Effectivity of *Trichoderma Asperellum* against Water Availability Level in Soybean

Nirwana and St. Sabahannur
Agriculture Faculty of Muslim University of Indonesia, Makassar, Indonesia
Email: {nirwana_tahir, siti_sabahan}@yahoo.com

***Abstract*—This study aims to analyze the effect of Trichoderma asperellum utilization on the level of water availability and nutrient in soybean.. This study was conducted by inoculating of Trichoderma with four dosage levels (without inoculation, 0.025 gram / seed inoculation, 0.050 gram / seed, and 0.075 gram / seed) combined with water level capability with three levels of field capacity (80-100%, 60-80 %, and 40-60%). The results showed that Trichoderma with a dose of 0.075 g / seed with a water level of 80-100% can improve the growth and production of soybean crops.**

***Index Terms*—soybean, Trichoderma asperellum, growing, production**

I. Introduction

Soybean (*Glycine* max (L.) Merrill) is one of the most important strategic food commodities needed because it is a source of protein, a producer of raw materials for the food industry, animal feed to green manure and nitrogen fixing, due to its ability to fix nitrogen in atmosfer in relation with Bacteria forming pimples (Bradyrhizobium). In Indonesia, the commodity occupies the third position after paddy and maize with consumption level of 8.12 kg / capita / year. Along with the development of population and the growing food processing industry in Indonesia so the need for soybean also increase. Within the period of five years (2010-2014) the average annual demand for soybeans reaches 2,300,000 tons of dry beans, while domestic production capacity is currently able to meet as much as 907,000 tons in 2010, 851,000 tons in 2011, 844,000 tons in 2012, 780,000 tons in 2013, and 954,000 tons in 2014 or 40.09% of the national demand [1].

The low production and productivity of soybean in Indonesia is currently caused by various factors, such as; soil factors, climate, pests and diseases and poor management practices. One of the climatic elements that affect the growth and yield of soybean crops is rainfall and groundwater availability. The groundwater content should be sufficient for germination, growth, flowering and filling of pods. Water strains directly or indirectly affect the plants. The direct effect, which can cause turgor reduction due to turgor pressure is very important in determining the size of the plant also affect the enlargement and multiplication of plant cells, opening and closing stomata, leaf development, formation and development of flowers [2]. While indirect effects, will be associated with physiological processes such as photosynthesis, nitrogen metabolism, nutrient absorption and translocation of photosynthesis [3].

Efforts to increase soybean production and productivity still need to be pursued, especially with the application of innovative technology that is more competitive (productive, efficient and qualified) through Integrated Crop Management (ICM). The ICM approach is expected to increase the productivity of soybean crops in a sustainable manner. One alternative that can be applied to overcome the above problems is the utilization of soil bio-technology (utilization of soil microbial services and natural fertilizer technology). This effort is in line with environmentally sound agricultural development policy and focuses on the efficiency of energy use and Background nature (back to nature) and organic go 2010, one of which is the use of microbial based biofuel that is Trichoderma sp.

Trichoderma sp. Is a type of fungus or fungi that has antifungal activity because it is antagonistic to other fungi, especially those that are pathogenic. For biotechnology purposes, these biocontrol agents can be isolated and used to deal with plant damage caused by pathogens The application of Trichoderma to soil as a biological agent, in greenhouses or under field conditions, not only results in reduced disease severity but also enhances plant growth [4]. It has been reported that the plant defense responses shown during the early stages of Tichoderma spread to the root system of plants [5], [6].

A study of single use of Trichoderma in various types of plants has been widely practiced. Plants infected with Pythium and Fusarium and Trichoderma treated yielded fruit 5 and 1.6-fold respectively compared to plants infected by pathogens without Trichoderma treatment [7]. In relation to this matter has been assessed the effectiveness of Trichoderma and the level of water availability in soybean crops. The purpose of the study was to analyze the effect of Trichoderma utilization and water availability level on soybean crops.

II. Research Method

The experiment was conducted by using factorial randomized block design consisting of two factors.

