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The effect of dolomite and silicon application on Rice (*Oryza sativa* cv. Situ Bagendit) cultivation on its performance

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Abstract

The research was aimed to obtain the role of dolomite and silicon on the performance of rice cv. Situ Bagendit. A 3x3 factorial experiment with a completely randomized design was used throughout the study. The first factor consisted of three levels of dolomite, Do-0 = no added-dolomite; Do-2 = 200 and Do-4 = 4 tons dolomite/ha. The second factor was three silicon levels, Si-0 = no added-silicon; Si-100 = 100 and S-200 = 200kg silicon/ha. The experiment was conducted at the experimental land of Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang, Indonesia from October 2018 to February 2019. It was located at 6°50'-7°10' South and 109°35'-110°50' East. Parameters observed were number of tillers and panicles, dry weight of shoots, roots and grains, N-shoot and N-root and the 1,000-grain weight. The obtained data were statistically processed using analysis of variance and Duncan multiple range test for multiple comparison among treatment. There was no significant effect due to the treatment of all observed parameters. It may be concluded that the application of up to 4 tons of dolomite/ha and 200kg of silicon/ha was not enough to improve soil quality so it has no effect on rice growth and yield. Therefore it was not recommended to apply to the cultivation of rice cv. Situ Bagendit. Further research needs to be carried out by increasing the dose of dolomite and silicon to obtain the optimum dose for the cultivation rice cv. Situ Bagendit.

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Introduction

Rice (*Oryza sativa*) is the staple food of Asian people, including Indonesian. Indonesia is the world's third rice producer after India and China. In order to meet the national rice needs since the 1970s, the Indonesian government has implemented intensive agricultural activities by massive application of inorganic fertilizers. Continuous use of inorganic fertilizer without organic fertilizer application may cause nutrient imbalance in the soil, low fertilizer efficiency, damage of soil structure and decrease the population of soil microorganism. At the end, within a decade that was around 1985, Indonesia was able to become self-sufficient in food, especially rice. Infact, the rice self-sufficiency only lasted for about a decade and after that Indonesia became one of the rice importer countries again. To meet the national rice needs, the Indonesian government continues to use various methods, including the development of various superior varieties of rice. These are needed considering the need for rice continues to increase along with the increase in population. For this reason, various superior varieties have been found and released by the government through the Ministry of Agriculture, one of which was the Situ Bagendit variety. Rice cv. Situ Bagendit was released by the Indonesian government in 2003. It is suitable to be cultivated in both dry and wet land with a potential yield of 3-5 and 5-6 tons/ha, respectively in dry and wet land. The Situ Bagendit variety aged about 110-120 days after planting (DAP), plant height 99-105cm, productive tillers ranged about 12-13 panicles per clump, the 1000-grain weight about 27-28g (Simanullang *et al.,* 2002).

Intensive agricultural activities may not only reduce soil macro elements but also reduce other beneficial elements such as Silicon (Si). The depletion of Si in the soil may be one of the factors that may cause a decrease in rice yields (Meena *et al.,* 2014; Ma *et al.,* 1989). The role of Si in the cultivation of two local Indonesian rice varieties, namely *Mentik Susu* and *Pandan Wangi*, has been evaluated by applying Si doses of up to 200kg SiO_2/ha (Widjajanto *et al.,* 2021). However, doses up to 200kg SiO_2/ha have not been able to significantly increase the productivity of those two local rice varieties.

The use of zeolite as a soil ameliorant showed that the application of zeolite had an impact on improving the physical and chemical properties of the soil and reducing the toxicity of heavy metals (Mondal *et al.,* 2021). Natural zeolite is a source of SiO_2, Cao and MgO containing 53% SiO_2, 27% CaO and 1.5% MgO respectively (Setiadi and Pertiwi, 2007). Meanwhile, dolomite as a soil ameliorant that may be used together with zeolite to improve soil quality and both will be able to support plant growth and production, especially rice.

Dolomite may increases soil pH through hydrolysis process and increases the availability of Ca^{2+} and Mg^{2+} which Ca^{2+} role the cell growth process and Mg^{2+} in forming chlorophyll. Increasing the Ca^{2+} and Mg^{2+} content of the soil due to the application of dolomite have beneficial for plants because these two macronutrients play an important role in plant metabolism (Castro and Crusciol, 2015; Pramita *et al.*, 2015). Study was conducted to evaluate the effect of dolomite and silicon applications on the performance of Rice cv. Situ Bagendit.

Materials and methods

Location of the study site

The experiment was conducted at the experimental soil of Department of Agriculture, Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang, Central Java, Indonesia. The research location is located at 6°50'-7°10' South and 109°35'-110°50' East, with an altitude of 256 meters above the sea level, with daily temperature ranged between 28.0-30.5°C, rainfall 3,100mm/year, and humidity ranged about 75-90% with climate type C in the criteria of Oldemen (Central Bureau of Statistics, 2017; Climatology Station of Semarang, 2019). The experiment was carried out during the rainy season from October 2018 to February 2019.

