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Nutrient Concentration and Yield in Several Soybean Varieties with Application of Mycorrhizal, Organic and Inorganic Fertilizer Package in Dryland North Lombok, Indonesia

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Abstract:- The application of inorganic fertilizers with high doses, which are usually applied intensively by farmers, can inhibit the development of mycorrhizae in the soil. Therefore, in its application, it is necessary to set the appropriate dose for the effect of mycorrhizae. This study aims to determine the nutrient concentration, nutrient uptake, and yield of several soybean varieties by applying inorganic fertilizer packages, organic matter, and mycorrhizal biological fertilizers in the dryland. This experiment used a Randomized Block Design with three replications. The treatment of soybean varieties tested was V1: Anjasmoro variety, V2: Biosoy II variety, V3: Detap variety I, V4: Dega variety I, V5: Dena variety I. The result shows that total N nutrient concentration, soil available P, plant N, and P nutrient uptake, mycorrhizal populationsand plant yields of Anjasmoro variety with the application of fertilizer packages for cattle manure (15 tons/ha) and mycorrhizal biological fertilizers (1.5 tons/ha) and inorganic fertilizers (Urea 60 kg/ha and NPK Phonska 120 kg/ha) showed the highest value.

Keywords:- *Dryland, fertilization package, mycorrhizae, Soybean.*

I. INTRODUCTION

Soybean is a strategic food crop to be cultivated in Indonesia and is one of the primary food commodities besides rice and maize. The need for soybeans is increasing yearly in line with population growth and public awareness of protein foods. The Central Statistics Agency (CSA, 2020) recorded that Indonesia's soybean imports in 2020 reached 1.27 million tons, while it was also seen in 2019, which gained 2.58 million tons and 2.67 million tons in 2018. Low soybean productivity In this country, on average, is caused by the conversion of agricultural land into settlements. The increasing demand for soybeans in the country must be balanced with regional and national production. Efforts to meet the needs of soybean consumption can be made by increasing the soybean planting area through the use of dry land.

Inundation is one of the main problems commonly found in agricultural areas in Indonesia, and soybean is a sensitive plant to inundation. In Indonesia, soybeans are generally cultivated in paddy fields after rice. In this condition, the flooded soil is one of the causes of the low productivity of soybeans in paddy fields caused by too long the paddy fields are inundated so that the water saturation condition is caused by the soil moisture content which is above field capacity (Hapsari and Adhie, 2010).

The dry land area in Nusa Tenggara Barat (NTB) is 1.8 million ha (84.19%) of the land area, and there is about 749,000 ha that can be developed for food crops (Suwardji, 2013). From the potential of dry land in NTB, North Lombok district has about 38,000 ha to grow food crops (Suwardji et al., 2007).

Soybean cultivation has many obstacles because soybean plants are susceptible to changes in the growing environment. For example, the evolution of seasons causes soybean plants to be easily attacked by pests and diseases. Another obstacle is the decreasing quality of soil fertility to inhibit plant growth. Thus, the solution to overcome this is through improving the physical, chemical, and biological properties of the soil. The fixing agent with a dual function in improving the three soil properties is organic matter (Handayanto et al. 2017).

The role of organic matter, in general, can affect the physical and biological properties of the soil. According to Hartatik et al. 2015, organic matter has the role of increasing soil water retention. Soil organic matter can absorb water 20 times its weight, provide the availability of organic matter from decomposition, and stabilize soil aggregates. The association of organic compounds with primary soil particles as a buffer changes in soil pH, increasing the cation exchange capacity (CEC) of the soil and as a source of energy for microbial activity.

Inorganic fertilizers are the best solution to overcome the availability of nutrients for plants in the dryland (Sylvia, 2005). Wherease, mycorrhizae are fungi that can enter plant roots to help meet the availability of nutrients for plants. Some of the important roles of mycorrhizal fungi include helping roots increase absorption of phosphorus (P) and other nutrients such as N, K, Zn, Co, S, and Mo from the soil, increasing plant resistance to drought, improving soil aggregates. One alternative to overcome nutrient deficiencies, especially facilitating phosphorus availability, is mycorrhizae (Smith et al., 2010).

II. MATERIALS AND METHODS

A. Research materials and tools

The materials used in this experiment were Urea fertilizer, Phonska fertilizer, cattle manure, mycorrhizal biofertilizer, OrgaNeem pesticide, soybean varieties, raffia, plastic bags, tissue, label paper, soil samples, root samples, methylene blue, 10% KOH, sucrose, aquates, filter paper, and stationery.The tools used in this experiment are oven, scales, binocular microscope, magnetic stirrer, beaker, tweezers, grated sieve, centrifuge, funnel, Petri, shovel, hoe, sickle, and hand counter.

