Growth and yield response of local soybean in the giving of various organic fertilizer

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Abstract. Soybean is the basic material for any kind of industry, such as tofu and tempeh industries. Soybean cultivation will be better if use a sustainable agricultural system, such as using organic fertilizers. This research purpose was to find out the effect of organic fertilizer on the growth and yield of local soybean. The research used a complete randomized design with one factor which was a variety of organic fertilizers with 6 treatments. Various fertilizers used in this research consist of inorganic fertilizer, liquid organic, compost, cow manure, rabbit urine, chicken manure, and goat manure. Each test unit consists of 4 pots (plants) and each was repeated 4 times. The results showed that the provision of compost and goat manure increased the growth of local soybean plants, include plant height and the number of leaves at 42 DAP and leaf area at 28 DAP. The application of various organic fertilizers (liquid fertilizer, compost, cow manure, goat manure, and rabbit urine) is unable to increase the yield and yield components of local soybeans.

1. Introduction

Soybean is a source of plant protein. In Indonesia, soybeans are used as raw materials for making tempeh and tofu. National soybean needs are quite large and this is fulfilled from national production and imports. The results of the projected average production are 1.2 million tons per year or an increase about 6.79% and the projected average consumption is 2.8 million tons per year or an increase of about 2.1%. Domestic soybean needs are met by 57% imported soybeans [1].

One of the efforts to reduce imports or become dependent is developing the cultivation of good quality local soybean varieties. Indonesia has a large variety of local soybean germplasm that potential to be used optimally as breeding material. Anjasmoro is one of the soybean varieties that is widely cultivated by farmers and has a potential yield of 2.03 - 2.25 tons/ha, mature pods 82.5 - 92.5 with a weight of 100 seeds 14.8 - 15.3 g [2]. Soybean varieties significantly affect the amount of yield [3]. Varieties play an important role in soybean production because achieving a high yield is largely determined by their genetic potential. Potential yield in the field is influenced by the interaction between genetic factors and environmental conditions management [4].

Soybean growth is influenced by soil fertility. Organic fertilizers can be used as an alternative for farmers to reduce the use of inorganic fertilizers. Organic fertilizer application has a positive effect, including increasing the microbial population in the soil [5]. The application of organic fertilizers can have a direct impact on plant growth. Organic fertilizers can support the development and growth of roots, improve environmental conditions which beneficial for human and animal health as it reduces the
dangerous materials on the inorganic fertilizer, and it provides micro and macronutrients during processing. Mineralization also improve and enhance the physical and biological quality of the soil [6].

Several previous studies related to the use of various organic fertilizers showed some results. Giving rabbit urine 80 ml/L of water caused soybean plant height to be 3.32 cm higher than not given fertilizer [7]. Rabbit urine contains essential nutrients for plant growth, such as nitrogen, potassium, and phosphate. The nitrogen content in rabbit urine is high because the rabbit's main food preferences are forage and drink little water. Rabbits can produce urine that contains ammonia (NH$_3$). The urine in the fertilizer will experience evaporation. This evaporation creates air-filled pore spaces in the soil which leads to increased soil aeration, nitrification, and N$_2$O production. This causes an increase in plant growth [8]. Another study showed that the dose of 30 tons/ha cow manure was the most effective fertilizer and the best result on day 56 after planting [9]. Spraying liquid fertilizer at a concentration of 2.86 ml/L gave the best results on the number of pods and the number of soybean seeds [10].

The increase in soybean yields will continue to meet domestic needs. One of the efforts is the provision of organic fertilizers such as manure, compost, and other organic fertilizers that can be used to increase soil productivity and yields. Based on this description, it is necessary to study the response of growth and yield of local varieties of soybeans to various organic fertilizers as base information for adaptation to environmentally friendly cultivation.

2. Material and methods

The research was carried out from June to October 2020. The experiment using pots/polybags was done at the Greenhouse of Agriculture Faculty, UNS, Surakarta. Laboratory analysis was held at the Plant Physiology and Biotechnology Laboratory, and the Plant Ecology and Management Laboratory, Faculty of Agriculture, Sebelas Maret University (UNS).

The equipment used in this study included analytical balances, spectrophotometers, and glassware. The materials used in this research were local soybean seeds of Anjasmoro variety, liquid organic fertilizer, rabbit urine fertilizer, leaf compost, cow manure, goat manure, pesticides, and fungicides. Soybean seeds of the Anjasmoro variety were treated with fungicides before planting. The growing media used consisted of soil and organic fertilizer (according to the treatment). Planting was carried out using polybags with a height and diameter of 30 cm x 30 cm, with a distance between polybags of 25 cm. Each polybag was filled with a mixture of soil and organic fertilizer, namely 7 kg of soil and 700g of organic fertilizer (according to treatment). This dose refers to Asrori et al. [11], which states that the use of manure on 4 kg of soil is 400 g or in 1 kg of soil is 100 g of manure. Organic fertilizers were given according to each treatment. One week before planting, solid fertilizer was given but then changed with liquid fertilizer two days before planting. Rabbit urine fertilizer (80 ml/L) was applied on the second week after planting then repeated until the flower bloom at the interval of one week through spraying the top and the bottom of the leaf. The liquid organic fertilizer (POC) used contains 22% organic acid and 4% potassium. In addition to organic fertilizers, during the growth of Anjasmoro soybeans, inorganic fertilizers are also given, including urea at a dose of 50 kg.ha$^{-1}$, SP-36 100 kg.ha$^{-1}$ and KCl 100 kg.ha$^{-1}$. Urea fertilizer was given 3 times, as much as 1/3 part when the plant was 7 DAP, 1/3 part at 20 DAP, and 1/3 part 32 DAP. SP-36 and KCl fertilizers were applied once at the age of 60 DAP.

