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Effect of Humic Acid on Nutrient Availability and Yield of Upland Rice Inoculated with Biofertilizers in the Coastal Area

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ABSTRACT

This study aims to determine the effect of humic acid on nutrient availability and upland rice production in coastal land. The research was carried out in June - November 2020 in the Beringin Raya Village, Muara Bangkahulu District, Bengkulu City. This study used a completely randomized block design with 2 factors. The first factor was the local Bengkulu upland rice variety, namely the Red upland rice variety and the White upland rice variety, while the second factor was the type of fertilizer, namely control (basic fertilizer only), humic acid, and fertilizer recommended for upland rice from BPTP (200 kg Urea ha^{-1}, 100 kg SP36 ha^{-1}, 100 kg KCl ha^{-1}). The results showed that the administration of humic acid in both the White and Red varieties resulted in the best KCl pH. And if you look at the yield per plot, the upland rice of the Red variety is better when given humic acid, which has an increase of 7.4% g/plot, while the White variety has better results when given the recommended inorganic fertilizer, which is an increase of 12% g/plot. The Red variety had a higher soil pH, but had a number of pithy grains per panicle, and a lower grain content percentage than the White variety. The application of humic acid resulted in better KCl, CEC, and N-total pH, but had plant height, number of pithy grains per panicle, and yields per plot that were almost the same as recommended inorganic fertilizers

INTRODUCTION

Indonesia is an archipelagic country which has a water area of three-quarters of its total area and has the largest number of islands in the world, namely 17,504 islands (Zuhri *et al.,* 2018). Indonesia has the second longest coastline in the world (Arief *et al.,* 2011). Bengkulu City Beach is a beach that is directly opposite the Indian Ocean when viewed from the geographical condition which is a sandy beach and includes a sloping beach (Syukhriani *et al.,* 2017). Coastal land is a marginal land that has low productivity (Achmad, 2016). Coastal land generally has soil physical properties; sandy texture, without structure, contains little clay and dust so that coastal land easily drains water, around 150 cm/hour and the ability of coastal land to store water is very low 1.6 – 3% of the total available water. This causes problems in the use of the land as agricultural land, especially food (Nurmas *et al.,* 2014). Most of the soils in coastal areas are in conditions of low organic matter content. Farmers usually add more nitrogen fertilizer to increase agricultural production. However, the addition of excessive nitrogen fertilizer will cause soil and plant damage (Suwardi & Wijaya, 2013).

So far, coastal land has not been managed and utilized optimally. But actually coastal land can be an alternative for the development of agricultural activities. Bertham *et al.* (2019) has succeeded in growing upland rice on coastal land using biofertilizer technology derived from local microorganisms. The results showed that biological fertilizers were able to increase soil fertility, growth and yield of upland rice compared to inorganic fertilizer applications, although in general the average yield of rice obtained was still below the potential yield of rice. Based on these results, other inputs are needed to optimize the role of biological fertilizers in improving coastal land fertility so that upland rice yields increase, one of which is the addition of humic acid. This is because one of the functions of humic acid in the soil is as a carbon source and helps the availability of nutrients for the growth of soil microorganisms. Soil pH greatly affects the community of microorganisms in the soil (Tikhonov *et al.,* 2010).

Several studies have shown that humic acid can improve soil health, especially increasing carbon storage in soils poor in C-organic content (Yeo *et al.,* 2015). Humic acid which is the active ingredient from the extraction of organic matter is a material that can function as a growth stimulant (Suwardi & Wijaya, 2013). Humic acid with a large surface area and internal electric charge can absorb and hold water seven times greater than clay (Hermanto *et al.,* 2013). Suwardi & Wijaya (2013) added that humic acid can affect increased production by improving plant roots so that plants can absorb nutrients in greater quantities. Riau *et al.* (2009) also added that humic acid extracted from organic matter will also increase soil CEC.