B. Research place and design

We conducted this research in Pemenang Barat Village, Pemenang Subdistrict, North Lombok Regency, from May to August 2021. The experimental design used was a Randomized Block Design with three replications and five treatments of soybean varieties, namely Anjasmoro variety, Biosoy2 variety, Detap1 variety, Dega 1 variety, and Dena 1 variety).

C. Conduct of Experiments

The land used for this study was processed utilizing a tractor until it was loose and cleaned of weeds. The soil was then made into five treatment plots in each block with a size of 4.8 m × 3 m; the width of the irrigation channel between the plots was 30 cm wide with a bed height of 25 cm, and the distance between blocks was 50 cm.

Mycorrhizal inoculation is done at the time of planting. The inoculum is placed at a depth of ± 10 cm evenly to form a layer. The inoculum used was harvested from 3-month-old cultured pots with the maize host plant, formulated to be a mixture of root pieces, fungal spores, and fungal hyphae, which were already in powder form. The mycorrhizal inoculation dose was 20 g/hole, which was given at planting. Mycorrhizal inoculum is a private collection of Dr. Ir. Wahyu Astiko., MP with the name isolate M AA 01, an Indigenous Mycorrhizal from North Lombok.

Seed planting is done by making holes 2 cm deep; then each hole is filled with three soybean seeds according to the treatment of each variety (5 types of varieties) with a spacing of 30 cm × 20 cm. Thinning by leaving two plants per planting hole was carried out 14 days after planting.

Provision of mycorrhizal biofertilizer at a dose of 1.5 tons/ha or the equivalent of 20 g/hole. Cattle manure at a dose of 15 tons/ha or the equivalent of 180 g/hole. Inorganic fertilizer with a dose of Urea 60 kg/ha or equivalent to 0.72 g/hole and Phonska at a dose of 120 kg/ha or equivalent to 1.44 g/hole. Gave the first application of all doses of manure was given at planting by immersing 7 cm from the soil hole, inorganic fertilizer at a dose of 50% by engaging 5 cm from the soil hole. At the same time, the second administration of inorganic fertilizer with a dose of 50% is given when the plant is three weeks after planting.

D. Variable observation

Observations were made on soil nutrients (total N and P available) and shoot nutrient uptake (N and P) at 40 DAP, mycorrhizal population (number of spores and percentage of root colonization at 40 DAP), crop yields (weight of harvested dry pods, weight of dried pods in the sun, weight of dry seeds, and weight of seeds). Measurement of plant yields was carried out by weighing the weight of the plant using a scale. Dry weight measurement was carried out by drying the ingredients using an oven at 60ºC for 48 hours.

Laboratory analysis was carried out at the Soil Chemistry Laboratory, Faculty of Agriculture, Mataram University. Soil pH and texture were measured by standard procedures (Imam &Didar, 2005). Determination of total N in the soil was determined using $(NH_4)\ _2SO_4$ extract and distillation with NaOH, where NH_4 + was determined by the indophenol blue colorimetric method and NH_3 was then titrated with 0.05N $H_2\ SO_4$ solution (Page et al., 1982). Total N in plants was measured using the indophenol blue spectrophotometric method with a wavelength of 636 nm after extraction with $(NH_4)\ 2SO_4$ and distillation with NaOH following Conway's procedure (Lisle et al., 1990). The available phosphorus in soil and plants was measured using a spectrophotometer (λ = 693 nm) after the extraction process using Bray and Kurt I solution (0.025 N HCl + NH_4 F 0.03 N) (Bray & Kurtz, 1945).

Extraction of mycorrhizal spores from the soil (100 g soil sample) was carried out using the wet sieving and decanting technique according to Brundrettet al. (1996). The filter results on the last sieve (38 m) with running water until clean. The supernatant was taken, then 60% sucrose solution was added and then rotated in a centrifuge at 3000 rpm for 10 minutes (Daniel and Skipper, 1982). The spores obtained were placed in a Petri dish to count the population per 100 g of soil under a stereo microscope with a magnification of 40 times. The colonization percentage variable was calculated using the clearing and staining method (Kormanik and Graw, 1982). The percentage of infection was calculated using the gridline intersect technique (Giovenneti and Mosse, 1980) under a stereomicroscope.

E. Data analysis

Data were analyzed using analysis of variance followed by the Honestly Significant Difference (HSD) test at a significant level of 5%.

