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# Appplication of Biochar and Rice Husk Ash to sulfur Absorption, Growth and Production of Shallots Plant (*Allium ascalonicum* L.)

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**Abstract:** Soil fertility decline and sulfur deficiency are major constraints in shallot (*Allium ascalonicum* L.) cultivation, especially in sandy soils with low cation exchange capacity. Biochar and rice husk ash are potential soil amendments known to improve soil structure, nutrient availability, and crop productivity. This study aimed to determine the effect of rice husk biochar and rice husk ash on the growth, yield, and sulfur uptake of shallots. A factorial experiment was conducted using a Randomized Group Design (RGD) with two factors: biochar and rice husk ash, each at three dose levels. Results showed that biochar application improved the number of leaves, number of tillers, and bulb weight per unit, while rice husk ash had a limited effect, mainly enhancing leaf number at early growth. No significant interaction between the two amendments was observed across measured parameters, including sulfur uptake. These findings suggest that biochar contributes more effectively to shallot growth and yield than rice husk ash under the tested conditions. Further studies are recommended to optimize the combined use of organic amendments and to explore their long-term effects on soil nutrient dynamics and crop performance.

**Keywords:** Biochar; Growth; Rice husk ash; Shallot; Sulfur uptake; Yield

## Introduction

Now, soil fertility and nutrient depletion are the biggest threats and challenges for farmers. And the harvesting process is one of the factors of soil nutrient deficiency (Li et al., 2022). Carbon is one of the most important nutrients contained in the soil to reduce the concentration of $CO_2$ in the atmosphere and increase soil fertility (Gamage et al., 2016). So that the crops obtained will also increase and produce considerable profits for farmers. Therefore, now the right tools are needed to reduce the threat of damage to the land (Amoah-Antwi et al., 2020).

Each type of land has a different cation exchange capacity (CEC). As in sandy soil, it has a lower cation exchange capacity (CEC) so that the negative charge to hold other cations will be less (Razzaghi et al., 2021; Volf et al., 2022).

Biochar is a carbon-rich solid material produced from the conversion of organic waste (agricultural biomass) through incomplete combustion or pyrolysis at a temperature of 250–350 °C depending on the type of biomass and combustion equipment used. Biochar functions as a soil improver, biochar that is put into the soil does not decompose so that it can stay in the soil for a long time. Biochar is also useful for mitigating climate change and global warming, and has a control effect on various plant diseases. The best source of biochar raw materials is organic waste, especially agricultural waste, such as wood waste from somil and furniture, even livestock manure and rice husks can also be utilized to become biochar (Juwanda et al., 2023).

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Organic matter derived from biochar will undergo physiochemical changes and the organic matter contained in biochar will be produced so as to produce biochar that is oxidized on the surface to molecular benzene polycarboxylic acids (Mia et al., 2017). In addition, Biochar also contains aromatic organic substances that are not volatile and easily condensed (Al Naggar et al., 2018).

Soil replacement media that are usually used are vermiculite, perlite, coconut fiber, peat, compost, firewood ash, and rice husks (Chang et al., 2023). In addition, media can also be added to the soil. As said by Karimi et al. (2020), Nepal et al. (2023), and Singh et al. (2022), that the addition of Biochar to the soil can improve soil quality to be more fertile because it affects the physical, chemical, and biological properties of the soil. According to Asadi et al. (2021), various biomass feedstocks such as plant residues, wood-based materials, green waste, animal manure and also agricultural waste such as rice husk can be utilized in producing rice biochar. Through the pyrolysis process by converting waste into rice biochar can produce benefits such as energy production, sustainable waste recycling, and carbon sequestration, improved soil quality and better plant growth.

Biochar has many benefits, namely it can reduce leaching of nitrate and phosphorus nutrients which act as biological stimulants in the soil, can strengthen roots and can also suppress diseases on the roots, can reduce the effects of greenhouse gas use. Biochar has so many benefits for the soil because biochar contains nutrients such as potassium and contains a high enough pH, so it can increase productivity in plants. But in some tests when used as a planting medium, the nutrients in the soil are taken into account. And so is the ph of biochar. The high pH of biochar is considered and the amount of lime in biochar is also reduced or even eliminated when it is added (Prasad et al., 2019).

