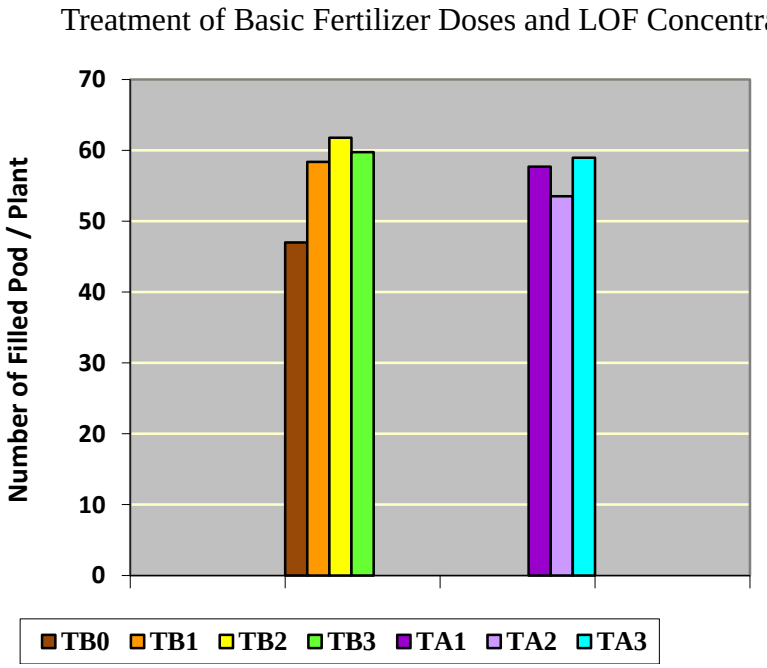

Figure 4. Average Number of Filled Pod / Plant (Gram) due to the treatment of Basic Fertilizer Doses and LOF Concentrate

Tabel 5. Average of yield potential (Mg/ha) due to the treatment of basic fertilizer doses and LOF concentration at the harvest time.

Treatment	Number of root nodule
Basic fertilizer doses	
TA1	2.22
TA2	2.31
TA3	2.34
BNT 5%	TN
LOF concentration	
TB0	2.13[b]
TB1	2.33[a]
TB2	2.36[a]
TB3	2.34[a]
BNT 5%	0.12

Note : The numbers that are followed by the same letter in the same column are not real difference in the BNT test at 5%.

development of root nodule and branches in the research area, but it encouraged the effective growth of nodule only. The plant growth happens because of the process of cleavage and cell extension that requires a lot of nutrient supply. This is in line with Nyakpa et al. (1998) who argued that if the nutrient is available in sufficient quantities and is absorbed properly, then the plant will grow optimally. Kaur et al. (2008) also found that application of organic fertilizer made from farmyard manure, poultry manure, and sugarcane filter cake alone or when this organic fertilizer is combined with chemical fertilizers; it improved the soil organic C, total N, P, and K status. As a result, larger populations of *Azotobacter chroococcum* and *Rhizobium leguminosarum biovar trifolii* in the rhizosphere of wheat and Egyptian clover, respectively were maintained in soils than in soils given chemical fertilizers alone.

In the production parameter which is indicated by the number of pods per plant and dry seed weight per ha, the TB2 treatment can produce a higher number of pods per plant and dry seed weight per ha compared with the control, though it is not significantly different with the TB1 and TB3 treaments. While the basic fertilizer doses treatment does not have significant effect, but with the tendency that TA3 treatment has the average number of pods per plant and dry seed weight per ha potentially higher compared with the TA1 and TA2 treatments.

The plant growth and production are the results of interaction process between internal and external factors of plants. It is influenced by both environmental condition (Gardner et al., 1985) and genetic characteristics (Nyakpa et al., 1998). Enviromental factors include nutrient content, water, temperature, humidity, solar radiation, soil condition, and interaction with other organisms such as OPT and microorganism. The growth and yield of plants can be very optimal if environmental factor is in an optimal condition. If the environment

