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Intercropping of Several Maize-Soybean Varieties Causes Changes in Nutrient Concentrations in Soil, Shoots and Growth in Dryland North Lombok, Indonesia

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Abstract:- Suboptimal land optimization through intercropping patterns of maize and soybeans using mycorrhizal biological fertilizers and plant nutrition sources has not received much attention. This study aims to determine the concentration of P, N, and plant growth in the intercropping pattern of maize-soybean added mycorrhizal biofertilizer and plant nutrition. The experimental design used was a factorial randomized block design consisting of two treatment factors. The first factor is mycorrhizal biofertilizer (M) which consists of 2 levels: M_0 = No mycorrhizal fertilizer and M_1 = Using biological fertilizer (1 ton/ha). The second factor is the source of nutrition (U) which consists of 4 levels, namely: U_0 = Without the addition of nutrients, U_1 = With the addition of 100% dose of inorganic fertilizer only (maize = urea 300 kg/ha and Phonska 200 kg/ha, soybeans = 60 kg/ha Urea and 120 kg/ha Phonska), U_2 = With the addition of 100% dose of cattle manure (12 tons/ha), and U_3 = With the addition of 50% dose of cattle manure (6 t/ha) + 50 % dose of inorganic fertilizer (maize = urea 150 kg/ha and Phonska 100 kg/ha, soybean = 30 kg/ha Urea and 60 kg/ha Phonska. The results showed that 50% dose of cattle manure (6 t/ha) plus 50% dose of inorganic fertilizer (maize = urea 150 kg/ha and Phonska 100 kg/ha, soybean = 30 kg/ha Urea and 60 kg/ha Phonska) plus mycorrhizal biofertilizer in maize-soybean intercropping gave the best concentration of N, P and plant growth.

Keywords:- *Cattle Manure, Mycorrhizae, Intercropping.*

I. INTRODUCTION

In Indonesia, maize and soybeans are food sources that have an important role for human life. The high demand for maize and soybeans as well as the low domestic production of maize and soybeans has resulted in high demand for imports for these commodities. Based on data from the Badan Pusat Statistik (BPS 2020), the projected value of Indonesia's maize import volume in 2016-2020 continues to increase with the projected average import value of 4.87 million tons. Meanwhile, in 2019, the total realized volume of soybean imports reached 2.67 million tons.

In an effort to increase the production of maize and soybeans in the country, it can be done by expanding the planting area and increasing productivity. Area expansion can be directed at potential lands, one of which is suboptimal land. According to Mulyani and Sarwani (2013), the potential for suboptimal land for food crop development in Indonesia reaches 3.7 million ha, mostly found in Bali and Nusa Tenggara, some in Sulawesi and Java. Meanwhile, according to Suwardji et al (2013), Nusa Tenggara Barat (NTB) has suboptimal land potential for development which reaches 84% or 1.8 million hectares of the existing land area of 2.015 million ha.

However, the uneven distribution of rainfall on suboptimal land during the period of plant growth can be a trigger for plant stress that affects yield reduction and even crop failure (Yazar and Ali 2017). According to Machado et al (2008), to optimize suboptimal land productivity where limited water availability can be achieved through the application of a cropping system that can improve the quality of water use efficiency, one of the cropping systems that can be applied is the intercropping system. Intercropping is defined as planting two or more crops at the same time and place. Intercropping land management will be more profitable than monoculture planting systems because of its high productivity, efficient in production costs, preventing erosion, maintaining soil fertility, reducing the risk of crop failure, and suppressing weed growth (Indriati, 2009). One of the common intercropping schemes is to pair cereal crops with legumes such as maize and soybeans.

Intercropping of maize and soybeans is possible because maize is a C4 plant that likes direct sunlight and requires relatively high nitrogen. While soybeans are included in C3 plants which are quite tolerant of shade. In addition, soybeans can also fix nitrogen through symbiosis with the bacterium Rhizobium japonika, so that they can donate N to maize plants (Advinda, 2018).

