INTERNATIONAL JOURNAL AGRITANI
Volume 01 Number 01
May 2025
p-ISSN: 0000-0000
e-ISSN: 0000-0000

Responses of liquid organic fertilizer application of shallots to the growth of various types of mustard plants

Suwinda Fibriani[1], Fitri Krismiratsih[1]

[1] *Department of Agribusiness Management, State Polytechnic of Jember, Indonesia*

Correspondence should be addressed to: Suwinda Fibriani suwinda@polije.ac.id

Abstract:
Mustard greens (Brassica sp.) are one of the horticultural plants widely cultivated by the community. Mustard production can be increased through fertilization activities. Mustard plants require balanced soil nutrients such as nitrogen, phosphorus, and potassium (N, P, K) to support optimal growth. Liquid organic fertilizer (POC) has been developed to reduce dependence on the use of inorganic fertilizers. POC made from shallots contains complete macro and micronutrients that can be utilized by mustard plants for optimal growth. This research aims to study the response of liquid organic fertilizer (POC) from shallots on the growth of various types of mustard greens. The research was conducted at the Jember State Polytechnic from June to August 2024, using a Factorial Randomized Block Design (RBD) with 3 replications, involving POC concentrations of 0, 20, 40, and 60 ml/L on the mustard varieties Pakcoy, Samhong, Pagoda, and Caisim. The results showed that the 60 ml/L POC concentration significantly increased the number of leaves and plant height in Samhong and Pagoda mustard greens at 40 days after planting.

Article info:
Submitted:
24-06-2025
Revised:
30-06-2025
Accepted:
30-06-2025

Keywords:
liquid organic fertilizer, shallots, mustard greens

INTRODUCTION

The agricultural sector plays a crucial role in meeting the food demands of society. Mustard greens (*Brassica juncea* L.) are among the most widely cultivated horticultural crops in Indonesia due to their high nutritional value and growing market demand (Putu et al., 2023). Several varieties of mustard, such as green mustard, white mustard, and pakcoy, are known for their distinct growth characteristics. These plants have a relatively short cultivation period and can be grown year-round, making them a primary choice for horticultural farmers in various regions (Aranda et al., 2023). Despite their high potential, mustard cultivation faces several challenges that can impact yield productivity and quality. Among the key issues are declining soil fertility and farmers' heavy reliance on synthetic fertilizers.

The long-standing practice of applying synthetic or chemical fertilizers in agriculture has been associated with several negative effects, including soil degradation, disruption of soil ecosystem health, reduced soil fertility, and dependency on chemical inputs (Wua et al., 2022). Shifting from synthetic fertilizers to more sustainable agricultural practices, such as the use of organic fertilizers and integrated farming systems, can help mitigate these impacts (Fibriani & Krismiratsih, 2025). Excessive and prolonged use of synthetic fertilizers may also contaminate soil and water, leading to changes in soil structure, reduced microbial diversity, and nutrient leaching (Liang et al., 2022).

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p-ISSN: 0000-0000
e-ISSN: 0000-0000

Sustainable agriculture emphasizes environmental balance and promotes eco-friendly cultivation practices. One of its approaches involves reducing reliance on synthetic fertilizers by adopting organic and environmentally sound alternatives (Marpaung et al., 2021). To achieve optimal growth, mustard plants require adequate and balanced nutrients, which can be effectively provided through organic fertilizers.

One innovative approach is the use of liquid organic fertilizer derived from agricultural waste, including shallot (*Allium cepa*) residues. Shallot waste, typically treated as garbage, contains significant potential as a source of organic nutrients for plants. Utilizing organic fertilizers made from shallot production waste, such as peels and sorting remnants (commonly called *wiwilan*), can support optimal growth of mustard plants. This is due to the content of macro- and micronutrients such as nitrogen (N), phosphorus (P), and potassium (K), as well as bioactive compounds that can stimulate plant growth. Furthermore, shallot waste is rich in naturally occurring plant growth regulators such as auxins and gibberellins (Krismiratsih and Fibriani, 2024).

According to Anggraeni, Anwar, and Gomes & Scortecci (2021), the auxin and gibberellin compounds present in shallot bulbs play important roles in plant growth. In another study (Abbas et al., 2020), auxin was found to contribute to the formation of parthenocarpy fruit in mustard plants. Organic fertilizers offer numerous advantages over synthetic fertilizers, including a more complete composition of macro and micronutrients, improvement of soil physical properties, and enhancement of soil microbial activity. Liquid organic fertilizer presents an environmentally friendly alternative for nutrient supply to crops (Triharyanto et al., 2022). Nevertheless, studies on the effect of shallot-based liquid organic fertilizer on the growth of different mustard varieties remain limited. Therefore, this research aims to investigate the growth response of various mustard cultivars to the application of shallot derived. The findings are expected to provide recommendations for farmers on how to utilize shallot waste as an organic fertilizer source. This study also seeks to contribute to the advancement of sustainable and environmentally friendly organic agriculture while improving the productivity and quality of mustard crops.

