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The effect of humic acid on biological properties of soil and upland rice plants in entisol Coastal Bengkulu City

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Abstract. Entisol is a type of soil on coastal land that has low soil fertility, low soil aggregation, low organic matter content, low soil microorganism activity and high salt content that can affect growth and development of crop yields. Application of humic acid is expected to increase the fertility of the entisol soil. This study aims to measure the effect of humic acid application on soil biological properties and yields of upland rice in Entisol Pesisir, Bengkulu city. The research was carried out in July-November 2020 in the Beringin Raya Village, Muara Bangkahulu District, Bengkulu City. The research design used a two-factor Completely Randomized Block Design with four replications, arranged in a factorial manner in experimental units. The first factor is humic acid which consists of not given humic acid, and given humic acid. The second factor is upland rice varieties consisting of Inpago 10, Merah rice, and Putih rice. The results showed that the application of humic acid was able to increase the biological activity of the soil including the total microbial population of 68.73% and the percentage of root colonization reaching 23.65% and increasing the pH, and rice yields per plot reached 14.2%. Inpago variety has better adaptability than local varieties (Merah and Putih) which is indicated by soil biological activity such as total microbial population reaching 570.16 x 10^6 CFU g^{-1} with root colonization percentage reaching 88.75%, pH, and upland rice yield per plot was 2033.68 g/plot. So based on the results of the study, it is recommended to cultivate Inpago 10 varieties compamerah to local varieties.

1 Introduction

The coastal area is a plain area on the edge of the sea that is affected by marine activities in the form of sandy flat land. Coastal soils have low fertility. Coastal soils are usually characterized by physical, chemical and biological soil properties that are less favorable for plant growth and yield [1, 2]. Utilization of coastal land for upland rice cultivation can be carried out using biological fertilizer technology derived from local microorganisms. The results showed that compared to the application of inorganic fertilizers, biological fertilizers were more capable of increasing soil fertility, growth and yield of upland rice. However, in general, the average yield of rice obtained is still not in accordance with the potential yield

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of rice [3]. Based on the results of this study, it is necessary to add other technologies to optimize the role of biological fertilizers in increasing the fertility of coastal lands so that upland rice yields increase, one of which is by adding humic acid.

Humic acids are complex compounds of aromatic macromolecules containing amino acids and sugars, peptides and aliphatic compounds linked together [4, 5]. Humic acids regulate soil chemical reactions and improve many soil functions [6]. Application of humic acid can reduce evapotranspiration, soil erosion, and also increase water holding capacity, soil structure, CEC and other physicochemical properties of soil [7]. Furthermore, humic acid can also increase rice production [8]. Administration by incubation of P solubilizing bacteria increases pH and available P [9, 10].

Rice (*Oryza sativa* L.) is one of the agricultural products used as the main food ingredient of the Indonesian people. Along with the population growth in Indonesia, the demand for rice has increased. However, in reality, domestic rice production has not yet been able to meet the needs of the Indonesian people. The current fundamental problem for Indonesia's food needs is the erosion of rice fields due to the conversion of land functions from agricultural to non-agricultural uses. While land use in coastal areas is a solution that can be used to meet land use needs. This study aimed to measure the effects of humic acid application on soil biological properties and upland rice yield at Entisol Pesisir, Bengkulu city.

2 Research methods

The examine turned into executed from June to November 2020 at Beringin Raya Village, Muara Bangkahulu Division, Bengkulu City. Initial and very last soil evaluation turned into finished on the Soil Science Laboratory of the Faculty of Agriculture, Bengkulu University. The experimental design of this study was a completely randomized two-factor block. The first element is humic acid, which does not accept humic acid and this acid accepts humic acid. The second factor is upland rice varieties including Inpago 10 rice, Merah rice and Putih rice. Apply humic acid by spraying evenly on the soil surface, the application is carried out 2 days before planting. The dose of humic acid used is 8 l/ha namely by dissolving humic acid into distilled water with a ratio of 1 liter of humic acid: 40 liters of distilled water so that it gets a suspension of humic acid as much as 328 l/ha or equivalent to 147.6 mL/plot.