The main problems with intercropping systems on suboptimal land are competition between plants to absorb water, nutrients, and low soil fertility. One of the efforts that can be done to overcome this is by giving fertilizer (Tabri, 2011). According to Simarmata (2005), continuous and excessive use of inorganic fertilizers can reduce soil fertility

and damage the environment so that the use of inorganic fertilizers needs to be reduced by increasing the use of biological fertilizers. Biofertilizer is a collection of living organisms whose activities can improve soil fertility. One of the biological fertilizers that can be used as an alternative is a mycorrhizal biofertilizer. Mycorrhizae are symbiotic associations between fungi and plant roots that form complex interactions. Mycorrhizae have many benefits for plants. According to Astiko et al. (2020) that mycorrhizal-infected plants showed higher growth with better root development and fatter stems compared to mycorrhizal-infected plants.

In addition to the provision of mycorrhizal biological fertilizers, additional nutritional sources can also be done to maximize the yield of maize and soybean intercropping. The application of organic fertilizers such as manure can improve the environmental conditions of plant growth which in turn can increase the yield of a plant. However, manure has a low nutrient content and is slow release, so organic fertilizer fertilization needs to be combined with inorganic fertilizers to get maximum results. Inorganic fertilizers have advantages for improving soil chemical properties. The application of inorganic fertilizers can add nutrients that are not available in the soil. However, if the use of inorganic fertilizers with excessive use will have an impact on decreasing soil quality and the environment (Setyorini et al, 2004). However, how much influence does the addition of mycorrhizal biological fertilizers and plant nutrient sources on the maize-soybean intercropping pattern have on P, N nutrient concentrations and plant growth in sub-optimal land in North Lombok has not been widely reported. For this reason, research has been carried out on "N, P Nutrient Concentrations and Plant Growth in Maize-Soybean Intercropping with Added Mycorrhizae, Organic Materials and Plant Nutrients in Suboptimal Land, North Lombok".

II. MATERIALS AND METHOD

A. Design of the Experimental

This research was conducted in Akar Akar Village, Bayan District, North Lombok Regency from May to August 2021. The experimental design used was a factorial randomized block design consisting of two treatment factors. The first factor is mycorrhizal biofertilizer (M) which consists of 2 levels: M_0 = No mycorrhizal fertilizer and M_1 = Using biological fertilizer (1 ton/ha). The second factor is the source of nutrition (U) which consists of 4 levels, namely: U_0 = Without the addition of nutrients, U_1 = With the addition of 100% dose of inorganic fertilizer only (maize = urea 300 kg/ha and Phonska 200 kg/ha, soybeans = 60 kg/ha Urea and 120 kg/ha Phonska), U_2 = With the addition of 100% dose of cattle manure (12 tons/ha), and U_3 = With the addition of 50% dose of cattle manure (6 t/ha) + 50 % dose of inorganic fertilizer (maize = urea 150 kg/ha and Phonska 100 kg/ha, soybean = 30 kg/ha Urea and 60 kg/ha Phonska. There were 8 treatment combinations repeated 3 times so there were 24 experimental plots. The proportion of intercropping used was 3 rows of maize: 3 rows of soybeans.

B. Conduct of Experiments

Tillage is carried out using a tractor to remove weeds from the soil. The land is then divided into 24 plots measuring 5.5 mx 2.9 m. Inoculum MA indigenous *Glomus mosseae* (mycorrhizal isolate M_{AA01} including soil, hyphae and mycorrhizal spores) was used by the propagation of culture pots for 3 months with soil and manure media (1: 1) sterile with the maize host plant. Mycorrhizae inoculation at a dose of 1 ton/ha for all plots of maize and soybean was given at the same time at the time of planting which was placed under the seed as much as 20 g per planting hole at a depth of 10 cm.

