Multidisciplinary Output Research For Actual and International Issue (MORFAI Journal) ISSN (e): 2808-6635
Volumes 6 No. 6 (2026)

YIELD COMPONENTS AND BULB YIELD OF SABU RAIJUA SHALLOT (*Allium ascalonicum* L.) IN RESPONSE TO DIFFERENT CONCENTRATIONS OF FERMENTED BOVINE RUMEN-BASED LIQUID ORGANIC FERTILIZER UNDER SEMIARID DRYLAND CONDITIONS

Laurensius Lehar[1*], Zainal Arifin[2], Heny Mathelda Cornelia Sine[3], Tri Luchi Proklamita[4], Micha Snoverson Ratu Rihi[5]
[1,2,3,4,5]State Agricultural Polytechnic of Kupang, Kupang, Indonesia
E-mail: author_1 laurensiusl@yahoo.co.id[1]*, author_2 zainalpolitani@yahoo.com.sg[2], author_3 henysine2019@gmail.com[3], author_4 proklamita@gmail.com[4], author_5 raturihimicha@gmail.com[5]

Received:05/10/2026 | **Revised** : 12/10/2026 | **Accepted:** 30/10/2026 | **Published:** 25/11/2026

Abstract

The utilization of bovine rumen contents as a raw material for liquid organic fertilizer (LOF) offers a circular agriculture strategy to improve horticultural productivity while reducing livestock waste. However, evidence regarding the effects of fermented bovine rumen-derived LOF on yield components and bulb yield of the Sabu Raijua shallot cultivar under semiarid dryland conditions remains limited. This study evaluated the responses of bulb diameter, bulb weight per clump, bulb weight per plot, and bulb yield to seven LOF concentrations: 0, 75, 100, 125, 150, 175, and 200 mL L^{-1}. Yield measurements were conducted at 60 days after planting. The 200 mL L^{-1} treatment produced the highest values for bulb diameter (30.25 mm), bulb weight per clump (50.27 g), bulb weight per plot (502.70 g), and bulb yield (2.095 t ha^{-1}). These results did not differ significantly from those obtained with 175 mL L^{-1}, which yielded a bulb diameter of 29.75 mm, bulb weight per clump of 49.77 g, bulb weight per plot of 497.70 g, and bulb yield of 2.074 t ha^{-1}. Relative to the untreated control, bulb yield increased by 27.20% and 25.93% at 200 and 175 mL L^{-1}, respectively. Bulb yield did not increase consistently across the concentration gradient, indicating a nonmonotonic treatment response. Overall, the 175–200 mL L^{-1} treatments achieved the highest bulb yield, with no statistically significant difference between them. Applying 175 mL L^{-1} may therefore reduce fertilizer use while maintaining comparable bulb yield, although economic efficiency requires further assessment in the evaluated semiarid dryland environment.

Keywords: bovine rumen contents; bulb yield; liquid organic fertilizer; Sabu Raijua shallot; semiarid dryland.

INTRODUCTION

Shallot (*Allium ascalonicum* L.) is a strategically important horticultural crop that contributes to food security, farmers' livelihoods, and food price stability. Beyond its substantial economic value, shallot contains bioactive compounds, including flavonoids, quercetin, and organosulfur compounds, with potential health-promoting properties. In Indonesia, increasing demand for shallots necessitates the development of productive and sustainable cultivation practices. The Pusat Data dan Sistem Informasi Pertanian (2024) estimated national shallot production at approximately 2.14 million tonnes in 2024, representing a 7.77% increase compared with the previous year. Nevertheless, productivity growth is projected to remain relatively modest, highlighting the need to improve crop yields through more efficient nutrient management.

Shallot production intensification continues to rely heavily on inorganic fertilizers to meet crop nutritional requirements (Ali et al., 2024). However, prolonged and imbalanced fertilizer application may adversely affect soil quality, increase nutrient losses, and disrupt soil microbial activity (Li et al., 2023; Sande et al., 2024). Excessive fertilizer use may also increase production costs and contribute to environmental contamination (Liu et al., 2023). Consequently, integrated nutrient management, involving the balanced utilization of organic and inorganic nutrient sources, has emerged as an important approach to sustaining crop productivity while maintaining soil health (Ali et al., 2024; Sande et al., 2024).

The conversion of livestock waste into organic fertilizers offers opportunities to implement circular agriculture by recycling nutrients within agricultural production systems. This approach can minimize waste generation while enhancing the value of locally available resources (Cordeiro & Sindhøj, 2024; Schmidt et al., 2025).

