

Effect of Boron Fertilizer and Double Inoculation of *Rhizobium sp* and Phosphate Solubilizing Bacteria on Soybean Growth and Production (*Glycine Max L.*)

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Abstrak. Soybean is an essential source of protein for human life. Efforts to improve the quality and quantity of soybean yields can be achieved by fertilizing such as biological fertilizers and micro fertilizers to meet the nutritional needs of plants during growth. This study aims to examine the effect of doses of boron fertilizer and double inoculation doses of *Rhizobium sp.* and Phosphate Solubilizing Bacteria (PSB) on soybean growth and production. This research was conducted using a completely randomized design (CRD) with a 3x4 factorial pattern with three replications. The first factor was the dose of boron fertilizer (B) with 3 treatment levels, namely B0 = 0 kg/ha (Control), B1 = 1 kg/ha, B2 = 2 kg/ha, B3 = 3 kg/ha. The second factor was the double inoculation dose of *Rhizobium sp.* and PSB (R) with four treatment levels, namely R0 = control, R1 = 6 g/seed, and R2 = 12 g/seed. The results showed that the double inoculation dose of *Rhizobium sp.* and PSB 12 g/seed managed to produce the best number of pods, number of seeds, weight of seeds, and number of root nodules. The application of boron fertilizer has not been able to affect soybean growth and production.

Keywords: Soybean, *Rhizobium*, PSB, Boron

1. Preface

Soybean (*Glycine max L.*) is a plant that belongs to the legume family. Soybean is a legume that plays a key role as a source of protein. Soybeans are one of the cultivated plants that contain high nutrients, including 30-50% protein and also high-fat content, which is 16% [1]. Based on data from BPS (Badan Pusat Statistika or Central Statistics Agency) in Indonesia, soybean production in 2017 was 538,738 tons and decreased from 2016, when soybean production 2016 was 859,653 tons. Soybean production in Indonesia is decreasing due to inadequate planting area, low productivity, and lack of attention to its cultivation techniques. Efforts to improve the quality and quantity of soybean yields can be done by fertilizing such as biological fertilizers and micro fertilizers to meet the nutritional needs of plants during growth.

Boron is a micronutrient that plays an important role in plant growth and production. Boron in the soil is available in the form of hydrate norate ion $B(OH)_4^-$, absorbed by plants in the form of boric acid (H_2BO_3) and the boron content available to plants is 5% of the total boron in the soil [2]. In soybean plants, boron plays a role in the transfer of sugar and nutrients, flower pollination, and seed formation [3]. The addition of boron fertilizer is also able to increase the chlorophyll content and the number of stomata so that it will affect photosynthesis and be able to produce

assimilation for plant growth and development [4]. Boron fertilization in soybeans can increase soybean yield potential by increasing branching, pod number, and various physiological processes that can contribute to higher seed yields [5]. Boron can increase the number of root nodules so that there is a symbiosis with nitrogen-fixing bacteria, the number of effective root nodules in the soil is also influenced by the number of nitrogen-fixing bacteria that already exist in the soil.

Bacteria *Rhizobium sp.* is a group of bacteria in symbiosis with leguminous plants that can fix the abundant nitrogen in the air and the mooring results can be used for plant growth [1]. This *Rhizobium sp* bacteria has the characteristic that it can attack the root hairs of legumes in temperate climates or some tropical areas and encourage the production of root nodules which make the bacteria an intracellular symbiosis [6]. These bacteria form root nodules (nodules) on the roots of soybean plants, and it is through these root nodules that the *Rhizobium sp* bacteria embed or fix nitrogen from the air so that it can be used by plants. *Rhizobium* bacteria can have a positive impact on soil physical and chemical properties, namely by improving soil structure, soil organic matter sources, and increasing nutrient sources N. *Rhizobium* is known to be beneficial in directly accelerating plant growth and development by producing growth regulators and improving nutrient uptake [7].

Phosphate solubilizing bacteria (PSB) are soil bacteria that can dissolve phosphate so that it can be absorbed by plants. Phosphate solubilizing bacteria play a role in increasing phosphate in the soil and play a role in vitamin D metabolism, improving root growth and increasing nutrient uptake. Phosphate solubilizing bacteria also dissolve P by the mechanism of releasing enzymes, soil enzymes that play a role in the process of mineralizing organic P compounds into inorganic P are a group of enzymes known as phosphatases. These phosphate solubilizing bacteria can produce organic acids that can chelate Al, Fe, Ca, and Mg to form stable organometal complexes and P becomes available to plants. Inoculation of phosphate solubilizing bacteria into the soil will also accelerate the decomposition process of organic matter, thus accelerating the addition of organic P.

