Application of humic acid and Vesicular Arbuscular Mycorrhiza (VAM) for growth and production of soybean

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Abstract. This study aimed to determine the effect of the application of humic acid and Vesicular Arbuscular mycorrhiza (VAM) on the growth and production of soybean plants (Glycine max (L.) Merril). An experiment of a two-factor factorial design with randomized block design (RBD) took humic acid as the first factor consisting of 3 levels: 0% (v/v), 10% (v/v), and 15% (v/v); VAM as the second factor consisting of 3 levels: 0 g, 6 g, and 12 g. Results showed that the application of humic acid did not have a significant effect on the growth component and some production component, yet it had a significant effect on the number of leaves 70 dap. Treatment of Vesicular Arbuscular Mycorrhizae (VAM) application did not have a substantial impact on the growth component and some production components. Likewise, there was no interaction between the treatment of humic acid application and VAM on growth components and some components of soybean production. Humic acid with a concentration of 10% (v/v) showed the best results on parameters of plant height, number of leaves, number of branches, flowering age, and root volume, while application of 6 g VAM gave the best results for plant height, flowering age, seed weight, and seed production per polybag.

1. Introduction

Soybean (Glycine max (L.) Merril) is the most popular source of vegetable protein for Indonesian people with an average annual soybean demand of 2.2 million tons. The average consumption of tempeh per person per year in Indonesia was 6.99 kg and tofu 7.51 kg. Ironically, as much as 67.99% of soybean are imported [1-2].

Soybean is a versatile plant with free nitrogen-fixing nodules in the root. It has high protein content hence are usable as green fertilizer and animal feed [3]. Soybean seeds are rich in protein and fat and several other important nutrients, for example, vitamins (phytic acid) [4]. In order to reduce dependence on imported soybeans that continue to increase, efforts are needed to increase domestic soybean production, both in terms of quantity and quality.

Soil fertility factors are thought to be one of the causes of low soybean production, so efforts to improve soil fertility are an important step in efforts to improve soybean productivity. Among the ways to improve soil quality is the use of humic acid.

Improvement of plant interactions with the plant environment also determines plant fertility. As a consequence, the presence of agents capable of helping plants is important. Mycorrhiza is an association or symbiosis between plants and fungi that colonize the tissue of the root cortex during the active period of plant growth. Most vesicular plants are involved in this association. The association is
characterized by the movement of carbon produced by plants to fungi and the movement of nutrients obtained by fungi to plants. One type of soil microbes that has an important contribution to soil fertility by increasing the ability of plants to absorb nutrients such as phosphate, water, and other nutrients is VAM [5].

The purpose of this study was to determine the effect of the application of humic acid and mycorrhizae on the growth and production of soybean plants.

2. Humic acid
Humic acid is a chemical obtained by extracting the remaining humus with dilute ammonium hydroxide. Acidification of ammonia extract precipitates a crude mixture known as humic acid. It is generally believed that humic acid in the soil originates from decaying lignin or plant carbohydrates, but this material can also contain nitrogen and inorganic substances. Humic acid, together with soil plays a role in several soil chemical reactions that can improve soil properties and directly affect plant growth [5].

Humic acid has an essential role in supporting the life of microorganisms in the soil. This organic acid can increase membrane permeability and help facilitate nutrition to penetrate cell walls, increase chlorophyll production and photosynthesis, stimulate hormones, and increase enzyme activity [6].

Application of humic acid can improve soil, which is generally less suitable for plant growth. It is closely related to the increase in the solubility of Phosphor and the supply of N. Humic acid with its ability to bind and form complex compounds with metal ions will affect the availability of nutrients which are essential for plants growth. In addition to the availability of Phosphor in the soil, plant growth is also influenced by the good physical properties of the soil, so that it can create conditions that are good for root growth. Good physical properties of soil can affect the availability of water and nutrients for more easy absorption [7].

3. Mikoriza Vesikular Arbuskular (VAM)
The term mycorrhiza (or root fungus) was first applied to tree fungus associations in 1885 by A.B. Frank, a forest pathologist from Germany. Since then, it is known that most plants form symbiotic associations with fungi, with an estimated 95% of plants belonging to the genus that forms mycorrhizae [8].

VAM infection can increase plant growth and its ability to utilize nutrients, especially P, Ca, N, Cu, Mn, K, and Mg. Mycorrhizal colonization in plant roots can improve the area of root uptake by the presence of external hyphae which grow and develop through root hairs. Subsequently, the VAM mycelia can grow and spread out about 9 cm in roots [5].

