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Effects of liquid organic fertilizer (LOF) derived from banana peels and tempeh waste on the growth and yield of peanut plants (*Arachis hypogaea* L.)

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ABSTRACT

This study, conducted at the Experimental Garden of the Faculty of Agriculture, Amir Hamzah University, Medan, aimed to evaluate the effects of liquid organic fertilizer (LOF) derived from banana peels and tempeh waste on peanut plant growth and yield. The study employed a factorial RBD (randomized block design), examining 2 factors. The first factor involved varying concentrations of LOF from banana peels: P0 = control (no application), P1 = 500 ml/plot, P2 = 1000 ml/plot, and P3 = 1500 ml/plot. The second factor assessed LOF from tempeh waste at different levels: T0 = control (no application), T1 = 0.750 liters of tempeh waste/1 liter of water/plot, T2 = 1.5 liters of tempeh waste/1 liter of water/plot, and T3 = 2.25 liters of tempeh waste/1 liter of water/plot. Parameters observed included plant height, number of branches, flowering age, number of pods per plant, number of filled pods per plant, weight of 100 seeds per plot, and production per plot. Results showed significant effects of tempeh waste-derived LOF on plant height, flowering age, number of pods per plant, number of filled pods per plant, and production per plot. Particularly, Level T3 (2.25 liters of tempeh waste/1 liter of water/plot) yielded optimal results across all parameters. Conversely, the application of LOF from banana peels showed no significant impact on observed parameters, and no interaction was observed between the two treatments.

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1. INTRODUCTION

Peanuts represent a promising food crop for development in Indonesia, owing to increasing domestic demand and the burgeoning agro-industrial sector (Marliah et al., 2010). Not only do peanuts hold significant economic importance in Indonesia, but they also offer substantial health benefits, thereby driving intensive cultivation efforts. These efforts encompass both extensive and intensive programs. From agroclimatic, technical, economic, and social perspectives, Indonesia exhibits considerable potential for peanut cultivation (Hayati et al., 2012).

In 2014, peanut production totaled 638.90 thousand tons of dried seeds, marking a decrease of 62.78 thousand tons (8.95%) compared to 2013. This decline was observed both on Java Island and beyond, with reductions of 46.48 thousand tons and 16.31 tons, respectively. The reduction in

peanut production was primarily attributed to decreases in harvested area by 19.72 thousand hectares (3.80%) and productivity by 0.73 quintals/hectare (5.40%) (Indonesia's Central Bureau of Statistics, 2014).

Domestic demand volume increases annually, parallel to population growth and the diversification of processed productions. This trend results in a yearly increase in imports, reaching up to 30,000 tons. By 2001, peanut imports had already reached 118,758 tons of dried seeds (Sarsini, 2007).

The utilization of organic fertilizers presents a potential solution to mitigate the excessive application of synthetic fertilizers, owing to the presence of organic matter capable of ameliorating soil physical, chemical, and biological properties. Physically, organic fertilizers improve soil structure, enhance aeration and drainage, promote particle aggregation, increase water retention capacity, prevent erosion and landslides, and revitalize soil tillage. Chemically, they enhance cation exchange capacity, increase nutrient availability, and accelerate mineral weathering processes. Biologically, organic fertilizers serve as a food source for soil microorganisms, including fungi, bacteria, and other beneficial microorganisms, thereby fostering their proliferation (Djufry & Ramlan, 2012).

The more effective and efficient use of organic fertilizers is in the form of liquid fertilizers. Liquid fertilizers are more readily absorbed by plants because their components have already decomposed. Plants can absorb nutrients not only through their roots but also through their leaves. The utilization of liquid fertilizers simplifies both work and application processes. With a single application of liquid organic fertilizer (LOF), three processes are achieved simultaneously: fertilization, watering, and plant treatment (Mardianto, 2014).

Banana peels, which are currently underutilized by society, can serve as fertilizer to alleviate the issue of accumulating waste, which may lead to environmental pollution. Despite the abundance of compost produced from solid waste, liquid fertilizer offers greater practicality in application, with a relatively straightforward production process and moderate associated costs (Hadisuwito, 2007).

Banana peels—often overlooked—contain elements beneficial to society, one of which is their potential use as liquid fertilizer. Banana peels contain essential elements, such as phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), and zinc (Zn), each contributing to plant growth and development, thus influencing maximum production yield (Hery, 2011).

