

Original article

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Growth Response of Edamame Soybean (*Glycine max* (L.) Merr.) with Application of Urea and *Rhizobium* Biofertilizer on Peat Soil Media

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ABSTRACT

Edamame is a type of soybean that is consumed in an immature period. High demand for market exports, especially to Japan, must be balanced by maximizing production by using marginal lands. One of marginal lands is peatland which might be used as growth media for edamame with Urea and *Rhizobium* biofertilizer application to support its growth. The recent study aimed to analyze the combination of Urea and *Rhizobium* biofertilizer on the growth of edamame on peat soil media. The experiment was conducted in Completely Randomized Design (CDR) with two factors. First factor was Urea dosage: $p_1 = 50 \text{ kg ha}^{-1}$, $p_2 = 150 \text{ kg ha}^{-1}$, $p_3 = 100 \text{ kg ha}^{-1}$, and $p_4 = 200 \text{ kg ha}^{-1}$. The second factor was *Rhizobium* biofertilizer treatment: $r_0 =$ without biofertilizer and $r_1 =$ with biofertilizer at 8 g kg^{-1} edamame seeds. All combination was repeated three times with three polybags of them, so that there were 72 plants in total. The results showed that there was a response between application of Urea and *Rhizobium* biofertilizer have a significant effect on the observed parameters, that is plant height (cm), number of trifoliolate leaves (strand), shoot dry weight (g) and root dry weight (g). The result showed that the application of Urea 50 kg ha^{-1} with *Rhizobium* biofertilizer increased plant growth of edamame on peat soil.

Keywords: biofertilizer, edamame soybean, fresh vegetable, wetland

1. Introduction

Edamame is a type of green soybean or vegetable soybean that is harvested and consumed as green pods *i.e.* at the stage of stadia R6 of its life cycle (Sharma & Kshattray, 2013). In Indonesia, edamame initiated to be planted in 1990 at Gadog, Bogor, West Java and in 1995 the yield was distributed to market in fresh or frozen form. Edamame is rich with protein, Fe, vitamin A, vitamin B1, vitamin C, and vitamin E (Soewanto & Prasongko, n.d.). These ingredients make high demand of edamame and mainly in Japan as the highest consumer country of edamame.

Indonesia was started to increase the production of edamame to fulfill the demand and the utilization of wetland area is one of this effort. Peatland as one of wetland environment, has an area 4.778.004 ha in Indonesia (Wahyunto, et al., 2014). Peatlands are divided into several types based on the depth of peat content, that is (1) Peaty soil that has a depth of peat less than $<50 \text{ cm}$ (2) Shallow peatland that has a thickness of peat around $50\text{-}100 \text{ cm}$ (3) Medium peatland that has a thickness of peat around $100\text{-}200 \text{ cm}$ (4) Deep peatland that has a thickness of peat around $200\text{-}300 \text{ cm}$ and (5) Very deep peatland that has a thickness of peat more than 300 cm (Hafif, 2021). However, utilizing peat soil has a limiting factor that is low soil pH and low macro and micronutrient N available, P, K, Ca, Mg, Cu, Zn, Mn, and B (Benziger & Shanmugasundaram, 1995).

Low N nutrient content could disrupt the growth of edamame in terms of its morphological characteristics such as plant height, number of leaves, number of fertile nodes, number of branches and plant dry weight, which in turn determine the yield of edamame. To resolve those problems, application of N at the beginning and the end of flowering period, can maximize the yield of edamame by 33%, as N element is an essential nutrient that is needed by every plant in a high amount. Urea is a fertilizer that contains a high amount of N nutrient (Brevedan, Egli, & Leggett, 1978).