2. Materials dan Methods

The research was conducted at the Greenhouse Agrotechnopark, Faculty of Animal Husbandry and Agriculture, Diponegoro University. The materials used in this study were soybean seeds of the Grobogan variety, soil, urea, KCl, SP-36, boron, and water. Ingredients for 1 liter of Yeast Mannitol Agar (YEM) + Congo Red (CR) media in the form of 0.5 g K₂HPO₄, 0.2 g MgSO₄·7H₂O, 20 g NaCl, 10 g Mannitol, 1 g yeast extract, 20 g bacto agar, 2.5 ml congo red 1%. Ingredients for 1 liter of Pikovskaya media are 10 g glucose, 5 g Ca₃(PO₄)₂, 0.5 g (NH₄)₂SO₄, 0.2 g KCl, 0.1 g MgSO₄·7H₂O, 0.1 g MnSO₄, 0.1 g FeSO₄, 0.5 g yeast extract, and 15 g of agar, NA media material consisted of 2.8 g of NA and 100 ml of distilled water. The tools used in the cultivation of soybeans are polybags measuring 35 cm x 35 cm, shovels, manual scales, barrels, stoves, gas, filters, rafia ropes, sprinkler, stakes, base plates, meter, sprayer, digital scales, meter, label, stationery, and cell phones. The tools used in the observations in the laboratory are analytical balance, pipette, micropipette, microtip, Bunsen flame, measuring cup, Erlenmeyer, petri dish, test tube, tube rack, mortar, autoclave, oven, laminar air flow, shaker, stirrer, ose, incubator and spectrophotometer.

The research procedure begins with the preparation of YEMA+CR and Pikovskaya media and the manufacture of *Rhizobium sp.* and phosphate solubilizing bacteria with the carrier medium in the form of peat soil. Planting is done by putting the soil into a polybag measuring 35x35 cm with a weight of 6 kg/polybag. The seeds that have been mixed with peat soil are then planted in each polybag of 3 soybean seeds. Fertilization is done by giving N, P, and K fertilizers which are given when the plants are 15 and 30 days after planting. The application of boron fertilizer was carried out at the age of 3 WAP and 5 WAP.

The design used in this study was a completely randomized design (CRD). The first factor was the dose of boron fertilizer (B) with 3 treatment levels, namely B0 = 0 kg/ha (Control), B1 = 1 kg/ha, B2 = 2 kg/ha, B3 = 3 kg/ha. The second factor was the double inoculum dose of *Rhizobium sp.* and PSB (R) with 4 treatment levels, namely R0 = control, R1 = 6 g/seed, and R2 = 12 g/seed. This study used 12 combinations with 3 replications to obtain 36 treatment units. The parameters of soybean growth and production observed included plant height, number of pods, number of seeds, seed weight, and number of effective root nodules.

3. Result and Discussion

3.1. Plant Height

The results of the analysis of variance showed that there was no interaction between the various doses of *Rhizobium sp.* and Phosphate solubilizing bacteria with a dose of boron fertilizer on the parameters of soybean plant height. The treatment of giving various doses of double inoculum of *Rhizobium sp.* and different phosphate solubilizing bacteria and different doses of boron fertilizers showed no significant effect on the parameters of soybean plant height. The results of the Duncan Multiple Range Test (DMRT) treatment of multiple doses of *Rhizobium sp.* and Phosphate solubilizing bacteria with a dose of boron fertilizer on the parameters of soybean plant height can be seen in Table 1.

