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Growth and Yield of Shallot Plants with the Application of Sp-36 Fertilizer and Poc from Red Devil Fish

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Abstract

Shallots (Allium ascalonicum L.) are one of the horticultural commodities with high economic value and are needed by the community as food. Shallots also contribute to national inflation. Shallots become potential commodity to be developed in the region of North Sumatra, especially in the Toba region. One of the efforts to increase the growth and production of shallot plants can be done by applying SP-36 Fertilizer and Red Devil Fish Liquid Organic Fertilizer. This research aims to determine the best SP-36 and Red Devil Fish Liquid Organic Fertilizer, growth and production of shallots. The research was conducted from September to December 2023 in Lumban Silintong Village, Balige District, Toba Regency, North Sumatra with an altitude of ± 945 m above sea level. The design used was a factorial Randomized Group Design with three replications. The treatments studied were the first factor of SP-36 dose with four levels of treatment (0 (control), 112.5 Kg/Ha, 225 Kg/Ha, 337.5 Kg/Ha and the second factor was the dose of liquid organic fertilizer of red devil fish (0 (control), 3 g/plot, 5 g/plot). The results showed that the provision of SP-36 had a significant effect on the observed variable, namely the fresh weight of plants per plot. Giving Red Devil Fish Liquid Organic Fertilizer can significantly increase plant height, plant fresh weight per plot, plant fresh weight per sample, number of tubers per plot and tuber diameter.

Introduction

Shallot (*Allium ascalonicum* L.) is one of the horticultural commodities that plays a strategic role in Indonesia, especially in North Sumatra Province. This plant is not only a staple ingredient in everyday cooking, but also has high economic value and is used as a traditional medicine. Firmansyah & Sumarni (2013) mention that shallots are beneficial for lowering cholesterol, preventing blood clots, and improving blood flow. The high demand and various benefits make this commodity a very promising business opportunity (Gibson et al, 2015).

Shallot production in Indonesia continues to show steady growth. Data from the Central Statistics Agency (BPS) shows that national production reached 1.82 million tons in 2020, an increase of around 14.88% from the previous year. North Sumatra, as one of the main production centers, contributed 53,962 tons in 2022. However, the seasonal nature of shallots often causes fluctuations in market availability, which ultimately triggers price instability. Therefore, efforts to increase production are crucial, and one effective way is through improving cultivation techniques, particularly fertilization (Barłóg et al., 2015; Xing & Wang, 2024; Tyagi et al., 2022; Penuelas et al., 2023; Govindasamy et al., 2023).

Fertilization is an important step to ensure sufficient nutrients for plants (Noulas et al., 2023; Ahmed et al., 2021; Grzebisz et al., 2022). Among the various essential nutrients, phosphorus (P) plays a vital role. Phosphorus is a key component in the formation of enzymes, proteins,

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ATP, RNA, and DNA, which are very important for photosynthesis, sugar metabolism, and energy transfer in plants. Since no other nutrient can replace the function of P, adequate P availability is essential for optimal growth and crop yield (Mardamootoo et al., 2021; Ibrahim et al., 2022; Dhakal & Lange, 2021; Maharajan et al., 2021).

Traditionally, farmers rely on inorganic fertilizers such as SP-36 to meet the phosphorus needs of plants (Herlina et al., 2022; Kaho et al., 2024; Hidayah et al., 2023). This fertilizer is superior due to its high P2O5 content (36%) and neutral nature, which does not affect soil acidity. SP-36 fertilizer has been proven effective in promoting early root growth, accelerating flowering, and increasing plant resistance to pests and diseases. However, dependence on this inorganic fertilizer brings a number of problems. Long-term use and high doses can reduce soil fertility, make it hard, and cause environmental pollution (Wijaya et al., 2015; Chaudhary et al., 2023; Yasir et al., 2025; Goud et al., 2022; Krasilnikov et al., 2022). In addition, uneven distribution often causes fertilizer shortages in some areas, and high prices make it difficult for small farmers to afford.

The problems caused by inorganic fertilizers demand alternative solutions that are more environmentally friendly and sustainable (Sporchia & Caro, 2023; Ejedegba, 2024). Liquid organic fertilizer (POC) is a promising option. Organic materials from animals, such as fish, are rich in nutrients. Hapsari & Welasi (2013) state that fish are rich in essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K), all of which are needed by plants.

The application of 615 kg/ha of fish fertilizer resulted in maximum potato tuber yield of 31.30 tons/ha. Research results (Karo et al., 2018) show that the application of 1000 kg/ha of fish fertilizer can increase plant weight, yield per plot, and the percentage of large-grade potatoes. Applying 615 kg/ha of fish fertilizer by pouring can increase plant height, weight per plant, production per treatment, and stem diameter in cauliflower plants. Therefore, it is considered very necessary to conduct research on the use of fish organic fertilizer in cauliflower vegetable plants.

