THE EFFECT OF RHIZOBIUM APPLICATION ON THE GROWTH AND PRODUCTION OF TWO SOYBEAN VARIETIES IN ACEH TAMIANG DISTRICT

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ABSTRACT

The application of Rhizobium on the growth and production of some soybean varieties in Aceh Tamiang district aimed to determine the doses of Rhizobium application on the growth and production of two soybean varieties. This study used a randomized block design (RBD) 4 x 2 factorial pattern with 3 repetitions. The factors observed were Rhizobium inoculation doses (Legin), consisted of 4 levels, namely: R0 = 0% (control), R1 = 5 g/kg of seeds, R2 = 10 g/kg of seeds, and R3 = 15 g/kg of seeds. The varieties used here were V1 (Grobogan) and V2 (Anjasmoro), with plant spacing of 20 cm x 40 cm, filled with two plants per hole. The highest yields about 1.425 t/ha of dry seeds were obtained in Anjasmoro variety with Rhizobium application 15 g/kg of seeds, and PNPK Ponska about 100 kg/ha compared to control which was about 1,175 t/ha. Meanwhile in Grobogan variety, the highest yields were obtained in Rhizobium application with the dose of 15 g/kg of seeds that can increase the yields up to 1.425 t/ha of dry seeds compared to control 1,250 t/ha. Beside that, there were some increases in the total number of pods per plant, the number of pods per plant, weight of pods per plant, weight of 100 seeds that affected the increase in production of both soybean varieties.

Keywords: Rhizobium, Soybean Varieties, Dryland.

I. INTRODUCTION

Soybean is one of the major commodities in Aceh with high economical value, good prospects, and market access, so that this commodity is considered highly competitive. Soybean production centers in Aceh are located in Bireuen district (9484 ha) of harvested area, Aceh Utara (1,597 ha), Tamiang (3,089 ha), Aceh Timur (581 ha), and Pidie (3506 ha). (BPS 2006).

From year to year, soybean productions in Aceh have had fluctuations. Range of soybean productions in the last six years (2002-2007) was about 18697-31170 tons, with an average productivity ranged from 1.25 tons/ha to 1.47 tons/ha, and the average of both was about 1.31 tons/ha. The productivity itself was still very low compared to the yield of improved varieties which was about 2.5 tons/ha. One of the major causes of low soybean productivity is the limitation of soy cultivation technology used by farmers, especially the use of adaptive improved varieties in specific location that are resistant to pests or primary diseases.

It is very necessary to make some attempts in order to increase soybean productions for the national and local needs. So far, the efforts to increase soybean productions in Aceh just rely on a few old varieties and seed multiplication by farmers that do not meet good quality. Therefore, even though many inputs are given to soybean cultivation, it will become useless if the seeds' quality is poor, causing bad plants and low productivity (Arsyad, et al., 1991; Saleh, et al., 2000).

Soybean is one of the cultivation crops with high nutrient content, including protein which is about 30-50% (Richard et al., 1984). High protein content indicates that soybean plants require high nitrogen nutrients. Until now, in Indonesia, soybean productions have not been able to meet the needs of domestic consumers so that they still need to be imported every year. According to Sumarno (1999), this case is likely caused by the inadequate crop acreage and low productivity. Besides, the fertilization technique at the farmer level is still poor and the risk of pest and disease attakcs is still high.

One of the attempts that should be done to improve soybean productivity is by using inoculant *Rhizobium* mixed with the seeds at the time of planting, so it will serve as a biological fertilizer. The advantage of using the inoculant is the partial Nitrogen (N) will remain in roots and the root nodules in the soil, so the nitrogen will be used by other microorganisms which finally end in the form of ammonium and nitrate.