Manuscript received September 25, 2017; revised February 9, 2018.

doi: 10.18178/joaat.5.2.134-138

A. Inoculation of Trichoderma sp. and Water Availability Level

By inoculating Trichoderma sp. (T0), 0.025 gram Trichoderma / seed (t1), 0.050 gram Trichoderma / seed (t2), 0.075 gram Trichoderma / seed (t3). Whereas the second factor is the level of water availability (A) consisting of 80-100% of the field capacity (a1), 60-80% of the field capacity (a2), 40-60% of the field capacity (a3) of the two attempted factors were obtained 12 repeated treatment combinations three times and each unit Experiments used 72 plants.

The experiment combination is as follows:

t_0a_1 = Without *trichoderma* in 80-100% field capacity
t_0a_2 = Without*trichoderma* in 60-80% field capacity
t_0a_3 = Without*trichoderma* in 40-60% field capacity
t_1a_1 = 0,025 gram *trichoderma* pada 80-100% field capacity
t_1a_2 = 0,025gram *trichoderma* pada 60-80% field capacity
t_1a_3 = 0,025 gram *trichoderma* pada 40-60% field capacity
t_2a_1 = 0,050 gram *trichoderma* pada 80-100% field capacity
t_2a_2 = 0,050 gram *trichoderma* pada 60-80% field capacity
t_2a_3 = 0,050 gram *trichoderma* pada 40-60% field capacity
t_3a_1 = 0,075 gram *trichoderma* pada 80-100% field capacity
t_3a_2 = 0,075 gram *trichoderma* pada 60-80% field capacity
t_3a_3 = 0,075 gram *trichoderma* pada 40-60% field capacity

To assess the effect of treatment, then observation of some parameters (Y) with the model of estimation analysis:

$$Yijk = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk} \quad (1)$$

which:

Yijk= Observation scorefactor A level to i, faktor B level to jandrepeated in-k
μ= Middle score
α_i= Influence factor of-A, level to-i
β_j= Influence factor ke-B, level ke –j
$(\alpha$= Interaction AB to level A of-i , level B to $j\beta)_{ij}$
ε_{ijk}= Galat experiment level of-i (A), level to-j (B) repeated of-k

The result of ANOVA test and to determine the best treatment, tested continued by comparing the two average values, using the test of real honest difference (BNJ). The parameters observed are:

- Nutrient content of plant growing media, observed prior to treatment, and at the end of the experiment. Wet weight of roots, Dry weight of roots, stems, leaves, and root ratios, were observed at the end of the experiment.

III. Result and Discussion Result

A. Dried Weight and Pupus-Root Ratio

The mean analysis of leaf dry weight, stems and roots showed that Trichoderma treatment had significant effect to the dry weight of leaves and stems but no significant effect on root dry weight. Water administration significantly influenced the dry weight of leaves, stems and roots, but the interaction of Tricoderma inoculation treatment with water administration had no significant effect.

TABLE I. Mean of Dry Weight of Leaves, Trunks and Roots (Grams) of Soybean Plants on Trichoderma Inoculation Treatment and Water Delivery Level

Air (% Kapasitas Lapang)	Dosisi Inokulasi *Tricoderma* Sp				Rata-rata	NP BNJ α 0.05
	t_0 (0,00g)	t_1 (0,25g)	t_2 (0,50g)	t_3 (0,50g)		
Berat kering daun (g)						
a_1 (80-100)	6.27	7.89	10.29	10.46	8.73^x	
a_2 (60 - 80)	5.45	7.62	8.29	7.96	7.33^y	0.97
a_3 (40 - 60)	4.77	6.73	8.35	7.29	6.78^y	
Rata- rata	5.50 c	7.41 b	8.97 a	8.57 a		
NP BNJ α 0.05			1.08			
Berat Kering batang dan cabang (g)						
a_1 (80-100)	8.24	10.67	14.57	15.97	12.36^x	
a_2 (60 - 80)	7.31	7.86	9.67	6.69	7.88^y	1.13
a_3 (40 - 60)	5.38	6.80	8.01	7.68	6.97^y	
Rata- rata	6.98c	8.44bc	10.75 a	10.12a		
NP BNT α 0.05			1.25			
Berat kering akar (g)						
a_1 (80-100)	2.03	2.32	2.40	2.62	2.34^x	
a_2 (60 - 80)	1.75	2.28	1.78	2.03	1.96^y	0.28
a_3 (40 - 60)	1.05	1.28	1.23	1.67	1.31^z	

Note: The numbers followed by the same letters rows (a, b, c) and in the (x, y) columns, are not significantly different at the 95% confidence level.