4. Methodology
The study was conducted in the form of two-factor factorial experiments with Randomized Block Design (RBD) as environmental design. This study had 2 factors: humic acid application (h) consisting of h0 = no application; h1= 10% (v/v); h2= 15% (v/v). The second factor was application of VAM (m), consisting of m0 = no application; m1 = 6 g; and m2 = 12 g. Each treatment was repeated 3 times, hence there were 27 experimental units.

4.1. Application of humic acid.
For each experiment unit, application of humic acid for each concentration was made with 100 ml of solution. For 10% (v/v) application, 10 ml of humic acid was diluted with 90 ml of water, whereas for the treatment of 5 % (v/v), 5 ml of humic acid was added into 95 ml of water. These solutions were applied to the plant by mixing it to the planting media at the time of seed planting.
4.2. Application of VAM.
The VAM was applied according to the treatment (0, 6, and 12 g per polybag). It was applied to the planting media once during seed planting.

5. Results
The results showed that the treatment of humic acid had no significant effect on almost all vegetative and production variables. Plant height, branch number, flowering age, root volume, and number of pods per polybag showed no significant effect by humic acid application. Production variables of 100 seeds weight and seed production per unit were not affected by the humic acid application. The only significant variable was in the variable of number of leaves at 70 days after planting.

Results of treatments which is not significant on vegetative parameters are seen in figure 1.

![Figure 1](image)

**Figure 1.** Several vegetative parameters of soybean growth which are not significantly affected by the application of humic acid and VAM

The only significant effect of the application is at the parameter of number of soybean leaves 70 days after planting, as seen in table 1.

**Table 1.** Average of number of leaves (unit) of soybean 70 days after planting on the application of humic acid and VAM

| Humic acid application | VAM application | Average | LSD 0.05 |
|------------------------|-----------------|---------|----------|
|                        | m0 | m1 | m2 | m0 | m1 | m2 | m0 | m1 | m2 | m0 | m1 | m2 |
| h0                     | 52.67 | 55.11 | 52.06 | 53.28<sup>h</sup> |
| h1                     | 57.17 | 61.56 | 66.72 | 61.82<sup>a</sup> | 6.89 |
| h2                     | 60.72 | 59.78 | 59.89 | 60.13<sup>b</sup> |
| Average                | 56.85 | 58.82 | 59.56 | 58.41 |

Numbers followed by different letters in the column were significantly different at the level of 95% (Tukey’s p≤0.05).
Results of the application of humic acid and VAM to production variables are seen in figure 2.

![Graph showing production parameters](image)

**Figure 2.** Several production parameters of soybean which are not significantly affected by the application of humic acid and VAM

Soybean lifespan is around 90 days; this time is estimated to be sufficient for the decomposition of humic acid for plant benefit. However, there is a concern regarding unavailability for roots due to washing by subsurface run-off. Therefore, plants have not given a significant response. Also, the bacteria in humic acid cannot symbiosis well on the soil, causing a lack of treatment effect on plant growth. The difference between biological fertilizer and chemical fertilizers is in terms of the time of response. Biological fertilizer absorbed slowly by plants, resulting in indirect nutrient supply. Therefore, the plants have not given a significant response. And the content contained in biological fertilizers is less influential on growth and production because biological fertilizers can be washed away due to extreme weather.

Differences in soybean growth relate with genetic and environmental factors. Different genotypes will show different appearances after interacting with a particular environment. It is because the vegetative period of soybean plants is influenced by external factors such as extreme weather and pathogens that affect soybean growth and development.

Condition of the soybean culture in this context has been stated by Siradz & Kabirun [9] that the vegetative phase of plant is a critical phase against extreme environmental conditions so that plants experiencing environmental stress at this stage cannot have optimal growth.

Application of Vesicular Arbuscular Mycorrhiza (VAM) did not significantly affect all growth components and production components; it is presumably due to extreme environmental and weather factors resulting in increased soil pests and pathogens.

About 95-99% of Phosphor is not soluble, hence not available or difficult to be absorbed by plant roots [10]. VAM infection in plant roots enables utilization of Phosphor previously unavailable for...
plants [11]. This symbiosis will be possible if the rhizosphere condition is supportive for plants and the microbes [12,13].

The results of statistical analysis showed that there was no significant interaction between humic acid and VAM when applied together in this research. It is presumably due to many factors that are known influential to the growth and yield of soybean; these factors such as genetics and environmental conditions, these factors are not independent and is related to one another. It might also be considerable to apply other type of bio fertilizer which has been proven efficient for soybean such as the use of bio-slurry [14].

6. Conclusion

Application of humic acid of 0% (v/v), 10% (v/v) and 15% (v/v) were not significant to vegetative and production variables of soybean which is presumably caused by unfavorable weather and pathogens. Similarly, application of VAM, as well as the interaction, did not affect the growth and production of soybean. It can be concluded the planting environment, especially within the rhizosphere.

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