The experiment used a one-factor completely randomized design (CRD) with six treatments, namely types of fertilizers. Types of fertilizers consist of no organic fertilizer, liquid organic fertilizer (POC), compost, cow manure, rabbit urine fertilizer, goat manure. Each experimental unit consisted of 4 pots (plants), each repeated 4 times. Observation variables include; plant height, leaves number, leaf area, plant dry weight, number of root nodules, pods number, seeds number, and seeds weight per plant. Data were analyzed using analysis of variance (ANOVA) and if they were significantly different, they were further tested with DMRT with a 95% confidence level [12].
3. Result and discussion

3.1. Height of plant, number of leaves, leaf area and root nodules number

The data analysis showed that the application of various organic fertilizers had a significant effect on the height of the plant and leaves the number of soybean aged 42 DAP and leaf area at 28 DAP. It is due to the ability of the planting medium to provide the nutrients needed by plants and the ability of plants to absorb nutrients optimally. Taller plants, higher leaves count, and wider leaf area are causing higher nutrient absorbance and photosynthesis rates.

Table 1. The effect of various organic fertilizers on the height of the plant, number of leaves, leaf area, and number of root nodules of Anjasmoro varieties

| Treatment              | Plant Height (cm) (42 DAP) | Number of leaves (sheet) (42 DAP) | Leaf Area (cm$^2$) (28 DAP) | Number of root Nodules |
|------------------------|-----------------------------|-----------------------------------|-----------------------------|------------------------|
| Without organic fertilizer | 114.60$^a$                | 59.00$^a$                         | 326.33$^a$                  | 13.13$^a$              |
| Liquid organic fertilizer | 117.08$^a$                | 56.00$^a$                         | 347.99$^a$                  | 19.63$^a$              |
| Compost                | 139.79$^b$                 | 68.00$^{ab}$                      | 576.99$^b$                  | 6.25$^a$               |
| Cow Manure             | 131.38$^b$                 | 61.00$^a$                         | 467.66$^{ab}$               | 2.25$^a$               |
| Rabbit urine fertilizer | 111.17$^a$                 | 61.00$^a$                         | 333.33$^a$                  | 12.13$^a$              |
| Goat manure            | 138.16$^b$                 | 81.00$^b$                         | 616.66$^b$                  | 6.88$^a$               |

Note: Numbers followed by the same letter in the same column indicate there is no significant difference at DMRT at 5% level; DAP: Day after planting

Based on Table 1, at 42 DAP Anjasmoro soybean was the highest in the compost fertilizer treatment (139.79 cm), but not significantly different from cow manure and goat manure. The leaves number at 42 DAP was the most in the application of goat manure (81 sheets) and was not significantly different from compost (68 sheets). The application of goat manure also produced the widest leaves at 28 DAP (616.66 cm$^2$) and was not significantly different from compost and cow manure. Compost, cow manure, and goat manure are solid organic fertilizers. The addition of organic fertilizers can increase organic matter and improve soil physical properties that play a role in root penetration, water absorption, and nutrition [13]. The results of the study by Imthiyas and Seran [14] showed that the addition of 1.5 kg.m$^2$ of goat manure produced the highest leaf area compared to other doses. Manure has a significant residual effect on the soil and can affect the production of more branches, leaves, and seeds. The addition of 10 tons.ha$^{-1}$ of goat manure was able to increase leaf area on chickpeas [15].

According to Anjarwati et al. [16], giving goat manure mixed with husk charcoal can increase leaf area in mustard greens. Goat manure can also increase crop dry matter yields, soil fertility, microbiological activity, water holding capacity, and can be a partial substitute for NPK fertilizer application [17]. Application of goat manure to soil also increases soil pH, organic matter, N total, P is available, exchangeable cations (K, Ca, and Mg), and cation exchange capacity. The formula contained in goat manure can positively increase plant growth and yield and is even worthy of being an alternative nutrient to conventional hydroponics [18]. Charcoal and compost can be sources to improve soil quality and fertility. Charcoal and compost can help increase soil nutrients and balance soil pH. It can also reduce the risk of soil pollution and increase crop productivity. The role of compost, manure, together with inorganic fertilizers is efficient to improve crop yields and also soil health [19].