Improperly managed livestock waste may contribute to environmental pollution and greenhouse gas emissions (Miller et al., 2024). Among the potentially valuable organic resources are bovine rumen contents, which can be processed through fermentation into liquid organic fertilizer (LOF). Their utilization may provide an alternative nutrient source while supporting more sustainable livestock waste management.

Organic fertilizers and biological soil amendments can improve nutrient availability and support crop productivity by influencing biological processes within the soil (Agegnehu et al., 2021; Ali et al., 2024). Bovine rumen contents harbor diverse microbial communities involved in organic matter decomposition, including microorganisms associated with fiber degradation and nutrient metabolism (Jami et al., 2013; Henderson et al., 2015). Nevertheless, the presence of microorganisms in the rumen does not necessarily indicate that all microbial populations remain viable or functionally active following fermentation. The agronomic effectiveness of rumen-derived LOF depends on feedstock characteristics, fermentation processes, nutrient composition, and application conditions. Previous studies by Rizkiana (2020) and Ramadani et al. (2023) provide a basis for exploring rumen-derived materials as alternative nutrient inputs for crop production.

The effectiveness of LOF application may vary considerably depending on fertilizer formulation, application concentration, soil properties, crop species, and environmental conditions (Ali et al., 2024; Fadiji et al., 2024). Such variability is particularly relevant to shallot cultivation because bulb formation and development require an adequate nutrient supply throughout critical growth stages. Insufficient LOF concentrations may fail to meet crop nutrient requirements, whereas increasing application concentrations does not necessarily result in proportional yield improvements. Therefore, evaluating different application concentrations is essential to identify treatments capable of optimizing yield components and bulb yield under specific cultivation conditions.

East Nusa Tenggara Province, Indonesia, is characterized by semiarid dryland agroecosystems with limited rainfall, uneven precipitation distribution, and relatively high ambient temperatures. These environmental constraints can restrict water availability and nutrient-use efficiency, thereby limiting horticultural crop performance (Pusat Data dan Sistem Informasi Pertanian, 2024). At the same time, cattle farming generates organic residues that could potentially be converted into valuable agricultural inputs. Integrating livestock waste management with horticultural production therefore offers opportunities to establish locally adapted, resource-efficient agricultural systems. The Sabu Raijua shallot cultivar represents an important local horticultural resource in East Nusa Tenggara, making the development of appropriate nutrient management strategies particularly relevant to its cultivation under semiarid conditions.

Although organic fertilizer applications have been widely investigated, information regarding the responses of yield components and bulb yield of the Sabu Raijua shallot cultivar to different concentrations of fermented bovine rumen-derived LOF under semiarid dryland conditions remains limited. In particular, the relationships between LOF application concentrations and bulb diameter, bulb weight per clump, bulb weight per plot, and bulb yield per unit area have not been sufficiently characterized for this cultivar and agroecosystem. This knowledge gap highlights the importance of cultivar-specific and location-specific investigations that integrate multiple yield-related parameters to assess the agronomic effectiveness of locally derived organic fertilizers.

Accordingly, this study aimed to evaluate the effects of different concentrations of liquid organic fertilizer produced from fermented bovine rumen contents on yield components and bulb yield of the Sabu Raijua shallot cultivar under semiarid dryland conditions. The study also sought to identify the application concentration that provides the most favorable agronomic response. The findings are expected to provide scientific evidence for developing locally adapted nutrient management strategies, promoting the productive utilization of livestock waste, and supporting sustainable shallot production in semiarid dryland agroecosystems.

LITERATURE REVIEW

Shallot (*Allium ascalonicum* L.) bulb yield is influenced by nutrient availability, crop physiology, and environmental conditions during bulb formation. Nitrogen supports vegetative growth and photosynthesis, phosphorus contributes to energy metabolism, and potassium facilitates assimilate transport and water regulation. However, greater nutrient inputs do not necessarily produce proportional yield increases. Prolonged or imbalanced inorganic fertilization may increase nutrient losses and environmental risks (Li et al., 2023; Liu et al., 2023; Sande et al., 2024). Integrated nutrient management therefore aims to sustain productivity while improving nutrient-use efficiency (Ali et al., 2024). Its effectiveness nevertheless depends on fertilizer composition, application concentration, and crop-specific requirements.

Bovine rumen contents represent a potential feedstock for liquid organic fertilizer (LOF) because they contain partially digested plant residues and diverse microbial communities. Studies of rumen ecology have

OPEN ACCESS

documented microorganisms associated with fiber degradation and nutrient transformation (Jami et al., 2013; Henderson et al., 2015). These findings provide a biological rationale for investigating rumen-derived materials but do not establish that microorganisms remain active after fermentation or that the resulting fertilizer improves crop yield. Recycling livestock residues into agricultural inputs supports circular agriculture principles (Cordeiro & Sindhøj, 2024; Schmidt et al., 2025) and may reduce environmental problems associated with poorly managed livestock waste (Miller et al., 2024).