Biochar is often used not only as a tool to improve the quality of soil but also to minimize environmental pollution problems that come from polluted waste in soil and plants (Gonzaga et al., 2022). Beckers et al. (2019) also stated that one example of contamination that occurs is Hg contamination of soil (Zhao et al., 2020) and also arsenic contamination which is very dangerous for plants (Alam et al., 2020). It happens because of the use of chemical fertilizers and pesticides that are harmful to the soil (Hemowng et al., 2021) or the use of inorganic fertilizers over a long period of time so that the soil will experience problems with its nutritional content (Karam et al., 2022). Thanks to the induction of systematic resistance, biochar can help reduce deficiencies in plants (Jaiswal et al., 2020) and it is also often referred to as a plant growth analyzer. In addition, the use of biochar can be used as a means of sequestering carbon in the soil so as to offset anthropogenic carbon dioxide ($CO_2$) emissions in the soil (Clough et al., 2013).

The application of biochar to the soil can make changes to soil properties. This is due to the reaction of nutrients and also the transformation of nutrients with microbes (Hossain et al., 2020). In addition, the addition of biochar can also increase the base cations that can later be exchanged so that the cation exchange capacity will be more effective and have base saturation in the soil which will also increase (Munera-Echeverri et al., 2018).

The benefits of applying biochar on the ground can reduce residues in organochlorine, organosulfate and carbamate pesticides. Residues that are reduced in the application of biochar, which is around 70-90%. The concentration of residues in agricultural products can be minimized by reducing the concentration of pesticide residues in the soil. Adding rice husk charcoal can have a significant effect on tuber volume. A good dose of rice husk charcoal is 20 tons ha-1 in shallots (Jali et al., 2022).

However, some types of biochar may also have a direct impact on soil biota and greenhouse gas effects (Molnar et al., 2016). One of the effects of using biomass itself is that it can neutralize $CO_2$ gas (Armynah et al., 2018) and is environmentally friendly. So that it makes many farmers become interested in the application of the use of biochar on agricultural land (Masresha et al., 2018). In addition, rice husk can be made into rice husk ash by burning, which is rich in nutrients such as potassium, phosphorus, magnesium, and calcium. Rice husk ash has benefits as a planting medium, soil improver, and source of nutrients for plants. Rice husk ash can also increase the porosity and structure of the soil, encourage the growth of microorganisms that can benefit plants, and can fertilize the soil and plants. In addition, the benefits of rice husk ash are as a source of energy, as a basic material in the manufacture of silica gel and also in the manufacture of charcoal (Manik, 2020).

The use of rice biochar on agricultural land will continue to be in demand. That is because biochar can be used as a tool to sequester carbon in the soil, can reduce emissions from the use of greenhouse gases, and can increase plant growth. While biochar has many benefits for the soil, it also has direct and indirect effects on its soil parameters. And it can affect the fate of nutrients in the terrestrial environment. One of the chemical effects is the availability of macro-nutrients (Nitrogen, Phosphorus, Potassium, Calcium) and micro-nutrients (Magnesium and Zinc). In addition, the chemical effect of using biochar is that it can change the Ph in the soil, redox, capacitate cation exchange and the occurrence of reactivity or sorption on the surface. The physical effect of using biochar is to modify the structure of the pore surface and bulk density which can cause changes in the dynamics of water and gas (Macdonald et al., 2014).

The use of biochar in conservation tillage is one of the agricultural strategies that can increase the organic carbon content in soil mixtures and biochar. This strategy has many environmental and economic benefits to the farming system. Combined application of crop residues and biochar can reduce the rate of soil organic matter turnover by 2-5 times compared to soil not mixed with biochar (Ding et al., 2023). Efforts to increase the productivity of horticultural crops such as soybeans, corn, cayenne pepper, and shallots can be done in many ways, including cultivation techniques. One of the appropriate cultivation techniques to increase the productivity of horticultural crops is by fulfilling the nutrient needs of plants through fertilization either using organic materials such as biochar fertilizer and rice husk ash or inorganic materials (Siregar et al., 2017).

Shallots are one of the horticultural commodities needed by the people of Indonesia. The need for shallot consumption continues to increase, characterized by large imports and fluctuating shallot prices in the market. In 2022, domestic shallot consumption in Indonesia increased by 8.33% compared to 2021. Onion consumption by the community increased in 2022 to an estimated 790.63 thousand tons (Indonesia, 2023). One way to increase the growth of shallot plants is by maintaining the productivity of the land which can be done by applying biochar and rice husk ash to the land (Jali et al., 2022).