Liquid waste from the tempeh industry is typically disposed into the surrounding environment, particularly water bodies or rivers. This waste primarily consists of 99.9% or more water and approximately 0.1% solid particles comprising both organic and inorganic substances. Originating from the processes of washing, soaking, and boiling soybeans, this liquid waste contains a substantial amount of essential nutrients, notably nitrogen, crucial for plant growth. For instance, soaking waste from 50 kg of soybeans contains a relatively high nitrogen content, approximately 1.5% soluble protein (Salamah et al., 2009).

One straightforward method of waste utilization is by converting it into liquid fertilizer. Liquid fertilizer contains beneficial bacteria that enhance soil fertility and plant growth. These bacteria play a pivotal role in binding essential nutrients such as nitrogen (N), phosphorus (P), potassium (K), and other elements necessary for plant development, consequently improving overall plant productivity. Moreover, in the production of liquid fertilizer, tempeh liquid waste serves as a nutrient source for beneficial bacteria, facilitating their proliferation before application (Fredi et al., 2009).

Drawing from the aforementioned background, the author is motivated to investigate the effects of liquid organic fertilizer (LOF) derived from banana peels and tempeh waste on peanut plants (Arachis hypogaea L.).

2. METHOD

This study was conducted at the Experimental Garden of the Faculty of Agriculture, Amir Hamzah University, Medan. The materials utilized included peanut seeds of the kelinci variety, kepok banana peels, tempeh waste, EM4, granulated sugar, Curacron 500 EC insecticide, Dithane M-45 fungicide, and water. Meanwhile, the tools used consisted of a hoe, rake, machete, knife, dibble, bucket, watering can, measuring tape, raffia string, analytical scale, calculator, and items of stationery.

The research employed a factorial RBD (randomized block design), examining 2 factors. The first factor involved the application of liquid organic fertilizer (LOF) from banana peels (P), comprising 4 treatment levels: P0 (0 ml/plot), P1 (500 ml/plot), P2 (1000 ml/plot), and P3 (1500 ml/plot). The second factor was the application of liquid organic fertilizer (LOF) from tempeh waste (T), also comprising 4 treatment levels: T0 (0 ml/plot), T1 (750 ml/1 liter of water/plot), T2 (1500 ml/1 liter of water/plot), and T3 (2250 ml/1 liter of water/plot). Thus, there were 16 treatment combinations. Each treatment was replicated 3 times, totaling 48 plots. Each plot contained 9 plants, with 4 plants selected as sample plants. The size of each plot was 100 cm × 100 cm, with a planting spacing of 30 cm × 30 cm. Furthermore, the distance between plots was 50 cm, and the distance between replications was 100 cm.

The data analysis model employed in this research was a factorial RBD (randomized block design), analyzed using ANOVA, and subsequently followed by Duncan's multiple range test (DMRT).

Apart from that, the observed parameters included plant height, number of branches, flowering age, number of pods per plant, number of filled pods per plant, production per plot, and weight of 100 seeds.

3. RESULTS AND DISCUSSION

3.1 Plant Height

The analysis of variance indicates that the treatment with liquid organic fertilizer (LOF) derived from tempeh waste significantly influences plant height at 2 weeks after planting (WAP), while the treatment with liquid organic fertilizer (LOF) from banana peels and the interaction between the two treatments do not exhibit significant effects. The results of the mean difference test using Duncan's multiple range test (DMRT) are presented in Table 1.

Table 1. The Effects of Liquid Organic Fertilizer (LOF) from Banana Peels and Tempeh Waste on Plant Height (cm) at 2 WAP

Liquid organic fertilizer from banana peels	Plant height (cm)
P_0	9,96
P_1	9,86
P_2	9,85
P_3	9,57
Liquid organic fertilizer from tempeh waste	
T_0	8,76 b
T_1	9,94 a
T_2	10,16 a
T_3	10,40 a

Note: Numbers followed by different letters in the same column indicate significant differences according to DMRT at the 5% level.

Table 1 reveals that the tallest plants were observed in the treatment receiving liquid organic fertilizer (LOF) from tempeh waste at level T3 (2.25 liters of tempeh waste/1 liter of water/plot), measuring 10.40 cm. This height is not significantly different from level T2 (1.5 liters of tempeh waste/1 liter of water/plot) at 10.16 cm and level T1 (0.75 liters of tempeh waste/1 liter of water/plot) at 9.94 cm, but it significantly differs from level T0 (control) at 8.76 cm.

