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Effect of Biochar and Nitrogen on Growth and Yield of Shallots (*Allium Ascalanicum L.*)

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Abstract

Shallots (Allium ascalanicum L.) is a vegetable commodity that has high economic value. The productivity of shallots in NTB is still relatively low because the level of soil fertility is still decreasing. One of the efforts to increase the productivity of shallots can be done through the addition of soil fertility enhancers by providing biochar and fertilization efficiency. This study aims to determine the effect of biochar, nitrogen fertilizer and interactions on the growth and yield of shallots. The experiment has been carried out since May –August 2021 at the Greenhouse of the Faculty of Agriculture, University of Mataram. The experiment was designed using a factorial Completely Randomized Design consisting of two factors, namely the dose of Biochar (4 levels) B0: 0 tons/ha without Biochar, B1: 10 tons/ha, B2: 20 tons/ha, B3: 30 tons/ha and the dose Nitrogen (5 levels) N0: 0 kg/ha without Nitrogen, N1: 200 kg/ha, N2: 400 kg/ha, N3: 600 kg/ha, N4: 800 kg/ha. The results showed that there was an interaction between the dose of biochar and nitrogen on growth (plant height, number of leaves and number of cloves) and yield (wet weight and dry weight), where doses of biochar 30 tons/ha and nitrogen 800 kg/ha gave growth and yields. and produces the highest nitrogen uptake efficiency.

Keywords: Biochar, Nitrogen, Onion Growth, Yield

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INTRODUCTION

Shallots (Allium ascalanicum L.) is one of the vegetable commodities that have important meaning for the community both from a high economic aspect and from the aspect of nutritional content. Shallots have many uses in everyday life. The tubers and leaves can be used as a cooking spice or food seasoning, and can also be used as a medicine for high blood pressure, diabetes, colds, insect bites, dysentery, and diarrhea. Shallots are beneficial for health because they contain active elements, have the power to kill bacteria, as an anti-biotic ingredient, stimulate the growth of body cells and as a source of vitamin B1 (Sutanto, 2002).

The province of West Nusa Tenggara (NTB) is one of the centers for the production of shallots. The production of shallots in NTB is still relatively low when compared to the National needs in 2020, which reached 342.598.000 tons, while the production of shallots in NTB from 2015 to 2020 reached its highest point of 2128849 tons. The reduced productivity of shallots has led to the non-fulfillment of national needs (BPS, 2020).

One of the obstacles that cause the reduced productivity of shallots is the land that continues to be degraded due to the excessive use of synthetic chemical fertilizers. Therefore, it is necessary to increase the production and productivity of shallots with innovative cultivation techniques that can improve the quality of soil fertility (Havlin et al, 2016). One strategy to improve the quality of soil fertility in shallots is to provide a combination of organic soil enhancers and inorganic fertilizers. One of the soil organic enhancers that has been reported by several researchers to be able to improve the quality of soil fertility is Biochar (Nisa, 2010).

Biochar is a soil organic repairer from the heating (pyrolysis) of organic biomass in limited oxygen conditions (Lantang and Widiastuti, 2017). Biochar has properties that are rich in aromatic carbon and a negative surface charge of carbolsil, hydroxyl groups that are able to capture positive charge nutrients. Biochar has a negative charge that is able to capture positively charged nutrients in nitrogen (urea fertilizer) in the soil so that ammonium ions can be retained by biochar and nutrients can be used efficiently by plants so that they are easily absorbed (Riziek et al, 2016). The addition of biochar into the soil can improve nutrient availability and soil cation exchange capacity (Brown, 2012). Biochar can improve soil conditions and increase crop production, especially on less fertile soils or degraded soils (Atkinson et al. 2010).

Nitrogen (N) is one of the macro nutrients needed by onion plants. Nitrogen plays an important role in the formation of chlorophyll, protoplasm, proteins, and nucleic acids. Thus nitrogen has an important role in the growth and development of all living tissues (Brady and Weil, 2002). Nitrogen source used is Urea Fertilizer.

METHOD

This study used an experimental method using polybags of various experimental units which had been carried out from May to August 2021 at the Greenhouse of the Faculty of Agriculture, University of Mataram. The tools used in this study were hoe, meter, scissors, weighing bottle, drying oven, desiccator, plastic shaker bottle, shaker machine, pH meter, 100 ml volumetric flask, measuring cup, spectrophotometer, volume pipette, whatman filter paper, distillation flask, 100 ml volumetric flask, 100 ml Elmeyer, distillator, titrator and digestion flask.

