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Effect of The Substitution of Compound Fertilizer With Single Fertilizer and Mycorrhizal Inoculation on The Growth and Yield of Soybean Among Eucalyptus

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ABSTRACT

The efforts to improve the productivity of soybean can be done through technological innovation by the provision of chemical fertilizers and mycorrhizae. This study were aimed to obtain information on the effect of a single fertilizer, which can provide the same or higher level of soybean crops if compared with those compound fertilizers, as well as to find out the effect of mycorrhizae to the improvement of efficiency in the use of inorganic fertilizers. It is expected that the mycorrhizae inoculation can reduce single fertilizer's dose to the level equivalent to the compound fertilizer given by farmers. The study was conducted in Bleberan Village, Playen Subdistrict, Gunung Kidul Regency, Yogyakarta from February to May 2015. It was conducted by using a two-factors factorial design arranged in a randomized block design with three replications. The first factor was inorganic fertilizer (N, P_2O_5 and K_2O), consisting of 5 levels, i.e. without fertilizer (0-0-0 kg ha^{-1}), Phonska fertilizer (45-45-45 kg ha^{-1}), single fertilizer (45 -45-45 kg ha^{-1}), a low single fertilizer (23-36-30 kg ha^{-1}) and high single fertilizer (23-108-90 kg ha^{-1}). The second factor was mycorrhizal inoculation, consisting of three levels, i.e. without mycorrhizae (0 g), medium dose (2.5 g) and high dose (5 g). Data were analyzed using Analysis of Variance (ANOVA) at a significance level of 5%. If there was a significant difference, analysis was followed by Duncan Multiple Range Test with a significance level of 5%. The relationship between variables observed was examined by a correlation analysis. The results showed that there was no interaction between inorganic fertilizer and mycorrhizal application. The dose of single fertilizer which was equivalent to the dose of compound fertilizer given to soybean could increase crops by 1.37 t ha^{-1} compared with plants treated with a compound fertilizer 1.13 t ha^{-1}. The results of correlation analysis among parameters showed that there were correlations between the grain crops and height (r = 0.506**), stem diameter (r = 0.303*), and the number of pods per plant (r = 0.313*).

Keywords: Combination of Inorganic Fertilizers-Mycorrhizae, Crops, Soybean

INTRODUCTION

Soybean (*Glycine max*) is a major commodity crops in addition to paddy and maize (Oktaviani *et al.*, 2014). Soybean plants are not only the source of protein, but also the important sources of fat, vitamins, and minerals for human being. Soybean plant is also the major source of protein for animal feeds, especially poultry.

Gunung Kidul communities are a group of farmers who cultivate eucalyptus on dry land. Besides eucalyptus, they cultivate soybeans among eucalyptus tree. Based on the structure and components of sites of the study, it is included into an early agro-forestry, because a horizontal space for a seasonal plant is more than 50%. This can be seen from the effect of trees in making the area being shadowed, thus leading to effective cultivating areas (Suryanto *et al.*, 2005). Soybean cultivation on dry land in Gunung Kidul Regency is done in the second rainy season from February to May. The development of soybean among the eucalyptus forests can be done regularly throughout the year because it is not hampered by eucalyptus canopy (Sudarmaji *et al.*, 2013). Ordinary farmers give fertilizers for soybean crops in a form of compound fertilizers. Mete *et al.* (2015) reported that N, P, and K fertilizers can increase soybean yield.

The compound fertilizers are much more practical than single fertilizer, but the balance of N: P: K nutrients (15:15:15) is not appropriate to meet the need for nutrients of soybean crop as legume crop that symbiosizes with root nodule bacteria in fixing the air nitrogen. The compound fertilizers are also more expensive. The saving of cost can be made by substituting the compound fertilizer with single fertilizers with the same dose. However, no information is available on th effect of this substitution in soybean yield. In addition, no information is available about whether the fertilizer doses given by farmers are optimal or not. The use of NPK compound fertilizers for soybean plants may be one of the underlying causes of low soybean yield in Gunung Kidul Regency. Soybean productivity in Gunung Kidul Regency is relatively low, ranging from 0.6 to 2.0 ton/ha while the national average is 1.29 ton/ha (Sudarmaji *et al*., 2013).

