International Journal of Agricultural Technology 2022Vol. 18(6):2353-2368
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Plant nutrient uptake and rice growth on marginal peat soil as affected by dolomite and NPK compound

Barchia, M. F.[1 *], Sulistyo, B.[1], Diantoni, Y.[1], Bertham, Y. H.[2] and Miswarti, M.[3]

[1]Department of Soil Science, University of Bengkulu, Indonesia; [2]Department of Environmental Studies, University of Bengkulu, Indonesia; [3]Bengkulu Assessment Institute for Agriculture Technology, Bengkulu, Indonesia.

Barchia, M. F., Sulistyo, B., Diantoni, Y., Bertham, Y. H. and Miswarti, M. (2022). Plant nutrient uptake and rice growth on marginal peat soil as affected by dolomite and NPK compound. International Journal of Agricultural Technology 18(6):2353-2368.

Abstract The inherent properties of the peat paddy field in Bengkulu, Indonesia, are marginal behaviour for agriculture activities due to its low fertility. The results showed that the peat soil ameliorated with dolomite had a significant impact on Ca_{exch} and Mg_{exch} in the soil, N and P uptake as well as plant attributes, such as productive rice tiller, fresh and dry straw weight, and dry rice grain weight. The applications of NPK fertiliser compounds significantly influenced total N and available P in the soil, N and P uptake by the plant, as well as the rice attributes. Soil Ca_{exch} was significantly correlated with soil pH, N, P and K uptake, as well as all rice attributes including productive rice tillers, fresh and dry straw weight, and rice grain. Soil Mg_{exch} significantly correlated with N uptake and productive rice tillers. N and P in the soil significantly correlated with N and P uptake and were highly correlated with all rice growth attributes. The rice growth and the harvested grains were increased by 10.733 kg plot-1 or equal to 8.40 Mg ha-1 due to the amelioration of the peat paddy with 2.000 Mg ha^{-1} dolomite and the highest dose of NPK fertiliser compounds at 1.200 Mg ha^{-1}. Therefore, the marginal peat soils in Bengkulu could be potentially used for rice cultivation following the correction of their inherent properties with soil ameliorants.

Keywords: Dolomite, Marginal Peat Soil, NPK Compound, Paddy Cultivation

Introduction

Lands and soils including peatlands with their characteristics and functions, are essential for providing goods and services to humans and their environment. Out of 17 Sustainable Development Goals (SDGs), 6 describes the importance of maintaining soil productivity (Evans *et al.,* 2021). For example, SDGs 1 and 2, which include no poverty and zero hunger, are related to soil, food production, and healthy life (Chandrasekhar, 2018). Rice is a

[*] **Corresponding Author:** Barchia, M. F.; **Email:** faizbarchia@unib.ac.id

primary food source for most Indonesians, its production is a vital SDG-related program in the country (Widarjono, 2018; Aprillya *et al.*, 2019a).

Traditional farmers in Indonesia harvested 54.6 M tons of rice from paddy fields of 10.67 M hectares (BPS-Statistics Indonesia, 2020). However, the rice production was insufficient to meet the population's demands (Mustikarini and Santi, 2020). Furthermore, in 1984 the country achieved its first successful rice self-sufficiency, but it has relied on imports, which peaked in 2018 with a cumulative of 2.14 M tons. The continuation of paddy farming through intensification and extensification is necessary to increase rice production, and escaping import traps (Aprillya *et al.,* 2019b). Through the Ministry of Agriculture, the Indonesian government aimed to become a self-sufficient rice country, rice exporting nation, and the world's food barn by 2045 (Sa'diah and Tamimi, 2020; Sulaiman, 2018).

The increasing demand for suitable and fertile land, particularly for agricultural exported commodities such as palm oil and rubber crop, limited availability of suitable underdeveloped drylands, and the interesting potential nature of available peatlands with abundant water reserve and their flat topographical landscape (Hergoualc'h e*t al.,* 2018) have led to the development of peatlands as prospective agricultural food expansion areas for rice production, ensuring national food security (Surahman e*t al.,* 2018). Indonesia had ever get yields between 16 and 27 million ha (Jaya *et al.,* 2018; Page *et al.*, 2007) or approximately 20.073 million ha (Rieley *et al.,* 1996) of peaty and peat soils, which covered 43%, 32% and 25% of the total landscape in Sumatra, Kalimantan and Papua islands, respectively (Osaki *et al.*, 2016).

Marginal soils cover peatlands for agricultural expansion (Ompusunggu *et al.,* 2020), hence, proper management related to their effective development as natural resources is essential for guaranteeing environmental sustainability and ensuring food security (Dalle *et al.,* 2020). The nutrient available for cultivation and the low fertility of peat soils makes them unsuitable for rice growth without reliable and affordable amelioration techniques (Nelvia, 2014). Most peatlands in Indonesia are ombrogenous peat soil (Sahfitra *et al.,* 2020) with oligotrophic properties for agricultural development (Hikmatullah *et al.*, 2013; Wheeler and Proctor, 2000). Furthermore, the use of this soil type is accompanied by many obstacles such as pH with high acidity, low Ca Mg K content and base saturation, the toxicity of organic acid, as well as macro and micronutrient deficiency (Septiyana e*t al.,* 2017; Maftu'ah and Nursyamsi, 2019).