Soil fertility degradation and nutrient depletion—especially sulfur (S) deficiency—pose serious challenges to sustainable shallot (*Allium ascalonicum* L.) production in tropical regions. Sandy soils, which dominate many agricultural areas in Indonesia, are characterized by low water-holding capacity, poor nutrient retention, and low cation exchange capacity (CEC), contributing to suboptimal plant growth and yield. Sulfur, a key macronutrient in protein synthesis and enzymatic activity, is often under-applied or leached easily from such soils.

To address this, biochar and rice husk ash have gained attention as promising organic amendments. Biochar, produced through pyrolysis of agricultural biomass, is known to enhance soil physical and chemical properties by improving CEC, moisture retention, and microbial activity. Rice husk ash, a by-product of rice milling, is also rich in silica and basic cations that can potentially improve soil fertility.

The novelty of this research lies in evaluating the combined and separate effects of biochar and rice husk ash on sulfur uptake and shallot productivity under field conditions—an area that remains underexplored in Indonesian sandy soils. Most previous studies have focused only on one amendment or did not assess S uptake specifically.

This study is important to support sustainable shallot cultivation by identifying eco-friendly and locally available soil amendments that can enhance growth, yield, and nutrient efficiency, while reducing dependency on synthetic fertilizers. The findings are expected to provide insights for smallholder farmers and agricultural policymakers aiming to improve soil health and food security through low-cost organic inputs. So based on the description above, the researcher concluded that the researcher was interested in conducting this study with the title "Application of Biochar and Rice Husk Ash to Sulfur Uptake, Growth and Production of Shallot Plants (*Allium ascalonicum* L.)".

## Method

This research was conducted on Jalan Glugur Rimbun - Diski Dusun III Glugur Kuta, Village, Sawit Rejo, Kec. Kutalimbaru, Deli Serdang Regency, North Sumatra which is located at 3°32'4.2'' LU and 98°33'12.2'' BT and has an altitude of ± 46 meters above sea level (masl). while the analysis of soil, rice biochar and rice husk ash were carried out at the Laboratory PT. Socfin Indonesia. The method used in this study was a factorial Randomized Group Design (RAK) method consisting of 2 factors studied and 3 replications. The first factor is rice husk biochar (B), consisting of 3 levels, namely B1 = 600 gr/plot (equivalent to 5 tons/ha), B2 = 1200 gr/plot (equivalent to 10 tons/ha), B3 = 1800 gr/plot (equivalent to 15 tons/ha). The second factor is rice husk ash (A), which consists of three levels: A1 = 60 gr/plot (equivalent to 0.5 tons/ha), A2 = 120 gr/plot (equivalent to 1 ton/ha), A3 = 180 gr/plot (equivalent to 1.5 tons/ha). Analytical methods on soil were SOC-LA/IK/12 (potentiometry), HNO3 with HNO3 spectophotometer with AAS, SOC-LA/IK/09 (Walkley & black), SOC-LA/IK/07 (Kjehldald), calculation, and SOC-LA/IK/10 (ammonium acetate). Analytical methods on rice biochar are gravimetry with furnace, H20 (1:5)-Electrometry, Amm. Acetate Ph 7 with spectrophotometer, turbidimeter, and dry ashing-HCL with AAS. The analysis methods on rice husk ash were H2O (1:5)- Electrometry, turbidimeter, and dry ashing-HCL with AAS. Data were analyzed using analysis of variance and Duncan's test.

The variables observed were plant height (cm), number of tillers per clump, wet weight per tuber, dry weight per tuber, sulfur uptake.

