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RESEARCH PAPER

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The effect of coconut shell charcoal (CSC) and liquid biocomposts on the growth and yield of shallot (*Allium cepa* L.) in dry land

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Abstract

This research was conducted to assist farmers in Indonesia in overcoming the problem of scarcity of fertilizers, expensive fertilizer prices and soil conditions on dry lands. The method used is an experimental method with experiments in the field. The activity started in August, 2022 until February 2023. The design used was a Randomized Block Design (RBD) with factorial experiments. The first factor was Coconut Shell Charcoal (CSC) with 2 levels, namely T_0 (soil without coconut shell charcoal) and T_1 (soil and coconut shell charcoal). The second factor was liquid biocompost consisting of 5 levels, namely P_0 (0 cc/litre water), P1 (1 cc/litre water), P2 (2 cc/litre water), P3 (3 cc/litre water) and P4 (4 cc/litre water). The results showed that coconut shell charcoal had a significant effect on shallot growth and yield. This treatment yielded 2.23 tonnes per hectare while the treatment without the addition of charcoal yielded 1.80 tonnes per hectare. The results of this study also showed that liquid biocompost had no significant effect on shallot growth and yield. However, the 4 cc/litre water liquid biocompost treatment gave better results, namely 2.43 tonnes per hectare when compared to the treatment without the addition of liquid biocompost with a yield of 1.80 tonnes per hectare. In addition, the results of data analysis showed that there was no interaction between coconut shell charcoal and liquid biocompost.

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Introduction

Shallots (*Allium cepa* L.) are one of the core commodities that can have an impact on inflation in Indonesia (Permentan, 2022). Shallots have an economic value with a high demand so that the cultivation of shallots has spread to almost every province in Indonesia. Anitasari *et al.* (2019), stated that even though shallots are not a basic necessity like rice, shallots are always needed as a seasoning for all Indonesian dishes. Every year the shallot harvested area decreases (BPS, 2020). This is influenced by the declining productivity of agricultural land as a result of the application of inorganic fertilizers (Hand et al., 2021), high doses of fertilization and pesticides that exceed recommended doses which have an impact on soil structure (Nur and Ismiati, 2007). The decrease in harvested area can be increased by utilizing dry land which has the potential to become productive agricultural land (Rahni *et al.,* 2003). However, not all dry land is suitable for farming. This is due to soil limiting factors such as very steep slopes or shallow soil solums. Therefore, the management of dry land in each region will be different depending on the existing limiting factors (Matheus *et al.,* 2017).

Kata *et al.* (2020) reported that to improve soil quality in dry land it is necessary to use organic matter. This is in accordance with the opinion of Suntoro (2003) that the application of organic matter can improve the physic, chemical and biological of the soil. Organic fertilizers are divided into two types, namely solid organic fertilizers and liquid organic fertilizers. Solid and liquid fertilizers both have the function of adding nutrients to plants for growth and production.

Planting media is an external factor needed by plants (Budiyani *et al.,* 2023). A good planting medium is a medium that is able to provide sufficient amounts of water and nutrients for plant growth. This can be found in soils with good aeration, good aggregates, good water holding capacity and optimal root system (Lewu and Killa, 2020).

This study is aims to utilizing waste that is considered useless as a solution to improve soil conditions in dry land and reduce the use of expensive and rare synthetic chemical fertilizers. In a previous study Apzani *et al.* (2015) conducted research on solid organic fertilizers and the results were good. However, Apzani *et al.* 2018a said that liquid fertilizer has the advantage of being easy to carry and nutrients are directly available to plants and can be applied through roots or leaves. Apzani *et al.* (2015) also have shown that the coconut shell charcoal has no effect on maize growth and yield. So, that is the motivation for investigated further the study about the effect of coconut shell charcoal and liquid biocompost on the growth and yield of shallot (*Allium cepa* L.) in dry land.

Materials and methods

Location and execution time

This research was carried out in dry land Toya Village East Lombok regency, West Nusa Tenggara from August 2022 to February 2023.

Equipment and materials

The tools used in this study were hoes, shovels, knifes, rulers, syringes, 2 liters hand sprayers, hand counters, analytical scales, ovens and stationery. The materials used in this study were soil, compost, and coconut shell charcoal (Fig. 1), onion bulbs of the Super Philip variety, liquid biocompost (Fig. 2), polybags, plastic bags and envelopes.

