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Effect of Tofu Waste Liquid Organic Fertilizer on the Growth and Production of Pulut Corn (Zea mays Ceratina) Plants

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Abstract:
Corn is one of the food crops in Indonesia that has great potential to be developed, one of which is pulut corn. Pulut corn itself is corn with a high amylase content, but the yield of this corn is in the low category. One way to increase the productivity of pulut corn is the use of liquid organic fertilizer made from tofu waste. The research was carried out on the Jember State Polytechnic land in July-October 2024. Using RBD, which consists of a single treatment, namely the concentration of tofu waste. There are six treatment levels, including control, 26 ml/l, 28 ml/l, 30 ml/l, 32 ml/l, and 34 ml/l. The results of the observation parameters will be tested further with BNJ. From the six levels of treatment given, it was found that treatment with a concentration of 34 ml/l could reduce the stem diameter at 21 DAT, the weight of corn cobs per sample. A concentration of 30 ml/l affects the diameter of the cobs, while a concentration of 32 ml/l affects the weight of the cobs per plot. The parameters of plant height and biomass weight provide significant ups and downs.

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liquid organic fertilizer, tofu waste, waxy corn

INTRODUCTION

Pulut corn is a commodity with great potential in various industrial sectors. With its unique characteristics, pulut corn not only contributes to food security but can also create economic opportunities for farmers and producers. Pulut corn is not only processed as traditional food, such as emping, boiled corn, and maring. However, pulut corn can also be converted into industrial raw materials, such as syrup, corn sugar, flour, oil, vinegar, ethyl alcohol, lactic acid, citric acid, and glycerol (Syahdiyah et al., 2023). According to Suarni (2013), pulut corn has both advantages and disadvantages. Besides its numerous benefits, pulut corn production is still relatively low, with local Sulawesi glutinous corn productivity reaching only 2 to 2.5 tons/ha. However, pulut corn has the potential to reach 8.09 tons/ha.

The problem of low productivity of pulut corn is caused by one of these factors, namely the lack of optimization in fertilization, where farmers rely solely on chemical fertilizers without utilizing organic fertilizers. This results in a low level of fertility, leading to reduced production of pulut corn (Dulur et al., 2019). Pulut corn farmers need to be educated on proper cultivation and fertilization techniques, which is expected to increase their productivity. This can strengthen local food security and improve farmers' economic welfare (Nasrullah and Novita, 2019). The application of organic fertilizer is one of the efforts to restore land productivity and increase pulut corn production. There are two primary types of organic fertilizers: solid and liquid organic fertilizers. Liquid organic fertilizers

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can be made from industrial waste materials, fruit waste, and other organic sources. The use of liquid organic fertilizer can improve the quality and structure of the soil, as it contains essential nutrients such as N, P, and K (Rasmito et al., 2019). One of the beneficial liquid organic fertilizers for increasing pulut corn production is tofu waste liquid organic fertilizer.

Many people in Indonesia consume tofu; however, the tofu production process in Indonesia still employs conventional methods, resulting in tofu waste that is not optimally utilized. Tofu waste can contribute pollutants to the environment, especially in water, if it is not treated before disposal. Tofu waste also contains a low pH. Therefore, an alternative method is needed for more effective and efficient tofu waste treatment that can be easily applied to the community. Some methods for processing tofu waste have the potential to produce liquid organic fertilizer, which offers benefits for both soil and plants. Therefore, tofu waste can potentially be utilized as a liquid organic fertilizer, as it contains organic compounds that can be used to fertilize plants. The compounds contained in tofu waste are approximately 40-60% protein, 25-50% carbohydrates, and 8-12% fat, and they also contain calcium, phosphorus, iron, and vitamins (Samsudin et al., 2018).

METHOD

This research was conducted from July to October in a single location, specifically on the grounds of Jember State Polytechnic, Sumbersari District, Jember Regency, East Java Province. The tools used during this research were a hoe, a kenco, a tugal, a meter, a vernier, a bucket, a jurigen, a measuring cup, a ruler, raffia, a knapsack, analytical scales, scissors, stationery, and a camera. The materials used in the study were pulut corn seeds of the arumba variety, tofu liquid waste, water, EM4, brown sugar, pesticides, Urea fertilizer, NPK, and manure. This study used a non-factorial Randomized Group Design (RAK). By using one factor, namely the concentration of POC tofu waste with 6 levels, namely: Without POC of tofu waste (P0), 26 ml/l (P1), 28 ml/l (P2), 30 ml/l (P3), 32 ml/l (P4), and 34 ml/l (P5). There are 6 levels in one treatment unit, and each treatment is repeated 4 times, resulting in 24 experimental units.

