Production Of Soybean (Glycine Max (L.) MERR.) Anjasmoro Varieties With Mycorrhizal And Azotobacter Inoculation On Ultisol

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Abstract: The objective of research was to analyze the production of soybean (Glycine max L.Merr.) Anjasmoro varieties with the application of various doses of Azotobacter sp. and Mycorrhizae on ultisol, and to obtain the information on the dose of combination of Azotobacter sp. and Mycorrhizal optimal in order the combination can be applied to improve soybean production at the field scale. The experiment was conducted in a greenhouse from August to December 2013 in the scale of polybags . The study was conducted with a completely randomized factorial design with two factors. The first factor is the Azotobacter sp., consists of three levels i.e. without Azotobacter; Azotobater with a density of 10^3 CFU ml-1; and Azotobater with a density of 10^6 CFU ml-1. The second factor is Mycorrhizae, consists of four levels i.e. without Mycorrhizae; Mycorrhiza 10 g; Mycorrhiza 20 g; Mycorrhiza 30 g, there are 12 combinations of treatments and was repeated four times. Soybean Anjasmoro varieties give different responses of inoculation of Azotobacter sp and Mycorrhiza on ultisol. Inoculation of Azotobacter sp and Mycorrhizae on ultisol significant effect on number of pods, number of pods main stem, number of pods branches, number of pods containing , weight pods, number of seeds, seed dry weight. Azotobacter sp. did not give significant effect in harvesting index, however, at Mycorrhizae real effect. Inoculation with Azotobacter sp density of 10^3 CFU ml-1 and Mycorrhizae of 30 g influence on the best of the number pods, pods main stem, number of pods branches, number of pods containing, weight pods , number of seeds, seed dry weight, harvest index and weight of 100 seeds dry. Highest protein content is the of treatment without Azotobacter sp. and Mycorrhiza 20 g.

Index Terms: Soybean, Azotobacter sp. and Mycorrhizal, ultisol

1. INTRODUCTION

The need of soybean in Indonesia is increasing as the growth of the population. Soybean is the source of vegetable protein for most of the population in Indonesia, the raw material for tahu and tempe production, and animals feed. The number of soybean produced in 2013 was 867.16 thousand tons of dry seeds, and national needs reached 2.95 million tons, import 2.128 thousan tons [1]. National production could cover the needs just 28.58%. Meeting the needs of increasing soybeans, must be accompanied by an increase of the production. The increasing of soybean production in Indonesia in 2013 was 0.47% from 2012. The increasing of soybean production contributed to the expantion of planting area about 0.69% [1]. The large of area fro soybean development in Southest Sulawesi is 4.101 ha with average of land productivity is 930 kg ha-1 [2] and 2013's production was 3874 ton [1]. One of planted soybean in Southeast Sulawesi is Anjasmoro variety, because this variety meets the season and climate of Southeast Sulawesi. This variety has potential production 2,02-2,25 ton ha-1, with medium size of seeds [3].

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The effort done to improve the national soybean production by intecification and extensification. Intensification is done through hybrid seeding, mycorhizae and bacterial using. While extensification is an extension to the area of soybean planting into marginal area like ultisol, because fertile areas in Indonesia has decreased. Ultisol spreaded in Sumatera, Kalimantan, Sulawesi dan Irian Jaya [4], it reached 25% from the total large of the islands of Indonesia [5]. Seen by its large/size, ultisol has a big potential to be used, otherwise, in its management there seems has problems from its physic and character, dense, and loe soil fertile, and erotion in big scale [6], low nutrient [7], organic content decreases rapidly after clearing [8], low organic content, high Al saturation [9], high soil acidity, poor nutrient content, especially P, K, Ca, and Mg, low organic content so the fertilizer support capabilities is low, due to soil fertilization ultisol inefficient [10]. Less Nutrition to Ultisols in P and exchangeable cations such as Ca, Mg, Na, and K, the high Al content, cation exchange capacity (CEC) is low and susceptible to erosion. High Al content in the soil causes the roots of the plants become rigid, root structure becomes damaged, inhibited cell division root, root respiration inhibited, binding inhibits the absorption of P and Ca, Mg, Fe, and NH4 [11]. Soybeans productivity could be increased by biological characteristic of ultisol soil. The existing of natural microorganism in ultisol is low, caused by the low of organic content. Microorganism in ultisol soil could be improved through microbial inoculation into soil and plants, and extracting organic contents into ultisol soil. Microbial provides nutrient and growth hormones, amino acids, vitamin, and fugiside to plants. Azotobacter sp is rhizhobacterial species, known for its nitrogen mooring which could convert free nitrogen (N2) in ammonium (NH3), could synthesize growth hormone vitamin B, indole acetate acid,giberrellins, and cytokinins to grow in plants [12, 13, 14]. Azotobacter inoculation aims to improve the availibilty of soil nitrogen because Azotobacter could bind free nitrogen to nitrogen which could be absorbed by plants and could produce phytohormones which could be used by

