



Research Paper

Effect of Potassium Sulfate (K_2SO_4) and Chicken Manure Application on Productivity, Morphology, Physiology, and Antioxidant Activity of Shallots in Floating Cultivation

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Abstract

Shallot is one of the vegetable commodities that has long been intensively cultivated by farmers. In addition, shallots are also a short-lived and commercial vegetable commodity. This study aims to evaluate the application of chicken manure and potassium sulfate (K_2SO_4) fertilizer on the growth and yield of shallot plants (*Allium ascalonicum* L.) cultivated in a floating manner. This research was conducted in Terawas Village, STL ULU Terawas District, South Sumatra. From May to July 2024. This research method Factorial Randomize Block Design (RAKF), consisting of 2 factors, namely the first factor of chicken manure consisting of 4 levels, and the second factor is sulfur fertilizer from K_2SO_4 consisting of 4 levels. With 3 block, in each block it was 3 planted plants. 3 treatment groups and 3 replications each replication consists of 16 plant units, resulting in a total of 144 plants used in this study. This treatment is the first factor: P_0 = control (without chicken manure), P_1 = 1 kg/polybag chicken manure, P_2 = 2 kg/polybag chicken manure, P_3 = 3 kg/polybag chicken manure. Second factor: S_0 = control (without potassium sulfate fertilizer (K_2SO_4)), S_1 = potassium sulfate fertilizer (K_2SO_4) 100 kg/ha, S_2 = potassium sulfate fertilizer (K_2SO_4) 200 kg/ha, S_3 = potassium sulfate fertilizer (K_2SO_4) 300 kg/ha. Parameters observed included plant height, number of leaves, number of tillers, wet stover weight, tuber diameter, fresh tuber weight, wind-dried tuber weight, root length, tuber length, tuber number, tuber volume, hectare-1 production, chlorophyll analysis and flavonoid content. Dosing potassium sulfate fertilizer (K_2SO_4) with an optimal dose of 142.5 kg/ha on the variable of estimated production per/ha, 174 kg/ha on the variable of tuber weight, 210 kg/ha on the variable of tuber volume, 154 kg/ha on the variable of wind dry weight, 214.45 kg/ha on the variable of antioxidant activity (flavonoids).

Keywords

Shallots; Chicken manure; K_2SO_4

1. INTRODUCTION

Shallots (*Allium ascalonicum* L.) are an excellent horticultural commodity that is often consumed by the public as a cooking ingredient and spice. This commodity has many benefits and high economic value, and is included in the essential spice category which functions as a seasoning, serves as a flavoring seasoning. In addition to being a popular horticultural commodity among the community, shallots also have significant development potential to meet domestic and export needs (Hadiawati et al., 2018).

In shallot production centers, farmers have been trying to increase their production to get the most profit. This is due to the increasing demand for shallots each year (Suwandi, 2014). Despite the increasing demand for shallots, the supply cannot meet the demand (Sudaryono, 2017; Baka and Tematan, 2020). Shallots have many nutrients. In 100 grams of fresh shallots, there are 72 kcal calories, 79.80

grams of air, 16.80 grams of carbohydrates, 7.87 grams of sugar, 2.5 grams of protein, 3.2 grams of fiber, 0.1 grams of fat, 31.2 mg of vitamin C, and 9 IU of vitamin A (Rismayeni, 2019; Baka and Tematan, 2020). Besides having many benefits, shallot plants have a high selling value (Tandi et al., 2015).

Shallots contain various active chemical compounds that have pharmacological health effects as antioxidants, including: Diallyl-sulfide, phloroglucinol, kaempferol, aliiin, allisin, adenosine, diallyl-disulfide, diallyl-trisulfide, prostaglandin A1, diallyl-sulfide, polyphenols, flavanoids and cycloalliin (Rahayu et al., 2015; Jiang et al., 2024; Shahrajabian et al., 2020). Flavonoid compounds contained in shallot skin play an important role as antioxidants. Antibacterial, anti-inflammatory, and antioxidant potential in shallot skin due to the content of secondary metabolite compounds, one of which is flavonoids (Agustina et al.,

2016).

Planting media with organic matter content including compost, manure, and biochar function to help the availability of nutrients for plants (Idris et al., 2018). Research conducted by Baka and Tematan (2020) found that the parameters of plant height, number of new parents, and wet weight per sample were significantly influenced by the application of chicken manure 2 kilograms per polybag. Fertilizer application is one of the determining factors to increase the growth and yield of plants. Fertilization is one of the determining factors in efforts to increase plant yields. The use of fertilizers in accordance with the recommendations is expected to provide economic results (Syafria and Jamarun, 2021).