Soil preparation begins with weeding. Before tillage, soil is sampled at 5 (five) points on the study area and then mixed. Conduct tillage with a hoe, then divide a plot of size 1.5 m x 3 m, the distance between the plots is 50 cm, the interval between repetitions is 100 cm. Then add 10 tons/ha of organic coffee husks equivalent to 5.4 kg/plot with absolute dry weight with 20% moisture. Add compost by sprinkling it evenly over the plot. Then incubate the soil 2 weeks before planting. During the study, crop care was carried out in the form of weeding, replanting, storing and controlling plant pests. Carrying out harvesting, specifically, 85% of the rice flowers were yellowed and blossomed and 90% of the rice flowers were yellowed, the ears were dropped. and leave no trace. Harvesting is done by cutting the base of the cotton with scissors. Then put it in the envelope to observe.

3 Results and discussion

3.1 Effect of humic acid treatment

The application of humic acid resulted in a higher total microbial population, respiration, root colonization, pH H_2O and pH KCl than without humic acid. The increase in the percentage of the total microbial population reached 68.73% when added humic acid (Table 1). This is because the application of humic acid to the soil is one source of nutrients to increase soil biological activity so that the number of soil microbial populations increases, respiration and the percentage of root colonization is high and soil pH [11].

Application of humic acid resulted in heavier grain weight per plant and yield per plot than without humic acid (Table 2). This is because humic acid increases soil fertility, including the physical and chemical properties of coastal soils. Increasing soil fertility status increases plant nutrient uptake and crop yields [12, 13]. In addition, humic acids also form chelates with microelements and release them gradually when needed by plants and prevent the formation of precipitation, fixation, leaching, and oxidation of micronutrients in the soil [14, 15].

Table 1. Effect of humic acid on total microbial population, respiration and root colonization.

Humic acid	Total (x 10^6 CFU g^{-1})	Respiration (mg m^{-2} $days^{-1}$)	Root colonization (%)	pH H_2O	pH KCl
Given Humic Acid	652.85 a	661.17 a	95.83 a	5.89 a	5.11 a
Without Humic Acid	386.93 b	477.25 b	77.50 b	5.77 b	4.76 b

Note: numbers followed by unequal letters in the same column mean significantly different

Table 2. Effect of humic acid on grain weight per plant and yield per plot.

Humic acid	Grain weight per plant (g)	Yield per plot (g/plot)
Given Humic Acid	36.42 a	1917.76 a
Without Humic Acid	29.53 b	1679.23 b

Note: numbers followed by unequal letters in the same column mean significantly different

3.2 Effects of upland rice

Inpago 10 variety has the highest respiratory capacity and root invasion compared to other varieties. This is thought to be due to the exudative factor secreted by the plant's roots. In each plant, the quantity and quality of root exudate varies depending on the number and type of roots. Plant age or plant growth stage affects root exudate production, including maize, with the greatest exudation occurring when the roots are young or during the vegetative stage rich in organic acids and protein. The presence of a substrate derived from root exudates can increase the number of MPFs, an increase also due to the influence of soil pH. Based on the results of the study, it was found that the variety had a significant effect on pH H2O (Table 3). This is probably because the quantity and quality of root exudates were the same for each variety, so there was no significant effect of the varieties on the organic C ratio.

The effect of variety on flowering and harvesting age is due to the nature of the plant and the genetic influence of each different upland rice variety. Meanwhile, for the Merah and Putih varieties, there is no significant difference between the flowering and harvesting ages, this is because they come from the same variety, namely the Bengkulu local variety. Upland rice varieties show a significant effect on grain weight per Plants and Yield per Plot, but did not show a significant effect on 1000 Seed Weight (Table 4). The variety that has good potential to be developed is the Inpago 10, where the yield per plot of this variety reaches 2033.68 g/plot with a grain weight per plant of 39.65 g. If this result is converted into hectare units, the yield per hectare is 4519.288 Kg/ha which has exceeded the average yield limit of 4000 Kg/ha. Genetic factors are the main factors that affect plant physiological growth including Grain Weight per Plant and Yield per plot but are also influenced by other factors.

Upland rice varieties affect grain weight per plant in indications of plant genetic characteristics [16].

Table 3. Effect of varieties on total microbial population, respiration and root colonization.

Varieties	Respiration (mg m^{-2} $days^{-1}$)	Root colonization (%)	pH H_2O
Inpago 10	702.02 a	88.75	5.93 a
Merah	434.01 b	86.25	5.83 a
Putih	571.62 b	85.00	5,72 b

Note: numbers followed by unequal letters in the same column have significantly different meanings

Table 4. Effect of varieties on total microbial population, respiration and root colonization.