plants to grow [15]. Based on the above reasons, the research on ultisol soil for soybeans planting with biological characteristic improvements through Azotobacter sp., Mikoriza application and Anjasmoro variety on greenhouse scale needs to be conducted. The research aims to analyze soybeans production (Glycine max L. Merr.) Anjasmoro variety to ultisol soil with various application of Azotobacter sp. And mycorrhizal dosage, to obtain information about the optimal dosage of Azotobacter sp. Mycorrhizal combination otherwise those combination could be applied in improving the production of soybeans.

2. MATERIALS AND METHODS

The research was conducted from August to December 2013 in greenhouse. The material used in the research included: soybeans seed anjasmoro variety, Azotobacter sp., Mycorrhizal, ultisol soil, organic fertilizer, organic fertilizer, Dolomite, Furadan, polybags 25x30 cm, labels. Tools used were electric scales, oven, balance Ohaus, sprayer, hoes and stationery. Azotobacter sp. used was obtained from the Laboratory of Agro-technology and IHPT Haluoleo University Faculty of Agriculture, sample of isolation of ultisol soil was taken from Endang Village South Konawe Regency. Indigenous mycorrhizal weed Imperata cylindrica (L.) Beauv and Eupatorium odoratum L., are collected in Sindang Kasih Village, Ranomeeto, South Konawe regency by Halim [16]. Ultisol soil used for the research was taken from husbandry faculty field of Haluoleo University. The research was conducted by using randomly method complete factorial with two factors. Factor I was Azotobacter sp. (A), consisted of 3 levels: without Azotobacter (A0), Azotobacter with density of 10^3 CFU ml-1 (A1), and Azotobacter wth density 10^6 CFU ml-1 (A2). Factor II was mycorrhizal (M), consisted of 4 levels: without Mycorrhizal extration (M0), with Mycorrhizal extration 10 g (M1), with mycorrhizal extration 20 g (M2) and Mycorrhizal extration 30 g (M3). From both of the factors, it was found that there were 12 combinations of a treatment. Each of the combinations of the treatments were repeated four times, therefore the total number of treatments were 48 in the polybag. The preparation for the growing medium was ultisol soil dried under the sun insideof the greenhouse fro 3 weeks under 38 degree temperathure in mid day. Six kg soil was put inside of polybag mixed with 12 g of organic fertilizer, 9 g of lime, 72 mg of furadan, it was conducted one week before the planting. Measurement of the parameter for the research was number of pods, main pods, main branches, and pods branch, weight of pods, number of seeds, dry seed weight, dry weight of 100 seeds, harvest index, and protein content. All parameters are calculated after the harvesting. Drying is done by using an oven with a temperature of 80 ^{0}C for 96 hours. Analysis of the data using the average analysis and ANOVA with 0.05, with a further testt of Duncan.

3. RESULTS AND DISCUSSION

Analysis of soil media

Based on the analysis on soils used in the research field classified Ultisol soil with pH 4.62 (sour), organic matter 1.18 (low), N-total of 0.78 (High), the P-total of 5.55 (very low), and available P 3.29 (very low), CEC 26.57 (high), K-total of 8.70 (low), K-available 0.31 (tranquility), Calcium 2.6 (very low), Magnesium 0.87 (low), Al-dd 2.32, Fe 0.30, 22.53 Sand, dust 62.17, 15.29% clay, and soil with clay dusty texture (analyzed at the Laboratory of Integrated Unit UHO). The results of the soil analysis used is Ultisol soil with poor soil conditions the growth of plants. High levels of N in the soil, but is thought to have low decomposition.

