Jurnal Agronomi Indonesia
(Indonesian Journal of Agronomy)

ISSN 2085-2916 | e-ISSN 2337-3652
December 2024, *52*(3), 349-357
DOI: https://dx.doi.org/10.24831/jai.v52i3.59781

Research Article

Growth and yield of peanut on peat soil with different dolomite and shrimp waste liquid organic fertilizer (LOF) levels

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ABSTRACT

The application of dolomite and shrimp waste liquid organic fertilizer (LOF) is expected to improve the quality of peat soil to support the growth and yield of peanuts. The study was aimed at the role of dolomite and shrimp waste LOF in the development and yield of peanuts on peat soil. The study was conducted in Kubu Raya Regency, West Kalimantan, from April to August 2024. A factorial completely randomized design was used for the field experiment. The treatment factors were the dosage of dolomite (3, 6, and 9 tons ha^{-1}) and the concentration of shrimp waste LOF (200, 300, and 400 mL L^{-1}). The results showed that using dolomite and shrimp waste LOF increased the growth and yield of peanuts on peat soil. The interaction of dolomite 6 tons ha^{-1} and shrimp waste LOF 400 mL L^{-1} effectively increased root volume. The best individual dolomite treatment level for peanut growth was 6 tons ha^{-1}, and for production, it was 9 tons ha^{-1}. The best individual shrimp waste LOF treatment level for growth was 300 mL L^{-1}, and for production, it was 400 mL L^{-1}.

Keywords: amelioration; peanut production; soil fertility

Edited by:
Abdullah Bin Arif
BRIN

Received:
18 October 2024
Accepted:
16 December 2024
Published online:
27 December 2024

Citation:
Samson, O. A., & Mahmudi (2024). Growth and yield of peanut on peat soil with different dolomite and shrimp waste liquid organic fertilizer (LOF) levels. *Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy)*, *52*(3), 349-357

INTRODUCTION

Peanuts (*Arachis hypogaea* L.) are a legume commodity whose demand is second-ranked after soybeans (Kasno & Harnow, 2014). The community needs peanuts as a source of vegetable protein, raw materials for the food industry, household needs, or processed directly (Wijaya et al., 2018). The level of peanut production in Indonesia from 2019 to 2023 has consistently decreased from year to year, from 420.10 thousand tons (2019), 418.41 thousand tons (2020), 390.46 thousand tons (2021), 379.93 thousand tons (2022), and lastly 350.02 thousand tons (2023) (Directorate General of Food Crop, 2023). Based on the data above, efforts to increase peanut production need to be continuously carried out to meet community needs and increase farmers' income.

The potential land that can be utilized to increase peanut production in West Kalimantan is peatland, which has a relatively broad distribution of around 1.5 million hectares (Pantau Gambut, 2024). The area of peatland used as agricultural land in West Kalimantan reaches 550,340 ha (Miettinen et al., 2016). The utilization of peatland has not been optimal due to the low fertility level caused by high acidity, which is toxic to plants (Khotimah et al., 2020). Based on the results of the analysis of the Soil Chemistry and Fertility Laboratory, Faculty of Agriculture, Tanjungpura University in 2024, the peatland that is used as a planting medium has a pH value of 3.14, total N content of 1.93%, phosphorus 157.22 ppm, potassium 0.61 (cmol$^{(+)}$kg^{-1}). This shows that peat soil conditions react academically to high total N content and low phosphorus and potassium levels (Sardiana et al., 2017; Suherman et al., 2019).

The enormous potential of peatlands to be utilized as cultivation land in West Kalimantan can be limited by such soil chemical conditions that act as limiting factors for the growth and development of plants. Application of appropriate cultivation technology is needed to increase the growth and yield of peanuts, including the application of dolomite and fertilization by utilizing shrimp waste as liquid organic fertilizer (LOF). Dolomite applied to peat soil can help increase the pH of peat soil (Putra et al., 2020; Yang et al., 2021). The increase in pH in peat from the liming process is due to the Ca^{+} and Mg^{2+} content contained in dolomite. Hydrolyzed dolomite will contribute to OH- ions, which can neutralize H^{+} ions from the soil solution to increase soil pH (Ilham et al., 2019).