When the microorganisms die, the weathering will occur in the form of amonification and nitrification, so partial Nitrogen tethered from the air will be available for the plant itself and for other nearby plants (Soepardi, 1983). Simarmata (1995) suggested that the use of a variety of biological fertilizers on marginal lands in Indonesia is able to increase the availability of nutrients and yields of various crops up to 20-100%. Similarly, it will also be able to reduce the use of artificial fertilizers and improve the fertilizer efficiency. Pasaribu et al. (1989) also suggested that the increase in soybean yields can be obtained with the application of *Rhizobium japonicum* inoculation. In addition, *Rhizobium* bacteria also have a positive impact on the physical and chemical properties of the soil (Alexander, 1977).

Previous experiments showed that the inoculation of legumes provided a considerable opportunity to increase the production, both in quality and quantity, as well as reducing the use of artificial fertilizers (Singleton and Taveres, 1986). However, in real life, *Rhizobium* bacteria showed differences in match, both in the varieties of plants and the environment where they grow.

Rhizobium match level can be seen from its ability to infect the host plant, the ability of symbiotic system to tie up N in the air and the growth responses of host plants (Usman, 1983; Yutono, 1985). In addition, the success of a given inoculant also depends on its ability to compete with the native *Rhizobium* in the soil and its ability to adapt to the environment (Frederick, 1975). Hence, it is necessary to do a selection in order to obtain some of the effective, efficient, and adaptive *Rhizobium* that will lead to an optimal symbiosis.

II. MATERIALS AND METHODS

The event was conducted on dry lands in Paya War Village, Rantau sub-district, Aceh Tamiang district, from May to August 2013. The materials used were soybean varieties such as Grobogan and Anjasmoro, Urea, SP-36 and KCl, Phonska NPK, manure, insecticides (Marshal, Prevaton, Decis), fungicides (Dithane M-45), Run-Up herbicide and dolomite lime. The tools used in this study were salinity measurement, pH step, hoes, shovels, machetes, meter measurement, marker rope, plastic buckets, sprayer, yells roomy shoes and other writing equipments. The experiment was organized in a randomized block design (RBD), factorial pattern (4 x 2) with 3 repetitions. The first factor namely the doses of *Rhizobium* inoculation (Legin) consisted of 4 levels; R0 = 0%/ (control), R1 = 5 g/kg of seeds, R2 = 10 g/kg of seeds, R3 = 15 g/kg of seed varieties while the second factor were soybean varieties; V1 = Grobogan, V2 = Anjasmoro). Soybean cultivation technology was shown in Table 1.

Table 1. Components of Soybean Cultivation Technology.

No	Component of Technology	Description
1	Land type	Dry land
2	Tillage	Once plowing and once hoeing to smoothen
3	Beds	5 m x 10 m in size, with a 40-cm-conduit between plots.
4	Seeds origin	Indonesian Legumes and Tuber Crops Research Institute (ILETRI) (Anjasmoro and Grobogan)
5	Seed needs	50 kg/ha, growth ability >90 %
6	Planting method	A dibble with 3-4 cm in depth.
7	Plant spacing	40 cm x 20 cm, 2 seeds/hole.
8	Fertilization	50 kg/ha Urea; 100 kg/ha SP36; and 100 kg/ha KCl. Fertilizers were done in a dibble beneath the plants at the age of 10 days after planting (10 DAP).
9	Maintenance	
	▪ Pests/Diseases Control - Dithane - M45, Curacron 500 EC, Marshall, Prevaton	Recommended doses, sprayed if there was any pest or disease found.
10	Harvest time	When the pods were 90% ripe and most of the leaves were withered.
11	Post-Harvest	Pods drying, seeding by using tresher, and seeds drying.

The observed variables were as follows: plant height, number of branches, number of empty pods, pithy pods, and number of root nodules. These variables were observed in 10 sample plants in each treatment and repetition, while the seed results were observed in the plot tile of 1 m x 2 m in size. The data were analyzed statistically to determine the differences among the treatments.

Farmer training activities about the *Rhizobium* application and the use of dry soil were also conducted in order to determine the fertilizer doses. The technology applied in this activity is actually quite familiar for the farmers as they have frequently applied it in farming activities. However, it is still rarely applied in soybean cultivation.

