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Improving Soybean Yield in the Dry Land of North Lombok Using Eggshell Waste and Arbuscular Mycorrhiza

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Abstract:- This study aims to determine soybean yield on dry land by utilizing eggshell waste and arbuscular mycorrhiza (AM). Factorial Randomized Block Design (RBD) consisting of 2 factors, namely the dose of AM and eggshell flour was used to design the study. AM (F) consists of three levels, namely f1 (AM dose 300 kg ha-1), f2 (dose AM 400 kg ha-1) and f3 (dose AM 500 kg ha-1) while that of eggshell flour (T), consists of five levels, namely t0 (without eggshell flour), t1 (with eggshell flour 50 kg ha-1), t2 (with eggshell flour 100 kg ha-1), t3 (with eggshell flour 150 kg ha-1) and t4 (with eggshell flour 200 kg ha-1). The parameters observed were soil nutrient availability N, P, and pH before and after the experiment, wet and dry weight of plant stover at harvest, dry pod weight per plant, seed weight per plant, the weight of 100 seeds, number of AM spores per 10 g soil and degree of root colonization. The results showed that 500 kg AM ha-1 can increase seed weight per plant and weight of 100 seeds by 22.6% and 12.12% respectively, which is significantly different from 300 kg AM ha-1. The dose of 200 kg ha-1 eggshell flour can increase the weight of wet and dry biomass, dry pod weight p, seed weight per plant and weight of 100 seeds by 22.56%, 47.56%, 55.8%, 38.6 % and 23.62% with significant difference compared to controls. The interaction of the dose of 500 kg AM ha-1 and eggshell flour 200 kg ha-1 can increase the number of AM spores and the percentage of infections in the roots.

Keywords:- *Arbuscular Mychorizal, Eggshell, Soybean.*

I. INTRODUCTION

Soybean is one of the plants with the ability to grow on dry land. It is the third major food product after rice and corn as well as a prioritized commodity by the National Agricultural Revitalization program in Indonesia (Abdurachman et al., 2008). Owing to the ever increasing population density, there is the need to increase its cultivation and production capacity.

Soybeans are cultivated in technical irrigated rice fields and on dry land (Ministry of Agriculture, 2012). Approximately 25.2 million hectares have been utilized or 76% for various high-value agricultural products out of the total of 32.9 million hectares of dry land (Suwardji, 2013). This development continues to improved, in order to meet food needs, with an increase in the conversion of water ways to dry lands as a result of an increase in population. However, its utilization is still constrained by the low productivity caused by poor soil fertility (Faturrahman, 2004).

One alternative method used to overcome this inconsistency by using eggshell combined with Arbuscular Mycorrhiza (AM). Eggshell is a household waste that can be processed and used as a substitute for lime to increase soil pH (Nurjayanti et al, 2012). Every year, a total of 860,000 tons of egg are consumed with 10% of that amount comprising of its shell. In 2010, the number increased resulting to 94,563 tons per year (Central Statistics Agency, 2015). This indicates that eggshell waste continues to increase every year. Fortunately, it has the potential to be used as a source of organic P for plants on dry land, making it to also overcome the problem of household waste pollution.

Kabirun (2002) stated that the administration of AM also increases the dry weight of canopy and roots in rice plants. According to Astiko et al., (2013) adding AM and manure increases nutrient intake, growth and yield of soybean by 41%.

II. MATERIALS & METHODS

A. Trial Implementation

Eggshell flour is made using egg shells, which is a household consumption waste. The following methods are used to process it: (1) Soak it in hot water at a temperature of 80oC for 15-30 minutes; (2) clean and dry; (3) mesh into flour. Mycorrhiza used are AM introduced into the Oza Plus brand containing species of Acaulospora tuberculata, with a spore density of 100,000 spores. The soybean seeds used in the study were Anjasmoro varieties in varieties are 2 kg with a land size of 500 m2 which is divided into 45 plots each measuring 2 x 2.5 m². Soil processing is carried out through piracy and transplantation while the soybean seeds are planted at a distance of 25 x 40 cm, culminating in 50 planting holes per plot with each containing. four seeds at a depth of 2.0 cm. At the end of the first week, thinning plants is carried out with a total of 100 plants per plot of experiment. The application of eggshell and AM dosage in the form of flour is carried out during planting, by placing it on the seed to form a layer

with the dose according to the treatment. Egg shells and AM applied in the form of flour.

B. Parameter Observation

The parameters observed in this study were: soil nutrient availability N (Kjeldahl method), P (Bray I method) and pH (Mater method pH) carried out before and after the experiment by taking samples at the experimental site and analyzing it in the laboratory.

Mycorrhiza population was measured using wet sieving technique according to Brundrett et al. (1996). The supernatant caught at 38 µm was transferred to centrifuge tubes and added with 60% of sucrose solution at 3000 rpm for 10 minutes (Daniel and Skipper 1982). The harvested spores were stored on the Whatman paper with permanent ink marked at 0.5 x 0.5 cm. Counting of mycorrhiza population was conducted using a stereomicroscope (40x magnification), while the root infection percentage was measured using a modified clearing and staining method (Kormanik and McGraw 1982), followed by counting using the Gridline Intersect technique (Giovannetti and Mosse 1980) under stereomicroscope observation. .