Amendment of peat limitations for agricultural activities is an essential management strategy for improving soil fertility, including neutralising its acidity, precipitating organic acid and toxic ions, as well as boosting available plant nutrients. The primary drawbacks of peatlands developed for agricultural activities include a highly acid soil reaction with low soil pH and a deficiency of plant nutrients, particularly macronutrients of NPK (Maftu'ah and Indrayati, 2013). The amelioration of this land with dolomite could be enhanced productivity by improving soil base saturation and significantly increasing the pH (Yulianingsing *et al.*, 2016). Furthermore, the availability of Ca and Mg in the plant growth media could be optimised by limestone treatment (Panhwar *et al.*, 2020). The recommended treatment of 315 kg urea ha^{-1}, 35 kg SP-36 ha^{-1}, and 90 kg KCl ha^{-1} yielded the best available plant nutrients for the growth of rice planted on the peat tidal lowland (Aksani *et al.*, 2018). Because the fertility of peat soils varies between regions, the recommended fertiliser amount was not suitable for the distinct conditions in the various study areas.

Bengkulu used to be approximately 63,000 ha (Wahyunto e*t al.*, 2006), and the majority of the peatlands in this area had been irrigated with dam and channel facilities. These infrastructures of Air Manjuto, Air Alas, Air Seluma, Air Riak Siabun, Peninjauan, Penago, and Air Hitam covered areas of 9,493 ha, 4,500 ha, 7,467 ha, 1,500 ha, 1,411 ha, 1,084 ha, and 1,500 ha, respectively (Zulkarnain, 2016). Local farmers converted portions of rice fields in these irrigation zones to oil palm plantations due to low productivity and harvest failure caused by low soil fertility. The study of peat amelioration using dolomite and fertilisers applied to marginal peat soils for rice cultivation which is essential to sustain Bengkulu's staple food production.

The research aimed to determine the significant effect of dolomite and NPK compound fertilisers on nutrient (N, P, K) uptake and the growth performances of rice cultivated on infertile paddy peat soils at Air Hitam irrigated field in Bengkulu, Indonesia.

Materials and methods

The study was conducted at the Field Research Station of the Department of Soil Science, Faculty of Agriculture, University of Bengkulu, Kandang Limun, Bengkulu Province, from June to November 2021 to investigate the effect of dolomite and NPK compound fertilisers on the growth of rice cultivated on marginal peat soils. The station lies on the Air Hitam irrigation area, which covers 1,500 ha. Appropriate agroclimatic conditions and available water supply on flat landscapes within the rice irrigation area are conducive to intensive paddy cultivation activities, despite the peat's inherent properties being a limiting factor. The average rainfall is 295.8 mm $month^{-1}$ and there are approximately 19 rainy days in a month. Maximum and minimum daily temperatures ranged between 32- 34℃ and 22-23℃, respectively, with a relative humidity range of 80-88%.

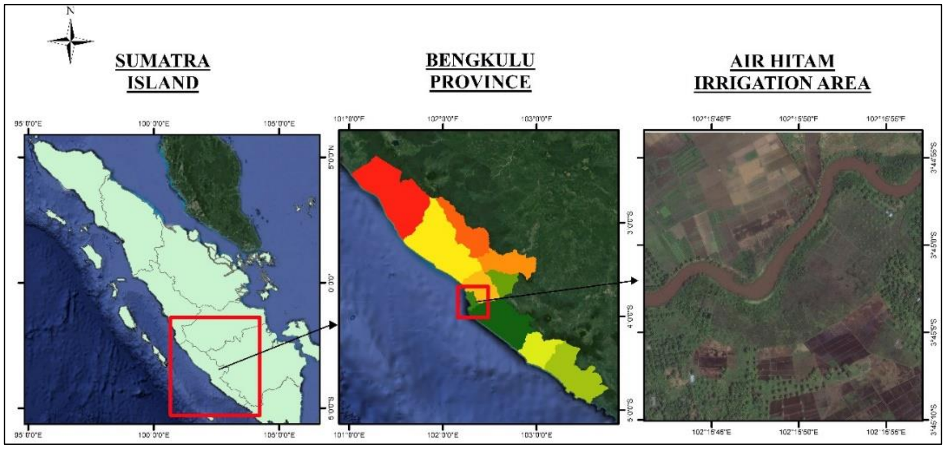

Figure 1. Research location

The used method was a factorial in randomised complete block design (RCBD) with two factors and three replications. The first factor was the dolomite rate consisting of two levels, namely D_1 = 600 g plot^{-1} (1.000 Mg ha^{-1}) and D_2 = 1,200 g plot^{-1} (2.000 Mg ha^{-1}). Secondly, was NPK fertilizer compounds consisting of four levels; F_1 = 180 g plot^{-1} (0.300 Mega gram, Mg ha^{-1}), F_2 = 360 g plot^{-1} (0.600 Mg ha^{-1}), F_3 = 540 g plot^{-1} (0.900 Mg ha^{-1}), F_4 = 720 g plot^{-1} (1.200 Mg ha^{-1}), and plot control D_0F_0 (without dolomite and NPK). There were 27 experimental plots, each with a 9 m^2 (3 m x 3 m) planted area. The spacing was 30 cm x 30 cm, ensuring that each plot contained 100 rice clumps. Avoiding the border effect, the outermost plant row of each plot was eliminated from sample selection, and the distance between each block and plot was 0.5 m.

The nutrient contents of the NPK fertiliser compound were 15% N, 15% P and 15% K. Dolomite was applied 2 weeks before planting, as shown in Figure 2, while the NPK compound was administered 2 days after planting. The experiment utilised a local variety of paddy seeds, sown in a bed media close to the plot. After 2 weeks of the dolomite application, the seedlings were transferred into the plots. The field was watered when there was no rain, the rice bed experienced a lack of water, the growth media was mechanically protected from weed proliferation, and organic pesticides Phepoc HCS were used for pest and disease control. Finally, rice was harvested when the panicles started ducking, and the grain showed 90 % maturity.