RESULTS

Recapitulation of ANOVA Variety Results

Based on the research results of applying POC tofu waste to the growth of pulut corn, six observation parameters were identified: plant height, stem diameter per sample, corn cob weight per sample, corn cob weight per plot, cob diameter, and dry biomass weight per sample. The parameters were analyzed using ANOVA, as shown in Table 1, with the following results.

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Table 1. Anova Recapitulation Results on All Observation Parameters

No	Observation Parameter		Tofu Waste POC Treatment Results
1.	Plant Height	14 HST	ns
		21 HST	ns
		28 HST	ns
		35 HST	ns
2.	Stem Diameter Per Sample	21 HST	*
		28 HST	ns
		35 HST	ns
3.	Corn Cob Weight Per Sample		*
4.	Corn Cob Weight Per Plot		*
5.	Cob Diameter Per Sample		*
6.	Dry Biomass Weight Per Sample		ns

Notes: * (significantly different) and ns (not significantly different)

Plant Height

Table 1 states that the treatment of tofu waste POC has not had a significant effect on plant height. According to the ANOVA results, the heights at 14 HST, 21 HST, 28 HST, and 35 HST have an average height that is almost the same. Therefore, this parameter was not tested further, BNJ.

Stem Diameter Per Sample

The diameter of the stem per sample showed significantly different results (*) at 21 HST, whereas at 28 HST and 35 HST, the results were not significantly different (ns). Then, the results that are significantly different need to be tested further, BNJ, with a 5% level of significance for the provision of POC waste tofu. The following are the results of the 5% BNJ further test:

Table 2. Stem Diameter Per Sample 21 HST Effect of Tofu Waste POC Application

Treatment (ml/l)	Stem Diameter Per Sample 21 HST (cm)
P0 (control)	1,20 b
P1 (26 ml/l)	1,29 ab
P2 (28 ml/l)	1,21 b
P3 (30 ml/l)	1,28 ab
P4 (32 ml/l)	1,26 ab
P5 (34 ml/l)	1,37 a
BNJ value 5%	0,141

Note: numbers followed by letters that are not the same show significantly different results in the 5% BNJ further test.

The best plant diameter at 21 HST was 1.37 cm in treatment P5 with a concentration of 34 ml/l. These results were significantly different from the P2 and P0 treatments at 1.21 cm and 1.20 cm, respectively. While the P1, P3, and P4 treatments had results that were not significantly different.

Corn Cob Weight Per Sample

The results in Table 1 show that the weight of corn cobs per sample is significantly different. With significantly different results, it is necessary to conduct a further BNJ test at the 5% level. The following are the results of the 5% BNJ further test of the parameters of corn cob weight per sample:

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Table 3. Weight of Corn Cobs per Sample of the effect of Tofu Waste POC application

Treatment (ml/l)	Corn Cob Weight Per Sample (g)
P0 (control)	186,1 ab
P1 (26 ml/l)	172,4 b
P2 (28 ml/l)	176,5 b
P3 (30 ml/l)	197,0 ab
P4 (32 ml/l)	205,3 ab
P5 (34 ml/l)	222,8 a
BNJ value 5%	41,65

Note: numbers followed by letters that are not the same show significantly different results in the 5% BNJ further test.

P1 treatment with a concentration of 26 ml/l yielded a result of 172.4 g, which was significantly different from P5. The highest result, 222.8 g, was obtained with a concentration of 34 ml/l. The P1 and P2 treatments yielded results that were not significantly different, as did the P0, P3, and P4 treatments.

Corn Cob Weight Per Plot

The weight of corn cobs per plot needs to be further tested by BNJ at the 5% level, as the results are significantly different, according to Table 1. The following are the results of the 5% BNJ further test of the corn cob weight parameter per plot as follows:

Table 4. Weight of Corn Cobs per Plot, effect of Tofu Waste POC application

Treatment (ml/l)	Corn Cob Weight Per Plot (kg)
P0 (control)	3,44 ab
P1 (26 ml/l)	3,33 b
P2 (28 ml/l)	3,70 ab
P3 (30 ml/l)	3,43 ab
P4 (32 ml/l)	4,13 a
P5 (34 ml/l)	4,00 ab
BNJ value 5%	0,841

Note: numbers followed by letters that are not the same show significantly different results in the 5% BNJ further test.

The highest result was obtained with a value of 4.13 kg in treatment P4, which had a concentration of 32 mL/L. These results were significantly different from those of the P1 treatment, which weighed 3.33 kg with a concentration of 26 mL/L. For the treatment of P0, P2, P3, and P5 found the results were not significantly different.