Research stages

Coconut shell charcoal (CSC) is made using the pyrolysis method, namely combustion without oxygen (Fig. 3). Coconut shells are burned and covered with banana tree fronds during the burning process so that the combustion conditions become devoid of oxygen. CSC is mixed with soil in a ratio of 1:1 according to the treatment. Liquid Biocompost is made by mixing solid compost (Fig. 4.) which has been fermented with water in a ratio of 1 kilogram of solid compost and 1 liter of water and then filtered through a cloth. Liquid Biocompost was applied at 10, 20, 30 and 40 Days after Planting (DAP) by spraying it on the plants based on treatments P1 (1 cc dose), P2 (2 cc doses) and P3 (3 cc doses) and P4 (cc doses).

The shallot seeds used are Super Philip from Bima, West Nusa Tenggara. The bulbs were soaked for 24 hours in lukewarm water to break dormancy (Rukmana, 1994). Shallot seeds are planted 3 (three) bulbs per polybag (Sa'adah, 2007).

Fig. 1. Coconut Shell Charcoal (CSC).

Fig. 2. Liquid Biocompost.

Fig. 3. Pyrolysis method for coconut shell charcoal production.

Fig. 4. Solid biocompost before diluted.

Variable Observations

The variables observed included plant height, number of leaves and number of saplings, fresh bulb weight and dry bulb weight.

Experimental Design and Treatment

This study used a factorial experiment designed in a Randomized Block Design (RBD) consisting of two factors. Factor 1 is coconut shell charcoal which consists of 2 levels T0 = soil and T1 = soil with coconut shell charcoal. While factor 2 was liquid biocompost consisting of 5 levels, namely P0 = 0 cc/litre liquid biocompost, P1 = 1 cc/litre liquid biocompost, P2 = 2 cc/litre liquid biocompost, P3 = 3 cc/litre liquid biocompost, and P4 = 4 cc/litre liquid biocompost. The treatment was a combination of factors 1 and 2, each of which was repeated 3 times to obtain 30 experimental units.

Analysis Method

Observational data were analyzed using analysis of variance with Randomized Block Design (RBD). When the results of the analysis there is a significant effect, then the analysis is continued with a follow-up test using the Honest Significant Difference (HSD) with a confidence level of 5% ($P \leq 0.05$).

Result and discussion

The treatment of CSC gave a significant effect on plant height, number of leaves, number of saplings, fresh bulb weight and dry bulb weight (Table 1).

While the treatment with the addition of liquid biocompost did not have a significant effect on all observed parameters as well as interactions.

Table 1. Summary results of the analysis observed parameter diversity.

Parameter	Source of Diversity		
	Coconut Shell Charcoal	Liquid Biocompost	Interaction
Plant Height	S	NS	NS
Number of Leaves	S	NS	NS
Number of Saplings	S	NS	NS
Fresh Bulbs Weight	S	NS	NS
Dry Bulbs Weight	S	NS	NS

Note: S= Significant, NS= Non Significant

The Plant Height

The treatment with CSC gave better growth compared to the treatment without CSC (table 2). While table 3 shows that the treatment of liquid biocompost gave insignificant growth. The existence of a positive effect given CSC indicates that this treatment contributes to plant growth. CSC can increase the growth of shallot plants, especially plant height. Plant height increased up to 50 DAP observations. After that there was no increase in plant height. This is because the vegetative phase of shallot plants has ended. This is in accordance with the opinion of Apzani *et al.* (2018b) which states that shallot plants begin to enter the vegetative phase after they are 11-35 DAP and the generative phase when the plants are 36 DAP. At the end of the vegetative phase, the addition of CSC gave a plant height of 38.37cm while CSC it was 35.57cm.

The increase in plant height due to the influence of CSC is thought to be caused by the ability of charcoal to increase the activity of microorganisms in the soil, bind groundwater (Tarigan, *et al.*, 2021), and hold nutrients (Multazam, 2012). So, nutrients are avoided from the leaching process and can be utilized the plant. This is strengthened by the statement of Khan *et al.* (2015) which states that coconut shell charcoal is able to stimulate the activity of soil microorganism life and can increase soil aggregates. Soil microorganisms can produce compounds that are useful as growth regulators (Susilawati *et al.*, 2016). These growth regulators help stimulate plant growth.