Shrimp waste liquid organic fertilizer (LOF) can increase peat soil fertility because shrimp shell waste contains high protein and minerals, such as Ca, P, Na, and Zn (Wahida & Suryaningsih, 2016). These minerals are essential for plant growth and development. In general, the nutritional components of shrimp shells contain 25-40% protein, 45-50% calcium carbonate, and 15-20% chitin (Pratama et al., 2016). According to Dewanti et al. (2023), LOF with waste content can increase soil C-Organic, Available N, Available P, and Available K, significantly improving mustard plant growth. The study was aimed at the role of dolomite and shrimp waste LOF in the development and yield of peanuts on peat soil.

MATERIALS AND METHODS

The research was conducted in Kubu Raya Regency, West Kalimantan, from April to August 2024. The research materials used were peanut seeds of the Takar 2 variety and liquid organic fertilizer with shrimp waste as the basic material. A completely randomized design was followed for the field experiment, with two factors and three replications. The first factor was the dosage of dolomite (3, 6, and 9 tons ha^{-1}), and the second factor was the concentration level of shrimp waste LOF (200, 300, and 400 mL L^{-1}). The total treatment combination was nine treatments, and therefore there were 27 experimental units. Four sample plants from each unit were observed, so in total there were 108 sample plants.

Planting media was prepared by cleaning peat soil with a hemic maturity level from remaining litter and roots, which was then air-dried for 24 hours under shade. Furthermore, the peat soil was put into polybags with a volume of 8 kg (polybag size 40*x*50 cm). Dolomite was applied by mixing it evenly with the peat soil in each polybag. The dose of dolomite given was according to the treatment (60, 120, and 180 g per polybag), then incubated for 2 weeks. Cow manure as an essential fertilizer was applied at the beginning of the preparation of the planting media, together with the provision of dolomite. The cow manure was given 300 g per polybag (15 tons ha^{-1}).

Peanut seeds were planted directly into polybags (two seeds per planting hole), and the best seedlings were selected at the age of 7 days after planting (DAP). Shrimp waste LOF was applied at the age of 7 DAP and repeated once a week with a concentration according to the treatment. The volume of watering the planting media was 300 ml per polybag. Watering the plants was performed in the morning and evening. During the application of LOF, the plants were not watered. Soil hilling was carried out when the plants were 28 days after planting.

Plant growth was observed by measuring the height of the plant from the base of the stem to the highest growing point at the age of 40 DAP. Plant dry weight and root volume were observed by removing one destructive sample plant at the age of 40 DAP. Root volume was observed using a measuring cup, and all parts of the plant were dried using an oven at a temperature of 90 ^{o}C for 2x24 hours. Plants that had been constantly dried were weighed using a digital scale. The plant production phase was observed after harvesting by counting all the pods formed in each sample plant. Furthermore, the dry weight of the seeds was monitored by weighing them after they had dried in the sun for 2*x*4 hours, and 100 dry seeds were weighed to measure the weight per 100 seeds.

The analysis of variance (ANOVA) was performed to analyze the average data obtained. Post-hoc tests were carried out on the source of variations showing significant effect using the Honestly Significant Difference (HSD) test with a confidence level of 95%.

RESULTS AND DISCUSSION

Nutrient content of peat soil

The laboratory analysis of peat soil used in this study showed that its initial pH was acidic (Table 1). The surly nature of peat soil is caused by poor hydrolysis of organic acids resulting from the decomposition of organic materials (Rinaldi et al., 2019; Qadafi et al., 2021). C-Organic, phosphorus, potassium, and CEC content have very high criteria, total N has high criteria, while the calcium and base saturation content have shallow criteria (Center for Soil Research, 1983). The pH condition of peat soil is an essential factor that can limit the decomposition of organic matter and determine the availability of nutrients. In acidic soil conditions, nutrients in the soil cannot be available for plants (Masud et al., 2020; Siregar et al., 2021).

Table 1. Nutrient content of peat soil.