This study proposes the use of Red Devil fish (*Amphilophus labiatus)* as the main raw material for POC. Red Devil fish are not endemic to Lake Toba, but rather an invasive species with a very large population (Lumbanraja & Nasution, 2024; Robin et al., 2023; Jatayu et al., 2023; Sari et al., 2023). Their predatory and invasive nature has become a serious threat to the Lake Toba ecosystem, especially to endemic fish. By processing this fish into organic fertilizer, two major benefits can be obtained: first, providing an effective and inexpensive alternative source of nutrients for farmers, and second, helping to control the Red Devil fish population, which will ultimately support Lake Toba's environmental conservation efforts. In addition, there are indications that Red Devil fish contain amino acids that are good for plant growth, making them a very potential raw material. This research is expected to make a significant contribution to the world of agriculture by providing more economical, environmentally friendly, and sustainable fertilizer alternatives, as well as supporting the preservation of the Lake Toba ecosystem.

Methods

This study was conducted in Balige District, Toba Regency, at an altitude of 900 meters above sea level. The study was conducted from September to December 2023.

The planting material used was shallot bulbs (*Allium ascalonicum L.)* of the Batu Ijo variety. This study used a Randomized Block Design (RBD) with 2 factors, namely: Factor 1 is (P) SP-36 fertilizer dosage consisting of 4 levels, namely:

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P0: Without SP-36 fertilizer

P1: 112.5 kg/ha

P2: 225 kg/ha

P4: 337.5 kg/ha

Factor 2 was (R) the dosage of Red Devil Fish Liquid Organic Fertilizer with 3 levels, namely:

K0: Without Red Devil Fish Liquid Organic Fertilizer

K1: 3 ml/liter of water per plot

K2: 5 ml/liter of water per plot

Research Implementation

The research implementation was divided into two stages, namely (1) Cultivation of shallots (*Allium ascalonicum L.*) with the application of four levels of SP-36 fertilizer (0%, 50%, 100%, and 150% of the recommended dose) and three levels of Red Devil liquid organic fertilizer (2) Collection of observation variables and data analysis.

Preparation

Preparatory activities consist of making red devil fish ponds, soil preparation, and applying SP-36 fertilizer. Soil preparation begins with clearing the area of weeds and debris. This step is a principle of integrated pest management and land sanitation. Weeds cause allelopathic competition (releasing chemicals that inhibit growth) and intraspecific competition (competition for nutrients, water, and light). By removing weeds, this ensures that the competition coefficient of the target crop (shallots) is reduced, so that the efficiency of nutrient absorption and the final results of your fertilizer treatment can be measured validly. Removing plastic waste also maintains soil ecological health and prevents physical growth barriers.

After the land has been cleared, loosening is carried out to improve soil structure by improving macro and micro porosity (Liu et al., 2022; Yang et al., 2021; Liu et al., 2021). This increase in porosity directly improves soil aeration (allowing the diffusion of O2 and CO2 gases), which is important for root respiration and nutrient decomposition by microorganisms. Shallots, as shallow-rooted crops, are very sensitive to root penetration resistance and anaerobic conditions, so tillage is key to minimal compaction and optimal bulb formation. The next step was to create blocks and experimental plots, resulting in a total of 36 experimental plots in the field. Each research plot was 80 cm x 80 cm with a shallot planting distance of 20 cm x 20 cm and a total population of 20 plants per plot. This is in accordance with the Basic Principles of Research (Replication and Control): The creation of 36 plots (3 replicates × 12 treatments) is an application of the principle of replication in experimental design (Randomized Block Design).

Replication aims to minimize experimental error, verify results, and ensure that observed differences in crop yields are actually caused by treatment and not by natural variations in the land. Meanwhile, uniform and measurable plot sizes ensure that all plants in a treatment plot receive environmental conditions that support the validity of comparisons between treatments. A planting distance of 20 cm × 20 cm for shallots is a common planting distance to optimize population density. This spacing balance land use efficiency and avoids excessive competition between plants (for air, light, and nutrients).

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Fertilization

Fertilization SP-36 fertilizer is used as a source of phosphorus (P) nutrients. It is applied as a base fertilizer before planting because this fertilizer has relatively low solubility and a slow release reaction, so it takes time to become available to plants. The application method is to spread it evenly according to the 4 levels of SP-36 fertilizer treatment (P0: No SP-36 fertilizer, P1: 112.5 kg/ha, P2: 225 kg/ha, P4: 337.5 kg/ha) on the beds and then mixed with the soil using a hoe or soil cultivator to a depth of ±10 cm. The aim is to ensure that phosphorus is distributed in the initial root zone, which is essential for stimulating root growth in the early vegetative phase of shallots.

