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Increasing Growth and Yield of Soybeans (*Glycine max* L.) by Providing Banana Stem LOF and SP-36 Fertilizer

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Abstract

Soybean productivity in Indonesia remains relatively low, partly due to declining soil fertility. One approach to address this issue is the application of liquid organic fertilizer (LOF) and phosphate fertilizers, such as SP-36. This study aimed to evaluate the effects of various concentrations of banana corm-based LOF and different doses of SP-36 fertilizer, as well as their interaction, on the growth and yield of soybean plants (*Glycine max* L.). The research was conducted in Medokan, Surabaya, using a two-factorial Randomized Block Design (RBD) with four levels of LOF concentration (0, 500, 600, and 700 ml/l) and three levels of SP-36 concentration (150, 200, and 250 kg/ha). The observed parameters included plant height, number of pods, percentage of empty pods, seed weight per plant, seed weight per hectare, and fruit set. The results indicated a significant interaction between LOF and SP-36 on plant height 42 days after planting, number of pods, percentage of empty pods, and fruit set. The most effective treatment was the combination of 600 ml/l banana corm LOF and 200 kg/ha SP-36. However, seed weight per plant and hectare did not show a significant effect. This study concludes that the appropriate combination of banana corm LOF and SP-36 fertilizer can significantly enhance soybean growth and yield. It is recommended to use 600 ml/L of banana corm LOF combined with 200 kg/ha of SP-36 fertilizer to optimize plant height, number of pods, and fruit set in soybean cultivation.

Keywords: Combination, Fertilizer, Randomized Block Design, Significantly Different

1. Introduction

Soybeans are a type of legume that is one of Indonesia's most important food commodities, after rice and corn. Soybeans play an essential role in improving community nutrition because they act as a source of vegetable protein that is safe for health at a relatively low price compared to animal protein. Soybeans have a high protein content of 40.4% in 100 g and have a good fat content of 18-22% and 30-35% carbohydrate content (Sari & Rahmawati, 2020). Although soybeans are the third most crucial food commodity, soybean production in Indonesia can still not meet community needs due to low productivity. Low productivity is inversely proportional to the demand for soybeans by the community, which increases yearly due to the increase in population, so soybean production cannot keep up with market demand (BPS, 2023).

Low soybean production is caused by several things, such as decreasing soil fertility for cultivation and using agricultural land that lacks nutrients. The lack of nutrients in the soil can be improved by using organic fertilizers. One type of organic fertilizer is liquid organic fertilizer (LOF). LOF is the result of extraction from organic materials that have rotted and contain various nutrients that are very important for plants, such as liquid organic fertilizer from banana stems. Banana stems contain nutrients needed by plants to increase soil fertility. Banana stem LOF has a P content of around 0.2–0.5%, which improves nutrition during plants' growth and production periods (Amir & Fauzy, 2018).

Based on previous research conducted by (Hodijah et al., 2023) shows that the provision of banana stump LOF can provide a significant effect on the parameters of plant height, number of leaves, number of branches, wet weight, and weight of soybean plant crowns at a concentration of 160 ml/L. However, the study has not examined more

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specifically the effect of banana stump LOF combined with inorganic phosphorus fertilizer, so this study has a novelty in examining the combination of banana stump LOF and inorganic phosphorus fertilizer SP-36 to obtain increased growth and yield in soybean plants.

Another factor affecting soybean plants' growth and productivity is phosphorus (P). Phosphorus is one of the most important macronutrients for soybean plants, and it is needed in large quantities during development and production. Still, its availability in the soil is often low, especially in acidic soils. According to (Habi et al., 2018), the low availability of P in the soil occurs due to fixation where phosphate ions (PO_4^{3-}) are firmly bound to aluminum (Al^{3+}) and iron (Fe^{3+}) elements that are active at low pH. These ions will react with phosphate and form compounds such as aluminum phosphate ($AlPO_4$) and iron phosphate ($FePO_4$) that are insoluble in water, making phosphorus unavailable to plants. The types of soil that tend to have low available phosphorus content are soils that contain a lot of iron and aluminum oxides, such as ultisols oxisols, and old alluvial soils with acidic reactions and low base saturation levels.