Previous research has demonstrated the potential of organic nutrient sources to support crop production, although responses vary according to feedstock characteristics, processing methods, soil properties, and crop species (Agegnehu et al., 2021; Ali et al., 2024). Formulation challenges identified for microbial biofertilizers further emphasize the importance of product quality and field validation (Fadiji et al., 2024). However, fermented rumen-based LOF should not automatically be classified as a microbial biofertilizer without evidence of viable functional microorganisms. Studies involving rumen-derived materials have provided preliminary support for their agricultural applications (Rizkiana, 2020; Ramadani et al., 2023), although their relevance to shallot bulb production requires further investigation.

Lehar (2010) investigated fermented organic liquid materials involving rumen contents for amaranth (*Amaranthus cruentus* L.) production. This study provided an early experimental foundation for utilizing locally available fermented organic materials in horticulture. However, the fertilizer formulation incorporated additional organic ingredients, while the experimental crop was cultivated primarily for vegetative biomass. Consequently, the reported responses cannot directly establish an appropriate fertilizer concentration for shallot, which differs substantially in harvested organs and physiological development.

Lehar et al. (2024a) investigated water hyacinth compost and Trichoderma sp. in dryland shallot cultivation, providing additional local evidence of the relevance of organic amendments and biological agents to shallot production. However, the materials and treatment structure differed from those of fermented bovine rumen-derived LOF evaluated in the present study.

Subsequently, Lehar et al. (2024b) evaluated fermented rumen-derived LOF in caisim (*Brassica chinensis* var. *parachinensis*) using seven concentrations ranging from 0 to 150 mL L^{-1}. The 150 mL L^{-1} treatment produced the most favorable reported growth and yield responses. Nevertheless, caisim productivity depends primarily on leaf and shoot biomass, whereas shallot productivity requires successful bulb initiation, assimilate allocation, and bulb filling. Furthermore, because 150 mL L^{-1} represented the highest tested concentration, the findings cannot establish whether higher concentrations would improve or reduce yield in bulb-producing crops. These limitations justify extending the investigation to shallot using a broader concentration range.

Fertilizer responses are particularly dependent on environmental conditions in semiarid dryland agroecosystems, where limited water availability and variable soil moisture may restrict nutrient mobility and uptake. The Sabu Raijua shallot cultivar is an important local horticultural resource in East Nusa Tenggara, yet cultivar-specific evidence concerning its response to fermented bovine rumen-based LOF remains limited. Evaluating bulb diameter, bulb weight per clump, bulb weight per plot, and bulb yield per unit area provides complementary indicators of crop performance and allows a more comprehensive assessment than vegetative measurements alone.

Another important consideration is distinguishing the highest numerical yield from statistically superior performance. When different fertilizer concentrations produce statistically comparable yields, increasing the application rate may not provide a meaningful agronomic advantage. Conversely, a lower concentration cannot be considered economically optimal without supporting information on fertilizer costs and financial returns. Such distinctions are essential for developing scientifically defensible fertilizer recommendations.

The principal research gap concerns the limited evidence linking fermented bovine rumen-based LOF concentrations to multiple bulb yield components of Sabu Raijua shallot under semiarid dryland conditions. The present study addresses this gap by evaluating seven concentrations (0, 75, 100, 125, 150, 175, and 200 mL L^{-1}) and integrating measurements of bulb diameter, bulb weight per clump, bulb weight per plot, and bulb yield. Its scientific contribution lies in extending previous investigations of rumen-derived organic fertilizers from leafy vegetable biomass production to cultivar-specific bulb yield assessment under semiarid conditions. The findings provide an empirical basis for identifying agronomically effective fertilizer concentrations while supporting the sustainable utilization of locally available livestock residues.

METHOD

Study Site and Plant Material

OPEN ACCESS

The study was conducted from April to October 2024 in Lasiana Village, Kelapa Lima District, Kupang City, East Nusa Tenggara Province, Indonesia. The experimental site is located in a semiarid tropical region at an altitude of approximately 0–50 m above sea level and is characterized by alluvial soil. The planting material consisted of shallot (*Allium ascalonicum* L.) bulbs of the local Sabu Raijua cultivar.