The relationship between the treatment of providing liquid organic fertilizer (LOF) from tempeh waste and plant height at 2 weeks after planting (WAP) is depicted in Figure 1.

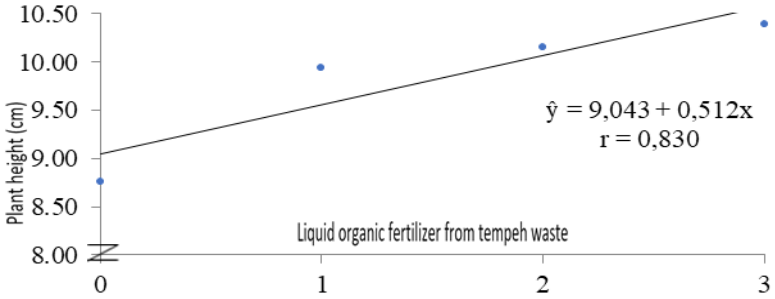

Figure 1. The Relationship between the Treatment of Providing Liquid Organic Fertilizer (LOF) from Tempeh Waste and Plant Height at 2 WAP

Figure 1 illustrates that plant height increases progressively with the rising treatment levels, exhibiting a positive linear relationship with the equation ŷ = 9.043 + 0.512x and an R-value of 0.830.

The analysis of variance indicates that the treatment of providing liquid organic fertilizer (LOF) from tempeh waste significantly influences plant height at 4 weeks after planting (WAP), while the treatment of providing liquid organic fertilizer (LOF) from banana peels and the interaction between the two treatments do not exhibit significant effects. The results of the mean difference test using Duncan's multiple range test (DMRT) are presented in Table 2.

Tabel 2. The effects of liquid organic fertilizer (LOF) from banana peels and tempeh waste on plant height (cm) at 4 WAP

Liquid organic fertilizer from banana peels	Plant height
P_0	16,67
P_1	16,73
P_2	17,45
P_3	16,82
Liquid organic fertilizer from tempeh waste	
T_0	15,90 b
T_1	16,51 ab
T_2	17,44 a
T_3	17,82 a

Note: Numbers followed by different letters in the same column indicate significant differences according to DMRT at the 5% level.

Table 2 reveals that the tallest plants were found in the treatment receiving liquid organic fertilizer (LOF) from tempeh waste at level T3 (2.25 liters of tempeh waste/1 liter of water/plot), measuring 17.82 cm. This measurement is significantly different from level T0 (control) at 15.90 cm, but not significantly different from level T2 (1.5 liters of tempeh waste/1 liter of water/plot) at 17.44 cm and level T1 (0.75 liters of tempeh waste/1 liter of water/plot) at 16.51 cm.

The relationship between the treatment of providing liquid organic fertilizer (LOF) from tempeh waste and plant height at 4 weeks after planting (WAP) is depicted in Figure 2.

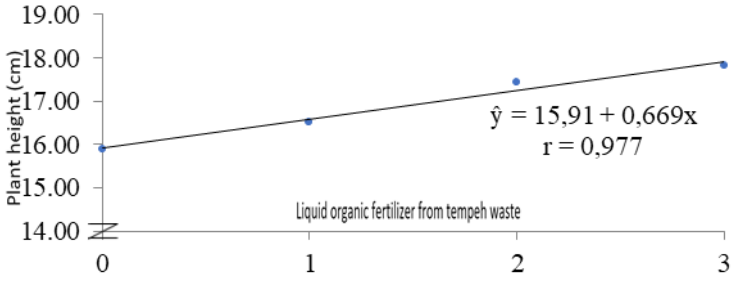

Figure 2. The Relationship between the Treatment of Providing Liquid Organic Fertilizer (LOF) from Tempeh Waste and Plant Height at 4 WAP

Figure 2 illustrates that plant height increases progressively with the rising treatment levels, forming a positive linear relationship with the equation ŷ = 15.91 + 0.669x and an R-value of 0.977.