Results from several studies showed that the use of mycorrhizae could improve nutrient uptake. Guissou (2009) reported that the application of mycorrhizal fungi was able to increase the nutrient uptake of N, P, K, and Mg. Mycorrhizal fungi are fungi that live symbiotically with plant roots and the colonization of roots by fungi provides benefits to host plants because mycorrhizal fungi can increase nutrient and water uptakes, and the host plants provides carbohydrates (carbon) resulted from photosynthesis (Cram and Dumroese, 2012).

The integrated provision of both chemical fertilizers and mycorrhizae can increase efficiency in the use of fertilizer and reduce the dose of chemical one (Simanungkalit, 2001). Mycorrhizae can act to increase soybean roots growth, so it is likely that the roots require the lower dose of fertilizer to achieve the same growth and crops. Mycorrhizal infection in plant can promote its growth and the ability to utilize the nutrients in the soil (Aldeman and Morton, 1986).

It is necessary to conduct a study for gaining the information on the effect of the use of single fertilizer that can provide the same or higher level of soybean yield if compared with those which are treated with the compound fertilizer, and the effect of the use of mycorrhizae which can improve efficiency in the use of single fertilizer. It is expected that the use of mycorrhizae can reduce the dose of single fertilizer with a dose equivalent to the dose of compound fertilizer given by farmers.

MATERIALS AND METHODS

Procedures of the Study

The study was conducted in Bleberan Village, Playen Subdistrict, Gunung Kidul Regency, Yogyakarta from February to May 2015. Materials of the study were soybean seeds of Grobogan variety, mycorrhiza, Phonska fertilizer of NPK (15:15:15), urea, SP-36, and KCl. The study was conducted by using a 5 x 3 factorial design prepared with a randomized block design with three replications. The combination of inorganic fertilizer and mycorrhizae doses can be seen in Table 1.

The size of land used was 337.5 m^2, consisting of 15 experimental plots with three replications. The size of experimental plots was 3 m in length and 2.50 m in width. The determination of the size of experimental plots was based on the width of path among eucalyptus. On each side of the experimental plots, ditches were made of 40 cm in depth and 30 cm in width. Soybean planting was done by dibbling with a pointed stick in order to sow seeds with a spacing of 25 cm x 35 cm and the number of seeds was 2-3 seeds per hole. The mycorrhizae and fertilizer were used in accordance with the procedures of treatment and in a separate manner; all were given by a dibbling technique with a depth of 5 cm. All mycorrhizae were given at first fertilization, while the treatment of fertilizer was given twice. The first fertilization was done when plants were three weeks after planting, i.e. 50% Phonska and 50% urea, while SP-36 and KCl were given consecutively at the first fertilization. Supplementary fertilization of 50% Phonska and 50% urea was done when the plants were five weeks old. Plants that did not grow, damaged, and dead were replaced when they were at one week old. Weeding was done by unplugging and using a small hoe. Pest and disease control was done chemically with dose and type of pesticide adjusted with the recommendation.

Observations

Data were collected for three sample plants per experiment plot. The observation of growth parameters was done at 9^{th} week after planting, while that of soybean crop components was done when the plants were 12 weeks after planting. The growth parameters observed were plant height and stem diameter, while the yield parameters observed were the number of pods per plant, weight of 100 seeds, and yield per hectare (tonnes).

