

Effect of liquid organic and guano fertilizer on growth and yield of edamame in ultisol soil

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Abstract

Edamame soybean is a plant rich in benefits, has a high protein content, and can be harvested when young. The purpose of this study was to get the best Interaction with the application of banana peel LOF and guano fertilizer on the growth and yield of edamame soybean plants in ultisol soil, to get the correct dose of banana peel LOF on the development and yield of edamame soybean plants in ultisol soil, and to get the proper dose of guano fertilizer on the growth and yield of edamame soybean plants in ultisol soil. The results showed that the Interaction of the doses of banana peel LOF and guano fertilizer was not able to give a real effect. Dosing of banana peel LOF was able to give a real effect on the height and number of plant leaves but gave a temporary negative effect on each observation variable. The design of this study used a Randomized Complete Group Design (RAKL) with two factorials, namely the dose of banana peel LOF and guano fertilizer. Factor I is the dose of banana peel LOF consisting of P1 = 0 liter/ha, P2 = 125 liter/ha, P3 = 250 liter/ha P4 = 375 liter/ha. Factor II is guano fertilizer consisting of K1 = 0 ton/ha, K2 = 0.5 ton/ha, K3 = 1 ton/ha. From the treatments used, 12 treatment combinations were obtained, and each treatment was repeated 3 times so that 36 experimental units were obtained with a plot size of 1.6 m x 1.2 m. The results showed that the Interaction of the doses of banana peel LOF and guano fertilizer was not able to give a real effect. Dosing of banana peel LOF had a tangible impact on the height and number of plant leaves but had a temporary negative effect on each observation variable. The dose of banana peel LOF significantly affected the height and number of plant leaves but negatively impacted each observation variable temporarily. The Interaction between banana peel LOF and guano has not been able to influence all observation variables significantly.

Keywords: Edamame, Organic-fertilizer, Ultisol

Introduction

Edamame is a soybean originating from Japan. In Indonesia, this soybean is called vegetable soybeans—Merill, which is almost the same as ordinary soybean species. The difference between edamame and ordinary soybeans lies in their production; ordinary soybeans are produced for dry seeds, while edamame is made to get fresh seeds and pods. Edamame has a classification of Kingdom Plantae, Order Polypetales, Family Leguminosae, Sub-family Papilionoideae, Genus Glycine, Species Soya, and Variety Ryokkoh (Yudiasuti et al., 2022).

Edamame is one type of legume plant that is very much in demand by the public



because it contains a high source of vegetable protein (Wahyuni & Indratin, 2020). Besides being rich in high vegetable protein sources, edamame also contains iron, calcium, vitamins C, A, and B1. In percentage, edamame contains 33% carbohydrates, 40% protein, 20% fat, 5% ash, and 6% fiber, so it is suitable for consumption (Aprizkiyandari et al., 2022).

Demand for soybeans in Indonesia continues to increase. Based on BPS data as of December 2023, national soybean production reached around 555,000 tons, while national demand reached 2.7 million tons (Badan Standardisasi Instrumen Pertanian 2023). This situation results in dependence on imports to meet soybean needs. One of the main factors for this decline is the reduction in production land area. Therefore, it is necessary to increase production, considering that most agricultural areas in Indonesia have marginal soil characteristics. From BPS data, the total distribution of critical (marginal) land in Indonesia has an area of 14,006,450 Ha / 2018 (BPS 2020).

Ultisol is one of the marginal lands with a low nutrient and organic matter content, and the soil is easily eroded (Pane et al., 2023). If this top layer is eroded, the soil becomes poor in organic matter and nutrients because the top layer determines the fertility of ultisol soil (Prasetyo & Suriadikarta, 2016). Ultisol soils are poor in macronutrients, especially P (phosphorus), K (potassium), Ca (Calcium), and Magnesium (Pasang et al., 2019). Adding organic fertilizers can overcome the constraints found in ultisol soils (Siregar, 2017). Organic fertilizers buffer the soil's biological, chemical, and physical properties, thus supporting increased land productivity and fertilizer efficiency (Dwi et al., 2022).

