Journal of Tropical Mycorrhiza
https://journal.ami-ri.org/index.php/JTM
E-ISSN 2829-467X
Vol. 1 No. 2 October 2022

Effect Of Biodive Fertilizer On N, P, And K Nutrition Status And Growth And Result Of Two Gogo Rice Varieties In Coastal Area

Muhammad Firza Alentamaru T[1], Yudhi Harini Bertham[1*], Kanang Setyo Hidnarto[1], Abimanyu Dipo Nusantara[2]

[1] Department of Soil Science, University of Bengkulu, Jalan WR Supratman, Jalan WR Supratman, Bengkulu. 38371, Indonesia.

[2] Faculty of Agriculture, University of Prof Dr Hazairin SH, Jalan Jend. A. Yani, Ros Gardens, Bengkulu City. 38115, Indonesia.

*Corresponding author : yudhyhb@unib.ac.id

ABSTRACT. This study aims to determine the effectiveness of the application of biological fertilizers on the availability of nutrients N, P, and K in the soil in coastal areas and the yield of upland rice varieties Inpago 10 and Sunggau. This research was conducted from September to December 2019 in Beringin Raya Village, Muara Bangkahulu District, Bengkulu City. The experimental design used was a two-factor Completely Randomized Block Design. The first factor is land rice varieties, namely varieties Inpago and Sunggo, while the second factor is fertilizer input, double inoculant of P solubilizing bacteria + K solubilizing bacteria + N fixing bacteria, double inoculant of AMF + solubilizing bacteria K + N-fixing bacteria , and inorganic fertilizer recommended by AIAT, namely 200 kg Urea/ha, 100 kg SP36/ha, 100 kg KCl/ha. The two factors were combined so that there were 6 treatment combinations which were repeated 4 times so that there were 24 experimental units. Each experimental unit consists of 50 plants so that the total plant population was 50 x 24 = 1,200 plants. The results showed that the use of biological fertilizers in upland rice cultivation in coastal areas was able to increase the availability of N, P, and K nutrients compared to the initial soil and recommended fertilizers. Upland rice varieties suitable for coastal areas are Inpago 10 with fertilizer in the form of a combination of biofertilizers of Phosphate Solubilizing Bacteria + K Solvent Bacteria + N Fixing Bacteria.

Keywords: *Coastal Areas, Upland Rice, Biological*

INTRODUCTION

Coastal land which is dominated by sandy soil generally has the following soil properties: low soil moisture, high evapotranspiration, high salt content, low organic matter content, poor in nitrogen and phosphorus elements (Suptiningsih, 2007). Actions to anticipate problems on coastal land are by giving organic matter or manure, using windbreaker plants, using soil improvers, and using varieties that have adaptive characters on coastal marginal land (Achmad and Aji, 2016).

Technology for improving sandy soil by adding organic fertilizers and inorganic fertilizers such as urea, TSP and KCL. The use of inorganic fertilizers in the long term can reduce the physical, chemical, and biological properties of the soil such as being easily eroded by water/rain flows, killing microorganisms and macroorganisms both living in the soil, changing soil pH, disturbing the balance of nutrients in the soil. Therefore, another technology is needed that can be used as a substitute for inorganic fertilizers. One of the cultivation techniques that can be applied is to utilize soil microbes such as arbuscular mycorrhizal fungi, azotobacteria and potassium solvent microbes. The presence of microbes in the soil plays an important role in the transformation that causes changes in the physical and chemical properties of the soil (Sudaryono, 2001).

As soil microorganisms, mycorrhizal fungi are key in facilitating the absorption of nutrients by plants (Suharno and Sufati, 2009). The role of mycorrhizae is to help the absorption of plant nutrients, increase growth and yield of plant products. Mycorrhizae are known to increase the efficiency of P fertilization (Garg and Chandel 2010). Mycorrhizae can increase the ability of roots to absorb nutrients and water to support plant growth and development (Zuhry et al., 2008). Nurhayati (2012) added that the main function of hyphae is to absorb water from the soil, P that accumulates in external hyphae will be immediately converted into polyphosphate compounds in the presence of phosphatase enzymes. In addition, the results of Bertham's (2002) study showed that mycorrhizae were able to release organic acids, resulting in an increase in pH.