The materials used in this research are Biochar, Urea Fertilizer, Onion Seed of Ketamonca Variety, Polybek Plastic, Envelopes, Aquades Water. The experiment was designed using a completely randomized design (CRD), factorial with the following treatments:

Factor 1: biochar dose consisting of 4 levels, namely:

B0: 0 ton/ha without Biochar
B1: 10 tons/ha
B2: 20 tons/ha
B3: 30 tons/ha

Factor 2: a dose of nitrogen fertilizer consisting of 5 levels, namely:

N0: 0 kg/ha without Nitrogen
N1: 200 kg/ha
N2: 400 kg/ha
N3: 600 kg/ha
N4: 800 kg/ha

The variables observed included growth (plant height, number of leaves and number of cloves), yield (wet weight and dry weight), soil chemical properties (pH, C-Organic and total N and NPK uptake in plant tissue. Observational data were analyzed using analysis of variance (ANOVA) at a significance level of 5% and further testing using the Honestly Significant Difference Test (BNJ) using the MINITAB Version 16 program.

RESULTS AND DISCUSSION

Onion Growth and Yield

Summary results of ANOVA variance analysis Effect of biochar, nitrogen and interactions on growth and yield of shallots are presented in Table 1.

Table 1. Results of analysis of variance Anova Effect of biochar, nitrogen and interactions on the growth of shallots

Observation Variable	Treatment		
	Biochar	Nitrogen	Biochar x Nitrogen
Plant height :			
15 hst	ns	ns	s
30 hst	ns	ns	s
45 hst	ns	ns	s
Number of leaves			
15 hst	ns	ns	s
30 hst	ns	ns	s
45 hst	ns	ns	s
Number of cloves			
30 hst	ns	ns	s
45 hst	ns	ns	s
Bobot basah	ns	ns	s
Bobot kering	ns	ns	s

Description: s = significant; ns = non significant

Table 1 shows that the application of biochar and nitrogen as well as interactions had a significant effect on plant height, number of leaves 15, 30 and 45 DAP, Number of cloves 30 and 45 DAP, Wet Weight and Dry Weight. Giving biochar combined with nitrogen significantly improved the growth and yield of shallots. The data on the average growth and yield of shallots (plant height, number of leaves, number of cloves, wet weight and dry weight) are presented in Tables 2, 3, 4 and 5.

Table 2. Average plant height aged 15, 30 and 45 DAP

Interaction	**Plant height (cm)**		
	Age 15 HST	**Age 30 HST**	**Age 45 HST**
B0N0	8.00 j	26.00 i	34.25 j
B1N0	11.00 hi	31.25 g	35.75 j
B2N0	13.25 gh	34.25 f	42.50 fgh
B3N0	17.00 ef	36.50 cde	43.50 defg
B0N1	9.50 ij	28.50 h	36.50 ij
B1N1	13.00 gh	35.75 ef	43.00 efgh
B2N1	15. 00 fg	36.75 cde	44.25 cdef
B3N1	18.25 de	37.00 bcde	46.00 abcdef
B0N2	10.75 hij	30.25 gh	39.50 hi
B1N2	16.75 ef	36.00 def	44.75 cdef
B2N2	20. 00 ed	37.50 abcde	45.00 cdef
B3N2	22.75 abc	38.50 abc	47.00 abcd
B0N3	11.75 hi	30.50 g	40.00 ghi
B1N3	17.25 def	37.25 abcde	45.25 bcdef
B2N3	21.75 bc	38.00 abcd	46.25 abcde
B3N3	24.00 ab	39.00 ab	48.75 ab
B0N4	12.50 gh	31.50 g	42.75 efgh
B1N4	17.75 def	37.75 abcde	45.50 bcdef
B2N4	22.50 abc	38.25 abc	47.75 abc

Interaction	Plant height (cm)		
	Age 15 HST	Age 30 HST	Age 45 HST
B3N4	24.75 a	39.25 a	49.25 a
BNJ	2.85	2.11	3.56

Note: The numbers followed by the same letter in the same column are not significantly different at the 5% significance level.

