



Phenolic and Flavonoid Responses of Bauji Shallots to Ammonium Sulfate under Floating Cultivation

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Abstract

Shallot is a high value horticultural crop valued for its flavor, aroma, and medicinal properties, and is rich in phenolics and flavonoids that contribute to antioxidant activity. Limited dryland and fluctuating demand in South Sumatra highlight the need for alternative systems such as floating cultivation. This study aimed to evaluate the effects of different ammonium sulfate (ZA) doses on the bulb yield, total phenolic, and flavonoid contents of Bauji shallots grown under floating cultivation. The experiment used a randomized complete block design with three replications and four ZA fertilizer treatments (0, 60, 180, and 360 kg ha⁻¹). Observed variables included total phenolic and flavonoid contents measured by spectrophotometry and dry bulb weight. The results indicated that the ZA application significantly increased dry bulb weight and total phenolic content but did not affect flavonoids. The highest bulb yield and flavonoid content were obtained with 60 kg ha⁻¹, whereas phenolics peaked under the control (0 kg ha⁻¹), suggesting a trade-off between yield and secondary metabolite accumulation. Correlation analysis revealed a positive association between bulb weight and flavonoid content, whereas phenolics were negatively related to fertilizer input. As the first report on Bauji shallots under floating cultivation, these findings indicate that moderate ZA fertilization (60 kg ha⁻¹) optimizes bulb yield while maintaining bioactive compound levels. However, further multi-season studies are needed for broader recommendations.

Keywords: fertilization; flavonoid content; medicinal plant; phenolic compounds; plant extracts

INTRODUCTION

Shallots are spice vegetables widely used as a primary ingredient in cooking and traditional medicine, giving them high economic value (Shahrajabian et al., 2020). Beyond their culinary and economic importance, shallots are also rich in secondary metabolites, particularly phenolic compounds and flavonoids. These bioactive molecules exhibit strong antioxidant properties and reduce oxidative stress (Rudrapal et al., 2022), as well as demonstrating anti-inflammatory (Al-Khayri et al., 2022), anticancer (Kopustinskiene et al., 2020), antibacterial

(Rosyada et al., 2023), and minimizing the occurrence of diabetes complications (Jin et al., 2023). Such health promoting potentials make shallots an essential research subject for their role in preventing and managing chronic diseases. The distinctive taste and aroma of shallots originate from the compound isoalliin, an isomer of alliin and the dominant S-alk(en)yl-L-cysteine sulfoxide present in shallots, which is formed through processes influenced by the plant's sulfur content (Hasrianda and Setiarto, 2022).

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In Indonesia, the availability of shallots often becomes limited before major religious and national holidays (Yuniarti et al., 2023), primarily due to farmers' inability to meet market demand. In South Sumatra Province, the annual consumption requirement for shallots reaches 23,288 tons, while local production amounts to only 8,965 tons (Statistics of Indonesia, 2024; Statistics of South Sumatra Province, 2024a; 2024b). One of the main obstacles farmers face in increasing shallot production is the limited availability of dryland suitable for cultivation, as the province's landscape is predominantly composed of swampy lowlands and peatlands (Wildayana and Armanto, 2018).

To meet local demand, shallots are often transported from major producing provinces, such as Central Java, one of Indonesia's largest shallot production centers (Rosyid et al., 2021). However, this approach poses logistical challenges. Transporting shallots over long distances requires time, and because shallots are bulb vegetables with limited storability, this method does not provide a sustainable supply solution (Sarjani et al., 2018). Another alternative is cultivating shallots in shallow swamp areas with water levels less than 25 cm during the rainy season (Armanto et al., 2018). Previous studies by Susilawati et al. (2021) have shown that when the soil water table falls below 20 cm from the surface, shallot growth and yield are adversely affected, leading to suboptimal production levels. Consequently, this cultivation method remains insufficient to meet the demand for shallot consumption in South Sumatra.

An innovative approach to overcoming these challenges is using floating cultivation systems (Pyka et al., 2020; Sofian et al., 2023), which enable shallot production in wetland areas. This system utilizes floating rafts on flooded lands, where plants are grown in polybags supported on buoyant structures (Hasbi et al., 2017). Floating cultivation allows crop production on otherwise unsuitable land, though nutrient management remains critical for optimal growth (Wawan and Fikrawati, 2021).

Among nitrogen fertilizers, urea is the most commonly used source but suffers from high volatilization losses under flooded and floating conditions due to rapid hydrolysis and ammonia emission (He et al., 2025). In contrast, ammonium sulfate fertilizer supplies nitrogen directly in the ammonium form, which is less prone to

volatilization, while also providing sulfur essential for secondary metabolite synthesis (Powlson and Dawson, 2022). As $(\text{NH}_4)_2\text{SO}_4$, ammonium sulfate enhances nitrogen use efficiency, promotes vegetative growth, and stimulates sulfur dependent compounds that contribute to the distinctive flavor and aroma of shallots (Hasanah et al., 2021). This study aims to evaluate the effects of varying ammonium sulfate fertilizer doses on the bulb yield, total phenolic, and flavonoid contents of shallots cultivated in a floating cultivation system. According to current evidence, this study was the first to investigate Bauji shallots under floating cultivation with varying ammonium sulfate doses, providing new insights into nutrient level responses in phenolic and flavonoid contents.