Based on previous research conducted by Sipayung et al.(2023), phosphorus accelerates root growth during seeding, flower and seed formation, maturity, and production. In this study, phosphorus fertilizer treatment significantly affected plant height, flowering age, 100 seed weight, and root length with a 16.25 grams/polybag dose. This study has not examined, more specifically, the combination of inorganic fertilizers with liquid organic fertilizers, especially those derived from banana stumps. In this study, the novelty lies in the evaluation of the interaction between banana stump LOF and SP-36 fertilizer on various parameters of soybean plant growth and yield, as well as the analysis of its effect on fruit set and the percentage of empty pods which have not been widely discussed in previous studies.

This study aims to determine the effect of banana stem LOF concentration and phosphate fertilizer dosage and their appropriate interactions on the growth and yield of soybean plants.

2. Material and Methods

This research was conducted at the Surabaya City Food Security and Agriculture Service (DKPP) Land in the Medokan Asri Utara area, Medokan Ayu, Surabaya, with coordinates 7°19'20.6 "S 112°47'41.4 "E, which is at an altitude of ± 3 meters above sea level. The research was conducted from December 2024 - April 2025. The tools used in the study were hoes, stakes, watering cans, buckets, trowels, and rulers. The materials used were soybean seeds of the Denasa 2 variety, soil, and compost planting media with a ratio of 2:1, polybags, Decis 25, Dithane M 45, Amistar Top, banana stumps, EM4, SP-36 fertilizer, NPK fertilizer, and labels.

This study is a factorial experiment with 2 treatment factors. It is designed following the rules of Randomized Block Design (RAK), with factor 1 being liquid organic fertilizer of banana stump, consisting of 4 levels of administration, namely B0 = 0 ml/l; B1 = 500 ml/l; B2 = 600 ml/l; B3 = 700 ml/l. Factor 2 is SP-36 fertilizer, consisting of 3 levels of administration, namely P1 = 150 kg/ha; P2 = 200 kg/ha; P3 = 250 kg/ha. There are 12 treatment combinations, each consisting of 3 replications. Each experimental unit consists of 3 sample plants, totalling 108 plants.

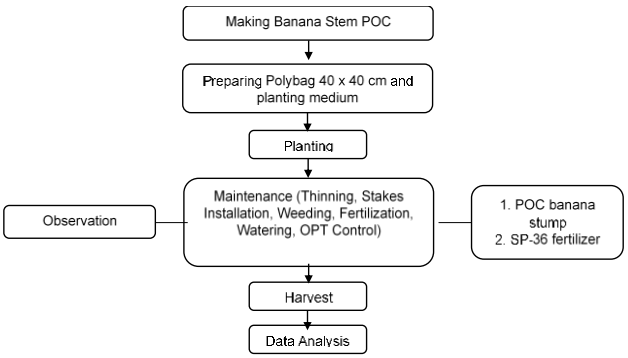

Figure 1. Research Implementation Flowchart

The parameters observed were plant height calculated using a 100 cm ruler, number of pods by manually calculating the total number of pods per plant, and percentage of empty pods by calculating using the formula:

$$\frac{\boldsymbol{Number\ of\ empty\ pods}}{\boldsymbol{Total\ of\ pods}} \times \mathbf{100}\%$$

The equipment used in the experiment comprised hoes, ovens, weighing scales, raffia string, markers, machetes, knives, measuring tapes, labels, plastic bags, analytical balances, aluminum cups, folders, HVS paper, rubber bands, tissues, and label paper.

seed weight per plant using analytical scales with an accuracy of 0.01 grams, seed weight per hectare by calculating using the formula:

$$\frac{\boldsymbol{seed\ weight\ per\ plant} \times \boldsymbol{number\ of\ plants}}{\mathbf{1000}}$$

And *fruit set* by calculating using the formula:

$$\frac{\boldsymbol{Number\ of\ Harvest\ Pods}}{\boldsymbol{Total\ flower}} \times \mathbf{100\%}$$

The data analysis was conducted using variance (ANOVA) based on a factorial randomized block design. When treatments were different, it was continued with a 5% BNJ test using the Microsoft Excel version 2504 application.