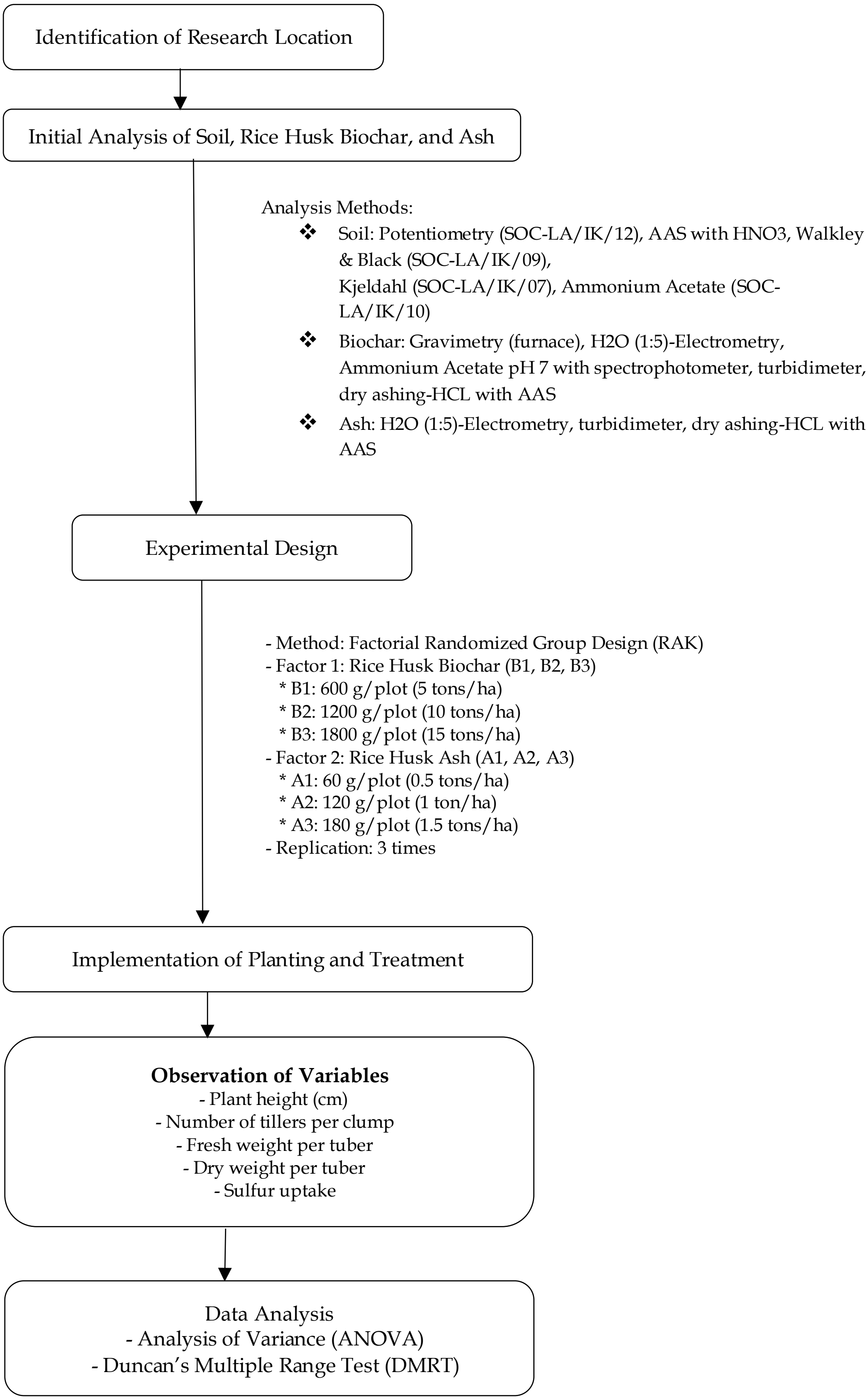


**Figure 1.** Flowchart Research

## Result and Discussion

*Research Results*

*Analytical Results of Soil, Biochar and Rice Husk Ash and Rice Husk Ash*

The results of soil analysis, biochar and rice husk ash and rice husk ash can be seen in the Table 1 below.

**Table 1.** Analytical results of soil, biochar and rice husk ash and rice husk ash

| Parameters | Land | Rice Biochar | Rice Husk Ash |
|---|---|---|---|
| C-organic (%) | 3.36 (T) | 30. 92 (ST) | - |
| N-Total (%) | 0.26 (S) | - | - |
| P-Total (%) | 0.22 (SR) | - | - |
| K (%) | 0.03 (R) | 0.56 (S) | 1.19 (T) |
| pH-H20 | 4.15 (SM) | 8.00 (AA) | 9. 92 (A) |
| S-Total (%) | 2.85 | 25. 20 | 36.58 |
| KTK (%) | 22.36 me/100g (S) | 27.94 me/100 g (T) | - |
| Ca (%) | - | - | 0.23 (SR) |
| Base Saturation (%) | 0.56 (SR) | - | - |
| K-Exchange (%) | 0.18 me/100 g (R) | - | - |

Source: PT Socfin Indonesia Laboratory 2024.