Table 2 shows that the effect of biochar and nitrogen doses on plant height at 15 DAP with the highest value found in the B3N4 interaction (24.75) and the lowest value found in the B0N0 interaction (8.00). The same thing happened at the age of 30 and 45 DAP that the effect of the dose of biochar and nitrogen was the highest value found in the B3N4 interaction (39.25) and the lowest value was found in the B0N0 interaction (26.00) while at the age of 45 DAP the highest value was found in the B3N4 interaction (49.25) and the lowest value was found in the B0N0 interaction (34.2)

Table 3. Average number of leaves aged 15, 30 and 45 DAP

Interaction	Number of plant leaves		
	Age 15 HST	Age 30 HST	Age 45 HST
B0N0	8.00 m	14.00 m	19.00 l
B1N0	13.00 j	18.50 kl	24.00 hij
B2N0	16.25 fgh	21.00 hij	27.00 fg
B3N0	18.00 def	24.50 def	30.00 bcd
B0N1	9.50 lm	17.00 l	21.00 kl
B1N1	14.00 ij	20.50 ijk	25.00 ghi
B2N1	18.50 cde	23.00 fgh	28.00 def
B3N1	19.50 abcd	26.00 bcd	31.00 bc
B0N2	11.00 kl	19.50 jk	22.00 jk
B1N2	15.00 hi	22.00 ghi	26.00 fgh
B2N2	19.00 bcde	25.00 cdef	28.00 def
B3N2	19.75 abcd	27.00 abc	31.00 bc
B0N3	12.25 jk	20.50 ijk	23.25 ij
B1N3	15.25 hi	23.25 fg	27.75 ef
B2N3	17.50 efg	25.50 bcde	29.25 cde
B3N3	20.00 abc	27.50 ab	31.50 b
B0N4	12.75 jk	21.50 ghij	24.50 hi
B1N4	16.00 gh	23.50 efg	28.00 def
B2N4	20.50 ab	26.00 bcd	31.00 bc
B3N4	21.00 a	28.50 a	35.00 a
BNJ	1.88	2.16	2.20

Note: The numbers followed by the same letter in the same column are not significantly different at the 5% significance level.

Table 3 shows that the effect of biochar and nitrogen doses on the number of leaves of plants aged 15 DAP with the highest value found in the B3N4 interaction (21.00) and the lowest value found in the B0N0 interaction (8.00). The same thing happened at the age of 30 and 45 days after the effect of the dose of biochar and nitrogen, the highest value was found in the B3N4 interaction (28.50) and the lowest value was found in the B0N0 interaction (14.00) while at the age of 45 the highest value was found in the B3N4 interaction (35.00) and the lowest value was found in the B0N0 interaction (19.00)

Table 4. Average number of cloves aged 30 and 45

Interaction	Number of Plants	
	Age 30 HST	Age 45 HST
B0N0	2.00 h	4.00 n
B1N0	4.00 gh	6.00 mn
B2N0	7.00 ef	9.00 jkl
B3N0	9.00 cde	12.00 ghi
B0N1	4.00 gh	7.00 lm
B1N1	7.00 ef	8.00 klm
B2N1	9.00 cde	11.00 hij
B3N1	11.00 abc	14.00 efg
B0N2	5.00 fg	8.00 klm
B1N2	8.00 de	11.00 hij
B2N2	11.00 abc	14.00 efg
B3N2	12.00 ab	17.00 bcd
B0N3	7.00 ef	9.00 jkl
B1N3	10.00 bcd	13.00 fgh
B2N3	11.00 ab	16.00 cde
B3N3	12.00 ab	19.00 ab
B0N4	10.00 bcd	10.00 ijk
B1N4	12.00 ab	15.00 def
B2N4	12.50 a	18. 00 bc
B3N4	13.25 a	21.00 a
BNJ	2.29	2.49

Note: The numbers followed by the same letter in the same column are not significantly different at the 5% significance level.

Table 4 shows that the effect of biochar and nitrogen doses on the number of plant cloves aged 30 days after planting with the highest value found in the B3N4 interaction (13.25) and the lowest value found in the B0N0 interaction (2.00). The same thing at the age of 30 hst that the effect of the dose of biochar and nitrogen the highest value was found in the B3N4 interaction (21.00) and the lowest value was found in the B0N0 interaction (4.00).