Table 2. Average the plant height of shallot in the treatment of coconut shell charcoal.

Treatments	Plant Height (cm)						
	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP
With CSC	13,25 a	18,65 a	26,45 a	38,27 a	38,37 a	38,37 a	38,37 a
Without CSC	12,02 b	17,29 b	24,88 b	35,45 b	35,57 b	35,57 b	35,57 b
HSD 5%	1,22	1,27	1,31	2,55	2,55	2,55	2,55

Note: Numbers in the same rows followed by different letters are significant in the 5% HSD test

Table 3. Average the plant height of shallot in the treatment of liquid biocompost.

Treatments	Plant Height (cm)						
	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP
0 cc/litre of water	11,47	16,92	24,60	35,27	35,35	35,35	35,35
1 cc/litre of water	12,98	18,32	25,67	36,17	36,30	36,30	36,30
2 cc/litre of waters	12,72	18,20	25,52	34,82	34,92	34,92	34,92
3 cc/litre of waters	12,63	18,10	25,75	38,28	38,40	38,40	38,40
4 cc/litre of waters	13,37	18,33	26,52	39,75	39,90	39,90	39,90
HSD 5%	2,75	2,89	2,96	5,79	5,79	5,79	5,79

In the last observation, the highest plant height of 39.90cm resulted from the addition of 4 cc/litre liquid biocompost (P4). While in the control treatment the plant height was 35.35cm. However, when viewed statistically the treatment was not significant. This means that the treatment with the addition of liquid biocompost has not been able to have a significant effect on plant height. This is because the liquid biocompost given is very small so the dosage needs to be increased again. This is in line with the results of Bertham's research (2018) which stated that liquid biocompost treatment could not increase plant height.

The Number of Leaves

The treatment with the addition of CSC produced a higher number of leaves compared to the treatment without CSC at all observation times (table 4). While Table 5 shows that the treatment with the addition of liquid biocompost did not show a significant increase in the number of leaves.

Table 4. Average the number of leaves of shallot in the treatment of coconut shell charcoal.

Treatments	Number of Leaves (strands)						
	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP
With CSC	7,40 a	13,07 a	18,53 a	19,20 a	19,20 a	19,20 a	19,20 a
Without CSC	6,00 b	9,07 b	14,93 b	15,67 b	15,67 b	15,67 b	15,67 b
HSD 5%	1,34	2,26	2,03	1,92	1,92	1,92	1,92

Note: Numbers in the same rows followed by different letters are significant in the 5% HSD test

Table 5. Average the number of leaves of shallot in the treatment of liquid biocompost.

Treatments	Number of Leaves (strands)						
	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP
0 cc/litre of water	5,33	10,17	14,33	15,00	15,00	15,00	15,00
1 cc/litre of water	5,83	11,50	16,50	17,50	17,50	17,50	17,50
2 cc/litre of waters	6,83	10,33	18,00	18,67	18,67	18,67	18,67
3 cc/litre of waters	8,00	11,33	16,17	16,67	16,67	16,67	16,67
4 cc/litre of waters	7,50	12,00	18,67	19,33	19,33	19,33	19,33
HSD 5%	3,04	5,13	4,60	4,37	4,37	4,37	4,37

More number of leaves produced on plants given CSC because charcoal is a good medium for the growth of soil microorganisms. In addition, CSC also has the ability to hold water (fig. 5) and nutrients, especially nitrogen. This is in accordance with the research of Apzani *et al.* (2015) which states that CSC can help in increasing the availability of nitrogen nutrients. Nitrogen is an essential element that is needed by plants, especially for leaf development and increasing green color. This resulted in the process of plant photosynthesis not being hampered and the spread of assimilates throughout the plant body to be faster and more optimal which in turn increased the number of leaves.

Fig. 5. The soils without coconut shell charcoal treatment (A) and with coconut shell charcoal (B).