Organic fertilizers are available in solid and liquid form. Liquid organic fertilizer has the advantage of being able to provide nutrients according to plant needs. Organic fertilizer can be made from organic waste, such as banana peels (Andriani et al., 2023). Banana peels can be used as liquid organic fertilizer because they have a high potassium content. The high potassium content can benefit plants, such as helping to build plant stems, preventing diseases, nourishing flowers and fruits, preventing plants from drying out, preventing wilting, and accelerating the growth of roots, flowers, and maturation of seeds and stems. In addition to the potassium content of 42%, banana peels also contain 0.55% organic C, 0.18% N-total, 0.043% P₂O₅, 1.137% K₂O, 3.06% C/N, and pH 4.5 (Armanda et al., 2023). Macronutrients in P and Ca in banana peels are also high; these macro elements can later add nutrients to the soil (Putri, 2018). The application of liquid organic fertilizer from banana peels significantly affects all parameters studied, with a 300 ml / l water/plot dose (Zamriyetti et al. 2021).

Swallow droppings have been considered waste by swallow breeders. Swallow droppings contain N, P, and K, which plants need to support plant vegetative growth, stimulate root growth, and strengthen plant tissues, especially plant stems. Swallow droppings have a C-Organic content of 50.46%, N/total 11.24%, and a C/N ratio of 4.49 with a pH of 7.97, Phosphorus 1.59%, Potassium 2.17%, Calcium 0.30%, Magnesium 0.01% (Talino et al., 2019). Applying guano fertilizer can increase soil pH, CEC, and available N, P, and K levels (Syofiani & Oktabriana, 2017). Fardyansjah and Hasan (2021), applying fertilizer from swallow dung has affected soybean plants with 5 and 10 tons/ha doses.

So far, there has not been much research on applying compost to plants, especially guano compost from swallow droppings. Especially in Bengkulu Province, the use of guano compost fertilizer (swallow droppings) has not been widely used by



the community because they do not know the benefits and lack knowledge; on the other hand, swallow breeders in Bengkulu every 6 months in one year produce swallow droppings that have not been utilized and are only left to accumulate (Gozali et al., 2022). This study aims 1) to get the best dose of guano fertilizer in the growth and yield of soybean plants, 2) to determine the dose of liquid organic fertilizer from banana peel waste on ultisol soil, 3) to get the interaction and results of growth and yield of edamame soybeans on the time of application of guano fertilizer and liquid organic fertilizer from banana peel waste.

Research Method

This research was conducted in August-October 2024 in the experimental land of the Agricultural Zone on Medan Baru Road, Muara Bangka Hulu District, Bengkulu City. The materials used in this study include soybean seeds of R-305 variety, Guano Fertilizer, banana peel LOF, Furadan 3G, Urea, TSP, and KCL. The tools used in this study include machetes, paddles, hoes, labels, meters, raffia, and stationery. This study used a Complete Randomized Group Design (RAKL) arranged factorially consisting of 2 factors, namely the first factor of liquid organic fertilizer (LOF) from banana peels, consisting of 4 levels, namely: P1 = 0 liter/ha, P2 = 125 liter/ha, P3 = 250 liter/ha, P4 = 375 liter/ha. The second factor is guano fertilizer with three levels: K1 = 0 ton/ha, K2 = 0.5 ton/ha, K3 = 1 ton/ha. From these two factors, 12 treatment combinations were obtained, and each was repeated 3 times so that 36 experimental units were obtained.

The research stages include: making liquid organic fertilizer from the banana peel, initial soil analysis, analysis of liquid fertilizer content from the banana peel, analysis of swallow guano fertilizer content, land preparation, application of swallow guano fertilizer, planting and application of base fertilizer, application of liquid organic fertilizer, plant maintenance, and harvesting. Observation variables include plant growth and yield.

Results and Discussion

This research was conducted from August to October 2024 in the Integrated Agricultural Zone, Medan Baru, Kandang Limun, Muara Bangkahulu District, Bengkulu City. The type of soil used in this research is Ultisol soil. The soil analysis results, organic fertilizer, and liquid organic fertilizer are in Table 1 below.

