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Effects of Banana Peel Liquid Organic Fertilizer and Chicken Manure on Growth and Yield Components of Soybean (Glycine max L.) in Andisol Soil

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Abstract. This study evaluated the effects of banana peel liquid organic fertilizer (LOF) and chicken manure on the growth and yield components of soybean (*Glycine max* L.) cultivated in Andisol soil. The experiment was conducted from December 2020 to April 2021 at the experimental field of the Faculty of Agriculture, Universitas Islam Sumatera Utara, using a factorial randomized block design with two factors: four doses of banana peel liquid organic fertilizer (0, 50, 100, and 150 mL polybag^{-1}) and four rates of chicken manure (0, 5, 10, and 15 t ha^{-1}). Data were analyzed using analysis of variance followed by Duncan's Multiple Range Test at the 5% significance level. The results showed that banana peel liquid organic fertilizer significantly increased the number of branches and the weight of 100 seeds but had no significant effect on plant height, stem diameter, or the number of pods. Chicken manure significantly increased stem diameter, number of branches, number of pods, and weight of 100 seeds, whereas its effect on plant height was not significant. No significant interaction was observed between banana peel liquid organic fertilizer and chicken manure for any of the observed variables. These findings indicate that both organic fertilizers independently improved soybean growth and yield components in Andisol soil, although their combined application did not produce a synergistic effect. Further studies involving comprehensive soil characterization, nutrient uptake, and economic evaluation are recommended to better understand the agronomic potential of banana peel liquid organic fertilizer under different environmental conditions.

Keywords: Banana peel liquid organic fertilizer, chicken manure, soybean, Andisol, yield components

1 Introduction

Soybeans are one of Indonesia's important sources of vegetable protein and agricultural commodities. The demand for soybeans continues to increase every year. According to data from the Central Statistics Agency (BPS), national soybean production in 2014 reached 892,600 tons of dry beans, an increase of 14.44 percent or 112,610 tons compared to 2013, which was 779,990 tons. Data from the National Soybean Council shows that domestic soybean consumption in 2014 was 2.4 million tons, while the soybean production target for 2014 was only 892,600 tons. There is still a supply shortage (deficit) of more than one million tons [1].

To overcome the shortage of soybean supply, efforts are needed to increase national soybean production, especially in North Sumatra. One of the reasons for Indonesia's low soybean production is farmers' lack of knowledge in the use of production technologies that support sustainable agriculture and the increasing depletion of fertile land resources due to the continuous use of inorganic fertilizers [2].

The problem faced in increasing soybean productivity today is the lack of productive land support. This is due to land degradation and damage caused by current conventional farming practices that prioritize the use of high inputs such as inorganic fertilizers and pesticides. Therefore, efforts to increase soybean productivity and quality must be made in better ways, such as using organic fertilizers. One important factor in cultivation efforts that supports the growth and production of a plant is the issue of fertilization [3].

Liquid organic fertilizer is a type of organic fertilizer that can be used in organic farming systems. Liquid organic fertilizer is a solution made from decomposed organic materials derived from plant residues, animal and

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human waste, which contain more than one nutrient element. One type of liquid organic fertilizer that can be used is liquid organic fertilizer made from banana peels. Banana peels themselves make up about 1/3 of a banana fruit. So far, the use of banana peels is still limited, with only a few people using them as animal feed. In addition to producing xylase enzymes, banana peels also contain chemical elements such as magnesium, sodium, phosphorus, and sulfur, making them a good potential source of organic fertilizer, both solid and liquid [4].

Manure is fertilizer derived from animal waste. Animals that can be raised by the community include cows, goats, and chickens. In addition to being solid, manure can also be liquid, derived from animal urine [5]. Manure is a source of several nutrients such as nitrogen, phosphate, potassium, and others. Nitrogen is one of the main nutrients for most plants that can be obtained from manure. Nitrogen from manure is generally converted into a form of available nitrate. Nitrate is easily soluble and moves to the root area of plants, a form that can be taken up by plants directly. In addition, manure can reduce nutrients that are toxic to plants [6].

The use of chicken manure is expected to have a direct and indirect effect on plant growth and development. Directly, it can increase the nutrient content in the soil, and indirectly, it can improve the physical properties of the soil and improve soil conditions, which will ultimately increase soybean productivity [7].