Regarding the plant height parameter, it can be observed that the treatment of liquid organic fertilizer (LOF) from tempeh waste significantly influences plant height growth. In this case, liquid organic fertilizer (LOF) from tempeh waste plays a pivotal role in plant growth, likely due to the nitrogen content in tempeh waste, which stands at 0.22%. This nitrogen is utilized by microorganisms as energy, and the subsequent decomposition yields inorganic compounds such as ammonium and nitrate, which are then absorbed by plant roots to support plant metabolism and growth. According to Wiryani (2006), waste from the tempeh production process is biodegradable, meaning it can be decomposed by microorganisms. The ammonium and nitrate compounds produced from liquid waste in the tempeh industry serve as valuable nutrients for plant growth, as they are readily absorbed by plant roots.

3.2 Number of Branches

The analysis of variance indicates that the treatment of providing liquid organic fertilizer (LOF) derived from banana peels and tempeh waste, as well as their interaction, does not have a significant impact on the number of branches of the plants at 2 and 4 weeks after planting (WAP).

Various factors could contribute to the lack of a positive effect of a treatment on cultivated plants. Possible factors influencing this insignificance include the plants themselves and the environmental conditions for plant growth that may not be conducive to the growth of peanut plant branches. The growth of a plant is influenced by internal factors, such as the plant's anatomy and physiology, while external factors encompass environmental elements like soil quality, temperature, humidity, sunlight exposure, and others. Soil rich in nutrients may exert a different influence compared to less fertile soil. Temperature also plays a crucial role in plant development. In addition, green plants require adequate sunlight for photosynthesis (Siswoyo, 2000).

3.3 Flowering Age

The analysis of variance reveals that the treatment of providing liquid organic fertilizer (LOF) from tempeh waste significantly affects the flowering age, while the application of liquid organic fertilizer (LOF) from banana peels and the interaction between the two treatments do not yield significant effects. Furthermore, the mean difference test using Duncan's multiple range test (DMRT) is presented in Table 3.

Tabel 3. The Effects of Liquid Organic Fertilizer (LOF) from Banana Peels and Tempeh Waste on flowering age (days)

Liquid organic fertilizer from banana peels	Flowering age (days)
P_0	24,33
P_1	24,42
P_2	24,25
P_3	24,42
Liquid organic fertilizer from tempeh waste	
T_0	24,83 a
T_1	24,42 ab
T_2	24,25 b
T_3	23,92 b

Note: Numbers followed by different letters in the same column indicate significant differences according to DMRT at the 5% level.

Table 3 illustrates that the most rapid flowering age occurred in the treatment receiving liquid organic fertilizer (LOF) from tempeh waste at level T3 (2.25 liters of tempeh waste/1 liter of water/plot), with a value of 23.92 days. This result significantly differs from the control level (T0) at 24.83 days, yet it does not significantly differ from level T2 (1.5 liters of tempeh waste/1 liter of water/plot) at 24.25 days and level T1 (0.75 liters of tempeh waste/1 liter of water/plot) at 24.42 days. The relationship between the treatment of proving liquid organic fertilizer (LOF) from tempeh waste and flowering age is depicted in Figure 3.

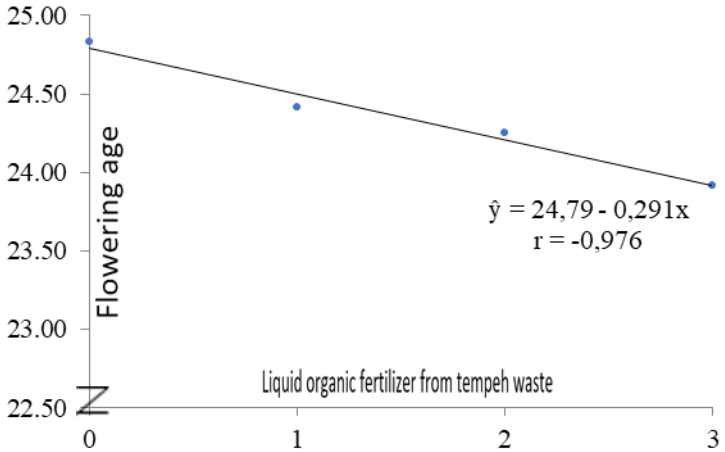

Figure 3. The Relationship between the Treatment of Providing Liquid Organic Fertilizer (LOF) from Tempeh Waste and Flowering Age

Figure 3 demonstrates that the flowering age accelerates with increasing treatment levels, forming a negative linear relationship with the equation ŷ = 24.79 – 0.291x and an R-value of -0.976.