Phosphate solubilizing bacteria (BPF) are bacteria capable of dissolving phosphate by excreting a number of low molecular weight organic acids such as oxalic, succinic, fumaric, and malic. BPF also plays a role in vitamin D metabolism, secretes phosphatase enzymes that play a role in the hydrolysis of organic P to inorganic P, and can produce growth regulators. Multiple application of AMF inoculants with phosphate solubilizing fungi (FPF) can increase soybean productivity (Nusantara et al. 2019), improve soil biological characteristics, nutrient uptake, and soybean seed quality (Bertham et al., 2019) in Bengkulu coastal soil. Potassium solubilizing microbes can dissolve potassium from binding insoluble potassium to a medium through secretion organic acids and potassium solubilizing microbes can utilize dissolved potassium in a medium to formation of new cells, resulting in binding (immobilization) potassium by microbes. Several groups of K solubilizing bacteria are known to be able to dissolve K such as Pseudomonas, Burkholderia, Azotobacter, Rhizobium, Bacillus, and Paenibacillus (Singh et al., 2010; Don and Diep, 2014).

Azotobacter bacteria are a type of biological fertilizer that has important benefits and roles for plants such as converting inorganic compounds into organic compounds, binding nitrogen free from the air, converting ammonia into nitrate compounds in the soil, loosening the soil, and improving soil erosion. Azotobacter is free-living as a saprophyte in soil, fresh water, marine environments and other natural habitats and has been used as an effective inoculum for increasing plant growth and controlling pests (Aquilanti et al. al., 2004). Numaset al. (2014) said that azotobacter bacteria have the ability to produce IAA, dissolve phosphate and are stable at pH 5, 6 and 7 which are able to survive at temperatures of 〚40〛^0C to 〚45〛^0C and potential azotobacter bacteria have physiological characters as biological fertilizers that are able to adapt in the environment. marginal land that has the potential to be planted with staple crops such as rice.

One type of food crop that can be developed in dry land is upland rice. In accordance with the opinion of Fitria et al. (2014) that dry land can be used for rice extensification by developing upland rice cultivation. Upland rice cultivation technologies that are effective in upland include regulating planting density because it is related to competition between plant root systems in the context of the use of fertilizers in manipulating plants to increase yields, where upland rice yields are relatively lower than lowland rice yields. According to the Central Statistics Agency (2014) Bengkulu only produces 33,365 tons of paddy per year which is very different from the production of lowland rice of 559,829 tons per year, Meanwhile, according to the Central Bureau of Statistics (2015) Bengkulu produces 552,713 tons of lowland rice per year and upland rice production of 25,941 tons per year, from the data, the production of lowland rice and upland rice has decreased in annual productivity which is the lack of public awareness to cultivate upland rice on coastal land by considering the limiting factors for lowland rice plants so as to get less than optimal results. This study aims to determine the efficiency of application of biological fertilizers on the nutrient status of N, P, and K in coastal soils as well as the growth and yield of upland rice varieties Inpago 10 and Sunggo.