The application of various organic fertilizers did not significantly affect the number of root nodules (Table 1). The most common root nodules produced were in the treatment of liquid organic fertilizer. According to Saputra et al. [20], liquid organic fertilizer from plant waste can increase the number of root nodules. In that research, the highest yield is the addition of liquid organic fertilizer from banana plant waste. Zein and Leilani [21] reported that liquid organic fertilizer addition at 240 ml/polybag produces the highest number of root nodules compared to other doses. The development of root nodules requires suitable environmental conditions so that rhizobium bacteria can live and develop properly so that root nodules can form which are effective for fixing nitrogen.
3.2. **Dry weight of plant**

The kind of organic fertilizer only had a significant effect on the dry weight of soybean plants aged 28 DAP, while at the age of 28 DAP and at harvest time (82 days after planting/DAP), there was no significant effect (Table 2).

**Table 2.** The effect of organic fertilizer on plant dry weight and number of root nodules on local soybean Anjasmoro

| Treatment                  | Dry weight of plant (g) | Harvest Time (82 DAP) |
|----------------------------|-------------------------|-----------------------|
|                            | 28 DAP | 56 DAP |                       |
| Without organic fertilizer | 2.27a | 10.90a | 3.59a                 |
| Liquid organic fertilizer  | 2.26a | 10.52a | 3.11a                 |
| Compost                    | 3.86b | 15.37b | 4.09b                 |
| Cow Manure                 | 3.76b | 10.79b | 4.23b                 |
| Rabbit urine fertilizer    | 2.13b | 16.88b | 4.57b                 |
| Goat manure                | 4.03b | 17.10b | 4.68b                 |

Note: Numbers followed by the same letter in the same column indicate there is no significant difference at DMRT at 5% level; DAP: Day after planting

Table 2 shows the highest dry weight of soybean plants at the age of 28 DAP, 42 DAP, and harvest time (82 DAP) was in the application of goat manure. The dry weight of plants age 28 DAP was highest in goat manure administration, but not significantly different from compost and cow manure. The dry weight of plants on the application of liquid organic fertilizer and rabbit urine fertilizer resulted in the dry weight of the plant is not significantly different from the control. The highest dry weight of soybean plants at the age of 28 DAP and 82 DAP (in harvest time) was also produced through the administration of goat manure fertilizer, although not significantly different from the other treatments. Agustiani [22] reported that the application of goat manure on soybean plants produced plant dry weight heavier than the treatment of vermicompost and cow manure. The application of goat manure at a dose of 18tons/ha also produced leaf dry weight, root nodule, and shoot is greater than the dose below it [23]. It shows that the higher the dose of goat manure given, the higher the growth rate of soybean plants. Besides that, goat manure decomposes faster than green manure or a combination thereof.

The addition of goat manure mixed with NPK fertilizer was able to produce good soybean growth. The nitrogen is used by plants to form amino acids which will be converted into proteins and are also needed to form compounds such as nucleic acids, enzymes, and chlorophyll. Besides that, Mg has a very important role in the formation of chlorophyll. If the needs of the plant are not fulfilled then the growth and development is not optimal [24].

3.3. **Yield and yield component**

The results of this study showed that the giving of various organic fertilizers did not significantly affect the yield and yield components of soybeans (Table 3). Both yield and yield components, the highest yield were produced by applying goat manure, although they were not significantly different from others. This is influenced by plant vegetative growth, where the highest vegetative growth of soybean plants was also in the application of goat manure.

**Table 3.** The effect of organic fertilizer on yield and yield components of local soybean Anjasmoro

| Treatment                  | Number of pods | Number of seed | Weight of seeds per plant |
|----------------------------|----------------|----------------|----------------------------|
| Without organic fertilizer | 27.25a         | 54.38a         | 5.85a                      |
| Liquid organic fertilizer  | 27.25a         | 52.63a         | 6.72a                      |
| Compost                    | 29.75a         | 53.25a         | 6.27a                      |
| Cow Manure                 | 28.25a         | 53.13a         | 6.23a                      |
| Rabbit urine fertilizer    | 32.75a         | 61.25a         | 6.87a                      |
| Goat manure                | 39.00a         | 72.25a         | 8.73a                      |

Note: Numbers followed by the same letter in the same column indicate there is no significant difference at DMRT at 5% level
The results of research by Setiawan et al. [25] showed that the highest number of pods was in the application of goat manure at a dose of 10 tons.ha$^{-1}$, while the highest seed weight was at the dose of goat manure of 30 tons.ha$^{-1}$. It indicates that the increased availability of nutrients can affect the pods' number per plant. Goat manure addition can increase the ability of the soil to bind water, the capacity of the soil to hold water is related to the structure and texture of the soil. The formula in goat manure can increase plant growth and yield and is even worthy of being an alternative nutrient to conventional hydroponics [18]. Goat manure has the highest potassium element compared to other manures, which is 0.93% where the potassium element functions to transport assimilated products in the form of photosynthate which is channeled into the pit in the form of pods [26].

4. Conclusion
This study concludes that the provision of compost and goat manure increased the growth of local soybean plants, including the plant height and the number of leaves at 42 DAP and leaf area at 28 DAP. In addition, the application of various organic fertilizers (liquid fertilizer, compost, cow manure, goat manure, and rabbit urine) has not been able to increase the yield and yield components of local soybeans.