MATERIALS AND METHOD

Study site

The experiment was conducted in 5 Ulu Darat Village, Seberang Ulu I Sub-district, Palembang, Indonesia. The site is geographically located at 104°45'45.1" E and 3°00'12.7" S, with an elevation of approximately 6 m above sea level (Figure 1). The study was conducted from December 2024 to February 2025 in a constructed pond measuring 2.5 m × 3.5 m in a residential area. During the experimental period, the average air temperature was 26.6 °C, relative humidity averaged 85.5%, rainfall was 9.6 mm, daily sunshine duration was 3.1 hours, and the mean wind speed was 2.1 m s⁻¹. Climatic data were obtained from the nearest meteorological station (Meteorology, Climatology, and Geophysics Agency of Palembang).

Procedures

Cultivation pond and floating rafts

The cultivation pond was constructed using *gelam* wood (local hardwood) and bamboo slats, and lined with a plastic tarp to retain water. The pond measured 3.4 m × 2.4 m and was filled with rainwater. After settling, the water exhibited a pH range of 4.5 to 5.0, while the temperature was maintained at 25 to 26 °C throughout the experiment. Floating rafts were fabricated using 1.5 l plastic water bottles as flotation devices, following the method described by Siaga et al. (2019), combined with bamboo slats as the supporting frame (Figure 2). Each raft measured 1 m × 2 m, and the experiment used three units.

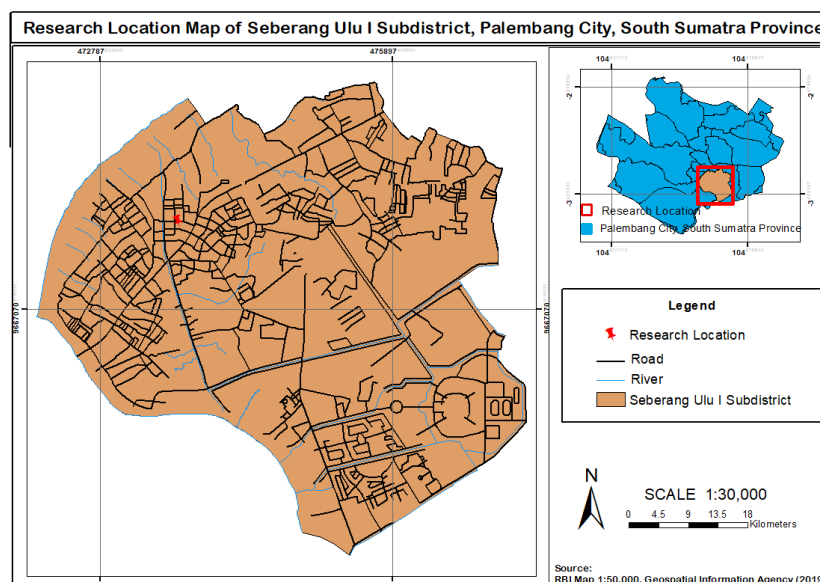


Figure 1. Research location map

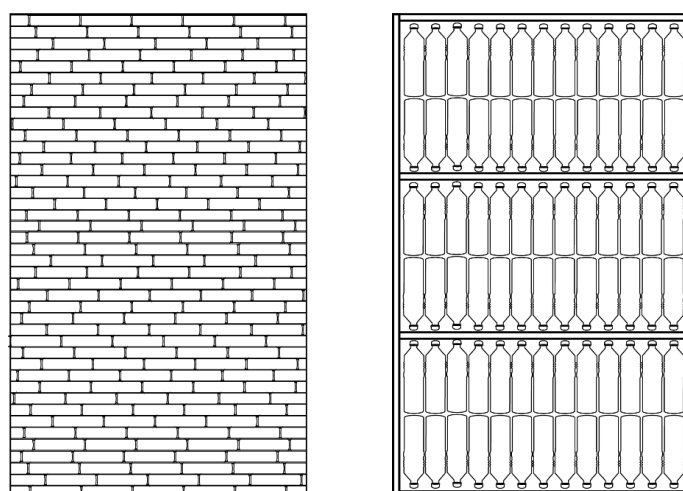


Figure 2. Floating raft top and bottom view

Planting media

The planting medium consisted of a mixture of topsoil, burned rice husk, and cow manure in a 2:1:1 ratio. The pH of the soil ranged from 4.5 to 6.0. The mixture was placed into 25 cm × 25 cm polybags before transplanting. Basal fertilization was applied once, one week before planting (Solagracya et al., 2025), with NPK 16:16:16 at 200 kg ha⁻¹ (Susilawati et al., 2022), SP-36 at 150 kg ha⁻¹ (Hadiawati et al., 2023), and KCl at 105 kg ha⁻¹ (Suminartika et al., 2022) to ensure nutrient availability during early growth.

Seed preparation

Shallot seedlings of the Bauji variety were obtained from mature bulbs (≥ 3 months old) with

firm outer skin, small size (2 to 3 g), uniform shape, and free from pests, diseases, or mechanical damage to ensure optimal growth. This cultivar was selected for its moderate adaptability to peatland conditions (Lestari and Maftu'Ah, 2021), making it a promising candidate for floating cultivation.

Planting procedure

Before planting, the shallot bulbs were trimmed by approximately one-third of their length to promote sprout emergence and stimulate lateral bulb formation (Tome et al., 2022). The bulbs were then soaked in a fungicide solution at a concentration of 1 ml l⁻¹ for 5 minutes. Planting was conducted by inserting the bulbs into the soil medium and gently twisting them to

ensure firm contact between the bulb base and the planting substrate.