MATERIAL AND METHODS

This research was conducted from September to December 2019 in Beringin Raya Village, Muara Bangkahulu District, Bengkulu City. The experimental design used was a two-factor Completely Randomized Block Design (RAKL). The first factor is land rice varieties, namely varieties V1 (Inpago) and V2 (Really), while the second factor is fertilizer input, namely P1 [double inoculant of P solubilizing bacteria + K solubilizing bacteria + N fixing bacteria], P2 [double inoculant of AMF + solubilizing bacteria K + N fixing bacteria], and P3 [inorganic fertilizer recommended by AIAT, namely 200 kg Urea/ha, 100 kg SP36/ha, 100 kg KCl/ha]. The two factors were combined so that there were 6 treatment combinations which were repeated 4 times so that there were 24 experimental units. Each experimental unit consisted of 50 plants so that the total plant population was 50 x 24 = 1,200 plants. Biocompost and biofertilizer inoculants are produced by the Soil Biotechnology Laboratory. The biocompost used comes from the main ingredient of coffee skin. While the biological fertilizer used is made from upland rice rhizosphere soil on coastal land. The data obtained were analyzed using variance (ANOVA) at the level of 5%. Observational variables that were significantly different in the F test, were further tested using the Least Significant Difference Test (BNT) at the level of 5%.

The land was cleaned of weeds, then tillage was carried out and plots were made measuring 1.5 mx 3 m with a distance between plots of 50 cm and a distance between plots of 100 cm. Provision of 10 tons ha-1 of coffee husk compost (equivalent to 4.5 kg plot-1) was carried out during land preparation. The coffee husk compost is sprinkled on the plot and then stirred until smooth. After that the land was incubated for 1 week before planting.

This is done by making a planting hole using a penugal made of wood and the tip is made sharp so that it is easy to press into the ground. The depth of the planting hole is ± 5 cm and the plant distance is 30 cm x 30 cm. Each planting hole is inserted 2 rice seeds while being given Carbofuran as much as ± 5 grains of planting holes then the planting hole is closed again. Agricultural lime with the active ingredient CaMg(CO3)2 at a dose of 200 kg ha-1 (equivalent to 90 g plot-1) was applied the day before planting in an even distribution between the rows. Inorganic basic fertilizers given amounted to 25% of the recommended dose, namely 50 kg ha-1 Urea, 25 kg ha-1 SP36 and 25 kg ha-1 KCl. Urea fertilizer is given separately, which is half the dose at the time of planting and the rest when the plant is 1 month after planting. TSP and KCl fertilizers are given at the same time at planting (Bertham, 2002). Inoculation of P solubilizing bacteria + K + N fixing bacteria was carried out by referring to the method developed by Bertham et al. (2016-2018). While AMF is inoculated by inserting as much as 2.5 grams of inoculant into the planting hole (Nusantara et al., 2012). Plant care that is carried out is weeding, watering and controlling pest plant organisms.

Harvesting is carried out in two stages, namely the vegetative and generative phases. Harvesting in the vegetative phase is done when the plant enters the early flowering phase (20% of flowering plants). While the generative phase of harvesting is carried out at approximately 19 weeks (132 days). Harvesting in the generative phase is carried out on plants that have shown signs of harvest, namely 85% of rice panicles are golden yellow, flag leaves and 90% of rice grains have turned yellow and the rice panicles are drooping, and grain grains are hard when pressed by hand and leave no marks. . Harvesting is done by cutting the base of the panicle using scissors. Then it was put into an envelope for observation.

RESULT AND DISCUSSION

The results of the analysis of variance showed that the interaction of varieties and types of fertilizers had a significant effect on plant dry weight and pithy grain weight per clump. Furthermore, upland rice varieties had a significant effect on total N content, plant height, plant dry weight, number of pithy grains per panicle, and pithy grain weight per clump. The application of different types of fertilizers significantly affected the available P content, total N content, plant dry weight, and grain weight per clump (Table 1).

