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Growth Response and Production of Soybean (*Glyicine max* (L.) on Application of Phosphorous Fertilizer and Rhizobium Inoculation

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Abstract. Increased soybean production both from quantity and quality continues to be pursued with extensification and intensification. During this time, fertilization is one of the cultivation techniques that is expected to contribute significantly in increasing soybean production. This study aims to determine the response of growth and production of soybean to Phosphorous (P) fertilizer and rhizobium inoculation. This research was conducted at Jl. Deli Serdang Sumatera Utara, from August-November 2017 with P fertilizer (SP-36) treatments (0, 50, 100, 150 kg/ha) and *Rhizobium* inoculation treatments (0, 5, 10 g/kg of seed). Variables observed were number of nodule root, number of filled pods, dry weight of seed per plant, dry weight of seed per plot and dry weight of 100 seeds. The results showed rhizobium inoculation significantly affected to the number of effective root nodules (nodules), filled pods, dry weight of seed per plant and dry weight of seed per plot with the best treatment was *Rhizobium* inoculation 5g/kg of seed) while the P fertilizer treatment and interaction between the two had no significant effect to all variables observed.

Keywords: phosphorous, rhizhobium, soybean

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1. Introduction

Soybean is the most popular source of protein for Indonesian people in general. Consumed in the form of tempe and tofu which is a side dishes for the people of Indonesia. Other forms of soy products are soy sauce, tauco, and soy milk. These products are consumed by most people. Indonesia is the largest tempe producer in the world and the largest soybean market in Asia [1].

The Central Bureau of Statistics (BPS) stated that soybean production in 2014 amounted to 955.00 thousand tons of dry beans or being increase of 175.01 thousand tons (22.44 percent) compared to 2013. The production of soybean in 2015 is estimated at 998.87 thousand tons of dried beans or increased by 43.87 thousand tons (4.59 percent) compared to 2014. The increase of soybean production is estimated to occur due to an increase in harvested area of 24.67

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thousand hectares (4.01 percent) and an increase in productivity of 0.09 quintal/hectare (0.58 percent) [2].

Increasing of soybean production both from quantity and quality continues to be pursued with extensification and intensification. During this time, fertilization is one of the cultivation techniques that are expected to contribute substantially in increasing soybean production. Phosphate (P) fertilizer is a cultivation component that is needed in soybean cultivation to get optimal results. Lately the need for P fertilizer on soybeans has become a problem for farmers, in addition the price too expensive, the demand is also quite large for high-yielding varieties ranging from 75 to 90 kg P_2O_5, equivalent to 140 to 200 kg TSP per Ha [3].

In soybean plants phosphat fertilizer shows a significant effect in stimulating the development of roots, so theplants will be more resistant on drought, accelerate the harvest and add nutritional value from seeds, play a role in respiration and photosynthesis, nucleic acid preparation, plant seed formation and fruit-producing, stimulant of root development, so that plants will be more resistant to drought and accelerate the harvest period so as to reduce the risk of delay in harvest time [4].

Phosphate fertilizer is needed in stimulating the development of roots so that plants will be more resistant to drought, accelerate the harvest period and add nutritional value from the seeds of phosphate fertilizer plants needed for maximum nodule activity greater than that required for root nodule formation [5].

Inoculation is an activity of transferring microorganisms in the form of bacteria and fungi from the place or source of origin to the new medium. Rhizobium inoculation on soybean plants has a long been known as one of the biological fertilizers. Rhizobium inoculation is expected to meet nitrogen needs in soybean plants so that it can reduce the need for inorganic nitrogen fertilizer. The need of soybean plants will be very high in nitrogen nutrients so that the availability of cheap nitrogen sources will help reduce production costs. In soybean plants to produce 1 kg of seeds, plants absorb 70-80 grams of nitrogen from the soil so that if the yield of 1.5 tons / ha it will absorb 105-120 nitrogen from the soil [6].

Inoculation of *R. japanicum* bacteria gives a significant influence on the growth of soybean plants, namely plant height, number of leaves and number of root nodules. However, it does not give a significant effect on the stem diameter. The most influential concentration of *Rhizobium* bacteria is at 5 g concentration, then 3 g concentration. It is recommended for a better resultsto use *Rhizobium japanicum* with a determined concentration of 3-5 grams [7].

Based on the above description, the authors are interested in conducting a research the growth response and production of soybean with the application of P fertilizer and *Rhizobium* inoculation.

2. Materials and Methods

This research was conducted in Helvetia Veteran, Deli Serdang, North Sumatra, Medan, on ± 32 meters above sea level and starting from August to November 2017. The result of soil analysis showed that the area has pH: 4.3; N: 0.17%; P: 0.12%; K: 0.05%. The material used in this study was Anjosmoro variety of soybean seeds, fertilizer P (SP-36) and *Rhizobium* inoculant as the treatments to be applied, Urea, KCl, Mankozeb. The study used a randomized block design (RCBD) with 2 factors: the first factor was treatment of fertilizer P (SP-36) with 4 levels, namely: P_0 = 0 kg / ha, P_1 = 50 kg / ha, P_2 = 100 kg / ha, P_3 = 150 kg / H. The second factor was *Rhizobium* inoculation with 3 levels, namely R_0 = 0 g /kg seed, R_1 = 5g/kg seed, R_2 = 10g/kg seed.

The research procedure started from land preparation and plot preparation (2 x 2 m), planting, application of *Rhizobium*, application of P fertilizer, application of N and K fertilizers. Variables observed were number of nodule root, number of filled pods, dry weight of seed per plant, dry weight of seed per plot and dry weight of 100 seeds. Data was analyzed using a significant variance analysis followed by a Duncan's Multiple Range Test with a level of α = 5%.