Crop maintenance

Weed management was performed manually by hand pulling. Pest and disease control was carried out using integrated methods. Mild disease symptoms were treated with biological agents, primarily *Trichoderma* sp. In cases of severe infestation, infected plants were removed to prevent further spread.

Harvesting

Shallots were considered physiologically mature and ready for harvest when approximately 60% of the foliage had wilted and turned yellow at approximately 60 days after planting.

Bioactive compound analysis

After harvest, only the bulb portion of the shallot samples was used. The bulbs were thinly sliced and air-dried, followed by oven-drying at 35 °C for 7 days. The dried samples were then ground into a fine powder using a blender and passed through a medium-sized mesh (approximately 2 mm) to obtain a homogeneous shallot powder extract.

Total flavonoid

This content was determined using UV-Vis spectrophotometry at 415 nm. The extract was reacted with aluminum chloride (AlCl_3) in 50% methanol to form a detectable flavonoid- AlCl_3 complex, following the method described by Aminah et al. (2017) and Ramadhani et al. (2020). Results were expressed as milligrams of quercetin equivalent per gram of sample (mg QE g^{-1}).

Total phenolic

This content was analyzed using the Folin-Ciocalteu colorimetric method. The extract was mixed with the Folin-Ciocalteu reagent and incubated under controlled conditions to allow the formation of a blue-green chromophore. Absorbance was measured at 725 nm using a UV-Vis spectrophotometer, as described by Muthia et al. (2023). Results were expressed as milligrams of gallic acid equivalent per gram of sample (mg GAE g^{-1}).

Methods

The experiment was arranged using a randomized complete block design (RCBD) with four levels of ammonium sulfate (ZA) fertilizer and three replications. Fertilizer applications were carried out 1 and 3 weeks

after planting (WAP), following the procedure described by Idly et al. (2024). Each replication consisted of 25 plants, resulting in 300 experimental units. The ZA fertilizer treatments were as follows: S0 = control (no fertilizer), S1 = 60 kg ha^{-1} , S2 = 180 kg ha^{-1} , S3 = 360 kg ha^{-1} .

Data analysis

Data were analyzed using analysis of variance (ANOVA), followed by Tukey's honestly significant difference (HSD) test at a 5% significance level, polynomial regression, and Pearson's correlation analysis. The observed variables were dry bulb weight, total phenolic, and flavonoid content.

RESULTS AND DISCUSSION

An increase in the dosage of ZA fertilizer resulted in a significant decrease in shallot dry bulb weight and total phenolic content (Table 1). In contrast, total flavonoid content showed no statistically significant differences among treatments. These results suggest that dry bulb weight and phenolic compounds were more responsive to changes in nitrogen and sulfur availability than flavonoids.

The application of fertilizer significantly influenced shallot dry bulb weight at 8 WAP. The 60 kg ha^{-1} fertilizer dose resulted in the highest dry weight, at 4.0 g (Figure 3a). This indicates moderate nitrogen input (60 kg ha^{-1}) supports optimal bulb development. The polynomial regression explained only 34.15% of the variation ($R^2 = 0.3415$) (Figure 3b), suggesting that dry bulb weight was weakly associated with ZA dosage and strongly influenced by other environmental or physiological factors. The final yield of bulbs is a direct function of the balanced relationship between soil nutrient uptake, favorable environmental conditions, and efficient metabolic activity within the plant.

Table 1. ANOVA

Variable	F-value	CV (%)
Dry bulb weight (g)	8.31*	10
Total phenol content	6.21*	6
Total flavonoid content	3.09 ^{tn}	12
F-table 5%	4.76	
F-table 1%	9.78	

Note: CV = Coefficient of variation; * = Significantly different; ** = Very significantly different; tn = Not significantly different

The control treatment (0 kg ha^{-1}) produced the highest phenolic content at $8.72 \text{ mg GAE g}^{-1}$, whereas higher ZA doses (180 to 360 kg ha^{-1}) reduced the phenolic content to 7.11 to $7.75 \text{ mg GAE g}^{-1}$ (Figure 4a). The polynomial regression analysis revealed that the tested dose range of ZA explained 99.94% of the variation in phenol content ($R^2 = 0.9994$) (Figure 4b). This decrease is associated with the plant's stress response (Buchory et al., 2020), as phenolic production tends to increase under nutrient-deficient conditions. In the absence of fertilizer, nitrogen and sulfur deficiencies likely induced metabolic stress, thereby triggering the biosynthesis of phenolic compounds as a protective mechanism and part of their defense strategy. Phenols are

potent antioxidants that help plants cope with various environmental stresses (Sharma et al., 2019).

These findings are consistent with previous studies by Narvekar and Tharayil (2021) and Ma et al. (2023), which reported increased phenolic content under low nitrogen or unfertilized conditions (Figure 4a). Under stress conditions, the plant's defense system is activated, particularly the phenylpropanoid pathway (Yadav et al., 2020), synthesizing protective phenolic compounds. The observed pattern, a decrease in phenol content from the control to a medium dose, followed by a slight increase at higher doses, is consistent with the carbon-nitrogen (C–N) allocation theory (Chen et al., 2024). This theory