The characteristics analysed in the Laboratory were soil pH H_2O (1:5 soil: H2O), pH KCl (1:5 soil: 1 *M* KCl) (Reeuwijk, 2002), total-N (semimicro-Kjeldahl) (Lee *et al.*, 2017), available P (P-Bray I, 0,03 *M* NH_4F + 0.025 *M* HCl) (Bray and Kurtz, 1945), exchangeable Ca (Ca_{exch}) and Mg (Mg_{exch}), and K (K_{exch}) (1 *M* NH4OAc pH 7) (Hajek *et al.*, 1972). N, P, and K are nutrient uptake in the plant (H_2SO_4-H_2O_2 digested conventional Kjeldahl analysis) (Thomas *et al.*, 1967).


Figure 2. Dolomite incubation


Figure 3. Early-stage growth

The rice performances were numbers of productive tillers, fresh and dry strawweight, as well as rice grain weight. The data were analysed with analysis of variance (ANOVA) at a significance level of 5%, and treatment means were compared with Duncan Multiple Range Test (DMRT) (Gomez and Gomez, 1984) using CropStat 7.2 statistical software program. Furthermore, the correlations between the chemical properties of soil, nutrient uptakes, and rice attributes after the application of dolomite and NPK fertiliser compounds were determined using Pearson correlation analysis (Karyati *et al.*, 2018).


Figure 4. Productive tillers


Figure 5. Rice grain ripening

Results

Inherent characteristics of peat

The peat soil used for this research is 10 m above sea level, 500 m from the coastal line, and 75 cm thick. Soil acidity is classified with an average pH (H_2O) of 5.93 and (KCl) of 4.86. The peat contains 0.62% total N, available P 0.866 ppm, and deficient availability for rice growth. Additionally, the K_{exch}, Ca_{exch}, and Mg_{exch}, of 0.22 me $100g^{-1}$, 8.01 me $100g^{-1}$, and 0.65 me $100g^{-1}$, respectively, had low availability.

Significancies of anova and correlations

Peat amelioration with dolomite had a significant impact on Ca_{exch} (Sig. 0.044*) and Mg_{exch} (Sig. 0.008**) in the soil, N (Sig. 0.001**) and P uptake (Sig. 0.005**), as well as plant attributes, such as productive rice tiller (Sig. 0.000**), fresh (Sig. 0.017*) and dry straw weight (Sig. 0.000**), and dry rice grain weight (Sig. 0.000**). However, it had not significantly affected on soil pH, $K_{exch,}$ and K uptake by the plant. The applications of NPK fertiliser compounds significantly influenced total N (Sig. 0.001**) and available P (Sig. 0.022*) in the soil, N (Sig. 0.019*) and P (Sig. 0.000**) uptake by the plant, as well as the rice attributes (Sig. 0.000**). However, it did not significantly affect soil pH, K_{exch} in the soil and the plant. The interactions between the dolomite and NPK significantly affected rice performance (Sig. 0.000**) but not the soil characteristics and nutrient uptakes (Appendix 1).

The correlation between soil characteristics, N, P, K in the plant, and rice growth and yield after applying dolomite and NPK fertilisers. Ca_{exch} were significantly correlated with pH (H2O, Sig. 0.615**), pH (KCl, Sig. 0.521**), N (Sig. 0.483*), P (Sig. 0.495*) and K uptake (Sig. 0.453*), as well as all rice attributes including productive rice tillers (Sig. 0.464*), fresh (Sig. 0.427*) and dry straw weight (Sig. 0.507*), and rice grain (Sig. 0.510*). Meanwhile, Mg_{exch} were significantly correlated with N uptake (Sig. 0.419*) and productive rice tillers (Sig. 0.407*). In general, N and P in the soil significantly correlated with their uptake and were highly correlated with all rice growth attributes. However, K_{exch} in the soil and K uptake did not appear to contribute to rice growth (Appendix 2).

Soil characteristics of the ameliorated peat

1.000 Mg ha^{-1} and 2.000 Mg ha^{-1} were neutralised the soil acidity from pH 5.93 to 6.03 and 6.14, respectively. It showed differences in soil characteristics and nutrient uptake based on the Duncan Multiple Range Test (DMRT) due to dolomite application (Table 1).

Table 1. Dolomite effects on the soil characteristics

Dolomite	**Soil pH**		**N-total**	**P_{av}**	**K_{exch}**	**Ca_{exch}**	**Mg_{exch}**
	(H_2O)	**(KCl)**	**(%)**	**(ppm)**	**(me $100g^{-1}$)**	**(me $100g^{-1}$)**	**(me $100g^{-1}$)**
D_0	5.93	4.86	0.63	0.86	0.14	8.01 a	0.65 a
D_1	6.03	4.95	0.94	5.78	0.47	10.83ab	1.05 a
D_2	6.14	5.08	1.04	6.43	0.73	17.19 b	2.25 b
Sig.	0.083	0.071	0.156	0.767	0.305	0.508	1.000

Note: A number followed by the same letter in the same column means no significant difference using DMRT at 5% level of significance

Ca_{exch} and Mg_{exch} in the soil were become increasingly significant available to the plant root when the amount of dolomite added to the rice peat soil reached 2.000 Mg ha^{-1}. N total, available P and K_{exch}, and also increased substantially following dolomite treatment, but the increased availability of these nutrients which had not significant affected on plant growth in the ameliorated peat soil.

