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Organic Fertilizing on Growth Parameters of Soybean (*Glycine max* (L.) Merr.) in Rainfed Agroecosystem of Manokwari, West Papua, Indonesia

[1]Samen Baan, [2*]Siska Syaranamual, [3]Eko Agus Martanto
[1] Department of Soil Science, Faculty of Agriculture, Papua University, Indonesia
[2*] Department of Agriculture, Faculty of Agriculture, Papua University, Indonesia
[3] Department of Agriculture, Faculty of Agriculture, Papua University, Indonesia
*Correspondence: Siska Syaranamual, Faculty of Agriculture, Papua University (UNIPA), Manokwari, Papua Barat, Indonesia.

Abstract:- Promoting the growth of soybean can be achieved by organic fertilization. The aim of the research is to determine the effect of the types and doses of organic fertilizers on soybean growth. The four month study was conducted at Manokwari Regency, West Papua, Indonesia. The treatments were laid out in a factorial randomized block design (RBD) in which the first factor is the types of organic fertilizer consisting of husk ash (F1), compost (F2), chicken manure (F3) and goat manure (F4), while the second factor is the organic fertilizer doses comprising of zero fertilizer rate (D0) and 5 tons/ha fertilizer rate (D1). The results showed that goat manure (F4) achieved the highest, while the type of fertilizer scored the lowest is compost (F2). Fertilizer doses were significantly different in all growth parameters, namely D1 (5 tons/ha) compared to D0 (without fertilizer). The interactions were insignificant statistically different in all growth parameters, when goat manure (F4D1) tended to record the highest and no application of compost fertilizer scored the lowest.

Keywords:- *Organic, Fertilization, Growth Parameters, Soybean, Rainfed.*

I. INTRODUCTION

Soybean status in Indonesia is very essential since it can be processed into several products such as tofu, tempeh, soy sauce, soy milk, and various types of snacks (Soehendi, 1996)**.** The demand for soybean in Indonesia has indeed been increasing in line with population growth as estimated by The Indonesian Research Institute of Peanut and Tuber Crops that the average annual demand of soybean is 2.3 million tonnes of dry beans while the average domestic production for the last five years was 982.47 in thousands of dry beans or equal to 43% of the demand (Malik & Nainggolan, 2020).

Manokwari Regency is one of the agricultural production centres in West Papua, Indonesia including soybean. In terms of its harvested area, production, and productivity, Manokwari has contributed the highest, almost 81 % of the total, with 1.781 ha, 1.898 ton, and 10,66 kW/ha, respectively (West Papua Province Statistics Centre Agency, 2018). However, the fact that there is a decline throughout the year in productivity due to poor soil fertility (Mariyono, 2019)**,** resulting from intensive utilization for many agricultural purposes.

Referring to other agricultural crops in common, the productivity of soybean is strongly determined by their growth (White et al., 2016) which is the initial process of the crops highly relying on inputs or agronomic treatments applied. Inputs are given as a way to obtain optimal farming systems including certified seeds application, pests and disease control, water management (irrigation), and other farming techniques such as fertilization. Fertilization is knowledgeable for local farmers and they perceived fertilizers and fertilization as the major part of their farmings and can not be excluded out of their farms (Mariyono, 2019; Yunus et al., 2016).

Fertilization is an essential part of cultivation techniques to promote optimal growth. It is also used to stimulate plants to induce fruit sets. Aside from fertilizing through the root (Khaerunnisa et al., 2015), another technique can also be done through the leaves by spraying (Fritz, 1978; Harper, 2015). Currently, most farmers are still depending on inorganic fertilizers containing several nutrients in large quantities. When inorganic fertilizer is used continuously it will then bring several negative impacts on soil conditions (Kuntyastuti & Suryantini, 2015; Patil & Udmale, 2016); Adnan, Utoyo and Kusumastuti, 2015; Sitorus, Setyorini and Suryanti, 2021).

To reduce the use of inorganic fertilizers, it is necessary to use organic fertilizers. Organic fertilizers which are defined as easily and sufficiently available in nature sourced-fertilizers (Hutasoit, 2012; Jones, 2012) have a significant role in the improvement of physical, chemical, soil biological and environmental properties (Bhogal et al., 2009), as a source of nutrients for plants as well as a source of energy and nutrients for soil microbes to increase microbial activity in providing nutrients for plants (Han et al., 2021). The growth response of soybean plants will be different from other types of plants to the input provided. Recent studies have shown response of various crops at different growth stages towards organic fertilizers application, for instance, on rice (Siavoshi et al., 2011), maize (Gao et al., 2020), palm oil seedlings (Syahminar et al., 2019). Yet, the response on vegetative growth of soybean, in particular rainfed agroecosystem, remains limited.