Cob Diameter Per Sample

Significantly different is the result of the observation of the cob diameter per sample. So, the 5% BNJ further test was conducted on this parameter. The results of the 5% BNJ further test are as follows:

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Table 5. Cob Diameter Per Sample of the effect of Tofu Waste POC application

Treatment (ml/l)	Cob Diameter Per Sample (cm)
P0 (control)	4,09 ab
P1 (26 ml/l)	4,04 ab
P2 (28 ml/l)	4,03 b
P3 (30 ml/l)	4,29 a
P4 (32 ml/l)	4,20 ab
P5 (34 ml/l)	4,21 ab
BNJ value 5%	0,256

Note: numbers followed by letters that are not the same show significantly different results in the 5% BNJ further test.

The highest cob diameter of 4.29 cm was obtained from the P3 treatment with a concentration of 30 ml/l. These results are significantly different from P2, which has a diameter of 4.03 cm with a concentration of 28 ml/l. While the treatment of P0, P1, P4, and P5 has results that are not significantly different.

Dry biomass weight per sample

The results obtained from the observation of dry biomass weight per sample are not significantly different (ns). Based on the results of the ANOVA analysis, it is known that the weight of biomass produced from each treatment has an almost identical average.

Table 6. Effect of the Interaction between application liquid fertilizer, bamboo shoot, with pruning time on dry seed weight per sample

Treatment	Average (g)	DMRT 5%
P2W0	34.1 a	-
P1W1	33.2 ab	7.367
P2W1	32.4 abc	7.726
P0W2	30.6 bc	7.949
P0W0	30.3 bc	8.102
P1W2	29.5 cd	8.215
P2W2	29.4 cd	8.296
P0W1	28.9 cd	8.360
P1W0	26.0 d	8.409

Notes: Numbers accompanied by different lowercase letters indicate significant differences based on the results of the DMRT test at the 0.05 level.

Based on the interaction between liquid fertilizer, bamboo shoot, and pruning time, the P1WI treatment (application of 100 mL/L of liquid fertilizer, bamboo shoot, and pruning 7 days after flowering) gave the best average yield, which was 33.2 grams. Meanwhile, the lowest average was obtained from the P1W0 treatment (application of 100 mL/L of liquid fertilizer bamboo shoot and control) with a value of 26 grams.

Dry seed weight per plot

The parameter of dry seed weight per plot revealed a significant interaction between liquid fertilizer, bamboo shoots, and pruning time. Therefore, further tests were carried out using DMRT at the 0.01 level with the following results:

DISCUSSION

Table 1 explains that plant height 14 HST, 21 HST, 28 HST, and 35 HST found results that were not significantly different. It is known that a plant responds differently to its environment. Despite the treatment, there were no significant differences in plant height, nutrient availability, or nutrient absorption rates during the vegetative phase. The availability of N in plant tissues affects metabolism because N is used to produce proteins, nucleic acids, and carbohydrates, which are the constituents of plant tissue cells (Syamsuwirman et al. 2023). During growth, corn plants require N nutrients in sufficient quantities. When viewed from this response, it is assumed that the provided nutrient content is insufficient for optimal needs (Mahdiannoor et al. 2016). The C-organic content contained in the tofu waste POC is also very minimal at 0.38%. The absorption of nutrients does not necessarily have to occur through the soil; it can also occur through the leaves, where the fertilizer enters and is absorbed through the stomata (Sangadji, 2018). It is known that the application of fertilizer through the leaves is more quickly absorbed and utilized by plants in the process of photosynthesis with the help of sunlight. However, the N content is insufficient for plant needs.

The parameter of stem diameter per sample showed significantly different results when the plants were 21 HST, and not significantly different at 28 HST and 35 HST. It should be noted that the widening of the stem diameter refers to secondary growth from meristem tissue division (Thamrin and Hama, 2019). The highest diameter was obtained when the plants were 21 HST, namely 1.37 cm, which was influenced by the concentration of 34 ml/l. Puspadewi et al. (2016) added that the initial focus on planting nutrients will be on increasing stem diameter. When the plant reaches the age of 21 HST, which is still young in the middle of the vegetative stage, it will absorb nutrients quickly. The nutrients absorbed are utilized to accelerate photosynthesis and enzyme activity during cell division, enabling the formation of plant organs such as roots, stem expansion, and perfect leaves (Louto et al., 2022). According to Suryani et al. (2021), fertilizer application through leaves is more effective and can be absorbed directly by plants. According to Hendri et al. (2015), plant leaf tissue can increase efficiency by as much as 90%, which is significantly greater than roots, which are only about 10% more efficient. While the absorption of nutrients in 28 HST and 35 HST corn plants entering the age of HST has not shown a difference in diameter among treatments. It can be seen that the P5 treatment (34 ml/L) yields a stem diameter of 1.37 cm. Plants will develop optimally when provided with adequate nutrients. As the age of the plant increases, so does the need for nutrients at this age (Situmorang, 2018).