Potassium fertilizer is an alternative that can be used for plant fertilization. The potassium element in shallots functions to accelerate photosynthesis, growth and yield, increase disease resistance, and extend the storage period of shallots. The use of potassium fertilizer can increase the growth and yield of shallot plants (Al-Amri and Al-Abdaly, 2021). Shallot is a type of plant that requires high sulfur content. Sulfur content has an important role in plant metabolism on parameters that determine the quality of the plant. In shallot plants, the sharpness of the aroma will correlate with the availability of sulfur elements in the soil. Potassium fertilizer is an artificial fertilizer in the form of granules or powders with the chemical formula K_2SO_4 . Potassium sulfate has a K_2O content of 48-52% and a sulfur content of 18%, with a weak acidic nature and contains relatively low Cl so it is safe to use for Cl-sensitive plants such as onions, fruits and tobacco. Based on research, it has been obtained that the effective dose of K_2SO_4 for the growth and yield of shallot plants is 200 kg/ha (Gunadi, 2009).

The demand for shallots continues to increase every year with an average growth of 8.69% kg/capita/year. In the period 2014-2017, shallot production was successively 1,233,989 tons/ha, 1,229,189 tons/ha, 1,446,869 tons/ha, 1,470,155 tons/ha. Planting shallot planting has been carried out in almost all provinces in Indonesia, including South Sumatra. However, shallot production in South Sumatra has shown a downward trend in recent years. In 2018, shallot production in the province reached 1,443 tons per year, but declined to 1,390 tons per year in 2019, and further dropped drastically to 819 tons per year in 2020 (Badan Pusat Statistik Provinsi Sumatera Selatan, 2023). Therefore, efforts need to be made to increase shallot production in South Sumatra.

South Sumatra is a province that has a large amount of wetlands because most of its territory is swampy. There are about 285,941 ha of lebak swamp land and 273,919 ha of tidal swamp land in South Sumatra (Badan Pusat Statistik Provinsi Sumatera Selatan, 2023). This swampland has considerable potential to be developed as a shallot growing area. However, this is constrained by the condition

of the swampland which has a long period of inundation (Irmawati et al., 2015). This causes the land area cannot be used for crop cultivation activities.

An alternative solution to this problem is to utilize a floating agricultural system using rafts as a medium for growing plants. The application of the floating system in terms of maintenance has the potential to lead to organic farming. In plant cultivation activities using the floating system, the thing that needs to be considered is the use of inorganic chemicals that are feared will be able to pollute the water pool below. Based on research, shallot cultivation using a floating system produces more bulbs compared to conventional methods (Susilawati et al., 2021).

The productivity of shallot plants is not only determined by the availability of nutrients from the soil, by proper cultivation, and the type of variety used. Superior varieties have advantages compared to local varieties in terms of production and resistance to pests and diseases and response to fertilization, so that the production obtained both quantity and quality can increase (Syafruddin et al., 2012).

Based on this background, this study was conducted with the aim of evaluating the effect of sulfur fertilizer application on shallot plants of the Tajuk variety grown on chicken manure and sulfur media in a floating planting system.

2. RESEARCH METHODS

Place and Time

This research was conducted in Terawas Village, STL ULU Terawas District with an altitude of 56 meters above sea level the research time began in May - July 2024.

Tools and Materials

Tools that will be used in this study include: 1. Polybag size 30×30 ; 2. Used bottle raft; 3. Meter, 4. Mistar; 5. Digital vernier; 6. Camera; 7. Scales/Reference analytic; 8. hoe; 9. machete; 10. Oven and 11. UV-Vis Spectrophotometer. The materials used in this research are: 1. Chicken manure fertilizer; 2. Shallot bulbs of Tajuk variety; 3. Soil, 4. K_2SO_4 fertilizer; SP-36, KCl and NPK (16:16:16); 5. pesticides; 6. Shallot extract; 7. Ethanol.

2.1 Research Methods

The method used in this study was a randomized group factorial design (RAK-F) with 16 treatments and 3 replicates so that 48 treatment units were obtained. With 3 replicates then each replicate has 3 plants. So there are 144 treatment units. The first factor is the dose of manure fertilizer consisting of 4 levels, namely:

P_0 = (Control)

P_1 = Dose of Manure 1 kg/polybag (1:2)

P_2 = Dose of Manure 2 kg/polybag (1:1)

P_3 = Dose of Manure 3 kg/polybag (2:1)

The second factor is potassium sulfate fertilizer K_2SO_4 which consists of 4 levels, namely:

S_0 = (Control)

S_1 = 100 kg/ha (K_2SO_4 = 1.6 g/plant). S = 18 kg/ha

S_2 = 200 kg/ha (K_2SO_4 = 3.3 g/plant). S = 36 kg/ha

S_3 = 300 kg/ha (K_2SO_4 = 5.5 g/plant). S = 54 kg/ha

The research data will be analyzed using orthogonal polynomial variance using R studio and excel software. Further test using orthogonal polynomial regression and Tukey HSD (Honestly Significant Difference).

