Role of Biofertilizers and Organic Fertilizers on Growth and Yields of Soybean

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ABSTRACT
The low soybean production is influenced by the use of inorganic materials continuously which can reduce quality of soil and irrigation water. One of the efforts made to improve soil quality is directed towards the use of environmentally friendly biofertilizers and organic fertilizers. This research aims to examine the potentiality of biofertilizers and organic fertilizers to increase growth and yield of soybean. The research conducted in the Experiment Screen House of Agriculture Faculty UNS, Sukosari Village, Jumantono District, Karanganyar Regency on Agustus to November 2018. This research used randomized completely block design consisted of 1 treatment factor with 13 levels. The results showed that application of biofertilizers and organic fertilizers could significantly increase growth and yield of soybean with the highest result was found in biofertilizers 45 kg/ha and organic fertilizers 10 tons/ha on paramaters of plant height, number of leaves, leaf area, weight of root nodules, plant dry weight, the number of pods, number of seeds, and weight of seeds each 43.68 cm, 11.17 leaves, 205,11 cm^2, 0,18 g, 3.56 g, 13 pods, 22.67 seeds, and 2.79 g.

Keywords: *soybean, biofertilizer, organic, growth, yield*

INTRODUCTION

Soybean is one of the important agricultural commodities crops in Indonesia after rice and corn. Soybean production varies in Indonesia from 0.5 tons/ha up to 1.7 tons/ha. According data of Kementerian Pertanian [14] Indonesia's average soybean production in 2016 decreased by 1.12% to 859,653 tons from 2015 amounted to 963,183 tons. The average of soybean consumption needs in Indonesia is 2.2 million tons per year. The problem is 67.99% of the soybean needs must be imported. This is because production has not been able to meet domestic demand [9].

The low soybean production is influenced by several factors including the area of agricultural land that is narrowing from year to year, pest and disease attacks, and excessive use of inorganic pesticides and fertilizers. The use of inorganic materials continuously in large quantities can cause various problems, one of which is the decrease in soil quality and irrigation water [15]. One of the intensification programs that can be carried out in dealing with the problem is directed at the use of environmentally friendly biofertilizers and organic fertilizers [33].

Provision of organic fertilizers has a positive role for plant quality and soil fertility through improvement in physical, chemical, and biological activities of the soil as a growth medium [27]. The addition of biofertilizers can help the performance of organic fertilizers, especially in increasing plant growth and yield. Microorganisms that are generally used as active ingredients of biofertilizers are N-fixing microbes, phosphate solvents, soil aggregates stabilizer, and organic decomposers [26]. This study aims to examine the ability of biological fertilizers and organic fertilizers to increase growth and yield of soybean.

MATERIAL AND METHOD

The study was conducted in August - November 2018. The location of this study was located at the Experiment Screen House of the Faculty of Agriculture, UNS, Sukosari Village, Jumantono District, Karanganyar Regency. According to Dwiarti (2016) the geographical condition of the location is located at 7^0 30' south latitude and 110^0 50' east longitude with a height of 180 meters above sea level. The air temperature in the study site around 20^0C – 31^0C and humidity 55% - 90%. This study used a Randomized Completed Block Design (RCBD) which was repeated 3 times and consisted of 1 treatment factor (Sinarbio biofertilizer and Petroganik organic fertilizer) namely P0 (control), P1 (organic fertilizers 5 tons / ha), P2 (organic fertilizers 10 tons / ha), P3 (biofertilizers 15 kg / ha), P4 (biofertilizers 15 kg / ha and organic fertilizers 5 tons / ha), P5 (biofertilizers 15 kg / ha and organic fertilizers 10 tons / ha), P6 (biofertilizers 30 kg / ha), P7 (biofertilizers 30 kg / ha and organic fertilizers 5 tons / ha), P8 (biofertilizers 30 kg / ha and organic fertilizers 10 tons / ha), P9 (biofertilizers 45 kg / ha), P10 (biofertilizers 45 kg / ha and organic fertilizers 5 tons / ha), P11 (biofertilizers 45 kg / ha and organic fertilizers 10 tons / ha), and NPK (Urea 25 kg / ha, SP - 36 100 kg / ha and KCL 50 kg / ha) and each treatment contained 2 unit plants. Data were analyzed by analysis of the various test levels α 5% and further analysis of Duncan's Multiple Range Test (DMRT). Variables observed were plant height, number of leaves, leaf area, number of root nodules, weight of root nodules, dry weight of plants, number of pods

per plant, number of seeds per plant, weight of seeds per plant, and weight per 100 seeds.