Table 1. NPK nutrient content, Al-dd, and pH

Sample	N (%)	P	K	Al-dd	pH
Banana peel LOF	0,35	0,31%	0,40%	Not analyzed	3,60
Swallow guano	1,28	10,2%	0,87%	Not analyzed	3,61
Soil of replicate 1	0,17	2,73 ppm	0,24 me/100gr	0,44 me/100gr	5,39
Soil of replicate 2	0,15	2,50 ppm	0,31 me/100gr	0,64 me/100gr	5,82
Soil of replicate 3	0,21	4,78 ppm	0,35 me/100gr	0,24 me/100gr	6,13

Soil with N content between 0.166-0.174% (classified as low), P content between 5.97-6.37 ppm (classified as low), pH 5.81-6.17% (classified as slightly acidic) (Dharmawan Margolang & Sembiring, 2015). Based on the Regulation of the Minister of Agriculture No. 7 of 2011 concerning organic fertilizers and biological fertilizers explains that the quality standards of solid organic fertilizers have a minimum content

of N, P, K of 4%, and liquid organic fertilizers at least 3-6% (Regulation of the Minister of Agriculture 2011). Based on the Regulation of the Minister of Agriculture, it can be concluded that the solid and liquid organic fertilizers used in this study do not meet the quality standards.

During the research, rainfall, temperature and humidity data obtained from the Bengkulu City Meteorology Climatology and Geophysics Agency website, the average rainfall conditions from August to October amounted to 2.40 mm. To get the optimal yield of edamame soybean plants requires rainfall between 100-200 mm/month (Ma'sum et al., 2020). Average temperature conditions from August to October were 27.82°C. The optimum temperature for edamame soybean plants ranges from 20-25°C (Yudhistira, 2019). Average humidity conditions from August to October were 83.41%. The optimum air humidity for soybean plants ranges from 75-90% during plant growth to pod filling stadia and low air humidity (60-75%) during pod maturation until harvest (Sela, 2021).

At the time of the research, rainfall from August to October 2024 was very low, so manual irrigation assistance was carried out. This irrigation was done twice a day in the morning and evening using a watering can with a capacity of 15 liters of water. The 15-liter capacity watering can be given to the two experimental plots. Intensive irrigation was carried out at planting time until the plants were 3 weeks old. At the age of 4 weeks until 5 weeks, watering was done once a day.

When the plants were 2 weeks old, they underwent changes characterized by the appearance of cotyledons (leaflets) from edamame soybean seeds that rose to the soil's surface. At the age of 2 weeks after planting, the research location in the experimental plot is overgrown with weeds such as teki-than grass. How to control it is by manual techniques by pulling weeds by hand. Entering the age of 4-5 weeks after planting, OPT (Plant Disturbing Organisms) attacks appeared, such as grasshoppers, walang sangit, and ladybugs, which resulted in damaged plant leaves. The control method is chemically by spraying pesticides containing the active ingredient profenofos 500g/l. Pesticide spraying is carried out when pest attacks cannot be controlled manually.

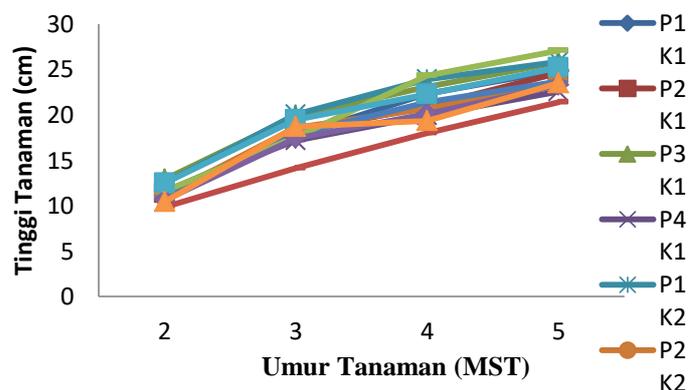


Figure 1. Growth pattern of Edamame Soybean Plant Height per week in two LOF treatments (P1 = 0 l/ha,