Experimental Design

The experiment was arranged in a randomized complete block design (RCBD) with a single treatment factor consisting of seven concentrations of fermented bovine rumen-based liquid organic fertilizer (LOF): P0 (0 mL L^{-1}), P1 (75 mL L^{-1}), P2 (100 mL L^{-1}), P3 (125 mL L^{-1}), P4 (150 mL L^{-1}), P5 (175 mL L^{-1}), and P6 (200 mL L^{-1}). Each treatment was replicated four times, resulting in 28 experimental units. The control treatment (P0) received water without LOF.

Preparation and Characterization of Liquid Organic Fertilizer

Liquid organic fertilizer was prepared from fresh bovine rumen contents through a two-stage anaerobic fermentation process. During the first stage, 1 kg of fresh bovine rumen contents was mixed with 1 L of water and fermented in an airtight container for 7–14 days. In the second stage, the fermented material was combined with 4 kg of fresh bovine rumen contents, 16 L of water, and 1 L of molasses or palm sugar solution. The mixture was subsequently fermented under anaerobic conditions for an additional 14–21 days.

The chemical characteristics of the resulting LOF were determined by the Soil Chemistry Laboratory, Faculty of Agriculture, Universitas Nusa Cendana, Indonesia, in 2024. Laboratory analysis indicated that the LOF contained 3.01% nitrogen (N), 1.01% phosphorus (P), and 1.18% potassium (K), with a total N + P + K content of 5.20% and a pH of 6.38.

Preparation and Application of LOF Treatments

The treatment solutions were prepared by measuring the required volume of fermented LOF and adding water to obtain a final solution volume of 1 L. Accordingly, the treatment concentrations were prepared using 0, 75, 100, 125, 150, 175, and 200 mL of LOF per liter of final solution. For example, the 175 mL L^{-1} treatment was prepared by measuring 175 mL of fermented LOF and adding water until the final volume reached 1,000 mL. The control solution contained only water.

The prepared LOF solutions were applied through foliar spraying or soil drenching around the root zone. The initial application was performed two weeks before planting, followed by applications at two, four, and six weeks after planting (WAP).

Field Layout and Crop Management

The experimental field consisted of 28 raised beds, each measuring 2.0 m in length, 1.2 m in width, and 0.30 m in height, providing a bed area of 2.40 m^2. The beds were separated by 0.30 m, with additional spacing between experimental blocks.

Shallot bulbs were planted at a spacing of 20 × 20 cm and a planting depth of approximately 3 cm, leaving part of each bulb exposed above the soil surface. Crop management practices, including irrigation, weeding, and other routine field maintenance activities, were conducted according to local agronomic conditions.

Data Collection and Measurement

Vegetative growth observations were conducted at four, six, and eight weeks after planting (WAP). The recorded growth parameters included plant height (cm), number of tillers per plant, and number of leaves per plant.

Bulb yield components were evaluated at 60 days after planting (DAP). Following harvest, the shallot bulbs were air-dried for four days before weighing. Therefore, the reported bulb weights represent postharvest bulb weights after four days of air-drying rather than weights measured immediately after harvest. The measured yield parameters included bulb diameter (mm), bulb weight per clump (g), bulb weight per plot (g), and bulb yield (t ha^{-1}).

Statistical Analysis

The collected data were subjected to analysis of variance (ANOVA) appropriate for a randomized complete block design to determine the effects of LOF concentration on the measured growth and bulb yield parameters. Statistical significance was evaluated at the 5% probability level ($p < 0.05$).

When significant treatment effects were detected, treatment means were compared using Tukey's Honestly Significant Difference (HSD) test at the 5% significance level. The results were used to identify statistically significant differences among LOF concentrations and evaluate their agronomic effectiveness in improving bulb yield components and bulb yield of the Sabu Raijua shallot cultivar.

OPEN ACCESS

RESULTS AND DISCUSSION

RESULTS

Bulb Diameter per Clump of Sabu Raijua Shallot at 60 Days After Planting (DAP)

Table 1. Effect of Fermented Bovine Rumen-Based Liquid Organic Fertilizer (LOF) Concentrations on Shallot Bulb Diameter at 60 Days After Planting (DAP)

LOF Concentration (mL L^{-1})	Bulb Diameter per Clump (mm)
0 (Control)	22.43 a
75	24.95 a
100	26.20 a
125	27.35 a
150	25.83 a
175	29.75 b
200	30.25 b
HSD (5%)	5.79

Note: Means sharing at least one letter are not significantly different according to Tukey's HSD test at the 5% significance level.

Shallot Bulb Weight per Clump at 60 Days After Planting (DAP)

Table 2. Effect of Fermented Bovine Rumen-Based Liquid Organic Fertilizer (LOF) Concentrations on Shallot Bulb Weight per Clump at 60 Days After Planting (DAP)

LOF Concentration (mL L^{-1})	Bulb Weight per Clump (g)
0 (Control)	39.53 a
75	40.58 a
100	40.68 a
125	47.53 b
150	41.80 a
175	49.77 c
200	50.27 c
HSD (5%)	5.00

Note: Means sharing at least one letter are not significantly different according to Tukey's HSD test at the 5% significance level.