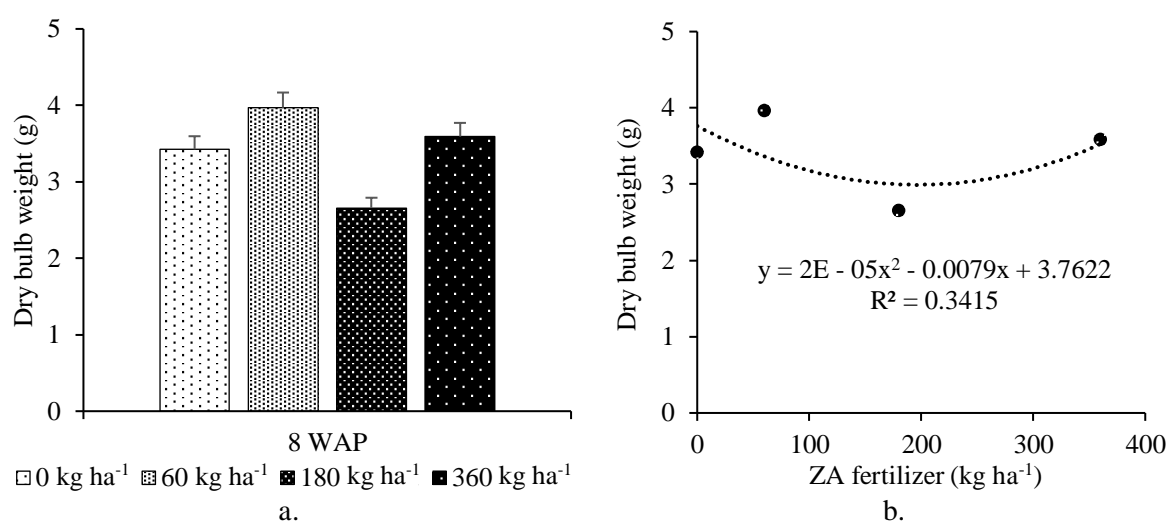


Figure 3. Shallot dry bulb weight (a) and polynomial regression analysis of shallot dry bulb weight (b)

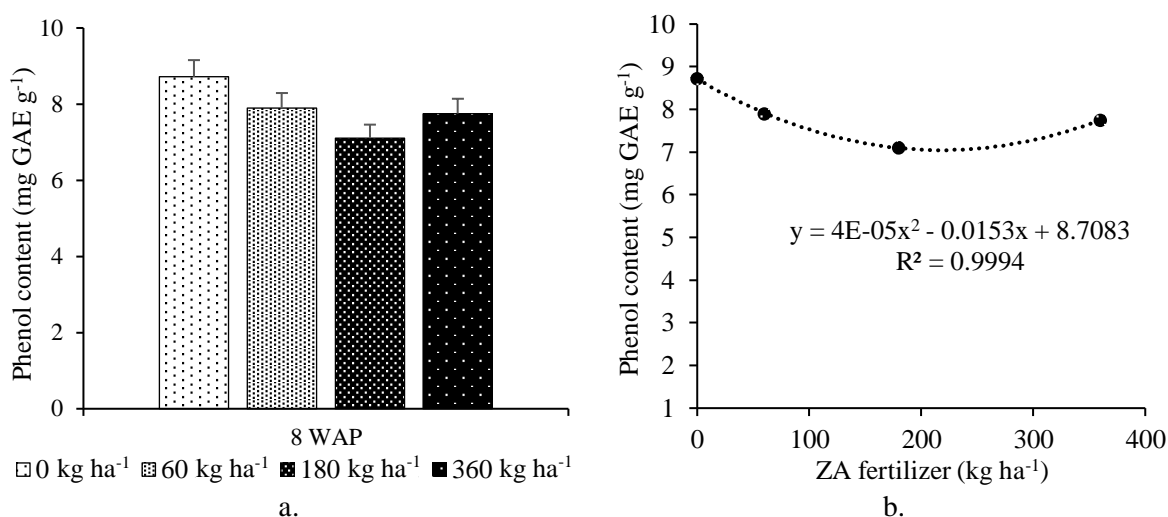


Figure 4. Total phenolic contents (a) and polynomial regression analysis of total phenolic contents (b)

explains that nitrogen deficiency significantly reduces the plant's ability to absorb CO₂, which is essential for photosynthesis and the subsequent production of assimilates. This triggers the accumulation of secondary metabolites. As nitrogen levels increase to a medium range, carbon is reallocated toward growth, reducing phenolic compounds.

No statistically significant variation in total flavonoid content was observed among the ZA fertilizer treatments. However, descriptive analysis indicated that the application of 60 kg ha⁻¹ ZA fertilizer yielded the highest flavonoid content (6.64 mg QE g⁻¹) (Figure 5). This suggests that at this dosage, the availability of nitrogen and sulfur was within the optimal range to support flavonoid biosynthesis. Sufficient nutrient levels likely promoted the maximal activity of key enzymes in the flavonoid biosynthetic pathway. This observation is supported by previous studies conducted by Shafira et al. (2024) and Marlin et al. (2022), which reported that moderate nitrogen application (approximately 60 to 90 kg ha⁻¹) significantly increased flavonoid content. In contrast, higher fertilizer doses (e.g., 180 to 360 kg ha⁻¹, as applied in this study) tended to reduce flavonoid levels.

The contrasting patterns between flavonoid and phenol accumulation in response to ZA fertilizer doses suggest that, although both compounds originate from the same biosynthetic pathway, their production is regulated through distinct mechanisms. This highlights the flexibility of plant secondary metabolism in adapting to environmental and nutritional variations. These findings are consistent with previous studies, which indicate that different molecular processes control the biosynthesis of flavonoids and non-flavonoid phenols (Davies et al., 2020).