RESULT AND DISCUSSION

General Condition

The soil used is Alfisols soil, before it is used as a planting medium, soil analysis is carried out, the results of which are classified using criteria from the Soil Research Institute [4]. The analysis shows that the soil used as a planting medium has a total N content; 0.20% (low), P_2O_5; 7.84 ppm (low), K_2O; 0.26 me% (low). Soil analysis results show that the soil also contains organic C of 1.69% (low), C / N ratio of 8.45 (low), organic matter of 2.91% (low). The pH in the soil used is 5.23 classified as acid. This research cannot be separated from various obstacles. One obstacle that requires control is pest. Soybean pests appear in the vegetative and generative phases

Application of biofertilizers and organic fertilizers on soybean (Glycine max (l.) Merill) growth parameters

Height is one of the parameters of plant growth that changes quantitatively during the plant life cycle and is irreversible. The results showed that the application of biofertilizers and organic fertilizers significantly affected plant height. The P11 treatment obtained the highest average of plant height that is 43.68 cm, but the plant height in the P11 treatment was not significantly different from the treatment of P10, P8, P7, P5, P4, P3, P2, and P1 (Table 1). Addition of organic matter can positively influence nitrogen deficiency in plants. Nitrogen uptake by plants will be more effective by reducing nitrogen deficiency so that the nitrogen requirements in the vegetative phase will be fulfilled. According to Luo et al. [18] N is needed by plants as a constituent of amino acids, nucleoproteins, nucleic acids, nucleotides and chlorophyll which are the most important ingredients for cell division and elongation, especially in the apical meristem. Zahidah and Maya [36]state that *Streptomyces.sp* can help the process of breaking down organic matter from complex compounds to be simple so that it can be available to plants.

The leaf is the main organ that contains chlorophyll as a place for photosynthesis. The increasing number of leaves can positively influence the total leaf area and the absorption of light by plants for the process of photosynthesis. The results showed that the application of biofertilizers and organic fertilizers significantly affected the number of leaves of soybean plants. The P11 treatment obtained the highest average of the number of leaves of soybean plants, namely 11.17, but the number of leaves in the P11 treatment was not significantly different from the treatments of P10, P8, P7, P5, P2, and P1 (Table 1). Increasing the number of leaves associated with plant height parameters. The height of a plant is due to the increase in the stem section where the leaves come out so as to determine the number of leaves produced. According to Fitrah and Nurbaiti [10] the provision of organic fertilizers can increase the availability of N elements needed by plants for vegetative growth, especially branches, leaves, stems, and roots. Ardakani et al [2] stated that *Azospirillum sp.* as nitrogen-fixing bacteria are able to help plant vegetative growth through N^2 fixation and produce IAA phytohormones. Supported by Chamangasht's research [6] which stated that *Azospirillum sp.* can increase the number of leaves in the *Lactuca sativa L.* plant by 46.08%.

Leaf area measurement needs to be known, because it is related to the ability of plant leaves to intercept sunlight for photosynthesis. The results showed that the application of biofertilizers and organic fertilizers significantly affected the leaf area of soybean plants. The P11 treatment obtained the highest average of the leaf area of soybean plants at 0.51, but the leaf area produced in the P11 treatment was not significantly different from P10, P8, P7, P5, P2, and P1 (Table 1). Leaf area is determined by the number of leaves and leaf size. According to Yunita [35] N nutrients are needed as constituents of chlorophyll. The sufficient amount of chlorophyll in the leaves will increase the ability to absorb sunlight for photosynthesis. Rahman et al. [23]states that the resulting photosynthate will be overhauled again through the process of respiration and produce energy for cell division in plant leaves which causes leaf size to increase.

Root nodules are organs in legume plants that are formed due to the association between roots and *Rhizobium* bacteria. Root nodules is derived from root hairs that are infected with Rhizobium bacteria and undergo changes in shape. The results showed that the application of biofertilizers and organic fertilizers significantly affected the number of soybean root nodules. The P2 treatment produced the highest average number of nodules at 22.67, but the number of nodules at P2 treatment was not significantly different from treatments P11, P10, P5, and P4 (Table 1). Formation of nodules is influenced by the population of *Rhizobium. Rhizobium* survival in forming nodules is influenced by environmental factors, namely temperature, light, soil moisture, soil pH, oxygen and nutrients. According to Liu et al. [17] the content of the element phosphorus (P) in organic fertilizers can influence the development of plant roots that have the potential to become *Rhizobium* infections in forming root nodules. Furthermore, according to Suryantini [28] P-solvent bacteria from the genus *Penicillium* and *Aspergillus* are able to assist in dissolving P-bound soil so that it can be available to plants.