III. RESULTS AND DISCUSSION

The results of variance analysis showed that Anjasmoro variety was higher and significantly different than Grobogan variety, while *Rhizobium* applications and their interaction did not significantly affect plant height of soybeans at the age of 75 days after planting (75 DAP). The average soybean plant height at the age 75 DAP due to *Rhizobium* treatment and varieties is shown in Table 2.

Table 2.The average plant height of soybeans at the age of 75 DAP after *Rhizobium* application activities on the growth and production of several soybean varieties in Aceh Tamiang district. MT, 2013.

Varieties	Plant Height (cm)				Average
	0	5	10	15	
Grobogan (V1)	56,3	56,8	55,8	57,5	56,6 a
Anjasmoro (V2)	60,8	64,1	64,4	63,0	63,1 b
Average	58,6	60,5	60,1	60,2	

Description: The numbers with the same letter in the column are not significantly different according to LSD 0.05.

The results of variance analysis showed that *Rhizobium* application, varieties and their interactions did not significantly affect the number of soybean branches at the age of 75 DAP. The average number of soybean branches at the age of 75 DAP due *Rhizobium* treatments and varieties is shown in Table 3.

Table 3. The average number of branches per plant at the age of 75 HST after *Rhizobium* application activities toward the growth and production of several soybean varieties.

Varieties	Number of Branches after the Application of Certain Doses of *Rhizobium* (g/kg of seeds)				Average
	0	5	10	15	
Grobogan (V1)	4,6	5,3	4,4	4,5	4,70 a
Anjasmoro (V2)	4,8	4,1	4,4	4,5	4,45 a
Average	4,7	4,7	4,4	4,5	

Description: The numbers with the same letter in the column are not significantly different according to LSD 0.05.

The results of variance analysis showed that the *Rhizobium* application, varieties and their interactions did not significantly affect the number of pods. The average number of pods per plant due to *Rhizobium* treatment and varieties is presented in Table 4.

Table 4. Average number of pods per soybean plants after *Rhizobium* application activities on the growth and production of several soybean varieties.

Varieties	Number of Pods after the Application of Certain Doses of *Rhizobium* (g/kg of seeds)				Average
	0	5	10	15	
Grobogan (V1)	125,8	109,5	122,7	1038	115,45 a
Anjasmoro (V2)	119,8	101,0	105,1	112,8	109,68 a
Average	122,8	105,25	113,90	108,30	

The results of variance analysis showed that the *Rhizobium* application, varieties and their interactions did not significantly affect the number of empty pods. The average number of empty pods per plant due to *Rhizobium* treatment and varieties is presented in Table 5.

Table 5.The average number of empty pods per soybean plant after *Rhizobium* application activities toward the growth and production of several soybean varieties.

Varieties	Number of Empty Pods after the Application of Certain Doses of *Rhizobium* (g/kg of seeds)				Average
	0	5	10	15	
Grobogan (V1)	10,55	14,44	13,33	9,92	12,11 a
Anjasmoro (V2)	11,03	11,25	12,74	12,81	11.96 a
Average	10,79	12,85	13,13	11,36	

The results of variance analysis showed that the *Rhizobium* application, varieties and their interactions did not significantly affect the amount of root nodules per plant. The average weight of 100 dry seeds due to *Rhizobium* treatment and varieties is presented in Table 6.

Table 6.Average number of root nodules per plant after *Rhizobium* application activities toward the growth and production of several soybean varieties.

Varieties	Number of Root Nodules after the Application of Certain Doses of *Rhizobium* (g/kg of seeds)				Average
	0	5	10	15	
Grobogan (V1)	5.33	9.20	7.67	9.33	7.88 a
Anjasmoro (V2)	6.33	8.60	9.47	8.90	8.22 a
Average	5.83	8.90	8.57	8.90	

The results of variance analysis showed that the *Rhizobium* application, varieties and their interactions did not significantly affect the weight of 100 dry seeds. The average weight of 100 dry seeds due to *Rhizobium* treatment and varieties is presented in Table 7.

Table 7.The average weight of 100 dry seeds (g) after Rhizobium application toward the growth and production of several soybean varieties.

