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Growth and yield of Shallots (*Allium ascalonicum* L.) with Boron fertilization and cow blood liquid organic fertilizer

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ABSTRACT

Shallots are annual plants that are widely used as a cooking spice or medicine. This study aims to analyse the effect of giving boron and cow blood liquid organic fertilizer on the growth and yield of shallot bulbs (*Allium ascalonicum* L.). This research was carried out in October - December 2023 on land in Banyuwangi Village, Bandongan District, Magelang Regency, Central Java using a Complete Randomized Block Design (CRDB) with the first factor being boron administration (0 and 2.5 g/plot) and the factor both doses of cow blood liquid organic fertilizer LOF (20; 40; 60 and 80 ml/plot). The results of the research on the first factor did not show any significant difference, while for the second factor there was a significant difference in the parameters of flavonoid content, while for interactions there was an interaction between the number of leaves on the boron treatment and the dose of cow blood liquid organic fertilizer. Unstable weather means that the provision of boron and cow blood liquid organic fertilizer is unable to increase shallot productivity.

Keywords: boron, cow blood liquid organic fertilizer, shallots.



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1. Introduction

Shallots (*Allium ascalonicum* L.) are one of the seasonal crops in Indonesia with high economic value, utilized as both a cooking spice and medicinal ingredient. According to data from the Indonesian Statistics Agency in 2022, the productivity of shallots reached 10.16 tons/ha, while in 2021, productivity reached 11 tons/ha. This data indicates a decline in shallot productivity. This decrease is suspected to be due to unstable weather conditions, predominantly rainy, which accelerate the spread of diseases and reduce shallot productivity. Therefore, selecting superior seeds, such as the Bima Brebes variety known for its resistance to bulb rot, is crucial. According to Basuki et al (2014), the Bima Brebes variety is a superior variety developed by the Vegetable Crops Research Institute.

Fertilization is essential to meet the nutrient requirements of plants. One such nutrient is boron, a micronutrient that plays a role in the development of meristem tissues, aiding plant growth (Kartina et al., 2023). A boron deficiency can hinder the growth and development of plants. Additionally, liquid organic fertilizer (LOF)

derived from cow blood is used because cow blood contains essential nutrients such as N, P, K, Ca, Mg, Fe, Zn, Cu, and Mn, required by plants (Dewi, 2019). The nutrient composition of cow blood-based LOF is presented in Table 1, as analyzed by (Putri, 2023).

Table 1. nutrient composition of cow blood-based LOF

No.	Parameters	Unit	Liquid Organic Fertilizer	Quality Standards
1	C – Organic	% (w/v)	4.74	min 10
2	Makro Nutrients :	% (w/v)		2 – 6
	N total		2.16	
	P ₂ O ₅		0.02	
	K ₂ O		0.04	
3	Micro nutrients **			
	Fe total	ppm	156.4	90 - 900
	Mn total	ppm	4.3	25- 500
	Cu total	ppm	1.0	25 - 500
	Zn total	ppm	3.8	25 – 500
	B total	ppm	37.4	12 – 250
	Co total	ppm	0.3	5 - 20
	Mo total	ppm	0.5	2 – 10
4	pH	-	6.6	4 – 9
5	Heavy metals			
	As	ppm	0.1	max 5.0
	Hg	ppm	0.2	max 0.2
	Pb	ppm	2.3	max 5.0
	Cd	ppm	0.7	max 1.0

2. Materials and Method

The research was conducted from October to December 2023 on agricultural land located in Banyuwangi Village, Bandongan District, Magelang Regency, at an elevation of 407 meters above sea level with reddish dark brown latosol experiment (2×4) arranged in a Completely Randomized Block Design (CRBD), consisting of two treatment factors, each replicated three times as blocks. The first factor was boron fertilizer application at two levels: 0 and 2.5 g/plot. The second factor was the application of LOF derived from cattle blood at four dosage levels: 20, 40, 60, and 80 ml/plot. Observed parameters included growth and yield variables such as number of leaves, plant height, fresh tuber weight per tuber, dry storage tuber weight per tuber, number of tubers per clump, fresh tuber weight per clump, dry storage tuber weight per m², tuber moisture content, sugar content, flavonoid content, and iron (Fe) content. The collected data were analysed using Analysis of Variance (ANOVA) at the 5% and 1% significance levels. If significant or highly significant differences were detected, further analysis was conducted using orthogonal polynomial contrast for the LOF dosage factor and interaction effects.