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II. MATERIAL AND METHODS

A. Experimental Site Description

A 3-month field trial was conducted in 2018 on the experimental station of The Crop Protection Centre Manokwari Regency under rainfed conditions in dryland agroecological zone (Syuaib, 2016). The experimental site lies on 0°55 S and longitude 133°52 E. The climate in the study area in association with thermal climates is tropical lowland (Fischer et al., 2008) while the soil type is Inceptisols derived from parental material of Aluvial.

B. Experimental Design And Treatments

The experiment was laid in a factorial randomized complete block design (RCBD) with two treatment factors and three replicates. The treatments consist of first factor of the type of organic fertilizers namely husk ash (F1), compost (F2), chicken manure (F3) and goat manure (F4) while the second factor comprised of two levels of organic fertilizer application of zero dose (D0) and 5 tons/ha (D1). The test crop was obtained from The Centre of Research on Nuts and Tubers Malang, East Java, Indonesia. There were twenty-four experimental plots each measuring 2.0m by 3.0m with inter-block and inter-plot distance of 1.0m and 1.0m respectively. The total land size for this experiment was 25m by 13m equals to 325 m^2. Plant growth was closely monitored, including daily inspection for growth disorders as well as pest and disease incidences. The pots were irrigated manually as required, based on environmental conditions. Pots were fertilized as per treatment each plot at 3 weeks after planting (WAP) by broadcasting proportionally around the plant.

C. Management Practices

The experimental field was ploughed and harrowed using a tractor and ridges were constructed manually. During the experiment, watering was applied manually 1-2 times a day (morning and evening) which was can also be adjusted to weather condition, if it rained then watering was not done. Replacement of soybean plants was carried out if the planted seeds did not grow or die, or were attacked by pests/diseases. Weeding was practiced by removing and cleaning unwanted plants (weeds) on the plots with the aim of preventing competition for nutrients between soybean plants and weeds.

D. Data Collection

Data were collected on growth parameters at every two weeks interval. Data were measured on the following crop variables: plant height, number of leaves and number of branches. Plant height was measured from the basal end of shoots to the top tip of the main shoot; the number of leaves was gained from trifoliate leaves on the main stem of each sample plant, not on leaves found on branches of soybean plants. While number of branches was derived from productive branches defined as the branches producing pods.

E. Statistics Analysis

All data collected were entered into Microsoft excel and subjected to Analysis of Variance (ANOVA) and treatment means were compared using the least significance difference (LSD) at 5% level of probability.

III. RESULTS AND DISCUSSION

Growth is an important process in the life and reproduction of a species. Growth in a plant takes place continuously throughout the plant's life cycle. The growth of a plant cannot be separated from the nutrients absorbed by the plant. Nutrients absorbed by these plants can be derived from air, soil and fertilizers. With the application of fertilizer to plants, the fertilized plants will process changes in nutrients into energy which is then used to fulfill the plant's life cycle.

A. Plant height

The development of plant height due to the application of various organic fertilizers from the age of 3, 5, 7 to 9 weeks after planting (WAP) is presented in Figure 1.

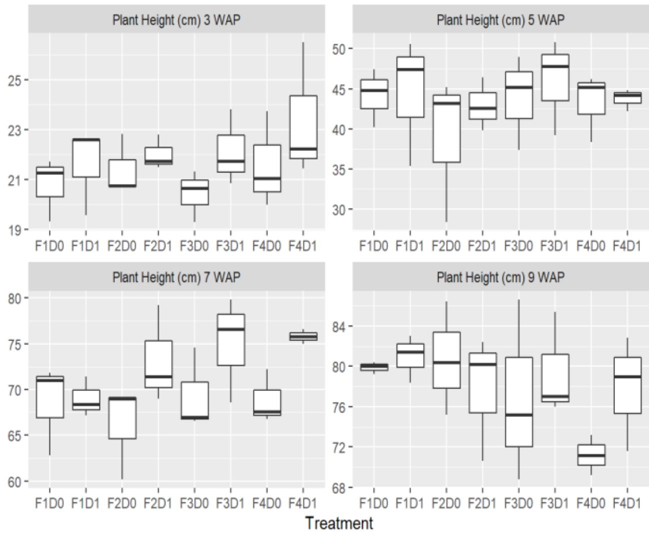

Fig 1:- Plant heights at 3, 5, 7 and 9 WAP

The high growth rate of soybean plants treated with fertilizers (F1, F2, F3 and F4) was fast in the first 3 WAP and the last week when entering the flowering phase. The increase in plant height occurs due to cell increase and especially) due to cell expansion in elongation process in the intercalar meristem, resulting in an increase in the number of cells and cell expansion which is largely determined by the nutrients absorbed by plants (Schulze et al., 2019).