Although numerous studies have reported the use of liquid organic fertilizers and animal manures to improve soybean growth, limited information is available regarding the combined application of banana peel liquid organic fertilizer and chicken manure on Andisol soils. Previous studies have generally focused on commercial liquid organic fertilizers, compost, or other animal manures under different soil conditions, whereas the response of soybean grown on Andisols remains insufficiently understood due to the unique characteristics of this soil, including high phosphorus retention and distinctive nutrient dynamics. Therefore, the present study specifically evaluates the independent and combined effects of banana peel liquid organic fertilizer and chicken manure on soybean growth under Andisol conditions while simultaneously promoting the utilization of locally available agricultural waste as an environmentally friendly fertilizer source. This approach provides additional scientific evidence regarding the potential use of banana peel waste for sustainable soybean cultivation on volcanic soils.

2 Research Method

This research was conducted at the experimental field of the Faculty of Agriculture, University of North Sumatra, Jalan Karya Wisata, Medan Johor District, Medan City, North Sumatra Province, at an altitude of ± 25 meters above sea level with flat topography. This research was conducted from December 2020 to April 2021.

The research method used was a factorial randomized block design consisting of two treatment factors, namely: 1. Liquid organic fertilizer administration factor consisting of four levels (doses), namely : Po = 0 ml/1air Kontrol, P1 = 50 ml/1 air/polybag, P2 = 100 ml/1 air/polybag, P3 = 150 ml/1 air/polybag. 2. , Chicken Manure Application Factors: K0 = 0 tons/ha, K1 = 5 tons/ha (0.5 kg/polybag), K2 = 10 tons/ha (1 kg/polybag), K3 = 15 tons/ha (1.5 kg/polybag)

To determine the effect of the treatment, an analysis of variance table was compiled, and for treatments with significant and highly significant effects, this was followed by a mean difference test based on Duncan's range test [8].

3 Results and Discussion

3.1 Plant Height

The analysis results showed that the . Liquid organic fertilizer treatment, , Chicken Manure treatment, and combination of both treatments had no significant effect on soybean plant height at 5 weeks after planting. This can be seen in Table 1.

Table 1. Average Soybean Plant Height in Liquid organic fertilizer and Chicken Manure Treatments at 5 WAP

Treatmen	Chicken Manure (g/polybag)				Average
	K_0	K_1	K_2	K_3	
Liquid organic fertilizer (ml/l water)					
P_0	57,17	63,17	57,50	60,33	59,54
P_1	64,83	57,33	64,33	59,00	61,38
P_2	46,00	58,67	59,17	59,33	55,79
P_3	58,17	69,00	59,83	64,33	62,83
Average	56,54	62,04	60,21	60,75	

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Table 1 shows that the application of Liquid organic fertilizer had no significant effect on the height of soybean plants at 5 weeks after planting, where treatment P3 (150 ml/polybag) showed the highest soybean plant height at 62.83 cm. The application of Chicken Manure also had no significant effect on plant height. The Chicken Manure treatment in treatment K1 (0.5 kg/polybag) showed a plant height of 62.04 cm, indicating better plant height.

Based on Table 3, it can be seen that the Liquid organic fertilizer treatment at 5 WAP age produced the best results in P3 (62.83 cm), which was not significantly different from P2 (55.79 cm), P1 (61.38 cm), and P0 (59.54 cm). This is because the initial soil analysis (appendix) shows that the N nutrient content is relatively low, so that the treatments given were unable to supply N with the different doses used in the study, and therefore could not sufficiently demonstrate the differences between each dose given on plant height.

Plant growth is determined by the adequacy of nutrients in the soil used. According to Buckman (2008), a plant will grow and reach high production levels if the nutrients it needs are sufficiently available and balanced in the soil, and Chicken Manure is one of the three (3) of the six macro nutrients that are absolutely necessary for plants [9]. Harjadi (2002) adds that plants will grow well if the nutrients they need are sufficiently available in a form that can be absorbed by the plants and supported by loose soil structure conditions [10].

Liquid organic fertilizer contains various minerals and essential substances needed by soil and plants, as well as plant growth hormones. Liquid organic fertilizers are more effective in stimulating growth and increasing the cation exchange capacity of soil compared to chemical fertilizers [11]. Cation exchange capacity is the ability of soil to increase interactions between ions in the soil so that it can provide various elements needed by plants [12].