Plant height is a measure of plants that is easy to observe and is often used as a parameter to measure the effect of a treatment. The graph of the growth pattern of edamame soybean plant height in the combination of banana peel LOF treatment and

swallow, guano has a linear growth pattern every week. The average graph above shows that the height of edamame soybean plants by giving a combination of doses of banana peel LOF and swallow guano fertilizer is the highest at 27.04 cm and the lowest with a plant height of 21.37 cm. The provision of banana peel LOF has not been able to increase the growth of soybean plant height, while the provision of swallow guano fertilizer at a dose of 1.5 tons/ha can increase the growth of soybean plant height. However, based on the description of the plant height of the Ryoko-305 variety at 50-70 cm, the results of plant height loading vegetative growth are less than optimum. This is thought to be a lack of phosphorus nutrient uptake in plants that affects the height of edamame soybean plants, in line with the statement (Murtiaksono, 2022) that the content of phosphorus nutrients influences plant height because phosphorus plays a role in helping the development of young roots, fertile plant roots, can strengthen the establishment of plants and can increase the absorption of nutrients needed by plants.

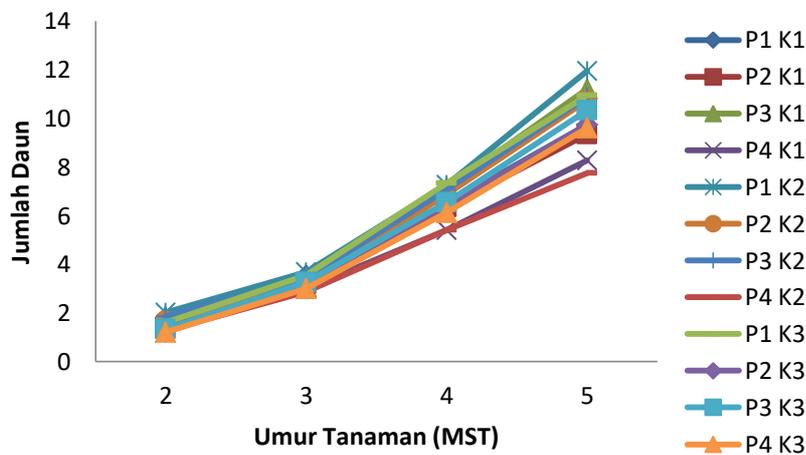


Figure 2. Growth pattern of the number of Edamame Soybean leaves per week in two treatments of LOF (P1= 0 l/ha, P2=125 l/ha, P3=250 l/ha, P4= 375 l/ha) and Guano (K1= 0 ton/ha, K2= 1 ton/ha, K3= 2 ton/ha).

The growth pattern of the number of leaves is the development process of plant leaves, starting from the formation of the mother leaf blade to the leaf blade. Based on the pattern of the growth graph of the number of leaves of edamame soybean plants the graph above shows that the number of plant leaves increases every week. The highest number of leaves from the combination of banana peel LOF and swallow guano with a total of 11.93 leaves and the lowest number of leaves was 7.73 leaves. Based on the number of leaves obtained in the study, the provision of organic fertilizer from swallow dung provides an optimum vegetative growth pattern. Soybean plants are suspected to need phosphorus, potassium, and nitrogen nutrients in the vegetative phase. However, nitrogen nutrients play an important role in plant growth as a regulator to control potassium, phosphorus, and other elements. Plants lacking nitrogen nutrients can interfere with plant growth (Sompotan et al., 2024). Because the nitrogen content can accelerate the photosynthesis process, the formation of leaf organs becomes faster (Sari, 2018). Organic fertilizers derived from swallow droppings contain high nitrogen nutrients, thus affecting the number of leaves.

Based on the analysis of variance (ANOVA), there was no significant interaction effect on the combination of banana peel LOF and guano fertilizer on all observation variables. The treatment of guano fertilizer has not been able to have a real effect on all observation variables. However, the treatment of banana peel LOF had a real effect on the variable of plant height and number of leaves. Variables that have a real effect are then tested further with the Orthogonal Polynomial (PO) further test. A summary of the analysis of variance in the growth of edamame soybeans on the provision of banana peel LOF and swallow manure guano fertilizer can be seen in Table 2 below.

