The Growth and Yield of Upland Rice (*Oryza sativa* L.) Appliced with Rice Husk Zeolite and N Fertilizer

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Abstract. Upland rice production can be increased by utilizing suboptimal land. However, efforts need to be made to increase the availability ofnutrients and water in the soil. This study aims to determine the interaction of rice husk zeolite treatment andN fertilizer on the growth and yield of upland rice. The research was conducted experimentally factorial using completely randomized design (CRD). The first factor of rice husk zeolite consisted of 3 levels (0, 200 and 400 kg.ha^{-1}) and the second factor of N fertilizer consisted of 3 levels (0, 75 and 125 kg N.ha^{-1}), each combination was repeated three times. The results showed that the application of rice husk zeolite 200 kg.ha^{-1} and N fertilizer dosage 125 kg N.ha^{-1} increased plant height, maximum number of tillers and weight of 1000 grains compared without rice husk zeolite and N fertilizer, and also increased the number of productive tillers and pithy grain per panicle, weight of dry milled grain per clump are 56.78%,16.8%, 80%, respectively compared without rice husk zeolite and N fertilizer.

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1 Introduction

Upland rice (*Oryza sativa* L.) is a commodity plant that produces rice as the main staple food for more than 90% of Indonesia's population, where the demand for it continues to increase along with the addition of population. Rice production of rice can be increased by increasing the productivity of upland rice in sub-optimal land and lowland rice productivity. Sub optimal land include Ultisol/Podzolic soils with an amount of around 25% (45 million ha) of the total land area of Indonesia (191.1 million ha) [1] and [2] and Oxisol soils of 8%. The productivity of upland rice in sub-optimal land around 2.439 ton.ha^{-1}[3], according to upland rice breeders the average yield of upland rice is 6,7 tons.ha^{-1} and the potential is 10,2 tons.ha^{-1} [4]. The low productivity of upland rice in Podzolic soils is due to various constraints: acid soil reaction, organic matter content, availability of macronutrients (N, P, K, Ca and Mg) and micronutrients (Mo), basa saturation (BS), cation exchange capacity rate (CEC<16 cmol.kg^{-1}) are low, Al exchangenable and Al saturation are high, so it is toxic to plants especially food crops.

Upland rice productivity in Podzolic soils can be increase which applicated by rice husk zeolite and N fertilizer. Zeolite has a high CEC and porosity so that it plays a role in increasing the soil's ability to absorb nutrients and water. The CEC and surface area of Na-A and Na-X zeolite were 506 Cmol.kg^{-1},317 Cmol.kg^{-1} and 171 m^2.g^{-1}, 676 m^2.g^{-1}, respectively [5]. The application of natural zeolite increased the productivity of paddy rice [6] and the application of zeolite Na-P1 increased the growth and yield of paddy rice [7]. The N fertilization is very important to increase N available in the soil, growth and production of paddy rice [8].

2 Material and method

The research was conducted at the Soil and Greenhouse Laboratory, Faculty of agriculture, Riau University, Pekanbaru, Indonesia from June to October 2022. The materials used in this study were upland rice seeds of Inpago 12 variety, podzolic topsoil taken in Balam Jaya Village, Tambang District, Kampar, Riau Province, rice husk zeolite, urea, SP-36, KCl as a source of N, P and K, polybag, Confidor 5 WP and Stage 18 EC insecticide, Antracol 70 WP fungicide. The tools used in this research are oven, furnace, porcelain dish, 25 mesh sieve, net, etc. The study was conducted experimentally in factorial form using a completely randomized design (CRD). The first factor is rice husk zeolite which consists of 3 levels (0, 200, 400 kg.ha^{-1} or 0.1 and 2 g per polybag) and the second factor is N fertilizer which consists of 3 levels (0.75, 125 kg N.ha^{-1} or 0, 0.815 and 1.3587 g per polybag), each combination was repeated 3 times.

3 Results and discussion

3.1 Chemical properties of soil and zeolite of rice husk

Chemical properties of soil before and after incubation with rice husk zeolite presented in table 1 and table 2.