Table 1. Summary of Variance Analysis Results

Observation Variables	F-count			KK (%)
	Interaction	Varieties	Fertilizer Types	
P-available content#	3.39 ns	1.08 ns	4.86 *	13.44
Total N content#	0.63 ns	7 ,41*	7.07 *	14.49
K-available content#	0.01 ns	2.69 ns	1.30 ns	10.18
Plant Height	0.60 ns	111.58*	1.35 ns	10.06
Plant Dry Weight	4.67 *	50.91*	17.34*	13.88
Number of pithy grains per panicle grain	0.37 ns	11.17*	2.24 ns	13.84
Pulp Weight per Clump	5.89 *	64.62*	13, 06*	14.31
F-table 5%	3.68	4.54	3.68	-

Note : * = significant effect, ns = no significant effect, KK = coefficient of diversity, # = data ransformation ($\sqrt{x+1}$)

Nutrient Status N -total, P-available, and K-available soil

The results showed that the nutrient status of N-total, P-available, and K-available soil was not affected by the interaction of upland rice varieties and types of fertilizers. On the other hand, upland rice varieties only had a significant effect on the total N-content of the soil. While the type of fertilizer gave a significant effect on the levels of available P and N-total soil (Table 1).

Total soil N content was significantly different between 2 upland rice varieties, where Inpago 10 variety produced 0.25% total soil N content which was classified as moderately higher than Sunggo variety which produced 0.21% total soil N content. classified as moderate. Furthermore, the Inpago variety also produced higher levels of available P and available K compared to the Sunggo variety with low nutrient status (Table 2). This is presumably because the quality of root exudates produced by the Inpago 10 variety was better than the Benar variety, so that the soil microbial activity was higher and the release of nutrients in the soil also increased. According to Widyati (2017) plants communicate with other organisms in the vicinity through the exchange of chemical compounds released in the form of root exudates. Furthermore, Singh*et al*. (2004) explained that in the rhizosphere microbial-plant interactions play an important role in many things related to vital processes in ecosystems, such as carbon sequestration and nutrient cycling.

Morrisseyet *al*. (2004) added that positive plant-microbial interactions have provided many benefits for plants, especially increasing the availability and uptake of nutrients.

Table 2. Effect of upland rice varieties on soil N, P, and K nutrient status

Varieties	Total N content (%)	Status	P-available (ppm)	Status	K-available (me/100 g)	Status
Inpago 10	0.25 a	M	5,11	R	0,30	L
Sunggo	0,21 b	M	4,82	R	0,28	L

Note: the numbers followed by the same letter in the same column mean that they are not significantly different in the DMRT follow-up test at 5% level , M = medium, L = low

Fertilizer application in the form of double inoculant BPF + BPK + BPN resulted in the highest available P content of 5.41 ppm which was not significantly different from fertilizer in the form of double inoculant AMF + BPK + BPN, but significantly different from inorganic fertilizer recommendation. Furthermore, the application of fertilizer in the form of double inoculant BPF + BPK + BPN also resulted in the highest total N content of 0.26% (medium class) which was not significantly different from fertilizer in the form of double inoculant AMF + BPK + BPN, but significantly different from the recommended inorganic fertilizer. The application of recommended inorganic fertilizers resulted in the lowest levels of available P and N-total, namely 4.39 ppm and 0.20%, respectively (Table 3). This is because the three microbes used have a role in helping to increase soil nutrients. Where BPF plays a role in dissolving P, BPK dissolves K, and BPN fixes N. In line with the results of Wuriesyliane's research (2017) which showed that double inoculation of Azotobacter and BPF was able to increase P-dd and N-total soil levels in rice plants.

These results indicate that in coastal areas the use of biological fertilizers is more effective in increasing the availability of nutrients, especially N, P, and K compared to inorganic fertilizers. This is because the coastal land is dominated by the spherical sand fraction so that the use of inorganic fertilizers will be easily lost, either evaporating or leached by the flow of water. Compared to the initial soil, it was seen that there was an increase in the levels of N, P and K in the soil. The results of laboratory analysis showed that the initial soil N, P, and K levels were 0.19%, 3.73 ppm, and 0.28 me/100 g of soil, respectively (Appendix 1). Based on these data, it can be seen that the fertilizer applied can increase the availability of soil nutrients. The highest increase in nutrient levels was found in the application of biological fertilizers in the form of BPF + BPK + BPN, namely the N content increased by 36.84%, P content increased by 45.04% and K content increased by 10.71% compared to the initial soil.