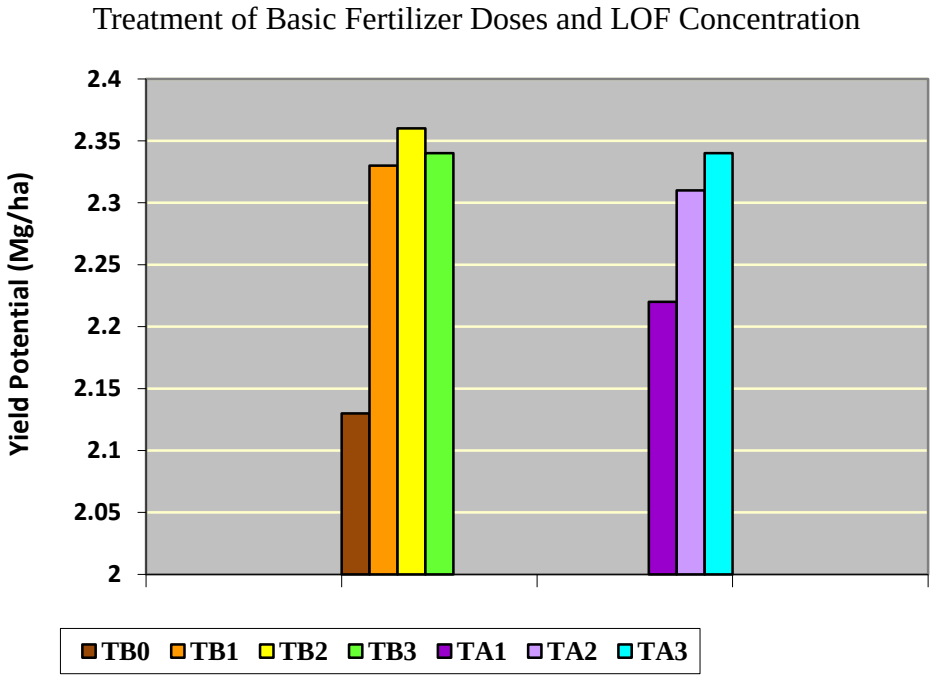

Figure 5. Average yield potential (mg/ha) due to the treatment of basic fertilizer doses and LOF concentration

factors are lacking, the growth of plant can be hampered and even stopped. Regarding the potential yield parameter, the results show that there is a significant difference in the application of LOF, in which application of LOF concentration treatment can reach the potential yield of 2.33 to 2.36 Mg/ha. This is in line with the plant description where the potential yield is 2.03 to 2.25 Mg/ha. Novizan (2003) explained that only small portion of nutrient derived from organic fertilizer can be directly utilized by plants, and others are decomposed over a long period of time, while the nutrient of N, P and K contained in organic fertilizer must undergo a decomposition process first in the soil to be able to be absorbed by the plants . The decomposition process itself depends on the C/N ratio and organic material source (Hakim et al., 1986).

Islam et al. (2017) concluded that the treatment with higher proportion of organic fertilizer (2/3 organic fertilizer: 1/3 in-organic fertilizer) produced higher yield in Tomato at 20.8 t/ha. The higher yield in tomato due to application of organic fertilizer made from cow dung and inorganic fertilizer has been reported in the literature by Solaiman and Rabbani (2006). Some researchers such as Ullah et al. (2008), Reddy et al. (2002), Haque et al. (2012), and Ahammad et al. (2009) reported that higher yield were obtained on brinjal, cabbage and mustard due to better performance of integrated nutrient management practices. Research conducted by Adesemoye at al. (2009) in Bangladesh showed that treatment on mixed fertilizer strategy and bio fertilizer Trichoderma-enriched fertilizer or the inoculation of rhizobacteria become very popular. It proved that the treatment encouraged microorganisms and plant growth by promoting rhizobacteria (PGPR). *Bacillus* spp. improves nutrient availability, nutrient use efficiency and increase the growth and yield of plants.

In the Table 6 presents the type and amount of microbes and nutrient content of organic fertilizer made from sugarcane pulp waste and sugarcane skin used in this study which is believed contributed to higher yield on soybean.

Conclusion

In summary, this research has provided significant evidence of the important and positive aspects on the use of organic fertilizer in cultivation, particulalrly on soybean plant. The summary is as follows:

1. There is a siginificant difference on the growth related to the number of root nodule parameter, the number of effective root nodule parameter, and the number of branches parameter caused by the application of LOF concentration treatment. While the impact of basic fertilizer doses treatment does not show any significant difference.
2. There is a significant difference on the application of LOF concentration treatment toward production parameter

Table 6. The Analysis result of type and amount of microbes and nutrient content of LOF sugarcane pulp waste and sugarcane skin.

Type	Content	
	Kol/ml	(%)
Lactobacillus bacteria	4.8×10^5	-
Pseudomonas bacteria	2.3×10^6	-
Phosphatase	3.1×10^6	-
Yeast	8.2×10^5	-
N	-	0.08
P_2O_5	-	0.18
K_2O	-	0.36
C/N Ratio	-	16.98

Source: Primary data of Laboratory Test Result in Industrial Research and Consultation Agency, Surabaya – East Java (2016)

namely the number of pods per plant and the dry weight of seed per ha as potential yield. While the basic fertilizer doses treatment does not show any significant difference.
3. There is no interaction between the LOF concentration treatment and the basic fertilizer doses on growth and plant production parameter.
4. The application of LOF can increase the potential yield up to 2.36/ha.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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