Fig. 5 shows that the soil treated with CSC (B) looks blacker and moister than the soil without CSC (A). CSC can hold soil moisture by absorbing and retaining water through adhesion and cohesion processes caused by biochar pores. Besides being able to hold water, CSC has the ability to retain nutrients due to the high Cation Exchange Capacity (CEC) of CSC, which is 251.71 me/100 g (Table 6).

This is in line with the opinion of Suntoro (2003) that organic matter has a relatively high negative charge which can increase soil CEC in holding nutrient cations so they are available to plants. The main sources of the negative charge of CSC are carboxyl (COOH) and phenolic (OH) groups (Brady, 1990).

The high negative charge of CSC is related to its acidity which reaches 9.9. At this acidity, the soil solution contains a lot of OH- and binds H+. The result is the release of H+ from the carboxyl and phenolic groups and an increase in negative charge (COO- and O-) so that CEC increases (Parfit, 1980 in Suntoro, 2003). The position of H+ which is detached from the carboxyl and phenolic groups on the CSC particles will be replaced by nutrient cations.

After the saturation of nutrient bonds occurs, the nutrients are released and can be utilized by plants, while the positions of nutrients are again replaced by hydrogen ions (H+). With the ability to bind nutrients by coconut shell charcoal particles, the plant's need for nutrients can be fulfilled optimally.

Table 6. The results of the analysis of chemical properties of coconut shell charcoal particles.

Parameter	Unit	Coconut Shell Charcoal	Note
Water Level	%	5,6	Medium
Acidity	-	9,9	Alkaline
C organic	%	80,59	Very high
N	%	0,34	Medium
P	%	0,10	Very low
K	%	0,84	High
Ca	%	0,04	Very low
Na	%	0,12	Low
Mg	%	0,06	Very low
Ash	%	7,36	Medium
CEC	Me. 100 g-1	251,71	Very high
C/N	%	237,03	Very high

In the last observation, the treatment with the addition of 4 cc/litre of liquid biocompost gave an average number of leaves of 18.67cm while the control treatment was 14.33cm. However, when viewed statistically the treatment was not significant.

This means that the treatment with the addition of liquid biocompost has not been able to have a significant effect on plant height. This is presumably because the amount of liquid biocompost given is very small, so the dose needs to be increased again.

The low dosage of liquid biocompost results in low nutrient levels in the soil (table 7). This causes the plant to experience nutrient deficiency so that the formation of plant biomass is not optimal.

Table 7. The results of the analysis of chemical properties of liquid biocompost.

Parameter	Unit	Liquid Biocompost	Note
Water Level	%	0,54	Low
N total	%	0,56	Low
C Organic	%	0,35	Low
C/N Rasio	%	0,72	Low
Acidity		7,0	Neutral
CEC	me/100 g	50,75	Low

Table 7 shows that the chemical properties of soil treated with highest liquid biocompost doses (4 cc/litre). Although that is highest doses but it shows that all of the parameter are have low result except acidity. The low quality of these parameters causes the nutrient not sufficient and not available for plant. If that happens, the plant cannot grow optimally. In the opinion of Apzani *et al.* (2018a) that to obtain optimal biomass, plants must obtain sufficient nutrient intake when the plant is in the vegetative phase.

The Number of Saplings

The CSC treatment has a significant effect (table 8). Significantly higher number of shallot plant saplings was obtained in the treatment with the addition of CSC. Meanwhile, in Table 8 it can be seen that the treatment with 2 cc/litre of organic fertilizer produced a higher number of saplings compared to the other treatments. However, statistically the treatment did not provide a significant difference.

Table 8. Average the number of saplings of shallot in the treatment of coconut shell charcoal.

Treatments	The Number of Saplings						
	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP
With CSC	2,07 a	2,47 a	3,40 a	4,20 a	4,20 a	4,20 a	4,20 a
Without CSC	1,93 b	2,13 b	3,07 b	3,73 b	3,73 b	3,73 b	3,73 b
HSD 5%	0,11	0,33	0,32	0,44	0,44	0,44	0,44

Note: Numbers in the same rows followed by different letters are significant in the 5% HSD test

Table 9. Average the number of saplings of shallot in the treatment of liquid biocompost.