In addition to absorbing N nutrients from the soil, edamame as legume crops, might fix Nitrogen from the atmosphere with the help of root nodules which symbiosis with *Rhizobium* bacteria. These bacteria can fix free N on the air and turned them into NH_3 which turned into amino acids so it can be used for edamame to grow and branch out, meanwhile *Rhizobium* bacteria received carbohydrate as an energy source from its plant host. So that there is a symbiotic mutualism bond between edamame and *Rhizobium* bacteria (Surtiningsih & Nurhariyati, 2009). Based on the explanation above, the authors were interested in analyzing the combination of Urea and *Rhizobium* biofertilizer on the growth of edamame on peat soil media.

2. Methods

This research was conducted in the greenhouse of Indonesia Swampland Agricultural Research Institute (BALITTRA) Banjarbaru South Kalimantan from February to April 2020. The materials used in this research are edamame seed variety Ryokko R-75, peat soil, Urea, *Rhizobium* biofertilizer, SP-36, KCl, lime, pesticides, water, hoe, polybag, hand sprayer, ruler, scale thermohyrometer, bucket, a cup of mineral water, germinator, small tray, tweezers, frosted paper, scissor, writing tools and camera.

The design of the research was Completely Randomized Design (CDR) with two factors. First factor was Urea dosage: $p_1 = 50 \text{ kg ha}^{-1}$, $p_2 = 100 \text{ kg ha}^{-1}$, $p_3 = 150 \text{ kg ha}^{-1}$, $p_4 = 200 \text{ kg ha}^{-1}$. The second factor was biofertilizer treatment: $r_0 =$ without *Rhizobium* biofertilizer and $r_1 =$ *Rhizobium* biofertilizer 8 g kg^{-1} edamame seeds. All of combinations was repeated three times with three polybags of them, so that there were 72 plants in total.

The stages conducted in this research were include the preparation, soil analysis, media preparation, liming, seed treatment, fertilization, maintenance, and measurement. The variables observed were plant height, number of trifoliolate leaves, shoot dry weight, root dry weight. Data obtained were tested for homogeneity using the Bartlett Test. Analysis of variance (anova) is continued if the data have been homogeneous. If the data are not homogeneous, transformation will be needed until the data becomes homogeneous. The results of anova analyses were continued to Tukey's Honestly Significant Difference Test (HSD) if it was showed significant difference. Data analyses were performed using Minitab 18.

3. Results and Discussion

Result

The response between Urea and *Rhizobium* biofertilizer on plant height at two and three weeks after sowing (WAS) is presented in Table 1.

Table 1. Response of plant height (cm) at two and three weeks after sowing to Urea and *Rhizobium* biofertilizer

Urea (kg ha^{-1})	2 WAS		3 WAS	
	<i>Rhizobium</i> biofertilizer			
	$r_0 =$ without <i>Rhizobium</i> biofertilizer	$r_1 = 8 \text{ g kg}^{-1}$ edamame seeds	$r_0 =$ without <i>Rhizobium</i> biofertilizer	$r_1 = 8 \text{ g kg}^{-1}$ edamame seeds
$p_1 = 50$	28.6 ^{ab}	28.8 ^{ab}	56.9 ^{ab}	58.9 ^{ab}
$p_2 = 100$	30.7 ^{ab}	29.9 ^{ab}	63.8 ^{ab}	57.9 ^{ab}
$p_3 = 150$	28.3 ^{ab}	26.7 ^b	58.8 ^{ab}	50.8 ^b
$p_4 = 200$	26.9 ^b	32.3 ^a	53.8 ^{ab}	67.1 ^a

Remark: Different letters indicate significant difference at $p < 0.05$ (Tukey HSD test)