Table 1. Chemical properties of soil and rice husk zeolite that used in this study

Parameters	unit	V	C
pH (H_2O)	-	4.72	a
pH (KCl)	-	3.88	-
C- Organic	%	1.59	l
N- total	%	0.34	m
C/N ratio	-	4.68	vl
P_2O_5 HCl 25%	mg.100g^{-1}	63.44	vh
K_2O HCl 25%	mg.100g^{-1}	22.05	vh
P_2O_5 Bray 1	mg.kg^{-1}	31.92	vh
K-exc.	C mol.kg^{-1}	0.54	vl
Na-exc.	C mol.kg^{-1}	0.46	m
Ca-exc.	C mol.kg^{-1}	1.54	vl
Mg-exc.	C mol.kg^{-1}	0.68	l
BS	%	31.72	l
CEC	C mol.kg^{-1}	10.15	l
Al-exc.	C mol.kg^{-1}	2.96	-
H-exc.	C mol.kg^{-1}	4.48	-
Al Saturation	%	27.77	h
CEC of rice husk zeolite	C mol.kg^{-1}	142.87	vh

Note: V is value, C is criteria, exc is exchangeable, BS is Basa saturation, CEC is cation exchange capacity and a, l, m, h, vl, vh are acid, low, medium, high, very low and very high, respectively.

Table 1 showed that the acid reacting soil has a C/N ratio and exchangeable Ca values are very low, while organic C, Mg-exc., BS and CEC are low, total N, K and Na.exc levels are moderate, only the P and K of 25% HCl extraction and available P are classified as very high, with Al saturation being relatively high. The chemical properties of the soil are classified as very low to moderate and high Al saturation is a limiting factor in plant growth and yield, thus the soil is classified as having a low fertility level. Table 1 also showed that the CEC of rice husk zeolite is very high, about 142.87 Cmol.kg^{-1}.Rice husk zeolite can be used as a soil amendment or ameliorant which has a dual function, aboutincreasing the CEC of the soil and the ability of the soil to absorb nutrients and water.

Table 2 showed that the application of rice husk zeolite at doses of 200 and 400 kg/ha can generally improve soil chemical properties such as increasing pH, K, Na, Ca and Mg-exc., BS and CEC as well as reducing Al saturation, so that soil fertility increases. This condition causes the availability of water and essential nutrients in the soil to increase for plants because the added nutrients and water adsorbed on zeolite. therefore, the amount of water

and nutrients that can be absorbed by plants also increases. This will stimulate physiological processes and plant metabolism so that it can increase plant growth and yield. The improvement in chemical properties due to the administration of zeolite.

Table 2. Soil chemical properties one month after incubation with rice husk zeolite

Parameters	Rice husk zeolite dosage (kg.ha^{-1})					
	0		200		400	
	V	**C**	**V**	**C**	**V**	C
pH H_2O	5.16	a	5.75	a	6.13	a
pH KCl	4.83	-	4.65	-	4.93	-
C- Organic	1.52	l	1.83	l	2.13	m
N- total	0.25	m	0.18	l	0.18	l
C/N ratio	6.08	l	10.17	l	11.83	m
P_2O_5 HCl 25%	188.6	vh	190.9	vh	196.0	vh
K_2O HCl 25%	213.4	vh	152.3	vh	179.2	vh
P_2O_5 Bray 1	47.6	vh	53.1	vh	59.3	vh
K-exc.	2.86	vh	0.87	h	2.65	vh
Na-exc.	0.79	m	1.48	vh	2.60	vh
Ca- exc	4.91	l	5.62	l	4.90	l
Mg-exc.	1.36	m	1.24	m	1.26	m
BS	93.0	vh	67.3	h	83.2	vh
CEC	10.7	l	13.7	l	13.7	l
Al-exc.	1.20	-	0.40	-	0.40	-
H-exc.	3.20	-	1.60	-	1.60	-
Al-S	8.38	l	3.57	vl	2.98	vl

Note: V is value, C is criteria, exc is exchangeable, BS is Basa saturation, CEC is cation exchange capacity, S is saturation and a, l, m, h, vl, vh are acid, low, medium, high, very low and very high, respectively. Units of the parameters same with in table 1.

3.2 The growth of upland rice

Table 3 showed that the application of rice husk zeolite dose of 200 kg.ha^{-1} and N fertilizer dose of 125 kg N. ha^{-1} gave the highest increase plant height, maximum and productive number of tillers compared to without rice husk zeolite and N fertilizer. This is more related to the contribution of N fertilizer and rice husk zeolite in increasing the availability of N and water in soil. Thus the uptake of N and water by plants increases and stimulates physiological and metabolic processes so as to increase the growth of rice plants.