The interaction between the two treatments had no significant effect on soybean plant height at 5 weeks after planting, but there was a tendency for plant height to increase with higher doses of both treatments.

3.2 Steam Diameter

The analysis results show that Chicken Manure treatment has a significant effect on plant stem diameter, but Liquid organic fertilizer treatment and the interaction of the two treatments have no significant effect on the stem diameter of soybean plants at 12 WAP. This can be seen in Table 2 below.

Table 2. Average Stem Diameter of Soybean Plants under Liquid organic fertilizer and Chicken Manure Treatments at 12 WAP

Treatment	**Chicken Manure (kg/polybag)**				**Average**
	K_0	K_1	K_2	K_3	
Liquid organic fertilizer (ml/l water)					
P_0	4,88	8,27	7,13	8,17	7,11
P_1	7,57	8,27	7,87	9,07	8,19
P_2	6,23	7,03	8,23	7,77	7,32
P_3	7,70	8,47	7,27	8,43	7,97
Average	6,60 a	8,01 c	7,63 b	8,36 c	

Note: Figures followed by the same letter in the same column are not significantly different at the 5% level based on the DMRT test.

Table 2 shows that the stem diameter of the Liquid organic fertilizer treatment in soybean plants at 12 WAP, where treatment P3 (7.97 mm) was not significantly different from P2 (7.32 mm), P1 (8.19 mm), and P0 (7.19 mm), and Table 3 also shows that the application of Liquid organic fertilizer has a significant effect on the stem diameter of soybean plants at 12 WAP. In the Liquid organic fertilizer treatment P1 (50 ml/polybag), the stem diameter of 8.19 mm indicates the best stem diameter for soybean plants. There was no significant difference in stem diameter. This is likely due to the high dose of Liquid organic fertilizer, which contains growth regulators such as cytokinin, auxin, and gibberellin. If applied excessively, these substances can inhibit stem diameter growth in plants.

Based on Table 2, the Chicken Manure treatment had a significant effect on stem diameter, where the Chicken Manure treatment at level K3 (1.5 kg/polybag) was 8.36 mm, showing a significantly higher stem diameter than K2 (7.63 mm) and K0 (6.60 mm) and not significantly different from K1 (8.01 mm).

The relationship between soybean stem diameter and Chicken Manure is linear with the equation $\hat{Y} = 0.98 x + 6.915$ $r = 0.691$ as shown in Figure 1.

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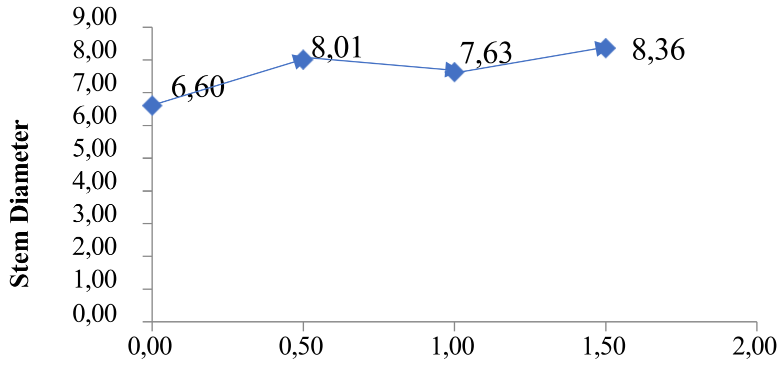

Figure 1. Relationship between Chicken Manure application and soybean stem diameter

The interaction between the two treatments had no significant effect on the stem diameter of soybean plants at 12 weeks after planting, but there was a tendency for stem diameter to increase with increasing treatment dose. The two treatments had a mutually exclusive effect on stem diameter.

3.3 Number of Branches

The analysis results show that Liquid organic fertilizer and Chicken Manure treatments have a significant effect on the number of branches, but the interaction of the two treatments does not have a significant effect on the number of soybean branches at 12 weeks after planting. This can be seen in Table 3.

Table 3. Average Number of Soybean Plant Branches in Liquid organic fertilizer and Chicken Manure Treatments at 12 WAP

Treatmen	Chicken Manu re (kg/polybag)				Average
	K_0	K_1	K_2	K_3	
Liquid organic fertilizer (ml/l water)					
P_0	3,33	5,67	7,67	5,67	5,58 a
P_1	5,33	9,33	5,33	9,00	7,25 b
P_2	7,00	8,33	5,33	10,00	7,67 b
P_3	6,00	7,33	8,00	11,00	8,08 c
Average	5,42 a	7,67 c	6,58 b	8,92 d	

Note: Figures followed by the same letter in the same column are not significantly different at the 5% level based on the DMRT test.