Experimental design, treatments and parameters observed

A 3x3 factorial experiment on the basis of a completely randomized design was used throughout the study. The first factor consisted of three levels of dolomite as Do-0: no added dolomite; Do- 2: 2 ton dolomite/ha; and Do-4: 4 ton dolomite/ha. The second factor was level of Silicon as Si-0, Si-100, and Si-200, respectively no added Silicon, 100, and 200kg SiO_2/ha. Parameters observed were morphological and generative characters such as number of tillers and panicles, dry weight and N content of shoots and roots, and grains and the 1,000-grain weight.

Preparation of land, Planting Materials and Planting

The soil were cleaned and tillaged using a hand tractor, followed by establishing beds with a size of 2x2 m^2 which was done manually using a hoe. After that dolomite was applied according to the treatment by spreading it on the soil surface. The soil layer was then rehoeed to mix the dolomite into the soil homogeneously. The soil was then allowed to stand for one week and after that zeolite was applied according to the treatment and carried out in the same way as dolomite application.

Fertilizers such as Urea, SP-36 and KCl according to the recommended dosages of 67.5kg N/ha, 36kg P_2O_5/ha, and 50kg K_2O/ha, respectively, were applied as basic fertilzers. The SP-36 fertilizer was applied at the planting time, meanwhile KCl and urea were added in stages with the initial application were 50% of the doses, and followed by 25% and 25% of the doses both at the 1^{st} and 2^{nd} stages, respectively. Harvesting was carried out where the rice was around 110 day after planting (DAP).

Rice seeds were soaked in water and allowed to stand for 24 hours. Only the seeds that sink to the bottom of the water were then taken and germinated using a seedling tray. Seedlings were then transplanted into the soil at a distance of 20 x 20cm one week after the zeolite was applied.

Data collection and analysis

The parameters observed were the number of tillers and panicles that collected every week during the growth period. At harvest, shoots, roots and grains were separated to determine fresh weight. Samples were then taken, weighed and dried in an oven at 105°C for 24 hours to determine the Dry weight (DW) of shoots, roots, panicles and weight of 1,000 grains Candra *et al.* (2009). In addition, some samples were ovenned at 70°C for 72 hours to determine the N content. The N content was determined using the Kjeldahl method. The data obtained were statistically processed using analysis of variance and Duncan's multiple range tests for multiple comparison among treatment at 5% Steel and Torrie (1960).

Results and discussion

The soil properties of experimental site

The soil is Latosol with reddish brown and Mediterranean or dark brown with a soil pH ranged from 5.5 to 6.0. Chemical properties of initial soil was presented at Table 1. Accordingly, the N content, C-organic and C/N ratio were low. Meanwhile the P and K content of soil were very high.

Table 1. The properties of soil at experimental land

Nutrient	Value	Criteria*	Methods
Total N (%)	0.18	Low	Micro-Kjedahl procedure (ISRIC in Eviati and Sulaeman 2009)
Total P (%)	0.18	Very high	Extract HCl 25% (ISRIC in Eviati and Sulaeman 2009)
Total K (%)	0.23	Very high	Extract HCl 25% (ISRIC in Eviati and Sulaeman, 2009)
C-Organic (%)	1.52	Low	(ISRIC in van Reeuwijk, 2002)
C/N Rasio	8.4	Low	
pH	5.8	Slightly acidic	Glass Electrode pH Meter (ISRIC in van Reeuwijk, 2002)

*Eviati and Sulaeman, 2009

Morphological performance of rice and its yield

The parameters observed consisted of number of tillers and panicles, dry weight (DW) of shoots and roots, DW yield of grain and the 1,000-grain weight. Number of tillers and panicles were presented at Table 2. There were no significant effects of application both dolomite and zeolite and the interaction effect of the two treatments on the number of tillers and panicles. This indicated that plants in the vegetative growth phase showed the same response to the treatment. It was assumed that the application of dolomite up to 4 tons/ha has not been able to increase soil pH significantly. This may affect the application of zeolite because it did not have a positive impact on both growth and yield of rice.

Table 2. Morphological performance and yield of Rice cv. Situ Bagendit.

Dolomite Dose (ton/ha)	Added-Silicon (kg SiO_2/ha	Tillers	Panicles	Dry weight			The 1,000-grain weight
				Shoots	Roots	Grains	
		-------Numbers--------		------------------------------g/m²------------------------------			
Do-0	Si-0	20.3±2.9	20.3±2.5	103.0±19.5	51.1±13.3	134.5±9.7	20.9±2.5
	Si-100	20.8±4.1	19.0±1.4	72.5±8.0	52.3±10.1	148.8±16.9	19.5±1.2
	Si-200	17.0±1.7	17.0±5.9	84.7±38.0	53.5±15.2	131.8±44.0	22.0±2.3
Do-2	Si-0	21.1±2.5	18.9±2.6	57.2±15.7	45.5±3.6	134.1±17.3	24.4±1.7
	Si-100	21.8±1.3	20.7±3.4	95.6±32.5	50.5±15.8	146.9±16.0	23.7±1.3
	Si-200	19.3±7.7	16.5±7.2	62.3±42.0	49.2±33.5	124.8±52.1	23.6±3.4
Do-4	Si-0	19.7±1.2	19.0±3.1	68.2±25.4	61.5±5.4	143.8±13.1	21.6±2.3
	Si-100	22.3±3.7	21.5±6.2	95.9±25.9	55.5±23.6	162.7±51.1	24.1±2.4
	Si-200	24.9±7.5	18.8±4.6	65.3±36.0	50.1±16.6	140.8±28.0	21.0±2.7