Number of Pods

Varians analysis shown that Azotobacter and Mycorrhizal factors was significantly affected number of pods of soybean, but the interaction of both the factors did not give significant effect. Average of soybean seeds and the result based on Duncan test (Table 1) shown that the average highest pods was adalah 69.50 (A1M3), the lowest was 14.50 (A0M0). Average mycorrhizal factor was 18.66 (M1). The treatment of M3, M2, and M1 were not significantly different, however three of them are significantly diffrenet from M0. The highest average of Azotobacter was A1 and the lowest was A0. Treatment of A1 was different from A0, but was not similar to A2.

Table 1. Average number of pods.

Azotobacter	Mycorrhizal				Average
	M0	M1	M2	M3	
A0	14.50	17.00	33.75	48.75	28.50a
A1	14.25	52.50	53.75	69.50	47.50a
A2	27.25	53.00	35.50	53.25	42.25b
Average	18.66a	40.83b	40.83b	57.16b	39.41

Information: *numbers followed by words in row and column were not significantly different from Duncan test 5 %*

Number of Pods Main Stem

Varians analysis shown that Mycorrhizal factor significantly affected the number of pods to the main trunk of soybeans, however, Azotobacter factors and their interaction no significant effect on the number of pods on the main stem. The average number of main stems of soybean pods and Duncan testt results (Table 2)

Table 2. Averages number of pods main stem

Azotobacter	Mycorrhizal				Average
	M0	M1	M2	M3	
A0	6.50	5.25	18.25	23.25	13.31a
A1	8.25	24.00	19.75	28.55	20.18b
A2	10.75	9.50	14.50	24.25	14.75ab
Average	8.50a	12.91a	17.50ab	25.41b	16.83

Information: *numbers followed by words in row and column were not significantly different from Duncan test 5 %*

Table 2 shown averages number of pods in main trunk of soybeans the highest was 28.75 (A1M3), the lowest was 6.50 (A0M0). Averages of mycorrhizal factor was 25.41 (M3) and the lowest 8.50 (M1). The treatment of M3 was not significantly different from M2 but different between M1 and M0. Averages of Azotobacter averages was 20.18 (A1) and the lowest was 13.31 (A0). The formation of pods with

the stems increased by the doze of mycorrhizal. The extraction of Azotobacter sp. Affected the formation of pods to the trunk with 10^3 CFU ml-1 density, and decreased when Azotobacter extracted with 10^6 CFU ml-1 density.

Number of pods branch

Varians analysis shown that Mycorrhizal and azorobacter factors significantly affected the number opf pods branch in soybeans, however the interaction of both of the factors were not significantly affect the number of pods branch. Averages branch of soybean pods based on Duncan test in table 3 shown that the highest average of pods branch was 40.75 (A1M3), the lowest was 8 (A0M0). The highest average of mycorrhizal factor was 31.75 (M3) and the lowest was 10.16 (M0). The treatment in M3 was not significantly different from M2, and M1, but different from M0. The highest average of Azotobacter factor was 27.50 (A2) and the lowest was 15.18 (A0). Treatment of was not significantly different from, but different from A0.

Tabel 3. Averages number of pods branch

Azotobacter	Mycorrhizal				Average
	M0	M1	M2	M3	
A0	8.00	11.75	15.50	25.50	15.18a
A1	6.00	28.50	34.00	40.75	27.31b
A2	10.50	43.50	21.00	29.00	27.50b
Average	10.16a	27.16a	23.50b	31.7b	23.33

Information: *numbers followed by words in row and column were not significantly different from Duncan test 5 %*

Number of Densed pods

Varians analysis shown that Azotobacter and Mycorrhizal were significantly affected the number of densed pods to soybeans, however the interaction of both interactions was not significantly affected the number of densed pods. The averages of densed pods based on Duncan test (table 4) shown that the averages of densed pods was 3.25 (A1M3), the lowest was 11.25 (A1M0). The highest average of mycorrhizal factor was 53 (M3) and the lowest was 16.83 (M0). The treatment of M3 was not significantly different from M2, and M1, however different from M0. The highest average of Azotobacter factor was 43.31 (A1) and the lowest was 25.25 (A0). The treatment of A1 was not different from A2, but not significantly similar to A0.