Effective root nodules are large and are located in the upper part of the plant and have a bright red color on the inside, while ineffective root nodules have a small size and are scattered throughout the root of the plant. The results showed that the application of

biofertilizers and organic fertilizers significantly affected the weight of soybean root nodules. The P11 treatment obtained the highest average yield on the root nodule weight of 0.1828 g, but the weight of the plant nodules in the P11 treatment was not significantly different from the treatments of P5 and P2 (Table 1). The symbiosis between the host plant and *Rhizobium* in forming nodules can be successful if there is harmony between *Rhizobium* and its host plants and supporting environmental factors. According to Vardien et al. [31] elements of phosphorus (P), molybdenum (Mo), and iron (Fe) contained in organic fertilizers are important elements for the process of root ingestion and N_2 fixation. The elements Fe and Mo are important components of several proteins from the enzymes nitrogenase, leghaemoglobin, and ferredoxin for the process of root nucleation and N_2 fixation (Brear et al. [5]. Hendrita [12] states that P nutrients are needed by plants to stimulate the inhibition of air N_2 through increasing the number of root nodules.

Plant dry weight is a growth parameter that shows the results of accumulated nutrients absorbed per unit weight of biomass produced. The results showed that the application of biofertilizers and organic fertilizers significantly affected the plant dry weight. The P11 treatment produced the highest average of plant dry weight e.i. 3.56 g, but the dry weight produced in the P11 treatment was not significantly different from the NPK, P10, P8, P7, P5, P4, P2 and P1 treatments (Table 1). Dry weight is closely related to the growth of organs in plants, especially leaves, because the leaves occur in the process of photosynthesis which then results from the process of photosynthesis accumulating into plant dry weight. According to Amir et al. [1] N elements contained in organic fertilizers can affect the growth of leaf size and expand its surface, thereby increasing the ability to absorb sunlight and photosynthesis process takes place better, consequently can increase the accumulation of photosynthesis in plant biomass. In addition to the N element, Vandamme et al. [30] states that the element P is also able to increase the dry weight of plants. Supported by the opinion of Haryadi et al. [11] that the element P is an important part in plant metabolism as the formation of ATP needed in the photosynthesis process.

Tabel 1. Growth and yield of soybeans in various treatments of biofertilizers and organic fertilizers.

Dose of Fertilizer	Height (cm)	Number of Leaves	Leaf Area (cm^2)	Number of Root Nodules	Weight of Root Nodules	Plant Dry Weight	Number of Pods	Number of Seeds	Weight of Seeds (g)	Weight per 100 Seeds (g)
P0	28.92 a	6.67ab	84.37a	6.17a	0.01a	1.43a	4.67a	7.00a	0.68a	9.68a
P1	40.20bcd	9.50cde	168.89cde	12.50abcd	0.09bc	2.72cd	11.67b	20.33b	2.31b	11.50abc
P2	42.00cd	9.67cde	176.23de	22.67e	0.17cd	3.23d	10.83b	20.67b	2.47b	12.39abc
P3	33.40abcd	6.83ab	97.76ab	6.67a	0.00a	1.44a	4.00a	7.50a	0.82a	11.35abc
P4	33.92abcd	7.83abcd	110.36abcd	16.17bcde	0.09b	2.54abcd	11.00b	17.33b	2.07b	12.01abc
P5	38.77abcd	9.00bcde	158.48bcde	18.33cde	0.13bcd	3.14d	11.00b	21.00b	2.54b	12.45abc
P6	28.77a	7.33abc	95.74ab	6.83a	0.01a	1.58ab	3.67a	7.33a	0.80a	10.86ab
P7	40.57bcd	9.50cde	170.21cde	13.83abcd	0.11bc	2.60bcd	9.33b	18.33b	2.27b	12.73bc
P8	36.27abcd	10.00de	182.97e	14.17abcd	0.11bc	2.74cd	11.50b	21.83b	2.59b	11.84abc
P9	30.50ab	6.50a	94.94ab	10.50abc	0.02a	1.85abc	4.00a	7.33a	0.93a	12.69bc
P10	39.98bcd	10.17de	165.10cde	15.67bcde	0.11bc	3.02d	10.83b	18.17	2.18b	13.90c
P11	43.68d	11.17e	205.11e	19.83de	0.18d	3.56d	13.00b	22.67b	2.79b	12.40abc
NPK	31.23abc	8.50abcd	103.56abc	9.17ab	0.07ab	3.12d	12.00b	21.00b	2.25b	10.91ab

Description: The numbers followed by the same alphabet in the column are not significantly different by Duncan Multiple(α=0.05).