Shallot Bulb Weight per Plot at 60 Days After Planting (DAP)

Table 3. Effect of Fermented Bovine Rumen-Based Liquid Organic Fertilizer (LOF) Concentrations on Shallot Bulb Weight per Plot at 60 Days After Planting (DAP)

LOF Concentration (mL L^{-1})	Bulb Weight per Plot (g)
0 (Control)	395.30 a
75	405.80 ab
100	406.80 ab
125	475.30 c
150	418.00 b
175	497.70 d
200	502.70 d
HSD (5%)	18.00

Note: Means followed by at least one common letter within the same column are not significantly different according to Tukey's Honestly Significant Difference (HSD) test at the 5% significance level.

Shallot Bulb Yield (t ha^{-1})

Table 4. Effect of Fermented Bovine Rumen-Based Liquid Organic Fertilizer (LOF) Concentrations on Shallot Bulb Yield at 60 Days After Planting (DAP)

OPEN ACCESS

LOF Concentration (mL L^{-1})	Bulb Yield (t ha^{-1})
0 (Control)	1.647 a
75	1.691 ab
100	1.695 ab
125	1.980 c
150	1.742 b
175	2.074 d
200	2.095 d
HSD (5%)	0.075

Note: Means followed by at least one common letter within the same column are not significantly different according to Tukey's Honestly Significant Difference (HSD) test at the 5% significance level. Bulb yield was calculated based on an experimental plot area of 2.40 m^2 (2.00 × 1.20 m).

DISCUSSION

The application of liquid organic fertilizer (LOF) derived from fermented bovine rumen contents was associated with variations in bulb diameter, bulb weight per clump, bulb weight per plot, and bulb yield of the Sabu Raijua shallot cultivar under semi-arid growing conditions. Overall, LOF concentrations of 175 and 200 mL L^{-1} produced the highest mean values across the evaluated yield parameters. Nevertheless, the response was not consistently dose-dependent, indicating that increasing LOF concentration did not necessarily result in proportional improvements in bulb development and productivity.

As presented in Table 1, bulb diameter ranged from 22.43 to 30.25 mm. The highest mean diameter was recorded at 200 mL L^{-1} (30.25 mm), followed by 175 mL L^{-1} (29.75 mm), whereas the control produced the smallest bulbs (22.43 mm). Relative to the control, bulb diameter increased numerically by 34.86% and 32.63% at 200 and 175 mL L^{-1}, respectively. These findings suggest that higher LOF concentrations may provide favorable nutritional conditions for bulb enlargement.

The observed response may be associated with the contribution of essential nutrients supplied by fermented bovine rumen-derived LOF. Laboratory analysis indicated that the fertilizer contained 3.01% nitrogen (N), 1.01% phosphorus (P), and 1.18% potassium (K), with a combined N + P + K content of 5.20% and a pH of 6.38. Nitrogen supports chlorophyll synthesis and photosynthetic tissue development, phosphorus contributes to energy metabolism and root growth, and potassium participates in osmotic regulation, enzyme activation, and assimilate transport. These physiological functions are particularly relevant during bulb initiation and enlargement.

Lehar et al. (2024b) demonstrated that liquid organic fertilizer derived from fermented rumen contents influenced the growth and yield of caisim (*Brassica chinensis* var. *parachinensis*), with the highest evaluated concentration of 150 mL L^{-1} producing the best overall performance. Although caisim and shallot differ in their growth characteristics and harvested organs, these findings provide relevant empirical support for the agricultural utilization of fermented rumen contents as a liquid organic fertilizer. The present study extends this research context to bulb production in the Sabu Raijua shallot cultivar under semi-arid conditions, where the highest numerical yields were obtained at concentrations of 175–200 mL L^{-1}.

Similarly, Triharyanto et al. (2022) demonstrated the relevance of liquid organic fertilizer management to shallot production and soil quality. Their findings provide additional support for investigating liquid organic nutrient sources as components of shallot fertilization strategies. However, differences in fertilizer formulation, application methods, and growing conditions should be considered when comparing responses across studies.

Bulb weight per clump exhibited a comparable numerical response. According to Table 2, the highest mean weight was recorded at 200 mL L^{-1} (50.27 g), followed by 175 mL L^{-1} (49.77 g), whereas the control produced the lowest value (39.53 g). Compared with the control, these treatments increased bulb weight numerically by 27.17% and 25.90%, respectively. The relatively small difference between the two highest concentrations suggests that additional LOF beyond 175 mL L^{-1} provided only a limited further increase in bulb biomass under the experimental conditions.