3. Results and Discussion

3.1. Plant Height

The results of the ANOVA statistical analysis of plant

height showed that the treatment of banana stump LOF and SP-36 fertilizer had a significant effect 42 days after planting (Table 1). Table 2 shows that the treatment of banana stump LOF had a considerable effect 56 days after planting, and the single factor of SP-36 fertilizer dose had a significant effect 49 days after planting and 56 days after planting.

The average value of 42 DAP is presented in Table 1 below, and the average value of plant height from 14-56 DAP is presented in Table 2.

Table 1. Average Height of Soybean Plants at 42 DAP in Combination Treatments Concentration of Banana Stem LOF and SP-36 Fertilizer Dosage

Banana Stem LOF Concentration (ml/L)	Plant Height 42 DAP (cm)		
	SP-36 Fertilizer Dosage kg/ha		
	150	200	250
0	31.56 ±2.26 [ab]	30.67 ±1.92 [ab]	34.47 ±2.08 [ab]
500	32.17 ±1.17 [ab]	34.72 ±3.25 [ab]	30.89 ±1.84 [ab]
600	28.22 ±3.67 [a]	30.86 ±4.11 [ab]	35.42 ±1.91 [b]
700	31.78 ±1.17 [ab]	32.33 ±0.76 [ab]	29.17 ±3.09 [ab]
BNJ 5%		6.93	

Note: Mean numbers followed by the same letter indicate no significant difference in the 5% BNJ test.

Table 2. Average Height of Soybean Plants in Single Concentration Treatments LOF Banana Stem and SP-36 Fertilizer Dosage

Banana Stem LOF Concentration (ml/L)	Average Plant Height (cm)					
	DAP					
	14	21	28	35	49	56
0	12.12 ± 1.50	15.26 ± 1.25	20.15 ± 1.18	27.80 ± 1.66	37.59 ± 3.58	42.39 ± 1.00 [a]
500	11.87 ± 1.00	15.27 ± 0.99	19.93 ± 1.13	27.02 ± 2.94	37.11 ± 2.69	42.04 ± 0.81 [a]
600	12.09 ± 1.08	15.47 ± 1.28	20.56 ± 2.01	27.15 ± 3.60	39.15 ± 3.35	44.83 ± 3.22 [b]
700	11.70 ± 0.90	14.91 ± 0.89	19.30 ± 0.96	25.81 ± 2.61	36.78 ± 2.47	43.70 ± 1.66 [ab]
BNJ 5%	tn	tn	tn	tn	tn	1.99
SP-36 Fertilizer Dosage (kg/ha)						
150	12.34± 1.26	15.10 ± 1.00	19.85 ± 1.37	26.83 ± 1.84	36.38 ± 1.90 [a]	42.64 ± 1.34 [a]
200	11.67 ± 1.17	14.87 ± 1.35	19.68 ± 1.45	26.91 ± 3.41	39.31 ± 3.17 [b]	44.60 ± 2.33 [b]
250	11.83 ± 0.81	15.71 ± 0.73	20.42 ± 1.38	27.09 ± 3.06	37.29 ± 3.37 [ab]	42.49 ± 2.13 [a]
BNJ 5%	tn	tn	tn	tn	2.82	1.55

Note: The average numbers followed by the same letter and at the same treatment and age show no significant difference in the 5% BNJ test; tn = not significant.

The analysis showed that the highest soybean plant height was found in the combination of 600 ml/l banana stem LOF concentration and 250 kg/ha SP-36 fertilizer dose, which showed a significant difference in the plant height 42 DAP. However, with the provision of 700 ml/l LOF, there was a decrease in plant height to 29.17 cm. This result shows excessive LOF concentration inhibits plant growth and provides no benefits. Providing banana stem LOF and SP-36 significantly affected plant height 42 DAP. This study is different from the results of the study (Wicaksono, 2015) in the provision of LOF and P fertilize, which did not significantly interact with the parameters of soybean plant height. This result can occur due to differences in fertilizer types, concentrations of each treatment, plant varieties, and the ability of plants to absorb the nutrients provided.