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Table 3. Plant height, tillers maximum and productive number of upland rice appliced with rice husk zeolite and N fertilizer

Rice husk zeolite dosage (kg.ha^{-1})	N fertilizer dosage (kg N.ha^{-1})			Average
	0	75	125	
Plant height (cm)				
0	98.00 c	118.33ab	122.67ab	113.00b
200	101.67c	122.67ab	126.33a	116.89ab
400	115.00b	121.33ab	124.33ab	120.22a
Average	104.89b	120.78a	124.44a	
Maximum number of tillers (stem)				
0	12.33 b	15.00ab	18.00ab	16.33 a
200	11.67 b	17.33ab	20.00 a	15.33 a
400	15.67ab	13.00ab	16.33ab	15.00 a
Average	13.44 b	15.11ab	18.11 a	
Productive number of tillers (stem)				
0	12.33 b	13.67ab	16.67ab	14.22 a
200	11.00 b	15.00ab	19.33 a	15.11 a
400	13.67ab	12.33 b	15.33ab	13.78 a
Average	12.33 b	13.67ab	17.11 a	

Note: Numbers in the same row and column followed by the same lowercase letters are not significantly different according to the DNMRT test at the 5% level.

Nitrogen and water are needed in large quantities which play a role in compiling various organic compounds in plants such as amino acids, chlorophyll and others. Amino acids are the main components of proteins, where proteins function as enzymes and make up the structure of cells or cell nuclei. Growth which means the increase in tissue begins with the division of the cell nucleus.

According to [9] Nitrogen is one of the constituent elements of chlorophyll which is the main agent of chloroplasts. [10] reported that the interaction of zeolite dose of 63.1 g and N fertilizer dose of 18.04 g ZA per plant tended to increase the height of deli tobacco plants (38.40 cm) compared to without zeolite and N. [11] reported that the media mixture Planting coconut coir, ferns, and zeolite produced Dendrobium orchid bulb height 1.15 cm (16.39%) higher than without zeolite application, and [12] reported that applying N fertilizer at a dose of 126.5 kg N.ha^{-1} increased the height of your plants by 35 day after planted compared to N fertilizer at a dose of 80.5 kg N.ha^{-1}. [13] reported that the interaction of various doses of N fertilizer and zeolite was not significant on the vegetative growth of sorghum, namely the number of leaves, and [14] reported that administration of various doses of zeolite had no significant effect on the maximum number of tillers and productive tillers of rice plants, further [15] reported that the application

of N fertilizer at a dose of 300 kg N.ha^{-1} compared to N fertilizer at a dose of 75 kg N.ha^{-1} showed a significant effect on increasing the number of leaves of sweet corn plants.

3.3 Age of panicle exit and harvest

Table 4 showed that the application of rice husk zeolite dose of 400 kg.ha^{-1} and N fertilizer dose of 75 kg N.ha^{-1} expedite the panicle exit, but harvest faster on application of rice husk zeolite dose 400 kg.ha^{-1} and N fertilizer 125 kg N.ha^{-1} compared to without rice husk zeolite and N fertilizer. This is closely related to the function of N which plays a role in the vegetative period of plants and plays a less role in the generative period. Nitrogen plays a role in many physiological processes, especially the vegetative growth phase and gives the green color of the leaves. However, too much nitrogen can inhibit flowering and fruiting and even invite pests and diseases [16]. [17] Reported that giving a 10% concentration of zeolite had no significant effect compared to no zeolite on the maturity of female maize flower emergence. [18] reported that the application of various N fertilizer frequencies had no significant effect on the aging of panicles but significant effect on harvest time.

Table 4. Age of panicle exit and harvest of upland rice appliced with rice husk zeolite and N fertilizer

Rice husk zeolite dosage (kg.ha^{-1})	N fertilizer dosage (kg N.ha^{-1})			Average
	0	75	125	
Age of panicle exit (day after planted)				
0	66.00 a	65.00ab	65.67 a	65.56 a
200	65.33 a	64.33ab	64.33ab	64.67ab
400	65.67 a	60.67 b	60.67 b	62.33 b
Average	65.67 a	63.33 a	63.56 a	
Age of harvest (day after planted)				
0	93.67 a	92.67 a	89.33ab	91.89 a
200	93.00 a	90.33ab	91.33ab	91.56 a
400	89.33ab	91.67ab	87.33 b	89.44 a
Average	92.00 a	91.56ab	89.33 b	

Note: Numbers in the same row and column followed by the same lowercase letters are not significantly different according to the DNMRT test at the 5% level.

