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Growth response and N uptake of two soybean varieties on inoculation of *Bradyrhizobium* sp. in Ultisol Binjai, Sumatera Utara

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Abstract. Ultisol problem is having acidic pH which makes soybean difficult to grow and symbiotic with *Brady rhizobium* sp. To fixate N. The aim of this research was studied the growth response and N uptake of two soybean varieties on inoculation *Brady rhizobium* sp. in Ultisol Binjai, Sumatera Utara. This research used Ultisol Binjai with pH 4.5 which was carried out with a pot experiment in the research field of Faculty of Agriculture, Universitas Sumatera Utara, using a Factorial Randomized Block Design with 3 factors. The first factor is *Brady rhizobium* sp inoculants consisting of without inoculant; BGR3 inoculant; and LP3 inoculant, the second factor is varieties consisting of Anjasmoro and Demas-1. The third factor is liming consisting of without liming and liming with a dose of 7.76 g/10 kg of soil (until pH 5.5). The results of the research showed that application of *Brady rhizobium* sp inoculant BGR3 was able to increase the N uptake of soybean in Ultisol with an acidic pH which was better than other inoculant. Shoot root ratio tended to increase in Anjasmoro without liming which were application of BGR3 inoculant about 14.15%.

1. Introduction

Soybeans are the most widely consumed type of beans as a source of vegetable protein which is very important in Indonesia [1]. The protein content in soybean seeds has a high percentage around 35-40%, so that soybean plants require large amounts of nitrogen compared to other plants [2].

Generally, soil in Indonesia is dominated by Ultisol which can cause problems in achieving agricultural productivity. Ultisol characteristics are having unstable aggregates, permeability, organic matter and low alkalinity [3], so that soybean plants growth will be disrupted if planted on the soil because nutrients are difficult to provide and the growth of microorganisms such as *Bradyrhizobium* sp which is able to fixate nitrogen and symbiosis with soybean is disturbed. Therefore, a better nutrient management in soybean cultivation is needed to obtain the expected growth. Lack of N nutrient in soybean can reduce its growth. To overcome this, inoculating by *Bradyrhizobium* sp as nitrogen fixer can provide nitrogen nutrients to plants, especially in acid soils. *Brady rhizobium* sp used in this research is which has been tested for resistance to acidic pH, so that the role of *Brady rhizobium* sp is

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expected to increase N nutrient uptake and the growth of two soybean varieties. Based on this, the research aimed to study the growth response and N uptake of two soybean plant varieties to the inoculation of *Brady rhizobium* sp. in the Ultisol of Binjai, Sumatera Utara.

2. Material and Methods

2.1. Research Area

This research used Ultisol of Binjai, Sumatera Utara, which was taken at the point of 3º39'18" North latitude and 98º29'32" East longitudes at an altitude of 28 masl. The soil has a pH of 4.5 which has clay texture with a composition of 42.92% sand, 33.64% dust and 23.44% clay. The soil water content is 5.4% with N content of 0.137%, P of 6 ppm and K 0, 06%. The research was conducted at research field Faculty of Agriculture, Universitas Sumatera Utara on April to June 2018.

2.2. Procedures

The research was carried out with pot using a factorial randomized block design with 3 factors. The first factor is *Brady rhizobium* sp inoculants consisting of without inoculants; BGR3 inoculant; and LP3 inoculant. The second factor is varieties consisting of Anjasmoro and Demas-1. The third factor is liming consists of without liming and liming with a dose of 7.76 g / 10 kg of soil [until pH 5.5]. The soil was taken from Binjai, Sumatera Utara and then air-dried and sieved with a 10 mesh sieve. Then the soil was put into a polybag as much as 10 kg. Liming was done 2 weeks before planting and then the soil was incubated. Fertilization was carried out with a dose of urea 25 kg/ha, SP_{36} 250 kg/ha and KCl 150 kg/ha. *Brady rhizobium* sp inoculation was carried out at 1 week after planting by pouring inoculants with a population of 10^8 / ml of solution to the soybean plant.

Parameters observed were shoot dry weight, root dry weight, and shoot root ratio used as an indicator of plant growth and Nitrogen uptake. Shoot and root dry weight was obtained after heating the plant for 24 hours in an oven at a temperature of 70ºC. Shoot root ratio was taken by dividing shoot dry weight with root dry weight. Nitrogen (N) uptake using the N-Kjehldal method taken by multiplying the N content of shoot with shoot dry weight.

2.3. Data Analysis

Data were subjected to analysis of variance and means were separated by *Duncan Multiple Range Test* ($p<0.05$).