Table 4. Average number of densed pods

Azotobacter	Mycorrhizal				Average
	M0	M1	M2	M3	
A0	13.25	14.50	27.75	46.50	25.25b
A1	11.25	48.75	50.00	63.25	43.31a
A2	26.00	51.00	31.25	50.25	39.62ab
Average	16.83 a	38.08 b	36.33a b	53.00 b	36.02

Information: *numbers followed by words in row and column were not significantly different from Duncan test 5 %*

Weight of Pods

Varians analysis shown that mycorrhizal and Azotobacter factors significantly affected the weight of pods, however the interaction of both of the factors were not significantly affect the weight of the pods. Averages of weight of the densed pods based on Duncan test in (table 4) shown that the highest average of pods weight was 27.72 (A1M3), the lowest was 3.87 (A1M0). The highest average of mycorrhizal factor was 19.06 (M3) and the lowest was 6.18 (M0). The treatment of M3 was not significantly different from M2, and M1, but significantly different with M0. The highest average of Azotobacter factor was 16.70 (A1) and the lowest was 7.49 (A0). The treatment of A1 was not significantly different with A2, but significantly different with A0.

Table 5. Averages of pods weight

Azotobacter	Mycorrhizal				Average
	M0	M1	M2	M3	
A0	3.97	4.35	8.15	13.50	7.49a
A1	3.87	16.45	18.75	27.25	16.70b
A2	10.70	19.52	12.75	15.97	14.73b
Average	6.18a	13.44ab	13.21ab	19.06b	12.97

Information: *numbers followed by words in row and column were not significantly different from Duncan test 5 %*

Number of Seeds

Varians analysis shown that Azotobacter and mycorrhizal were significantly affected the number of soybean seeds, however the interaction of both the factors were not significantly affected the number of the seeds. Averages of seeds number based on Duncan test in table 6.

Table 6. Averages of number of seeds

Azotobacter	Mycorrhizal				Average
	M0	M1	M2	M3	
A0	19.50	16.50	39.00	83.00	39.56a
A1	16.75	77.50	77.75	133.50	76.37b
A2	53.75	92.75	60.00	82.25	72.18b
Average	30.00a	62.25a	58.91a	99.66b	62.70

Information: *numbers followed by words in row and column were not significantly different from Duncan test 5 %*

From table 6 shown that the highest average of seeds number was 133.50 (A1M3), the lowest was 16.75 (A1M0). The highest Averages of mycorrhizal factor was 99.66 (M3) and the lowest was 30 (M0). The treatment of M3 was different with M2, M1 and M0. The treatment of A1 was not different from A2, but significantly different from A0.

Weight of Dry Seeds

Varians analysis shown that Azotobacter dan mycorrhizal significantly affected the weight of the dry seeds, however the interaction from both of the factors were not significantly affected. Averages of weight of dry seeds based on Duncan test (table 7) shown that the highest average so f dry seeds weight was 18.92 (A1M3), the lowest was 2.28 (A1M0). The highest averages of mycorrhizal factor was 12.72 (M3) and the lowest was 3.32 (M0). The treatment of M3 was

significantly different from M0, but was not different from M1. The highest averages of Azotobacter factor was 10.58 (A1) and the lowest was 4.53 (A0). The treatment of A1 was not significantly different from A2, but different from A0.