Varieties	Flowering Age (hst)	Harvesting Age (hst)	Grain weight per plant (g)	Yield per plot (g/plot)
Inpago 10	84.88 a	117.50 a	39.65 a	2033.68 a
Merah	102.38 b	176.75 b	33.19 b	1697.13 b
Putih	101.88 b	173.88 b	33.29 b	1664.68 b

Note: numbers followed by unequal letters in the same column have significantly different meanings

3.3 Effect of interaction between humic acid and varieties

Percentage of root colonization between plants given humic acid was higher than without humic acid in all upland rice varieties (Table 5). This is because humic acid is able to improve plant rhizosphere to be more optimum for Arbuscular Mycorrhizal Fungi (AMF). The results showed that the percentage of colonization on the Inpago 10 variety reached 100% but when without humic acid it only reached 77.5%, this indicates an increase of 29.03%. But exudate is very dependent on the type of plant. Differences in root exudate production will result in different microbial interactions where a root exudate composition will form different rhizosphere communities. This is in accordance with the results of the study where each variety has a different percentage of colonization, namely the Inpago 100%, Merah 97.5% and Putih 90.0% varieties. The percentage of root colonization between upland rice varieties showed no significant difference if not given humic acid. However, when given humic acid between varieties, the percentage of root colonization was significantly different. The difference in the magnitude of this percentage is because the level of compatibility or adaptation between plant varieties and colonizing microbes is different where it is influenced by the infectivity and effectiveness of the host, because only the host favomerah by Arbuscular Mycorrhizal Fungi (AMF) provides symbiotic and maximum colonization.

The high percentage of root colonization has an impact on increasing nutrient uptake, especially P, so that rice yields also increased. This is evident from the results of the study which showed that in addition to producing higher root colonization, the application of humic acid was also able to increase the yield per plot compamerah to without humic acid. On the other hand, the Inpago 10 variety consistently had the highest yield per plot, both with and without humic acid (Table 6). Humic acid has the ability as a ligand that is able to bind nitrogen in the form of $NO3^-$ or $NH4^+$ forming complexes, which can temporarily store nutrients in the soil and release them when plants need them, thereby merahucing the occurrence of evaporation of nitrogen in the soil [17].

Table 5. Effect of humic acid and upland rice varieties on root colonization (%).

Varieties	Given Humic	Acid Without
Inpago 10	100.0 A	77.5 B
Merah	97.5 A	75.0 B
Putih	90.0 A	80.0 B

Note: numbers followed by the same uppercase letter in the same row and the same lowercase letter in the same column means they are not significantly different

Table 6. Effect of humic acid and upland rice varieties on yield per plot (g plot^{-1}).

Combination Treatment	Yield per plot (g plot^{-1})
Humic acid + Inpago 10	2310.36 a
Humic acid + Merah	1762.02 b
Humic acid + Putih	1680.92 b
No humic acid + Inpago 10	1757.00 b
No humic acid + Merah	1632.24 b
No humic acid + Putih	1648.45 b

Note: numbers followed by unequal letters in the same column have significantly different meanings

Based on the results of the interaction analysis of humic acid and upland rice varieties on yields per plot showed significant differences. The highest yield per plot was Inpago 10 variety with the addition of humic acid, which reached 2310.36 g plot-^{1}, which was significantly different from the yield without the addition of humic acid for the same variety, which was 1757.00 g plot-1, the difference between the two. that is equal to 553.36 g plot-1 so that the increase reaches 31.5%. Meanwhile, local varieties (Merah and Putih) showed no significant difference between given humic acid and without humic acid. Based on the results obtained for the results of the local merah variety given humic acid with the Inpago 10 variety without humic acid, there was no significant difference as well as the Putih variety given humic acid or without humic acid. However, for local varieties, the best yield was on the Merah variety which was given humic acid of 1762,015 g plot-^{1}.

4 Conclusion

The interaction between humic acid and upland rice varieties showed a significant effect on root colonization and yield per plot, where Inpago 10 and Merah varieties given humic acid resulted in root colonization percentages of 100% and 97.5% and yields per plot, namely 2310.36 g/plot and 1762.01 g/plot. A humic acid application can increase the soil's biological activity, such as microbe population, by 68.73%, root colonization percentage by up to 23.65% and rice production by up to 14.2%. Inpago variety has an ability to be better adapted than local variety (red and white), which is shown by soil biological activity like microbe population total reaching 570,16 x 106 CFU g-1 with the root colonization percentage of 88.75%, pH, and Gogo rice production per plot in the amount of 2033.68 g/plot.

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