Table 5 above shows that the application of Liquid organic fertilizer had a significant effect on the number of soybean branches at 12 weeks after planting. The Liquid organic fertilizer treatment at level P3 (150 ml/polybag) had 8.08 branches, which was the highest number of soybean branches and significantly different from P2 (7.67) P1 (7.25), and P0 (5.58). The Chicken Manure treatment also had a significant effect on the number of soybean plant branches. At the K3 treatment level (8.92), it was significantly different from K2 (6.58), K1 (7.67), and K0 (5.42).

The relationship between the number of soybean branches and Liquid organic fertilizer is linear with the equation $\hat{Y} = 0.015x + 15.95$ r = 0.868, as shown in Figure 2 below.

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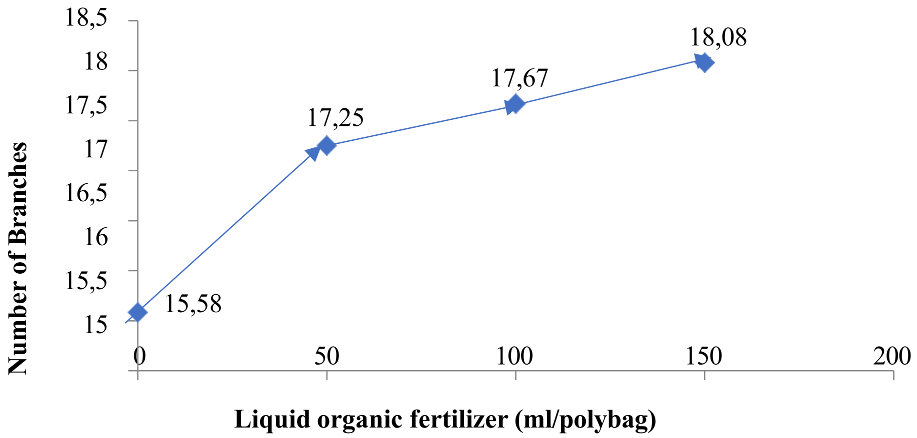

Figure 2. Relationship between Liquid organic fertilizer application and the number of soybean branches

Based on statistical tests conducted on the number of soybean branches, it was found that the application of Liquid organic fertilizer had a significant effect on the number of soybean branches. This shows that Liquid organic fertilizer can influence the increase in the number of branches. Other factors that can influence growth consist of internal and external factors. Internal factors are the soybean plants themselves. Meanwhile, external factors include: spraying time, rainfall, sunlight intensity, planting media, and physiological stress.

Leaves contain stomata, which play an important role in this study because of their connection to the photosynthesis process that produces the number of branches. Good leaves result in perfect photosynthesis, which increases the production of branches [12]. Thus, this causes Liquid organic fertilizer to have a significant effect on the increase in the number of soybean branches.

The relationship between the number of soybean branches and Chicken Manure is linear with the equation $\hat{Y} = 1.882x + 15.73$ $r = 0.658$, as shown in Figure 3 below.