Preparation of planting material

The shallot seeds used are shallot seeds of the Tajuk variety which come from bulbs that are ready to be planted or cultivated.

Variables Observed

Plant height (*cm*), number of shallot leaves (strands), number of tillers (clumps) calculated starting from two weeks after planting until the eighth week, done once a week. Measurement of tuber diameter (*cm*) was carried out by measuring the diameter of the tuber using a digital caliper. Fresh Weight of Plant Bulbs (*g*), weighing is done during harvest and weighed using a digital scale. The dry weight of the plant air (*g*) is weighed after drying for 7 days and then weighed using a digital scale. Chlorophyll analysis was carried out twice, namely a week after treatment fertilization and one week after the second treatment fertilization by taking one leaf sample per plant, then tested in the physiology laboratory then chlorophyll extract was taken from the ependorf, then put into a new ependorf. Absolute ethanol was added until the volume was 1.5 ml, then shaken with a vortex to mix well. The chlorophyll extract was incubated at 4°C in a dark room for 30 minutes. The chlorophyll extract from the centrifuge (supernatant) was transferred to a 5mL cuvet. Chlorophyll content was measured by absorbance using a spectrophotometer at λ 649 nm and 665 nm. 96% ethanol was used as Wintermans and De Mots comparator.

$$\text{Chlorophyll a} = (13.7 \times A_{665}) - (5.76 \times A_{649})$$

Productivity is the calculation of the conversion of fresh tuber weight per plant.

Production hectare-1 (ton) =

$$\frac{\frac{\text{Land area (m)}}{\text{Planting distance}} \times \text{fres tuber weight (g)}}{100000}$$

Antioxidant levels in shallots are carried out in the agricultural product engineering laboratory. Testing of total flavonoid content was carried out based on the working method proposed by Amalia and Anggarani (2022) using quercetin as a standard. The preparation of quercetin standard solution was carried out at several concentration variations namely 10, 20, 30, 40 and 50 ppm. Thick extract of 60 mg was dissolved with 96% ethanol to a volume of 10 mL,

then pipetted as much as 500 μ L and added 1.5 mL ethanol p.a, 0.1 mL $AlCl_3$ 10%, 0.1 mL sodium acetate 1 M, and 2.8 mL distilled water. Then allowed to stand for 30 minutes and measured the absorbance using a UV-Vis Spectrophotometer at a wavelength of 435 nm with 3 repetitions. Data analysis in this study includes the conversion of absorbance results from the UV-Vis Spectrophotometer using a quercetin standard curve, followed by statistical tests (ANOVA or t-test) to determine differences between treatments. Software such as SPSS, R, or Excel can be used to facilitate data analysis and interpretation more accurately.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Plant height in shallot plants that are cultivated in a floating manner shows an increase in plant height from time to time. Table 2 shows the effect of manure application in various doses (0 kg, 1 kg, 2 kg, and 3 kg) on plant height during several observation periods (2nd week to 8th week). The dose of 2 kg of manure produced the highest plant height overall, especially at the observation of 6WAP to 8MST, with a maximum height of 39.4 cm at 8MST, indicating that this dose was optimal to support plant height growth. The 1 kg dose also gave good results, although lower than the 2 kg dose. And on the relationship between the dose of K_2SO_4 (potassium sulfate) fertilizer application and plant height at various observation ages (Week 2 to week 8). Increasing the dose of K_2SO_4 fertilizer from 0 kg/ha to 300 kg/ha showed varying effects on plant height. At 2 WAP (early observation age), plant height tended to be lower at higher fertilizer doses.

The 3 kg dose produced lower plant height than all other doses, especially in the early phase (week2 to week4). This could be due to the side effects of excess organic matter accumulation, such as increased salinity or soil saturation. Without manure (0 kg), plants still grew but less optimally than other treatments, indicating the importance of manure application. Manure contains essential nutrients (N, P, K) that support vegetative tissue formation and plant height increase (Kumar et al., 2017). Application of fertilizer at a dose of 2 kg provides the best combination for nutrient availability and soil balance, while excessive application (3 kg) can cause decreased performance due to nutrient stress (Zhang, 2019).