3. Result and Discussion

The analysis of variance results indicated that the application of boron to shallot plants did not have a statistically significant effect on the observed parameters. The application of liquid organic fertilizer (LOF) derived from bovine blood had a highly significant effect on the flavonoid content of shallots but showed no significant differences on other parameters. The interaction between boron and bovine blood LOF significantly affected the number of leaves at 42 days after transplanting (DAT), whereas no significant differences were observed for the other parameters (Table 2).

Table 2. Results of analysis of variance (ANOVA) on the measured parameters

Research Parameter	F Value from Treatment		
	B	P	B × P
Number of Leaves at 14 DAS (leaves)	0,803 ^{ns}	1,106 ^{ns}	0,638 ^{ns}
Number of Leaves at 28 DAS (leaves)	0,643 ^{ns}	0,866 ^{ns}	1,911 ^{ns}
Number of Leaves at 42 DAS (leaves)	0,059 ^{ns}	0,035 ^{ns}	4,046 *
Plant Height at 14 DAS (cm)	0,004 ^{ns}	0,364 ^{ns}	1,706 ^{ns}
Plant Height at 28 DAS (cm)	0,199 ^{ns}	0,409 ^{ns}	1,019 ^{ns}
Plant Height at 42 DAS (cm)	0,014 ^{ns}	0,077 ^{ns}	1,745 ^{ns}
Fresh Tuber Weight per Tuber (g)	0,010 ^{ns}	0,114 ^{ns}	0,772 ^{ns}
Dry Tuber Weight per Tuber (g)	0,391 ^{ns}	0,208 ^{ns}	0,981 ^{ns}
Tuber Weight per Clump (g)	0,135 ^{ns}	0,778 ^{ns}	1,376 ^{ns}
Fresh Weight per Clump (g)	0,579 ^{ns}	0,092 ^{ns}	0,877 ^{ns}
Stored Dry Tuber Weight per m ² (g)	0,297 ^{ns}	1,143 ^{ns}	0,318 ^{ns}
Tuber Moisture Content (%)	0,021 ^{ns}	0,081 ^{ns}	0,609 ^{ns}
Sugar Content (°Brix)	0,003 ^{ns}	2,495 ^{ns}	0,519 ^{ns}
Flavonoid Content (%)	0,000 ^{ns}	6,218 **	0,000 ^{ns}
Fe Content (%)	0,073 ^{ns}	0,546 ^{ns}	1,720 ^{ns}

3.1. The Effect of Boron Application

The application of boron did not result in significant differences across several parameters, including the number of leaves, plant height, fresh bulb weight per bulb, dry storage bulb weight per bulb, number of bulbs per clump, dry storage bulb weight per square meter, bulb moisture content, sugar content, flavonoid content, and iron (Fe) content, as shown in Table 2. This lack of effect is likely due to suboptimal boron absorption by the plants. Several factors may have contributed to the inefficient uptake of boron, such as weather conditions, soil characteristics, and other environmental variables.

Shallot cultivation was conducted in October during the dry season. During this month, rainfall was recorded only four times with low intensity. Boron was applied when the plants were 15 DAT using 100 mL of solution per plant. However, due to dry soil conditions, root systems were unable to effectively absorb the boron. The dryness caused the soil to harden, further restricting boron uptake by the roots (Tinto, 2022).

Another factor inhibiting boron absorption was high ambient temperature combined with inappropriate fertilizer application methods, which caused boron to evaporate before being absorbed by the plant. Based on evapotranspiration calculations, shallot plants required approximately 11.191 liters per plot or 147 mL per plant. However, only 100 mL of boron solution was applied per plant, which was insufficient for optimal delivery to the root zone. As a result, the boron solution likely evaporated before reaching the roots, particularly under dry soil conditions, rendering the application ineffective for all measured parameters.