Table 1. Soybean Plant Height at *Rhizobium sp.* and PSB Doses with Boron Fertilizer Doses

Bacteria <i>Rhizobium</i> & PSB	Boron Fertilizer				Average
	0 kg/ha	1 kg/ha	2 kg/ha	3 kg/ha	
	----- cm -----				
0 g/seed	110,33	91,33	82,50	89,17	93,33
6 g/seed	95,67	100,83	109,67	98,33	101,13
12 g/seed	94,33	99,33	112,50	109,83	104,00
Average	100,11	97,17	101,56	99,11	

Based on Table 1. it was found that the dose treatment of *Rhizobium sp.* and Phosphate Solubilizing Bacteria (PSB) had no significant effect on soybean plant height. Soybean plant height in the treatment of *Rhizobium sp.* and PSB gave higher yields compared to no inoculum, although not significant. Inoculation of *Rhizobium sp.* and PSB had no significant effect on plant height, presumably due to environmental conditions that did not support *Rhizobium sp.* and PSB, thus affecting the growth of soybean plants. The ability of *Rhizobium sp.* and PSB which is less effective in increasing soybean plant growth is caused by different adaptability to the environment where it grows. [8] the activity of bacteria in providing nutrients is highly dependent on temperature, humidity, pH, food supply, and environmental conditions during growth. The application of *Rhizobium sp.* and PSB can increase plant height because of its ability to provide N and P nutrients needed by plants as important nutrients in metabolic processes, especially during cell elongation in the vegetative phase. [9] PSB can produce growth regulators (auxins, gibberellins) around the roots which cause an increase in plant height.

The dose of boron fertilizer did not significantly affect the number of soybean pods. The application of boron fertilizer on soybean plants at a dose of 2 kg/ha showed the highest yield among other treatments, although not significant. Factor that caused the boron treatment to have no significant effect was presumably weather factors with very high rainfall during the investigation process. High rainfall will affect the increase in humidity, decrease in temperature, and decrease in sunlight it will affect plant growth. [10] the availability of nutrients that are ready to be absorbed by plants and environmental conditions such as rainfall greatly affect the physiological processes of plants. Boron fertilizer can help plants accelerate cell elongation,

thereby increasing plant height. [11] The application of boron fertilizer can enlarge the cells and will affect the high volume of the crown as indicated by the height of the plant height parameter.

3.2. Number of Pods

The results of the analysis of variance showed that there was no interaction between the various doses of *Rhizobium sp.* and Phosphate solubilizing bacteria with a dose of boron fertilizer on the parameter of the number of soybean pods. The treatment of giving various doses of double inoculum of *Rhizobium sp.* and different phosphate solubilizing bacteria showed a significant effect ($p < 0.05$) on the number of soybean pods, but different doses of boron fertilizer had no significant effect. The results of the Duncan Multiple Range Test (DMRT) treatment of multiple doses of *Rhizobium sp.* and phosphate solubilizing bacteria with a dose of boron fertilizer on the parameters of the number of soybean pods can be seen in Table 2.

Table 2. Number of Soybean Pods at *Rhizobium sp.* and PSB Doses with Boron Fertilizer Doses

Bacteria <i>Rhizobium</i> & PSB	Boron Fertilizer				Average
	0 kg/ha	1 kg/ha	2 kg/ha	3 kg/ha	
	----- pieces -----				
0 g/seed	33,67	31,33	36,00	42,67	35,92 ^b
6 g/seed	36,67	42,33	43,33	39,00	40,33 ^b
12 g/seed	40,33	47,00	48,00	46,00	45,33 ^a
Average	36,89	40,22	42,44	42,56	

Note: Different superscript letters in the same column indicate significant differences based on DMRT ($p < 0.05$)

Based on Table 2. it was found that the dose treatment of *Rhizobium sp.* and Phosphate Solubilizing Bacteria affect the number of soybean pods. The number of soybean pods in the treatment of *Rhizobium sp.* and PSB gave higher yields compared to no inoculum. The number of soybean pods with a dose of *Rhizobium sp.* and PSB of 12 g/seed (R2) was not significantly different from the dose of 6 g/seed (R1), but the dose of *Rhizobium sp.* and PSB 12 g/seed (R2) was significantly different from the control treatment (R0), while the dose of *Rhizobium sp.* and PSB 6 g/seed (R1) was not significantly different from the control treatment (R0). The treatment of *Rhizobium sp.* and PSB with a dose of 12 g/seed (R2) gave the highest number of pods. This is due to the effectiveness of the double inoculation, so that the nutrients needed by plants are fulfilled. [12] inoculation of *Rhizobium sp.* which plays a role in stimulating the formation of root nodules, these root nodules help provide the N element and this element stimulates the formation of protein and protoplasm and chlorophyll which is ultimately able to assist the process of pod formation. While the role of PSB in the soil is that it can dissolve phosphate into available P in the soil, the function of phosphorus in plants is to accelerate flowering and increase the number of filled pods per plant. [9] with sufficient levels of N and P in soybean plants, it means that the assimilation will increase the number of filled pods per plant and can reduce the percentage of empty pods.