Varieties	Weight of 100 Dry Seeds after the Application of Certain Doses of *Rhizobium* (g/kg of seeds)				Average
	0	5	10	15	
Grobogan (V1)	13,30	13,70	14,30	13,30	13,65 a
Anjasmoro (V2)	13,20	13,20	12,80	13,60	13,20 a
Average	13,25	13,45	13,55	13,45	

The results of variance analysis showed that *Rhizobium* application, varieties and their interactions did not significantly affect the results of dry seeds per hectare. The average result of dry seeds per hectare due to *Rhizobium* treatment and varieties is presented in Table 8.

Table 8.The average yield of dry seeds (t/ha) after *Rhizobium* application toward the growth and production of several soybean varieties.

Varieties	Number of Dry Seed Yields after the Application of Certain Doses of *Rhizobium* (g/kg of seeds)				Average
	0	5	10	15	
Grobogan (V1)	1,250	1,250	1,175	1,425	1,275 a
Anjasmoro (V2)	1,175	1,250	1,325	1,425	1,294 a
Average	1,213	1,250	1,250	1,425	

IV. DISCUSSION

The results of statistical analysis showed that the number of branches per plant (Table 3) were significantly different in each treatment. Anjasmoro variety had more branches at the age of 75 DAP, and it was not significantly different from Grobogan variety. It was caused by climatic conditions, especially high amount of rainfall when the plants were at 60 DAP, in which soil condition was saturated with water so that the roots of soybean plants could not thrive.

The results of the statistical analysis showed that the highest percentage of empty pods was found in farmer technology package (R0V1 and R0V2), but it was not significantly different with the introduction of technology package. This showed that the the number of filled pods was strongly influenced by the level of soil fertility. The soil condition at the assessment place in Paya War village (dry land) had low nutrient status (low N, intermediate P and low K), based on PUTS and PUTK.

Rhizobium application could reduce the number of empty pods, where the lowest number of empty pods were found in R2V2 in the introduction of technology package (*Rhizobium* treatment of 10 g/kg of seeds and Anjasmoro variety), but it was not significantly different with the introduction of the technology package R2V1 (*Rhizobium* treatment of 10 g/kg of seeds and Grobogan variety). Meanwhile, the dominant seeds' size was primarily influenced by plants' genetic, in which Anjasmoro variety had larger size than Grobogan variety (Table 4).

Soybean production was the combination of result components. The statistical analysis showed that the highest yields achieved was R3V2 in the introduction of technology package (*Rhizobium* treatment 15 g/kg of seeds and Anjasmoro variety), but it was not significantly different from the technology package R3V1 (*Rhizobium* treatment 15 g/kg of seeds and Grobogan variety). Meanwhile, the lowest result was found in the farmer technology package (R0V1 and R0V2/without *Rhizobium*). According to Kasim and Djunainah (1993), the number of yields is also determined by the interaction between genetic factors and the environmental condition where the plants grow such as soil fertility, water availability and crop management. Similarly, the success in soybean cultivation is primarily determined by farming land preparation, varieties, seeds' quality, plant spacing, irrigation, drainage, weed/pests/diseases control. Not only that, soil amelioration, fertilization, and *Rhizobium* inoculation also take part in determining the productivity in the infertile, low pH, and virgin lands. (Adisarwono, T, et al, 2000).

Furthermore, Saleh et al, 2000, asserted that the key technology in the development of soybean is the use of high quality seeds from improved varieties. Crop managements such as weed control and pest and disease controls are highly needed to ensure the success of farming system, while other technology components are specific. The use of high quality seeds with varieties that suit the specific agro-ecosystem in production center areas is considered very important. In other words, if the seed quality is poor, it will be useless despite many inputs are given to soybean cultivation which finally results in bad crops and low productivity (Arsyad, et al. 1991; Saleh, et al., 2000).