The peat soil's available P and N total were increased significantly when NPK fertiliser compound were applied. The differences in soil characteristics as modified by NPK application was shown in Table 2.

Table 2. NPK effect on the soil characteristics

NPK	Soil pH		N-total	P_{av}	K_{exch}	Ca_{exch}	Mg_{exch}
	(H_2O)	(KCl)	(%)	(ppm)	(me $100g^{-1}$)	(me $100g^{-1}$)	(me $100g^{-1}$)
F_0	5.93	4.86	0.63 a	0.86 a	0.14	8.01	0.65
F_1	6.03	4.95	0.71 a	2.78 ab	0.24	11.00	1.33
F_2	6.05	4.95	0.78 a	5.45 b	0.27	12.33	1.52
F_3	6.05	5.05	0.91 a	6.28 bc	0.69	12.80	1.81
F_4	6.21	5.11	1.55 b	9.91 c	1.20	19.91	1.92
Sig.	0.177	0.082	1.000	0.306	0.097	0.095	0.102

Note: A number followed by the same letter in the same column means no significant difference using DMRT at 5% level of significance

N total and available P in the soil were increased with the dose of NPK applied. The highest dose of peat soil NPK fertiliser, F_4 with 1.200 Mg ha^{-1}, resulted in a significant increase in soil total N, while the application of 0.600 Mg ha^{-1}led to a considerable increase in available P, and followed by the application of NPK, available K in the form of K_{exch} increased with it was not significantly differed.

NPK in plant

N and P uptake increased when dolomite was applied at 2.000 Mg ha^{-1} to peat soil for rice cultivation, but the ameliorant did not significantly increase in K uptake by the plant. The differences in nutrient uptake by the rice due to the application of dolomite is shown in Table 3.

Table 3. Dolomite effects on the nutrient uptake by rice plant

Dolomite	N in plant	P in plant	K in plant
		(%)	
D_0	1.12a	0.24a	1.34
D_1	1.99b	0.29b	2.09
D_2	2.53c	0.32b	2.26
Sig.	1.000	1.000	0.304

Note: A number followed by the same letter in the same column means no significant difference using DMRT at 5% level of significance

The doses of NPK fertiliser enhanced soil N and P levels along with rice absorption of N and P, but these fertiliser doses did not significantly alter the plant's uptake of K due to low soil Kexch levels. The differences in N, P, K uptake as a function of the doses of NPK fertiliser is shown in Table 4.

Table 4. NPK applied on the N, P, K uptake by the rice plant

NPK	N in plant	P in plant	K in plant
		(%)	
F_0	1.12 a	0.24 a	1.34
F_1	1.92 b	0.26 ab	2.08
F_2	2.21 bc	0.28 b	2.14
F_3	2.36 bc	0.33 c	2.16
F_4	2.57 c	0.35 c	2.33
Sig.	1.000	0.346	0.213

Note: A number followed by the same letter in the same column means no significant difference using DMRT at 5% level of significance

A significant increase in soil N and P, which was affected by the doses of the NPK added, N and P uptakes were affected by the rice plants. Meanwhile, K uptake by the rice showed no significant differences between doses of NPK, and there was no substantial K_{exch} in the soils. N and P uptake by the plant were significantly affected when 0.300 Mg ha^{-1} and 0.600 Mg ha^{-1} of NPK compound fertiliser were added, respectively.

Rice growth and yield

Rice growth and yields were responded by addition of dolomite and NPK fertilisers, and these two treatments significantly influenced the plant's performance. Furthermore, they increased when the soil was ameliorated with dolomite and NPK fertilisers at the lowest dose. The rice growths and yields influenced by the interaction between dolomite and NPK fertilisers is shown in Table 5.

Rice growth and yield were inhibited when the peat paddy field was not amended with dolomite and fertilisers. The plant produced only 6.740 kg plot^{-1} of biomass which corresponded to 7,488.89 Mg ha^{-1} and harvested grain of 3.366 kg plot$^{-1,}$ which corresponded to 3.740 Mg ha^{-1}. The rice biomass production and grain harvested were 16.246 kg plot$^{-1,}$ and 10.733 kg plot^{-1}when the peat soil was ameliorated with 1,200 g plot-1 dolomite and 1,200 g plot-1 NPK compound.

Table 5. Interaction dolomite and NPK fertiliser to rice performances

Dolomite*NPK	Fresh Straw Weigh	Dry Straw Weight	Productive Tiller	Dry Grain Weight
	(kg plot^{-1})		(Stem clump^{-1})	(kg plot^{-1})
D_0F_0	21.586 a	6.740 a	10.8 a	3.366 a
D_1F_1	23.953 b	8.046 b	14.9 b	4.266 b
D_2F_1	24.493 b	8.246 bc	16.8 c	4.466 c
D_1F_2	25.946 c	8.453 c	17.2 c	5.353 d
D_2F_2	26.893 d	9.146 d	20.7 d	5.526 d
D_1F_3	30.580 f	10.393 e	22.7 e	6.746 e
D_2F_3	29.806 e	10.880 f	26.1 f	6.880 e
D_1F_4	32.826 g	14.326 g	26.6 f	9.506 f
D_2F_4	34.126 h	16.246 h	29.2 g	10.733 g
Sig.	1.000	1.000	1.000	1.000

Note: A number followed by the same letter in the same column means no significant difference using DMRT at 5% level of significance

Discussion

The average peat thickness in the Air Hitam irrigation area was 75 cm therefore the peat is considered shallow (Sutejo *et al.*, 2017). The average soil pH in this location was 5.93, and much higher when comparing to previous research which closed to this area with the soil pH ranged between 4.8 and 5.2. The soil pH in this area was classified as acidic but suitable for cultivation (Hadi e*t al.*, 2019). Total N content in soil was 0.63% and it was classified with high content, but only a small amount of it was present in the plant as ammonium or nitrate (Saidy, 2002). Furthermore, the low concentration of inorganic nitrogen in tropical peatlands results from the slow rate of N mineralisation and immobilisation or denitrification. Peat soil's chemical limiting factors were low nutrient content for plant growth (Purnomo and Subiksa, 2021).