Increasing the dose of K_2SO_4 fertilizer from 0 kg/ha to 300 kg/ha showed variable effects on plant height. At week 2 (initial observation age), plant height tended to be lower at higher fertilizer doses. However, from week 6 to week 8, higher doses generally increased plant height until it peaked at 100 kg/ha. The 100 kg/ha dose produced the highest plant height consistently from week 6 to week 8 compared to the other doses. This indicates that fertilizer application at this dose provides optimal potassium for growth. This is in line with Wang et al. (2013), Potassium

Table 1. Average plant height 2-8 weeks after planting in chicken manure and potassium sulfate (K_2SO_4) fertilizer treatments

Treatment	Plant Height (cm)						
	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP	7 WAP	8 WAP
P0 0 (kg/plant)	12,1a	14,9a	20,0a	25,4a	28,1a	31,2a	33,4a
P1 1 (kg/plant)	13,7a	17,7a	24,3ab	27,9ab	33,6a	33,7b	35,3b
P2 2 (kg/plant)	13,7a	18,3ab	25,7b	29,2b	33,3b	36,8c	39,4b
P3 3 (kg/plant)	8,7b	12,9b	16,0c	19,7c	23,6c	26,8d	29,2c
S0 0 (g/plant)	12,7a	16,4a	20,8a	25,2a	29,1a	32,0ab	34,5a
S1 1,6 (g/plant)	12,5a	16,3a	21,6a	23,5a	29,4a	32,9a	35,5ab
S2 3,3 (g/plant)	12,1a	15,6a	22,3a	26,1a	30,1a	32,8a	34,4ab
S3 5,5 (g/plant)	10,9a	15,4a	21,0a	25,1a	27,7a	30,6b	32,8b

Description: Numbers followed by different letters in the same column are significantly different based on the 5% HSD test.

has an important role in water regulation, photosynthesis, and enzyme activation in plants. The application of K_2SO_4 can increase the efficiency of plant metabolism, thereby improving growth. At doses of 200 kg/ha and 300 kg/ha, plant height did not show a significant increase or even slightly decreased. This may be due to toxicity effects or nutritional imbalance due to excessive accumulation of potassium (Zörb et al., 2013). The graph shows a significant trend of plant growth as the age of the plant increases. All fertilizer treatments showed an increase in plant height at different rates. The optimal dose of potassium varies depending on the type of plant, soil conditions, and other environmental factors (Marschner and Marschner, 2012). The decrease in growth at doses of 200 kg/ha and 300 kg/ha is consistent in this graph.

3.2 Number of Tillers (Leaves)

The number of leaves on shallot plants that are cultivated in a floating manner shows an increase in plant height from time to time. Figure 3 shows the effect of manure application in various doses (0 kg, 1 kg, 2 kg, and 3 kg) on plant height during several observation periods (Week 2 to week 8). The dose of 2 kg manure produced the highest number of leaves overall, especially at the observation of 7 weeks after planting. And on the relationship between the application dose of K_2SO_4 (potassium sulfate) fertilizer and plant height at various observation ages (2nd week to 8th week). Increasing the dose of K_2SO_4 fertilizer from 0 kg/ha to 300 kg/ha showed varying effects on the number of leaves.

At the beginning of the observation (week 2 to week 4), the number of tillers increased slowly without significant differences between the fertilizer doses. Starting from week 5 to week 8, the 2 kg fertilizer dose produced the highest number of tillers compared to the other doses. The 3 kg

dose tended to produce a lower number of tillers than the 2 kg dose, although it remained higher than the control (0 kg). The 2 kg dose of manure showed the best results, especially in week 7 and week 8, with the number of tillers reaching 7.1 in week 8. This indicates that this dose provides balanced nutrients to support the growth of the number of tillers. Manure is a source of macro and micro nutrients that improve soil structure and support soil microbial activity, which contributes to plant growth and tiller production (Ahmad et al., 2019). The graph shows that the number of tillers continued to increase from week 2 to week 8 at all fertilizer doses, although the rate of increase varied according to the treatment. At the 3 kg dose, the decrease in the number of tillers began to appear from week 5. This may be due to nutrient saturation in the soil which inhibits root development and tiller growth. Excessive application of manure can lead to accumulation of salts or unbalanced nutrients, thus inhibiting growth (Zhang et al., 2020).

This table shows the relationship between the dose of K_2SO_4 fertilizer (0 kg/ha, 100 kg/ha, 200 kg/ha, and 300 kg/ha) and the number of tillers at various stages of observation age (Week 2 to week 8). At the beginning of the observation (week 2 to week 4), higher doses of K_2SO_4 fertilizer (200 kg/ha and 300 kg/ha) showed a lower number of tillers than the 0 kg/ha dose. Starting from week 5 to week 8, the 200 kg/ha fertilizer dose gave the highest number of tillers compared to the other doses, with significant differences especially at week 7 and week 8. The 200 kg/ha dose gave the best results from week 6 to week 8, producing 7.1 tillers in week 8. This indicates that this dose provides the optimal amount of potassium to support the development of lateral shoots and tillers (Wang et al., 2013). The 300 kg/ha dose produced a lower number of tillers than the 200 kg/ha dose. This may be due to toxicity or nutrient