The trichoderma inoculation treatment of 0.075 g per seed (t3) showed the mean of leaves and stems more heavily and significantly different from the inoculation of Trichoderma (t0) and Trichoderma inoculation 0.025 g per seed (t1) but not significantly different from the Trichoderma inoculation 0.050 g Per seed (t2) (Table I).

Treatment of water supply 80-100% The field capacity (a1) shows average dry weight of leaves, stems and roots higher and significantly different from water 60 - 80% of field capacity (a2) and 40 - 60% of field capacity (a3).

The analysis of biomass mean biomass, dry weight and pupus root ratio showed that the Trichoderma treatment had significant effect to the dry weight of biomass and the dry weight of the pupus but did not significantly affect the root ratios. Water administration significantly influences the mean weight of biomass, dry weight and pupus-root ratio, but the interaction between the Trichoderma inoculation treatment and water administration is not significant.

Trichoderma inoculation of 0.075 g per seed (t3) showed mean Bimassa and Pupus were more severe and significantly different from Trichoderma (t0) inoculation and Trichoderma inoculation 0.025 g per seed (t1 but not significantly different from Trichoderma inoculation 0.050 g per seed (T2) (Table II)

Treatment of water supply 80-100% of field capacity (a1) shows the average of biomass and dry weight of the pupil is higher and significantly different than that of 60 - 80% field capacity (a2) and 40-60% of field capacity (a3) On the other hand, the water treatment ratio of 40-60% of the field capacity (a3) shows higher and significantly different ratios than the root-to-water ratio of 60-80% of the field capacity (a2) and 80-100% of the capacity Roomy (a1).

TABLE II. Mean of Biomass, Pupus Dry Weight (Gram) and Soybean-Root Poppy Ratio on Trichoderma Inoculation Treatment and Water Delivery Level

Air (% Kapasitas Lapang)	Dosisi Inokulasi *Tricoderma* Sp t_0 (0,00g)	t_1 (0,25g)	t_2 (0,50g)	t_3 (0,50g)	Rata-rata	NP BNJ α 0.05
Biomassa (g) (Daun + Batang + Cabang +Akar)						
a_1 (80-100)	17.38	21.13	27.07	29.39	23.74 x	
a_2 (60 - 80)	15.53	16.89	19.10	14.89	16.60 y	0.57
a_3 (40 - 60)	11.94	14.30	16.07	16.01	14.58 y	
Rata- rata	14.95 c	17.44 b	20.75 a	20.09 a		
NP BNJ α 0.05			2.29			
Pupus (g) (Batang + Cabang + Daun)						
a_1 (80-100)	15.34	18.81	24.67	26.77	21.40 x	
a_2 (60 - 80)	13.78	14.61	17.32	12.86	14.64 y	1.80
a_3 (40 - 60)	10.89	13.02	14.83	14.34	13.27 y	
Rata- rata	13.34 c	15.48 b	18.94 a	17.99 a		
NP BNJ α 0.05						
Rasio Pupus-Akar						
a_1 (80-100)	8.17	8.33	10.34	11.10	9.48 y	
a_2 (60 - 80)	8.89	6.92	9.68	6.71	8.05 y	1.55
a_3 (40 - 60)	11.28	12.02	11.59	10.18	11.27 x	

Note: The numbers followed by the same letters rows (a, b, c) and in the (x, y) columns, are not significantly different at the 95% confidence level.