Flowering age serves as a parameter indicating the transition of plant growth phases from the vegetative stage to the generative stage. During the vegetative phase, if a plant attains optimal height and experiences an increase in leaf count, it accumulates sufficient nutrients, signaling readiness to progress to the generative phase. Conversely, untreated plants exhibit delayed flowering ages due to nutrient deficiencies, prolonging the vegetative phase. Adequate nutrient supply, encompassing both macro and micronutrients, facilitates smooth plant development and productivity (Rismunandar, 1996).

3.4 Number of Pods per Plant

The analysis of variance reveals that the treatment with liquid organic fertilizer (LOF) from tempeh waste significantly influences the number of pods per plant, while the application of liquid organic fertilizer (LOF) from banana peels and the interaction between the two treatments do not exhibit significant effects. The mean difference test using Duncan's multiple range test (DMRT) is presented in Table 4.

Tabel 4. The Effects of Liquid Organic Fertilizer (LOF) from Banana Peels and Tempeh Waste on number of pods per plant

Liquid organic fertilizer from banana peels	Number of pods per plant
P_0	25,21
P_1	25,17
P_2	25,44
P_3	25,79
Liquid organic fertilizer from tempeh waste	
T_0	24,25 b
T_1	25,19 ab
T_2	25,81 a
T_3	26,35 a

Note: Numbers followed by different letters in the same column indicate significant differences according to DMRT at the 5% level.

Table 4 indicates that the highest number of pods per plant is observed in the treatment with liquid organic fertilizer (LOF) from tempeh waste at level T3 (2.25 liters of tempeh waste/1 liter of water/plot), with a value of 26.35. This result significantly differs from the control level (T0) at 24.25, yet it does not significantly differ from level T2 (1.5 liters of tempeh waste/1 liter of water/plot) at 25.81 and level T1 (0.75 liters of tempeh waste/1 liter of water/plot) at 25.19.

The relationship between the treatment with liquid organic fertilizer (LOF) from tempeh waste and the number of pods per plant can be observed in Figure 4.

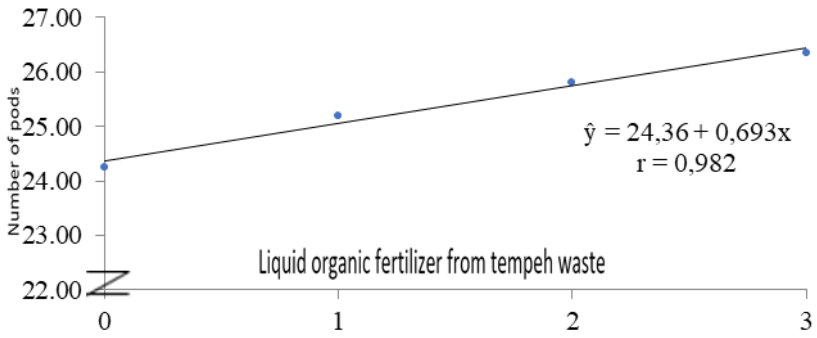

Figure 4. The Relationship between the Treatment of Providing Liquid Organic Fertilizer (LOF) from Tempeh Waste and the Number of Pods per Plant

Figure 4 illustrates that the number of pods per plant increases with the escalation of treatment levels, forming a positive linear relationship with the equation ŷ = 24.36 + 0.693x and an R-value of 0.982.

Peanut plants thriving in fertile conditions yield high-quality fruits. Nutrients are translocated to the fruits during optimal vegetative growth. Fruit development necessitates ample mineral nutrients, prompting mobilization and transport from vegetative tissues to the sites of fruit and seed

development (Gardner et al., 1991). When plant nutrients are adequately available, metabolic processes generate proteins, enzymes, hormones, and carbohydrates. Consequently, rapid cell division, enlargement, and elongation occur, facilitating optimal plant growth and productivity (Dartius, 1990).

3.5 Number of Filled Pods per Plant

The analysis of variance indicates that the treatment with liquid organic fertilizer (LOF) derived from tempeh waste significantly influences the number of filled pods per plant, while the liquid organic fertilizer (LOF) from banana peels and the interaction between the two treatments do not have significant effect. The mean comparison test using Duncan's multiple range test (DMRT) is shown in Table 5.