The planting of maize and soybean seeds is done by inserting them into the soil. The treatment pattern of maize-soybean intercropping was 3 rows of maize and 3 rows of soybeans. Each hole was filled with 3 maize seeds and 3 soybean seeds with a maize spacing of 60 cm x 40 cm while the spacing of soybeans was 30 cm x 20 cm. Embroidery is done by replanting maize and soybean seeds at the age of 7 days after planting (DAP) to replace dead plants or grow abnormally. After the plants grew, thinning was carried out leaving two plants at the age of 14 days after planting.

Fertilization using inorganic fertilizers (urea and phonska), manure, and mycorrhizal biofertilizers according to each treatment. Mycorrhizal inoculation was given as much as 20 g of inoculum per planting hole and inorganic fertilization with a dose of 50% of the first administration. Manure is given at planting by burying 5 cm from the soil hole to a depth of 7 cm by giving all doses of fertilizer. While the second administration of inorganic fertilizers (Urea and Phonska) with a dose of 50% is given when the plant is 3 weeks after planting.

Plant maintenance includes weeding the weeds that grow by cleaning them using a sickle after the plants are 10 days after planting and subsequent weeding is done every 10 days interval until the plants are 50 days old. Irrigation is done by entering the water from the irrigation canal at the time of planting, at the age of 20 DAP, and 40 DAP until the soil reaches field capacity.

Plant protection is carried out by spraying "OrgaNeem" (an organic pesticide extracted from the Azadirachtin plant) with a concentration of 5 ml of OrgaNeem per liter of water. OrgaNeem was applied from the age of 10 to 40 days after spraying with a spray interval of 7 days.

C. Observation of Parameters

Observations were made on parameters including soil nutrients (total N and available P) at 40 DAP, plant nutrient uptake (N and P) at 40 DAP, vegetative growth (dry weight of roots and shoots of maize and soybeans per plant) at 40 DAP.

D. Data analysis

Observational data were analyzed using analysis of variance followed by the Least Significant Difference (BNT) test at a significance level of 5% using the Costat for Windows program.

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III. RESULTS AND DISCUSSION

A. Nutrient concentration and nutrient uptake

The results showed that the M_1U_3 treatment was the application of mycorrhizal biological fertilizer (1 ton/ha) combined with a 50% dose of cattle manure (6 t/ha) plus a 50% dose of inorganic fertilizer (maize = urea 150 kg/ha). and Phonska 100 kg/ha, soybean = 30 kg/ha Urea and 60 kg/ha Phonska) in an intercropping system using Bisi 18 maize variety and Biosoy II soybean variety had a significant effect on total soil nutrient concentrations of N and available P at 40 days after planting, with the highest average value (Figure 1).

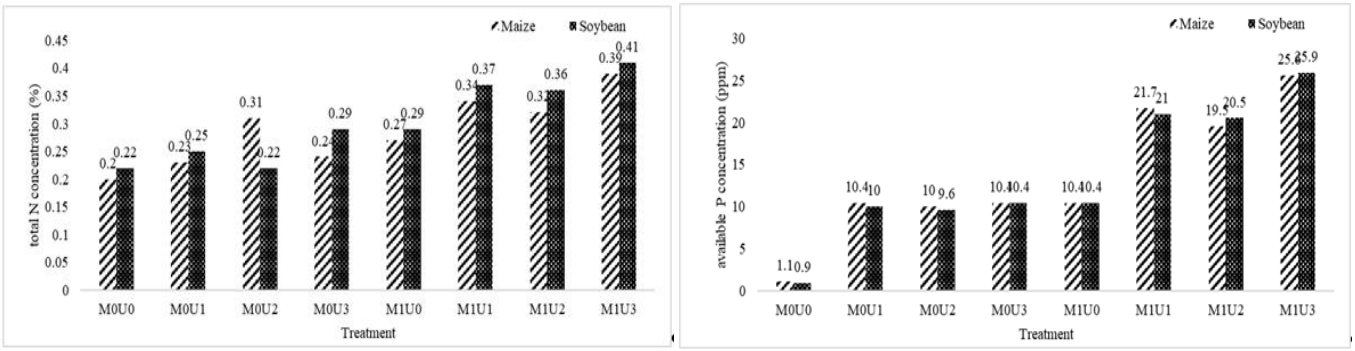

Figure 1:- Mean concentrations of total N and P nutrients available in the maize-soybean intercropping rhizosphere in the treatment of several nutrients for plants aged 40 DAP