The application of organic fertilizers on plant height growth at 5 and 7 WAP gave no significant difference. Plant growth is also strongly influenced by external (environmental) and internal (genetic) factors, where research is carried out in open land with climatic conditions that can change at any time. This statement is in accordance with the opinion of Fourcaud et al. (2008) suggested that empirically, plant growth can be expressed as a function of genotype x environment = f (internal growth factors and external growth factors). DNA encodes the sequence of amino acids into specialized proteins and enzymes, building genetic capacity for growth, development and completing morphogenesis (Goss, 1970). The interaction between the genotype and the environment provides an appearance of this genetic potential.

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The doses of organic fertilizers (D0 and D1) were significantly different at 7 WAP and not significantly different at 3, 5 and 9 WAP. However, fertilizer doses (D0 and D1) gave the highest yield on plant height growth at 3 WAP. (D0: 21,82), 5 WAP (D1: 44,27), week 7 (D1: 73,25) and 9 WAP (D1: 78,98), it can be seen that 5 tonnes/ha of plant height gave the best results at plant height growth rates compared to no fertilizer dose (D0). (Henckel, 1964) stated that plant growth is a process of increasing the size of an organism (protoplasm increase). This increase is caused by an increase in the size of plant organs such as plant height as a result of plant metabolic processes.

The interaction between the type of fertilizer and the dose of fertilizer (F1D0, F1D1, F2D0, F2D1, F3D0, F3D1, F4D0 and F4D1) was significantly different, namely, at 3, 7 and 9 WAP. Hasanah and Rahmawati (2015), stated that one of the indicators of plant growth is the increase in plant height. Plant height is a parameter of plant growth. Plant height increase is the difference in plant height with a certain interval occurring gradually. In addition, growth is also a process of increasing plant size. The increase in height in a plant is caused by cell division (increase in number) and cell enlargement (increase in size). Both of these processes require protein synthesis and are non-reversible processes (Vince, 1964).

B. *Number of leaves*

The development of leaf numbers due to the application of various organic fertilizers from the ages of 3, 5, 7 to 9 weeks after planting (WAP) is presented in Figure 2.

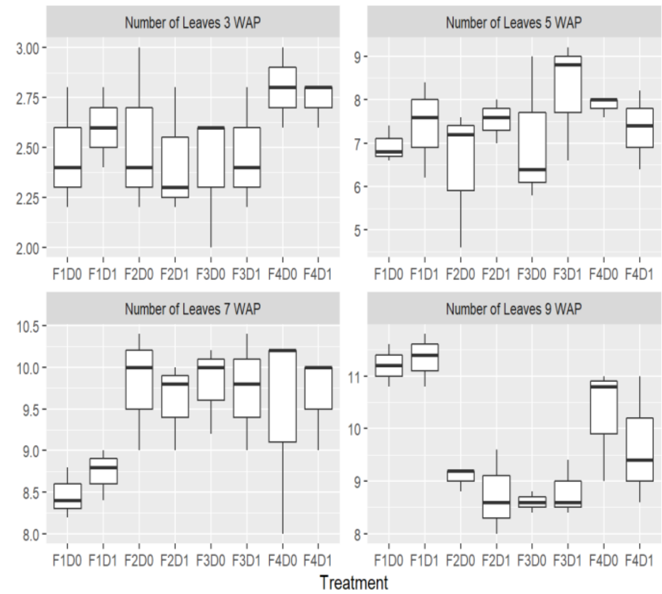

Fig 2:- Leaf numbers at 3, 5, 7 and 9 WAP

The growth in the number of leaves due to the application of organic fertilizers (F1, F2, F3 and F4) was significantly different, namely at 7 WAP and 9 WAP, while at 3 and 5 WAP were not significantly different. This occurs because, the growth and development of a plant is a continuous process that leads to the morphogenetic characteristics of the species. Both of these processes are controlled by genotype and environment in which the degree of their influence depends on the characteristics of the plant. In addition, soybean growth does not necessarily rely only on nutrients from the soil, thus it is necessary to add nutrients such as fertilizers containing elements of N, P and K given to plants (Hellal et al., 2013).