The dose of boron fertilizer did not significantly affect the number of soybean pods. The application of boron fertilizer on soybean plants at a dose of 3 kg/ha showed the highest yield among other treatments, although not significant. Application of boron fertilizer can increase the number of pods, because the application of boron to soybean plants will increase the percentage of flowers that turn into pods so that it can increase the number of pithy pods. [11] application of boron fertilizer can increase flower pollination, so that a high number of flowers that do not wilt can increase the total number of pods which allows the number of filled pods to increase. [13] Boron (B) functions to increase the number of flowers which also results in the number of pods formed.

3.3. Number of Seeds

The results of the analysis of variance showed that there was an interaction between the various doses of the double inoculum of *Rhizobium sp.* and PSB with a dose of boron fertilizer on the parameter of the number of soybean seeds. The treatment of giving various doses of double inoculum of *Rhizobium sp.* and different PSB showed a significant effect ($p < 0.05$) on the number of soybean seeds, but different doses of boron fertilizer had no significant effect. The results of the Duncan Multiple Range Test (DMRT) treatment of multiple doses of *Rhizobium sp.* and PSB with boron fertilizer dose on the number of soybean seeds parameters can be seen in Table 3.

Tabel 3. Number of Soybean Seeds at *Rhizobium sp.* and PSB Doses with Boron Fertilizer Doses

Bacteria <i>Rhizobium</i> & PSB	Boron Fertilizer				Average
	0 kg/ha	1 kg/ha	2 kg/ha	3 kg/ha	
	----- pieces -----				
0 g/seed	85,00 ^{ab}	55,00 ^d	60,67 ^{cd}	78,67 ^{abc}	69,83 ^b
6 g/seed	70,33 ^{bcd}	93,00 ^a	88,00 ^{ab}	79,33 ^{ab}	82,67 ^a
12 g/seed	75,67 ^{abcd}	86,67 ^{ab}	95,67 ^a	86,33 ^{ab}	86,08 ^a
Average	77,00	78,22	81,44	81,44	

Note: Different superscript letters in the same column indicate significant differences based on DMRT ($p < 0.05$)

Based on Table 3. it was found that the dose treatment of *Rhizobium sp.* and Phosphate Solubilizing Bacteria affect the number of soybean seeds. The number of soybean seeds in the treatment of *Rhizobium sp.* and PSB gave higher yields compared to no inoculum. The number of soybean seeds with a dose of *Rhizobium sp.* and PSB of 12 g/seed (R2) was not significantly different from the dose of 6 g/seed (R1), but the dose of *Rhizobium sp.* and PSB 12 g/seed (R2) and 6 g/seed (R1) were significantly different from the control treatment (R0). In the treatment of *Rhizobium sp.* and PSB with a dose of 12 g/seed (R2) gave the highest number of seeds. This is due to the effectiveness of each of the bacteria *Rhizobium sp.* and inoculated PSB are able to work together to provide sufficient nutrients for biochemical processes that occur in plants, so that the administration of double inoculum at the right dose can provide a synergistic effect on the number of plant seeds. [14] the combination of *Rhizobium sp.* and PSB with the right dose is more synergistic, because an increase in plant N will affect the rate of P uptake, and result in the rate of seed filling, where it is known that plants need high N and P for seed formation. [9] sufficient P causes the formation of flowers and seeds to be more perfect.

The dose of boron fertilizer did not significantly affect the number of soybean seeds. The application of boron fertilizer on soybean plants at a dose of 2 kg/ha and 3 kg/ha showed the same and higher results among other treatments, although not significant. [11] boron affects fertilization by increasing pollen production in the anthers and viability of pollen grains, resulting in an increase in the percentage of flowers turning into pods, an increase in the percentage of flowers turning into pods will increase the number of pods. seed. [3] the application of boron fertilizer is basically able to increase the number of soybean seeds, because in soybeans boron plays a role in the transfer of sugar and nutrients, flower pollination, and seed formation.