Furthermore, the lack of significant effect of boron on shallot growth may also be attributed to unstable weather conditions, especially toward the end of the growing season. Unexpected rainfall occurred between 48 and 60 DAT, contradicting the standard operating procedures for shallot cultivation, which recommend no irrigation two weeks prior to harvest to ensure dry bulbs that are less prone to rot. This unexpected rainfall caused stress in the plants, delaying the harvest maturity from the expected 60 DAT to 83 DAT due to excessive soil moisture. These findings align with Choubey (2014), who stated that appropriate rainfall can enhance shallot yield, whereas untimely precipitation can reduce yield and prolong the crop cycle.

3.2. The Effect of Doses Cow Blood LOF Application

3.2.1 Flavonoid Content. Based on the F-test results in Table 2, the application of different doses of LOF derived from cow blood showed a highly significant effect on the flavonoid content of shallots. Further analysis was conducted, and the results are presented as follows.

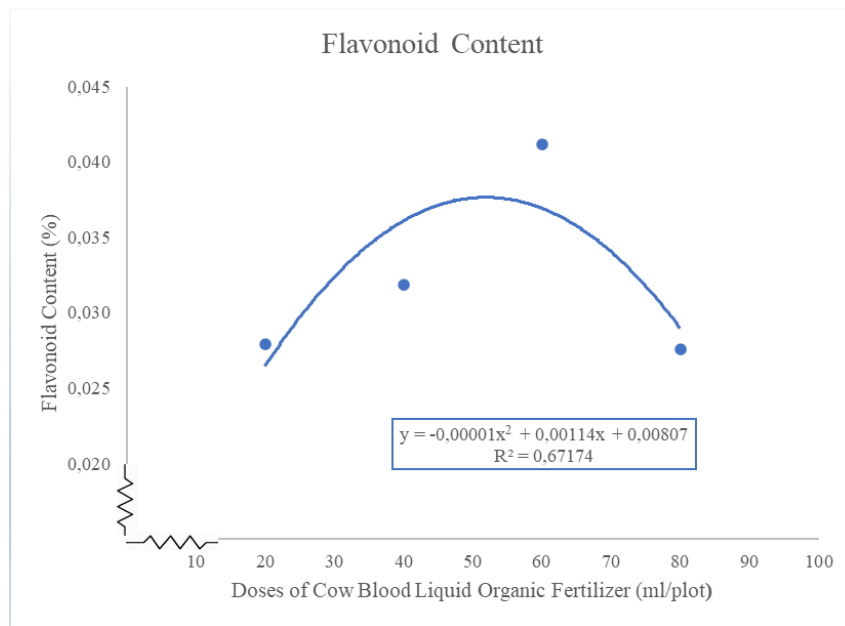


Figure 1. Graph of the Effect of Cow Blood LOF Dose on Flavonoid Content in Shallots.

Based on further analysis using orthogonal polynomial in Figure 1, the quadratic equation obtained was $y = -0.00001x^2 + 0.00114x + 0.00807$ with an R^2 value of 0.67174, indicating that the dose of cow blood LOF influenced the flavonoid content in shallots by 67.17%, while the remaining 32.83% was influenced by external factors such as environmental conditions and others. From Figure 1, the optimal dose was found to be 57 ml/plot, which resulted in a flavonoid content of 0.046%, classified as low compared to the flavonoid content of shallot bulbs harvested at 12 weeks after planting, which is 2,655.43 mg QE/100 g or 2.655% (Utama et al., 2024).

The low flavonoid content in shallots is suspected to be due to the cow blood LOF composition not yet meeting the required standards. According to the nutrient analysis conducted by Putri (2023), only certain elements such as total N, Fe, and B have met the standard POC criteria, as shown in Appendix 23. According to Putri (2021), flavonoid content is influenced by macro nutrients such as N, P, K, and sulfur, which are essential for plant development. This indicates that the nutrient supply necessary for flavonoid biosynthesis has not been sufficiently met, resulting in low flavonoid accumulation in shallots.