Table 2. Average number of tillers 2-8 weeks after planting in chicken manure and potassium sulfate (K_2SO_4) fertilizer treatments

Treatment	Number of tillers (leaves)						
	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP	7 WAP	8 WAP
P0 0 (kg/plant)	3,7a	4,3a	4,5a	5,9a	6,0a	6,5a	7,0
P1 1 (kg/plant)	3,8a	4,3a	4,8a	5,8a	6,0a	6,5a	6,9
P2 2 (kg/plant)	3,8a	4,1a	4,6a	5,9a	6,3a	6,6a	7,1
P3 3 (kg/plant)	3,7a	3,9a	4,2a	5,4a	5,5a	5,8a	6,1
S0 0 (g/plant)	4,2a	4,4a	4,8a	5,6a	5,8a	6,3a	7,0
S1 1,6 (g/plant)	3,7a	4,0a	4,4a	5,4a	5,7a	6,1a	6,4
S2 3,3 (g/plant)	3,5a	4,0a	4,4a	6,1a	6,3a	6,7a	7,1
S3 5,5 (g/plant)	3,4a	3,9a	4,3a	6,0a	6,1a	6,3a	6,6

Description: Numbers followed by different letters in the same column are significantly different based on the 5% HSD test.

imbalance due to excessive accumulation of potassium in the soil.

3.3 Number of Leaves (strands)

The number of leaves on shallot plants that are cultivated in a floating manner shows an increase in plant height from time to time. Figure 3 shows the effect of manure application in various doses (0 kg, 1 kg, 2 kg, and 3 kg) on plant height during several observation periods (Week 2 to week 8). The dose of 2 kg manure produced the highest number of leaves overall, especially at the observation of 7 WAP. And on the relationship between the application dose of K_2SO_4 (potassium sulfate) fertilizer and plant height at various observation ages (Week 2 to week 8). Increasing the dose of K_2SO_4 fertilizer from 0 kg/ha to 300 kg/ha showed varying effects on the number of leaves.

Table 3 shows the effect of manure application in various doses (0 kg, 1 kg, 2 kg, and 3 kg) on the number of plant leaves at several observation times (week 3 to week 8). Overall, the number of leaves increased over time from week 3 to week 8 for all doses of manure. The most significant increase occurred between week 5 and week 6, reflecting the acceleration of vegetative growth during the active growth period of the plants. As early as week 3, differences between doses were minimal. This could be due to the initial effect of manure, which takes time to break down into available nutrients. From week 6 to week 8, it was seen that the 2 kg dose gave the highest number of leaves compared to the other doses, indicating that this dose was optimal. The highest dose (3 kg) appeared to produce lower leaf number growth than 2 kg, especially in week 7 and week 8. This may indicate the negative effects of excess fertilizer application, such as nutrient imbalance or environmental stress due to accumulation of organic matter. This is in line with research by (Laghari, 2018) showed that the use

of manure at optimal levels can increase leaf growth and vegetative biomass of plants by providing nutrients in a sustainable manner. However, over-dosing can cause nutrient saturation and decrease oxygen availability in the soil, which is consistent with the graphical results at a dose of 3 kg. The highest increase in the number of leaves at a dose of 2 kg at week 6 to week 8 indicates the ability of manure to provide sufficient nutrients during that period. At a dose of 0 kg (control), although the number of leaves also increased, the value remained lower than the treatment with manure, indicating the importance of nutrients for plant growth.

This graph illustrates the relationship between the application of K_2SO_4 fertilizer at various doses (0 kg/ha, 100 kg/ha, 200 kg/ha, and 300 kg/ha) to the number of plant leaves in several time periods (week 2 to week 8). In general, the number of leaves showed an increase from M2 to M8 for all fertilizer doses. This reflects the physiological development of the plant over time. At the higher fertilizer dose (300 kg/ha), the number of leaves was greater than the lower dose, especially in the final phase of observation (M7 and week 8). K_2SO_4 fertilizer contains potassium and sulfur, which are essential for photosynthesis, nitrogen metabolism and protein formation. Based on the graph, increasing the dose of K_2SO_4 seems to support the vegetative growth of plants, such as the number of leaves (Ahmad et al., 2019). At a dose of 300 kg/ha, plants reached the highest potential number of leaves, but lower doses (100 kg/ha and 200 kg/ha) also gave significant results compared to the control (0 kg/ha). At the beginning of growth (week 2 to week 4), the difference between doses was not very significant. However, from week 5 to week 8, the increase in the number of leaves with fertilizer dose was more obvious. Marschner and Marschner (2012) explained that potassium plays an important role in the regulation of stomata and