The soybean pods were dried for 2-3 days. Seeds were cleaned, and water content was measured using

Table 1. Combination of Inorganic Fertilizer Dose (N, P2O5, K2O) and Mycorrhizae

Doses	Factor I			Factor II		
	Inorganic Fertilizer (kg ha^{-1})			Mycorrhizae (g.plant^{-1})		
	N	P_2O_5	K_2O	Without (0) (M0)	Moderate (2.5) (M1)	High (5) (M2)
Without (P0)	0	0	0	P0M0	P0M1	P0M2
Phonska by Farmers (P1)	45	45	45	P1M0	P1M1	P1M2
Single Fertilizer by Farmers (P2)	45	45	45	P2M0	P2M1	P2M2
Low Single Fertilizer (P3)	23	36	30	P3M0	P3M1	P3M2
High Single Fertilizer (P4)	23	108	90	P4MO	P4M1	P4M2

a moisture tester. The observation of soybean yield per hectare was calculated by using a formula according to Sirappa & Rieuwpassa (2010).

$$H=\frac{100\%-ka\%}{100\%-14\%}\,x\,\frac{10000xb}{1} \quad \text{.....(1)}$$

where, H: yield of dry seeds per hectare; I: plot area (m2); b: weight of air dried seeds on the plot area (g); ka: air dried seed moisture content at harvest plot determined by moisture tester; 10,000: plot area per ha (m^2).

Data Analysis

The data obtained from the observations were analyzed using analysis of variance (ANOVA) at a significance level of 5%. If the ANOVA result showed F-statistics was > F-table, it means that there was a significant difference between the treatments, therefore the analysis was followed-up by Duncan Multiple Range Test with a significance level of 5%. Relationship between the variables observed was examined by a correlation analysis.

RESULT AND DISCUSSION

Growth Parameters

Table 2 showed that there was no interaction between fertilization and mycorrhizal inoculation on plant height and stem diameter. Mycorrhizal inoculation did not affect either the height or diameter of stem. Wangiyana (2007) reported that the use of leaf fertilizer and mycorrhizal inoculation also showed no significant difference in height of soybean plants of 7 weeks compared to plants without any treatments.

Table 2 also showed that fertilization did not affect the plant height, but could increase soybean stem diameter. Aziz *et al*. (2016) reported that the use of P_2O_5 fertilizer at 49 kg ha^{-1} did not cause significant difference in plant height compared with the plants without any fertilizers. The substitution of compound Phonska with single fertilizer with various doses also did not affect the height and diameter of stem.

Yield Parameters

There was no interaction between fertilizer and mycorrhizal inoculation and the yield of soybean grown among eucalyptus stands. There was no effect of fertilization on the number of pods formed, but the effect of fertilization on the weight of 100 grains of seed was found (Table 3).

The use of a single fertilizer with a dose equivalent to the dose of Phonska given by farmers did not significantly increase the seed size. The use of Phonska as usually given by farmers, or a single fertilizer with low or high doses could significantly increase seed size (Table 3). Mandal et al. (2009) reported that the use of fertilizers N, P, and K for 70 days after planting could increase the weight of 1000 seeds compared to plants without any fertilizers.

The seed yield was affected by fertilization. The use of Phonska given by farmers actually did not significantly increase the seed yield (Table 3). The substitution of low doses single fertilizer also did not increase the seed yield. Soybean yield could increase when the high dose of single fertilizer was given or simply when a single fertilizer with a dose similar to the dose of Phonska given by farmers was used.

The number of pods and the weight of 100 seeds were not affected by the mycorrhizal inoculation, so that it did not affect seed yield. Muis *et al*. (2013) reported that the use of mycorrhizae did not cause a significant difference in the number of pods, the number of seeds, the weight of 100 seeds, and the weight of seeds per plant.