The interaction between treatment doses of *Rhizobium sp.* and Phosphate Solubilizing Bacteria 12 g/seed with a dose of boron fertilizer of 2 kg/ha gave the best results on the parameters of the number of soybean seeds, but not significantly different from the treatment with an inoculum dose of 12 g/seed and a boron fertilizer dose of 0 kg/ha (B0R2), the inoculum dose was 12 g/seed and the boron fertilizer dose was 1 kg/ha (B1R2), and the inoculum dose was 12 g/seed and the boron fertilizer dose was 3 kg/ha (B3R2). The interaction between the two treatments had a significant effect because each treatment worked synergistically so that it was effective in increasing the number of soybean seeds. [2] boron can increase the number of

root nodules so that there is a symbiosis with nitrogen-fixing bacteria, the number of effective root nodules in the soil is also influenced by the number of nitrogen-fixing bacteria that are already in the soil, so it can assist in the process plant growth and production.

3.4. Seed Weight

The results of the analysis of variance showed that there was no interaction between the various doses of *Rhizobium sp.* and Phosphate solubilizing bacteria with boron fertilizer dose on soybean seed weight parameters. The treatment of giving various doses of double inoculum of *Rhizobium sp.* and different phosphate solubilizing bacteria showed a significant effect ($p < 0.05$) on the parameters of soybean seed weight, but different doses of boron fertilizer had no significant effect. The results of the Duncan Multiple Range Test (DMRT) treatment of multiple doses of *Rhizobium sp.* and Phosphate solubilizing bacteria with a dose of boron fertilizer on the weight parameters of soybean plants can be seen in Table 4.

Tabel 4. Soybean Seed Weight at *Rhizobium sp.* and PSB Doses with Boron Fertilizer Doses

Bacteria <i>Rhizobium</i> & PSB	Boron Fertilizer				Average
	0 kg/ha	1 kg/ha	2 kg/ha	3 kg/ha	
	----- pieces -----				
0 g/seed	9,83	6,00	7,67	8,50	8,00 ^b
6 g/ seed	8,67	10,00	9,33	8,83	9,21 ^{ab}
12 g/ seed	9,50	9,83	10,17	10,50	10,00 ^a
Average	9,33	8,61	9,06	9,28	

Note: Different superscript letters in the same column indicate significant differences based on DMRT ($p < 0.05$)

Based on Table 4. it was found that the dose treatment of *Rhizobium sp.* and PSB affect soybean seed weight. The weight of soybean seeds in the treatment of *Rhizobium sp.* and PSB gave higher yields compared to no inoculum. The weight of soybean seeds with a dose of *Rhizobium sp.* and PSB of 12 g/seed (R2) was not significantly different from the dose of 6 g/seed (R1), but the dose of *Rhizobium sp.* and PSB 12 g/seed (R2) was significantly different from the control treatment (R0). In the treatment of *Rhizobium sp.* and PSB with a dose of 12 g/seed (R2) gave the highest seed weight yield. This is due to the interaction between the inoculation of biological fertilizer *Rhizobium sp.* and phosphate solubilizing bacteria can synergistically increase the weight of soybean seeds. [15] the inoculation of *Rhizobium sp.* and PSB synergistically increase the availability of N and P nutrients optimally which affects the functional balance which can increase the weight of plant seeds up to 17.20%. [16] the presence of *Rhizobium sp.* in an effective manner, 50-75% of the total nitrogen requirement can be met from fixation by *Rhizobium sp.*, and causes an increase in seed weight.

The dose of boron fertilizer did not significantly affect the weight of soybean seeds. Application of boron fertilizer on soybean plants with a dose of 0 kg/ha (control) showed the highest yield among other treatments. Similar studies show different results with this study. [17] boron fertilizer can basically increase seed weight by stimulating physiological processes during the reproductive phase, especially the pollen germination process and pollen elongation. [18] boron is also involved in the carbohydrate translocation system in plants, including seed filling.