Red Devil Liquid Fish Organic Fertilizer is applied once a week in 3 levels according to the number of treatments (K0: Without Red Devil Liquid Fish Organic Fertilizer, K1: 3 ml/liter of water per plot, K2: 5 ml/liter of water per plot at 2 weeks after planting (WAP) to 6 WAP for shallots. The application period for POC, from 2 Weeks After Planting (WAP) to 6 WAP, is a critical and highly strategic phase for red onions. 2 WAP: This marks the beginning of the intensive vegetative phase. During this phase, the plants begin to rapidly form leaves and photosynthetic tissue. 4 WAP - 6 WAP: This period is a transition toward the bulb formation phase.

Fertilization was carried out according to the SP-36 dosage applied in 4 stages in accordance with the number of treatments. The basic P fertilizer in the form of SP-36 fertilizer was applied once, precisely 1 week before planting, by spreading and mixing it with the soil. Red Devil Fish Liquid Organic Fertilizer is applied 3 times according to the SP-36 dosage applied in 3 stages according to the number of treatments at 2 Weeks After Planting to 6 Weeks After Planting (WAP) of shallots.

Observation Variables

The observation parameters in this study include growth characteristics, namely plant height, fresh weight of plants per plot, fresh weight of bulbs per plot, and bulb diameter.

Data Analysis

Parameter data analysis was conducted to determine the effect of treatment on the observed parameters. Observed variable data such as plant height and stem diameter were analyzed using analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) at a 5% level. The N, P, and K nutrient content was not analyzed using ANOVA.

Results and Discussion

The application of Red Devil liquid organic fish fertilizer had a significant effect on plant height (Table 1), where the application of liquid organic fertilizer significantly increased plant height at 4 weeks after planting, but plant height with the application of SP-36 fertilizer was not significantly different from the SP-36 fertilizer treatment. The application of Red Devil liquid organic fish fertilizer had a significant effect on plant height at 4 weeks after planting.

In general, the application of Red Devil liquid organic fish fertilizer produced the best plant height compared to no application of Red Devil liquid organic fish fertilizer. The application of 5 ml/plot of Red Devil liquid organic fish fertilizer tended to increase plant height more, reaching 27.07 cm. Plant height growth occurs in the apical meristem of the stem, with the stem elongating as a result of increased cell number. For normal plant growth, nutrients are required in optimal quantities and concentrations and must be in balance in the soil. Organic matter can

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maintain water availability, nutrients, and enhance microbial activity in the soil, so that the applied organic matter can increase the plant height produced in shallot plants.

This plant height response is supported by the nutrient content and availability of liquid organic fertilizer from fish waste. The results of N analysis show that liquid organic fertilizer from fish waste contains 1.36% total N.

Table 1. Height of shallot plants aged 2, 4, 6, and 8 weeks after sowing when fertilized with SP-36 and Red Devil fish POC.

Age	SP-36 Fertilizer	Red Devil fish POC			Average
		Kontrol (R0)	3 ml/plot (R1)	5 ml/plot (R2)	
……cm……					
2 WAP	Control (P0)	17,70	18,26	17,58	17,85
	112 kg/ha (P1)	17,74	18,88	18,62	18,41
	225 kg/ha (P2)	18,65	17,86	17,83	18,11
	337,5 kg/ha (P3)	17,22	18,96	17,68	17,95
	Average	17,83	18,49	17,93	
4 WAP	Control (P0)	24,18	26,61	27,08	25,96
	112 kg/ha (P1)	26,17	24,84	26,09	25,70
	225 kg/ha (P2)	23,00	25,31	25,25	24,52
	337,5 kg/ha (P3)	24,90	26,62	27,00	26,17
	Average	24,56 b	25,84 b	26,36 a	
6 WAP	Control (P0)	28,48	28,17	29,92	28,86
	112 kg/ha (P1)	30,21	30,86	29,50	30,19
	225 kg/ha (P2)	30,46	28,53	28,27	29,08
	337,5 kg/ha (P3)	29,96	29,48	29,96	29,80
	Average	29,78	29,26	29,41	
8 WAP	Control (P0)	31,17	32,38	33,08	32,21
	112 kg/ha (P1)	32,08	33,75	32,75	32,86
	225 kg/ha (P2)	31,08	33,42	32,83	31,80
	337,5 kg/ha (P3)	32,17	33,04	32,50	32,57

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	Average	31,63	32,73	32,79	

Note: Numbers followed by different letters in the same row group are significantly different based on Duncan's Multiple Range Test at the 5% level.