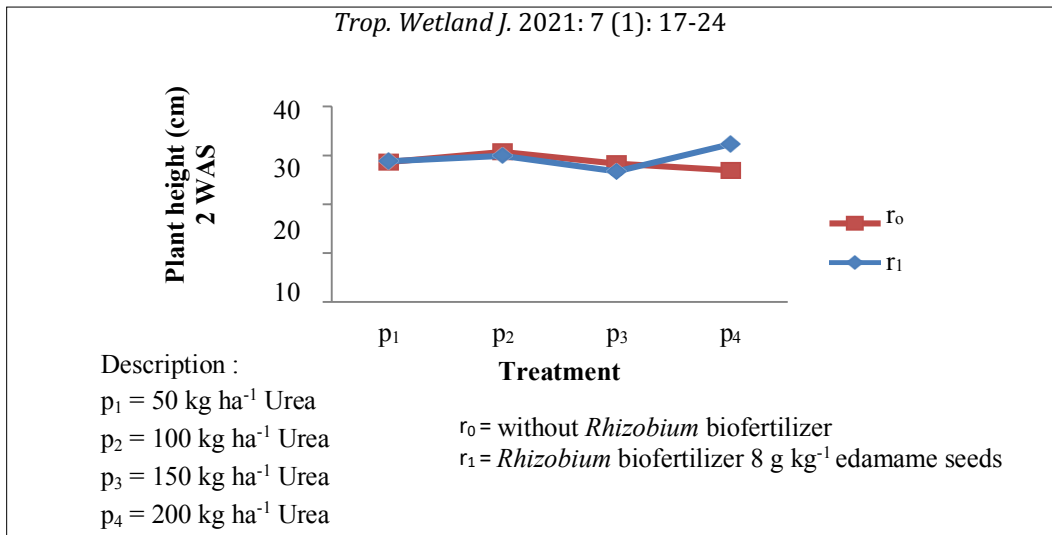


Figure 1. Graphic of plant height (cm) at two weeks after sowing.

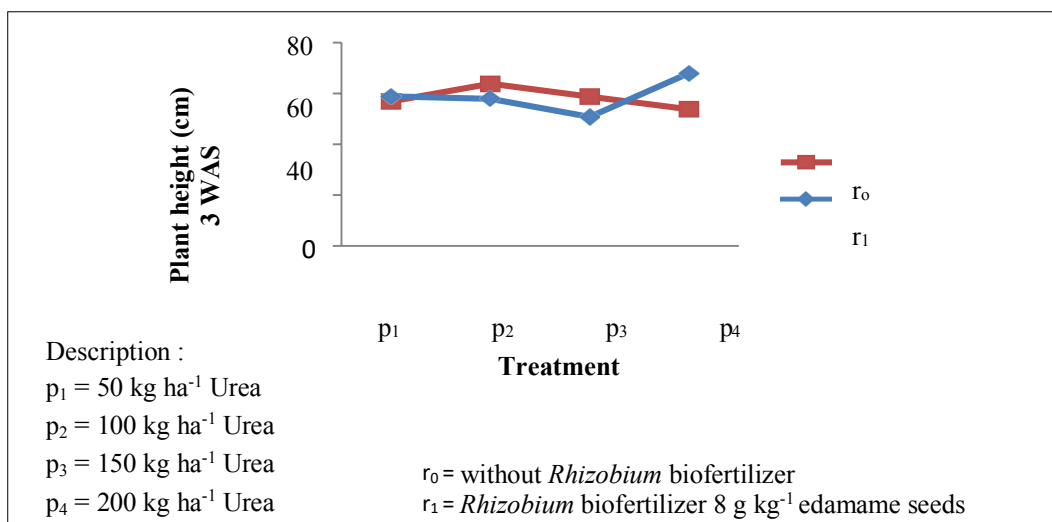


Figure 2. Graphic of plant height (cm) at three weeks after sowing.

Table 1 and Figure 1 show that the highest plant at 2 WAS was observed on treatment p₄r₁ (32.3 cm). This treatment was not significantly different with p₁r₀, p₁r₁, p₂r₀, p₂r₁, p₃r₀, and p₃r₁, but significantly different with p₄r₀. It was also observed at 3 WAS, the highest plant (67.1 cm) was showed on treatment p₄r₁ that was not significantly different with p₁r₀, p₁r₁, p₂r₀, p₂r₁, p₃r₀, and p₃r₁, but significantly different with p₄r₀ (Tabel 1 and Figure 2). The response between Urea and *Rhizobium* biofertilizer on plant height at four and five weeks after sowing (WAS) is presented in Table 2.