The soil in this location was categorized an acid soil therefore in order to provide suitable plant growth media, the soil needed the application of lime in this case the dolomite application to raise the soil pH. The application of dolomite up to 2.000 Mg ha^{-1} raised soil pH to 6.16. The peat soil pH in rice fields was below 6.0 required the application of lime as an ameliorant for neutralising acidic soil limited the dolomite from 2.600 Mg ha^{-1} to 5.490 Mg ha^{-1} (Gultom and Mardaleni, 2017).

The application of the dolomite significantly affected the Ca_{exch} and Mg_{exch} in the soil which the 2.000 Mg ha^{-1} of dolomite increased the Ca_{exch} from 8.01 meq $100g^{-1}$ to 17.19 meq $100g^{-1}$ and Mg_{exch} from 0.65 meq 100 g^{-1} to 2.25 meq 100 g^{-1}. Dolomite was an effective ameliorant for pH enhancement and increased Ca and Mg in paddy peat soils (Saputra and Sari, 2021). The fertility in peatlands with low pH could be managed by applying ameliorant in the form of lime at a dose of 3 Mg ha^{-1} to increase soil pH (Waramui *et al.*, 2019). Furthermore, peat lands issues can be overcome using agricultural lime combined with inorganic fertilisers to improve the condition and increase pH as well as the availability of nutrients in the soil, hence, accelerating soil health and plant yield. Furthermore, the application of dolomite with 1.000 Mg ha^{-1} was significantly affected N and P uptake to 1.99% and 0.29% comparing to no dolomite application, 1.12% and 0.24%, respectively. Liming with dolomite increases plant root proliferation by mitigating the toxic effects of soil elements, thereby increasing the nutrient uptake of N, P and K (Chang and Sung, 2004).

The increased doses of NPK compound were followed by the increased N and P in the soil, however the significantly increased of N in the soil when the highest doses of 1.200 Mg NPK ha^{-1} and the significantly increased of P in the soil when the dose of 0.600 Mg NPK ha^{-1} applied. While, N uptake increased significantly when the application of NPK was 0.300 Mg ha^{-1} and P uptake when the application of NPK 0.600 Mg ha^{-1}. The varying implementations of N, P, and K fertiliser compounds significantly affected the nutritional uptake (Gewaily *et al.*, 2018). The concentrations determined plant nutrient uptake in soils and dry biomass harvested (Kihanda *et al.*, 1998). Furthermore, the nutrient absorption through plant roots was determined by the ionic forms in the rhizosphere, which were affected by soil acidity and nutrient concentrations as well as interactions in the soil solution. Dolomite and NPK applications enhanced the availability of N, P, and K, which the crop could ultimately absorb due to the reduced soil acidity.

The application of dolomite together with the application of NPK compound were significantly affected the rice growth and yields. When each of these treatments was increased, the rice growth and yields raised significantly.

Dolomite application as a liming practice on acidic soils improved soil behaviours and increased crop yields (Mansingh *et al.*, 2019). Furthermore, its application as an ameliorant increases the number of productive tillers and grain and straw yield of rice. When paddy is grown in marginal soils, the fertilisers provided as a source of nutrients play a crucial role in enhancing harvested productivity, particularly N, P, and K as the principal macronutrients for plant growth and rice yields (Kaushik and Djiwanti, 2017). These components performed better when the paddy cultivation media was treated with the NPK fertilisers. This fertiliser added in optimum quantities to rice fields generated high grain, and a deficiency of either nutrient leads to yield losses (Masni and Wasli, 2019). Marginal soils require more NPK fertiliser to mitigate the low fertility status. Its doses of more than 0.480 Mg ha^{-1} could improve rice growth (Paiman *et al.*, 2021). Adding the N, P, and K fertilisers provided vigorous growth in rice cultivation (Wu *et al.*, 1998). This crop's better growth and yield performances could be attributed to the neutralisation of soil pH during liming, the related improvement in nutrient availability, and many other characteristics of soil fertility (Kumar *et al.*, 2012).

The peat paddy field in Bengkulu is categorised as a marginal soil with low pH and nutrient content for rice growth. Furthermore, the dolomite and NPK fertilisers applied ameliorated its behaviour. The dolomite neutralised soil pH, increased Ca_{exch}, Mg_{exch}, N and P uptake, rice growth, and yield. The application of NPK fertiliser compound increases N and P in the paddy soil and significantly affects rice growth and yield. Amelioration recommended for the peat for paddy cultivation in Bengkulu was 2.000 Mg ha^{-1} dolomite and NPK fertiliser compounds at a high dose of 1.200 Mg ha^{-1} because based on this research this recommendation promoted rice growth and grain harvested to approximately 8.4 Mg ha^{-1}.

Acknowledgements

This research was funded by FACULTY OF AGRICULTURE, UNIVERSITY OF BENGKULU, Contract no. 5914/UN30.11/KU/2021, August 10, 2021.

References

Aksani, D., Budianta, D. and Hermawan, A. (2018). Determination of Site-Specific NPK Fertilizer Rates for Rice Grown on Tidal Lowland. Journal of Tropical Soils, 23:19-25.