3. Results and Discussion

3.1. Shoot dry weight

The shoot dry weight of the two soybean varieties with *Brady rhizobium* sp inoculation which resistant to acid can be seen in Table 1. BGR3 inoculant tended to increase the shoot dry weight of two soybean varieties about 9.95% when compared to LP3 inoculants and 39.42% when compared to without inoculants. This indicated that the inoculation of *Brady rhizobium* sp BGR3 was able to increase shoot dry weight as an indicator of soybean plant growth because the inoculant was able to fixate more N so it could be used by soybean plants to increase its growth. As we know nitrogen is a nutrient that is needed by plants in its growth period. The symbiosis of rhizobium-plants occurs in special organs namely nodules as a place for rhizobia to change atmospheric nitrogen effectively into ammonium to facilitate nitrogen fixation in amino acids, which is beneficial for host plants [4], so that the host plant can increase its growth. In other research showed that interaction of inoculation of *Bradyrhizobium japonicum*, induction of genistein and soil moisture condition increased shoot dry weight [5]. It also indicate there is interaction between soybean and *Bradyrhizobium* sp to increase soybean growth.

Table 1. Shoot dry weight of two soybean varieties with the inoculation of *Bradyrhizobium* sp. in Ultisol of Binjai, Sumatera Utara

Inoculant of *Bradyrhizobium* sp	Variety	Liming		Mean
		Without liming	liming with a dose of 7.76 g/10 kg of soil (pH to 5.5)	
		-----------------------g----------------------		
Without inoculant	Anjasmoro	7.68	7.26	7.47
	Demas-1	8.78	9.26	9.02
BGR3 Inoculant	Anjasmoro	11.87	10.13	11.00
	Demas-1	11.36	12.61	11.99
LP3 Inoculant	Anjasmoro	10.31	9.91	10.11
	Demas-1	11.73	9.93	10.83
Mean		10.29	9.85	

Shoot dry weight of Anjasmoro variety tended to be lower than Demas-1 [Table 1]. Whereas liming tended to reduce shoot dry weight by 4.28% compared to without liming. Liming application can increase the mineralization of N in soils. However the liming can either decrease N mineralization or not have any direct effect on N mineralization. Repeated liming applications will increase soil N mineralization, but the overall impact of liming will depend on net mineralzation or net immobilisation ultimately occur based on the C:N ratio of plant detritus returned to soils [6].The treatment combination between BGR3 inoculation on Demas-1 variety in liming soil tended to show the highest shoot dry weight compared to other treatment combinations. Shoot dry weight with no inoculant treatment, BGR3 and LP3 inoculants on Anjasmoro varieties tended to decrease with soil liming but on Demas-1 varieties occur otherwise except for LP3 inoculants.

3.2. Root dry weight

BGR3 inoculant tended to increase the root dry weight of two soybean varieties by 19.87% when compared to LP3 inoculant and 43.19% when compared to without inoculant (Table 2).

Table 2. Root dry weight of two soybean varieties on inoculation of *Brady rhizobium* sp in Ultisol of Binjai, Sumatera Utara

Inoculant of *Bradyrhizobium* sp	Variety	Liming		Mean
		Without liming	liming with a dose of 7.76 g/10 kg of soil (pH to 5.5)	
		-----------------------g----------------------		
Without inoculant	Anjasmoro	1.21	1.01	1.11
	Demas-1	1.33	1.59	1.46
BGR3 Inoculant	Anjasmoro	1.65	1.74	1.70
	Demas-1	1.73	2.23	1.98
LP3 Inoculant	Anjasmoro	1.53	1.40	1.46
	Demas-1	1.74	1.48	1.61
Mean		1.53	1.58	

Root dry weight of Anjasmoro varieties tended to be lower than Demas-1 and liming tended to increase root dry weight by 3.27% compared to without liming. Unlike the case with crown dry weight, liming is able to increase the roots dry weight of soybean plants. Liming will provide benefits by improving microbial activity, improving soil physical properties to be better and improving nitrogen fixation in legumes [7], so that the roots of soybean plants are able to develop better and fixate N.

The treatment combination of BGR3 inoculant on Demas-1 varieties in liming soil also tended to show the highest root dry weight compared to other treatment combinations. Root dry weight with treatment without inoculant and inoculant LP3 on Anjasmoro varieties tended to decrease with liming except for inoculant BGR3 whereas in Demas-1 varieties occur otherwise except in LP3 inoculants.