Flavonoid content is not only affected by macro nutrients but also by micro nutrients. Micro nutrients influencing flavonoid levels include Zn, Mn, Cu, Si, and Fe. However, the content of these micro nutrients in the POC has not yet reached the required standard, which limits their role in supporting flavonoid biosynthesis. Micro nutrients play a vital role in flavonoid biosynthesis by activating enzymes involved in their formation. Among these, Zn is considered the most influential. According to Ballabh et al (2013) Zn application can increase ascorbic acid levels, which serves as a cofactor in the formation of cinnamic acid—a precursor in the biosynthesis of flavonoids.

3.2.2. Number of Leaves, Plant Height, Fresh Bulb Weight per Bulb, Dry Storage Bulb Weight per Bulb, Number of Bulbs per Clump, Dry Storage Bulb Weight in m^2 , Bulb Moisture Content, Sugar Content, and Fe Content.

Based on the F-test results in Table 2, the parameters for number of leaves, fresh bulb weight per bulb, dry storage bulb weight per bulb, and sugar content showed no significant difference. This is presumed to be due to the nutrient content in the cow blood LOF not meeting the nutritional requirements of the shallot plants. According to research by Putri (2023), the nutrient levels in the cow blood LOF did not meet the standard criteria for organic fertilizer. These nutrients play an essential role in the growth and yield of shallots.

Environmental factors also influenced the growth of shallots. The growth phase occurred during the dry season, which resulted in suboptimal plant development. The applied dose of cow blood LOF was 100 ml per plant, which was lower than the plant's evapotranspiration rate, causing more of the fertilizer to evaporate than to be absorbed. This observation is in line with the findings of Fauziah et al., (2016) who reported that watering volumes not aligned with the plant's evapotranspiration needs can lead to a reduction in total harvest weight.

3.3. Interaction Between Boron and Cow Blood LOF Dose

3.3.1. Number of Leaves at 42 DAP

The F-test results presented in Table 2 show a significant interaction between boron application and the dose of cow blood LOF on the number of leaves at 42 days after planting (DAP). Therefore, further analysis was conducted, and the following results were obtained.

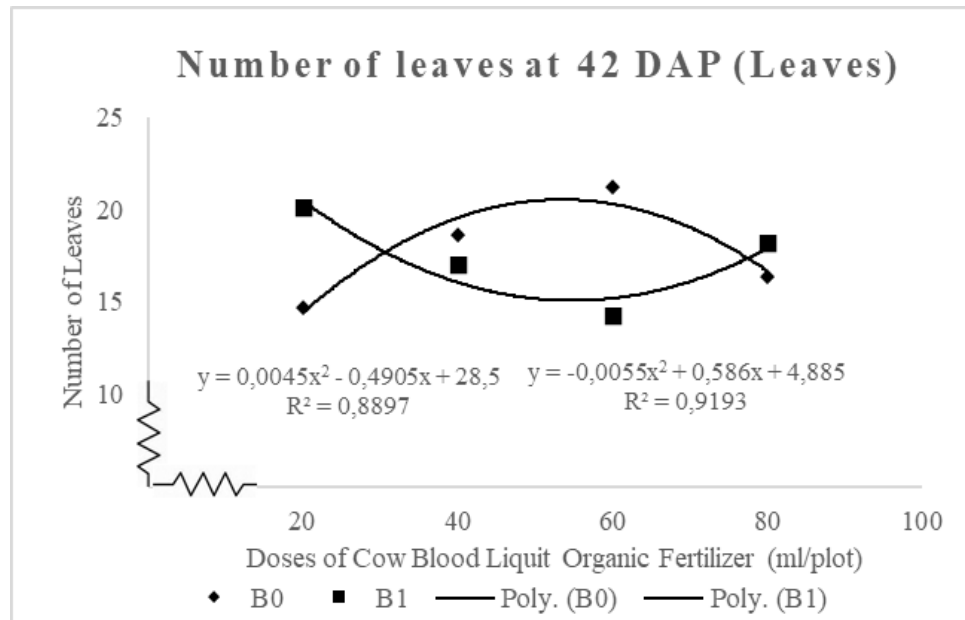


Figure 2. Graph of Interaction Between Boron and Cow Blood LOF Dose on Number of Leaves at 42 DAP.