Table 2. Analysis of variance on growth and yield of edamame soybean on banana peel LOF and guano fertilizer

No.	Variable	F-count Valu 5%			KK (%)
		LOF (P)	GUANO (K)	Interaction	
1	Plant Height	4.01*	0.83 ns	0.54 ns	9.06
2	Number of Leaves	3.77 *	0.54 ns	0.83 ns	16.73
3	Leaf Greenness	0.89 ns	0.55 ns	1.34 ns	4.99
4	Number of Productive Branches	1.48 ns	0.81 ns	0.66 ns	23.56
5	Number of Empty Pods	2.36 ns	0.15 ns	0.31 ns	23.29
6	Net Pod Weight	1.68 ns	0.70 ns	0.38 ns	30.49
7	Root Dry Weight	1.30 ns	2.70 ns	1.20 ns	21.55
8	Crown Dry Weight	0.03 ns	1.27 ns	0.81 ns	34.59
9	Pod Weight Per Hectare	1.65 ns	0.68 ns	0.38 ns	30.23
10	Root Crop Ratio	1.13 ns	0.25 ns	0.35 ns	23

Description: (*): significant effect, (ns): not significant effect, (KK): coefficient of variation

The application of banana peel LOF significantly affects the height of edamame soybean plants presented in Figure 3

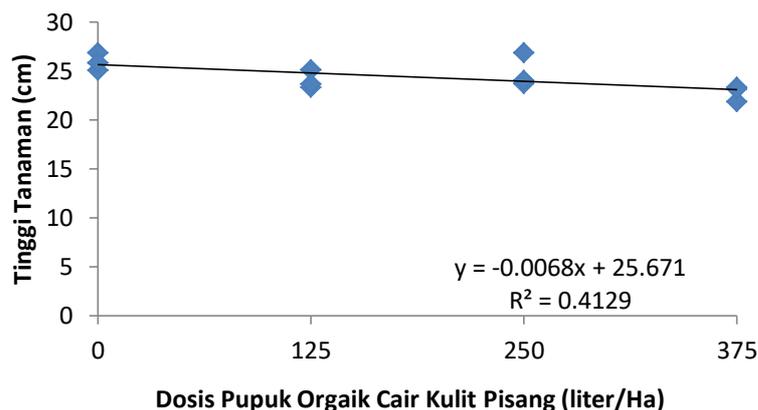


Figure 1. Effect of banana peel LOF on plant height of edamame soybean

Based on the polynomial test, it shows that the growth pattern of plant height forms a linear regression pattern $y = -0.006x + 25.67$. The regression pattern relationship between plant height and the dose of banana peel LOF is negative. The regression equation means that every increase in LOF dose of 125 liters/ha decreases the growth of edamame soybean plant height. The results of plant height continued to decrease linearly as the dose of banana peel LOF increased to 375 liters/ha. Based on

the above statement, banana peel LOF has not been able to increase the height of edamame soybean plants on ultisol land.

This is thought to be caused by several factors, such as the low nutrient content in banana peel LOF. According to (Sukiman et al., 2021), to increase the nitrogen element in liquid organic fertilizer, it is necessary to add organic matter in the form of manure and legume plants (beans) for phosphorus, chopped banana or banana stems, while for potassium, a mixture of organic matter in the form of banana stems, potato peels, or seaweed is added. In addition to the factor of low nutrient content, it is suspected that the effect of the decrease in plant height after being treated with banana peel LOF is caused by competition between plants and weeds. This is explained (Darmanti, 2016) that teki is a weed whose presence is always present in soybean cultivation, and teki-taking weeds are challenging to eradicate manually or with herbicides. The presence of Teki-taking weeds can inhibit and reduce plant height; this is reinforced by research (Christia et al., 2016) stating that taking weeds, such as *Cyperus rotundus*, can reduce the rate of soybean plant height. Pemberian LOF kulit pisang berpengaruh nyata terhadap jumlah daun kedelai edamame yang disajikan pada Gambar 4 berikut.