Application of biofertilizers and organic fertilizers on soybean (Glycine max (l.) Merill) yield parameters

Pods are one of the important components in crop production, especially in legume crops. Formed and enlarged soybean pods will increase with age and the number of flowers formed. The results showed that the application of biological and organic fertilizers significantly affected the number of pods per plant. The P11 treatment produced the highest average number of pods per plant of 13 pods, but the P11 treatment produced a number of pods that were not significantly different from the NPK, P10, P8, P7, P5, P4, P2, and P1 treatments (Table 1). Providing organic fertilizers can increase the P content available in the soil needed by plants in the formation of flowers and pods. According to Samosir et al. [24] P nutrients needed by plants for the formation and filling of pods. Dhull et al. [7] stated that *Pantoea sp.* can produce organic acids that are able to react with phosphate-binding agents such as Al3+, Fe3+, and Mg3+ to form a more stable organic chelate so that the bound P ions can be released and available to plants to produce pods.

The number of seeds per plant indicates the total number of seeds formed per soybean plant. The number of seeds per plant is an important component that determines soybean production, because the more seeds formed, the higher the production of plants produced. According to Utomo et al. [29] seeds are one component of the yield whose formation is influenced by environmental factors and is limited by

the genetic characteristics of cultivar factors. The results showed that the application of biological fertilizers and organic fertilizers significantly affected the number of seeds per soybean plant. The P11 treatment obtained the highest average yield of the number of seeds per plant that was 22.67 grain, but the number of seeds in the P11 treatment showed results were not significantly different from the NPK, P8, P7, P5, P4, P2, and P1 treatments (Table 1). The provision of organic fertilizers can increase the availability of macro and micro nutrients as well as the water holding capacity needed to support seed formation. According to Sarianti et al. [25]the P element is able to stimulate the formation of flowers, fruits, and seeds.The Boron (Bo) element also has a role in multiplying the amount of flowers which is positively linear in the number of pods formed [32]. Arista et al. [3] states that the presence of element K can help pods not fall out easily so as to increase the seeds produced.

Weight of seeds per plant is the overall weight of soybean plants. Seed weight measurements were carried out to determine the yield of crop produced. The results showed the provision of biological fertilizers and organic fertilizers significantly affected the weight of seeds per soybean plant. The P11 treatment produced the highest average seed weight per plant at 2.79 g, but the seed weight in the P11 treatment was not significantly different from the treatments of P1, P2, P4, P5, P7, P8, P10, and NPK (Table 1). The P element contained in organic fertilizers is thought to be able to increase protein content and seed weight. According to Nurdin et al [21] the element P is needed by plants in the formation of ATP in the process of photosynthesis. Throughout the reproductive growth of annual crops such as soybeans make seeds as a storage organ for food reserves. This is in line with the opinion of Irwan and Nurmala [13] which stated that the filling of seeds originates from photosynthates produced after flowering and is transplanted for seed filling. Nawawi et al. [20] and Yin et al. [34] stated that *Penicillium oxalicum* and *Aspergillus niger* contained in biological fertilizers are also able to increase the availability of the phosphorus element because it is able to release phosphorus bound in the soil into a form available to plants.

Weight per 100 seeds of plants is one component that shows the superior seeds produced by measuring the weight of crop seeds divided by the number of seeds multiplied by 100. The results showed that the application of biological fertilizers and organic fertilizers did not significantly affect the weight per 100 soybean seeds. The P10 treatment produced the highest average weight per 100 seeds of 13.90 g, but the weight per 100 seeds in the P10 treatment was not significantly different from the treatments of P1, P2, P3, P4, P5, P7, P8, P9, and P11 (Table 1).The difference in size and number of seeds is influenced by plant genetic characteristics, environmental conditions, and nutrient availability. According to Mahdiannoor et al. [19] the addition of organic fertilizers can increase the availability of phosphate and nitrogen, thus affecting the formation of productive branches, number of pods, and plant seeds. Lambers et al. [16] stated that the phosphate element also acts as an important component making up energy transfer compounds (ATP and Nucleoprotein) for metabolic processes in plants, especially in the seed filling phase.

CONCLUSION

1. 45 kg/ha of biofertilizers and 10 tons / ha of organic fertilizers can optimally stimulate the growth of soybean plants (Glycine max) on parameters of plant height, number of leaves, leaf area, root nodules weight and plant dry weight.
2. 45 kg/ha of biofertilizers and 10 tons/ha of organic fertilizers can increase soybean yield in parameters of number of pods, number of seeds, and weight of soybean seeds.

SUGGESTIONS

Suggestions that can be conveyed from the results of the research is biofertilizers 45 kg/ha and organic fertilizers 10 tons / ha can be recommended to farmers to be applied as fertilizer in soybean cultivation.

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