Table 2 shows that the single factor of banana stump LOF administration did not significantly affect 14-49 DAP but reduced 56 DAP with a concentration of 600 ml/l on plant height. The single factor of SP-36 administration significantly affected the age of 49-56 DAP with a dose of 200 kg/ha. The increase in plant height from age 14-56 DAP took place more optimally with LOF 600 ml/l and SP-36 200-250 kg/ha. The data pattern in the treatment showed that the treatment was able to support plant growth even better. This result can happen because banana stump LOF has an organic material content that can affect the soil's chemical, physical, and biological properties to increase the soil's fertility. Based on the statement (Ariani et al., 2025), liquid organic fertilizer can improve the physical properties of the soil because it contains organic material that makes the soil loose so that the roots can develop and absorb water and nutrients more optimally.

Meanwhile, phosphorus is also one of the main macronutrients and energy sources, playing an essential role in plant cells' photosynthesis and energy metabolism, especially in the storage and distribution of energy in plant biochemical reactions. In addition, phosphorus also plays a role in the formation and elongation of new plant cells and the thickening of plant tissue. Giving SP-36 fertilizer with the correct dose will increase nutrient absorption plants' availability and allow the metabolic process to run optimally (Kurniawan et al., 2022). The results of this study differ from the results of Hodijah's study (2023), which showed that the administration of 160 ml/L banana stem LOF had a significant effect on the height of soybean plants

by 77.00. This difference can occur due to differences in plant varieties where the maximum height of the Denasa 2 soybean plant variety in this study was 50 cm. In comparison, the soybean variety used in the previous study was the Anjosmoro variety, with a maximum height of 68 cm. In addition, differences in research locations and soil types can cause differences in results between studies.

Based on the results of the ANOVA statistical analysis, it was shown that the combination of banana stem LOF concentration and SP-36 fertilizer dose significantly affected the number of pods per plant. The single factors of banana stem LOF concentration and SP-36 fertilizer dosage each had no significant effect. The average value of the number of pods per plant can be seen in Table 3 below.

3.2. Number of Pods

Table 3. Average Number of Soybean Pods in the Concentration Combination Treatment LOF Banana Stem and SP-36 Fertilizer Dosage

Banana Stem LOF Concentration (ml/L)	Average Number of Pods		
	SP-36 Fertilizer Dosage (kg/ha)		
	150	200	250
0	76.67±4.16 [ab]	64.44±2.50 [ab]	66.50±6.26 [ab]
500	76.17±4.31 [ab]	64.89±2.78 [ab]	67.33±6.33 [ab]
600	70.11±6.46 [ab]	80.67±8.02 [b]	69.33±5.20 [ab]
700	64.56±4.30 [ab]	65.17±5.01 [a]	67.17±5.35 [ab]
BNJ 5%		16.12	

Note: Mean numbers followed by the same letter show no significant difference in the 5% BNJ test.

Based on the research, the optimal results on the number of pods parameter were found in the combination of banana stump LOF concentration of 600 ml/l and SP-36 fertilizer dose of 200 kg/ha of 80.67 pods. The lowest results were found in the combination without banana stump LOF treatment of 0 ml/l and SP-36 fertilizer dose of 200 kg/ha of 64.44 pods. The combination of banana stump LOF treatment of 600 ml/l concentration with SP-36 fertilizer dose of 200 kg/ha was not significantly different in all treatments except for the combination of LOF treatment of 700 ml/l + SP-36 200 kg/ha. Based on the table, the highest results were obtained using LOF 600 ml/l + SP-36 200 kg/ha. In comparison, at a dose of 150 kg/ha with low concentration, LOF produced a stable number of pods. At a dose of 250 kg/ha, the number of pods increased at a LOF concentration of 600 ml/l and decreased with increasing LOF concentration. Likewise, administering a dose of 200 kg/ha increased the number of pods at a LOF concentration of 600 ml/l and decreased at a LOF concentration of 700 ml/l. This result shows that the optimal LOF concentration is 600 ml/l, and administration of higher concentrations will cause a decrease in soybean pod yield.