Parameter	Unit	Value*	Criteria**
pH H_2O	-	3.09	Very acidic
C-Organic	%	56.52	Very high
N-Total	%	I.93	Low
Phosphorus	ppm	157.22	Very high
Calcium	(cmol$^{(+)}$kg^{-1})	1.37	Very low
Potassium	(cmol$^{(+)}$kg^{-1})	0.61	Very high
Sodium	(cmol$^{(+)}$kg^{-1})	0.97	High
CEC	(cmol$^{(+)}$kg^{-1})	115.26	Very high
Base saturation	%	3.20	Very low

Note: *Results of analysis at the Soil Chemistry and Fertility Laboratory, Faculty of Agriculture, Tanjungpura University (2024), **Center for Soil Research Staff (1983).

Nutrient content of shrimp waste LOF

The nutrient content of shrimp waste LOF applied to peat soil is an important factor in determining the growth and development of peanut plants. The higher the nutrient content, the better the impact on plant growth and development. The analysis of the Soil Chemistry and Fertility Laboratory, Faculty of Agriculture, Tanjungpura University showed that the value ratio C/N of shrimp waste LOF was 10.75, meaning that the LOF used in the study was perfectly mature. The nutrient contents included total nitrogen content (0.12%), phosphorus (8.47 ppm), and potassium (1211.16 ppm) (Table 2). This showed that the levels of N, P, and K in shrimp waste LOF were still below the minimum standard value for liquid organic fertilizer quality (Keputusan Menteri Pertanian RI, Nomor 261/KPTS/SR.310/M/4/2019). According to (Kusmiyarti, 2013), the high and low nutrient content in LOF is due to the mineralization process when the composition and quality of nutrients highly depend on the raw materials' characteristics. In addition, low nutrient levels in LOF content can also be caused by microorganisms that decompose organic materials utilizing organic matter and nutrients for their metabolic activities (Rusmini et al., 2023; Anwar et al., 2024).

Table 2. Nutrient content of shrimp waste LOF.

Parameter	Unit	Value*
pH	-	6.29
C-Organic	%	1.29
Ratio C/N		10.75
N-Total	%	0.12
Phosporus	ppm	8.47
Potassium	ppm	1,211.16
Calcium	ppm	338.70
Magnesium	ppm	515.38

Note: *Results from analysis at the Soil Chemistry and Fertility Laboratory, Faculty of Agriculture, Tanjungpura University (2024).

Plant height

The ANOVA test showed that the dolomite and shrimp waste LOF treatments had a significant difference in peanut plants' height. However, the interaction between dolomite treatment and shrimp waste LOF was insignificant. Furthermore, the dolomite treatment, given a dose of 6 tons ha^{-1}, showed that the HSD test was significantly better at increasing plant height than the 3 tons ha^{-1} treatment. However, plant height was not significantly increased with a dose of 9 tons ha^{-1} (Table 2). The better increase in plant height in the dolomite dose treatment of 6 and 9 tons ha^{-1} was due to increased soil pH values suitable for peanut plant growth (6.0-6.5) (Beddes & Drost, 2020). The pH value of peat soil in the dolomite treatment was 6.17 (at 6 tons ha^{-1}) and 6.47 (at 9 tons ha^{-1}) with slight acid criteria, while at a dolomite dose of 3 tons ha^{-1}, the pH value was 5.3 (strong acid) (Figure 1). This condition is very beneficial in supporting plant growth because the nutrients needed by plants can be available and dissolved in water so that plants can absorb them (Fajeriana & Wijaya, 2020). According to (Jiang et al., 2017), the appropriate soil pH condition is one of the crucial factors in supporting plant growth, including increasing plant height and biomass.

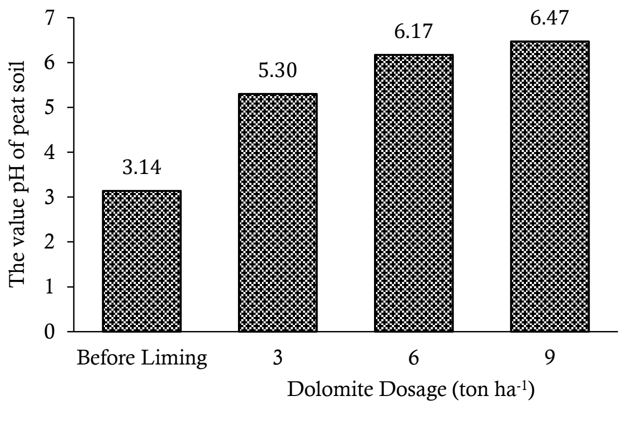

Figure 1. The value of peat soil pH at different dolomite dosages.