C. Data analysis

Data were analyzed using analysis of variance (ANOVA), followed by means comparison using the Least Significant Difference test at 5% level of significance.

III. RESULTS AND DISCUSSION

Characteristics of Soil in the Experiment Site

The soil used in this experiment is dusty clay-soils which are prone to erosion due its low water trap. The results of the analysis of some of the main properties of the soil in the topsoil 0-30 cm sections as taken from the experimental sites in North Lombok are presented in Table 1.

Soil characteristic	**Value**	**Category***
pH (H_2O)	6.40	Rather acidic
C-Organic (g kg^{-1})	5.40	Low
N-Total (g kg^{-1})	0.70	Very low
Available P (mg kg^{-1})	10.02	High
K-exchanged (me%)	0.97	High
Cation Exchange Capacity (me%)	11.18	Low

Table 1:- Characteristics of soil at the experimental site (* Categories according to the Soil Research Center – Bogor (1983)

Table 1 shows that the land used for the study had a neutral pH value with very low N-Total, C-Organic, CEC content, P-Available, and high K-Swapped. In general, the research area is a dry land with dusty clay, comprising of limited water availability, with elephant grass planted as animal feed owing to its resistance to arid conditions. Its low level C-Organic content indicates that the experimental site is very poor in nutrient, therefore, the plant cannot grow properly without fertilization. In order to enhance its nutrient value, organic materials are required.

The results of soil analysis revealed that the available P-location was in high criteria, with 100% source P applied from inorganic fertilizers so that it did not support soil microbial life, especially AM. Evident from the results of this study stated that the addition of eggshell flour from a dose of 50-200 kg ha-1 can increase the available P-soil, thereby, increasing the growth and yield of plants with rise in doses of eggshell flour. In addition, eggshell flour contains very high calcium (Ca), which plays a role in improving soil quality.

Effect of Egg Shell and Mycorrhiza Doses on Soybean Yield

The application of AM dosage did not give a significant effect on the weight of plant wet stover, dry plant and pods, but gave a significant effect on seed weight and 100 seeds of soybean plants. The interaction between the AM dosage factor and eggshell flour did not have a significant effect on wet stover, dry plant and pod at harvest (Table 2-4).

Dose AM (kg ha^{-1})	WWW (g)	DBW (g)	DPW (g) *)
300	12.90	3.63	1.06
400	16.27	24.20	12.22
500	16.53	26.60	12.08

Table 2:- Effect of N dose on weight of wet and dry biomass, as well as harvested dry pods (*WWW = weight of wet biomass , DBW = dry biomass weight, DPW = dry pod weight)

Table 2 shows that the AM dosage treatment has no significant effect on the weight of wet and dry biomass, as well as dry pods. This indicates that the quality of AM inoculations applied in this study is still low, even though it is expected that at 500 kg ha-1 it spurs crops. However, the results of the study shows that at 300 kg ha-1 the plant weight is the same at 400 kg ha-1 and 500 kg ha-1. This is allegedly caused by the results of the analysis of soil characteristics used in this experiment, with N total classified as very low (Table 1), making it difficult to spur growth in the vegetative period. According to Astiko et al. (2015), to improve crop yields on dry land it is necessary to add inorganic and organic fertilizers (manure) as additional nutrients to increase mycorrhiza effectiveness to soil nutrient and crop yields.

Dose AM (kg ha^{-1})	Seed Weight (g)	Weight of 100 Seeds (g)*
300	4.72 a	9.57 a
400	5.74 ab	9.87 ab
500	5.79 b	10.73 b
LSD 5%	1.06	0.94

Table 3:- Effect of AM dosage on seed weight per plant and weight of 100 seeds (*The numbers followed by the same letters in the same column are not significantly different from the 5% LSD test

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Table 3 shows that the application of 500 kg ha-1 AM dose increases seed weight per plant and weight of 100 seeds by 22.6% and 12.12% respectively, which is significantly different than the dose of AM 300 kg ha-1. This is because at the highest AM dosage there are higher levels of available P-soil nutrients owing to its ability to increase the area for nutrient and water exchange between plants and hosts. Phosphorus is an important element in the composition of high-energy substrates (ATP, ADP, AMP) which plays an important role in plant metabolism. The activities of plants supported by sufficient energy can develop reproductive organs in a sustainable manner, as the end result is a large seed weight of 100. Mycorrhiza also act as biological controllers, increasing resistance to water stress and producing hormones and growth regulators that function to enhance plant growth and yield (Hildebrandt et al., 2002). The results of this study are in line with the Rahim's (2002) study which states that AM inoculation along with P fertilization can provide better outcome.