METHOD

This study was conducted at the Experimental Field of the State Polytechnic of Jember, located at an altitude of approximately 385 meters above sea level, with temperatures ranging from 21–32 °C and average wind speeds between 14–25 km/h. The research was carried out from February to April 2025. The tools used in this experiment included a measuring cylinder, an analytical balance, buckets, drums, hoses, scissors, knives, a hand sprayer, a ruler, writing utensils, and a camera. The materials consisted of seeds of various Brassica types (caisim, samhong, pagoda, and pakcoy), soil, shallot-based liquid organic fertilizer, labeling materials, cable paper, and raffia string.

Prior to the experiment, the liquid organic fertilizer was prepared using shallot waste materials, such as peels, sorting residues (*wiwilan*), and spoiled shallots. These materials were combined with molasses, livestock manure, EM4 (Effective Microorganism 4), and rice-washing water. The preparation began by chopping the shallots into small pieces to facilitate decomposition, followed by mixing them with molasses, rice-washing water, and a small amount of manure. The mixture was placed in a closed container, to which EM4 was added to accelerate the fermentation process. The fermentation was allowed to proceed for 2 to 3 weeks. After fermentation, the solid residue was separated, and the liquid extract was used as the organic fertilizer.

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p-ISSN: 0000-0000
e-ISSN: 0000-0000

A factorial randomized complete block design was employed, consisting of 16 treatment combinations with 3 replications, resulting in 48 experimental units. The first factor was the dosage of shallot-based LOF:

- P0 = 0 ml/L
- P1 = 20 ml/L
- P2 = 40 ml/L
- P3 = 60 ml/L

The second factor was the type of Brassica:

- S1 = Pakcoy
- S2 = Samhong
- S3 = Pagoda
- S4 = Caisim

Each experimental unit involved planting Brassica in a 30×30 cm polybag. Prior to planting, seeds were sown in seed trays containing a medium composed of rice husk charcoal, soil, and manure in a 1:1:1 ratio. Seeding grooves were made 1 cm deep, the seeds were placed, and the media were moistened with water. Transplantation was carried out when the seedlings reached 2 weeks of age and had developed 3 to 4 true leaves. The seedlings were transplanted carefully to avoid damaging the root system. The treatments began when the plants were 2 weeks after transplanting and were applied every two days according to the treatment dosage.

Plant maintenance included thinning and pest and disease control, which was conducted manually. Harvesting was done at 4 weeks after transplanting by cutting the plant at the base, separating the roots. The observed variables were plant height (cm), number of leaves (leaves), and fresh plant weight (g). Data were analyzed using analysis of variance (ANOVA), and when significant differences were found, the means were further compared using Duncan's Multiple Range Test (DMRT) at a 5% significance level.

RESULT

The effect of liquid organic fertilizer for shallots on the growth of mustard greens

The application of shallot liquid organic fertilizer had a significant effect on plant height and leaf number parameters, while no significant differences were observed among fertilizer dosage treatments for fresh weight (Tables 1, 2, and 3). Among the mustard varieties, Brassica juncea cv. Casisim (S4) exhibited the highest growth response, significantly outperforming the other cultivasrs. In contrast, the pagoda variety (S3) showed the lowest growth performance. These results indicate a differential genetic response among mustard types to the same fertilizer treatment.

Table 1. Average plant height of mustard at various liquid organic fertilizer dosages and mustard varieties

Mustard type (S)	Liquid Organic Fertilizer (P)				Total	Average
	P0	P1	P2	P3		
S1	61.50	60.00	67.80	59.50	248.80	20.73^{ab}
S2	51.60	56.70	59.80	63.80	231.90	19.33^{b}
S3	37.70	41.00	36.50	46.30	161.50	13.46^{c}
S4	62.70	68.10	64.90	69.20	264.90	22.08^{a}
Total	150.80	157.70	164.10	169.60	907.10	
Average	16.76	17.52	18.23	18.84		18.90

*In centimeters

**Different letters following the number in the same row indicate significant differences at the 5% test level.

Based on data, the 60 mL/L dose (P3) descriptively showed the highest average plant height; however, the differences between doses were not statistically significant. This is presumed to be due to the auxin content in the shallot-based liquid organic fertilizer, which stimulates cell elongation in the apical meristem. Auxins are known to regulate apical dominance and inhibit lateral bud growth, thereby promoting optimal stem elongation in plants (Gomes & Scortecci, 2021)

Number of Leaves

The dosage of shallot liquid organic fertilizer also affected the number of leaves in mustard plants. The best treatment combination was observed in the Pagoda mustard variety (S3) at the P3 dose (60 mL/L), which produced a significantly higher number of leaves compared to other treatments (Table 2).