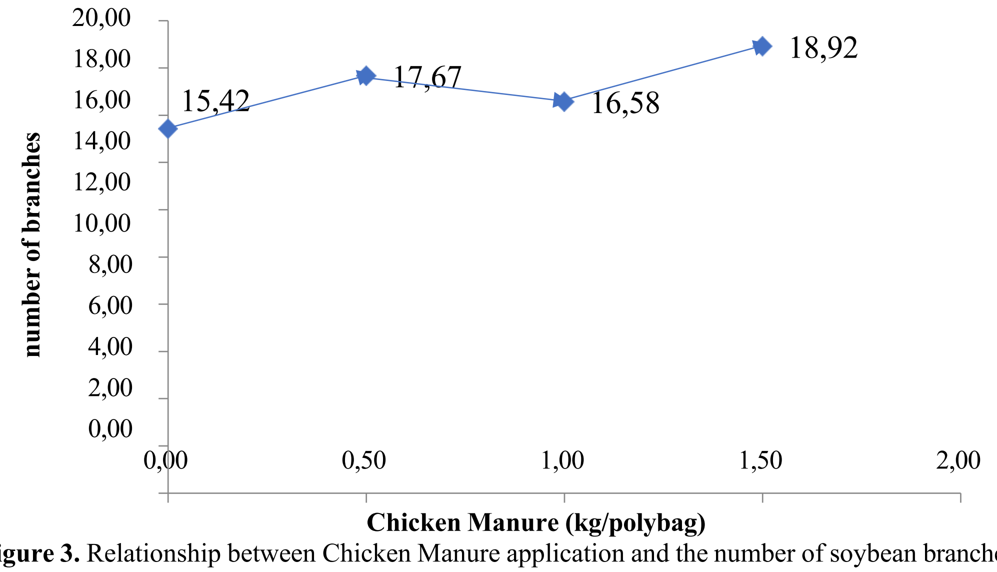

Figure 3. Relationship between Chicken Manure application and the number of soybean branches

Based on the graph above, it can be seen that soil treated with Chicken Manure can increase the number of branches. This may be due to the high N and P nutrient content in the fertilizer. This statement is in line with the results of research by Nana and Salamah (2014) that N nutrients play a role in the formation of leaf chlorophyll for photosynthesis, so that indirectly it can also increase the number of soybean branches [13].

The interaction between the two treatments had no significant effect on the number of soybean branches at 12 weeks after planting, but there was a tendency for the number of branches to increase with higher doses of both treatments.

3.4 Number of Pods

The results of the analysis show that the Chicken Manure treatment had a significant effect on the number of soybean pods, whereas the application of Liquid organic fertilizer and the interaction between the two treatment

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factors had no significant effect on the number of soybean pods at 12 weeks after planting. This can be seen in Table 4 below.

Table 4. Average Number of Soybean Plant Pods in Liquid organic fertilizer and Chicken Manure Treatments at 12 WAP

Treatmen	Chicken Manure (kg/polybag)				Average
	K0	K1	K2	K3	
Liquid organic fertilizer (ml/l water)					
P0	115,00	130,00	180,00	195,00	155,00
P1	131,67	188,33	181,67	261,67	190,83
P2	120,00	163,33	223,33	185,00	172,92
P3	140,00	228,33	185,00	233,33	196,67
Average	126,66 a	177,5 b	192,5 ab	218,75 ab	

Note: Figures followed by the same letter in the same column are not significantly different at the 5% level based on the DMRT test.

Table 4 shows that the application of Liquid organic fertilizer had no significant effect on the number of soybean pods at 12 weeks after planting; in the Liquid organic fertilizer P3 treatment (150 ml/polybag), the number of pods was 196.67, which was the highest among all treatments, whereas the Chicken Manure treatments showed a significant effect on the number of soybean pods at 12 weeks after planting. The K3 treatment (218.75) differed significantly from the K1 (177.5) and K0 (126.66) treatments, but did not differ significantly from the K2 treatment (192.5). This means that at the K2 treatment level (1 kg/polybag), the number of soybean pods was already increased. The interaction between the two treatments had no significant effect on the number of pods. The P3K3 treatment (233.33) was the treatment combination with the highest number of pods.

The relationship between the number of soybean pods and Chicken Manure fertilizer is linear, with the equation $\hat{Y} = 58.29x + 135.1$ and $r = 0.941$, as shown in Figure 4 below.

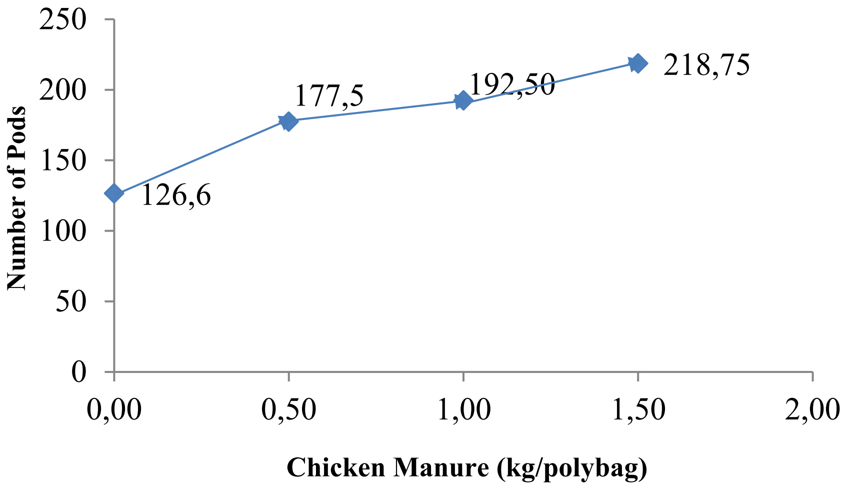

Figure 4. The Relationship Between Chicken Manure fertilizer and the Number of Soybean Pods