Table 3. Average number of leaves 2-8 weeks after planting in chicken manure and potassium sulfate (K_2SO_4) fertilizer treatments

Treatment	Number of Leaves (strands)						
	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP	7 WAP	8 WAP
P0 0 (kg/plant)	12,21a	12,97a	16,63a	20,02a	23,30ab	26,16a	29,74ab
P1 1 (kg/plant)	11,94a	12,85a	15,52a	20,08a	23,57a	26,35a	29,80ab
P2 2 (kg/plant)	10,96a	11,30a	14,85a	16,85b	21,44ab	25,49a	30,88a
P3 3 (kg/plant)	10,53a	11,46a	14,99a	17,16b	20,71b	24,38a	27,27b
S0 0 (g/plant)	11,96a	12,83a	16,19a	19,85a	23,70a	26,60a	30,16a
S1 1,6 (g/plant)	11,02a	12,08a	16,05a	18,85a	22,41a	25,85a	29,69a
S2 3,3 (g/plant)	10,96a	12,02a	15,22a	17,77a	21,49a	25,16a	29,30a
S3 5,5 (g/plant)	10,83a	11,66a	14,74a	17,63a	21,41a	24,77a	28,55a

Description: Numbers followed by different letters in the same column are significantly different based on the 5% HSD test.

the process of photosynthesis, which directly affects leaf growth.

3.4 Bulb Diameter (mm)

Fertilization of chicken manure and potassium sulfate fertilizer in shallot floating cultivation significantly ($P < 0.001$) affected the diameter of the bulbs. The 2kg chicken manure treatment ($1.48 \text{ mm plant}^{-1}$) was significantly different from the other treatments with the lowest bulb diameter in the 3kg chicken manure treatment ($1.01 \text{ mm plant}^{-1}$) and in the 3.3 gr/plant potassium sulfate fertilizer treatment ($1.28 \text{ mm plant}^{-1}$) which was not significantly different from the other treatments with the lowest bulb diameter in the 5.5 gr/plant potassium sulfate fertilizer treatment ($1.10 \text{ mm plant}^{-1}$). The tuber diameter can be moderately predicted from the addition of potassium sulfate dose in floating cultivation with a quadratic equation $y = -0.0156x^2 + 0.0802x + 1.1403$ ($R^2 = 0.6691$) (Figure 1A) while the tuber diameter can be moderately predicted from the addition of chicken manure dose in floating cultivation with a quadratic equation $y = -0.0953x^2 + 0.2831x + 1.0873$ ($R^2 = 0.2693$) (Figure 1B)

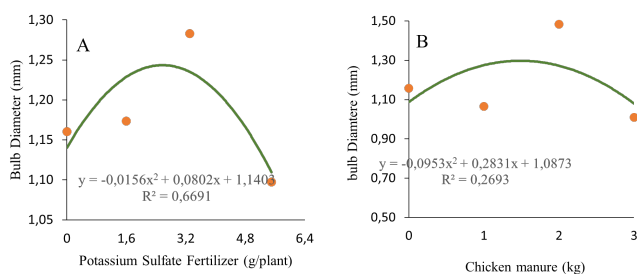


Figure 1. Orthogonal polynomial regression test results of potassium sulfate fertilizer (A) and manure (B)

Tuber diameter increased with higher fertilizer doses up to an optimal level. Manure was more effective than sulfur, as it gradually releases nutrients, improves soil structure, and enhances photosynthesis. Its organic matter improves water retention and cation exchange capacity, leading to larger and heavier tubers (Rizwan, 2019). Sulfur supports protein synthesis and enzyme activity (Gunes, 2014), but its effectiveness depends on other nutrient availability. The increase in tuber size indicates that both organic matter and sulfur contribute to the accumulation of photosynthates in the tuber (Hanifah, 2020).

3.5 Weight of Fresh Tubers (g) and Weight of Wind-Dried Tubers (g)

Based on the analysis of variance, the interaction between chicken manure and potassium sulfate fertilizer had no significant effect on the fresh or wind-dried bulb weight of the plants. However, the application of chicken manure alone showed notable results. The highest fresh tuber weight was observed in the P2 treatment (2 kg of chicken manure), with an average of 54.47 g, while the lowest was in the treatment without chicken manure (3 kg), averaging 16.05 g. For wind-dried tuber weight, the highest value was also recorded in the P2 treatment, with an average of 45.30 g, and the lowest was in the treatment without chicken manure (3 kg), averaging 15.38 g (Figure 2). In terms of potassium sulfate application, the highest fresh tuber weight was observed in the S2 treatment, with an average of 35.11 g, while the lowest was in the control (no potassium sulfate), averaging 29.80 g. For wind-dried tubers, the highest weight was again in S2, averaging 32.38 g, whereas the lowest was in the S3 treatment (5.5 g potassium sulfate per plant), with an average of 20.77 g.