Dose EF (kg ha^{-1})**	WWB (g)	DBW (g) *)	DPW (g) *)	SW (g)	Weight of * 100 Seeds (g)
0	23.89 a	13.33 a	8.84 a	4.74 a	9.44 a
50	23.67 a	15.00 ab	10.75 ab	4.97 a	9.53 a
100	24.44 ab	15.00 ab	11.17 ab	4.76 a	9.46 a
150	24.78 ab	16.78 b	12.67 b	6.04 ab	10.17 ab
200	29.28 b	19.67 c	13.78 b	6.57 b	11.67 b
LSD 5%	5.17	2.86	3.15	1.36	1.21

Table 4:- Effect of dose of eggshell flour on the weight of wet and dry biomass, dry pod weight, seed weight per plant and weight of 100 seeds (* The numbers followed by the same letters in the same column are not significantly different from the 5% LSD test. **EF = eggshell flour, WWB = weight of wet biomass, DBW = dry biomass weight, DPW = dry pod weight, SW= seed weight)

Table 4 shows that the application of doses of eggshell flour can increase the weight by 22.56%, 47.56%, 55.8%, 38. 6% and 23.62% respectively compared to controls. There are indications that the higher the dose of eggshell flour applied, the greater yields of soybean plants in 200 kg ha-1 owing to the increase in available P-soil nutrients. In general, the function of nutrient P for plants is to stimulate flowering and fertilization, seed formation, strengthen stems, trigger root development, accelerate fruit ripening and improve plant quality. The above facts show that the addition of fertilizer (eggshell and mycorrhiza) as an additional source of nutrition is very important to increase plant growth and yield. This is closely related to the role of nutritional sources other than as a provider of nutrients needed by plants, as well as a source of energy for mycorrhiza growth. According to Pattern and Glick (2005), these are needed in increasing plant growth, which among others is driven by the presence of hormones produced by biological fertilizers. Wibowo (2007) reported that the use of biological fertilizers was able to increase the IAA hormone content by an average of 73-159% in mustard greens, corn and soybean plants, which also enhances soybean yields. Soybean production in the treatment of 200 kg/ha eggshell flour dose was 1.31 tons/ha 38% higher compared to the control treatment (0.95 tons /ha-1).

Effect of Eggshell Dosage and AM on number of spore and percentage of infections

Based on the number of spores and the percentage of AM infection, it was shown that the AM dose factor, the dose of eggshell flour and their interaction had a significant effect in increasing the number of spores. The AM dosing factor and the interaction of the two factors did not have a significant effect on the percentage of root infections, however, the dosage of eggshell flour had a significant effect on the percentage of root infections. The complete can be seen in Tables 5 and 6.

Dose AM (kg ha^{-1})	Egg Shell Flour Dosage (kg ha^{-1})*				
	0	50	100	150	200
300	52.33 a	53.00 a	60.67 b	60.67 b	61.67 b
400	54.00 a	57.00 b	60.33 c	60.33 c	62.33 d
500	52.67 a	53.33 a	53.67 a	71.00 b	73.67 c

Table 5:- Effect of interaction between AM dosage and dose of eggshell flour on the number of AM spores per 10 g of soil (*The numbers in the row followed by the same letters are not significantly different according to the LSD 5% test)

Dose AM (kg ha^{-1})	Egg Shell Flour Dosage (kg ha^{-1})*				
	0	50	100	150	200
300	28.89 a	43.33 b	53.33 b	50.00 bc	63.33 c
400	20.00 a	43.33 b	40.00 b	50.00 b	50.00 b
500	30.00 a	56.67 b	60.00 b	60.00 b	66.67 b

Table 6:- Effect of the interaction of the AM dose with the dose of eggshell flour on the percentage of root infection (*The numbers in the row followed by the same letters are not significantly different according to the LSD 5% test)

The observations results on the number of AM spores and the percentage of root infections showed that the treatment of AM doses, the dose of eggshell flour and their interaction had a significant effect in increasing the number of spores and percentage of root soybean infections. The average number of MA spores and the percentage of infections increased with increase in doses of eggshell flour at all AM levels. This means that AM and eggshell flour synergize in increasing the number of spores and the percentage of infection in the roots of soybeans on dry land, because at low doses a high quantity of eggshell flour is required .

The number of AM spores and the percentage of infections increases with rise in plant dosage. According to Wilson and Trinick (1983), its ability to produce spores shows the effectiveness of AM symbiosis in plant roots. According to Alloush et al. (2000), addition of fertilizers reduces the benefits of AM, with the availability of P element able to decrease the number of root exudates (Graham et al., 1981), and changes i its quality (Elias and Safir, 1987).

IV. CONCLUSION

The dose of 500 kg AM ha-1 increases seed weight per plant and weight of 100 seeds by 22.6% and 12.12% respectively. It is also significantly different from the dose of 300 kg AM ha-1. Eggshell flour at 200 kg ha-1 increases the weight of wet and dry biomass, dry pod weight p, seed weight per plant and weight of 100 seeds by 22.56%, 47.56%, 55.8%, 38.6 % and 23.62% respectively. The interaction of 500 kg AM ha-1 and 200 kg ha-1 eggshell can increase the number of AM spores and the percentage of infections in the roots.

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