III. RESULTS AND DISCUSSION

A. Soil nutrient status and plant nutrient uptake

The results of the LSD test at the 5% level showed that the use of the Anjasmoro variety accompanied by the provision of organic fertilizer packages, mycorrhizal biological fertilizers, and inorganic fertilizers could increase the total N and P concentrations of available soil (0.47 gkg -1 and 17.07 mg kg -1) and plant nutrient uptake of N and P (3.29 gkg -1 and 0.43%). The highest increase and significantly different occurred in the use of the Anjasmoro variety (Table 1).

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Varieties	Soil nutrient status		Plant nutrient uptake	
	N total ($g.kg^{-1}$)	P available ($mg.kg^{-1}$)	N uptake ($g\ kg^{-1}$)	P Absorption (%)
Anjasmoro	0.47 [a]	17.07 [a]	3.29 [a]	0.43 [a]
Biosoy2	0.37 [c]	10.43 [e]	2.94 [a]	0.27 [d]
Detap1	0.43 [b]	14.61 [b]	3.31 [a]	0.37 [b]
Dega1	0.43 [b]	12.12 [c]	3.29 [a]	0.29 [c]
Dena 1	0.38 [c]	11.65 [d]	2.99 [a]	0.27 [d]
HSD 5%	0.01	0.67	64.99	0.01

Table 1: Average nutrient status and uptake of N and P for each variety aged 40 DAP

Nutrient uptake of N and P of Anjasmoro variety was generally higher and significantly different than other varieties. This difference in nutrient uptake patterns between varieties is thought to be an adaptation of the soybean genotype to a dry land environment where the Anjasmoro variety shows better adaptation (Supandie, 2013). The Anjasmoro variety absorbs more N and efficiently uses N to increase root and shoot dry weight. Nutrient uptake of N on leaves of Anjasmoro variety was statistically the same as other varieties, but root and shoot dry weight of Anjasmoro variety was significantly higher than that of different varieties. This indicates that the Anjasmoro variety uses more nutrients to form roots and plant crowns. Organic matter is a source of energy for soil micro-organisms. Without organic matter, all biochemical activities will stop; the effectiveness of nutrient absorption is also strongly influenced by its levels in the soil. The application of organic matter, especially on acid soils, was able to increase the efficiency of P fertilizer application. The organic acids contained in organic fertilizers were able to act as chelating Al compounds so that P became more available. In general, it can be said that organic matter increases the availability of soil phosphorus through its decomposition, which produces organic acids and CO_2 (Hanum, 2013). The increase in the population of rhizobium on soybean roots of the Anjasmoro variety is thought to increase the roots' ability to absorb nutrients, thereby increasing the dry weight of the roots and plant shoot (Ningsih and Iswandi, 2004).

B. Mycorrhizal Development

The effect of treatment using the Anjasmoro variety was significantly different according to the 5% HSD test compared to other soybean varieties on the parameters of the number of mycorrhizae spores and the percentage of root colonization at 40 DAP (Table 2). The value of the number of spores and the highest percentage of colonization was found in the treatment of the Anjasmoro variety, which was 492.01 spores100 g^{-1} of soil and 73.51 percent of colonization. The value of the number of spores and the lowest percentage of colonization was found in the treatment of the Biosoy2 variety, which was 266.01 spores100 g^{-1} of soil and 45.51 percent of colonization.

Varieties	Number of spores	Colonization
Anjasmoro	492.01[a]	73.51[a]
Biosoy 2	266.01[c]	45.51[c]
Detap 1	444.01[a]	69.51[ab]
Dega 1	380.00[b]	62.01[ab]
Dena 1	373.50[bc]	52.51[bc]
HSD 5%	102.04	17.09

Table 2: The average number of spores (spores per 100 g of soil) and value of colonization (%-colonization) at 40 DAP for each variety

Judging from the response of the Anjasmoro variety to the increase in the average number of spores and the percentage of colonization on the roots, it shows that there is a symbiosis between soybean plants and mycorrhizae which can increase the number of spores and root infection around the plant rhizosphere (Astiko et al., 2015). The increase in the spore population varies depending on plant characteristics and several environmental factors such as temperature, pH, soil moisture, phosphorus, and nitrogen content (Astiko et al., 2013). It is suspected that the environment in the tested growing media supports an increase in the number of spores and mycorrhizal infections. (Ghulamahdi et al., 2006).

C. Crop Yield

In Table 3 it can be seen that the average soybean yield of various varieties showed that the Dena 1 variety gave the highest yield on the parameters of harvested dry pod weight, oven dry pod weight, pod length, pod diameter, and seed dry seed weight per plant.