The graph shows the relationship between fertilizer dose (kg/ha) and tuber weight with the manure and sulfur

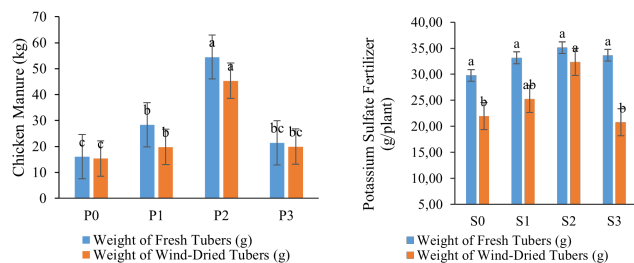


Figure 2. Results of orthogonal polynomial regression test of wind dry weight as influenced by potassium sulfate fertilizer and chicken manure

treatments analyzed. The analysis showed different effects between the two treatments on tuber weight. The regression equation y of manure showed that the variability of manure dose had almost no effect on tuber weight. This indicates that manure application at various dose levels (0-300 kg/ha) did not significantly increase tuber weight. Previous research mentioned that manure generally plays a more role in improving long-term soil fertility by improving organic matter content and soil structure (Anwar et al., 2019). showed a more significant relationship. Increasing sulfur dosage up to about 175-200 kg/ha resulted in an increase in tuber weight. After this point, increasing doses showed a downward trend in tuber weight, which could indicate toxicity effects due to excess sulfur accumulation. Sulfur is a secondary nutrient essential for protein synthesis, chlorophyll formation, and plant metabolism (Kumar et al., 2017). However, high sulfur levels can cause stress in plants, reduce photosynthetic efficiency, and potentially damage soil structure due to increased acidity (Scherer, 2001).

The graph illustrates the effect of fertilizer dosage on the wind-dry weight of plants. Wind-dry weight increases with higher fertilizer doses up to an optimal point, after which it declines. This suggests that there is a specific dose that yields the best results. The plants responded more positively to manure than to sulfur fertilizer. Manure produced higher wind-dry weights at certain doses, likely due to its organic matter content, which enhances soil quality and supports vegetative growth. At higher fertilizer levels, the wind-dry weight declined, possibly due to nutrient toxicity or imbalances in the soil. The response curve demonstrates fertilizer use efficiency, indicating that the optimal dose maximizes wind-dry weight before it starts to decrease. Manure contains a variety of macro and micronutrients that are released slowly, promoting root development and overall plant biomass (Rizwan, 2019). It also improves soil porosity and water retention. Sulfur plays a key role in protein synthesis and the formation of essential plant compounds, but excessive amounts can disrupt the balance of other nutrients like nitrogen and phosphorus (Marschner and Marschner, 2012).

3.6 Flavonoids

Fertilization of chicken manure and potassium sulfate fertilizer in shallot floating cultivation significantly ($P < 0.001$) affected flavonoids. The treatment of 2kg chicken manure (213.69) was significantly different from other treatments with the lowest flavonoids in the treatment without chicken manure 100.60 (Figure 3A) and in the treatment of potassium sulfate fertilizer 3.3 g/plant (162.58) which was significantly different from other treatments with the lowest flavonoids in the treatment without potassium sulfate fertilizer 110.30 (Figure 3B). Flavonoids can be moderately predicted from the addition of chicken manure fertilizer dose with floating cultivation with a quadratic equation $y = -27.627x^2 + 97.063x + 85.861$ ($R^2 = 0.483$) (Figure 3A) while tuber diameter can be moderately predicted from the addition of potassium sulfate fertilizer dose in floating cultivation with a quadratic equation $y = -3.6203x^2 + 26.155x + 106.31$ ($R^2 = 0.8396$) (Figure 3B).

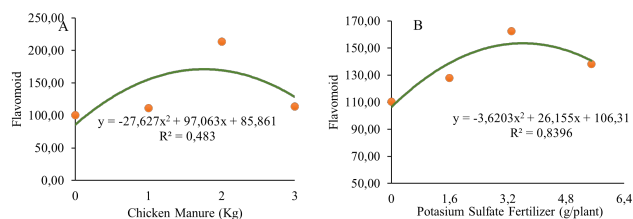


Figure 3. Results of orthogonal polynomial regression test of flavonoids as influenced by the application of chicken manure (A) and potassium sulfate fertilizer (B)

This relationship is weaker than that of manure, which means that sulphur fertilizer does not affect flavonoid levels as much. Manure showed a more significant effect on increasing flavonoid levels than sulfur fertilizer. This can be seen from the higher R^2 value, although both have the same relationship pattern. Optimal range In case of manure, a dose of about 200 kg/ha seems to give the maximum flavonoid levels before a decline occurs. Manure, having a high organic matter content, often increases levels of secondary metabolites (such as flavonoids) as it provides nutrients gradually and improves soil conditions (Parsa, 2022). Sulfur, although important in the synthesis of secondary compounds, may require interaction with other elements for optimal results (Gunes, 2014).