Description = Soil quality standard, Rice Biochar and Rice Husk Ash Low (R), Very Low (SR), High (T), Very High (ST), Alkalis (A), Somewhat Alkalis (AA), Very Acidic (SM), Moderate (S).

In Table 1 it can be concluded that the content of the soil is C-organic (3.36%) means High, N-total (0.26%) means Medium, P-total (0.22%) means Very low, S-total (2.85%) and soil pH 4.15 means very acidic. The content of rice biochar C-Organic (30.92) means very high, K-total (0.46%) means medium, while the content of rice husk ash K-total (1.19%) means high, Ca (0.23%) means very low.

*Crop Height*

In Table 2, it can be seen that the average height of shallot plants has an influence on the application of biochar and different rice husk ash. The highest average in the application of rice biochar was at the age of 5 weeks after planting with level B2 (33.33 cm), while the smallest average was at the age of 5 weeks after planting with level B1 (31.86 cm). The highest average in the application of rice husk ash was at the age of 5 weeks after planting with level A1 (33.23 cm), while the smallest average was at the age of 5 weeks after planting with level A3 (31.53 cm). The second highest average in the treatment interaction was at the age of 5 weeks after planting with the combination of B2A1 (33.72 cm) and the lowest average was at the age of 5 weeks after planting with the combination of B3A3 (30.50 cm).

**Table 2.** Average of crop height of shallot with different biochar and rice husk ash application at age 2, 3, 4 and 5 MST

| Treatments | Crop Height (cm) | | | |
|---|---|---|---|---|
| | 2 MST | 3 MST | 4 MST | 5 MST |
| B1 | 19.36 | 26.23 | 30.74 | 31.86 |
| B2 | 19.35 | 27.54 | 30.86 | 33.33 |
| B3 | 18.46 | 26.30 | 29.75 | 32.05 |
| A1 | 19.50 | 27.58 | 31.06 | 33.23 |
| A2 | 19.08 | 26.63 | 30.28 | 32.48 |
| A3 | 18.58 | 26.26 | 30.00 | 31.53 |
| B1A1 | 19.66 | 26.73 | 30.61 | 32.34 |
| B1A2 | 18.84 | 26.27 | 30.33 | 31.89 |
| B1A3 | 19.57 | 26.90 | 31.29 | 31.35 |
| B2A1 | 20.02 | 28.18 | 30.98 | 33.72 |
| B2A2 | 19.09 | 27.31 | 30.99 | 33.53 |
| B2A3 | 18.95 | 27.14 | 30.60 | 32.74 |
| B3A1 | 18.83 | 27.84 | 31.60 | 33.63 |
| B3A2 | 19.33 | 26.31 | 29.52 | 32.03 |
| B3A3 | 17.23 | 24.75 | 28.12 | 30.50 |

*Number of Tillers per Clump*

**Table 3.** Average number of tillers per clump of shallot plants with different biochar and rice husk ash at age 2, 3, 4 and 5 weeks after planting

| Treatment | Number of tillers (tubers) | | | |
|---|---|---|---|---|
| | 2 MST | 3 MST | 4 MST | 5 MST |
| B1 | 4.44 | 4.64 | 4.91a | 5.24a |
| B2 | 4.11 | 4.29 | 4.49ab | 4.82ab |
| B3 | 3.67 | 3.89 | 4.02b | 4.33b |
| A1 | 3.87 | 4.18 | 4.49 | 4.49 |
| A2 | 4.38 | 4.89 | 4.98 | 5.42 |
| A3 | 3.98 | 4.19 | 4.50 | 4.57 |
| B1A1 | 4.33 | 4.47 | 4.73 | 4.93 |
| B1A2 | 4.60 | 4.80 | 5.00 | 5.40 |
| B1A3 | 4.40 | 4.67 | 5.00 | 5.40 |
| B2A1 | 4.20 | 4.40 | 4.53 | 4.87 |
| B2A2 | 4.33 | 4.53 | 4.73 | 5.00 |
| B2A3 | 3.80 | 3.93 | 4.20 | 4.60 |
| B3A1 | 3.07 | 3.53 | 3.67 | 3.93 |
| B3A2 | 4.20 | 4.47 | 4.53 | 4.87 |
| B3A3 | 3.47 | 3.67 | 3.87 | 4.20 |