Table 7. Averages of weight dry seeds

Azotobacter	Mycorrhizal				Average
	M0	M1	M2	M3	
A0	2.48	2.25	5.41	7.97	4.53a
A1	2.28	8.80	12.31	18.92	10.58b
A2	5.19	12.85	8.68	11.26	9.49b
Average	3.32a	7.97ab	8.80b	12.72b	8.20

Information: *numbers followed by words in row and column were not significantly different from Duncan test 5 %*

Weight of 100 Seeds

Weight of 100 seeds of soybean was not statistically testted, this caused by a half of the planting did not produce that number of seeds. Per plant could be seen in table 8. Table 8 shown that the highest weight of 100 seeds was A1M3 (15.6) and the lowest was A0M0 (12.9). Based on that weight, the intensity injection density of zotobacter will increase the weight of the seeds becoame 100, routinely, A0, A1, dan A2. The effect of mycorrhizal factor towards the weight shown that 13.7 (M0) was low, hence M1 (15.10) was improved, then decreased to 4.93 (M2) and 14.80 (M3).

Table 8. Weight 100 of soybean seeds

Azotobacter	Mycorrhizal				Average
	M0	M1	M2	M3	
A0	12.90	14.70	14.30	13.60	13.87
A1	14.20	14.40	15.40	15.60	14.92
A2	13.90	16.20	15.10	15.20	15.10
Average	13.70	15.10	14.93	14.80	14.63

Information: *numbers followed by words in row and column were not significantly different from Duncan test 5 %*

Harvest Index

Varians analysis shown that mycorrhizal significantly affected towards the harvet index however azotobacter factor and the interaction of both factors did not affect. Averages of harvest index based on Duncan testt (Tabel 9) shown that the highest averages of harvest index was 0.35 (A1M3), the lowest was 0.09 (A0M0). The highest averages of mycorrhizal factor was 0.35 (M3) and the lowest was 0.18 (M0). The treatment of M3 significantly different from M1 and M0, but did not different from M2.

Table 9. Averages of harvest index

Azotobacter	Mycorrhizal				Average
	M0	M1	M2	M3	
A0	0.09	0.19	0.23	0.31	0.22a
A1	0.15	0.23	0.30	0.35	0.26a
A2	0.23	0.29	0.22	0.31	0.26a
Average	0.18a	0.23a	0.25ab	0.32b	0.25

Information: *numbers followed by words in row and column were not significantly different from Duncan test 5 %*

Harvest index shown that the comparison of assimilation result of distributing economic biomass with total biomass [17]. Azotobacter sp. inoculation did not affect the distribution of photosyntat to soybeans seeds, however it was affected by mycorrhizal.

Protein Contents

Protein contents of the seeds was not statistically testted, this was caused by the testt conducted once in every treatment. Protein content of the treatment is in (table 10). Based on the averages of protein content of seeds shown that without Azotobacter injection contains high protein, hence it was given atreatment to A1 and A2. The effect of mycorrhizal towards the average of seeds protein increased to M2 ant decreased to M3.the lowest Protein contents of soybeans seeds due to mycorrhizal injection was M0 (34.96) and the highest was M2 (34.96). The averages of protein from both of the factors was 35.24, and these contents assumed have not reach the protein contents of anjasmoro variety for the optimal growth that is 41.8-42,1% [3]. Lower protein contents shown that phosphor and nitrogen in the soil is also low to be absorbed by the plants. The low protein contents in the treatment of Azotobacter sp. showing that ultisol soil might deficit of P, therefore P with deficit number could not provide nutrient for Azotobacter energy formation for N fixation, this seemed to make competition fro Azotobacter in using P to produce energy for the lively cell, therefore, Azotobacter sp. inoculation to ultisol soil did not increase protein content to soybean seeds. Protein contents to soybeans could be improved through the availability of P in the soil, and it is sufficicent to form the energy for Azotobacter to be fixed with N, and it is expected that the availability of P in the soil support the exist of N as it is important for the protein formation of protein [18].

Table 10. Protein contents in soybean seeds

Azotobacter	Mycorrhizal				Average
	M0	M1	M2	M3	
A0	38.97	43.23	45.63	36.96	41.19
A1	30.96	36.89	26.42	28.42	30.67
A2	34.96	26.15	34.43	39.90	33.86
Average	34.96	35.42	35.49	35.09	35.24

Information: *numbers followed by words in row and column were not significantly different from Duncan test 5 %*