Other attempts that may increase the national production and soybean productivity are through the application of seed varieties, the increase in the doses of *Rhizobium*, and site-specific farming technology. The successful increase in soybean productivity as much as 3 t/ha is largely determined by the availability of high quality seeds, appropriate planting time, organic manure application, and impartial fertilizers. The use of improved varieties is expected to increase soybean production in Aceh, so Aceh will become one of the central areas of soybean production in Indonesia.

One of the efforts that should be done to increase the soybean productivity is by applying *Rhizobium* inoculant as a biological fertilizer. The advantage of using the inoculant was the partial N will still remain in the roots and root nodules in the soil, so the nitrogen can be utilized by other microorganisms in the form of ammonium and nitrate. When these microorganisms die, the weathering will occur in the form of amonification and nitrification, so most of the tethered N from the air will be available for the plant itself and other nearby plants (Soepardi, 1983).

Pasaribu et al. (1989) also suggested that the increase in soybean yields apparerently occurs with *Rhizobium japonicum* inoculation. Additionally, *Rhizobium* bacteria give a positive impact on the physical and chemical properties of the soil (Alexander, 1977).

From the previous experiments, it is showed that the inoculation of legumes provided a considerable opportunity to increase the production, both in quality and quantity, as well as reducing the use of artificial fertilizers (Singleton and Taveres, 1986). However, in real life, *Rhizobium* bacteria showed differences in match, both in plant varieties and the environment where they grow.

Rhizobium match level can be seen from its ability to infect the host plant, its ability of symbiotic system to tie up N in the air, and the growth responses of the host plants (Usman, 1983; Yutono, 1985). In addition, the success of a given inoculant also depends on its ability to compete with the native *Rhizobium* in the soil and its ability to adapt with the environment (Frederick, 1975). Therefore, it is highly necessary to do a selection in order to get some of the effective, efficient, and adaptive *Rhizobium* that will lead to an optimal symbiosis.

One of the important factors that determines the soybean productivity is the management of harvesting and post-harvesting. Several things that must be considered during the harvest preparation are the age of crops, drying, seeding, seed cleaning, and storage.The planted varieties should be in a proper age in planting pattern of the existing agro-ecosystems. This is crucial to avoid a shift happens at the time of planting after soybean harvest.

In the study of Legin Application Effect on the Growth and Production of Some Soybean Varieties, harvesting was conducted when 90% of the leaves had dried and withered. Before harvesting, the soybean plants were at the age of 86 DAP. Meanwhile, 25% of Grobogan variety was not ripe yet. In fact, at the age, of 76-80 DAP, it should be ready to harvest. This was likely due to high amount of rainfall which caused the plants to soak and hampered the generative growth of Grobogan variety.

The use of the *Rhizobium* in each variety (Grobogan and Anjasmoro) in this study had no effect on yields' age. The range of productions was estimated at 1.25 tons/ha - 1.44 tons/ha, as well as the growth and yield components except the number of branches per plant. This indicated that all tested varieties had given responses and adaptations that were slightly different when they were cultivated in dry soil.

Referring to some research results due to the use of Legin (*Rizhobium*) in soybean farming, it can obviously improve the growth component. This is due to the increasing number of root nodules that can also increase the growth of the soybean plants. As a result, it will cause the increase of *Rhizobium* bacteria symbiosis in tethering free N from the air as well. This, surely, will lead to an increase in N availability to the plants that influence an increase in soybean plants' growth.

The increasing growth of the soybean crops is expected to increase N fixation from the air that affects plant metabolism which thus producing assimilates/more photosynthesis delivered to the storage organs. The study results showed that there was an increase in the total number of pods per plant, number of pods per plant, weight seeds per plant, weight of 100 dry seeds that affected the increase in production. In addition, another component that can be seen from the results is the decrease in the number of empty pods per plant.

V. CONCLUSION

1. Anjasmoro variety with Rhizobium application of 15 g/kg of seeds produced the highest dry seed yields namely 1.425 t/ha compared with farmer technology or control namely 1,175 t/ha.

2. Grobogan variety with Rhizobium application of 15 g/kg of seeds produced dry seed yields namely 1, 425 t/ha compared with farmer technology or control namely 1,250 t/ha.

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