3.5. The Effective Nodule Number

The results of the analysis of variance showed that there was no interaction between the various doses of *Rhizobium sp.* and Phosphate solubilizing bacteria with a dose of boron fertilizer on the

parameters of the number of effective root nodules of soybean plants. The treatment of giving various doses of double inoculum of *Rhizobium sp.* and different phosphate solubilizing bacteria showed a significant effect ($p < 0.05$) on the number of effective root nodules in soybeans, but different doses of boron fertilizer had no significant effect. The results of the Duncan Multiple Range Test (DMRT) treatment of multiple doses of *Rhizobium sp.* and Phosphate solubilizing bacteria with a dose of boron fertilizer on the parameters of the number of effective root nodules of soybean plants can be seen in Table 5.

Tabel 5. The Number of Effective Root Nodules of Soybeans at *Rhizobium sp* and PSB Doses with Boron Fertilizer Doses

Bacteria <i>Rhizobium</i> & PSB	Boron Fertilizer				Average
	0 kg/ha	1 kg/ha	2 kg/ha	3 kg/ha	
	----- pieces -----				
0 g/ seed	0,000	0,667	1,000	1,333	0,750 ^b
6 g/ seed	1,667	1,667	2,333	3,000	2,167 ^{ab}
12 g/seed	3,667	3,000	5,667	4,333	4,167 ^a
Average	1,778	1,778	3,000	2,889	

Note: The different superscript letters in the same column show significant differences based on DMRT ($p < 0.05$)

Based on Table 5. it was found that the dose treatment of *Rhizobium sp.* and PSB affect the number of effective root nodules of soybean plants. The number of effective root nodules of soybean plants in the treatment of *Rhizobium sp.* and PSB gave higher yields compared to no inoculum. The number of effective root nodules of soybean plants with a dose of *Rhizobium sp.* and PSB of 12 g/seed (R2) was not significantly different from the dose of 6 g/seed (R1), but the dose of *Rhizobium sp.* and PSB 12 g/seed (R2) was significantly different from the control treatment (R0). In the treatment of *Rhizobium sp.* and PSB with a dose of 12 g/seed (R2) gave the highest number of effective root nodules. The existence of symbiosis between the bacteria *Rhizobium sp.* Soybean plants are able to produce nitrogen-fixing organs, namely root nodules. [12] the bacterium *Rhizobium sp.* can fix the fixation of N₂ into the roots and these bacteria will symbiotically form root nodules. Provision of inoculum *Rhizobium sp.* This causes the fixation of free nitrogen in the air more effectively so that it can increase the number of effective root nodules. [1] the effective symbiotic ability is known through the formation of root nodules on plants inoculated with *Rhizobium*, which means the nitrogen fixation process is going well.

The dose of boron fertilizer did not significantly affect the number of root nodules of soybean plants. The application of boron fertilizer to soybean plants at a dose of 2 kg/ha showed the highest yield among other treatments, although not significant. Similar studies show different results with this study. [19] boron can regulate the formation of root nodules and increase the number of root nodules so that symbiosis occurs with nitrogen-fixing bacteria. [20] boron is involved in the formation of *Rhizobium* and legume symbiosis, because boron is required for the development of nodule infection threads.

4. Conclusion

The bacterial inoculum of *Rhizobium sp.* and PSB affected the number of pods, number of seeds, seed weight, and number of effective root nodules. Inoculum *Rhizobium sp.* and PSB with a dose of 12 g/seed gave the highest yield on soybean production. The application of boron fertilizer did not improve soybean growth and production, while the interaction between doses of *Rhizobium sp.* and PSB with a dose of boron fertilizer affects the number of soybean seeds.