The HSD test of shrimp waste LOF application showed that at a concentration of 300 mL L^{-1}, it was significantly better in increasing plant height compared to a concentration of 200 mL L^{-1}, while the addition of shrimp waste LOF concentrations of up to 400 mL L^{-1} obtained equally good results (Table 3). This indicated that the higher the concentration of shrimp waste LOF applied to the soil, the greater the supply of nutrients for plants, where plants need these nutrients for the metabolic process (Santoso & Maghfoer, 2022). Based on Table 1, the nitrogen nutrient content in the shrimp waste LOF used is still relatively low. Thus, a higher LOF concentration is needed to meet the needs of peanut plants and increase their growth. Nitrogen plays an essential role in supporting plant height growth (Wang et al., 2020). Nitrogen elements absorbed by plants play a role in cell division and enlargement and can support increasing plant height growth (Poudel et al., 2018).

Plant dry weight

The ANOVA test showed that the shrimp waste LOF treatments significantly differed in peanut plants' dry weight. However, the interaction between dolomite treatment and shrimp waste LOF and the dolomite individually was insignificant. The HSD test showed the average dry weight of plants with a shrimp waste LOF concentration level of 300 mL L^{-1}, which showed a significantly better dry weight value than a concentration of 200 mL L^{-1}. In contrast, a concentration of 400 mL L^{-1} showed equally good results (Table 3). This is because the availability of nutrients, especially N, P, and K nutrients absorbed by plants, increased along with the increasing concentration of LOF given to the soil. Plants need large amounts of nutrients, and they play an important role in photosynthesis activities (Firmansyah et al., 2017). The increase in a plant's dry weight reflects the accumulation of organic compounds from the plant synthesis process (Suryati et al., 2015; Lorensius et al., 2018).

Table 3. The results of the HSD test on the average plant height, dry plant weight, number of pods, dry seed weight, and weight of 100 seeds due to dolomite and shrimp waste LOF treatment.

Dolomite (tons ha^{-1})	Plant height (cm)	Plant dry weight (g)	Number of pods (pods)	Dry seed weight (g)	Weight of 100 seeds (g)
3	19.20b	4.27	18.38b	25.34b	42.64b
6	20.10a	4.39	19.92b	27.01b	45.34ab
9	20.25a	4.64	26.21a	36.41a	51.02a
HSD 5%	0.79	-	4.24	4.55	6.12
Shrimp waste LOF (mL L^{-1})	Plant height (cm)	Plant dry weight (g)	Number of pods (pods)	Dry seed weight (g)	Weight of 100 seeds (g)
200	19.11b	4.05b	17.52b	24.23b	40.81b
300	19.94a	4.49ab	20.98b	28.44b	47.48a
400	20.51a	4.75a	26.02a	36.09a	50.71a
HSD 5%	0.79	0.58	4.24	4.55	6.12

Note: Numbers followed by the same letters in the same column are not significantly different based on the HSD test at the 5% level.

Root volume

The ANOVA found that each dolomite and shrimp waste LOF treatment significantly differed in the root volume. Nevertheless, the dolomite and shrimp waste LOF individually was not significant. The HSD test showed that the dolomite (9 tons ha^{-1}) and shrimp waste LOF of 400 mL L^{-1} were significantly better than the other treatment interactions but were not different from the interaction of dolomite 6 tons ha^{-1} and shrimp waste LOF 400 mL L^{-1} (Table 4). This was because the increasing soil pH, supported by a greater supply of nutrients from the applied LOF concentration, obtained a balance of soil fertility that supports better root growth and development.