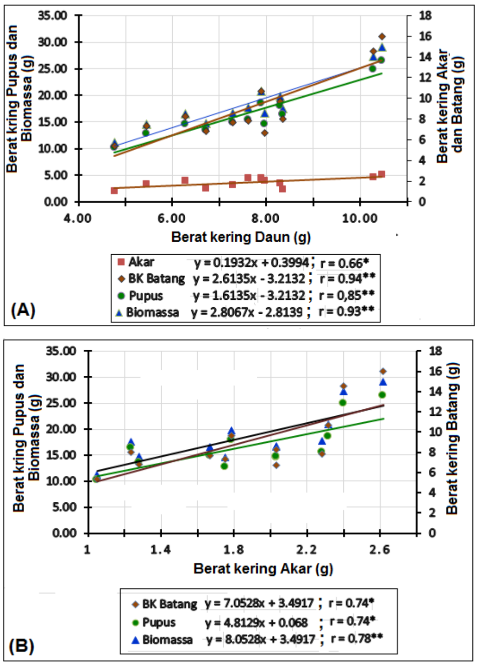

Figure 1. Graph of Correlation between Dry Weight Leaves with Dry Weight Roots, Rods, Pupus and Biomass (A), as well as the Correlation between Root Dry Weights with Dry Weight Rods, Pupus and Biomass (B)

The correlation analysis showed that the leaf dry weight correlated positively linearly with the dry weight of roots, stems, pupus and plant biomass by following the successive equations y = 0.1932x + 0.3994; r = 0.66*, y = 2.6135x - 3.2132; r = 0.94**, y = 1.6135x - 3.2132; r = 0,85** dan y = 2.8067x - 2.8139; r = 0.93** (Fig. 1A). The root dry weight correlates positively linearly with the dry weight of the stem following the equation y = 7.0528x + 3.4917; r = 0.74*, with the dusk weight following the equation y = 4.8129x + 0.068; r = 0.74* and with plant biomass following the equation y = 8.0528x + 3.4917; r = 0.78** (Fig. 1B).

IV. Discussion

A. *Water Treatment Influence*

Water is a major abiotic factor that contributes to the success or failure to obtain maximum soybean yield, because Water affects the use of other environmental resources. The efficiency of the use of solar radiation from soybean plants remains relatively constant at different stages of development. When there is moderate water stress, soy tends to maximize the efficiency of radiation use and reduce the efficiency of interception of photosynthetically active radiation, while under severe water deficits, there is a reduction of radiation utilization efficiency.

The results showed that the treatment of water level had significant effect to real growth parameter observed. Provision of water 80 -100% field capacity shows the best growth and development of plants. The lower the rate of water delivery below the field capacity the lower the value of growth and production achieved.

B. *Influence of Tricoderma sp Inoculation*

Trichoderma is a soil fungus, ecologically rich in broad adaptation, can grow under different environmental conditions and on various substrates [8]. Current use of biological fertilizers has been widely circulated and largely based on the beneficial symbionts of the genus Trichoderma [9]. Much research has been reported that mushrooms as biological fertilizers help to increase crop yields and increase sustainable agricultural production and are safe for the environment [10], [11].

The results showed that Tricoderma sp treatment had no significant effect. However, the embedding data of total leaf area in the reproduction phase and maximal pod formation showed the highest average value in the Tricoderma treatment of 0.50 g and 0.75 g per plant. This is likely due to the fungus in the genus Trichoderma has evolved to several mechanisms that produce improved plant growth [12]. Furthermore, from the results of research by [13]. reported that Tricodermapada inoculation of maize crops can increase the development of leaf area significantly than without inoculation. Trichoderma is able to increase nutrient uptake, so as to increase the rate of photosynthesis that produces the raw material to increase the leaf area development and overall plant growth [14].

Trichoderma spp. Allegedly able to promote plant growth at least through two different mechanisms: [15] that controls the population of pathogenic microorganisms in the rhizosphere, and influences the physiological processes of plants through the dissolution of soil minerals or hormone secretion [16]. The results of studies have shown that inoculation. Trichodermasp 0.75

g planting (t3) showed the highest and significantly different leaf chlorophyll index compared with no inoculation and 0.25g and 0.50 g of cultivation in the vegetative growth stage. The results of this study are consistent with the research conducted by [17] reported that Trichoderma viridi inoculation significantly increases the levels of khlofil a, b and total leaf kholorifil in soybean plants. An increase in chlorophyll index in the Trichodermasp inoculation treatment may be due to Trichoderma sp. Which infects the root area, interacts with host plants for metabolite exchange which can cause significant changes to host plant metabolism [18]. The research [19] reported that the administration of Trichoderma sp biocompos can increase total sugar content, a ascorbat, b-carotein, lycopene and tomato plant protein content.