Bulb biomass accumulation depends on the production, transport, and partitioning of photosynthates into developing storage organs. Nutrient availability is therefore an important factor influencing bulb development. Sopha and Aprianto (2024) investigated nutrient management in shallot production under peatland conditions, emphasizing

OPEN ACCESS

the importance of appropriate nutrient supply for crop productivity. Although their study was conducted under different soil conditions, it reinforces the relationship between nutrient management and shallot yield formation.

Furthermore, Maghfoer et al. (2022) reported that integrated nutrient management involving inorganic fertilizers, organic amendments, and beneficial microorganisms improved eggplant production in an intercropping system. Their findings provide broader evidence that combining nutrient sources can support horticultural productivity. However, the present study did not directly measure plant nutrient uptake, photosynthetic activity, or carbohydrate partitioning. Consequently, the physiological mechanisms underlying the observed bulb-weight response remain plausible explanations rather than experimentally confirmed processes.

As shown in Table 3, bulb weight per plot increased numerically from 395.30 g in the control to 502.70 g at 200 mL L^{-1}. The second-highest mean was obtained at 175 mL L^{-1} (497.70 g), followed by 125 mL L^{-1} (475.30 g). Relative to the control, the two highest concentrations increased bulb weight per plot by 27.17% and 25.90%, respectively. The difference between 175 and 200 mL L^{-1} was only 5.00 g per plot, below the reported 5% honestly significant difference (HSD) value of 18.00 g.

These results indicate that the two highest LOF concentrations produced closely comparable bulb weights per plot. This finding is relevant to fertilizer-use decisions because increasing the concentration from 175 to 200 mL L^{-1} did not produce a proportional increase in harvested bulb weight. However, the agronomic response should be interpreted in relation to the specific growing conditions, fertilizer characteristics, and crop-management practices employed in the experiment.

Jayanti et al. (2026) reported that integrating organic amendments with inorganic fertilization and appropriate water management improved shallot yield and irrigation water productivity. Their findings demonstrate that nutrient management and water availability jointly influence shallot performance. Although the fertilizer formulations differed from those examined in the present study, their research provides useful comparative evidence regarding the importance of integrated crop management in shallot production.

Bulb yield followed the same overall response pattern as bulb weight per plot because productivity was calculated from harvested bulb weight and the experimental plot area of 2.40 m^2. As presented in Table 4, the highest numerical yield was obtained at 200 mL L^{-1} (2.095 t ha^{-1}), followed by 175 mL L^{-1} (2.074 t ha^{-1}), whereas the control produced the lowest yield (1.647 t ha^{-1}). Based on the rounded values reported in Table 4, these treatments increased yield numerically by 27.20% and 25.93%, respectively, compared with the control. The yield difference between the two highest concentrations was 0.021 t ha^{-1}, below the reported 5% HSD value of 0.075 t ha^{-1}.

An important feature of the yield response was its non-linear pattern. Bulb yield increased from 1.647 t ha^{-1} in the control to 1.980 t ha^{-1} at 125 mL L^{-1}, declined to 1.742 t ha^{-1} at 150 mL L^{-1}, and subsequently increased to 2.074 and 2.095 t ha^{-1} at 175 and 200 mL L^{-1}, respectively. Comparable fluctuations were observed in bulb diameter, bulb weight per clump, and bulb weight per plot. These results indicate that the relationship between LOF concentration and bulb production was not strictly linear. Variation in nutrient availability, plant development, soil moisture, and other environmental factors may have contributed to this response, although these potential mechanisms were not directly examined.

The semi-arid growing environment is another important consideration when interpreting the results. Zgallai et al. (2024) investigated the use of organic waste compost to mitigate soil water deficits under semi-arid conditions. Similarly, Panta et al. (2026) examined the potential contributions of biochar and compost to soil health and water-related functions in semi-arid agroecosystems. These studies highlight the importance of organic resource management in water-limited agricultural environments. Nevertheless, their findings concern solid organic amendments and should not be interpreted as direct evidence that fermented bovine rumen-derived LOF improves soil water retention.

In East Nusa Tenggara, Lehar et al. (2026) investigated the effects of bokashi and water deficiency on kailan growth, further emphasizing the relevance of organic amendment management under conditions of limited water availability. Although the crop species and organic materials differed, the study provides regional context for developing horticultural production strategies adapted to semi-arid environments.