Tabel 5. The Effects of Liquid Organic Fertilizer (LOF) from Banana Peels and Tempeh Waste on number of filled pods per plant

Liquid organic fertilizer from banana peels	Number of fillet pods per plant
P_0	22,85
P_1	23,15
P_2	23,27
P_3	23,21
Liquid organic fertilizer from tempeh waste	
T_0	21,60 b
T_1	22,85 ab
T_2	23,56 ab
T_3	24,46 a

Note: Numbers followed by different letters in the same column indicate significant differences according to DMRT at the 5% level.

Table 5 demonstrates that the highest number of filled pods per plant is observed in the treatment receiving liquid organic fertilizer (LOF) from tempeh waste at level T3 (2.25 liters of tempeh waste/1 liter of water/plot), recording 24.46. This value significantly differs from the control level T0, which is 21.60, yet shows no significant difference compared to levels T2 (1.5 liters of tempeh waste/1 liter of water/plot) and T1 (0.75 liters of tempeh waste/1 liter of water/plot), with values of 23.56 and 22.85, respectively.

The correlation between the treatment of providing liquid organic fertilizer (LOF) from tempeh waste and the number of filled pods per plant is depicted in Figure 5.

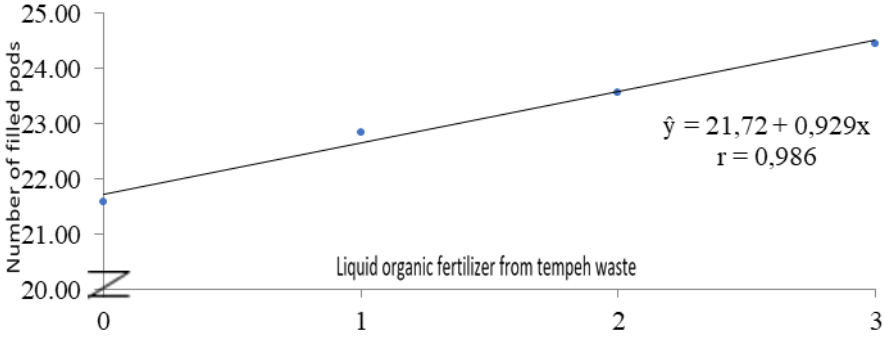

Figure 5. The Relationship between the Treatment of Providing Liquid Organic Fertilizer (LOF) from Tempeh Waste and the Number of Filled Pods per Plant

Figure 5 illustrates an increasing trend in the number of filled pods per plant with the rising treatment levels, demonstrating a positive linear correlation described by the equation $\hat{y} = 21.72 + 0.929x$ and an R-value of 0.986.

However, not all pods in each treatment reach full capacity. This can be attributed in part to the nutrient availability in the soil. The formation of filled pods indicates the peanut variety's capacity to absorb nutrients present in the soil, as pods serve as storage organs for plant reserves.

As noted by Gardner et al. (1991), during pod filling, pods serve as assimilate sinks, with most assimilates utilized to increase seed weight. The development of filled pods is influenced by soil moisture levels and the availability of essential nutrients, particularly phosphorus and calcium, necessary for fertilization and seed maturation.

Tempeh liquid waste contains the nutrients required for pod formation. This aligns with findings by Diba et al. (2013), who reported that tempeh liquid waste comprises a complex

composition, including 0.42% protein, 0.13% fat, 0.11% carbohydrates, 98.87% water, 13.60 ppm calcium, 1.74 ppm phosphorus, and 4.55 ppm iron.

3.6 Production per Plot

The analysis of variance indicates that the treatment with liquid organic fertilizer (LOF) from tempeh waste significantly affects the production per plot, while the use of liquid organic fertilizer (LOF) from banana peels and the interaction between the two treatments do not have a significant impact. Duncan's multiple range test (DMRT) for mean differences is presented in Table 6.

Tabel 6. The Effects of Liquid Organic Fertilizer (LOF) from Banana Peels and Tempeh Waste on Production per Plot (g)

Liquid organic fertilizer from banana peels	Production per plot (g)
P_0	276,25
P_1	305,00
P_2	299,17
P_3	313,33
Liquid organic fertilizer from tempeh waste	
T_0	275,00 b
T_1	285,42 b
T_2	310,83 ab
T_3	322,50 a

Note: Numbers followed by different letters in the same column indicatesignificant differences according to DMRT at the 5% level.