In Table 3, it can be concluded that the application of biochar fertilizer can significantly affect the number of tillers on plants. The highest average B1 with an average (5.24 tillers) is not significantly different from B2 (4.82 tillers) and significantly different from treatment B3 (4.33). The application of rice husk ash can have no significant effect on the number of tillers, the highest average is in the A2 treatment (5.42 tillers) and the lowest is in the A1 treatment (4.49 tillers). The interaction between biochar fertilizer and rice husk ash had no significant effect on the number of tillers.

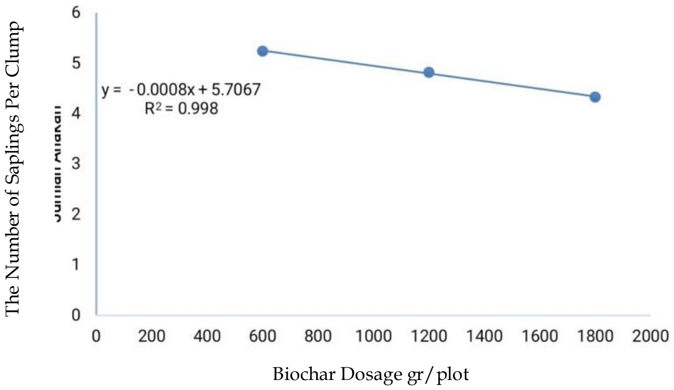


**Figure 2.** The effect of rice biochar dosage on the number of saplings per clump in shallot plants at the age of 5 weeks after planting

In Figure 2 shows that the effect of the dose of rice biochar and rice husk ash has a significant effect on the number of tillers per clump on shallot plants. The results showed that the higher the dose of rice biochar and rice husk ash, the more the number of tillers per clump on shallot plants.

*Wet Weight Per Tuber (Gram)*

**Table 4.** Average wet weight per bulb of shallot plants with different applications of biochar and rice husk ash

| Treatment | Dose of Rice Husk Ash (gr) | | | Average |
|---|---|---|---|---|
| Dose of Biochar | A1 | A2 | A3 | |
| B1 | 4.74 | 4.31 | 6.13 | 5.06b |
| B2 | 7.03 | 6.47 | 6.64 | 6.71ab |
| B3 | 7.88 | 7.30 | 8.30 | 7.83a |
| Average | 6.55 | 6.03 | 7.02 | |

Description: The number followed by the same letter in the same column and treatment group means no different at the 5% Duncan test level.

In Table 4, it can be concluded that the effect of rice biochar application on wet weight per bulb in shallot plants is obtained with the highest average value at level B3 (7.83 gr) with a treatment dose of 1800 gr/plot has a significantly different effect from B1, but has an effect that is not significantly different from B2. At the lowest average value at the B1 level (5.06 gr). The highest average of the two interactions has a treatment found in the combination of B3A3 (8.30 gr) and the lowest average value is found in the combination of B1A2 (4.31 gr).

In Figure 3, it can be seen that the application of rice husk ash at a dose of 1800 gr/plot has produced a wet weight per bulb in shallot plants of 7.83 gr. Table 4 shows that the application of rice husk ash can have an unreal effect on the wet weight per bulb in shallot plants, but the highest average value was obtained in the A3 treatment (7.02 gr) and the lowest average value in the A2 treatment (6.03 gr).