From a practical perspective, the small difference in bulb yield between 175 and 200 mL L^{-1} suggests that increasing LOF concentration beyond 175 mL L^{-1} may provide limited additional production benefits. At an equivalent final application volume, the 175 mL L^{-1} treatment requires 12.5% less LOF than the 200 mL L^{-1} treatment, while the latter produced only approximately 1.01% greater numerical yield. Therefore, 175 mL L^{-1} may represent a promising alternative for reducing fertilizer use. However, a definitive economic recommendation requires an assessment of fertilizer preparation costs, application expenses, and crop revenue.

OPEN ACCESS

The findings also have implications for agricultural by-product utilization. Bovine rumen contents are organic materials that can potentially be transformed through fermentation into agricultural inputs. Their utilization as LOF may provide an additional pathway for recycling livestock-derived materials within horticultural production systems. The findings of Lehar et al. (2024b), together with research on shallot fertilization and organic amendment management (Triharyanto et al., 2022; Jayanti et al., 2026), support the scientific rationale for further evaluating this resource under locally specific agroecological conditions.

Overall, fermented bovine rumen-derived LOF at concentrations of 175–200 mL L^{-1} produced the highest numerical values for bulb diameter, bulb weight per clump, bulb weight per plot, and bulb yield of the Sabu Raijua shallot cultivar. The present study contributes field-based evidence concerning the response of a locally important shallot cultivar to fermented livestock-derived organic fertilizer under semi-arid conditions. Further research should examine nutrient-release characteristics, plant nutrient uptake, soil responses, and economic performance to establish a more comprehensive basis for fertilizer recommendations across different growing seasons and production environments.

CONCLUSION

The application of liquid organic fertilizer (LOF) derived from fermented bovine rumen contents showed promising potential for improving bulb development and yield of the Sabu Raijua shallot cultivar under semi-arid conditions. The highest numerical performance was obtained at 200 mL L^{-1}, producing a bulb diameter of 30.25 mm, bulb weight per clump of 50.27 g, bulb weight per plot of 502.70 g, and bulb yield of 2.095 t ha^{-1}, representing a 27.20% yield increase over the untreated control. However, the 175 mL L^{-1} treatment produced a comparable bulb yield of 2.074 t ha^{-1} while requiring 12.5% less LOF, indicating its potential as a more resource-efficient application concentration. These findings highlight the potential of fermented bovine rumen contents as a locally available organic fertilizer for shallot production in semi-arid agroecosystems. Further field validation and economic evaluation are recommended to establish an optimal application rate and support practical fertilizer recommendations.

REFERENCES

Agegnehu, G., Srivastava, A. K., & Bird, M. I. (2021). The role of biofertilizers and organic amendments in improving soil health and crop productivity: A review. *Soil Systems, 5*(3), 37. https://www.sciencedirect.com/science/article/pii/S0929139316304954?via%3Dihub

Ali, A., Niu, G., Masabni, J., Ferrante, A., & Cocetta, G. (2024). Integrated nutrient management of fruits, vegetables, and crops through the use of biostimulants, soilless cultivation, and traditional and modern approaches—A mini review. *Agriculture, 14*(8), 1330. https://doi.org/10.3390/agriculture14081330

Cordeiro, C. M., & Sindhøj, E. (2024). Situating the discourse of recycled nutrient fertilizers in circular economy principles for sustainable agriculture. *Frontiers in Sustainability, 5*, 1465752. https://doi.org/10.3389/frsus.2024.1465752

Fadiji, A. E., Xiong, C., Egidi, E., & Singh, B. K. (2024). Formulation challenges associated with microbial biofertilizers in sustainable agriculture and paths forward. *Journal of Sustainable Agriculture and Environment, 3*, e70006.

Henderson, G., Cox, F., Ganesh, S., et al. (2015). Rumen microbial community composition varies with diet and host but a core microbiome is found across a wide geographical range. *Scientific Reports, 5*, 14567.

Jami, E., Israel, A., Kotser, A., & Mizrahi, I. (2013). Exploring the bovine rumen bacterial community from birth to adulthood. *The ISME Journal, 7*, 1069–1079.

Jayanti, K. D., Cahyono, O., Komariah, & Mujiyo. (2026). Integrating water management and organic amendments to enhance shallot yield and irrigation water productivity. *Journal of Ecological Engineering, 27*(4), 106–118. https://doi.org/10.12911/22998993/214754

Lehar, L. (2010). Pertumbuhan dan hasil bayam (Amaranthus cruentus L.) akibat pemanfaatan bahan organik cair hasil fermentasi isi rumen. Jurnal Penelitian Pertanian Terapan, 10(3), 164–170.