The weight of the cob per sample produced is influenced by the rate of nutrient assimilation through root absorption and photosynthesis. Table 4.3 explains that the largest cob weight per sample, at 222.8 g, was observed in the P5 treatment (34 ml/L). The application of tofu waste POC was done three times at 14 HST, 21 HST, and 28 HST. The POC given contains MOL (Local Micro Organisms), as indicated by the lab test results, with a total of 6.20 x 10^6 CFU. According to Nuryani et al. (2019), plant seeds contain cell membranes, enzyme materials that play a crucial role in protein production, especially in green tissues, as well as carbohydrates and grains. Small water droplets are easily absorbed and, due to their location in the leaves, accelerate the photosynthesis process, which requires water without the need for transportation from the roots (Naeem et al. 2017). Arif et al. (2023) also stated that in cob filling, the greater the dose of potassium fertilizer used, the greater the effect on the translocation rate associated with the role of K^+ cations in the processes of respiration and photosynthesis.

The cob weight per plot produced was also significantly different and in line with the cob weight per sample. This is because the bacteria contained in the tofu waste POC have colonized the soil,

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resulting in an increase in plant growth in one plot. Because POC is made from a solution from the decay of organic matter derived from crop residues, agro-industrial waste, and animal manure, it contains more than one nutrient (Tanti et al. 2019). POC itself has a function in addition to replacing inorganic fertilizers and can also supply live bacteria in the soil by providing organic matter in the form of fermented tofu waste, and is useful in improving soil structure both chemically, physically, and biologically (Taisa et al. 2021). It was found that the P4 treatment with a concentration of 32 ml/l weighed 4.13 kg of corn per plot. Additionally, reducing the dose of chemical fertilizers also affects plant growth and production, as plants must adapt to the new environment (Nurnawati et al. 2022). Coupled with research conducted by Irsyad and Kastono (2019) when the application of inorganic fertilizers combined with liquid organic fertilizers can increase the growth and yield of corn plants at certain doses.

The cob diameter per sample also obtained results that were in line with the cob weight per sample and plot. The P3 treatment (30 ml/l) can increase the cob diameter by 4.29 cm. Cob diameter is related to the rate of nutrient absorption and availability. Solihin et al. (2019) stated that liquid organic fertilizer is more easily absorbed by plants because the compounds in it have decomposed, and liquid organic fertilizer also contains a binding material, allowing the fertilizer solution to be directly utilized by plants. With the easy absorption of the fertilizer given, it will stimulate the width of the cob produced. Previously observed parameters indicated that an attachment occurs when the plant enters the generative phase, where the treatment influences cob filling (Arif et al., 2023). The bacteria given indirectly colonize and increase when the plants enter the generative age. That way, the new POC has a real influence (Irsyad and Kastono, 2019). Fertilization applied to the leaves aims to increase microelements, which play a crucial role in plant growth. This is because the microelements contained in the POC will be combined with elements from root absorption.

The final weight of dry biomass aims to determine how many nutrients plants can absorb. The accumulation of absorbed nutrients increases the weight of biomass; the higher the rate of nutrient absorption, the higher the biomass weight. A healthy plant can be observed through its development and changes; if the plant exhibits symptoms of overdosing or deficiency, it may indicate that there are factors interfering with nutrient absorption (Mamonto, 2015). When examining nutrient requirements, it can be observed that corn plants require a high level of the N element to support cell development, which is essential for the growth of plant organs. That way, when the availability of N in the soil is reduced or in small amounts, it will affect plant growth (Amin et al. 2017). Pramitasari et al. (2016) argue that N itself is the element that plays the greatest role in increasing plant volume, where the weight of biomass measures the size of the plant. Paerah et al. (2022) stated that the availability of nutrients is not balanced, preventing plants from reaching the optimal growth point, which in turn affects the growth of other organs and production.

CONCLUSION

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CONFLICTS THAT MAY OCCUR

Possible conflicts in the application of tofu waste POC in pulut corn cultivation can arise from differences in interests between farmers, variations in production quality, and differences in soil quality. The main conflict is that if the tofu waste POC is applied improperly, it can cause environmental pollution. Excessive use of tofu waste POC can also cause changes in soil physical properties and disturbance of soil pH balance. Farmers often lack understanding of the importance of processing tofu waste and switching to organic fertilizers, largely due to inadequate education for farmers.

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