The inoculation of Azotobacter was siginificantly affected the parameters of plants production, except harvest index. Averages analysis shown that the treatment of Azotobacter with the density 10^3 CFU ml-1 was the best treatment, however it was significantly different regarding to statistic analysis without Azotobacter inoculation, and was not significantly different from the treatment of Azotobacter with the density of 10^6 CFU ml-1. The treatment of A1 and A2 was not significantly different, it was caused by the limitation of the availability of organic material to ultsol soil. The treatment of A2 brought a high competition to organic material, compared to the treatment of A1. The content of C organic in ultisol soil to soil medium was 1.18 % with pH 4.62, therefore Azotobacter sp and the plants was inhibited to grow. Growing inhibition on soybeans at ultisol soil was

caused by the deficit of P and N. In the soil with less than pH 5 of P would be fixation with Al and Fe [4, 10], therefore the deficit occurred in P. Fluctuation in N2 fixation by Azotobacter related to number of colony in the soil, particularly to the root area of the plants [19]. The number of colony in the soil was caused by the existence of organic material of the soil, according to [20], organic material is one of mineral and energy resource to Azotobacter sp.and other microbes. Organic material content to planted medium is low (1.18%), causing the population of Azotobacter did not well develop, it even died due to insufficient nutrition. According [21], organic material of soil should give significant increase to the plant production if the content of its organic material contents more than 2%. Organic material's function into the soil is to sustain the moisture of the soil, increase the acid pH of the soil, avoid the hard structure of the soil so root could absorb, improve cation exchange capacity (CEC), and improve the soil biological activity [22]. Azotobacter sp. could increase the availability of N soil, where sufficient organic materials are available, as the source of nutrient and energy for the activity of N moored, and hence was absorbed by plants. Azotobacter sp. as the free agent of nitrogen moor would be available in nitrate and ammonium. The absorbs of NO_3^- and NH_4^+ by the plants perhaps would form various nitrogen compounds particularly protein. Nitrogen would trigger the growth of leaves and energy for photosynthesis to produce sugar and eventually affect the growth and procuctivity of soybeans. Azotobacter sp. migrated and proliferate throughout the growth of roots, due to the stimulation of the exudate of young root. Azotobacter sp. could improve the avilibility of N in the soil, as well indol acetate, cytokinins, and gibberelin acid, Azotobacter could also provide another nutrients like; P, S, Fe Cu and could control diseases caused by bacterials and fungi [23]. Mycorrhizal was significantly affected the whole parameters on soybeans productions. Averages analysis shown that the treatment of 30 g mycorrhizal was regarded the best treatment and was significantly different without mycorrhizal treatment, however it was not different with the treatment of 20 g and 10 g of mycorrhizalr. The treatment of M3, M2, and M1 was not significantly different, due to the activity of mycorrhizal regarded not yet optimum and less of organic material availability. The unoptimalized growth of soybeans caused the roots formation as symbiosis between mycorrhizal and the plants also unoptimal. Mycorrhizal and root of plants affected to each others improvements. Mycorrhizal extraction as natural fertilizer could improve the availability of P to the soil. Mycorrhizae produce phosphatase enzyme which can release the P element-bound elements of Al and Fe in sour soil and Ca in calcareous soil so P would be available for the plants [24]. The CMA infected plants could absorb higher P element compared to the plants which were not infected [25, 26]. P element was important in forming the energy, adenosine monophosphate (AMP) and the availability of P to form adenosine diphosphate (ADP), and then formed into adenosine triphosphate (ATP) as a source of energy in photosynthesis.

4. CONCLUSION

Soybean Anjasmoro variety responded different from Azotobacter sp. and mycorrhizal inoculation to ultisol soil. Azotobacter sp. and mycorrhizal inoculation to ultisol soil was significantly affected the number of pods, pods to main branch, densed pods,weight of pods, number of seeds, weight of dry seeds. Azotobacter sp. did not significantly affect the harvest index, however mycorrhizal was significantly affected. Azotobacter sp inoculation with 10^3 CFU ml-1 density and 30 g mycorrhizal gave best impact towards number of pods, number pods in main branch, densed pods, weight of pods, number of seeds, number of dry seeds, harvest index and weinht 100 dry seeds. The highes Protein content of soybean in ultisol soil without Azotobacter sp. and mycorrhizal was 20 g.

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