The Pearson correlation analysis showed that ZA fertilization influences both secondary metabolism and yield formation in shallots (Table 2). Phenol content declined with increasing ZA doses but showed a weak association with dry bulb weight, while flavonoid content strongly and positively correlated with yield. This suggests that flavonoids contribute more directly to bulb development than phenols. Therefore, moderate nitrogen application optimizes the balance between growth and secondary metabolite synthesis, leading to improved yield performance.

Transcriptomic and metabolomic analyses in species such as *Leymus chinensis*, *Foxtail millet*, and *Litsea coreana* have demonstrated that flavonoid accumulation is regulated by the expression of specific genes such as *phenylalanine ammonia-lyase (PAL)*, *chalcone synthase (CHS)*, *flavanone 3-hydroxylase (F3H)*, as well as transcription factors including *myeloblastosis (MYB)* and *basic helix-loop-helix (bHLH)*, which are not always involved in the regulation of total phenol content (Wu et al., 2024; Xie et al., 2024; Ye et al., 2025).

This differentiation is further supported by fertilization studies in various plant species such as *Elaeis guineensis*, *Justicia gendarussa*, *Amaranthus caudatus*, and *Adenostemma lavenia*, where identical nitrogen doses resulted in varying levels of flavonoid and phenol accumulation. These differences were influenced by environmental factors such as light intensity, shading, and the type of fertilizer applied (Marlin et al., 2022; Maulana et al., 2024; Shafira et al., 2024). Such findings reflect metabolic flux competition and the differential regulation of biosynthetic enzymes, whereby flavonoids may reach optimal accumulation at specific fertilizer doses. At the same time, other phenolic compounds tend to accumulate more under nutrient deficient conditions. Moreover, a molecular review by Shi et al. (2024) revealed that flavonoid biosynthesis is strongly influenced by environmental factors such as light, temperature, and hormonal signals, which activate the flavonoid pathway through specific regulatory cues.

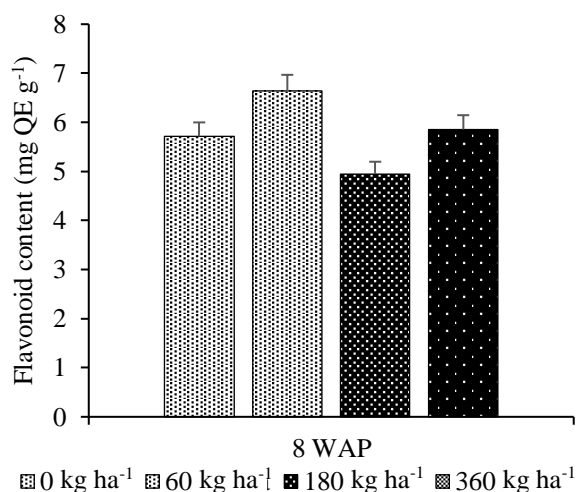


Figure 5. Total flavonoid content

Table 2. Pearson correlation

Variable		ZA fertilizer	Total phenol content	Total flavonoid content	Dry bulb weight
ZA fertilizer	Pearson correlation	1			
	Sig. (2-tailed)				
	N	12			
Total phenol content	Pearson correlation	-0.45	1		
	Sig. (2-tailed)	0.14			
	N	12	12		
Total flavonoid content	Pearson correlation	-0.18	0.31	1	
	Sig. (2-tailed)	0.58	0.32		
	N	12	12	12	
Dry bulb weight	Pearson correlation	-0.12	0.28	0.67*	1
	Sig. (2-tailed)	0.72	0.37	0.016	
	N	12	12	12	12

Variations in phenolic and flavonoid accumulation under different ZA fertilizer treatments indicate that, although both originate from the phenylpropanoid pathway, the biosynthesis of flavonoids and non-flavonoid phenols is regulated by distinct enzymes and genetic mechanisms, resulting in different responses to nutrient availability. The highest dry bulb weight and flavonoid content observed at 60 kg ha⁻¹ of ZA fertilizer, along with the highest phenol content recorded under the control (no fertilizer) condition, likely reflects the complex regulatory mechanisms of secondary metabolite biosynthesis, which are highly specific to each compound type, their associated genes, and the prevailing environmental conditions.

CONCLUSIONS

Varying ZA fertilizer doses in floating cultivation of Bauji shallots affected total phenolic, with the highest content at 0 kg ha⁻¹ (8.72 mg GAE g⁻¹) under nutrient deficiency stress and dry bulb weight at 60 kg ha⁻¹ (4.00 g). Flavonoid content showed no significant differences, although a tendency toward higher accumulation was observed at 60 kg ha⁻¹ ZA (6.64 mg QE g⁻¹). These findings provide the first evidence of contrasting nutrient-level responses of phenolic and flavonoid pathways in Bauji shallots under floating cultivation. Future studies should be conducted across multiple seasons and shallot varieties, integrating soil property analysis and antioxidant assays to validate the consistency of ZA fertilization effects under floating cultivation systems.