Aprillya, M. R., Suryani, E. and Dzulkarnain, A. (2019a). The Analysis of Quality of Paddy Harvest Yield to Support Food Security: A System Thinking Approach (Case Study: East Java). Procedia Computer Science, 161:919-926.

Aprillya, M. R., Suryani, E. and Dzulkarnain, A. (2019b). System Dynamics Simulation Model to Increase Paddy Production for Food Security. JISEBI, 5:67.

BPS-Statistics Indonesia (2020). Statistik Indonesia 2020. BADAN PUSAT STATISTIK: Jakarta, Indonesia.
Bray, R. H. and Kurtz, L. T. (1945). Determination of Total, Organic, and Available Forms of Phosphorus in Soils. Soil Science, 59:39-46.
Chandrasekhar, P. (2018). The role of soils in achieving the SDGs. UNU Institute for Integrated Management of Material Fluxes and of Resources**.** Ammonstrasse 74 Dresden, 01067 Germany. Retrieved from https://flores.unu.edu/en/news/news/the-role-of-soils-in-achieving-the-sdgs.html
Chang, C. S. and Sung, J. M. (2004). Nutrient Uptake and Yield Responses of Peanuts and Rice to Lime and Fused Magnesium Phosphate in an Acid Soil. Field Crops Research, 89:319-325.
Dalle, J., Hastuti, D. and Akmal, F. (2021). Evaluation of Peatland Suitability for RiceCultivation Using Matching Method. Polish Journal of Environmental Studies, 30:2041-2047.
Evans, D. L., Bassett, V. J., Borrelli, P., Claire Chenu, C., Ferreira, C. S. S., Griffiths, R. I., Kalantari, Z., Keesstra, K., Rattan Lal, R., Panos Panagos, P., Robinson, D. A., Aghmiuni, S. S., Smith, P., Steenhuis, T. S., Thomas, A. and Visser, S. M. (2022). Sustainable futures over the next decade are rooted in soil science. European Journal of Soil Science, 73:e13145. 1-16
Gewaily, E.; Ghoneim, A. and Elhabet, H. (2018). Effects of Soil Fertilisation on Sakha 105 Rice Cultivar Productivity, NPK Uptake and Soil Nutrient. Journal of Soil Sciences and Agricultural Engineering, 9:253-259.
Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedures For Agricultural Research, 2nd ed.; A Wiley-intersclence Publication: United States Of America.
Gultom, H. and Mardaleni, M. (2017) Uji Adaptasi Beberapa Varietas Padi Sawah (*Oryza Sativa* L.) Dan Kapur Dolomit Pada Tanah Gambut. Dinamika Pertanian, 29:145-152
Hadi, A., Syarbini, M. and Panjaitan, M. S. L. (2019). Land Suitability of Agricultural Crops for Supporting Peat Restoration In South Kalimantan, Indonesia. Journal of Wetlands Enviromental Management, 7:115.
Hajek, B. F.; Adams, F. and Cope, J. T. (1972). Rapid Determination of Exchangeable Bases, Acidity, and Base Saturation for Soil Characterization. Soil Science Society of America Journal, 36:436-438.
Hergoualc'h, K., Carmenta, R., Atmadja, S., Martius, C., Murdiyarso, D. and Purnomo, H. (2018). Managing Peatlands in Indonesia: Challenges and Opportunities for Local and Global Communities; Center for International Forestry Research (CIFOR).
Hikmatullah, H., Nugroho, K. and Sarwani, M. (2013). Characterising the Cultivated Lowland Peat Soils in Two Physiography Positions in Kalimantan, Indonesia. International Research Journal of Agricultural Science and Soil Science, 3:246-255.
Jaya, A., Inoue, T., Limin, S. H., Darung, U. and Banuwa, I. S. (2018). Microclimate of Developed Peatland of the Mega Rice Project in Central Kalimantan. Journal of Tropical Soils, 15:63.
Karyati, K., Ipor, I. B., Jusoh, I. and Wasli, M. E. (2018). Correlation between Soil Physicochemical Properties and Vegetation Parameters in Secondary Tropical Forest in Sabal, Sarawak, Malaysia. IOP Conference Series: Earth and Environmental Science, 144:012060.
Kaushik, S. and Djiwanti, S. R. (2017). Genetic Improvements of Traits for Enhancing NPK Acquisition and Utilisation Efficiency in Plants. In *Plant Macronutrient Use Efficiency*; Elsevier, 267-283.

Kihanda, F. M.; Wood, M. and O'Neil, M. K. (1998). Effect of Lime, Farmyard Manure and NP Fertilisers on Maize Yield and Soil Chemical Characteristics in an Ando-Humic Nitosol of Central Kenya; International Maize and Wheat Improvement Center.

Kumar, M., Hazarika, S., Choudhury, B. U., Ramesh, T., Verma, B. C. and Bordoloi, L. J. (2012). Liming and Integrated Nutrient Management for Enhancing Maize Productivity on Acidic Soils of Northeast India. Indian Journal of Hill Farming, 25:35-37.

Lee, S.-B., Sung, J.-K., Lee, Y.-J., Lim, J.-E., Song, Y.-S., Lee, D.-B., and Hong, S. Y. (2017). Analysis of Soil Total Nitrogen and Inorganic Nitrogen Content for Evaluating Nitrogen Dynamics. Korean Journal of Soil Science and Fertilizer, 50:100-105.

Maftuah, E. and Indrayati, L. (2013). The Use Of Biochar For Improve Soil Properties And Growth Of Paddy In Peatland. Agrivita, Journal of Agricultural Science, 35 (3).