Treatments	Number of Saplings						
	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP
0 cc/litre of water	1,83	2,17	3,00	3,50	3,50	3,50	3,50
1 cc/litre of water	2,00	2,33	3,17	4,00	4,00	4,00	4,00
2 cc/litre of waters	2,17	2,50	3,67	4,17	4,17	4,17	4,17
3 cc/litre of waters	2,00	2,17	3,00	4,00	4,00	4,00	4,00
4 cc/litre of waters	2,00	2,33	3,33	4,17	4,17	4,17	4,17
HSD 5%	0,44	0,77	0,77	1,26	1,26	1,26	1,26

There is a significant effect of CSC because can increase soil acidity so that nutrients are available to plants (Apzani *et al.*, 2018b). Therefore, the needs of shallot plants are sufficient. Malik *et al.* (2022) stated that increasing soil acidity by CSC can also increase the activity of soil microorganisms (Fig. 6). This makes the availability of nutrients in the soil also increase due to the process of decomposition of organic matter (Rizwan *et al.*, 2018). Lingga and Marsono (2005) also stated that if the nutrients needed by plants are available in sufficient quantities, metabolic results such as biomass synthesis will increase so that the numbers of saplings in shallots will increases.

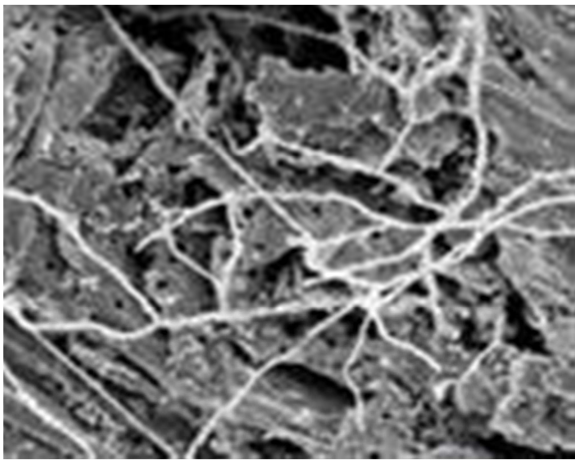

Fig. 6. The growth of white hyphae of *Trichoderma* spp. on coconut shell charcoal (Situmeang, 2020).

Microscopically, Fig. 6 shows the growth of white hyphae from *Trichoderma* spp. on CSC. This happens because the acidity conditions are suitable for the life of soil microorganisms. However, the treatment with liquid biocompost did not have a significant effect. This is presumably because the dose of liquid biocompost given is very small, so it is necessary to increase the dose. Meiyana *et al.* (2021) which stated that the treatment of liquid biocompost did not show a significant effect on the number of saplings, so further research was needed to increase the dose.

The Weight of Fresh and Dry Bulb

The significant effect and weight of the fresh and dry bulbs of the best shallot plants obtained in the treatment with the addition of CSC (table 10). The difference in the weight of fresh and dry bulbs of shallot plants by CSC treatment is because CSC can help increase the availability of nitrogen and phosphorus nutrients in the soil (Sonia, 2014). This can make the layers of leaves enlarge and coalesce. CSC has good porosity (Fig. 7) for root respiration and soil microorganisms (Apzani *et al.,* 2018a). Good root respiration will result in more optimal absorption of nutrients (Hasiholan *et al*, 2000). Therefore, the weight of the plant increases as a reflection of the optimal metabolism of biomass formation. CSC can increase the number of leaves so that the photosynthesis process is more optimal (Apzani *et al.,* 2018b). Optimum photosynthesis process makes assimilates can be spread throughout the plant body during the vegetative and generative phases. In the generative phase, assimilate will flow to the bulbs (Apzani and Sunantra, 2022). This is causes the weight of the onion bulbs to increase.

Table 10. Average the weight of dry and fresh bulb of shallot in the treatment of CSC.