3. Results and Discussion

3.1. Effective Number of Roots

Tabel 1 showed the highest number of effective root nodules found in *Rhizobium*inoculation 10 g/kg seed (56.42 nodules), which was not significantly different from *Rhizobium*inoculation 5 g/kg seed(43.25 nodules) but significantly different than without application of *Rhizobium*inoculation (35.58nodules). This is due to the presence of effective root nodules that can provide nutrients in supporting plant growth. However rhizobium has begun to infect the roots, since the formation of the roots so the root nodules formed can bind nitrogen from the air. Silalahi [8] states that since the roots are formed, rhizobium bacteria form the formation of root nodules, which are about 4-5 days after planting and root nodules can bind nitrogen from the air at the age of 10-12 days of planting.

Table 1. Number of Effective Root Nodules in P Fertilizer Application and *Rhizobium* Inoculants

Fertilizer P (kg/ha)	**Inoculation of*Rhizobium* (g/kg seed)**			**Mean**
	R_0 (0)	**R_1 (5)**	**R_2 (10)**	
	....nodule..			
P_0 (0)	9.00	37.33	62.33	36.22
P_1 (50)	51.67	48.67	72.33	57.56
P_2 (100)	55.33	49.67	41.00	48.67
P_3(150)	27.33	37.33	50.00	38.22
Mean	35.83b	43.25a	56.42a	

3.2. Number of Filled Pods

Table 2 showed that the highest number of contained pods in the application of *Rhizobium* inoculation 5 g/kg seed was 173.25 pods which is not significant with *Rhizobium* inoculation 10 g/kg seed (159.17pods) but significantly different with *Rhizobium* inoculation 0 g/kg seed (128.25 pods). This is because effective root nodules can provide nutrients that will support plant growth and development. The results of this study are consistent with Alam et al. [9] which stated that soybean pods were higher in the inoculation with Rhizobium sp. Compared without inoculation. Further research El-Shaarawi *et al*. [10] and Ntambo *et al.* [11] stated that integrated *B. japonicum* and lower nitrogen levels has increased growth and soybean growth and yield.

Table 2. The Number of Pods Filled in the Application of P Fertilizer and *Rhizobium* Inoculants

Fertilizer P (kg/ha)	Inoculation of Rhizobium (g/kg seed)			Mean
	R_0 (0)	R_1 (5)	R_2 (10)	
	....pod..			
P_0 (0)	129.07	187.13	178.00	164.73
P_1 (50)	121.00	174.20	162.80	152.67
P_2 (100)	131.73	163.20	172.27	155.73
P_3(150)	131.20	168.47	123.60	141.09
Mean	128.25b	173.25a	159.17ab	

3.3. Seed Dry Weight Per Plant

Based on Table 3, it can be seen that the highest seed dry weight per plant that was found in the application of *Rhizobium* inoculation 5 g/kg seed (40.69 g), which was not significantly different from *Rhizobium* inoculation 10 g/kg seed (40.03 g) but significantly different at without *Rhizobium* inoculation (33.36g). This is related to the symbiotic relationship of rhizobia (bacteria), which can fix the nitrogen atmosphere into the roots of soybean so that an increase in soybean yield is indicated by seed weight per plant. This is in accordance with Lamptey et al. [12] and statement that rhizobium inoculation and P application increased the number of pods per plant, seeds per pod, weight of 100 grains and significantly significant results.

Table 3. Seed Dry Weight per Plant in P Fertilizer Application and *Rhizobium* inoculants

Fertilizer P (kg/ha)	Inoculationof Rhizobium (g/kg seed)			Mean
	R_0 (0)	R_1 (5)	R_2 (10)	
	....gr..			
P_0 (0)	33.27	42.93	42.76	39.65
P_1 (50)	29.60	43.29	39.48	37.45
P_2 (100)	35.85	39.68	38.38	37.97
P_3(150)	34.72	36.87	39.49	37.07
Mean	33.36b	40.69a	40.03a	

3.4. Seed Dry Weight Per Plot

The application of *Rhizobium* inoculation significantly affected of seed dry weight per plot, where the highest seed dry weight per plot was found in the application of *Rhizobium* inoculation 5 g/kg seed (1188.33 g) and the lowest in without application of Rhizobium inoculation (973.33 g) (Table 4). The increase in seed dry weight per plot could be attributed to increase in yield components of the crop through *Rhizobium sp.* inoculated plots. This is line with Abitew *et al* [13] thatreported increase in seed dry weight due to *B. japonicum* inoculation of soybean.

Table 4. Seed Dry Weight Each Plant in P Fertilizer Application and *Rhizobium* inoculants

Fertilizer P (kg/ha)	**Inoculation of Rhizobium (g/kg seed)**			**Mean**
	R_0 (0)	**R_1 (5)**	**R_2 (10)**	
	....gr…			
P_0 (0)	930.00	1243.33	1336.67	1170.00
P_1 (50)	913.33	1263.33	1173.33	1116.67
P_2 (100)	1083.33	1116.67	1040.00	1080.00
P_3(150)	966.67	1130.00	1190.00	1095.56
Mean	973.33	1188.33a	1185.00a	

4. Conclusion and Recommendation

The application of Phosphate fertilizer had no significant effect on the all variable. The application of rhizobium inoculation gave a highest of the number of effective root nodules, number of pods contained, seed dry weight per plant, seed dry weight per plot on 5g/kg of seed. The interaction between P fertilizer application and rhizobium inoculation had no significant effect on the all variable.

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