Table 2. Response of plant height (cm) at four and five weeks after sowing to Urea and *Rhizobium* biofertilizer

Urea (kg ha ⁻¹)	4 WAS		5 WAS	
	<i>Rhizobium</i> biofertilizer			
	r ₀ = without <i>Rhizobium</i> biofertilizer	r ₁ = 8g kg ⁻¹ edamame seeds	r ₀ = without <i>Rhizobium</i> biofertilizer	r ₁ = 8g kg ⁻¹ edamame seeds
p ₁ = 50	98.1 ^{ab}	98.0 ^{ab}	102.0 ^{ab}	103.2 ^{ab}
p ₂ = 100	103.5 ^{ab}	97.5 ^{ab}	110.4 ^a	96.0 ^{ab}
p ₃ = 150	100.8 ^{ab}	81.3 ^b	106.4 ^{ab}	85.4 ^b
p ₄ = 200	90.1 ^{ab}	108.1 ^a	98.0 ^{ab}	109.8 ^a

Remark: Different letters indicate significant difference at p<0.05 (Tukey HSD test)

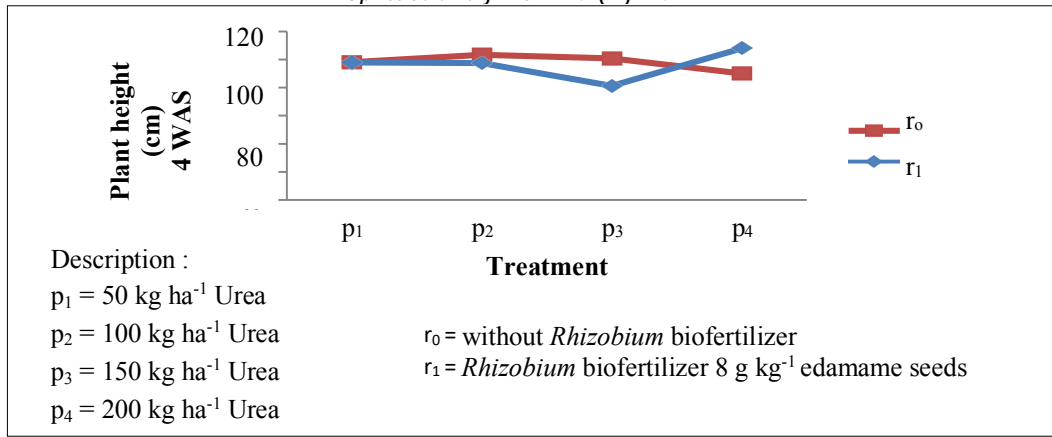


Figure 3. Graphic of plant height (cm) at four weeks after sowing.

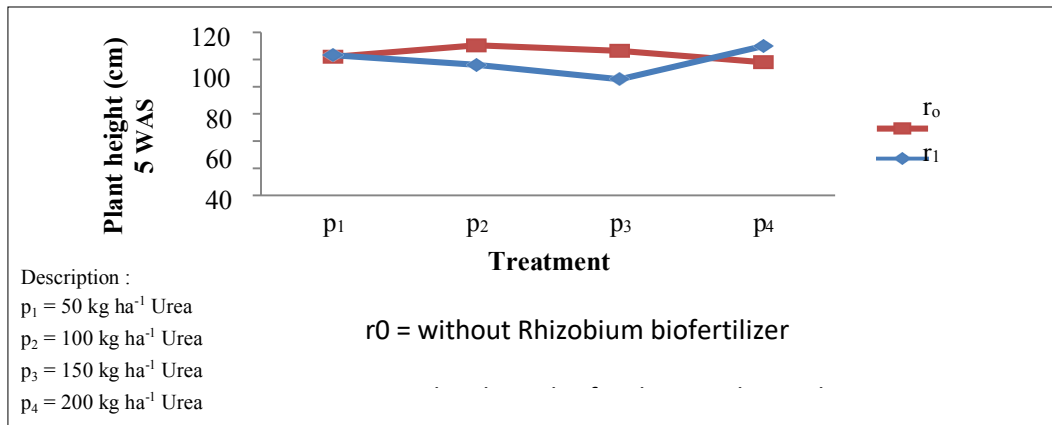


Figure 4. Graphic of plant height (cm) at five weeks after sowing.