Various studies have shown that humic acid can increase the production of food crops and plantations (Suwardi & Wijaya, 2013). Humic acid can improve root development and nutrient uptake, thereby increasing the number of tillers, plant height, total tillers and productive tillers (Suwardi *et al.,* 2009). Humic acid also has a role in increasing the ability of plants to absorb P nutrients which play a role in grain formation and increased production (Ruhaimah *et al.,* 2009).

Rice is an important food crop in Indonesia, especially Bengkulu Province, where this commodity is a priority in supporting agricultural businesses. However, rice productivity is still relatively low. Rice productivity is 46.03 ku ha^{-1} with a harvest area of 64,406.86 ha in Bengkulu Province (BPS, 2019). Rice (*Oryza sativa* L.) is the main food material and strategic commodity for Indonesia. However, the national rice production has not been able to meet the needs of the population. Dry land is a land resource that can be used for rice extensification through upland rice cultivation. Mezuan *et al.* (2002) added that one of the efforts that will be made to meet the needs of rice is through the development of farming in dry land.

Based on the above background, this study aims to determine the effect of humic acid on nutrient availability and upland rice production in coastal areas.

MATERIALS AND METHODS

The research was carried out in June – November 2020 in the Beringin Raya Village, Muara Bangkahulu District, Bengkulu City. This study used a completely randomized block design with 2 factors. The first factor was the local Bengkulu upland rice variety, namely the Red upland rice variety and the White upland rice variety, while the second factor was the type of fertilizer, namely control (basic fertilizer only), humic acid, and fertilizer recommended for upland rice from BPTP (200 kg Urea ha^{-1}, 100 kg SP36 ha^{-1}, and 100 kg KCl ha^{-1}).

Humic acid was applied by spraying on the surface of the soil with a dose of 8 L ha^{-1} dissolved into distilled water with a ratio of 1 L humic acid : 40 L aquadest so that a suspension of humic acid was obtained as much as 328 L ha^{-1} or equivalent to 147.6 mL. square^{-1}. Basic inorganic fertilizers and recommended fertilizer treatments were applied at the time of planting. The basic inorganic fertilizer given is 25% of the recommended dose, namely 50 kg ha^{-1} Urea (equivalent to 22.5 g plot^{-1}), 25 kg ha^{-1} SP36 (equivalent to 11.25 g plot^{-1}), and 25 kg ha^{-1} KCl (equivalent to 11.25 g plot^{-1}). All experimental units were given basic inorganic fertilizer, so that in the fertilizer treatment the recommended dosage was 125%, namely 250 kg urea ha^{-1} (equivalent to 112.5 g plot^{-1}), 125 kg SP36 ha-1 (equivalent to 56.26 g plot$^{- 1}$) and 125 kg KCl ha-1 (equivalent to 56.26 g plot^{-1}). Urea fertilizer is given separately, i.e. half the dose at the time of planting and the rest when the plant is 1 month after planting. SP36 and KCl fertilizers are given at the same time at planting.

The data obtained were analyzed using analysis of variance (ANAVA) at 5% level. Variables that were significantly different in varieties and types of fertilizers would be further analyzed with 5% DMRT.

RESULTS AND DISCUSSION

The results of the analysis of variance showed that varieties only had a significant effect on pH H_2O, percentage of grain content and number of pithy grains. Furthermore, the type of fertilizer significantly affected the pH of KCl, CEC, N-total, plant height, number of spikelets per panicle and yield per plot. Meanwhile, the interaction of varieties and types of fertilizers only had a significant effect on KCl pH and yield per plot (Table 1).

Table 1. Summary of the results of the analysis of variance

Observation variables	F			CV (%)
	Varieties	Fertilizers	Interac-tion	
pH H_2O	10.50*	2.77 ^{ns}	2.36 ^{ns}	1.88
pH KCl	3.39 ^{ns}	19.19*	4 ,16*	3.04
CEC	0.05 ^{ns}	7.20*	3.06 ^{ns}	15.52
N-total	0.67 ^{ns}	9.61*	0.32 ^{ns}	16.81
Plant height	2.66 ^{ns}	5.58*	0.58 ^{ns}	5.78
Productive	1.18 ^{ns}	1.02 ^{ns}	3.09 ^{ns}	21.72
Percentage of grain content	5.63*	0.28 ^{ns}	0.59 ^{ns}	3.33
Grain weight per plant	2.87 ^{ns}	2.44 ^{ns}	2.42 ^{ns}	4.74
Weight of 1000 Seeds	0.26 ^{ns}	1.10 ^{ns}	0.28 ^{ns}	14.15
Number of piths per pani-cle	7.43*	6.92*	1.86 ^{ns}	6.65
Yield per plot	2.06 ^{ns}	3.84*	6.03*	5.20