Fertilizer doses (D0 and D1) were significantly different on the number of leaves at 5 WAP. Lawlor et al. (2001) suggested that applying fertilizers with the right dose will increase plant growth, increase plant metabolism, protein formation, carbohydrates resulting in the increased plant growth. Providing sufficient nutrients can improve plant vegetative growth, where plants growing on sufficiently fertilized soil can provide better results (Fageria & Baligar, 2005).

While the application of fertilizer doses (D0 and D1) on the growth of the number of leaves that were not significantly different occurred at 3, 7 and 9 WAP. It is assumed to occur due to the tendency of accelerated leaf aging due to an unfavorable environment, the emergence of new leaves, the existence of mutual shade and increased competition for nutrients as well as the increasing age and size of the plant. Lemaire et al. (2008) also added that the maximum leaf weight and area in a plant is reached at the beginning of its life cycle, after which the increase in leaf weight and area is the same, with a decrease in a status known as critical leaf area.

The interaction of the two factors observed on the number of leaves, namely the type of fertilizer and the dose of fertilizer (F1D0, F1D1, F2D0, F2D1, F3D0, F3D1, F4D0 and F4D1) at 5, 7 and 9 WAP were significantly different. This is because optimal fertilizer application can increase plant growth, thereby increasing protein synthesis and chlorophyll formation (Etesami & Maheshwari, 2018). The availability of sufficient nutrients is an essential element needed by plants, because if one element is not available, the process of metabolism and plant growth is disrupted and even results in death. Sufficient nutrient content in the soil will increase plant vegetative growth. In addition, mineralization plays an important role in the process of plant growth, where this mineralization process occurs due to the release of plant nutrient minerals (macro and micronutrients) in uncertain and relatively small amounts which are very much needed to promote plant growth (Fageria et al., 2002).

Mineralization is the process of converting organic form from nitrogen into mineral form. The nitrogen mineralization process includes the breakdown of N-organic into N-minerals in the soil. Soil nitrogen is largely in organic form, so N-organic weathering is a process that makes nitrogen available to plants. Weathering, which is a complex biochemical process, releases carbon dioxide and finally nitrogen is released in the form of ammonium (NH4 +) available for plants (Nieder & Benbi, 2008). Moreover, the addition of organic fertilizer (ripe) with a low C/N ratio will be very easily absorbed by plant roots. The C/N ratio of a proper fertilizer is in the range of 12-15 with temperatures almost the same as the ambient temperature. A low C/N ratio can increase the plant growth rate, meaning that organic fertilizers quickly decompose into nutrients needed by plants, as a result, they will spur plant growth (Raven et al., 2004). Nitrogen is needed to form important compounds such as chlorophyll, nucleic acids, and enzymes, while micro-nutrients function primarily in the formation of leaves and chlorophyll in leaves (Fageria & Baligar, 2005; Harper, 2015; Raven et al., 2004). Cosgrove (2005) investigated that if plants get enough N, the leaves will grow bigger and expand their surface. The broad leaf surface allows the leaves to absorb more sunlight so that the photosynthesis process takes place faster, as a result the photosynthate formed will accumulate in plant weight which is the economic result of the plant. N is needed in large quantities at every stage of plant growth, especially shoot formation, stem and leaf development.

C. Number of branches

The development of the number of branches due to the application of various organic fertilizers from the age of 5, 7 to 9 weeks after planting (WAP) is presented in Figure 3.

