The efficiency of Mycorrhiza biofertilizer treatment to the growth and yield of soybean

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Abstract. Soybean is one of the major commodities in Indonesia. Due to its high demand, its requires an effort to increase the production. Soybeans are generally cultivated in dry land, for that its need a special management to increase the yield. The association between Mycorrhiza and roots help the plant to get water and nutrients. In this regard Mycorrhiza expected to increase soybean yield and efficiency. This research aim is to study the dose of Mycorrhiza on the growth and yield of soybean efficiently. The experiment was conducted in Selogiri District, Wonogiri, while the analysis of Mycorrhiza and soil was in Faculty of Agriculture, Universitas Sebelas Maret Surakarta from February to April 2016. Randomized Complete Block Design (RCBD) with two factors was employed for this experiment. The treatments are compost dose (derived from Waste Management Faculty of Agriculture UNS) and Mycorrhizal dose (obtained from BPPT Serpong). The result showed that the Mycorrhiza treatment was able to improved the growth and yield of soybean. The most efficient dose of is Mycorrhiza treatment at 0.64 ton ha⁻¹.

1. Introduction
Soybean is one of important commodities in Indonesia. Soybean production was increased by 4.59% from 2014 to 2015 (in total 998.87 thousand tons) however it does not the national market demand [1]. For that, Indonesian government set an effort in form of strategies by land and science intensification to improve the soybean production in attempt to meet the demand. One of strategy is to use Mycorrhiza as biofertilizer.

Soybeans are generally cultivated in dry land, therefore requires special management to increase its production. Mycorrhiza is a symbiotic association between fungus and plant roots which form a complex interaction. Mycorrhiza associations help the plan to obtain water and nutrients in dry conditions and poor nutrients [2]. Arbuscular Mycorrhiza can increase growth and yield of soybean. To improve Soybean yields its need the right application of Mycorrhiza dose, in order to get the fertilizer efficiency. Right amount of fertilizer would be give a better result of Soybean growth and production [3], for that this things need to be studied.
2. **Methods**

2.1. **Location and Time Research**
Field trials conducted in February 2016 until April 2016 in the BPP of Selogiri District, Wonogiri. Analysis of the results carried out in the Laboratory of Ecology and Management of Plant Production, analysis of mycorrhiza took place in the Laboratory of Biological Soil and soil analysis took place in the Laboratory of Chemistry and Soil Fertility in Faculty of Agriculture, Universitas Sebelas Maret.

2.2. **Tools and Materials**
The tools used in this study include field analysis equipment are hoes, ruler, cameras, stationery, logbook and sprinkler hose; equipment for laboratory analysis include an analytical balance, oven, scissors, waterbath, etc. Materials used in this study include soil samples and chemical for laboratory analysis covering 70% alcohol, distilled water, 10% KOH, 1 N HCl, 0.05 % trypanblue, 1 N ammonium acetate, 10% NaCl, 45% NaOH, 0.1N HCl, 2% boric acid and other chemical materials.

2.3. **Research Design and Data Analysis**
This research used a Complete Block Randomized Design (RAKL) with factorial pattern arranged in a single dose treatment factor that is mycorrhiza inoculants (BPPT Serpong production). Mycorrhiza dosage is 0 ton ha⁻¹, 0.64 ton ha⁻¹ and 1.28 ton ha⁻¹.

3. **Results and Discussion**

3.1. **General Conditions Research Sites**
This research was conducted in Kaliancar village in Selogiri District of Wonogiri which has 106 meters above sea level altitude. Land which used for soybean cultivation is the BPP Selogiri office yard with large of the yard is 312.625 m². Environmental conditions (temperature) the annual average in 2015 around the area of cultivation range is 26.5°C. The desired temperature of soybean crop is between 21-34°C, but the optimum temperature for growth of the soybean crop is 23-27°C.