Table 5. Average wet weight and dry weight

Interaction	Crop Variable	
	Wet Weight	Dry Weight
B0N0	26.00 i	17.00 i
B1N0	30.00 hi	20.00 hi
B2N0	36.00 fg	26.00 fg
B3N0	40.00 cdef	30.50 cde
B0N1	30.00 hi	20.00 hi
B1N1	33.00 gh	23.75 g
B2N1	38.00 ef	27.75 ef
B3N1	42.50 bcd	30.00 cde
B0N2	33.00 gh	23.00 gh
B1N2	36.00 fg	26.00 fg
B2N2	38.00 ef	29.75 cde
B3N2	44.25 ab	33.00 bc
B0N3	36.00 fg	26.00 fg
B1N3	39.00 def	29.00 def
B2N3	42.00 bcde	32.00 bcd

Interaction	Crop Variable	
	Wet Weight	Dry Weight
B3N3	46.00 ab	35.00 ab
B0N4	39.00 def	29.00 def
B1N4	42.00 bcde	32.00 bcd
B2N4	44.00 abc	34.75 ab
B3N4	47.50 a	37.25 a
BNJ	4.14	3.57

Note: The numbers followed by the same letter in the same column are not significantly different at the 5% significance level.

Table 5 shows that the effect of biochar and nitrogen doses on wet weight with the highest value found in the B3N4 interaction (47.50) and the lowest value found in the B0N0 interaction (26.00). The same thing with the dry weight interaction that the effect of the dose of biochar and nitrogen was the highest value found in the B3N4 interaction (37.25) and the lowest value was found in the B0N0 interaction (17.00).

Table 2, Table 3, Table 4 and Table 5 show that each additional dose of biochar and nitrogen has a positive effect on all observations. The increase in growth in each observation was influenced by the improvement in the availability of soil properties, especially Nitrogen, Phosphate and Potassium. This is evidenced by the increased uptake of Nitrogen, Phosphate and Potassium nutrients which can be seen in Table 7.

According to the opinion of Warnock et al. (2007) stated that biochar is able to absorb nutrients and retain water so that it is available to plants. Furthermore, biochar can improve and optimize plant growth and production, reduce the amount of leached nutrients and provide nutrients for plants. The same thing is also in the opinion of Lehmann and Joseph (2009), that biochar treatment can increase water holding capacity, CEC and provide nutrients to improve nutrient uptake by plants.

The results showed that the application of biochar and nitrogen significantly affected plant height, number of leaves at the age of 15, 30 and 45 DAP, the number of cloves at the age of 30 and 45 DAP and base weight and dry weight. The best plant growth and yields were obtained with the application of biochar (30 tons/ha) and nitrogen (800 kg/ha). It is suspected that the use of biochar and nitrogen can increase the growth of microorganisms in the soil, bind groundwater so that it has a good effect on the growth of shallots as indicated by plant height, number of leaves 15, 30 and 45 DAP, number of cloves aged 30 and 45 DAP, weight the wet weight of the cluster tubers and the dry weight of the cluster tubers.

Biochar has micro pores that can be used as a habitat for microorganisms which will result in reduced competition between microorganisms which can increase soil biological activity. Furthermore, the higher the activity of soil microorganisms which can increase the availability of nutrients in the soil which causes plants to be able to absorb nutrients properly and increase plant production (Widowati, 2010).

Soil microorganisms can produce metabolites that have the effect of growth regulators. The role of soil microbes in the cycle of various nutrients in the soil is very important, so that if one type of microbe does not function there will be an imbalance in the nutrient cycle in the soil, the availability of nutrients is closely related to the microbial activity involved in it (Nasahi, 2010).

The application of biochar to the soil can increase the availability of major cations and phosphorus, total nitrogen and cation exchange capacity in the soil. Availability of sufficient nutrients for plants is the impact of increasing nutrients directly from biochar and nutrient retention as well as changes in soil dynamics. The long-term advantage of biochar application for plant nutrient availability is related to higher organic carbon stability compared to organic materials that can be used in agricultural cultivation (Nisa, 2010).

Steiner (2007) states that the application of biochar has a good and long-lasting effect on the soil because biochar can increase soil moisture and soil fertility. Besides that, biochar can function as a soil enhancer, increase plant growth, and the ability of the soil to bind water. Biochar can reduce the rate of soil erosion and bind water so that biochar plays a very important role in the activity of microorganisms in the soil (Balipta, 2011).