REFERENCES

- Al-Khayri, J. M., Sahana, G. R., Nagella, P., Joseph, B. V., Alessa, F. M., & Al-Mssallem, M. Q. (2022). Flavonoids as potential anti-inflammatory molecules: A review. *Molecules*, 27(9), 2901. <https://doi.org/10.3390/molecules27092901>
- Aminah, Tomayahu, N., & Abidin, Z. (2017). Penetapan kadar flavonoid total ekstrak etanol kulit buah alpukat (*Persea americana* Mill.) dengan metode spektrofotometri UV-Vis. *Jurnal Fitofarmaka Indonesia*, 4(2), 226–230. <https://doi.org/10.33096/jffi.v4i2.265>
- Armanto, M. E., Wildayana, E., & Syakina, B. (2018). Dynamics, degradation and future challenges of wetlands in South Sumatra Province, Indonesia. *E3S Web of Conferences*, 68(1), 04001. <https://doi.org/10.1051/e3sconf/20186804001>
- Buchory, G. N., Anwar, S., & Kristanto, B. A. (2020). Pertumbuhan, produksi simplisia, dan kandungan fenolik total selasih (*Ocimum basilicum* L.) pada berbagai taraf cekaman kekeringan dan waktu panen. *Jurnal Agrotek*, 5(2), 37–48. <https://doi.org/10.33096/agrotek.v5i2.166>
- Chen, L. H., Xu, M., Cheng, Z., & Yang, L. T. (2024). Effects of nitrogen deficiency on the photosynthesis, chlorophyll a fluorescence, antioxidant system, and sulfur compounds in *Oryza sativa*. *International Journal of Molecular Sciences*, 25(19), 10409. <https://doi.org/10.3390/ijms251910409>

- Davies, K. M., Jibrán, R., Zhou, Y., Albert, N. W., Brummell, D. A., Jordan, B. R., ... & Schwin, K. E. (2020). The evolution of flavonoid biosynthesis: A bryophyte perspective. *Frontiers in Plant Science*, 11(7), 508087. <https://doi.org/10.3389/fpls.2020.00007>
- Hadiawati, L., Fitrotin, U., Suriadi, A., & Nazam, M. (2023). Application of silicon foliar spray to increase growth and yield of shallot (*Allium ascalonicum* L.) under sprinkler and furrow irrigation system. *IOP Conference Series: Earth and Environmental Science*, 1253(1), 012056. <https://doi.org/10.1088/1755-1315/1253/1/012056>
- Hasanah, Y., Mawarni, L., Hanum, H., Sipayung, R., & Ramadhan, M. T. (2021). The role of sulfur and paclobutrazol on the growth of shallots (*Allium ascalonicum* (L.) Sanren F-1 varieties from true shallot seed. *IOP Conference Series: Earth and Environmental Science*, 782(4), 042039. <https://doi.org/10.1088/1755-1315/782/4/042039>
- Hasbi, H., Lakitan, B., & Herlinda, S. (2017). Persepsi petani terhadap budidaya cabai sistem pertanian terpadu di Desa Pelabuhan Dalam, Ogan Ilir. *Jurnal Lahan Suboptimal*, 6(2), 126–133. <https://doi.org/10.33230/JLSO.6.2.2017.297>
- Hasrianda, E. F., & Setiarto, R. H. B. (2022). Potensi rekayasa genetik bawang putih terhadap kandungan senyawa komponen bioaktif allicin dan kajian sifat fungsionalnya. *Jurnal Pangan*, 31(2), 167–190. <https://doi.org/10.33964/jp.v31i2.586>
- He, J., Wang, Y., Li, H., Ma, J., Yue, X., Liang, X., ... & Liu, R. (2025). Controlled release fertilizer improving paddy yield and nitrogen use efficiency by reducing soil residual nitrogen and leaching losses in the yellow river irrigation area. *Plants*, 14(3), 408. <https://doi.org/10.3390/plants14030408>
- Idly, N. S., Susilawati, S., Suwandi, S., & Oksilia, O. (2024). Aplikasi sulfur terhadap karakter agronomi, morfologi dan aktivitas antioksidan bawang merah (*Allium ascalonicum* L.) dibudidayakan terpadu. *Jurnal Penelitian Pertanian Terapan*, 24(4), 619–629. <https://doi.org/10.25181/jppt.v24i4.3449>
- Jin, Q., Liu, T., Qiao, Y., Liu, D., Yang, L., Mao, H., ... & Zhan, Y. (2023). Oxidative stress and inflammation in diabetic nephropathy: Role of polyphenols. *Frontiers in Immunology*, 14, 1185317. <https://doi.org/10.3389/fimmu.2023.1185317>
- Kopustinskiene, D. M., Jakstas, V., Savickas, A., & Bernatoniene, J. (2020). Flavonoids as anticancer agents. *Nutrients*, 12(2), 457. <https://doi.org/10.3390/nu12020457>
- Lestari, Y., & Maftu'Ah, E. (2021). Amelioration and variety selection to increase shallot yield in peatlands. *IOP Conference Series: Earth and Environmental Science*, 648(1), 012168. <https://doi.org/10.1088/1755-1315/648/1/012168>
- Ma, Y., Zhang, S., Feng, D., Duan, N., Rong, L., Wu, Z., & Shen, Y. (2023). Effect of different doses of nitrogen fertilization on bioactive compounds and antioxidant activity of brown rice. *Frontiers in Nutrition*, 10, 1071874. <https://doi.org/10.3389/fnut.2023.1071874>
- Marlin, M., Simarmata, M., Salamah, U., & Nurcholis, W. (2022). Effect of nitrogen and potassium application on growth, total phenolic, flavonoid contents, and antioxidant activity of *Eleutherine palmifolia*. *AIMS Agriculture and Food*, 7(3), 580–593. <https://doi.org/10.3934/agrfood.2022036>
- Maulana, F., Batubara, I., & Nurcholis, W. (2024). Productivity of phenolic, flavonoid, and antioxidant in *Justicia gendarussa* Burm. f. by different shade and dose of nitrogen fertilizer. *Yuzuncu Yil University Journal of Agricultural Sciences*, 34(4), 596–607. <https://doi.org/10.29133/yyutbd.1300943>
- Muthia, R., Bin Jamaludin, W., & Damayanti, L. (2023). Karakterisasi dan penetapan kadar fenol total ekstrak etanol umbi bawang dayak (*Eleutherine bulbosa* urb.) berdasarkan variasi waktu tumbuh tanaman. *Jurnal Ilmiah Farmasi (Scientific Journal of Pharmacy) Special Edition*, 83–93. Retrieved from <https://journal.uin.ac.id/JIF/article/view/28991>
- Narvekar, A. S., & Tharayil, N. (2021). Nitrogen fertilization influences the quantity, composition, and tissue association of foliar phenolics in strawberries. *Frontiers in Plant*