Based on Figure 4 above, it can be seen that plants treated with 1.5 kg/polybag of Chicken Manure fertilizer had the highest average number of pods compared to plants in the other treatment groups. This may be due to the fact that the Chicken Manure nutrient content was sufficient for soybean pod production.

This finding is further supported by the average number of pods shown in Table 4, where plants treated with 1.5 kg/polybag exhibited the highest average increase in the number of pods compared to the other treatments. The control plants, which were not given Chicken Manure fertilizer, had the fewest pods compared to the treated plants. This may be because the control plants did not receive additional nutrients, particularly Chicken Manure, resulting in a significantly lower number of pods.

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3.5 Weight of 100 Seeds

The results of the analysis show that the Liquid organic fertilizer and Chicken Manure treatments had a significant effect on the weight of 100 soybean seeds, whereas the interaction between the two treatment factors had no significant effect on the weight of 100 soybean seeds at 12 weeks after planting. This can be seen in Table 5 below.

Table 5. Average Weight of 100 Soybean Seeds Under the Liquid organic fertilizer and Chicken Manure Treatments at 12 MST

Treatmen	Chicken Manure (kg/polybag)				Average
	K_0	K_1	K_2	K_3	
Liquid organic fertilizer (ml/l water)					
P_0	13,64	15,24	14,39	16,47	15,43 a
P_1	15,34	14,76	15,68	15,72	15,62 b
P_2	15,02	15,29	16,51	16,08	15,73 c
P_3	15,56	16,25	15,55	15,68	15,76 c
Average	14,89 a	15,13 b	15,53 c	15,99 d	

Note: Figures followed by the same letter in the same column are not significantly different at the 5% level based on the DMRT test.

The relationship between the weight of 100 soybean seeds and the application of Liquid organic fertilizer is linear, with the equation $\hat{Y} = 0.22x + 15.47$, $r = 0.904$, as shown in Figure 5 below. The table shows that as the dose of Liquid organic fertilizer treatment increases, the weight of 100 soybean seeds also increases.

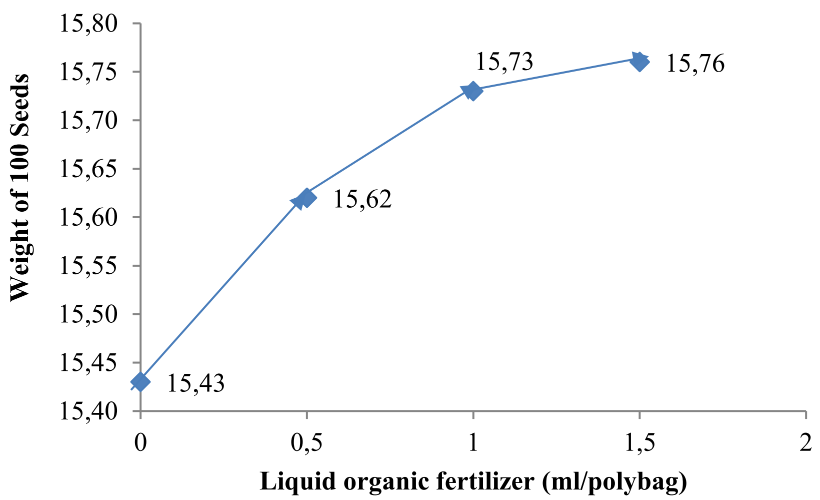

Figure 5. Relationship Between Liquid organic fertilizer Application and the Weight of 100 Soybean Seeds Soybean Plants

The relationship between the weight of 100 soybean seeds and the application of Chicken Manure is linear, with the equation $\hat{Y} = 0.74x + 14.83$, $r = 0.98$, as shown in Figure 6 below. The figure illustrates that as the dose of Chicken Manure increases, the weight of 100 soybean seeds also increases.