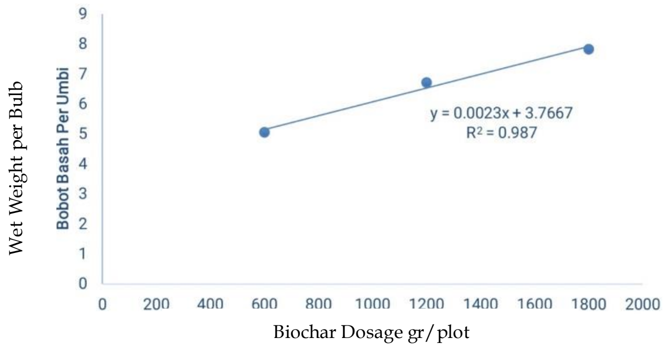


**Figure 3.** Effect of dosing rice biochar on wet weight per bulb in shallot plants

*Dry Tuber Weight Per Tuber (Gram)*

**Table 5.** Average weight of dry bulbs per bulb of shallot with different applications of biochar and rice husk ash

| Treatment | Dose of Rice Husk Ash | | | Average |
|---|---|---|---|---|
| Biochar Dosage | A1 | A2 | A3 | |
| B1 | 4.49 | 4.03 | 5.62 | 4.71b |
| B2 | 6.77 | 6.13 | 6.42 | 6.44ab |
| B3 | 7.55 | 6.81 | 7.75 | 7.37a |
| Average | 6.27 | 5.66 | 6.60 | |

In Table 5. it can be seen that the effect of the application of rice biochar on the weight of dry bulbs per bulb in shallot plants obtained the highest average value at level B3 (7.37 gr) with the treatment dose is 1800gr/plot with a significantly different effect with B1, but has an effect that is not significantly different from B2. The lowest average value was at the B1 level (4.71 gr). The second highest average value has an application interaction found in the combination of B3A3 (7.75 gr) and the lowest average value is found in the combination of B1A2 (4.03 gr).

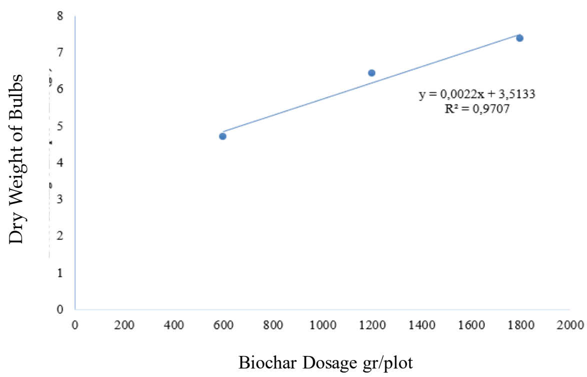


**Figure 4.** Effect of biochar dosage on the dry weight of bulbs per bulb of shallot

In Figure 4, it can be seen that the application of rice husk ash with a large dose of 1800 gr/plot has produced a dry bulb weight per bulb in shallot plants of 7.37 gr. In Table 5, it can be seen that the application of rice husk ash can have an unreal effect on the dry bulb weight per bulb in shallot plants, but the highest average value is obtained in the A3 treatment (6.60 gr) and the lowest average value in the A2 treatment (5.66 gr).

*Sulfur Uptake (g/plant)*

**Table 6.** Sulfur uptake analysis results

| Treatment | A1 | A2 | A3 | Average |
|---|---|---|---|---|
| B1 | 2.73 | 3.68 | 4.57 | 3.66 |
| B2 | 5.00 | 4.50 | 4.01 | 4.50 |
| B3 | 4.52 | 5.14 | 3.76 | 4.47 |
| Average | 4.08 | 4.44 | 4.11 | |

In Table 6, it can be seen that the application of large doses of biochar fertilizer and rice husk ash to sulfur uptake with the highest average value is found in the B2A1 treatment, while the lowest value is found in the B1A1 treatment.

*Sulphur Content of Soil, Biochar and Rice Husk Ash*

**Table 7.** Properties of soil, rice husk biochar and rice husk ash

| Properties | Soil | Rice Husk Biochar | Rice Husk Ash |
|---|---|---|---|
| Org-C (%) | 3.36 (T) | 30. 92 (ST) | - |
| Total-N (%) | 0.26 (S) | - | - |
| Total-P (%) | 0.22 (SR) | - | - |
| pH-$H_20$ | 4.15 (SM) | 8.00 (AA) | 9. 92 (A) |
| Total-S (%) | 2.85 | 25. 20 | 36.58 |
| CEC | 22.36 me/100g (S) | 27.94 me/100 g (T) | - |
| Ca (%) | - | - | 0.23 (SR) |
| Base-Saturation (%) | 0.56 (SR) | - | - |
| K-Exchange (%) | 0.18 me/100 g (R) | - | - |

Description = Low (R), Very Low (SR), High (T), Very High (ST), Alkaline (A), Somewhat Alkaline (AA), Very Acidic (SM), Moderate (S)

In Table 7, it can be seen that the amount of sulfur in the soil is 2.85%. In rice biochar is 25.20%. And in rice husk ash is 36.58%.