- Science*, 12, 613839. <https://doi.org/10.3389/fpls.2021.613839>
- Powlson, D. S., & Dawson, C. J. (2022). Use of ammonium sulphate as a sulphur fertilizer: Implications for ammonia volatilization. *Soil Use and Management*, 38(1), 622–634. <https://doi.org/10.1111/sum.12733>
- Pyka, L. M., Al-Maruf, A. A., Braun, B., Shamsuzzoha, M., & Jenkins, J. C. (2020). Floating gardening in coastal Bangladesh: Evidence of sustainable farming for food security under climate change. *Journal of Agriculture, Food and Environment*, 01(04), 161–168. <https://doi.org/10.47440/jafe.2020.1424>
- Ramadhani, N., Samudra, A. G., & Pratiwi, L. W. I. (2020). Analisis penetapan kadar flavonoid sari jeruk kalamansi (*Citrofortunella microcarpa*) dengan metode spektrofotometri UV-VIS. *Jurnal Mandala Pharmacon Indonesia*, 6(01), 53–58. <https://doi.org/10.35311/jmpi.v6i01.57>
- Rosyada, A. G., Prihastuti, C. C., Sari, D. N. I., Setiawati, S., Ichsyani, M., Laksitasari, A., ... & Kurniawan, A. A. (2023). Aktivitas antibiofilm ekstrak etanol kulit bawang merah (*Allium cepa* L.) dalam menghambat pembentukan biofilm *Staphylococcus aureus* ATCC 25923. *Jurnal Kedokteran Gigi Universitas Padjadjaran*, 35(1), 34–40. <https://doi.org/10.24198/jkg.v35i1.42451>
- Rosyid, A. H. A., Viana, C. D. N., & Saputro, W. A. (2021). Penerapan model box jenkins (ARIMA) dalam peramalan harga konsumen bawang merah di Provinsi Jawa Tengah. *Jurnal Agri Wiralodra*, 13(1), 29–37. <https://doi.org/10.31943/agriwiralodra.v13i1.19>
- Rudrapal, M., Khairnar, S. J., Khan, J., Dukhyil, A. B., Ansari, M. A., Alomary, M. N., ... & Devi, R. (2022). Dietary polyphenols and their role in oxidative stress-induced human diseases: Insights into protective effects, antioxidant potentials and mechanism(s) of action. *Frontiers in Pharmacology*, 13, 806470. <https://doi.org/10.3389/fphar.2022.806470>
- Sarjani, A. S., Palupi, E. R., Suhartanto, M. R., & Purwanto, Y. A. (2018). Pengaruh suhu ruang simpan dan perlakuan pasca penyimpanan terhadap mutu dan produktivitas umbi benih bawang merah (*Allium cepa* L. group *Aggregatum*). *Jurnal Hortikultura Indonesia*, 9(2), 111–121. <https://doi.org/10.29244/jhi.9.2.111-121>
- Shafira, A. E., Aziz, S. A., Farid, M., Ridwan, T., & Batubara, I. (2024). Effect of light intensities and nitrogen fertilizer dosages on growth, phenolics, and flavonoid production of *Adenostemma lavenia*. *Journal of Agricultural Engineering*, 13(1), 113–122. <https://doi.org/10.23960/jtep-l.v13i1.114-123>
- Shahrajabian, M. H., Sun, W., & Cheng, Q. (2020). Chinese onion, and shallot, originated in Asia, medicinal plants for healthy daily recipes. *Notulae Scientia Biologicae*, 12(2), 197–207. <https://doi.org/10.15835/nsb.12210725>
- Sharma, A., Shahzad, B., Rehman, A., Bhardwaj, R., Landi, M., & Zheng, B. (2019). Response of phenylpropanoid pathway and the role of polyphenols in plants under abiotic stress. *Molecules*, 24(13), 2452. <https://doi.org/10.3390/molecules24132452>
- Shi, T., Su, Y., Lan, Y., Duan, C., & Yu, K. (2024). The molecular basis of flavonoid biosynthesis response to water, light, and temperature in grape berries. *Frontiers in Plant Science*, 15(1), 1441893. <https://doi.org/10.3389/fpls.2024.1441893>
- Siaga, E., Lakitan, B., & Bernas, S. M. (2019). Floating seedbed for preparing rice seedlings under unpredictable flooding occurrence at tropical riparian Wetland. *Bulgarian Journal of Agricultural Science*, 25(2), 326–336. Retrieved from <https://www.agrojournal.org/25/02-16.pdf>
- Sofian, A., Rahim, S. E., Rosmiah, R., Aminah, I. S., Astuti, D. T., Amir, N., ... & Lusiah, M. (2023). Application of floating rice science and technology on the Lebak Swamp Land in Agrotourism Tekno 44 Gelebak Dalam Village. *Altifani Journal: International Journal of Community Engagement*, 4(1), 46–51. <https://doi.org/10.32502/altifani.v4i1.6886>
- Solagracya, J. H. P., Hanum, H., & Sarifuddin. (2025). Optimizing shallot plant growth and plant nutrient through site-specific fertilizer