This study aligns with research (Gusmiatun et al., 2023) showing that the combination of 100% LOF and 300 kg/ha P fertilize significantly affects the number of soybean pods of 125.47 pods. Although the number of pods of previous researchers was higher than in this study, the combination of LOF and P fertilizer significantly affected soybean yield parameters. Different types of LOF, soybean varieties, or environmental conditions may cause differences in the number of pods. Still, these findings strengthen the hypothesis that LOF and P fertilizer synergy is an effective strategy to increase soybean productivity. The interaction of pod filling in soybean plants is thought to be greatly influenced by phosphorus. (Ardian et al., 2023) stated that phosphorus content in plants plays a role in the metabolic process, which can ultimately increase the number of filled pods. The number of filled pods then affects the weight of the pods and seeds. In line with this, (Utami et al., 2021) reveal that the number of pods on a plant will affect the weight of the wet pods, the dry pods, and the dry weight of the seeds.

3.3. Empty Pod Percentage

The statistical analysis results on combining banana stem LOF and SP-36 fertilizer significantly affected the percentage of empty pods. The administration of SP-36 fertilizer doses as a single factor had a significant effect, while the single factor of banana stem LOF concentration did not significantly impact. The average results of the percentage of empty pods in soybean plants are presented in Figure 2 below.

The results of the study showed that there were significant differences in the combination of banana stem LOF concentration and SP-36 fertilizer dosage. Figure 1. It can be seen that the combination of treatments on the empty pod parameter, which was slightly found in the LOF concentration of 600 ml/l and SP-36 dosage of 200 kg/ha, was 4.92%, and the highest empty pods occurred in the combination of LOF 600 ml/l + SP-36 150 kg/ha.

Based on the research results, administering a LOF concentration of 600 ml/l + SP-36 fertilizer dose of 200 kg/ha reduced the number of empty pods of soybean plants. This finding is different from the results of the study (Wicaksono, 2015), which showed that the administration of a combination of azolla LOF and SP-36 fertilizer did not provide significant interaction on empty pods, but the administration of a single factor SP-36 had a significant effect in reducing the number of empty pods at a dose of

200 kg/ha. When compared quantitatively, the optimal LOF concentration in this study (600 ml/l) was much higher than the Azolla LOF concentration in Wicaksono's study (80 ml/l). Still, both studies showed that combining liquid organic fertilizer and SP-36 fertilizer at a 200 kg/ha dose gave the best results. This result indicates that banana corm LOF has a role in the generative development period of plants because LOF has a high content of phenolic acid so that it helps bind Al, Fe, and Ca ions to enable the availability of soil phosphorus (P), which is helpful in the flowering and fruit formation process (Chaniago et al., 2017).

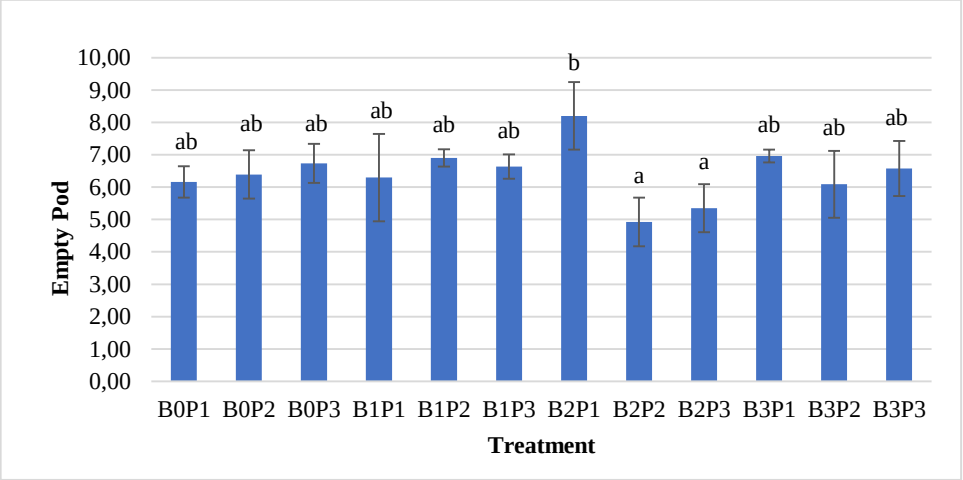

Figure 2. Graph of Percentage of Empty Pods (%). Note: B0P1:0 ml/L; B1:500ml/L; B2:600ml/L; B3:700ml/L; P1:150 kg/ha; P2: 200 kg/ha; P3: 250 kg/ha