Correlation between Parameters

There was a relationship among seed yield and plant height and stem diameter (Table 4). The plants with better growth were shown by taller stem and larger diameter as well as higher number of seed yield. The seed yield of taller plants were higher because the plants formed more pods, but not larger seeds. Da-yong *et al*. (2012) showed that there was

Table 2. Soybean Plant Height and Stem Diameter at 9 Weeks after Planting

Treatment	Plant Height (cm)	Stem Diameter (cm)
	9 Weeks after Planting	9 Weeks after Planting
Inorganic Fertilizer (N, K_2O_5 and K_2O_5) (kg ha^{-1})		
Without Treatment (0-0-0)	40.46 a	3.37 b
Phonska by Farmers (45-45-45)	42.48 a	3.76 a
Single Fertilizer by Farmers (45-45-45)	44.21 a	3.94 a
Low Single Fertilizer (23-36-30)	41.96 a	3.95 a
High Single Fertilizer (23-108-90)	42.62 a	3.93 a
Mychoriza (g $plant^{-1}$)		
Without Treatment (0)	42.61 a	3.78 a
Moderate (2,5)	42.89 a	3.88 a
High (5)	41.53 a	3.72 a
Interaction	(-)	(-)
CV %	12.76	10.43

Remarks: The values followed by the same letter were not different from DMRT 5%

Table 3. Number of Pods per Plant, Weight of 100 Seeds and Weight of Seeds per Hectare at 12 Weeks after Planting

Treatment	Number of Pods per Plant (fruits)	Weight of 100 Seeds (Seeds)	Crops (t/ha)
Inorganic Fertilizers (N, K_2O_5 dan K_2O_5) (kg ha^{-1})			
Without Treatment (0-0-0)	15.62 a	16.35 b	0. 97 c
Phonska by Farmers (45-45-45)	16.98 a	17.89 a	1.13 bc
Single Fertilizer by Farmers (45-45-45)	16.36 a	16.96 ab	1.37 ab
Low Single Fertilizer (23-36-30)	19.49 a	17.48 a	1.07 bc
High Single Fertilizer (23-108-90)	20.62 a	17.78 a	1.49 a
Mychoriza (g $plant^{-1}$)			
Without treatment (0)	14.64 a	17.55 a	1.14 a
Moderate (2.5)	20.47 a	16.92 a	1.23 a
High (5)	18.33 a	17.40 a	1.25 a
Interaction	(-)	(-)	(-)
CV %	10.43	5.92	26.43

Remarks: The values followed by the same letter were not different from DMRT 5%

Table 4. Correlation Coefficient among Parameters

	PH_9MST	SD _9MST	NPP	W100grain	Yield
PH_9MST	1				
SD _9MST	0.206^{ns}	1			
JPpT	0.151^{ns}	0.46^{**}	1		
B100B	-0.007^{ns}	0.270^{ns}	-0.121^{ns}	1	
Crops	0.506^{**}	0.303^{*}	0.313^{*}	0.112^{ns}	1

Remarks: PH : Plant height, SD : Stem Diameter, NPP: Number of pods per plant; W= weight
**) significant at a significance level of 1%; *) significant at a significance level of 5%; ns: no significant different at a significance level 5%.

a positive correlation between seed yield and pods (r = 0.87 **).

CONCLUSION

There was no interaction between fertilizer and mycorrhizal application on growth parameters and yield parameters of soybean cultivated among eucalyptus stands. The use of compound fertilizer with usual doses given by farmers of 45-45-45 kg/ha did not increase the seed yield of soybean compared with those without fertilization. The substitution of compound fertilizer with single fertilizer of Urea, SP-36, and KCl with similar doses that were usually given by farmers for compound fertilizers could increase the seed yield when compared to those without fertilization and the use of compound fertilizers by farmers. The substitution of compound fertilizer with single fertilizer of Urea, SP-36, and KCl in a low dose (23-36-30) did not increase the seed yield compared to those without fertilization. The seed yield increased when the high doses fertilizer were given (23-108-90). The highest seed yield of 1.49 t/ha was obtained with the high dose of single fertilizer, but it was not significantly different from the seed yield of a single fertilizer given by farmers, i.e. 1.37 t/ha. The high level of seed yield was achieved because the plants formed many pods but not larger seeds.

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