| No | Analyzed properties | Analysis  | Results     | Explanation |
|----|---------------------|-----------|-------------|-------------|
| 1  | pH                  | Elektrometrys | 6.58       | Neutral     |
| 2  | Total N             | Kjeldhal  | 0.19%       | Low         |
| 3  | P provided          | Brays     | 5.78 ppm    | Low         |
| 4  | K provided          | Flame     | 0.25 me%    | Low         |
| 5  | Organic materials   | Walkley& Black | 0.53%    | Very Low    |

Laboratory analysis of vertisol soil in BPP Selogiri shows the pH value is 6.58 which is classified in the category of neutral. Based on international standards, criteria total N of vertisol soil has a low percentage is 0.19% [4]. The loss of N from the soil for used by plants or microorganisms and N in nitrate form easily washed away by rainwater. The result of the laboratory analysis of available P is 5.78 ppm and K provided is 0.25 me%. [5] results of P provided in a preliminary analysis of the land included low criteria when value shows<6.5 ppm.

3.2. **Variable of Plant Growth**

3.2.1. **Plant height** Plant height is used as growth parameter of a plant in vegetative phase. Obstacles that arise during the vegetative phase are the caterpillars eat leaves until plant shoots. Prevention is performed by spraying a systemic pesticide with active ingredient in form fipronil to the entire body of the soybean crop at a dose of 1 ml/ l.
Figure 1. Effect of arbuscular mycorrhiza on plant height of soybeans in vertisol soil

Figure 1 shows the growth of plants from first week to 10 weeks after planting (MST). Week 6 shows reduction in the rate of growth because it started to get generative period. The generative period indicated by the emergence of interest. Result of variance analysis showed that dose of mycorrhiza increases soybean height.

Figure 2. Effect of arbuscular mycorrhiza dose on soybeans height in vertisol soil

Effect of doses of mycorrhiza on soybean height in figure 2 shows the highest plant height due to the effect of mycorrhiza 1.28 ton ha\(^{-1}\). Dose of mycorrhiza 0 ton/ha with an average plant height of 61.92 cm has the same effect with dose of mycorrhiza 0.64 tonnes/ha with average height of 66.12 cm plants. [6] that mycorrhiza can help absorption of water, so stem length and number of leaves can grow optimally and increase in line with the addition of mycorrhiza dose.

3.2.2 Productive Branch Dose of mycorrhiza increase the number of productive branches. The more productive branches, the amount of fruit will increase [7]. inoculation FMA is an effort that can be done to improve availability, uptake and help phosphor transfer [8]. Phosphorus has an important role in the body such as plant cell division, formation of flowers, fruits and seeds, and stimulating root development.
Figure 3. Effect of arbuscular mycorrhiza dose on the number of soybeans productive branches in vertisol soil

Referred to Figure 3, the dose of mycorrhiza 0.64 ton ha⁻¹ generates an average of 3.25 productive branches, whereas a dose of 0 ton/ha produce 3.08 but both have the same effect on the productive branches. Arbuscular mycorrhiza dose of 1.28 ton ha⁻¹ generates average of 3.83 productive branches. Dosage of 1.28 tonnes/ha generates more productive branches and significantly different compared to the dose of mycorrhiza 0 ton ha⁻¹ and 0.64 ton ha⁻¹.

3.2.3 The Filling Pods per Plant Dose of 0 ton ha⁻¹ generates an average number of pods 43.72; dose of 0.64 ton ha⁻¹ generates average of pods 49.30 and mycorrhiza dose of 1.28 ton ha⁻¹ generates average number of pods 54.38. Number of filling pods increased with increasing doses of mycorrhiza but no difference in the effect of three doses. [9] explains that the number of fillinf pods per plant was not affected by fertilizer, but influenced by varieties or genetic factors.

[10] the large number of filling pods depending on the number of pods pithy and the number of empty pods. [11] adds that the genetic properties of soybean plants greater role in determining the age of flowering. The sooner plant entered the flowering phase can add a variety of opportunities to form more pods.