3.4. Seed Weight per Plant

The results of the ANOVA analysis of variance on the combination of banana stem LOF concentration and SP-36 fertilizer dose did not significantly affect the seed weight parameter per plant. In single factors, the administration of banana stem LOF and SP-36 fertilizer did not considerably affect the seed weight per plant.

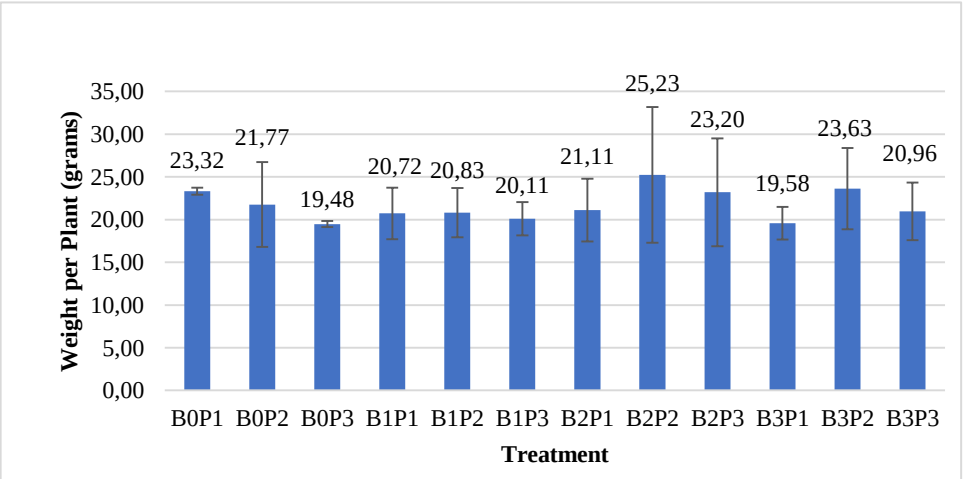

Figure 3. Graph of Seed Weight per Plant (grams). Note: B0P1:0 ml/L; B1:500ml/L; B2:600ml/L; B3:700ml/L; P1:150 kg/ha; P2: 200 kg/ha; P3: 250 kg/ha.

The results of the statistical analysis of the parameters of seed weight per plant show that neither treatment of banana stem LOF fertilizer nor SP 36 had a significant effect (Figure 3). This result indicates that the treatment given was not effective enough in increasing the yield of seed weight in the plants tested. This finding is not in line with the research of Gusmiatun (2023), where the administration of 100% fish waste LOF and 300 kg/ha P fertilizer significantly increased the number of seeds per soybean plant by 79.73 grams. Meanwhile, in this study, the average seed weight per plant did not experience a significant increase in all treatment combinations, even at the highest doses and concentrations. This result can occur due to differences in LOF content, soybean plant varieties used, the study's environment, and the suitability of the application dose. This finding confirms that the

effectiveness of LOF is greatly influenced by the composition of raw materials, doses, plant varieties, and plant adaptation to the environment, as also emphasized by (Saputra, 2021)that the administration of fertilizer at the right time, the appropriate dose or concentration, and the type of fertilizer itself greatly affect the increase in production. In addition, plant adaptation to its growing environment is a determining factor in plant productivity.

3.5. Seed Weight per Hectare

Based on the analysis of variance on the combination of treatment of giving banana stump LOF concentration and SP-36 fertilizer dosage, it did not significantly affect the parameter of seed weight per hectare in soybean plants. Separately, giving banana stump LOF concentration and SP-36 fertilizer dosage on a single factor did not significantly affect the seed weight parameter per hectare.

