Rhizobium and organic fertilizer improve growth and development of soybean (*Glycine max* L.)

A Anhar1*, A Marliah1, E Nurahmi2, Nurhayati2, Jumini2, Nura3 and E Hayati3

1 Department of Agrotechnology, Faculty of Agriculture, Universitas Syiah Kuala, Darussalam – Banda Aceh, 23111
2 Laboratorium of Crop Physiology, Faculty of Agriculture, Universitas Syiah Kuala, Darussalam – Banda Aceh Indonesia
3 Laboratorium of Genetics and Plant Breeding, Faculty of Agriculture, Universitas Syiah Kuala, Darussalam – Banda Aceh Indonesia

*E-mail: ashabul.anhar@unsyiah.ac.id*

**Abstract.** This study aims to examine the effect of the combination between rhizobium and organic fertilizer on growth and development of soybean. This study was conducted in the Research Station of Agriculture Faculty, University of Syiah Kuala, Banda Aceh from October to November 2016. This experiment as arranged in a non-factorial randomized completely block design three replications. The treatment were: control (without rhizobium and organic fertilizer), without rhizobium + organic fertilizer, rhizobium + without organic fertilizer, rhizobium + organic fertilizer, 0.5 dosage of rhizobium + 0.5 dosage of organic fertilizer. The variables observed were plant height, number of leaves, number of nodules and number of effective nodules. Treatment between rhizobium and organic fertilizer resulted in higher soybean high and number of leaves. Treatments without organic fertilizer resulted in higher number of nodules and effective nodules. That means that the number of nodules and effective nodules were better when the medium was without organic fertilizer.

1. **Introduction**

Soybean (*Glycine max* L.) is very important in meeting Indonesian national food needs [1]. Indonesia’s soybean production has fluctuated in recent years. In 2018, it reached 982,598 tons, which was increased from 538,728 tons in 2017, and 859,653 tons in 2016, but it was actually closed to the production in 2015, that was 963,183 ton. Unfortunately, the domestic production did not meet Indonesian consumption, which was around 2.5 million tons. Efforts to achieve self-sufficiency in soybeans in Indonesia face several main problems, including: inadequate planting areas, because they have to adjust to cropping patterns and rotations; low productivity; and the profit from soybean farming is relatively low when compared to other crops, especially corn.

One of the efforts to increase soybean production in Indonesia is by expanding the planting area of soybeans to suboptimal land or acid dry land [2]. The area of acid land in Indonesia is estimated at 18.5 million ha. In addition to low pH, PMK soil also contains low levels of C-organic, nutrients N, P and Ca, high Al, Fe and Mn which are constraints for plant growth [3].

Soybean is one of the legume plants that can utilize energy sources biologically [4]. The symbiosis of legume and rhizobium is able to utilize nitrogen (*N*₂). Rhizobium converts the element nitrogen (*N*₂)
into ammonia (NH₃) so that it accounts for 65% of nitrogen needs in agriculture. Inoculation is generally done by giving a culture of Rhizobium sp. into the soil so that these bacteria associate with legume plants and bind free N₂ from the air.

The application of inorganic fertilizers without the application of organic fertilizers is not able to increase soybean productivity. Provision of inorganic fertilizers continuously can have a negative impact on soil fertility and plant productivity can decrease. To increase the productivity and quality of soybean seeds is the provision of organic fertilizers. Organic fertilizers are fertilizers derived from dead plants, animal manure and animal parts or other organic waste that have been engineered, in solid or liquid form, which can be enriched with minerals and microbes which are useful for increasing nutrient content and soil organic matter and can improve soil physical, chemical and biological properties. The purpose of this study was to examine the effect of the combination between rhizobium and organic fertilizer on growth and development of soybean [5].