Table 2 and Figure 3 show that the highest plant at 4 WAS was observed on treatment p₄r₁ (108.1 cm). This treatment was not significantly different with p₁r₀, p₁r₁, p₂r₀, p₂r₁, p₃r₀, and p₄r₀, but significantly different with p₃r₁. Meanwhile, at 5 WAS the highest plant (110.4 cm) was at treatment p₂r₀ (Table 2 and Figure 4). This treatment was not significantly different with p₁r₀, p₁r₁, p₂r₁, p₃r₀, p₄r₀, and p₄r₁, but significantly different with p₃r₁.

The response between Urea and *Rhizobium* biofertilizer on number of trifoliolate leaves at three and five weeks after sowing (WAS) is presented in Table 3.

Table 3. Response of number of trifoliolate leaves at three and five weeks after sowing to Urea and *Rhizobium* biofertilizer

Urea (kg ha ⁻¹)	3 WAS		5 WAS	
	<i>Rhizobium</i> biofertilizer			
	r ₀ = without <i>Rhizobium</i> biofertilizer	r ₁ = 8g kg ⁻¹ edamame seeds	r ₀ = without <i>Rhizobium</i> biofertilizer	r ₁ = 8g kg ⁻¹ edamame seeds
p ₁ = 50	4.0 ^{ab}	4.0 ^{ab}	16.6 ^{ab}	16.1 ^{ab}
p ₂ = 100	4.2 ^{ab}	4.0 ^{ab}	17.6 ^b	16.6 ^{ab}
p ₃ = 150	4.0 ^{ab}	3.1 ^b	16.5 ^{ab}	14.8 ^{ab}
p ₄ = 200	3.9 ^{ab}	4.6 ^a	13.7 ^a	17.9 ^b

Remark: Different letters indicate significant difference at p<0.05 (Tukey HSD test)

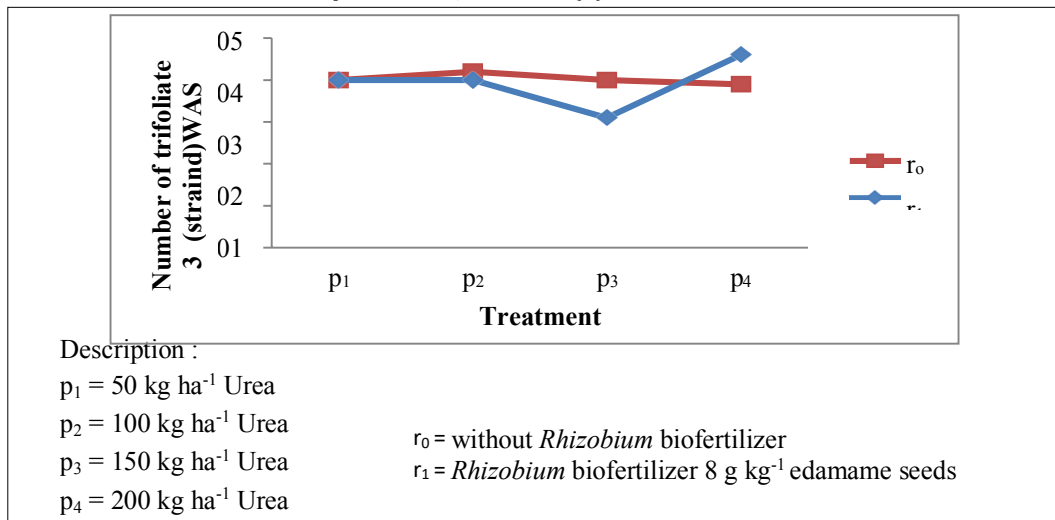


Figure 5. Graphic number of trifoliolate leaves at three weeks after sowing.