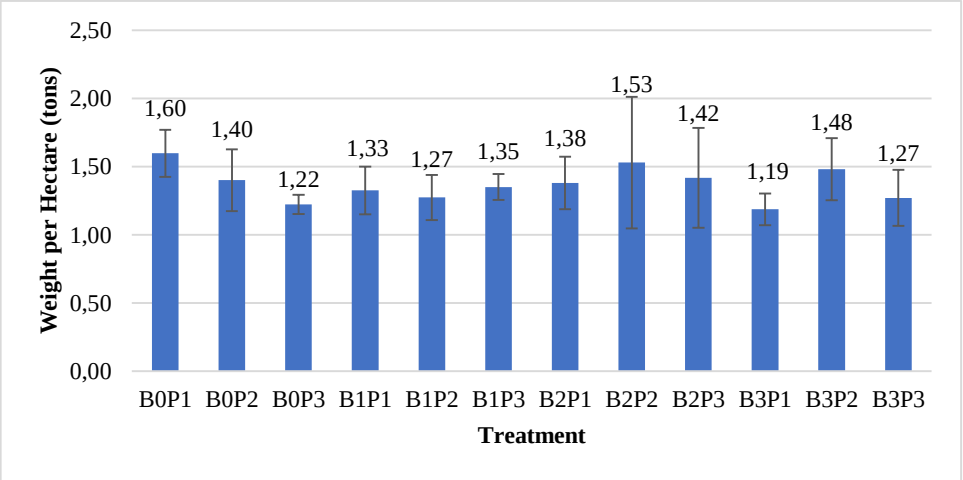

Figure 4. Graph of Seed Weight per Hectare (tons). Note: B0P1:0 ml/L; B1:500ml/L; B2:600ml/L; B3:700ml/L; P1:150 kg/ha; P2: 200 kg/ha; P3: 250 kg/ha.

Figure 4 shows the single factor of giving banana stem LOF concentration and SP-36 fertilizer dose. Separately, the single factor of banana stem LOF concentration and SP-36 fertilizer dose did not differ significantly in the parameter of seed weight per hectare. The results of this study are not in line with the results of the study (Puspitasari & Elfarisna, 2017), that the provision of LOF and inorganic fertilizers can increase seed weight per hectare by 4.64 tons/ha with a combination of LOF 200 ml/l + inorganic 50%. The study of Walid and Susilowati (2016) also showed that providing LOF can significantly affect soybean seed weight per hectare with a LOF nasa concentration of 4 ml/L. This difference can occur due to the less-than-optimal nutrient absorption efficiency in plants in this study and the complex interaction between treatment and environmental conditions that are not always directly proportional to the increase in fertilizer dose. This result is thought to occur due to several factors, such as less than optimal nutrient absorption efficiency by the plants and interactions that are not directly proportional between treatment and environmental conditions. This result aligns with the statement(Febriani et al., 2021) that plants will reach their maximum growth limit without any decrease in production if the factors get balanced elements, the right dosage, and the nutrients are fulfilled. Giving the wrong dosage will result in difficulty in absorbing the nutrients themselves by the plants.

3.6. Fruit Set (%)

The statistical analysis results of the combination of banana stem LOF concentration and SP-36 fertilizer dose showed a significant effect on fruit set parameters. The average value of the further test of the fruit set can be seen in Figure 5 below.

The combination of treatment between the concentration of banana stem LOF and the dose of SP-36 fertilizer showed a significant difference of 57.88% in the fruit set parameter. This result is because the content of macronutrients, especially P, contained in LOF can increase and accelerate the flowering process, increase seed and fruit development protein synthesis, and neutralize organic acids from metabolism, thus supporting optimal flower formation and having a direct impact on increasing the number of pods (Ardian et al., 2023). Meanwhile, phosphorus fertilizer, namely SP-36, can increase the growth period of flowers and seeds and the percentage of flower formation into seeds. A lack of phosphorus cause plants to be unable to produce pods optimally, inhibiting the pod ripening process and the pod yield itself (Wicaksono, 2015).