3.2.4. Weight of 100 Seeds Seeds weight carried by weighing seeds in random and repeated three times. Giving dose arbuscular mycorrhiza of 0 ton ha⁻¹ generates 17.14 g weight and increased in a dose of 0.64 tonnes/ha that is 17.36 g. Dose mycorrhiza of 1.28 ton ha⁻¹ also showed an increase to 17.89 g. The increase seed weight has the same effect with increasing doses of mycorrhiza, because of variations in seed weight depends on a variety of genetic factors [12]. According to Conservation et al. (2013) each variety has a genetic advantage that different so that each variety has different seed production also vary. In addition, seed development is also a factor formation of seeds.

3.2.5. Dry Stover Weight Dry plant weight reflects the growth of plants and the amount of nutrients absorbed. The increase of dry stover weight with the addition of mycorrhiza show that increasing doses of mycorrhiza, the nutrients are absorbed more and more. In accordance [13] highest dry weight at FMA administration which showed that plant growth is affected by the FMA.
Figure 4. Effect of arbuscular mycorrhiza dose on the weight of soybeans dry stover in vertisol soil

Figure 4 shows the dose mycorrhiza of 0 ton ha\(^{-1}\) significantly different from the 0.64 ton ha\(^{-1}\) and 1.28 ton ha\(^{-1}\). Dose mycorrhiza of 0.64 ton ha\(^{-1}\) generates 11.41 grams weight and increase after the dose was increased to 1.28 ton ha\(^{-1}\) that is 12.41 g weight. FMA symbiotically to plant roots can increase water uptake and phosphorus that can be utilized to leaves and stems to grow [13].

3.2.6. Dry Pods Weight per Hectare

Dry pod is soybean pods are dried until the color is yellow and hard. Giving mycorrhiza significantly affect to dry pods of soybeans weight gain. Add that the use of arbuscular mycorrhiza inoculation on soybean plants in addition to increasing germ vigor, also increase grain yield and protein content.

Figure 5. Effect of arbuscular mycorrhiza dose on the weight of soybeans dry pods per hectare in vertisol soil

Each additional of mycorrhiza dose has effect to each of the dry pod yield. Figure 5 shows that each individual dose of mycorrhiza 0 ton ha\(^{-1}\), 0.64 ton ha\(^{-1}\) and 1.28 ton ha\(^{-1}\) have a different effect on the weight of dry pod and its weight increased from 2.59 tons; 2.88 ton and 3.11 ton. Dose of mycorrhiza 1.28 ton/ha had the highest influence on the weight of dry pods of soybean of 3.11 ton.

3.2.7 The percentage of infections Mycorrhiza

Mycorrhiza used is an arbuscular mycorrhiza fungi (AMF) with zeolite medium. Based on laboratory results, each 10 gram equals 25 mycorrhiza spores. [15] mycorrhiza inoculation of 7.5g or 30 spores per plant showed mycorrhiza inoculation in sterile soil gives the best results in the increase of crop growth. Based on the results of laboratory analysis of mycorrhiza infection present in all dose mycorrhiza. Corresponding calculation results showed that the highest percentage of mycorrhiza is 83 %.
3.2.8. Fertilizer Use Efficiency The different doses of fertilizer gain different influence on the growth and yield. According to [16] use of fertilizer too little can lead to a lack of nutrients in the soil and if too much is also a negative impact. The effect of a dose of arbuscular mycorrhiza on fertilizer use efficiency did not show improvement.

Dosage of mycorrhiza 0.64 tonnes/ha is 6.14 %. The next increase mycorrhiza dose is 1.28 tonnes/ha showed a lower percentage that is 5.60 %. The percentage decrease shows that increasing the percentage of mycorrhiza did not increase efficiency. Based on these data showed the most efficient outcome is dose of mycorrhiza 0.64 ton ha$^{-1}$.

4. Conclusions
From this study it is concluded that dose of Arbuscular Mycorrhiza is able to increases the growth and yield of soybean, however, the Mycorrhiza dose does not improve the fertilizer efficiency. The most efficient dose of Mycorrhiza according to the growth and yield of soybean was 0.64 ton ha$^{-1}$.

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