Table 6 shows that the highest production per plot is achieved under the treatment with liquid organic fertilizer (LOF) from tempeh waste at level T3 (2.25 liters of tempeh waste/1 liter of water/plot), with a value of 322.50 g. This value is significantly different from level T1 (0.75 liters of tempeh waste/1 liter of water/plot) at 285.42 g and level T0 (control) at 275.00 g. However, there is no significant difference observed compared to level T2 (1.5 liters of tempeh waste/1 liter of water/plot) at 310.83 g.

The relationship between the treatment with liquid organic fertilizer (LOF) from tempeh waste and the production per plot is illustrated in Figure 6.

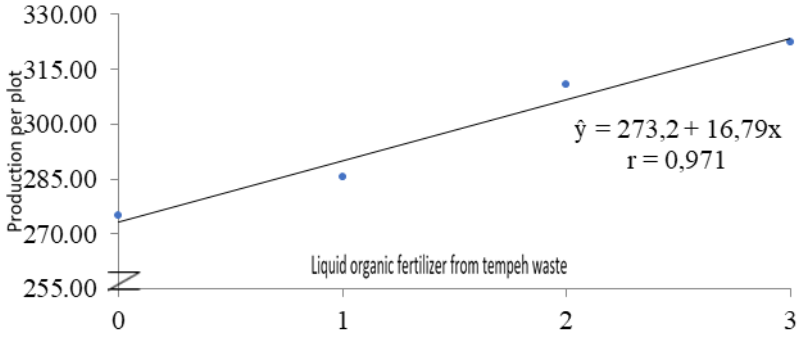

Figure 6. The Relationship between the Treatment of Providing Liquid Organic Fertilizer (LOF) from Tempeh Waste and the Production per Plot

Figure 6 demonstrates that the production per plot increases linearly with the increasing treatment levels, as depicted by the equation $\hat{y} = 273.2 + 16.79x$ and an R-value of 0.971.

The pod-filling stage in peanut plants also determines the yield components. Liquid organic fertilizer (LOF) from tempeh waste contains elements such as nitrogen (N), phosphorus (P), and potassium (K), which significantly influence the parameters. Nitrogen stimulates overall growth, crucial for photosynthesis as it contributes to leaf greening. Potassium activates numerous enzymes essential for photosynthesis, respiration, and stem growth. It also plays a role in enzyme activation and starch formation. Meanwhile, phosphorus accelerates flowering and seed and fruit ripening in plants. According to Diba et al. (2013), fermented tempeh wastewater for 8 days contains nitrogen (N) (0.22%), phosphorus (P) (0.063%), potassium (K) (0.041%), and pH 3.9. If all the required nutrients are met, plant production will be optimal.

3.7 Weight of 100 Seeds

The analysis of variance indicates that the application of liquid organic fertilizer (LOF) from banana peels and tempeh waste, as well as the interaction between the two treatments, do not significantly affect the weight of 100 seeds.

This suggests that genetic factors tend to have a greater influence on the weight of 100 seeds than the treatments applied. According to Sitompul & Guritno (1995), the weight of 100 seeds is closely related to the achieved yield. A higher weight of 100 seeds corresponds to a higher yield. However, this is still influenced by the genotype and variety of the plant itself. This is further supported by the statement from Mimbar (1991), which suggests that the maximum number and size of seeds are determined by genetic factors and the conditions experienced during seed filling.

4. CONCLUSION

The application of liquid organic fertilizer (LOF) derived from banana peels did not significantly affect all observed parameters in peanut plants. On the other hand, the application of liquid organic fertilizer (LOF) from tempeh waste at a rate of 2.25 liters/1 liter water/plot resulted in the most significant effects on various growth parameters. This included the plant height at 4 weeks after planting (WAP) (17.82 cm), the fastest flowering age (23.92 days), the highest number of pods per plant (26.35), the highest number of filled pods per plant (24.46), and the highest production per plot (322.50 g). Moreover, there was no significant interaction observed between the application of liquid organic fertilizer (LOF) from banana peels and tempeh waste across all parameters.

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