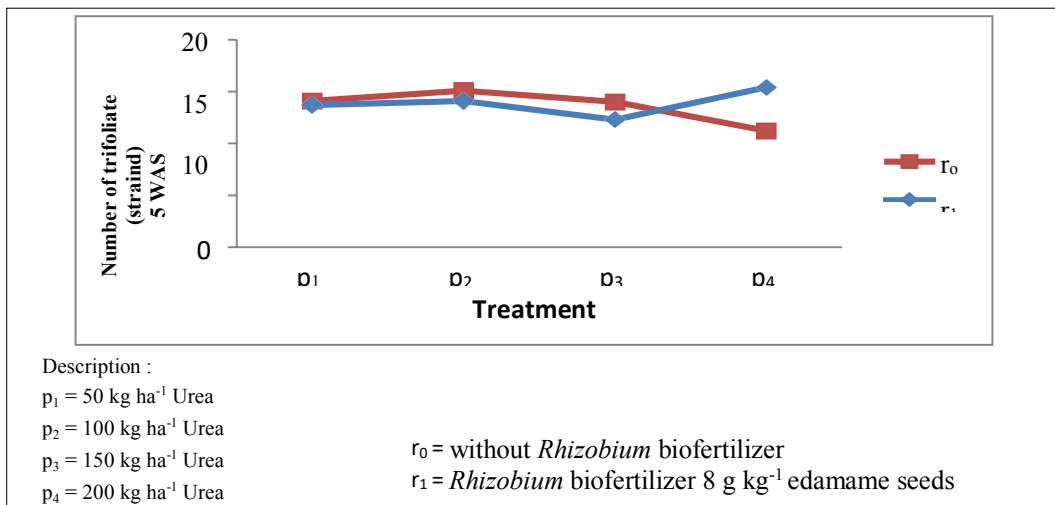


Figure 6. Graphic number of trifoliolate leaves at five weeks after sowing.

Table 3 and Figure 5 show that the number of trifoliolate leaves at 3 WAS is highest (4.6) at treatment p₄r₁. This treatment was not significantly different with p₁r₀, p₁r₁, p₂r₀, p₂r₁, p₃r₀ and p₄r₀, but significantly different with p₃r₁. This result was also observed at 5 WAS, treatment p₄r₁ has the most trifoliolate leaves (17.9) even though this treatment was not significantly different with p₁r₀, p₁r₁, p₂r₀, p₂r₁, p₃r₀ and p₃r₁, but significantly different with p₄r₀ (Table 3 and Figure 6).

The response between Urea and *Rhizobium* biofertilizer on shoot dry weight at five weeks after sowing (WAS) is presented in Table 4.

Table 4. Response of shoot dry weight (g) at five weeks after sowing to Urea and *Rhizobium* biofertilizer

Urea (kg ha ⁻¹)	<i>Rhizobium</i> biofertilizer	
	r ₀ = without <i>Rhizobium</i> biofertilizer	r ₁ = 8g kg ⁻¹ Edamame seeds
p ₁ = 50	7.3 ^{ab}	9.3 ^a
p ₂ = 100	5.7 ^{ab}	6.3 ^{ab}
p ₃ = 150	7.3 ^{ab}	3.2 ^b
p ₄ = 200	2.5 ^b	6.7 ^{ab}

Remark: Different letters indicate significant difference at p<0,05 (Tukey HSD test)