Based on (Table 2), it shows that the application of SP-36 fertilizer at a rate of 115 kg/ha resulted in the highest wet weight of plants at 1686.83 g, which was not significantly different from the treatment with Red Devil liquid organic fertilizer. The Red Devil fish liquid organic fertilizer at a dose of 3 ml/plot produced a significantly higher fresh plant weight compared to without the application of Red Devil fish POC and SP-36 fertilizer, at 1751.20 g.

In Sada et al. (2018) stated that applying liquid organic fertilizer every 5 days can provide more nutrients. The available nutrient content can enhance plant growth and production.

The optimal dose indicates that fish POC at concentration R1 shows optimal synergy. Fish-based POC is high in organic nitrogen (N) and amino acids, which support chlorophyll and protein synthesis for strong vegetative growth, which ultimately correlates positively with tuber filling. This is consistent with showing that fish waste POC can increase wet tuber weight due to its N and organic matter content, which supports root growth and photosynthate translocation (Alivia et al., 2025).

Meanwhile, the administration of 5 ml/plot of red Devil fish POC was numerically lower. This indicates a threshold or negative effect at higher concentrations (R2), possibly due to nutrient toxicity, high salinity, or inhibition of water absorption due to excessive POC concentration. Excessively concentrated fish POC can increase the salinity of the growing medium or cause phytotoxicity due to high levels of N and certain minerals, which inhibit water and nutrient absorption, thereby suppressing tuber growth.

Although the results of the variance analysis were not significant, the P1R1 combination produced the highest average yield (1753.00 g), showing a tendency that the combination of organic (POC) and inorganic (SP-36) fertilizers often produces better yield increases than single use. Organic fertilizer improves soil structure and fertility, supports P absorption from SP-36, thereby maximizing fertilizer effectiveness. Rinasari et al. (2016) stated that applying a combination of organic and inorganic fertilizers in certain ratios can improve plant quality and quantity. The combination of organic fertilizer and compound NPK fertilizer can increase the nutrients needed by plants for growth. Nitrogen plays a role in the formation of all protein compounds, fats, and various other organic compounds and influences the use of carbohydrates in plants. Nitrogen use directly affects carbohydrate synthesis in plant cells and subsequently affects plant vigor and increased vegetative growth (Damanik et al., 2011), causing plants to grow well and increase their dry weight.

Table 2. Average fresh weight of shallots per plot when fertilized with SP-36 and Red Devil fish POC.

SP-36 Fertilizer	**Red Devil fish POC**			**Average**
	Control (R0)	**3 ml/plot (R1)**	**5 ml/plot (R2)**	
……g……				
Kontrol (P0)	1422,70	1751,20	1214,67	1462,86
112 kg/ha (P1)	1686,83	1753,00	1394,80	1611,54
225 kg/ha (P2)	1482,17	1658,10	1093,97	1411,41
337,5 kg/ha (P3)	1218,23	1479,50	1668,23	1455,32
Average	1452,48 b	1660,45 a	1342,92 b	

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Note: Numbers followed by different letters in the same row group are significantly different based on Duncan's Multiple Range Test at the 5% level.

The application of SP-36 fertilizer and Red Devil liquid organic fertilizer had a significant effect on the fresh weight of plants per sample (Table 3). The SP-36 fertilizer treatment had a significant effect on the fresh weight of plants per sample. This is thought to be because SP-36 fertilizer has a higher P content than Red Devil liquid organic fertilizer, which plays an important role in cell growth, the formation of fine roots and root hairs, strengthening straw so that plants do not easily fall over, improving plant quality, flower, fruit, and seed formation, and strengthening resistance to disease. According Sugeng (2005), phosphorus can stimulate root growth, which then affects above-ground growth and subsequently affects plant weight.

Table 3. Average fresh plant weight per shallot sample after fertilization with SP-36 fertilizer and Red Devil Fish POC.

SP-36 Fertilizer	**Red Devil fish POC**			**Rataan**
	Control (R0)	**3 ml/plot (R1)**	**5 ml/plot (R2)**	
	……g……			
Control (P0)	105,51	95,34	122,83	107,89 ab
112 kg/ha (P1)	93,61	123,30	94,70	103,87 b
225 kg/ha (P2)	109,71	106,79	112,43	109,64 a
337,5 kg/ha (P3)	106,63	95,19	100,39	100,74 c
Average	103,87 b	105,16 ab	107,59 a	

Note: Numbers followed by different letters in the same row and column group are significantly different based on Duncan's Multiple Range Test at the 5% level.