Table 3. Effect of fertilizer type on soil N, P, and K nutrient status

Type of fertilizer	Total N content (%)	Status	of available P content (ppm)	Status	of available K content (me/100 g)	Status
BPF + BPK + BPN	0.26 a	S	5.41 a	R	0.31	R
AMF + BPK + BPN	0.24 a	S	5.10 ab	R	0.29	R
Fertilizer Recommended	0.20 b	S	4.39	SR	0.28	R

b: the numbers followed by the same letter in the same column means that they are not significantly different in the DMRT follow-up test at % level, S = moderate, R = low

.

5plant height and plant dry weight. Based on the results of the analysis of variance, plant height was only affected by rice varieties, while plant dry weight was influenced by rice varieties and types of fertilizers either singly or by their interaction (Table 1).

Plant height is an important agronomic character and can be used as an important identity for a genotype (Herawati *et al.,* 2009). The results showed that the pattern of rice plant height of Inpago 10 and Sunggo varieties continued to increase along with the age of the plant. Plant height of Inpago 10 and Sunggo varieties experienced a significant increase at the age of 2 to 8 weeks, then at the age of 8 to 10 weeks the increase in plant height tended to be gentle (Figure 1). This is because at the age of 2 to 8 weeks, upland rice plants are still entering the vegetative phase so that the pattern of plant height growth has increased significantly. In contrast, at the age of 8 to 10 mst upland rice plants almost entered the generative phase so that the growth pattern of the plant height did not increase significantly. The results of the study are in line with Suete *et al.* (2017) that the plant height growth of 3 upland rice cultivars experienced a significant increase at the age of 2 mst to 8 mst. Furthermore, Sunar *et al.* (2021) reported that there was no significant increase in rice plant height at the age of 9 to 11 weeks.