Lingga and Marsono (2007) said that the main role of N for plants is to stimulate overall growth, especially stems, branches and leaves. Nitrogen plays an important role in the formation of green leaves which is very useful for the process of photosynthesis. Furthermore, plant growth depends on the availability of nutrients in the soil, the number of plant leaves is smaller, thinner and less in number if they do not get the amount of N as needed, while the plant receives N in accordance with the amount needed, leaves are formed more and more widely (Poerwowidodo, 1992).

Soil Chemical Properties

Data on changes in soil chemical properties observed including pH, C-organic, total N are presented in Table 6.

Table 6. Average soil pH, C.Organic and N-Total at various doses of biochar and nitrogen

Interaction	Parameter		
	pH	C.Organik (%)	N-Total (%)
B0N0	6.17	1.07	0.08
B1N0	6.70	1.43	0.12
B2N0	6.80	1.76	0.13
B3N0	7.03	1.92	0.22
B0N1	6.30	1.13	0.09
B1N1	6.73	1.46	0.12
B2N1	6.83	1.37	0.12
B3N1	7.07	1.54	0.17
B0N2	6.37	1.19	0.12
B1N2	6.77	3.20	0.11
B2N2	6.83	2.04	0.13
B3N2	7.10	1.78	0.12
B0N3	6.47	1.42	0.10
B1N3	6.80	2.50	0.12
B2N3	6.87	1.68	0.11
B3N3	7.13	3.39	0.11
B0N4	6.50	1.19	0.10
B1N4	6.90	1.57	0.13
B2N4	6.93	1.62	0.13
B3N4	7.30	3.47	0.23
Criteria	Neutral	High	Moderate

Table 6 shows that there has been an increase in the value of the chemical properties of the soil studied and has been able to improve the character of the soil for the better based on the criteria for assessing soil quality (Appendix 6). This indicates that the treatment dose of biochar, dose of nitrogen and the interaction of the two treatments can increase the nutrient content.

Table 6 also shows changes in soil chemical properties after planting; pH (7.30) Neutral, C-Organic (3.47%) high, N total (0.23%) moderate. The increase in soil chemical content after treatment with biochar doses was thought to be due to the long-lasting nature of biochar and able to improve soil nutrient content. This is in line with research by Lehman, et al., (2003) which states that biochar in the short term can increase the availability of nutrients such as P, Zn, Fe, K and Co, while the long term effect can increase the availability of nutrients including organic matter. in the soil is more stable, releasing nutrients slowly and increasing nutrient retention due to an increase in CEC. Biochar functions as an absorbent material that can increase the storage and release of nutrients and moisture in the soil. Biochar can last up to hundreds of years because it is resistant to microbial degradation.

Furthermore, the chemical properties of the soil before planting with changes in the chemical properties of the soil after planting showed an increase in all soil chemical properties with the addition of doses of biochar and nitrogen. In principle, the addition of organic matter in the soil can increase the pH of the soil and can reduce the soil-altered Al (Suroyo and Suntoro, 2013).

An increase in soil pH will occur if the organic matter we add has decomposed further (mature), because the mineralized organic matter will release its minerals, in the form of basic cations. The role of organic matter on the availability of nutrients in the soil cannot be separated from the mineralization process which is the final stage of the process of overhauling organic matter to improve the chemical properties of the soil (Diels et al., 2004).

Nisa (2010) said that biochar can increase soil pH depending on the amount given, the more amount given, the higher the soil pH. The role of biochar in this case can be seen with the increase in C-Organic. According to Schmidt and Noack (2000) biochar is a material that contains high organic C. and is more stable in the soil. The role of biochar to increase the total N content in the soil is very small. The increase in total N does not represent changes in soil chemical properties due to the biochar dose factor. The increase in total N in the soil was thought to be caused by the effect of nitrogen (urea fertilizer) given in the soil bound by biochar. This is in accordance with the opinion of Noorizqiyah (2009) which states that the main source of soil nitrogen is organic matter which will then undergo a mineralization process, namely the conversion of nitrogen by microorganisms from organic nitrogen (protein and amine compounds) into inorganic forms ($NH4+$ and $NO3-$) so that it becomes available for use. absorbed by plants.