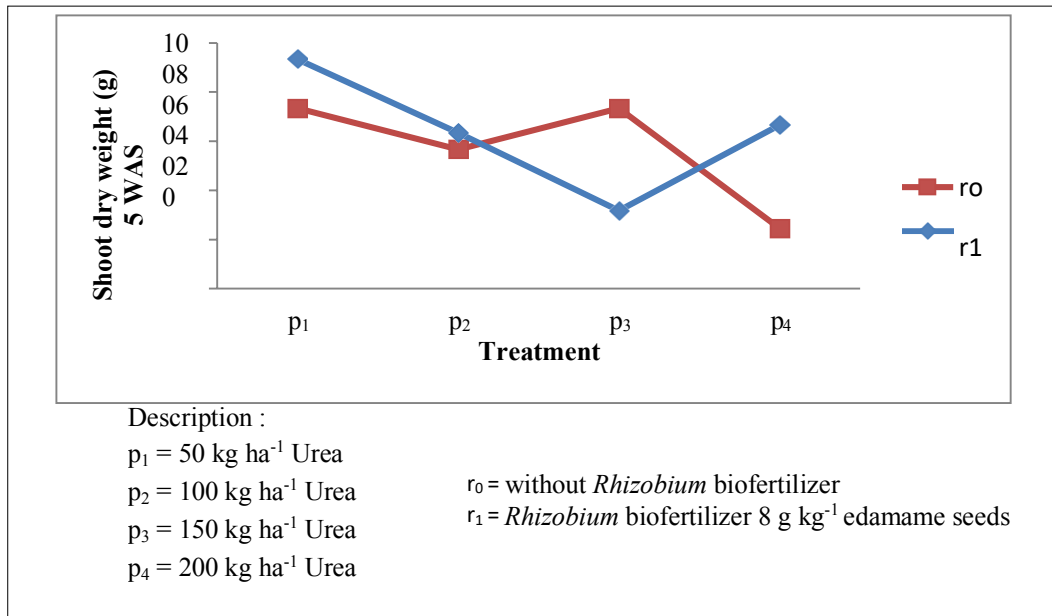


Figure 7. Graphic of shoot dry weight (g) at five weeks after sowing.

Table 4 and Figure 7 show that the greatest shoot dry weight at 5 WAS was observed on treatment p₁r₁ (9.3 g). This treatment was not significantly different with p₁r₀, p₂r₀, p₂r₁, p₃r₀, p₄r₀, and p₄r₁, but significantly different with p₃r₁.

The response between Urea and *Rhizobium* biofertilizer on root dry weight at five weeks after sowing (WAS) is presented in Table 5.

Table 5. Response of root dry weight (g) at five weeks after sowing to Urea and *Rhizobium* biofertilizer

Urea (kg ha ⁻¹)	<i>Rhizobium</i> biofertilizer	
	r ₀ = without <i>Rhizobium</i> biofertilizer	r ₁ = 8g kg ⁻¹ edamame seeds
p ₁ = 50	3.1 ^b	3.1 ^b
p ₂ = 100	2.0 ^{ab}	2.1 ^{ab}
p ₃ = 150	2.1 ^{ab}	1.5 ^a
p ₄ = 200	1.8 ^{ab}	1.7 ^{ab}

Remark: Different letters indicate significant difference at p<0.05 (Tukey HSD test)