2. Materials and methods
This study was conducted at the Research Station of Agriculture Faculty, University of Syiah Kuala, Aceh from October to November 2016. The experiment was arranged in a non-factorial randomized completely block design with three replications. The factor was combination between rhizobium and organic fertilizer (Table 1).

| Treatments | Combinations                                      |
|------------|---------------------------------------------------|
| R₀P₀       | control (without rhizobium + without organic fertilizer) |
| R₀P₁       | without rhizobium + organic fertilizer            |
| R₁P₀       | rhizobium + without organic fertilizer            |
| R₁P₁       | rhizobium + organic fertilizer                     |
| R₀₀P₀₀₅     | 0.5 dosage of rhizobium + 0.5 dosage of organic fertilizer |

The seeds were Anjasmoro soybean varieties. Before planting, the seeds that were relatively the same size were selected, moistened with water and mixed with rhizobium powder. Then, the seeds were dried and aired in the shade. Seeds were planted at land that previously had been prepared with planting holes 2-3 cm deep as much as 1-2 seeds per hole. Thinning was done a week after planting, leaving one plant per hole. Maintenance of the plants was watering, weeding and controlling pests and diseases. The variables observed were plant height, number of leaves, number of nodules and number of effective nodules at vegetative stages.

3. Results and discussion
3.1. Plant height
Height of soybean treated with rhizobium + organic fertilizer at 7 day after planting (DAP) higher than those treated with 0.5 dosage of rhizobium + 0.5 dosage of organic fertilizer (Figure 1). At 14, 21, and 28 DAP, height of soybean treated rhizobium + organic fertilizer was not significantly different with other treatments. The results of this study are in line with the results of the study [6] which stated that rhizobium did not significantly affect plant height at the age of three and six weeks after planting on soybean plants.
Figure 1. The mean of soybean height at 7, 14, 21, and 28 DAP due to combination of rhizobium and organic fertilizer; the same letter on the same boxes pattern and colour are not significantly different (LSD P<0.05); R0P0 - control (without rhizobium + without organic fertilizer); R1P0 – (without rhizobium + organic fertilizer); R0P1 – (rhizobium + without organic fertilizer); R0.5P0.5 – (0.5 dosage of rhizobium + 0.5 dosage of organic fertilizer); R1P1 - (rhizobium + organic fertilizer).

Soybean treated with rhizobium + organic fertilizer resulted in the highest plant height. The result indicated that the combination of rhizobium inoculation and organic fertilizer increased in soybean plant height (Figure 1). The results are in line with the finding by [7] showed that the highest soybean plant height was occurred in the fourth to sixth week of observation, that was an increase in 113% and 112%, respectively, for giving rhizobium than without rhizobium.

Rhizobium inoculation in soybean did not always give better results. It did not always have a good effect on plant growth. and in some cases, it was often failed. Several factors are thought to be the cause of this, such as the low ability of indigenous bacteria (natural bacteria) to infect roots, as well as the effect to the development and activity of rhizobium in the soil. The factors are the content of organic matter, moisture, aeration, temperature, soil acidity, supply organic nutrients, soil type and percentage of sand and clay [8] The combination of rhizobium and organic fertilizer. This was in accordance with the finding of [9] which stated that there was a significant effect on plant height because the microbes applied were able to decompose organic fertilizer for plant growth and development.
3.2. Number of leaves

Mean of the number of soybean leaves was significantly affected by combination of rhizobium and organic fertilizer treatments at 7, 14, 21, and 28 DAP. At 7 and 14 DAP, soybean treated with 0.5 dosage of rhizobium + 0.5 dosage of organic fertilizer resulted in higher number of leaves (Figure 2). At 21 and 24 DAP, the soybean treated with rhizobium + organic fertilizer resulted in the highest number of leaves, which was significantly higher than control (Figure 2).

![Figure 2](image)

*Figure 2.* The mean of the number of soybean leaves at 7, 14, 21, and 28 days after planting due to combination of rhizobium and organic fertilizer; the same letter on the same boxes pattern and colour are not significantly different (LSD P<0.05); R0P0 - control (without rhizobium + without organic fertilizer); R1P0 – (without rhizobium + organic fertilizer); R0P1 – (rhizobium + without organic fertilizer); R0.5P0.5 – (0.5 dosage of rhizobium + 0.5 dosage of organic fertilizer); R1P1 - (rhizobium + organic fertilizer).

The addition of organic fertilizers gave insignificantly different results to the number of leaves from the first week of observation to the last week of observation. The number of leaves increased each week, but the increase was not significantly different between treatments, except with control or treatment without organic fertilizer. This was consistent with finding of [10], which stated that manure treatment had a significant effect on the number of leaves at a dose of 20 tons ha⁻¹. [11] stated that plant growth was associated with the number of leaves formed. The plants could well adapt to their environment and were able to take nutrients, water and CO₂ for photosynthesis, therefore, more leaves were formed. Rhizobium plays an important role in providing nutrient N, which forms root nodules of legumes that
function to fix N for plants. Nitrogen is the main nutrient for plant growth in the formation of plant vegetative organs such as leaves, stems and roots.