(Table 4) shows that, in general, the application of SP-36 fertilizer and red devil fish liquid organic fertilizer produces a higher number of tubers compared to without the application of SP-36 fertilizer and red devil fish liquid organic fertilizer.

The nitrogen contained in liquid organic fertilizer made from fish functions as a protein component that helps meristem tissue division and promotes leaf and root growth. Plant root organs can enlarge thanks to the P nutrient. The amount of P available to plants increases with increasing fertilizer concentration.

Table 4. Average Number of Shallot Bulbs with SP-36 Fertilizer and Red Devil Fish POC Fertilizer.

SP-36 Fertilizer	**Red Devil fish POC**			**Average**
	Control (R0)	**3 ml/plot (R1)**	**5 ml/plot (R2)**	
	……jumlah umbi……			
Control (P0)	6,00	6,00	6,42	6,14
112,5 kg/ha (P1)	7,00	7,00	8,25	7,42
225 kg/ha (P2)	5,83	7,50	6,50	6,61
337,5 kg/ha (P3)	6,33	5,25	7,25	6,28
Average	6,29	6,44	7,10	

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Based on observation data and variance analysis results (Table 5), it shows that tuber diameter increases significantly due to the application of Red Devil fish liquid organic fertilizer. Red Devil fish POC has a significant effect on tuber diameter, which encourages its development, due to the energy required during cell filling. Tuber layer cells contain vacuoles filled with essential oils (Fahn, 1992). Essential oils are secondary metabolites that belong to aromatic compounds. As a result of competition in obtaining energy, the metabolism of these compounds is inhibited, so that only a small amount is stored in the leaf base cells. Although they are layered, they can relatively increase the diameter of the tubers significantly (Robinson, 1995).

Table 5. Average diameter of shallot bulbs when fertilized with SP-36 and Red Devil fish POC.

SP-36 Fertilizer	**Red Devil fish POC**			**Average**
	Control (R0)	**3 ml/plot (R1)**	**5 ml/plot (R2)**	
……mm……				
Control (P0)	15,99	18,64	17,95	17,53
1 112 kg/ha (P1)	15,85	18,58	18,39	17,61
225 kg/ha (P2)	16,22	19,19	22,42	19,27
337,5 kg/ha (P3)	16,59	18,42	18,80	17,94
Average	16,16c	18,70b	19,39a	

Note: Numbers followed by different letters in the same row and column group are significantly different based on Duncan's Multiple Range Test at the 5% level.

Evidence shows that the SP-36 fertilizer and Red Devil Fish POC had considerable effects on growth of plants and there was a strong synergy between the two fertilizers. The height was steadily raised by adding POC as 16.16 in the control (R0) to 18.70 in the 3ml plot (R1), and 19.39 in the 5ml plot (R2). This trend indicates that POC organic compounds and endogenous growth regulators cause physiological reactions that lead to cell growth and vegetative growth.

Similarly, the highest response was obtained with application of SP-36 that provided essential phosphorus to the root and shoot development with the average growth increase of 19.27mm and maximum response rate of 337.5kg ha.

The reaction of the two fertilizers became the most evident with the mixture of SP 36 at 225kg/ha-1 and POC at 5ml/plot (P2R2) which yielded the highest growth (22.42mm). This synergy is likely due to POC increasing biological activity and phosphorus availability of soils through the stimulation of phosphate-solubilizing microorganisms, resulting in the increase of the efficacy of SP-36 application and the performance of plants as a whole.

Overall, the case of concurrent use of SP-36 and Red Devil Fish POC explains why a moderate approach to fertilization based on the incorporation of both organic and inorganic fertilizers can both promote the development of plants and maintain the condition of the soil. The P2R2 treatment comes out as the most effective, and the longest-sustainable dosage, which reflects the agronomic importance of the synergetic management of nutrients in achieving the highest plant productivity.

Conclusion

The application of SP-36 fertilizer has not been able to increase the growth and yield of shallots, while the application of Liquid Organic Fertilizer (POC) from Red Devil fish has been proven

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to increase growth at certain doses. Specifically, a dose of 5 ml/plot significantly increased plant height parameters at the 4-week interval after planting and shallot yield in terms of fresh plant weight per plot, fresh plant weight per sample, and bulb diameter, but it has not been able to increase shallot production. The improvements observed at the individual plant level did not directly correlate with an increase in overall yield, and statistical analysis showed no synergistic interaction between the application of SP-36 fertilizer and Red Devil Fish POC in increasing onion production. The combination of both treatments did not produce better results than the single application of Red Devil Fish POC.

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