3.3. Shoot root ratio

Shoot root ratio of Anjasmoro tended to be higher in BGR3 inoculant than other treatments but Demas-1 soybean tended to be higher in LP3 inoculant [Table 3]. Liming treatment also showed that the shoot root ratio tended to be higher and Anjasmoro varieties tend to have a higher shoot root ratio than Demas-1. The high shoot root ratio showed that plant assimilation is more widely used for shoot growth than roots. Shoot root ratios help to assess health at the plant growth phase. The shoot weight is greater than the root weights in the growth phase due to the growth of leaves and subsequent stems [8].

Table 3. Shoot root ratio of two soybean varieties on inoculation of *Bradyrhizobium* sp. in the Ultisol of Binjai, Sumatera Utara

Inoculant of *Bradyrhizobium* sp	Variety	Liming		Mean
		Without liming	liming with a dose of 7.76 g/10 kg of soil (pH to 5.5)	
Without inoculant	Anjasmoro	6.36	7.31	6.84
	Demas-1	6.59	5.96	6.28
BGR3 Inoculant	Anjasmoro	7.26	7.43	7.34
	Demas-1	6.61	5.84	6.23
LP3 Inoculant	Anjasmoro	6.59	7.11	6.85
	Demas-1	6.43	6.94	6.68
Mean		6.64	6.77	

In Anjasmoro varieties which were given *Brady rhizobium* sp inoculants, liming treatment would increase the shoot root ratio (Table 3). Anjasmoro soybeans without liming which were given BGR3 inoculant. The shoot root ratio was 14.15% higher than without inoculant and 10.17% higher compared to LP3 inoculant. Anjasmoro with liming treatment which was given BGR3 inoculant showed an increasing in the shoot root ratio is less than other treatments. This showed that BGR3 inoculants are adaptable to growth in acid soils.

Meanwhile, in Demas-1 variety which was given *Brady rhizobium* sp inoculant. liming treatment decreased the shoot root ratio except in LP3 inoculant (Table 3). Demas-1 soybeans are genetically acid resistant so they grow better in acid soils.

3.4. N uptake of plants

N uptake of two soybean varieties was significantly higher in the BGR3 inoculant treatment which was significantly different from the treatment without inoculant and was not significantly different from the LP3 inoculant treatment (Table 4). High N uptake indicates that soybean are able to fixate N well. *Bradyrhizobium* sp is a bacteria that capable to fixate N_2 from free air which is symbiotic with soybean plants so that it will increase N absorption in soybean plants. This mutualism symbiosis benefits the host plant and *Bradyrhizobium* sp; host plants provide carbon for energy sources of growth while *Bradyrhizobium* sp functions to improve N_2 in the atmosphere and provide it for plants with reduced sources of nitrogen in the form of ammonium [9].

Table 4. N uptake of two soybean plant varieties on inoculation of *Brady rhizobium* sp. in the Ultisol of Binjai, Sumatera Utara

Inoculant *Bradyrhizobium* sp	Variety		Mean
	Anjasmoro	Demas-1	
	--------------------------mg/plant-------------------------		
Without inoculant	139.358	157.854	148.606 b
BGR3 Inoculant	220.194 (58.00%)	210.073 (33.08%)	215.134 a
LP3 Inoculant	201.755 (44.77%)	195.910 (24.11%)	198.832 ab
Mean	187.103	187.946	

Note: 1.The number followed by the same letters on the same column are not significantly different according to Duncan's Multiple Range Test [DMRT] at 5% level.
2. Numbers in parentheses showed an increase in N uptake compared to treatments without inoculants in each variety.

N uptake of Demas-1 varietiy tended to be 0.45% higher than Anjasmoro, but the increase in N uptake in each variety, the increase in N uptake of Anjasmoro variety was higher than Demas-1 which was given inoculant compared to without inoculant. The treatment combination between BGR3 inoculant with Anjasmoro variety tended to show higher N uptake than other treatment combinations. This showed that by giving inoculant *Bradyrhizobium* sp BGR3 will be able to increase the N uptake of plants both in Anjasmoro and Demas-1 varieties (Table 4). It indicates that *Bradyrhizobium* sp BGR3 inoculant is able to fixate N for soybean well in acidic pH. Plants growth in acidic soil and low nitrogen will be affected. Therefore, application of *Bradyrhizobium* sp which is capable of fixing N on acidic soils is expected to increase soybean growth because of increased N uptake [10].

4. Conclusion

Inoculant application of *Brady rhizobium* sp BGR3 was able to increase N uptake of soybean plants in Ultisol with an acidic pH which was better than LP3 inoculant and without inoculant. Shoot root ratios tended to increase in Anjasmoro varieties without liming which were given a BGR3 inoculant as much as 14.15%. Variety treatment, liming and interaction of these three treatment factors did not show a significant effect to increase the growth and N uptake of soybean plants.

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