The results showed that the application of mycorrhizal biological fertilizer (1 ton/ha) combined with the application of 50% dose of cattle manure (6 t/ha) plus 50% dose of inorganic fertilizer (maize = urea 150 kg/ha and Phonsk a 100 kg/ha). ha, soybean = 30 kg/ha Urea and 60 kg/ha Phonska) had a significant effect on N and P nutrient uptake in maize and soybean plant tissues with the highest values (Figure 2).

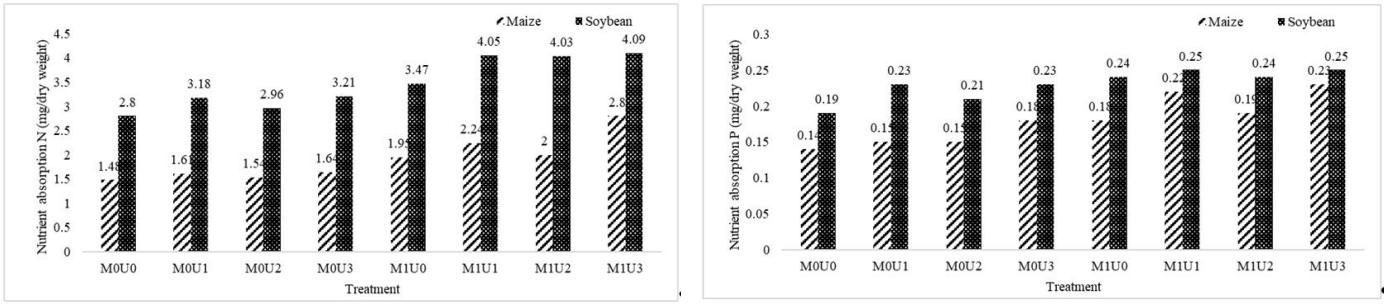

Figure 2:- Average N and P uptake of plants (mg $^{-1}$ plant dry weight) maize-soybean intercropping in the treatment of providing several nutrients to plants aged 40 DAP

The application of mycorrhizal biological fertilizer (1 ton/ha) was combined with the application of 50% dose of cattle manure (6 t/ha) and 50% dose of inorganic fertilizer (maize = urea 150 kg/ha and Phonska 100 kg/ha, soybean = 30 kg/ha of urea and 60 kg/ha Phonska) in the cropping system maize Bisi 18 with soy Biosoy II provides a real influence on the concentration of N, P uptake of soil and plant tissue N and P compared with other treatments. It appears that the concentration of soil nutrients and nutrient uptake by plant tissue has a significant interaction between plants given mycorrhizal biofertilizer with the addition of 50% dose of cattle manure plus 50% dose of inorganic fertilizer. The addition of mycorrhizal biological fertilizers significantly increased the concentration of P in the soil and the uptake of P by plants, especially at 50% doses of cattle manure and 50% doses of inorganic fertilizers (Urea and Phonska). Here it appears that the role of mycorrhizae helps plant roots with the help of external hyphae to reach P nutrients beyond the reach of roots even at long distances to be absorbed by plants (Setiadi, 2001). There is an indication that the application of mycorrhizal biological fertilizers combined with the provision of 50% cattle manure and 50% inorganic fertilizers can increase soil nutrient concentration and nutrient uptake by plants and is significantly higher than the treatment without mycorrhizal application, treatment with the mycorrhizal application alone, fertilizer cattle manure or inorganic fertilizer treatment only. The results of this study are in line with the results of research by Nirwana et al (2015), which stated that giving mycorrhizae to soybeans can increase N and P uptake in leaves higher than without mycorrhizal administration. The increased uptake of nitrogen (N) and phosphorus (P) in plant tissues due to the activity of the synthesis of glutamate and mycorrhizal enzymes indicates a mutually beneficial synergy in increasing the concentration and uptake of plant N and P (Permatasari and Nurhidayati, 2014).