The addition of dolomite and zeolite up to 4 tons/ha and 200kg SiO_2/ha, respectively, did not show any significant difference compared to the control. This indicates that the application of dolomite into the soil was unable to improve the soil significantly so that the addition of zeolite into the soil has not been able to affect the growth and yield of rice cv. Situ Bagendit. The finding was in accordance with that reported by Widjajanto *et al.* (2021) that two local varieties of rice cv. *Mentik Susu* and cv. *Pandan Wangi* cultivated with the application of 100 and 200kg SiO_2/ha did not show different performances than the control. On the other hand, it was not in line with the previous studies [3, 16]. This may be due to the fact that the added doses of both dolomite and zeolite were lower than that doses applied in the previous studies.

This suggests that the application of zeolite may not be sufficient to increase the availability of Si and other elements in the soil. Consequently the application of zeolite may not support the uptake of Si and other soil elements especially macro nutrients by plants. The presence of Si was not enough and effective in triggering the growth of rice cv. Situ Bagendit. Therefore, Si uptake was not able to increase the strength of plant cell walls optimally and this condition did not affect the physical growth of plants (Hattori *et al.*, 2005). This shows that the addition of Si has no effect on the physical growth of plants so that it did not affect the potential of sunlight absorption intensity. As the rate of photosynthesis did not increase and consequently did not affect crop yields (Ma *et al.,* 1989; Yoshida, 1981).

Dry weight of shoots and roots

There were no significant effects of application both dolomite and zeolite and the interaction effect of the two treatments on the dry weight (DW) of shoots and roots (Table 2.). The DW of shoots and roots was determined by the number of tillers and panicles formed during the vegetative phase. Therefore, the DW of shoots and root had the same response as shown by the number of tillers and panicles to the treatment. Both parameters were not affected by dolomite and zeolite applications (Ma *et al.,* 1989; Yoshida, 1981).

Rice yield and the 1,000-grain weight

There was no significant effect of dolomite and zeolite addition on rice yield and the 1000-grain weight of rice. Rice yields were determined not only by macro nutrients but also by beneficial elements such as Si availability that may be generated from zeolite application. The findings in this study were inconsistent with previous studies (Alvarez and Datnoff, 2001; Gillman *et al.,* 2002; Matichenkov and Bocharnikova, 2010; Ibrahim *et al.,* 2018). There were many possibilities in connection with the inconsistent between the results of this experiment with the previuos study. The differences of plant objects used in the study including different spesies or variety of crop. Besides, the use of dolomite in increasing soil pH has not functioned properly, therefore, the increase in pH has not been in accordance with what is needed by rice cv. Situ Bagendit. Therefore, Rice cv. Situ Bagendit that treated with lime and without addition of lime showed insigficantly results.

N content of shoots and roots

Treatment of dolomite and Si levels and their interactions did not show a significant effect on N content shoots and roots (Fig. 1).

This finding was in line with (Widjajanto *et al.,* 2021; Islam and Saha, 2018; Greger *et al.,* 1969) where the application of Si reduces N uptake by plants and translocation of N to shoots and roots.

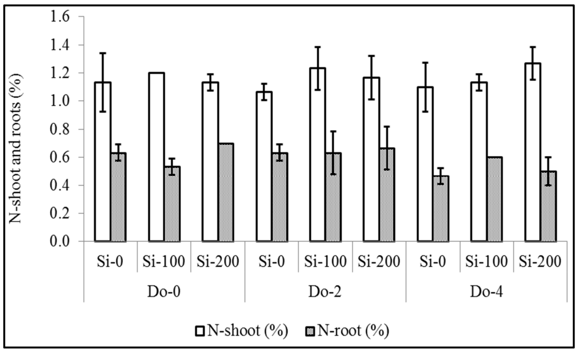

Fig. 1. N content of shoots and roots.

Conclusion

The results showed that the addition of dolomite and zeolite at the level doses used in this study was not able to improve soil conditions indicated by no increased effect on growth and production of rice cv. Situ Bagendit. Therefore it is necessary to carry out further research by considering increasing the application level dose optimal of dolomite and zeolite so that maximum performance may be achieved.

Recommendation

The research results should not be recommended to be applied to rice cultivation, especially rice cv. Situ Bagendit. Further research needs to be carried out by increasing the dose of dolomite and silicon to obtain the optimum dose for the cultivation rice cv. Situ Bagendit.

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