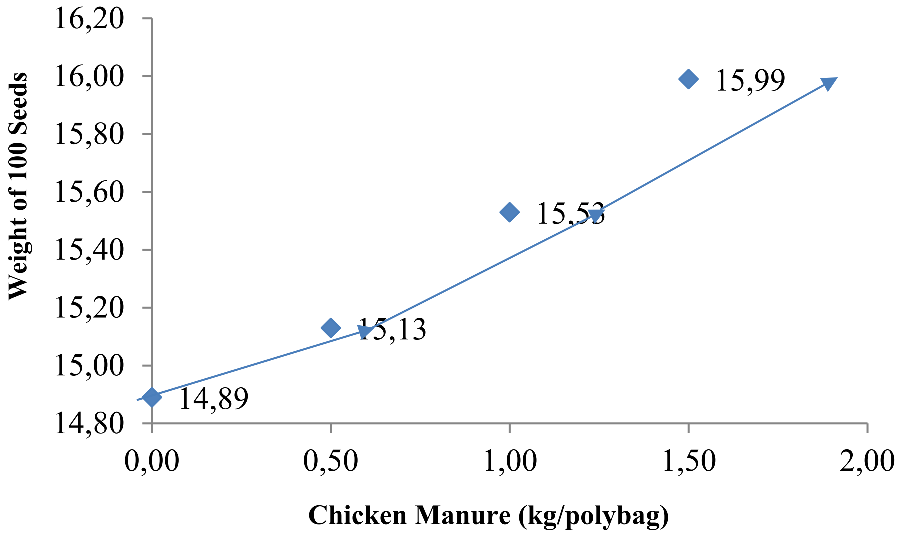

Figure 6. Relationship Between Chicken Manure Application and the Weight of 100 Soybean Seeds Soybean Plants

Based on Figure 6 above, it can be seen that the soil treated with a Liquid organic fertilizer concentration of 150 ml/polybag yielded the highest average weight of 100 seeds compared to plants in other treatment groups. This may be due to the high N and P nutrient content in Liquid organic fertilizer. This finding is consistent with the results of a study by Nana and Salamah (2014), which indicated that banana peels contain nitrogen (N), a nutrient that plays a role in the formation of leaf chlorophyll for photosynthesis, thereby indirectly increasing soybean yield [13]

The application of liquid organic fertilizer made from banana peels is believed to promote plant growth by increasing nutrient availability and improving rhizosphere conditions, thereby supporting plant physiological processes. However, since this study did not measure Rhizobium bacterial activity, nutrient uptake, or the rate of nitrogen fixation, this mechanism remains a hypothesis based on the results of previous studies. Optimal plant growth can essentially only be achieved when nutrients are available in sufficient, balanced amounts that are easily absorbed by the plants, and when supported by suitable environmental conditions [14].

It is known that the application of chicken manure has a significant effect on the weight of 100 soybean seeds. The increase in seed weight is thought to be related to the increased availability of nutrients required during the seed-filling phase. In addition, adequate light plays a crucial role in the photosynthesis process, which produces photosynthates as a source of energy and a building block for biomass, thereby supporting optimal seed formation and filling. Thus, crop production is influenced by the interaction between nutrient availability and environmental conditions, particularly light intensity, which determines photosynthetic efficiency and the distribution of photosynthates to reproductive organs [15].

4 Conclusion

Banana peel liquid organic fertilizer significantly increased the number of branches and the weight of 100 soybean seeds, although it did not significantly affect plant height, stem diameter, or the number of pods. Chicken manure significantly improved stem diameter, number of branches, number of pods, and weight of 100 seeds, indicating that it contributed positively to both vegetative growth and reproductive development of soybean cultivated in Andisol soil. However, no significant interaction was observed between banana peel liquid organic fertilizer and chicken manure for any of the measured variables, suggesting that each fertilizer acted independently under the conditions of this study.

The present findings demonstrate that banana peel liquid organic fertilizer has potential as an alternative organic fertilizer derived from agricultural waste, while chicken manure remains an effective organic nutrient source for improving soybean performance in Andisol soil. Nevertheless, the absence of significant interaction and the lack of detailed analyses of nutrient dynamics, soil properties, and fertilizer composition indicate that the mechanisms underlying plant responses require further investigation. Future research should include comprehensive characterization of liquid organic fertilizer and soil chemical properties, measurements of nutrient uptake and soil microbial activity, evaluation under different soybean cultivars and soil types, as well as economic feasibility analyses to support wider application in sustainable soybean production

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