- dose evaluation. *Indonesian Journal of Agricultural Research*, 8(1), 32–39. <https://doi.org/10.32734/injar.v8i1.17133>
- Statistics of Indonesia. (2024). *Weekly average consumption of several food items commodity per capita, 2007-2024*. Retrieved from <https://www.bps.go.id/id/statistics-table/1/OTUwIzE%3D/rata-rata-konsumsi-per-kapita-seminggu-beberapa-macam-bahan-makanan-penting--2007-2022.html?>
- Statistics of South Sumatra Province. (2024a). *Population by province (thousand people), 2024*. Retrieved from <https://sumsel.bps.go.id/id/statistics-table/2/NTczIzI%3D/jumlah-penduduk-menurut-provinsi.html?>
- Statistics of South Sumatra Province. (2024b). *Horticultural crop statistics of South Sumatra Province 2023*. Retrieved from <https://sumsel.bps.go.id/id/publication/2024/07/01/8207449e54f1d4c1ee04bddd/statistik-tanaman-hortikultura-provinsi-sumatera-selatan-2023.html>
- Suminartika, E., Deliana, Y., Hapsari, H., & Fatimah, S. (2022). The effect of input factor and optimization of input factor of shallot farm. *IOP Conference Series: Earth and Environmental Science*, 1107(1), 012110. <https://doi.org/10.1088/1755-1315/1107/1/012110>
- Susilawati, Irmawati, Sukarmi, S., Ammar, M., Kurnianingsih, A., Yusnita, & Yayandra. (2021). Growth and yield of shallot under several levels of soil water. *Russian Journal of Agricultural and Socio-Economic Sciences*, 114(6), 199–206. <https://doi.org/10.18551/rjoas.2021-06.23>
- Susilawati, Irmawati, Sukarmi, S., & Ammar, M. (2022). The application of chicken manure and NPK fertilizer on growth and yield of shallot plant in tidal land of Banyuasin Regency. *Jurnal Lahan Suboptimal: Journal of Suboptimal Lands*, 11(2), 197–205. <https://doi.org/10.36706/jlso.11.2.2022.582>
- Tome, V. D., Rai, I. N., Dwiyan, R., & Wijana, G. (2022). Effect of quality seed and improvement of cultivation technology to increase the yield of shallots (*Allium cepa* L. Var. *Aggregatum*). *GSC Biological and Pharmaceutical Sciences*, 21(1), 238–246. <https://doi.org/10.30574/gscbps.2022.21.1.0306>
- Wawan, & Fikrawati. (2021). Hasil tanaman selada (*Lactuca sativa* L.) pada komposisi medium berbeda yang dipupuk dengan urea dalam sistem budidaya terapung lahan rawa gambut. *Jurnal Agroekotek*, 13(2), 153–165. Retrieved from <https://jurnal.untirta.ac.id/index.php/jav/article/download/13155/8121>
- Wildayana, E., & Armanto, M. E. (2018). Lebak swamp typology and rice production potency in Jakabaring South Sumatra. *Agriekonomika*, 7(1), 30–36. <https://doi.org/10.21107/agriekonomika.v7i1.2513>
- Wu, H., Naren, G., Han, C., Elsheery, N. I., & Zhang, L. (2024). Exploring the flavonoid biosynthesis pathway of two ecotypes of *Leymus chinensis* using transcriptomic and metabolomic analysis. *Agronomy*, 14(8), 1839. <https://doi.org/10.3390/agronomy14081839>
- Xie, N., Guo, Q., Li, H., Yuan, G., Gui, Q., Xiao, Y., ... & Yang, L. (2024). Integrated transcriptomic and WGCNA analyses reveal candidate genes regulating mainly flavonoid biosynthesis in *Litsea coreana* var. *sinensis*. *BMC Plant Biology*, 24(1), 231. <https://doi.org/10.1186/s12870-024-04949-1>
- Yadav, V., Wang, Z., Wei, C., Amo, A., Ahmed, B., Yang, X., & Zhang, X. (2020). Phenylpropanoid pathway engineering: An emerging approach towards plant defense. *Pathogens*, 9(4), 312. <https://doi.org/10.3390/pathogens9040312>
- Ye, Z., Qin, N., Fu, S., Zhang, H., Zhu, C., Dai, S., ... & Li, J. (2025). Targeted metabolomic and transcriptomic analyses provide insights into flavonoid biosynthesis in the grain of *Foxtail millet*. *BMC Genomics*, 26(1), 610. <https://doi.org/10.1186/s12864-025-11780-x>
- Yuniarti, E., Noviyanti, E., Radiastuti, N., Kosasih, J., Aminah, S., Suryadi, Y., & Susilowati, D. N. (2023). Shallot growth and production responses to application of microorganisms based-biostimulant and NPK fertilizer combinations on acid soil. *IOP Conference Series: Earth and Environmental Science*, 1253(1), 012040. <https://doi.org/10.1088/1755-1315/1253/1/012040>