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B. Dry biomass weight

The results showed that the treatment of mycorrhizal biological fertilizer (1 ton/ha) combined with the application of 50% dose of cattle manure (6 t/ha) plus 50% dose of inorganic fertilizer (maize = urea 150 kg/ha and Phonska 100 kg/ha). ha, soybean = 30 kg/ha Urea and 60 kg/ha Phonska) in the maize-soybean intercropping system had a significant effect on root and shoot dry biomass weight and gave the highest dry biomass weight value (Figure 3)

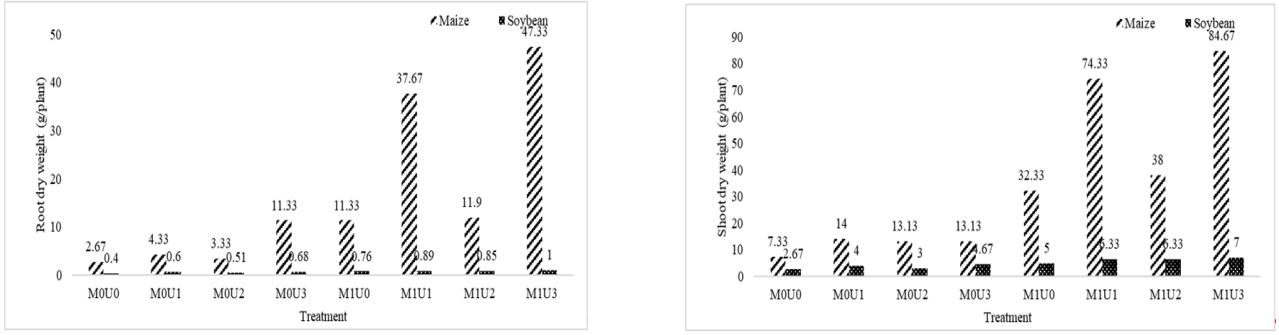

Figure 3:- Average dry biomass weight of roots and shoots (g/plant) of maize-soybean intercropping in the treatment of providing several nutrients to plants aged 40 DAP

Plant dry weight reflects plant growth and the number of nutrients absorbed per unit weight of biomass produced. The higher the dry weight value of the resulting plant, the better the plant growth and the more nutrients absorbed (Musfal, 2010). The availability of N in the soil is a limiting factor for plant growth so that even though the condition of other nutrients, such as P and K, is sufficient in the soil, it still gives the possibility that the dry weight of a plant can decrease (Syarifuddin et al 2006). With the addition of microbial inoculum, the presence of nutrients in the soil can increase to stimulate plant growth. In this study, it was found that the provision of mycorrhizae accompanied by the addition of cattle manure and inorganic fertilizer with a recommended dose of 50% gave a significant effect on increasing plant dry biomass weight.

Macro and micronutrients have a role in supporting plant growth and production and facilitating plant nutrient uptake. Nutrients N and Fe are needed in the formation of chlorophyll and protein synthesis contained in chloroplasts, as well as stimulating plant vegetative growth, such as increasing plant dry weight. If enough N is available for plants, then the chlorophyll content in the leaves will increase and the photosynthesis process will also increase, so that more assimilation is produced, resulting in better plant growth (Zahrah, 2011).