Lehar, L., Proklamita, T. L., & Arifin, Z. (2024a). Effects of water hyacinth compost and biological agents (*Trichoderma* sp.) on the growth and yield of shallots (*Allium ascalonicum* L.) in dry land. *Ilmu Pertanian (Agricultural Science), 9*(1), 43–50. https://doi.org/10.22146/ipas.74820

OPEN ACCESS

Lehar, L., Proklamita, T. L., & Sine, H. M. C. (2024b). The effect of liquid organic fertilizer from rumen contents fermentation on the growth and yield of caisim (*Brassica chinensis* var. *parachinensis*). *Agriprima: Journal of Applied Agricultural Sciences, 8*(1), 94–103. https://doi.org/10.25047/agriprima.v8i1.654

Lehar, L., Suryawati, Proklamita, T. L., Sine, H. M. C., & Amalo, B. K. (2026). Effect of bokashi and water deficiency on the growth of kailan (*Brassica oleracea* var. *acephala*) in East Nusa Tenggara, Indonesia. *OnLine Journal of Biological Sciences, 26*(1). https://doi.org/10.3844/ojbsci.2026.26.01.016

Li, Y., Zhang, X., Wang, J., Liu, H., & Chen, Q. (2023). Long-term chemical fertilization affects soil quality, microbial communities, and nutrient cycling in agricultural ecosystems. *Journal of Soil Science and Plant Nutrition, 23*, 4458–4474. https://doi.org/10.1007/s42729-023-01267-4

Liu, X., Zhao, Y., Sun, J., & Wang, R. (2023). Impacts of excessive chemical fertilizer application on soil health and sustainable agricultural production: A review. *Sustainability, 15*(18), 13724. https://doi.org/10.3390/su151813724

Maghfoer, M. D., Lehar, L., & Lestari, M. W. (2022). Efficiency of integrated nutrient management to improve eggplant production in intercropping systems. *Journal of Ecological Engineering, 23*(11), 217–227. https://doi.org/10.12911/22998993/153603

Miller, A., et al. (2024). Livestock manure: From waste to resource in a circular economy. *Journal of Agriculture and Food Research, 17*, 101255.

Panta, S., Bista, P., Angadi, S., & Ghimire, R. (2026). Biochar and compost as sustainable amendments for soil health and water functions in semi-arid agroecosystems. *Sustainability, 18*(3), 1369. https://doi.org/10.3390/su18031369

Pusat Data dan Sistem Informasi Pertanian. (2024). *Outlook bawang merah 2024–2028*. Kementerian Pertanian Republik Indonesia.

Ramadani, D., Harun, H., & Ridwan, R. (2023). Pembuatan pupuk organik cair rumen sapi dan pemanfaatannya untuk bibit kakao (*Theobroma cacao* L.). *Jurnal Saintis*.

Rizkiana, A. (2020). *Pengaruh pupuk organik cair dari rumen sapi terhadap serapan nitrogen dan produksi pada dua varietas bawang merah (Allium cepa L.)*.

Sande, T. J., Tindwa, H. J., Alovisi, A. M. T., Shitindi, M. J., & Semoka, J. M. (2024). Enhancing sustainable crop production through integrated nutrient management: A focus on vermicompost, bio-enriched rock phosphate, and inorganic fertilizers—A systematic review. *Frontiers in Agronomy, 6*, 1422876. https://doi.org/10.3389/fagro.2024.1422876

Schmidt, S., Krishnan, V., Gamage, H., et al. (2025). Enabling the circular nitrogen economy with organic and organo-mineral fertilisers. *Nutrient Cycling in Agroecosystems, 130*, 33–48.

Sopha, G. A., & Aprianto, F. (2024). Nutrient management of shallot (*Allium cepa* Aggregatum group) in Riau peatlands, a pot experiment. *Journal of Degraded and Mining Lands Management, 11*(2), 5119–5126. https://doi.org/10.15243/jdmlm.2024.112.5119

Triharyanto, E., Setyaningrum, D., & Muhammad, D. M. (2022). Potential of liquid organic fertilizer on flowering, yield of shallots (*Allium cepa* L. Aggregatum) and soil quality. *Universal Journal of Agricultural Research, 10*(5), 526–533. https://doi.org/10.13189/ujar.2022.100507

Zgallai, H., Zoghlami, R. I., Annabi, M., Zarrouk, O., Jellali, S., & Hamdi, H. (2024). Mitigating soil water deficit using organic waste compost and commercial water retainer: A comparative study under semiarid conditions. *Euro-Mediterranean Journal for Environmental Integration, 9*, 377–391. https://doi.org/10.1007/s41207-023-00437-4

OPEN ACCESS