Network Nitrogen

The observed nutrient uptake data including Nitrogen, Phosphate and Potassium can be presented in table 7.

Table 7. Average N, P, K content of tissue and N, P, K uptake in shallot plants

Interaction	Tissue N, P, K Concentration (%)			Absorption N, P, K (mg/rumpu)		
	N	P	K	N	P	K
B0N0	0.40	0.17	0.67	70	30	110
B1N0	0.41	0.33	1.14	80	60	220
B2N0	0.42	0.22	1.06	110	80	270
B3N0	0.44	0.30	1.16	130	90	350
B0N1	0.42	0.20	0.81	80	40	150
B1N1	0.45	0.27	1.05	100	60	240
B2N1	0.49	0.27	1.04	140	80	300
B3N1	0.54	0.24	1.06	160	70	320
B0N2	0.45	0.31	0.75	100	70	170
B1N2	0.53	0.27	1.04	130	70	260
B2N2	0.57	0.24	0.98	170	70	290
B3N2	0.62	0.27	1.05	210	90	350

Interaction	Tissue N, P, K Concentration (%)			Absorption N, P, K (mg/rumpu)		
	N	P	K	N	P	K
B0N3	0.47	0.22	0.77	120	60	200
B1N3	0.61	0.27	0.99	180	80	290
B2N3	0.67	0.19	0.86	210	60	280
B3N3	0.70	0.26	1.47	250	90	520
B0N4	0.60	0.26	1.03	170	70	300
B1N4	0.67	O.27	1.24	220	90	400
B2N4	0.75	0.33	1.44	260	120	500
B3N4	0.77	0.38	1.55	290	140	580

Table 7 shows that there was a very high increase in plant nitrogen content based on the criteria for assessing values. It is presumed that the treatment of biochar, nitrogen and their interaction can increase the nutrient content and provide the plant needs rapidly.

Table 7 also shows that nitrogen content increases with increasing nitrogen dose and has an impact on uptake. Uptake improvement is largely determined by the amount of nitrogen available in the soil. The availability of nitrogen in the soil is due to biochar being able to withstand the ammonium union from urea fertilizer. Crawford (1995) stated that plants need Urea in the form of ammonium and nitrate. In soil, urea is hydrolyzed to ammonium and nitrate so that plants can easily absorb it.

Nitrogen is absorbed through the roots in the form of nitrate ions, ammonium in the form of organic compounds in low molecular amounts such as amino acids (Richardson et al., 2009). The absorption of N in the form of nitrate requires a K-paired cation compared to N in the form of ammonium, the nitrate form can increase K uptake (Bar Tal, 2011).

Richardson et al. (2009) stated that in addition to being absorbed through mass flow, N can also be absorbed through diffusion. If N absorbs with mass flow then the water content factor in plant roots is very important. The mechanism of absorption through diffusion with the concentration of water nutrients in the soil has an important role. Furthermore, there is a different way for phosphorus (P) and potassium (K) nutrients which only absorb through diffusion. Plants have another way to absorb nutrients by the roots, namely by interception. Interception is one way that direct nutrient contact with roots and this method will benefit thicker roots and can help absorb more nutrients

The role of organic matter on the availability of nutrients in the soil cannot be separated from the mineralization process which is the final stage of the process of overhauling organic matter. In the mineralization process, plant nutrient minerals will be completely released in an indefinite amount. The role of biochar dominates the chemical properties of the soil (Diels et. al, 2004).

Rina (2015) stated that the nutrient N functions as a constituent of amino acids (proteins), nucleic acids, nucleotides, and chlorophyll in plants, so that the presence of N makes plants greener and accelerates plant growth (height, number of tillers, number of leaves). the role of element K for plants is as an enzyme activator.

CONCLUSION

Based on the results and discussion in the scope of this research, it can be concluded as follows: (1) Administration of biochar and nitrogen interacted with the growth and yield of shallot (Allium ascalanicum L.). The effect of biochar followed by the effect of nitrogen had a positive effect on plant height, number of leaves, number of cloves, wet weight and dry weight with doses of 30 tons/ha and 800 kg/ha producing the highest growth and yields. (2) The application of biochar and nitrogen can increase the efficiency of nitrogen uptake. Administration of biochar at a dose of 30 tons/ha and nitrogen 800 kg/ha resulted in the highest nitrogen absorption efficiency.

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