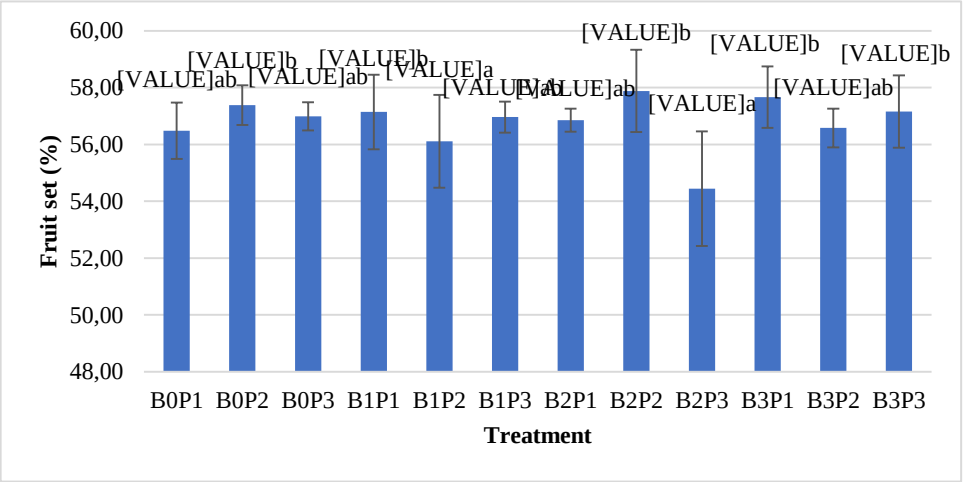

Figure 5. Fruit Set Graph (%). Note: B0P1:0 ml/L; B1:500ml/L; B2:600ml/L; B3:700ml/L; P1:150 kg/ha; P2: 200 kg/ha; P3: 250 kg/ha.

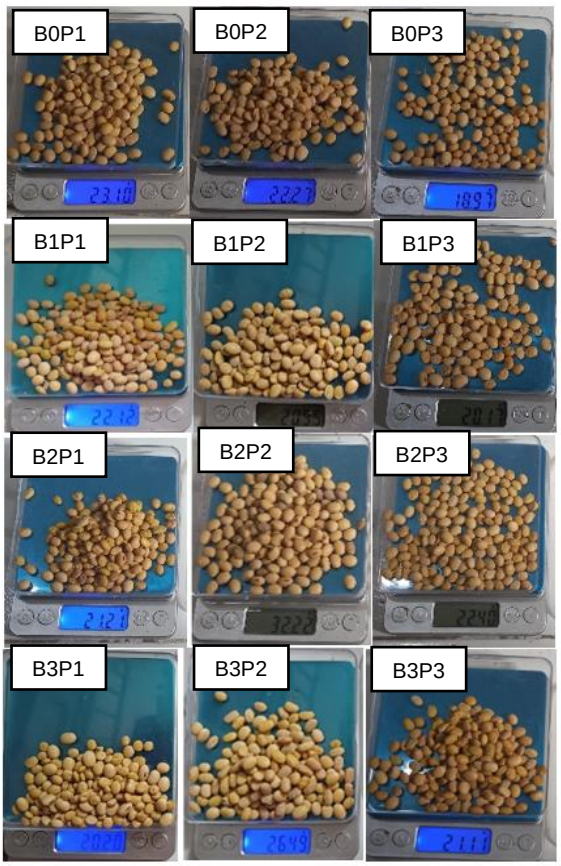

Figure 6. Seed weight per plant (grams)

4. Conclusion

The combination of 600 ml/l banana stem LOF, and 200 kg/ha SP-36 fertilizer provided significant interactions on several vegetative growth parameters (plant height 44.83 cm at 56 DAP) and generative results of soybean plants (number of pods, fruit set, and reduction of empty pods). The single factor of banana stem LOF on the plant height parameter at 56 DAP gave optimal results at a concentration of 600 ml/l. The single factor of SP-36 fertilizer at a dose of 200 kg/ha significantly affected plant height at 49 and 56 DAP. Although it did not significantly affect seed weight, this combination is recommended to increase soybean productivity, especially in areas with low phosphorus availability. Banana stem LOF is a source of organic nutrients (N, P, K) that accelerate flowering, while SP-36 supports the formation of pods and seeds. For further

research, it is necessary to study the dosage adjustment strategy to increase seed weight and adaptation to superior soybean varieties and weather or environmental climate conditions.

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