Table 2. Average number of leaves

Mustard Type (S)	Liquid Organic Fertilizer (P)			
	P0	P1	P2	P3
S1	13.67^{d}	18.33^{d}	15.67^{d}	16.33^{d}
S2	18^{d}	19.33^{d}	17^{d}	16,33^{d}
S3	29.66^{bc}	33.33^{b}	33.33^{b}	49.66^{a}
S4	18,67^{d}	16.33^{d}	19^{d}	20.66^{cd}

*Different letters following the number in the same row indicate significant differences at the 5% test level.

The interaction effect between fertilizer dosage and plant variety indicates that the influence of the liquid organic fertilizer is highly dependent on the mustard variety. The pagoda variety responded better to increasing liquid organic fertilizer doses compared to other varieties. This may be attributed to the gibberellin content in the shallot, which can stimulate leaf formation and the elongation phase (February & Santoso, 2022).

Fresh Weight of Plants

The fresh weight parameters did not show significant differences among fertilizer dosage, although there were variations among mustard varieties (Table. 3). The caisim variety (S4) exhibited the highest fresh weight, followed by Samhong (S2) and pakcoy (S1), while the pagoda variety (S3) had the lowesr fresh weight.

Table 3. Average fresh weight of mustard plants (g)

Mustard type (S)	Liquid Organic Fertilizer (P)				Total	Average
	P0	P1	P2	P3		
S1	44.33	215.80	216.25	219.05	695.43	57.95^{a}
S2	163.80	235.50	235.85	149.45	784.60	65.38^{a}
S3	95.90	128.85	134.00	155.35	514.10	42.84^{b}
S4	256.65	212.95	194.50	188.60	852.70	71.06^{a}
Total	304.03	580.15	586.10	523.85	2846.83	
Average	33.78	64.46	65.12	58.21		59.31

*Different letters following the number in the same row indicate significant differences at the 5% test level.

DISCUSSION

Liquid organic fertilizer derived from shallot waste has been shown to contain bioactive compounds such as auxins and gibberellins, which can physiologically influence plant growth. In

Volume 01 Number 01
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p-ISSN: 0000-0000
e-ISSN: 0000-0000

addition, shallot-based LOF contains essential nutrients including phosphorus (P), nitrogen (N), potassium (K), magnesium (Mg), calcium (Ca), and zinc (Zn), which support root development (Putu et al., 2023). Auxins play a critical role in promoting cell elongation, apical dominance, and root formation, while gibberellins stimulate leaf growth and plant tissue development (Gomes & Scortecci, 2021). Previous research by Fauziah et al. (2022) reported that liquid organic fertilizer made from locally sourced organic materials can improve the physical and chemical properties of the soil, enhance soil microbial activity, and sustainably supply essential nutrients. These effects contribute to improved vegetative growth, including increased plant height and leaf number (Suhastyo & Raditya, 2021), as observed in the results of this study.

Plant type is also a crucial factor. The physiological responses and genetic adaptations of mustard cultivars significantly influence the effectiveness of the fertilizer. In this study, Brassica juncea cvs. Caisim and Pagoda exhibited different growth performances across measured parameters, indicating that fertilizer formulations may need to be tailored to specific cultivars. Therefore, the application of shallots at a concentration of 60 ml/L proved to be the most effective treatment for enhancing mustard growth, particularly in terms of plant height and leaf number. However, for fresh weight parameters, further research is necessary to examine the interactions between environmental conditions, application frequency, and plant developmental stages.

CONCLUSION

The application of liquid organic fertilizer derived from shallot waste significantly affected the growth of mustard plants, particularly in terms of plant height and leaf number. The treatment with a concentration of 60 ml/L (P3) produced the highest average plant height and leaf number across the tested cultivars, indicating its effectiveness as a nutrient source. Among the tested varieties, Brassica juncea cv. Caisim (S4) showed the most favorable growth response in terms of plant height and fresh weight, while Pagoda (S3) exhibited the greatest response in terms of leaf number. The positive effects observed can be attributed to the presence of essential macro and micronutrients, as well as natural growth regulators such as auxin and gibberellin contained in the shallot-based. Although treatments did not result in statistically significant differences in fresh weight among all treatments, certain combinations, particularly S4 with P2 and P3, showed promising results. These findings suggest that shallots can serve as a sustainable alternative to synthetic fertilizers by enhancing plant growth and supporting environmentally friendly agricultural practices. Overall, this study confirms the potential of utilizing shallot agricultural waste as a liquid organic fertilizer to support the sustainable cultivation of mustard greens. Further research is recommended to explore the long-term effects and nutrient dynamics of shallots on different soil types and climatic conditions.

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