Note: * = significant effect, ^{ns} = no significant effect

pH KCl showed no significant difference between varieties if not fertilized (control) and fertilized with humic acid. However, when recommended inorganic fertilization was applied, the varieties had a significantly different KCl pH, where the Red variety had a KCl pH of 4.94 higher than White, which was 4.58. On the other hand, between types of fertilizers, the pH of KCl was significantly different in both the Red and White varieties (Table 2). The increase in soil pH was caused by humic acid being able to bind H+ ions in the soil by the OH- activity of the carboxyl group (-COOH) and the hydroxyl group (-OH) causing the soil pH to increase.

The results per plot showed no significant difference between varieties if not fertilized and fertilized with humic acid. However, when upland rice plants were given inorganic fertilizer recommendations between varieties had significantly different yields per plot, where the White variety yielded 1871.50 g plots^{-1}, which was heavier than the Red variety, which was 1650.60 g plots^{-1}. On the other hand, fertilization on upland rice produced yields per plot that were not significantly different for the Red and White varieties. The application of humic acid to the Merah variety yielded the heaviest yield per plot of 1762.01 g plot^{-1}. However, in the Putih variety, the heaviest yield was obtained from the application of recommended inorganic fertilizer, which was 1871.50 g plot^{-1} (Table 3). These results indicate that each variety has a different response to the type of fertilizer given. In accordance with Malahayati *et al.,* (2019) which states that each variety will give a different response to different environmental conditions. Furthermore, humic acid can improve the status of good soil fertility so that plant growth and production will be more optimal. The direct effect of humic acid is to improve metabolic processes in plants, such as increasing the rate of photosynthesis in plants (Heil, 2005), due to the increased chlorophyll content in leaves (Ferrara & Brunetti, 2010). Sarno & Eliza (2011) reported that the application of humic acid could increase plant height, wet and dry crown weight. Furthermore, the positive effect of humic acid administration has been reported by Shaaban *et al.* (2009) which states that the application of humic acid can also reduce the use of NPK fertilizers through the soil by 25%, and can also increase stalk length, stalk weight, and seeds in rice plants.

Table 2. Effect of variety and type of fertilizer on pH KCl

Varieties	Type of Fertilizer		
	Control	Humic Acid	Recommended
Red	4.73 b A	5.09 a A	4.93 ab A
White	4.69 b A	5.15 a A	4.58 b B

Note : numbers followed by the same capital letter in the same column and the same lowercase letters in the same row stated that there was no significant difference in DMRT at 5% level

Table 3. Effect of variety and type of fertilizer on yield per plot

Varieties	Type of Fertilizer		
	Control	Humic Acid	Recommended
Red	1632.24 b A	1762.01 a A	1650.60 b B
White	1648.45 b A	1680.92 b A	1871.50 a A

Note : numbers followed by the same capital letter in the same column and the same lowercase letters in the same row stated that there was no significant difference in DMRT at 5% level

The single factor for upland rice varieties only shows a significant difference to pH H_2O. The Red variety has a higher soil pH than the White variety (Table 4). This is presumably because the red variety has better root exudate than the white variety. The ability of roots to absorb cations from each variety is different. If a lot of cations are absorbed by the roots, then a lot of H+ ions will come out of the roots into the soil so that the soil becomes more acidic. If many anions are absorbed by the roots, then many are released by the roots into the soil so that the soil becomes more alkaline (Firmansyah & Sumarni, 2013). In addition, the number of pithy grains per panicle and the percentage of grainy grains of upland white rice varieties were higher than upland rice varieties Merah (Table 4). This is presumably because the White variety has better genetic characteristics than the Red variety. According to Yuniarti & Kurniawati (2013) genetic factors will affect plant physiology such as grain weight per plant and yield per plot. The number of productive tillers and the number of panicles formed will affect the production of rice plants.