3.7 Estimated Production hectare⁻¹

Fertilization of chicken manure and potassium sulfate fertilizer in shallot floating cultivation significantly ($P < 0.001$) affected production hectare⁻¹. The highest chicken manure treatment was 2kg (11.25 tons ha⁻¹) which was significantly different from the other treatments with the lowest hectare-1 production in the 3kg chicken manure treatment (4.90 tons ha⁻¹) and the highest potassium sulfate

fertilizer treatment was 3.3 gr/plant (7.42 tons ha⁻¹) which was significantly different from the other treatments with the lowest hectare-1 production in the treatment without potassium sulfate (5.91 tons ha⁻¹). Tuber diameter can be moderately predicted from the addition of potassium sulfate dose in floating cultivation with quadratic equation $y = -1.7847x^2 + 5.8444x + 4.2437$ ($R^2 = 0.5098$) (Figure 4A) while tuber diameter can be moderately predicted from the addition of chicken manure dose in floating cultivation with quadratic equation $y = -0.082x^2 + 0.7003x + 5.8389$ ($R^2 = 0.9473$) (Figure 4 B).

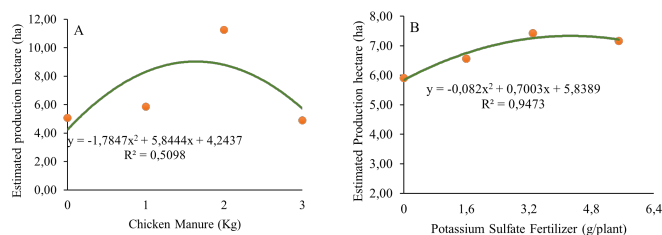


Figure 4. Results of orthogonal polynomial regression test of flavonoids as affected by the application of chicken manure (A) and potassium sulfate fertilizer (B)

The graph shows that the response pattern of production per ha increases with the addition of fertilizer dose, both manure and sulphur, until it reaches a certain dose. The application of sulphur significantly affects shallot production per hectare. Treatments with optimal levels of sulphur resulted in increased production up to a peak before declining at higher doses, indicating toxicity effects or nutrient imbalances. Sulfur application supports essential metabolism, such as protein synthesis, chlorophyll and other metabolites, which directly affect photosynthesis and growth. The graph shows the increase in production per hectare as the sulfur dosage increases up to the optimum point. The optimum dose of sulfur fertilizer was 142.5 kg/ha while that of manure was 146 kg/ha. After reaching this dose, production tends to decrease, indicating toxicity effects or nutrient imbalance. The relationship between sulfur dose and yield followed a quadratic pattern, indicating an initial increase followed by a decrease at higher doses. Manure is rich in organic matter and micro-nutrients that are released slowly, improving soil fertility and supporting root growth and nutrient uptake (Rizwan, 2019). Manure has an effect on shallot production, similarly to sulfur fertilizer (K₂SO₄) Manure can work synergistically with sulfur, where increased soil organic content helps plants utilize sulfur more effectively, increasing chlorophyll and photosynthesis (Hanifah, 2020). The combination of manure and sulfur improves soil structure, maximizing root spread and sulfur uptake efficiency (Mukhim et al., 2019).

CONCLUSION

This study shows that the application of chicken manure and potassium sulfate fertilizer (K₂SO₄) influences the growth and yield of shallot plants cultivated using a floating method. Among the various treatment combinations tested, the combination of 2 kg/ha of chicken manure and 200 kg/ha of potassium sulfate fertilizer produced the best results, with significant improvements in several growth and yield parameters, including plant height, number of tillers, fresh tuber weight, tuber diameter, and yield per hectare. Additionally, this treatment also showed a positive effect on the flavonoid content in the plants, which can contribute to the overall quality of shallots. Therefore, this combination can be recommended for floating shallot cultivation to optimize yield and production quality.

Research Suggestions

Further research can be conducted with a wider variation of chicken manure and potassium sulfate doses to determine the optimal dosage under different environmental conditions. Additionally, it is recommended to evaluate the effectiveness of this fertilizer combination in different cultivation methods, such as conventional fields or hydroponics, and to analyze its long-term impact on tuber quality.

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