Based on the follow-up test, the regression equation $y = -0.0055x^2 + 0.586x + 4.885$ was derived, indicating that the combination of 0 g/plot boron and 54.27 ml/plot cow blood LOF resulted in the highest number of leaves, 20.49 leaves. The application of boron to shallot plants led to a lower number of leaves compared to no boron application. This is likely due to the low to neutral soil pH, which interferes with boron uptake, subsequently reducing leaf production. This finding is consistent with Dhaliwal et al., (2019), who stated that boron absorption is limited under acidic to neutral pH conditions, and that different boron species experience competitive adsorption influenced by soil pH. According to Long and Peng (2023), boron uptake is also closely related to the presence of other nutrients—zinc (Zn), in particular, competes with boron for plant absorption sites.

The cow blood LOF contributed to the highest number of leaves at a dose of 54.27 ml/plot. This is attributed to the nutrient content in the LOF, particularly its nitrogen, which is readily absorbed by the plant. According to Putri (2023), the nitrogen content in cow blood LOF is higher than that of other macro nutrients. Nitrogen plays a critical role in vegetative growth, including leaf number and development (Rianti et al., 2021).

3.3.2. Number of Leaves at 14 and 28 DAP, Plant Height, Fresh Bulb Weight per Bulb, Dry Storage Bulb Weight per Bulb, Number of Bulbs per Clump, Dry Storage Bulb Weight per m², Bulb Moisture Content, Sugar Content, and Fe Content.

Based on the F-test results, the interaction between boron application and the dose of cow blood liquid organic fertilizer (LOF) did not have a significant effect on the following parameters: number of leaves at 14 and 28 days after planting (DAP), fresh bulb weight per bulb, dry storage bulb weight per bulb, flavonoid content, and sugar content.

The lack of significant results is likely due to pest and disease attacks that negatively affected the observation data. Armyworm (*Spodoptera litura*) infestations began in the second week, damaging newly emerging leaves at a critical stage of plant establishment. Armyworms feed on shallot leaves and are typically active during sunset, necessitating insecticide application in the late afternoon. In addition to armyworms, fungal infections, possibly Fusarium wilt, were observed, leading to plant death in nearly all plots—affecting up to 50% of the

total population, approximately 800 plants.

These pest attacks on shallot foliage during the growth period had a negative impact on plant development. The armyworm's feeding activity damages internal leaf tissue, turning the leaves white and translucent, which severely reduces the plant's photosynthetic ability and overall growth (Soraya, 2019). This pest pressure is likely one of the factors contributing to the non-significant interaction effects.

The hypothesis in this study proposed that the combination of 2.5 g/plot boron and 40 ml/plot cow blood LOF would produce the best growth and yield. However, the results indicated that boron application did not enhance the growth or yield of shallots. The cow blood LOF only showed a highly significant effect on flavonoid content, while no significant interaction was observed between boron and LOF treatments. This may suggest a negative interaction between boron and certain components of the cow blood LOF, potentially inhibiting the expected synergistic effects.

4. Conclusion

Based on the research conducted, it can be concluded that the application of boron did not result in significant differences across all observed parameters in shallot cultivation. However, the application of cow blood liquid organic fertilizer (LOF) had a significant effect on flavonoid content, with the highest dose of 55 ml/plot producing a flavonoid content of 0.046%, which is still considered low. The interaction treatment without boron and with 54.27 ml/plot of cow blood LOF resulted in the highest number of leaves, recorded at 20.49 leaves. Based on these findings, further research is recommended to explore lower boron doses with more variation as well as alternative application methods such as foliar spraying or soil drenching. Additionally, in shallot cultivation, it is advised to select high-yielding varieties that are well-adapted to environmental conditions. The use of liquid organic fertilizer should be improved by supplementing with phosphorus (P) and potassium (K) to meet standard nutrient requirements.

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Declaration of generative AI use

The authors declare that no generative AI or AI-assisted technologies were used in the preparation of this manuscript.

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