The results showed that the inoculation treatment of Trichoderma sp 0, 50 and 0.75 g of plantation showed higher dry weight of the plant compared with inoculation and inoculation of Trichoderma sp 0, 25 g of cropping (Table I and II). Trichoderma sp allegedly promotes the growth of plants, at least through two different mechanisms: [15] that controls the population of pathogenic microorganisms in the rhizosphere, and influences the physiological processes of plants through mineral dissolution or hormone secretion [20], [21]. The results of demonstrated that micronutrients and phosphates are insoluble to become soluble and available to plants in the root zone of plants infected with Trichoderma harzianum. Various species of Trichoderma fungus are economically important as a source of enzymes and antibiotics; Plant growth promoters; Xenobiotic degraders, and as commercial biofungicides [17]. In addition, Trichoderma is also effective in promoting growth and yield in various plants. [21] and is beneficial to plant growth through various mechanisms such as nutrient mobilization and host defense induction [22]. The results showed that root development correlated positively linearly with the development of branches of stems and leaves, and vice versa that leaf development was positively correlated with root and branch development.

V. Conclusion

Trichoderma Influence Analysis and Water Supply Level on Growth, Production, Nutrient Availability Level and Effectivity of Soya Hut Absorption shows that: Trichoderma dosage of 0.075 g per seed with 80-100% water level can improve the growth and production of soybean crops.

References

[1] KEMENTAN, *Rencana Strategis Kementerian Pertanian Tahun 2015-2019*, Jakarta: Kementerian Pertanian Republik Indonesia, 2015.

[2] T. Islami and W. H. Utomo, *Hubungan Tanah Air dan Tanaman*, IKIP Semarang Press, 1995.

[3] F. B. Salisbury and C. W. Ross, *Fisiologi Tumbuhan*, Jilid I. Edisi IV, ITB, Bandung, 1995.

[4] Y. C. Chang, R. Baker, O. Klefield, and I. Chet, "Increased growth of plants in the presence of the biological control agent Trichoderma harzianum," *Plant Dis*., vol. 70, pp. 145-148, 1986.

[5] I. Yedidia, N. Benhamou, Y. Kapulnik, and I. Chet, "Induction and accumulation of pr protein activity during early stages of root colonization by the mycoparasite *Trichoderma harzianum* strain T-203," *Plant Physiol. Biochem.*, 2000.

[6] I. Yedidia, A. K. Srivastva, Y. Kapulnik, and I. Chet, "Effect of *Trichoderma harzianum* on microelement concentrations and increased growth of cucumber plants," *Plant Soil*, vol. 235, pp. 235-242, 2001.

[7] R. P. John, R. D. Tyagi, D. Prévost, S. K. Brar, S. Pouleur, and R. Y. Surampalli, "Mycoparasitic *Trichoderma* viride as a biocontrol agent against Fusarium oxysporum f. sp. adzuki and Pythium arrhenomanes and as a growth promoter of soybean," *Crop Protection*, vol. 29, pp. 1452-1459, 2010.

[8] D. S. Powlson, P. J. Gregory, W. R. Whalley, J. N. Quinton, D. W. Hopkins, A. P. Whitmore, P. R. Hirsch, and K. W. T. Goulding,. "Soil management in relation to sustainable agriculture and ecosystem services," *Food Policy*, vol. 36, pp. 72-87, 2011.

[9] S. L. Woo, F. Scala, M. Ruocco, and M. Lorito, "The molecular biology of the interactions between *Trichoderma* spp, phytopathogenic fungi, and plants," *Am Phytopathol Soc*., vol. 96, no. 2, pp. 181-185, 2006.

[10] L. R. Bulluck, M. Brosius, G. K. Evanylo, and J. B Ristaino, "Organic and synthetic fertility amendments influence soil microbial, physical and chemical properties on organic and conventional farms," *Applied Soil Ecology*, vol. 19, pp. 147-160, 2002.

[11] M. A. Leck, V. T. Parker, and R. L. Simpson, *Seedling Ecology and Evolution*, Cambridge: Cambridge University Press, 2008.