As photosynthesis increases it will increase cell growth and elongation, so that plant growth will increase (Buckman and Brady, 1982). When fertilizer is used properly, the effectiveness of the fertilization can be achieved, so that it can support plant growth, including plant dry weight (Soepardi, 200).

C. Mycorrhizal population

The results showed that the M_1U_3 treatment was the application of mycorrhizal biological fertilizer (1 ton/ha) combined with the application of 50% dose of cattle manure (6 t/ha) plus 50% dose of inorganic fertilizer (maize = urea 150 kg/ha and Phonska 100 kg/ha, soybean = 30 kg/ha Urea and 60 kg/ha Phonska) in the maize-soybean intercropping system had a significant effect on the number of spores per 100 g of soil and the percentage of colonization on roots with the highest yield and significantly different compared to other treatments (Figure 4).

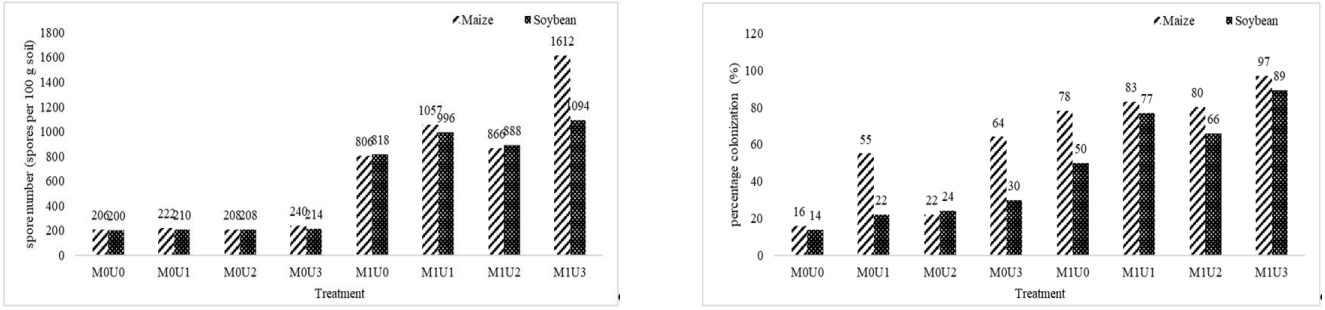

Figure 4:- The mean number of spores (per 100 g of soil) and %-root colonization of maize-soybean intercropping in the treatment of providing several nutrients to plants aged 40 DAP

Mycorrhizal biological fertilizer combined with the provision of 50% of the dose of cattle manure and 50% inorganic fertilizers (Urea and Phonska) can increase the population of mycorrhizal. However, in the treatment without giving mycorrhizal a, giving mycorrhizae alone, giving manure alone, or giving inorganic fertilizers with a dose of 100% only reduced the mycorrhizal population compared to the combination treatment. It is suspected that

the application of 100% inorganic fertilizer will accelerate the decomposition of organic matter so that the organic matter used as a source of nutrients for the proliferation of mycorrhizae is reduced. It appears that in the treatment of mycorrhizal administration combined with the application of 50% cattle manure and 50% inorganic fertilizer the number of spores per 100 g of soil and the percentage of mycorrhizal colonization in roots increased (Astiko et al, 2019).

IV. CONCLUSION AND SUGGESTIONS

Application of mycorrhizal biological fertilizer (1 ton/ha) combined with 50% dose of cattle manure (6 t/ha) plus 50% dose of inorganic fertilizer (corn = urea 150 kg/ha and Phonska 100 kg/ha, soybean = 30 kg /ha Urea and 60 kg/ha Phonska) in intercropping using Bisi 18 corn varieties and Biosoy II soybean varieties gave the best concentrations of N, P and plant growth. To obtain soil nutrient concentrations, plant nutrient uptake, and the best growth, it is suggested to use three rows of maize Bisi II and three rows of soybeans variety Biosoy II with the application of mycorrhizal fertilizer package, cattle manure, and inorganic fertilizer dose of 50% recommended.

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