*Discussion*

*Effect of Biochar Application on Growth and Yield of Shallot Plants and Sulfur Uptake*

The results of the variance test showed that the provision of biochar had a significant effect on the number of leaves per bulb, the number of tillers per clump, wet weight per bulb and dry weight per bulb, but had no significant effect on plant height, wet weight of bulbs per clump and dry weight of bulbs per clump.

The results showed that the amount of biochar fertilizer dosage of 600 gr/plot produced the highest number of leaves. This is due to the amount of biochar fertilizer dosage of 600 gr/plot is the optimal dose to provide sufficient plant nutrients for the growth of shallot plant leaves. Where biochar has the ability to release carbon and nitrogen slowly and affect microbial activity, thus improving soil properties. The potential of biochar as a soil improver can also increase the availability of phosphorus so that it can increase the uptake of P nutrients for plants (Iswidayani & Sulhaswardi, 2022). This is in accordance with the opinion of Iswidayani & Sulhaswardi (2022) which states that the provision of rice husk biochar in shallot plants gives an indication of the highest yield in the number of leaves, this is because rice husk biochar provides nutrients for the growth of the number of shallot leaves.

The results showed that biochar fertilizer had a significant effect on wet weight per tuber. This is influenced by the function of biochar which can increase nutrient uptake and of course will greatly affect the wet weight of plants. Nutrients that are easily absorbed can spur the development of cells, tissues and plant organs so that the wet weight of the plant will increase, the leaves will get wider, and the stems will get bigger and longer. According to Yadav et al. (2023) biochar acts as a soil improver that can encourage plant growth by providing various beneficial nutrients and improving the physical and biological properties of the soil. The increase in the number of leaves on the plant automatically increases the fresh weight of the plant, because the leaves of the plant are organs that contain zinc and water, the more leaves, the more water the plant holds and the higher the wet weight of the plant (Mapegau et al., 2022).

The use of biochar fertilizer has a significant effect on the weight of dry bulbs in shallot plants. It is suspected that the availability of water greatly affects the formation of shallot bulbs. The presence of water will increase the uptake of nutrients by plant roots needed in the photosynthesis process. According to Saragih et al. (2021), the photosynthate produced is then translocated to the bulbs, so that the weight of the bulbs produced also becomes heavier, the organic matter contained in biochar can improve various soil functions, including the retention of various essential nutrients for plant growth, biochar is more effective in retaining nutrients for their availability to plants than other organic materials.

*Effect of Rice Husk Ash Application on Growth and Yield of Red Onion Plants and Sulfur Uptake*

The results of the variance test showed that the application of rice husk ash had a significant effect on the number of leaves, but had no significant effect on plant height, number of tillers, wet weight of bulbs per bulb, wet weight of bulbs per clump, dry weight of bulbs per bulb and dry weight of bulbs per clump.

The results showed that rice husk ash had a significant effect on the number of leaves in shallot plants. This is thought to be because rice husk ash can improve the physical quality of the soil, such as reducing moisture and improving drainage, which allows plant roots to develop better and absorb nutrients more effectively, rice husk ash can increase the availability of nutrients, such as potassium, which is important for vegetative growth and shallot bulb production, rice husk ash can increase the water absorption capacity of plants. According to Manik (2020), rice husk ash has a high silicate content so that it can provide nutrient needs in shallots. The application of rice husk ash at several doses can increase the number of plant leaves compared to without rice husk ash, this is due to the availability of nutrients and planting media conditions that are more suitable for shallot growth and production, rice husk ash has several elements that are quite high, namely the content of Phosphorus (P), Potassium (K), and Magnesium which are very beneficial for the physiological and metabolic processes of plants that will trigger plant growth.

## Conclusion

The application of biochar had a positive influence on certain growth and yield parameters, particularly the number of leaves, number of tillers, and bulb weight per unit. Meanwhile, rice husk ash showed a limited effect, only improving the number of leaves in early growth. No synergistic effect was observed from the interaction between biochar and rice husk ash on any measured variables. These findings suggest that biochar can be a promising soil amendment to enhance vegetative growth and bulb development, while the use of rice husk ash may require further investigation to optimize its benefits. Future studies are recommended to explore long-term effects and mechanisms behind the observed responses.

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**Conflicts of interest**

The authors declare no conflict of interest.

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