References

- [1] Purwaningsih S 2015 Pengaruh inokulasi *rhizobium* sp. terhadap pertumbuhan tanaman kedelai (*Glycine max* L.) varietas wilis di rumah kaca *J. Berita Biologi*, **14** 1 69-76.
- [2] Nurani K C, Budiyanto S, dan Purbajanti E D 2020 Dosis dan waktu aplikasi boron terhadap pertumbuhan dan hasil kacang hijau *J. Penelitian Agronomi*, **22** 2 64-71.
- [3] Sari E P, Agustiansyah, dan Nurmiaty Y 2015 Pengaruh penyemprotan boron dan silika terhadap pertumbuhan dan produksi benih kedelai (*Glycine max* (L.) Merrill) *J. Agrotek Tropika*, **3** 1 36-40.
- [4] Julita H D, Syamsuddin dan Hayati R 2016 Pengaruh pemberian nitrogen dan boron melalui daun terhadap mutu benih kedelai (*Glycine max* L. Merrill) *J. Floratek*, **11** 1 10-17.
- [5] Devi K N, Singh L N K, Singh M S, Singh S B dan Singh K K 2012 Influence of sulphur and boron fertilization on yield, quality, nutrient uptake and economics of soybean (*Glycine max*) under upland conditions *J. of Agricultural Science*, **4** 4 1-10.
- [6] Sari R dan Prayudyaningsih R 2015 *Rhizobium* : pemanfaatannya sebagai bakteri penambat nitrogen. *Buletin Eboni*, **12** 1 51-64.
- [7] Ni'am A M dan Bintari S H 2017 Pengaruh pemberian inokulan legin dan mulsa terhadap jumlah bakteri bintil akar dan pertumbuhan tanaman kedelai varietas grobogan *J. Mipa*, **40** 2 80-86.
- [8] Lestari W, Linda T M dan Martina A 2021 Kemampuan bakteri pelarut fosfat isolate asal sei garo dalam penyediaan fosfat terlarut dan serapannya pada tanaman kedelai *J. Biospecies*, **4** 2 : 1-5.
- [9] Marlina N dan Gusmiatun 2020 Uji efektivitas ragam pupuk hayati untuk meningkatkan produktivitas kedelai di lahan lebak *J. Agrosaintek*, **4** 2 129-136.
- [10] Margaretha C, Yafizham Y, Hidayat K F dan Karyanto A 2015 Pengaruh kombinasi dosis pupuk anorganik dan pupuk slurry cair terhadap pertumbuhan dan produksi tanaman kacang hijau (*Phaseolus radiatus* L.) *J. Agrotek Tropika*, **3** 1 18-23
- [11] Ermawati, Agustiansyah dan Sandhy P D A 2018 Pengaruh penyemprotan boron dan GA pada pertumbuhan, produksi dan mutu benih kedelai (*Glycine max* L.) *J. Agrotek Tropika*, **6** 2 72-78.
- [12] Meitasari A D dan K P Wicaksono 2017 Inokulasi *rhizobium* dan penimbangan nitrogen pada tanaman kedelai (*Glycine max* (L) Merrill) varietas wilis *J. Plantropika*, **2** 1 55-63.
- [13] Walid L F dan Susylowati 2016 Pengaruh konsentrasi pupuk organik cair (POC) terhadap pertumbuhan dan hasil beberapa varietas tanaman kedelai (*Glycine max* (L.) Merrill) *J. Ziraah*, **41** 1 84-96.
- [14] Hanum C 2010 Pertumbuhan dan hasil kedelai yang diasosiasikan dengan *Rhizobium* pada zona iklim kering E (klasifikasi oldeman) *J. Ilmu-ilmu Hayati dan Fisik* **12** 3 176-183.
- [15] Salman S dan U Dani 2021 Sinergisme inokulasi *bradyrhizobium* japonicum dan mikroba pelarut fosfat terhadap pertumbuhan dan hasil tanaman kedelai *J. Agrivet*, **9** 2 167-175.
- [16] Purwaningsih O, Indradewa D, Kabirun S dan Shiddiq D 2012 Tanggapan tanaman kedelai terhadap inokulasi *rhizobium* *J. Agrotrop*, **2** 1 25-32.
- [17] Misra S M dan B D Patil 1987 Effect of boron on seed yield in lucerne (*Medicago sativa* L.) *J. Agron. Crop Scie*, **158** 1 7-34.
- [18] Rosliani R, Palupi E R dan Hilman Y 2012 Penggunaan benzil amino purin dan boron untuk meningkatkan produksi dan mutu benih true shallots seed bawang merah (*Allium cepa* var. ascalonicum) di dataran tinggi *J. Hort*, **22** 3 242-250.
- [19] Raj A B dan Raj S K 2019 Zinc and boron nutrition in pulses: a review *J. of Applied and Natural Science*, **11** 3 673-679.
- [20] Hamdaoui A E, Nieto M R, Rivilla R, Bonilla I dan Bolanos L 2003 Effects of boron and calcium nutrition on the establishment of the *rhizobium* leguminosarum-pea (*Pisum sativum*) symbiosis and nodule development under salt stress *J. Plant, Cell and Environment*, **26** (1003-1011).