Treatments	Weight of Dry Bulb (gram/plant)	Weight of Fresh Bulb (gram/plant)
With CSC	13,53 a	8,93 a
Without CSC	11,27 b	7,20 b
HSD 5%	1,86	1,34

Note: Numbers in the same rows followed by different letters are significant in the 5% HSD test

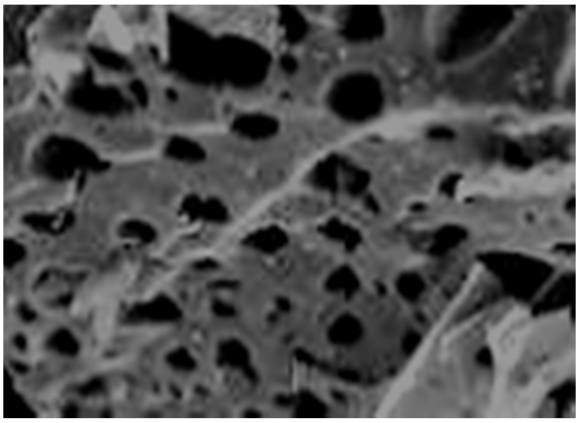

Fig. 7. Pores of coconut shell charcoal microscopically (Situmeang, 2020).

Fig. 7 shows the presence of pores in CSC which function as way of oxygen for root respiration and soil microorganisms. Meanwhile, in table 10 it can be seen that the addition of liquid biocompost has not been able to have a significant effect.

Addition liquid biocompost statistically did not have a significant effect. It causes by the nutrient on the treatment not enough for growth and generative phases. Meanwhile, the treatment with 4 cc/litre gave better results compared to other treatments (table 11).

Table 11. Average the weight of dry and fresh bulb of shallot in the treatment of liquid biocompost.

Treatments	Weight of Dry Bulb (gram/plant)	Weight of Fresh Bulb (gram/plant)
0 cc/litre of water	12,50	7,17
1 cc/litre of water	12,17	8,17
2 cc/litre of waters	11,00	7,50
3 cc/litre of waters	11,50	7,83
4 cc/litre of waters	14,83	9,67
HSD 5%	4,22	3,05

Base on the table 11, the weight of fresh and dry show that the bulb yield did not have a difference. The addition has not been significant because the nutrients available in the fertilizer are not sufficient for the vegetative growth of plants so that it can affect the yield of these plants. The low nutrients found in fertilizers cause plants to be unable to carry out metabolic processes and can affect crop production. This is in line with research by Hayati *et al.* (2012), which stated that treatment with liquid biocompost did not have a significant effect. Even though it could not give a significantly different effect, the treatment tended to show an increase in the weight of fresh and dry bulbs. The addition of bulbs weight is a reflection of the efficiency of nutrient uptake by plants (Gardner *et al.*, 1991).

Yield Potential

Based on the conversion of the dry weight of stored bulbs (Table 12), the results showed that the treatment with the addition of coconut shell charcoal gave higher shallot yields 2.23 tons per hectare) compared to the treatment without the addition of charcoal (1.80 tons per hectare). This means that the addition of charcoal gives an increase in yield of 23.89%.

Table 12. Yield conversion of shallot plants in the treatment of coconut shell charcoal.

Treatment	Yield (ton/hectare)
With CSC	2,23
Without CSC	1,80

Table 13 shows that the treatment with the addition of liquid biocompost gave higher shallot yields compared to other treatments. The treatment with the addition of 4 cc/litre gave a yield of 2.43 tons per hectare while the control treatment was 1.80 tons per hectare. This means that the addition of liquid biocompost can increase yields by 35%.

Table 13. Yield Conversion of Shallot Plants in the Treatment of Liquid Biocompost.

Treatments	Yield (ton/hectare)
0 cc/litre of water	1,80
1 cc/litre of water	2,03
2 cc/litre of waters	1,88
3 cc/litre of waters	1,95
4 cc/litre of waters	2,43

The states need for shallots in Indonesia from year to year has increased by 5% so that domestic production needs to be increased (BPS, 2020). Therefore, by adding coconut shell charcoal and liquid biocompost, it is expected that shallot production can be increased so that domestic demand can be met and shallot imports can be reduced or even eliminated.

Conclusion

Based on the results of data analysis and discussion, it can be concluded that CSC treatment had a significant effect on the growth and yield of shallots which increased the yield by 23% compared to the control. But, the treatment with liquid biocompost and interaction did not have a significant effect on increasing the growth and yield of shallots. There was no interaction between the coconut shell charcoal factor liquid biocompost factors. However, liquid biocompost treatment can increase the yield by 35% compared to the control. So, CSC can be used as an alternative to support agriculture in dry land.

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