[12] M. Shoresh, G. E. Harman, and F. Mastouri, "Induced systemic resistance and plant responses to fungal biocontrol agents," *Annu. Rev. Phytopathol*., vol. 48, pp. 1-23, 2010.

[13] S. A. Akladious and S. M. Abbas, "Application of *richoderma harziunum* T22 as a biofertilizer supporting maize growth," *African Journal of Biotechnology*, vol. 11, no. 35, pp. 8672-8683, 2012.

[14] G. E. Harman, "Overview of mechanisms and uses of Trichoderma spp.," *Phytopathology*, vol. 96, pp. 190-194, 2006.

[15] M. Perazzolli, B. Roatti, E. Bozza, and I. Pertot, "*Trichoderma harzianum* T39 induces resistance against downy mildew by priming for defense without costs for grapevine," *Biological Control*, vol. 58, no. 1, pp. 74-82, 2011.

[16] M. M. Ainhoa, R. Antonio, A. Alfonso, and A. P. Jose, "The interaction with arbuscular mycorrhizal fungi or *Trichoderma harzianum* alters the shoot hormonal profile in melon plants," *Phytochemistry*, vol. 72, pp. 223-229, 2011.

[17] P. Rojan, J. Tyagi, R. Prevost, D. Satinder, D. Brar, S. K. Pouleur, and R. Y. Surampalli, "Mycoparasitic *Trichoderma viride* as a biocontrol agent against *Fusarium oxysporum* f. sp. adzuki and Pythium arrhenomanes and as a growth promoter of soybean," *Crop Protection*, vol. 29, pp. 1452-1459, 2010.

[18] F. Vinale, E. K. Sivasithamparam, R. Marra, M. Barbetti, H. Li, S. Woo, and M. Lorito, "A novel role for Trichoderma secondary metabolites in the interactions with plants," *Physiol. Mol. Plant Pathol*., vol. 72, pp. 80-86, 2008.

[19] M. A. Hossain, M. M. Haque, M. A. Haque, and G. N. M. Ilias, "Trichoderma-Enriched biofertilizer enhances production and nutritional quality of tomato (*Lycopersicon esculentum* Mill.) and minimizes NPK fertilizer use," *Agric. Res.*, vol. 1, no. 3, pp. 265-272, 2012.

[20] S. Latinas and U. Bal, "Application of *Trichoderma harzianum* increases yield in cucumber (Cucumis sativus) grown in an unheated glasshouse," *Journal of Applied Horticulture*, vol. 7, pp. 25-28, 2005.

[21] Y. Elad and Freeman, "Biological control of fungal plant pathogen," in *The Mycota, a Comprehensive Treatise on Fungi as Experimental System for Basic and Applied Research. XI Agricultural Applications,* F. Kempken, Ed., Heidelberg, Germany: Springer, 2002.

[22] D. L. Rudresh, M. K.Shivaprakash, and R. D. Prasad, "Effect of combined application of Rhizobium, phosphate solubilizing bacterium and *Trichoderma* spp. on growth, nutrient uptake and yield of chickpea (*Cicer aritenium* L.)," *Applied Soil Ecol.*, vol. 28, pp. 139-146, 2005.

Nirwana is a permanent lecturer at the Faculty of Agriculture of Muslim University of Indonesia, Makassar since 1988. An undergraduate degree in agriculture was obtained from the Faculty of Agriculture of Hasanuddin University, Makassar in 1986. In 2002 she obtained a master's degree from the Faculty of Agriculture of Hasanuddin University and in 2016 obtained her doctoral degree of agricultural science from Hasanuddin University, Makassar.

St Sabahannur is a permanent lecturer at the Faculty of Agriculture of Muslim University of Indonesia, Makassar since 1991. An undergraduate degree in agriculture was obtained from the Faculty of Agriculture of Hasanuddin University, Makassar in 1988. In 1999 she obtained a master's degree from the Faculty of Agriculture of Brawijaya University and in 2015 obtained her doctoral degree of agricultural science from Hasanuddin University, Makassar. She is involved in several cocoa researches, including physical and chemical analysis of various cocoa clones, the use of various fermentation box size, s and research on the addition of yeast and sucrose during fermentation of seeds.