The plant root system can be influenced by various factors such as water availability, soil texture, aeration, nutrient availability, pH, and temperature (Schneider et al., 2017; Hartmann et al., 2018; Correa et al., 2019; Hadir et al., 2021). According to Lopez et al. (2023), the important nutrients plants need to increase root growth are N and P, where conditions of N and P deficiency in the soil can cause plant root growth to decrease. According to Nuryani et al. (2019), the nutrient P in plants plays a role in stimulating root growth.

Table 4. The results of the HSD test on the average root volume (cm^3) due to the interaction of dolomite and shrimp waste LOF treatment.

Dolomite (tons ha^{-1})	Shrimp waste LOF (mL L^{-1})			Average
	200	300	400	
3	12.83c	13.15c	13.22bc	13.07b
6	14.40bc	14.02bc	14.96ab	14.46a
9	13.21c	13.51bc	16.49a	14.40a
Average	13.48b	13.56b	14.89a	
HSD 5%	Interaction (1.72)	Dolomite (0.72)	Shrimp waste LOF (0.72)	

Note: Numbers followed by the same letters were not significantly different based on the HSD test at the 5% level.

Number of pods

Following the analysis of variance (ANOVA), the number of pods showed a significant difference in the level of dolomite and shrimp waste LOF treatment individually. However, the interaction between the dolomite and shrimp waste LOF showed no significant results. The HSD test showed that applying 9 tons of ha^{-1} of dolomite was better than doses of 3 and 6 tons of ha^{-1} produced peanut pods (Table 2). The HSD test of several pods on the shrimp waste LOF treatment showed that at a concentration of 400 mL L^{-1}, it increased significantly better results compared to 200 and 300 mL L^{-1} (Table 3). The increase in the formation of peanut pods obtained in this study can be caused by the availability of increasingly high phosphorus nutrients along with the increasing soil pH and the supply of nutrients through higher LOF concentrations.

The formation of pods on a plant is influenced by the plant's ability to assimilate photosynthate and the role of N and P nutrients as raw materials for plants for the photosynthesis process (Lubis et al., 2013; Kurniawan et al., 2017). The availability of N and P nutrients for plants optimizes the photosynthesis process so that the carbohydrates produced are sufficient for plant growth to the production stage (Sumbayak & Gultom, 2020).

Dry seed weight and weight of 100 seeds

The ANOVA test of dry seed weight and weight of 100 seeds showed a significant difference in each treatment of dolomite and shrimp waste LOF. On the other hand, the interaction of the dolomite and shrimp waste LOF showed an insignificant effect. The HSD test for the dolomite dose level treatment of 9 tons ha^{-1} showed a significantly better dry seed weight than the treatment levels of 3 and 6 tons ha^{-1} (Table 3). The HSD test on the shrimp waste LOF treatment for dry seed weight showed that at a concentration of 400 mL L^{-1}, it was significantly heavier than the concentration treatments of 200 and 300 mL L^{-1} (Table 2).

The HSD test for the weight of 100 seeds at the dolomite level of 9 tons ha^{-1} produced a better weight of 100 seeds than the levels of 3 tons ha^{-1}, while the dolomite level of 6 ton ha^{-1} showed no significant difference (Table 3). The HSD test for the shrimp waste LOF at a level of 400 mL L^{-1} obtained a better weight of 100 seeds compared to the level of 200 mL L^{-1}, while a concentration level of 300 mL L^{-1} obtained equally good results (Table 3). According to Effendi et al. (2023), LOF applied to plants supports seed filling, resulting in better dry seed weight. The availability of P nutrients greatly influences the weight of dry and 100 seeds in a plant. Plants' lack of phosphate elements inhibits the pod-filling process (Sumbayak & Gultom, 2020). Sufficient P elements in peanut plants can improve the process of seed formation and development (Laila et al., 2017).

CONCLUSIONS

The combination of dolomite 6 tons ha^{-1} and shrimp waste LOF 400 mL L^{-1} effectively increases the volume of plant roots. The best individual treatment level of dolomite for peanut growth was 6 tons ha^{-1}, and for production was 9 tons ha^{-1}. The best individual treatment level of shrimp waste LOF for growth was 300 mL L^{-1}, while for peanut production, it was 400 mL L^{-1}.

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