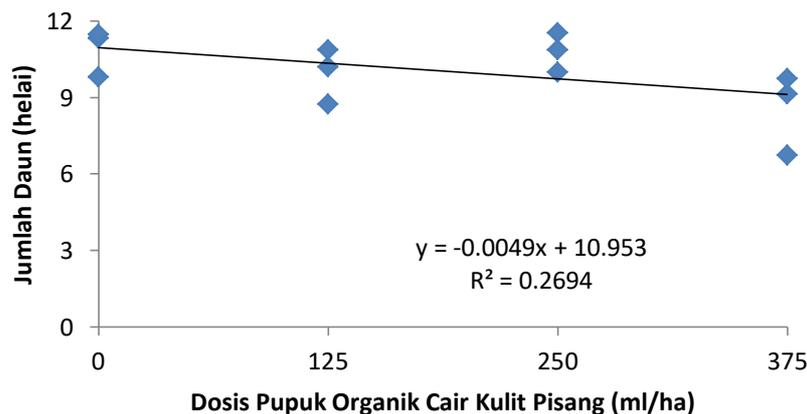


Figure 4. Effect of banana peel LOF on the number of leaves of edamame soybean

Based on the polynomial test, the growth pattern of the number of leaves forms a linear regression pattern $y = -0.004x + 10.95$. The regression pattern relationship between the number of plant leaves and the dose of banana peel LOF is negative. The regression equation means that every increase in the LOF dose of 125 liters/ha decreases the growth of the number of leaves. The number of plant leaves decreased linearly as the dose of banana peel LOF increased to 375 liters/ha. Soybean plants are suspected to be less than optimal in absorbing phosphorus and nitrogen nutrients contained in banana peel LOF. According to (Anggraeni et al., 2024), plants grow well and balanced when nutrients are sufficient. The increase in the number of optimal leaves on the plant indicates that the macro and micronutrients needed by plants are in optimal condition. Rerata hasil pemberian LOF kulit pisang terhadap variabel pengamatan dapat dilihat pada Tabel 3 berikut.

Table 3. Average results of banana peel LOF application on edamame soybean growth variables

LOF	TKD (unit SPAD)	JCP (branch)	JPB (pods)	BPB (gr)	BPP (ton)	BKA (gr)	BKT (gr)	RTA (%)
P1	41,71	2,73	32,18	57,65	6,73	2,64	4,69	1,79
P2	42,15	2,38	31,02	53,85	6,28	2,25	4,75	2,09
P3	42,06	2,73	33,73	60,80	7,09	2,29	4,89	2,12
P4	40,72	2,27	25,36	44,31	5,20	2,21	4,92	2,14

Ket : TKD = Tingkat Kehijauan Daun, JCP = Jumlah Cabang Produktif, JPB = Jumlah Polong Bernas, BPB = Bobot Polong Bernas, BPP = Berat Polong Perhektar, BKA = Berat Kering Akar, BKT = Berat Kering Tajuk, RTA = Rasio Tajuk Akar.

The average greenness level of edamame soybean leaves by giving various doses of banana peel LOF obtained a minimum leaf greenness level of 40.72 and a maximum leaf greenness level of 42.15. It can be interpreted that the higher the chlorophyll content, the more intense the green color of the leaves. The content of nitrogen elements is significant to increase the greenness of the leaves. In line with the statement, high nitrogen content makes foliage greener, while low nitrogen content results in pale yellow and dark green leaf color.

The average number of productive branches of edamame soybeans in the provision of various doses of banana peel LOF obtained a minimum number of productive branches of 2.27 and a maximum number of productive branches of 2.73. The provision of banana peel LOF has not been able to affect the number of productive branches of edamame soybeans have really. This is thought to be a lack of nutrient uptake in edamame soybeans, according to the statement (Yusuf et al., 2024), stating that plants that receive nutrients optimally will grow and develop.

The application of banana peel LOF had no significant effect on the number of pods. It is suspected that the pod ladybug attacked the pods during the pod-filling process, which caused the pods to become dry and empty. In line with the statement (Budi Al Hadi, Sri Handayani 2018) states that ladybugs suck pod liquid by stabbing their stylets on the pod skin and continuing to seed to cause poor pod growth and provide suboptimal results at harvest.