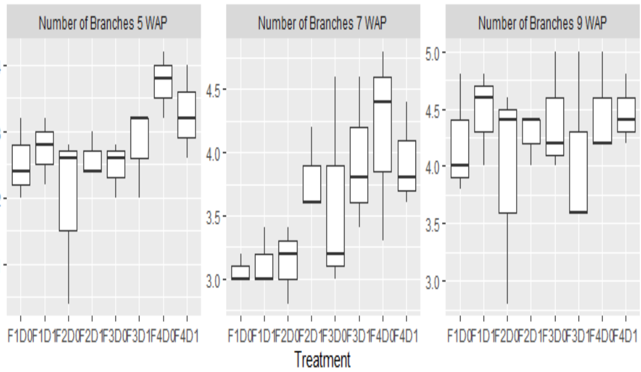

Fig 3:- Branch numbers at 5, 7 and 9 WAP

The growth of branches in a plant occurs because of the potential for branching in the axillary, because there is a bud on each axillary with its potential for branch growth (McWilliams et al., 1999). Levels of types of organic fertilizers (F1, F2, F3 and F4) were insignificantly different in the number of branches of soybean plants occurred in 5 and 7 WAP. Plant growth is the growth of all parts of the plant including plant height, number of leaves and number of branches. While the types of organic fertilizers that were not significantly different occurred at 9 WAP. This is presumably because the growth of branches in soybean plants has stopped at 9 WAP. Rudall (2020) stated that vegetative growth of plants with a determinite type will stop when the plant initiates its generative growth.

The doses of fertilizer (D0 and D1) on the growth of the number of branches were not significantly different. However, the application of fertilizer dose of 5 tonnes/ha (D1) gave the best results compared to without a fertilizer dose (D0). Soane (1990) explained that applying the amount of organic matter added to the soil indicates that there will be an increase in aggregate porosity and a decrease in aggregate weight, and aggregate distribution in a narrow range as a consequence of low soil weight. Increasing the ratio of organic matter can improve the physical properties of the soil, thus plant roots can absorb more nutrients and water for optimizing the growth.

The interaction of the two factors, namely the type of fertilizer and the dose of fertilizer (F1D0, F1D1, F2D0, F2D1, F3D0, F3D1, F4D0 and F4D1) were insignificantly different to the number of branches of soybean plants, namely at 3 and 5 WAP. There is a strong relationship between levels of nutrient uptake with plant growth rate indicating that nutrient uptake rate affects plant growth. The availability of the element potassium can spur the photosynthesis process, increase the distribution of photosynthate, and it can eventually enhance plant growth (Engels et al., 2011). Meanwhile, at 9 WAP, the growth in the number of productive branches has no significant effect. Siavoshi et al. (2011) stated that nitrogen in plants functions as a constituent of protoplasm, chlorophyll molecules, nucleic acids and amino acids producing protein. Consequently, if there is deficiency of nitrogen it may disrupt vegetative growth of plants.

The dose of fertilizer that gives the best results in all components of growth and production is D1 (5 tons/ha) while the dose of fertilizer that gives the lowest results is D0 (without fertilizer). Fertilization aims to increase the nutrients needed by plants because the nutrients in the soil are not always sufficient to spur plant growth optimally. Organic fertilizers are one of the most important inputs to improve soil fertility. Organic fertilizers are formed due to the collaboration of decomposing microorganisms with the weather and human treatment. These microorganisms play a role in translocating or digesting crude organic matter into finer forms available for plants (Bolan et al., 2011).

The interaction between types of organic fertilizers and dosage of organic fertilizers (F1D0, F1D1, F2D0, F2D1, F3D0, F3D1, F4D0 and F4D1) gave the best results in almost all components of growth and production, namely goat manure (F4D1), because goat manure contains more nutrients than other organic fertilizers. This is supported by the studies conducted by Verde et al. (2013) and Wuta (2012) reported that goat manure contains higher K nutrients compared to other manure fertilizers and the same N and P nutrients as other manure fertilizers. Zhang et al. (2017) stated that manure fertilizer as a source of nitrogen (protein) will first decompose into amino acids known as the aminization process, which then by a large number of heterotrophic microbes break down into ammonium known as ammonium. ammonification process. This ammonification can take place in almost any circumstances, therefore, ammonium can be the main form of inorganic nitrogen (mineral) in the soil. The ammonium produced can be directly absorbed and used by plants during the growth. Meanwhile, the interaction which gave the lowest yield in almost all growth and production components was without the use of compost (F2D0). This happens because there are no additional nutrients given to soybean plants.

IV. CONCLUSION

Based on the analysis of variance of the various types of organic fertilizers used (F1, F2, F3 and F4) there were no significant differences in all growth components. However, the type of goat manure fertilizer (F4) resulted the highest, while the type of fertilizer recorded the lowest was compost (F2). Fertilizer doses were not significantly different in all components of growth where D1 (5 tons/ha) tended to record higher than D0 (without fertilizer). In line with that, the interaction between the type and the dose of organic fertilizer (F1D0, F1D1, F2D0, F2D1, F3D0, F3D1, F4D0 and F4D1) was not significantly different in all growth components. However, goat manure (F4D1) revealed the highest, while the interaction that expressed the lowest was without the use of compost (F2D0).

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