Varieties	WHDP (g)	WODP (g)	LP(cm)	DP(cm)	WDS (g)
Anjasmoro	216.2[bc]	25.2[a]	11.2[cd]	4.21[c]	155 [bc]
Biosoy 2	178.5 [c]	18.5 [b]	10.0 [d]	4.90 [b]	145 [c]
Detap 1	244.5 [ab]	21.5 [ab]	14.5 [ab]	4.85 [b]	165 [ab]
Dega 1	215.5 [bc]	19.0 [b]	13.0 [bc]	5.15 [ab]	120 [d]
Dena 1	271.5 [a]	25.5 [a]	16.5 [a]	5.31[a]	181[a]
HSD 5%	40.21	0.047	2.7447	0.317	0.018

Table 3:- Results of Harvested Dry Weight of Pods, Oven Dry Weight of Pods, Length of Pods, Diameter of Pods, Weight of Dry Seeds per Plant on Various Soybean Varieties
(WHDP = Weight of Harvested Dry Pods, WODP = Weight of Oven Dry Pods, LP = Length of Pods, DP = Diameter of Pods, WDS = Weight of Dry Seeds)

Table 3 shows that the dry weight yield per plant of the Dena 1 variety was significantly greater than the other varieties, with a value of 271.5 g, as well as the oven-dry weight per plant of the Dena 1 variety, which was significantly higher than the other varieties with a value of 25.5 g. In the yield of pod length per plant, Dena 1 variety was significantly different compared to other varieties, which was 16.5 cm. The pod diameter parameter of the Dena I variety was significantly different, with an average value of 5.31 cm. For dry seed weight per plant, the Dena I variety also had a significantly different dry seed weight compared to other varieties, with a value of 181 g.

Varieties	WHDP (kg)	WDP (kg)	WDSP (kg)	1000 seeds (g)
Anjasmoro	111.01[ab]	7.87[c]	5.74[c]	279.01[a]
Biosoy 2	106.01[b]	8.44[bc]	6.21[bc]	278.01[ab]
Detap 1	111.01[ab]	8.04[c]	6.54[bc]	285.02[a]
Dega 1	138.02[a]	9.74[b]	6.97[b]	264.01[b]
Dena 1	157.02[a]	11.74[a]	8.54[a]	288.02[a]
HSD 5%	4,653	1,641	1.073	14,245

Table 4: Yield Weight of Harvested Dry Pods, Weight of Dry Pods, Weight of Dry Seeds Per Plot and Weight of 1000 Seeds on Various Soybean Varieties
(WHDP = Weight of Harvested Dry Pods, WDP = Weight of Dry Pods, WDS = Weight of Dry Seeds, Weight of 1000 Seeds)

In Table 4, it can be seen the Dena 1 variety had the highest yield on harvest dry weight per plot with a value of 157.02 kg, the weight of dry dried pods per plot of 11.74 kg, the weight of dry seed shells per plot of 8.54 kg, and weight of 1000 grains Seeds 288.02 g.

Mycorrhizae can increase the potential for uptake of nutrients, especially P, through the roots of soybean plants that have been infected with mycorrhizae. Mycorrhizae, through external hyphae around the roots of the host plant, effectively absorb nutrients, especially P, from the soil to be distributed to the roots of the host plant (Astiko et al. 2019). One of the working principles of mycorrhizae is to infect the host plant's root system, producing hyphae intensively so that plants containing mycorrhizae will be able to increase their capacity for nutrient absorption (Muis et al., 2013). Mycorrhizae are able to absorb P nutrients which play a role in the formation of compounds needed by plants, especially in the formation and filling of pods (Susanti et al., 2018). The Dena I variety gives high yields; this is presumably because the Dena I variety has a better response to the application of fertilizer packages, thereby triggering an increase in the availability of nutrients that can increase crop yields (Astiko and Sudantha, 2019a; Astiko et al., 2021). The high weight of 1000 seeds and the weight of the dry sheed Dena I variety are thought to be influenced by genetic factors related to the ability of plants to allocate photosynthetic results for plants to increase seed yields. Photosynthesis that runs optimally will increase the amount of photosynthate until it reaches a maximum. The results of this photosynthesis are translocated to the generative parts of the soybean plant, namely seeds and pods (Duaja et al., 2019).

IV. CONCLUSION

The result shows that total N nutrient concentration, soil available P, plant N, and P nutrient uptake, mycorrhizal populations and plant yields of Anjasmoro variety with the application of fertilizer packages for cattle manure (15 tons/ha) and mycorrhizal biological fertilizers (1.5 tons/ha) and inorganic fertilizers (Urea 60 kg/ha and NPK Phonska 120 kg/ha) showed the highest value.

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