3.4 The yield of upland rice

Table 5 showed that the aplication of rice husk zeolite doses of 200 and 400 kg.ha^{-1} with N fertilizer doses of 75 and 125 kg N.ha^{-1} had no significant effect on number and percentage of pithy grain compared to without rice husk zeolite and N fertilizer. Weight of 1000 grain and dry milled of grain increased at application of of rice husk zeolite doses of 200 kg.ha^{-1} and N fertilizer doses of 125 kg N. ha^{-1} compare to without rice husk zeolite and N fertilizer. This is closely related to N which plays a role in the vegetative phase, is the formation of tillers, while P and K play a role in the generative phase. This is related to [19], that nitrogen plays a role in leaf development (vegetative period), phosphorus plays a role in energy metabolism in plants and potassium acts as an activator of enzymes needed to form starch and protein.

Table 5. Number and percentage of pithy grain of upland rice appliced with rice husk zeolite and N fertilizer

Rice husk zeolite dosage (kg.ha^{-1})	N fertilizer dosage (kg N.ha^{-1})			Average
	0	75	125	
Weight of 1000 grains (g)				
0	124.23a	157.84a	150.60a	144.22a
200	149.77a	139.75a	145.21a	144.91a
400	169.92a	160.70a	165.95a	165.52a
Average	147.97a	152.76a	153.92a	
Weight of dry milled grain per clump (g)				
0	82.28 a	80.38 a	76.82 a	79.82 a
200	81.93 a	78.38 a	80.57 a	80.29 a
400	80.81 a	84.18 a	84.33 a	83.12 a
Average	80.57 a	80.98 a	80.75 a	

Note: Numbers in the same row and column followed by the same lowercase letters are not significantly different according to the DNMRT test at the 5% level.

These three nutrients must have a balanced value, a lack of one nutrient will cause abnormalities in plant growth, for example a lack of nitrogen will cause inhibition of the growth of vegetative organs in plants. [20], stated that the treatment of various doses of zeolite had no significant effect on panicle length and panicle number of grains. [21], stated that the treatment of various doses of N fertilizer had no significant effect on panicle length and number of spikes per panicle. [22], also stated that the treatment of various doses of N fertilizer did not significantly affect the percentage of pithy grain.

3.5 Weight of 1000 grains and dry milled grain per clump

Table 6. Weight of 1000 grains and dry milled grain per clump of upland rice appliced with rice husk zeolite and N fertilizer

Rice husk zeolite dosage (kg.ha^{-1})	N fertilizer dosage (kg N.ha^{-1})			Average
	0	75	125	
Weight of 1000 grains (g)				
0	21.89 c	21.98 c	22.86 abc	22.25 b
200	22.44bc	22.66bc	23.87 a	22.99 a
400	22.39bc	22.80 abc	23.16ab	22.78ab
Average	22.24 b	22.48 b	23.29 a	
Weight of dry milled grain per clump (g)				
0	35.35 b	50.04ab	56.98ab	43.736a
200	33.35 b	49.14ab	63.63 a	44.89 a
400	50.78ab	45.28ab	57.44ab	47.20 a
Average	37.10 b	44.14ab	54.60 a	

Note: Numbers in the same row and column followed by the same lowercase letters are not significantly different according to the DNMRT test at the 5% level

Table 6 showed that the application of rice husk zeolite dose of 200 kg.ha^{-1} and N fertilizer dose of 125 kg N.ha^{-1}showed the highest yield of 1000 grains of pithy grain (23.87 g) and weight of dry milled grain per clump (63.63 g). This showed that the interaction between rice husk zeolite doses of 200 kg.ha^{-1} and N fertilizer doses of 75 kg N.ha^{-1} increased the yield of milled dry grain weight per clump by 80% compared to no treatment. This is in accordance with the results of research by [23], that the treatment of Urea (50%) + zeolite (50%) and the highest wet weight and dry weight of mustard plants were 80.46 g tan^{-1} and 4.43 g tan^{-1} compared without treatment. Urea + zeolite which only 20.8 g ton^{-1} wet weight and 1.33 g ton-1 dry weight, [24], reported 750 kg of zeolite treatment ha^{-1} showed a significant effect compared to without zeolite on the weight of 1000 grains of rice. [13] also stated that the average total dry weight of plants at the interaction of N fertilizer at a dose of 150% (180 kg N.ha^{-1}) and a dose of 150% zeolite was not significantly different compared to a dose of 50% N fertilizer (60 kg N.ha^{-1}) and a dose of 50% zeolite.

4 Conclusion

The application of rice husk zeolite 200 kg.ha^{-1} and N fertilizer dosage 125 kg N.ha^{-1} increased plant height, maximum number of tillers and weight of 1000 grains compared without rice husk zeolite and N fertilizer, and also increased the number of productive tillers and pithy grain per panicle, dry milled grain weight per clump are 56.78%,16.8%, 80%, respectively compared without rice husk zeolite and N fertilizer.

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