Table 4. Effect of variety on pH H_2O, number of pithy grain per panicle and percentage of pithy grain

Varieties	pH H_2O	Number of pithy grains per panicle (seed)	Percentage of pithy grain (%)
Red	5.87 a	83.29 b	85.10 b
White	5.72 b	89.70 a	87.89 a

Note: the numbers followed by the same letter in the same column mean not significantly different at 5% level DMRT

Administration of humic acid produces pH H_2O, pH KCl , CEC and N-total were best compared to control and recommended inorganic fertilizers (Table 5). In line with Sarifuddin *et al.* (2017) that the application of humic acid can increase soil pH. Furthermore, Astuti *et al.* (2014) explained that the increase in soil pH with the addition of organic matter occurs through the mechanism of increasing negative charges (electrons) on the colloidal surface (deprotonization). In this case the electrons from the decomposition of organic matter can neutralize the amount of positive charge present in the colloidal system so that the soil pH increases. Riau *et al.* (2009) reported that humic acid extracted from organic matter would increase soil CEC.

Table 5. Effect of fertilizer type on pH H_2O, pH KCl, CEC and N-total

Type of Fertilizer	pH H_2O	pH KCl	CEC (me/100)	N-Total (%)
Control	5.72	4.71 b	13.43 b	0.19 b
Humic Acid	5.84	5.12 a	17.71 a	0.27 a
Recommendation	5.83	4.75 b	16.26 a	0.26 a

Note : numbers followed by the same letter in the column the same means that there was no significant difference at 5% level DMRT

The results showed that the application of humic acid and recommended fertilizers was equally good for plant height, number of pithy grains per panicle and yield per plot, and was higher than the control (Table 6). This is because the N-Total and CEC of soil on humic acid and recommendations were significantly different so that the growth and yield of plants tended to be not different. According to Putra (2012), the N element is needed by plants for the period of vegetative growth such as the formation of leaves or shoots and the number of tillers which will later support crop yields. Provision of recommended fertilizers and humic acid is strongly suspected to be able to meet plant needs for nutrients, especially N, P, and K so that the yield increases. Nazirah & Sengli (2015) and Kaya (2013) reported that N, P, and K fertilizers affect the growth and yield components of rice. On the other hand, the positive effect of humic acid on rice yields was also reported by Wijaya (2013) that the addition of 5-15 L ha^{-1} of humic acid was able to increase crop yields by 15-33 %.

Table 6. Effect of fertilizer type on plant height, number of pithy grains per panicle and yield per plot

Type of Fertilizer	Plant Height (cm)	Number of pithy grains per panicle (seed)	Yield per plot (g/plot)
Control	122.04 b	85.89 b	1640.34 b
Humic Acid	130.75 a	86.68 a	1721.46 ab
Recommendation	134.11 a	86.61 a	1761.05 a

Note: numbers followed by the same letter in the same column are not different significant at 5% DMRT level

CONCLUSION

There is an interaction effect between the type of fertilizer and upland rice varieties on soil pH and yield per plot. Provision of humic acid in both the White and Red varieties resulted in the best KCl pH. And if you look at the results per plot, the upland rice of the Red variety is better when given humic acid, which is 1762.01 g $plot^{-1}$, which has an increase of 7.4%, while the White variety has better results if given inorganic fertilizer recommendations, it has an increase of 12%, which is equal to 1871.50 g $square^{1}$. The Red variety has a higher soil pH, but has a number of pithy grains per panicle, and a lower percentage of grain content than the White variety. The application of humic acid resulted in better KCl, CEC, N-total pH, but had plant height, number of pithy grains per panicle, and yields per plot that were almost the same as recommended inorganic fertilizers.

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