The average weight of edamame soybean pods on providing various doses of banana peel LOF obtained a minimum weight of 44.31 g and a maximum of 60.80 g. The provision of banana peel LOF has not been able to affect the variable weight of pods. This is thought to be influenced by the attack of pod ladybug pests that cause pods and seeds to become dry and empty, thus affecting the weight of the pods of soybean plants. In addition to pest attacks in the form of ladybugs, the number of soybean pods is influenced by several factors, including plant growth, light intensity, adequate nutrient availability, and the yield power of each variety (Pandiangan & Rasyad, 2017).

The application of banana peel LOF has not had a real effect on the variable weight of pods per hectare. It is suspected that the phosphorus (P) element content in banana peel LOF is low, thus affecting the yield of pod weight. According to (Rosi et al., 2018), the element phosphorus (P) is important to accelerate fruit and seed formation and increase production. Seed growth and production will be optimal if plants are given enough phosphorus elements.

The average dry weight of roots with a dose of 375 liters/ha of banana peel LOF was 2.21 grams, and the dry weight of roots without dosing banana peel LOF was 2.64 grams. This shows that the application of banana peel LOF has not been able to increase the dry weight of the roots. It is suspected that the content of the element (P) phosphorus in banana peel LOF is low, in line with research (Sihaloho et al., 2015), which states that the content of 36% phosphorus element can increase the dry weight of the roots of edamame soybean plants.

The average crown dry weight with a dose of 375 liters/ha of banana peel LOF was 4.92 grams, and the crown dry weight without dosing banana peel LOF was 4.69 grams. Based on the average obtained, the provision of banana peel LOF has not been able to have a significant effect on crown dry weight. In line with research conducted (Pangestu, 2020), the low content of NPK elements in liquid organic fertilizer can affect the dry weight of the crown.

Based on the average table, the dose of banana peel LOF 375 liters/ha obtained the maximum amount of 2.14%, while the dose without banana peel LOF treatment obtained the minimum amount of 1.79%. The quality of crown dry weight and root dry weight influences root crown ratio.

The average results of guano application on observation variables can be seen in Table 4 below.

Table 4. Average results of swallow guano fertilizer application on edamame soybean growth variables

Guano	TT (cm)	JD (bladei)	TKD (%)	JCP (branch)	JPB (pods)	BPB (gr)	BPP (ton)	BKA (gr)	BKT (gr)	RTA (%)
K1	24,44	9,63	42,11	2,48	29,80	53,86	6,28	2,22	4,81	2,11
K2	23,62	10,32	41,21	2,40	30,48	50,31	5,89	2,20	4,27	1,98
K3	24,73	10,15	41,66	2,70	31,43	58,30	6,80	2,63	5,35	2,02

Notes. TT = Plant Height, JD = Number of Leaves, TKD = Leaf Greenness Level, JCP = Number of Productive Branches, JPB = Number of Blanched Pods, BPB = Blanched Pod Weight, BPP = Per Hectare Pod Weight, BKA = Root Dry Weight, BKT = Crown Dry Weight, RTA = Root Crown Ratio.

The table above explains that applying swallow guano fertilizer does not affect all aspects of the observation variables. This is thought to be caused by the slow decomposition process of organic matter in the fertilizer so that plants for growth cannot directly absorb it (Rosa et al., 2017). In addition to the slow decomposition process, it is suspected that the NPK nutrient content in swallow guano is low, thus affecting growth. According to (Rohman and Candra B 2019), the number of leaves growing is important because the leaves are the organ where photosynthesis occurs. The number of leaves on the plant greatly determines the results of photosynthesis, where the results of this photosynthesis process will be carried by the vascular network to be circulated throughout all parts of the plant and used for the formation of new organs in the process of plant growth and development.

Based on the study's results, the dose of 1 ton/ha has not been able to have a real effect on all observation variables. It is suspected that the dose of swallow guano fertilizer is not optimal, so the absorption of nutrients for plants is limited. In line with research (Amir Nurbaiti et al., 2020), increasing the dose of Guano fertilizer tends to increase the yield of peanut plants with doses (5 and 10 tons/ha).

Conclusion

1. The best dose of swallow guano fertilizer at 1.5 tons/ha increases the edamame soybean plant height growth pattern.
2. The dose of banana peel liquid organic fertilizer has not been able to influence all research variables.
3. The interaction effect between banana peel LOF and swallow guano has not been able to influence all research variables.

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