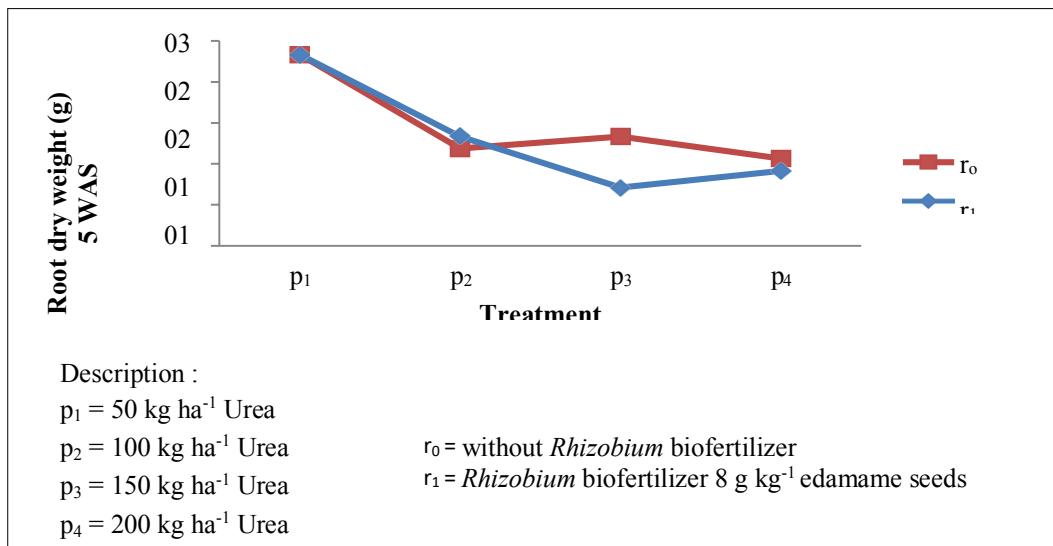


Figure 8. Graphic of root dry weight (g) at five weeks after sowing.

Table 5 and Figure 8 show that the greatest root dry weight at 5 WAS was observed on treatment p_{1r_0} and p_{1r_1} (3,1 g). These treatments were not significantly different with p_{2r_0} , p_{2r_1} , p_{3r_0} , p_{4r_0} , and p_{4r_1} , but significantly different with p_{3r_1} .

Discussion

Plant height of edamame soybean at two up to five weeks after sowing showed response to interaction of Urea fertilizer and Rhizobium fertilizer. It was observed that 50 kg ha⁻¹ of Urea fertilizer combined with Rhizobium biofertilizer 8 g kg⁻¹ of edamame seeds was able to increase the plant height.

According to (Supriono, 2021), the application of Urea fertilizer of 100 kg ha⁻¹ has already increased the height of edamame soybean. In addition, (Surtiningsih & Nurhariyati, 2009) stated that additional bacteria *Rhizobium* as inoculant material can increase the plant height of edamame soybean. The same author also mentioned that the combination between Urea fertilizer and *Rhizobium* biofertilizer is effective in fixing N₂ from the atmosphere and maximize N nutrient absorption by plant.

Application of N fertilizer and *Rhizobium* biofertilizer in this study was appropriate with whose stated that N nutrient is a dominant element among other nutrient elements in supporting plants vegetative period. The application of N nutrient and *Rhizobium* as inoculants can optimize the growth of soybean plants. According to Kuswandi in (Soverda, 2009) the increased of chlorophyll and the number of formed leaves, the better of photosynthesis process, and the more photosynthate is produced, leading to the better growth of soybean. This an increase plant growth rate will tend to produce higher plant dry weight.

(Buckman & Brady, 1982) stated that the dry weight influenced by N nutrient inside the plant that is functioned to expand leaf area and increasing protein in the plant. This matter is in accordance with (Sutedjo, 2002) which stated that N nutrient could increase the growth of roots of edamame soybean which is also affecting root dry weight. Furthermore, application of small amount of N fertilizer (40 kg N ha⁻¹) in combination with Rhizobial inoculation seemed to be appropriate cultivation practice for increasing the productivity of soybean (Ahmed, 2013). This condition generates a good environment for increasing the rate of photosynthesis and respiration, therefore it would support the plant growth in general. Furthermore, based on the result of research by (Sánchez-Cabrera et al., 2021) the combination of N fertilizer 150 kg ha⁻¹, P fertilizer 100 kg ha⁻¹ and K fertilizer 75 kg ha⁻¹ can stimulate the rate of photosynthesis so that it has a significant effect on addition of plant dry weight. This is in line with the statement of (Purbayanti et al., 1995), that the addition of N nutrient combined with other nutrients such as P and K will increase plant dry weight.

4. Conclusion

The application of Urea 50 kg ha⁻¹ combined with *Rhizobium* biofertilizer increased plant growth of edamame on peat soil. This result might be used as reference for edamame cultivation in wetland area.

5. References

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