Maftu'ah, E.and Nursyamsi, D. (2019). Effect of Biochar on Peat Soil Fertility and NPK Uptake by Corn. Agrivita, Journal of Agricultural Science, 41 (1).

Mansingh, M. D. I., Suresh, S., Raj, M. A. and Vignesh, S. (2019). Effect of Liming on Yield and Nutrient Uptake of Rice in Acidic Soils. International Journal of Chemical Studies, 7:2540-2543.

Masni, Z. and Wasli, M. E. (2019). Yield Performance and Nutrient Uptake of Red Rice Variety (MRM 16) at Different NPK Fertilizer Rates. International Journal of Agronomy, 1-6.

Mustikarini, E. D. and Santi, R. (2020) The Empowerment Strategy of Newly Irrigated Rice Field Farmers through LEISA. Society (Bangka. Online), 8:23-36.

Nelvia, N. (2014). Response of Rice and Carbon Emission to Application of Ameliorant Dregs in The Peat Soil with Saturation and Unsaturation Condition. International Journal on Advanced Science, Engineering and Information Technology, 4:461.

Ompusunggu, D. S., Purwanto, B. H., Wulandari, C. and Utami, S. N. H. (2020). Effect of Salted Fish Waste and Cow Manure on NPK Availability and Uptake of Lowland Rice on Peat Soil in Pelalawan Riau. Ipas, 5:11.

Osaki, M., Setiadi, B., Takahashi, H. and Evri, M. (2016). Peatland in Kalimantan. In *Tropical Peatland Ecosystems*; Osaki, M., Tsuji, N., Eds.; Springer Japan: Tokyo: 91-112.

Page, S. E., Banks, C. J. and Rieley, J. O. (2007) Tropical Peatlands: Distribution, Extent and Carbon Storage – Uncertainties and Knowledge Gaps. Peatlands International, 2:8

Paiman, P., Ardiyanta, A., Kusumastuti, C. T., Gunawan, S. and Ardiani, F. (2021). Maximising the Rice Yield (*Oryza Sativa* L.) Using NPK Fertilizer. TOASJ15, 33-38.

Panhwar, Q. A., Naher, U. A., Shamshuddin, J. and Ismail, M. R. (2020). Effects of Biochar and Ground Magnesium Limestone Application, with or without Bio-Fertilizer Addition, on Biochemical Properties of an Acid Sulfate Soil and Rice Yield. Agronomy, 10:1100.

Purnomo, J. and Subiksa, I. G. M. (2021). Effect of P Fertiliser Formula to the Growth and Yield of Sweet Corn on Peatland. IOP Conference Series: Earth and Environmental Science, 648:012194.

Reeuwijk, L. P. V. (2002). Procedures for Soil Analysis, 6th ed.; International Soil References and Information Centre: 6700 AJ Wageningen, Netherlands.

Rieley, J. O., Wüst, R. A. J., Jauhiainen, J., Page, S. E., Wösten, H., Hooijer, A.,Siegert, F., Limin, S. H., Vasander, H. and Stahlhut, M. (1996). Tropical Peatlands: Carbon Stores, Carbon Gas Emission and Contribution to Climate Change Process. International Peat Society, 34.

Sa'diah, S. A. and Tamami, N. D. B. (2020). Projection of National Rice Export through Triple Export Movement on Agriculture in Indonesia (Proyeksi Ekspor Beras Nasional Melalui Gerakan Tiga Kali Lipat Ekspor (Gratieks) Pertanian Indonesia)(in Indonesian Language). Pamator, 13:159-169.

Sahfitra, A. A., Hanudin, E, Wulandari, C. and Utami, S. N. H. (2020). NPK Uptake and Growth of Maize on Ombrogenous Peat as Affected by the Application of Mycorrhizal Fungal Multi-Spores and Compound Fertilizers. Ipas, 5:76.

Saidy, A. R. (2002). Carbon and Nitrogen Mineralisation in Tropical Peats: Role of Peat Properties and Management Practices. (*Doctoral Disertation*), The University of Adelaide, Australia.

Saputra, R. A. and Sari, N. N. (2021). Ameliorant Engineering to Elevate Soil PH, Growth, and Productivity of Paddy on Peat and Tidal Land. IOP Conference Series: Earth and Environmental Science, 648.

Septiyana. Sutandi, A. and Indriyati, L. T. (2017). Effectivity of Soil Amelioration on Peat Soil and Rice Productivity. Journal of Tropical Soils, 22:11-20.

Sulaiman, A. (2018). Self-Sufficient Achievement: Indonesia as World Food Barn, 2045 (Sukses Swasembada: Indonesia menjadi Lumbung Pangan Dunia, 2045) (in Indonesian Language), Second Edition; The Ministry of Agriculture, Republic of Indonesia: Jakarta.

Surahman, A., Soni, P. and Shivakoti, G. P. (2018). Are Peatland Farming Systems Sustainable? Case Study on Assessing Existing Farming Systems in the Peatland of Central Kalimantan, Indonesia. Journal of Integrative Environmental Sciences, 15:1-19.

Sutejo, Y., Saggaff, A., Rahayu, W. and Hanafiah. (2017). Physical and Chemical Characteristics of Fibrous Peat; Palembang, Indonesia, p 090006.

Thomas, R. L., Sheard, R. W. and Moyer, J. R. (1967). Comparison of Conventional and Automated Procedures for Nitrogen, Phosphorus, and Potassium Analysis of Plant Material Using a Single Digestion. Agronomy Journal, 59:240-243.