3.3. Number of effective nodules
Mean of the number of nodules and effective nodules were affected by combination of rhizobium and organic fertilizer treatments at 35 DAP. Rhizobium inoculation without organic fertilizer resulted in the highest number of nodules (Figure 3). Rhizobium inoculation without organic fertilizer resulted in more effective nodules, which was significantly higher than the other treatment (Figure 3).

![Figure 3](image.png)

**Figure 3.** The mean of the number of nodules and effective nodules at 35 days after planting due to combination of rhizobium and organic fertilizer; the same letter on the same boxes pattern and colour are not significantly different (LSD P<0.05); R0P0 - control (without rhizobium + without organic fertilizer); R1P0 – (without rhizobium + organic fertilizer); R0P1 – (rhizobium + without organic fertilizer); R0.5P0.5 – (0.5 dosage of rhizobium + 0.5 dosage of organic fertilizer); R1P1 - (rhizobium + organic fertilizer).

The number of nodules produced could be used to determine the level of treatment infectivity [12]. Infectivity is the ability of rhizobium bacteria to form nodules. Nodules will form if the plant roots at the germination level meet rhizobium. Nodules would effectively meet around 75% of soybean plant needs for nitrogen [13]. However, our result showed that the number of nodules and effective nodules were better when the medium without organic fertilizer. It mean that nodules formation would be inhibited when the soil was less fertile. Our finding was in line with [14] showed that co-inoculation
with rhizobia and AM fungi significantly increased soybean growth under low P and/or low N conditions as indicated by increased shoot dry weight, along with plant N and P content. In another study, [15, 16] showed that plants treated with chemical fertilizer formed the least number of rhizobium than treatment with no fertilizer.

4. Conclusion
Combination between rhizobium and organic fertilizer resulted in higher soybean high and number of leaves than those of control. Treatments without organic fertilizer resulted in higher number of nodules and effective nodules than those with organic fertilizer. That means that the number of nodules and effective nodules were better when the medium was without organic fertilizer.

References
[1] Kementerian Pertanian 2019 https://www.pertanian.go.id/Data5tahun/TPATAP-2017(pdf)/24-ProdKedelai.pdf 13 [diakses pada 13 August 2020]
[2] Dariah A and Heriyan N 2014 J. Sumberdaya Lahan Edisi Khusus: 1-16
[3] Sudaryono, Wijanarko A and Suyamto 2011 Penelitian Pertanian Tanaman Pangan 30 43-51
[4] Simon Z, Kelvin M and Amare G 2014 American J. of Plant Sci. 5 4050-67
[5] Pusat Penelitian dan Pengembangan Tanaman Pangan 2012 Berita Puslitbangtan No. 51 Oktober 2012
[6] Ramadhan I 2009 Balai Pengkajian Teknologi Pertanian (BPTP) Nusa Tenggara Barat
[7] Permanasari I, Mokhamad I and Abizar 2014 J. Agrotek 5 29-34
[8] Manasikana A, Lianah and Kusrinah 2019 Al-Hayat: J. of Bio and Applied Bio 2 133-43
[9] Muslihak S, Sudiarso, Setyobudi L 2016 J. Degraded and Mining Lands Management 4 709-15
[10] Gani J S A, Bahua M I and Zakaria F 2013 [Skripsi] Universitas Negeri Gorontalo, Gorontalo
[11] Ervina O, Andjarwati and Historiwati 2016 J. Ilmu Pertanian Tropika dan Subtropika 1 12-22
[12] Thomson J A, Bhromsiri A, Shutsriung A and Lillakan S 1991 J. Plant and Soil 135 53-65
[13] Sarief E S 1986 Kesuburan Tanah dan Pemupukan Tanah Pertanian Pustaka Buana Bandung 182p
[14] Wang X, Pan Q, Chen F, Yan X and Liao H 2011 Mycorrhiza 21 173-81
[15] Bhattarai N, Baral B, Shrestha G and Yami K D 2011 Scientific World 9 66-9
[16] Sudarjat, Kusumiayti, Hasanuddin, Munawar AA 2019. In: IOP Conference Series: Earth and Environmental Science. Institute of Physics Publishing.