Wahyunto, W., Ritung, S.;, Suparto, S. and Subagjo, S. (2005). Peat and Carbon Storage in Sumatera and Kalimantan (Sebaran Gambut Dan Kandungan Karbon di Sumatera d) an Kalimantan 2004) (in Indonesian Language); Wetlands International – Indonesia Programme: Bogor.

Waramui, Y.; Islami, T. and Sudiarso, S. (2019). Effects of ameliorant and fertilizer on the growth and yield of maize grown in peatlands soil of West Kalimantan Indonesia. Journal of Degraded and Mining Lands Management, 6:1779-1787.

Wheeler, B. D. and Proctor, M. C. F. (2000). Ecological Gradients, Subdivisions and Terminology of North-West European Mires. Journal of Ecology, 88:187-203.

Widarjono, A. (2018). Analysis of Rice Imports in Indonesia: AIDS Approach. JEBAV 21 (2): 259-268. Retrieved from https://journal.perbanas.ac.id/index.php/jebav/article/view/1212

Wu, G., Wilson, L. T. and McClung, A. M. (1998). Contribution of Rice Tillers to Dry Matter Accumulation and Yield. Agronomy Journal, 90:317-323.

Yulianingsing, E., Susilawati, H. and Setyanto, P. (2016). Contribution of Ameliorant Application on Carbon Balance in Rice (*Oryza Sativa* L.) Cropping in Peatland. Journal of Wetlands Enviromental Management, 3 (2).

Zulkarnain, H. (2016). Assignment Memorabilia from Head Regional Office of Sumatera VII River Management (Buku Memori Tugas Kepala Balai Wilayah Sungai Sumatera VII (in Indonesian Language); Directorate General of Water Resource, The Ministry of General Work and Public Housing. Republic of Indonesia.

(Received: 15 June 2022, accepted: 28 October 2022)

Appendix 1. Summary F calc. from analysis of variance

Attributes	Dolomite		NPK Compound		Interaction	
	F calc.	Sig.	F calc.	Sig.	F calc.	Sig.
pH H_2O	1.972	0.182	1.256	0.327	0.758	0.536
pH KCl	2.465	0.139	0.928	0.455	0.462	0.713
P-Bray (ppm)	0.215	0.650	4.409	0.022*	0.255	0.856
N (%)	0.683	0.422	9.934	0.001**	2.378	0.114
K_{exch} (meq 100 g^{-1})	0.372	0.552	1.208	0.343	0.178	0.910
Ca_{exch} (meq 100 g^{-1})	4.915	0.044*	1.955	0.167	0.936	0.450
Mg_{exch} (meq 100 g^{-1})	9.671	0.008**	0.478	0.703	0.041	0.988
N in plant (%)	18.115	0.001**	4.593	0.019*	0.226	0.877
P in plant (%)	11.158	0.005**	14.473	0.000**	0.682	0.578
K in plant (	2.017	0.177	0.841	0.494	0.455	0.718
Productive tiller $clump^{-1}$ (stem)	714.841	0.000**	2605.616	0.000**	13.621	0.000**
Fresh straw weight (kg $plot^{-1}$)	7.295	0.017*	482.112	0.000**	5.909	0.008**
Dry straw weight (kg $plot^{-1}$)	174.644	0.000**	2665.985	0.000**	36.809	0.000**
Dry grain weight (kg $plot^{-1}$)	70.701	0.000**	2175.551	0.000**	25.453	0.000**

Appendix 2. Correlation among soil characteristics, nutrient uptake, and rice performances

Atributes	Soil							Plant						
	pH	pH	P-Bray	Total N	Ca-exch	Mg-exch	K-exch	N Content	P content	K content	Productive tiller	Fresh straw weight	Dry straw weight	dry grain weight
	(H2O)	(KCl)	(ppm)	(%)	(me 100 g^{-1})	(me 100 g^{-1})	(me 100 g^{-1})	(%)	(%)	(%)	(stem $clump^{-1}$)	(kg $plot^{-1}$)	(kg $plot^{-1}$)	(kg $plot^{-1}$)
Soil pH (H2O)	1	0.826**	0.303	0.06	0.614**	0.025	0.077	0.376	0.34	0.031	0.35	0.308	0.416*	0.406*
Soil pH (KCl)		1	0.28	-0.08	0.521**	0.022	0.268	0.419*	0.470*	-0.055	0.418*	0.377	0.398	0.394
Soil P (P-Bray ppm)			1	0.490*	0.105	0.108	0.137	0.382	0.434*	0.029	0.639**	0.637**	0.648**	0.670**
Total Soil N (%)				1	0.037	0.037	0.303	0.239	0.3	0.228	0.591**	0.659**	0.685**	0.666**
Soil Ca-exch (me 100g^{-1})					1	0.383	0.228	0.483*	0.495*	0.453*	0.464*	0.427*	0.507*	0.510*
Soil Mg-exch (me 100g-1)						1	-0.06	0.419*	0.385	0.312	0.407*	0.253	0.288	0.281
Soil K-exch (me 100 g^{-1})							1	0.188	0.264	0.047	0.354	0.435*	0.396	0.381
N Content in plant (%)								1	0.636**	0.359	0.656**	0.552**	0.587**	0.568**
P content in plant (%)									1	0.382	0.863**	0.794**	0.761**	0.782**
K content in plant (%)										1	0.371	0.33	0.377	0.379
Productive tiller (stem $clump^{-1}$)											1	0.958**	0.908**	0.925**
Fresh straw weight (kg $plot^{-1}$)												1	0.937**	0.960**
Dry straw weight (kg $plot^{-1}$)													1	0.989**
Dry grain weight (kg plot-1)														1