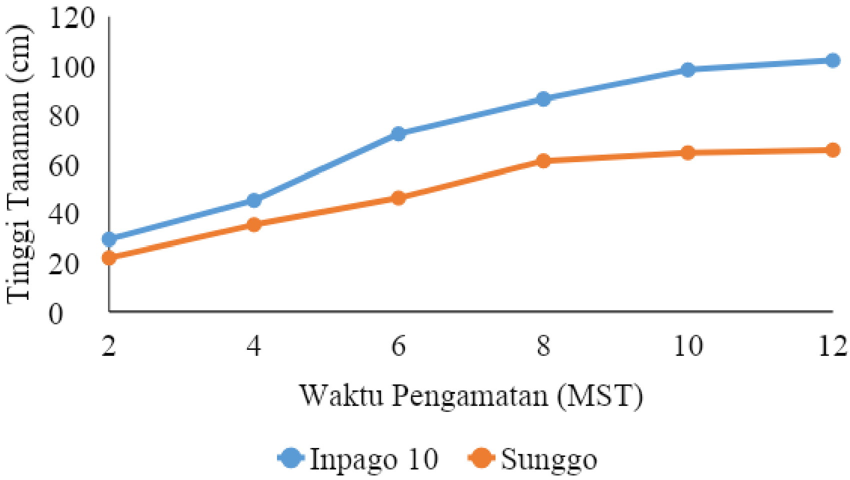

Figure 1. Growth pattern of rice plant height of Inpago 10 and Sunggo

varieties The interaction between upland rice varieties and types of fertilizers resulted in significantly different plant dry weight and grain weight per clump (Table 1). The results showed that the highest plant dry weight was produced by upland rice varieties Inpago 10 fertilized with double inoculants BPF + BPK + BPN weighing 89.37 g which was significantly different from other combination treatments. Meanwhile, the lowest plant dry weight was produced by upland rice of the Benar variety which was given recommended inorganic fertilizer, although it was not significantly different from the Benar variety which was inoculated with AMF + BPK + BPN and BPF + BPK + BPN, and the Inpago variety which was given recommended inorganic fertilizer, but significantly different. with Inpago 10 variety inoculated with biological fertilizers, both double inoculants FMA + BPK + BPN and BPF + BPK + BPN (Table 4). This is thought to be due to genetic factors, where the adaptation level of the Inpago 10 variety is thought to be better than the Benar variety. Differences in genetic makeup is one of the causes of diversity in plant appearance. Genetic programs that are expressed in various plant traits that include plant forms and functions that produce diversity (Safrida *et al.*, 2019). The character of grain weight per clump is controlled by genetic traits, so that the differences in these characters are genetic traits (Herawati *et al.*, 2017).

In addition, in this study the presence of multiple inoculants of biological fertilizers was able to increase plant nutrient uptake so that the dry weight of the plant increased. Biofertilizers are live microorganisms that are given into the soil as inoculants to help plants facilitate or provide certain nutrients for plants (Sriwahuni and Parmila *et al.,* 2019). Biofertilizer application was able to increase plant biomass between 6-12% greater than control plants. Microbial colonies have increased plant height and biomass, this is thought to occur due to increased cell metabolic activity.

Table 4. Effect of combination of varieties and types of fertilizers on plant dry weight (g)

Types of Fertilizers	Varieties	Dry Weight of Plants (g)
BPF + BPK + BPN	Inpago 10	89.37 a
FMA + BPK + BPN	Inpago 10	72.45 b
Inorganic Fertilizer Recommendations	Inpago 10 52.70	c
BPF + BPK + BPN	Sunggo	54.41 c
FMA + BPK + BPN	Sunggo	45.48 c
Inorganic Fertilizer Recommendation	Sunggo	42.48 c

Note: numbers followed by the same letter in the same column are meaningful not significantly different in the DMRT follow-up test at 5% level

. Components of the Plant Generative Phase

The plant components in the generative phase of upland rice observed in this study were the number of pithy grains per panicle and the weight of pithy grains per clump. The results of the analysis of variance showed that the number of pithy grains per panicle was only affected by upland rice varieties, while the pithy grain weight per clump was influenced by the rice variety and the type of fertilizer, either singly or by the interaction of both (Table 1). The Inpago 10 variety produced 96.37 grains per panicle, which was significantly different from the Sunggo variety, which produced 79.73 grains per panicle (Table 5). This can occur due to genetic and environmental factors that affect the adaptability of plant growth.)difference in yields obtained is due to each variety having different genetic, morphological and physiological properties and having different yield potentials (Alavan *et al.*, 2015; Ikhwani and Rustiati, 2018.graincontents is one of the characters of rice plants that is controlled by many genes (Herawati *et al.*, 2019)

Table 5. The effect of upland rice varieties on the number of pithy grains per panicle

Varieties	Number of pithy grains per panicle
Inpago 10	96.37 a
Sunggo	79 ,73 b

Note: the numbers followed by the same letter in the same column mean that they are not significantly different in the DMRT follow-up test at 5% level.

Upland rice of the Inpago 10 variety fertilized with double inoculants BPF + BPK + BPN resulted in the weight of pithy grains per clump the heaviest, weighing 18.64 g, although it was not significantly different from upland rice of Inpago 10 variety inoculated with AMF + BPK + BPN, but significantly different from Inpago 10 variety which was given recommended inorganic fertilizer, and the Really variety which was given recommended inorganic fertilizer and fertilizer inoculant. biological. While the lowest grain weight per clump was produced by upland rice of the Benar variety which was given recommended inorganic fertilizer, although it was not significantly different from the Benar variety which was inoculated with AMF + BPK + BPN and BPF + BPK + BPN, and the Inpago variety which was given recommended inorganic fertilizer. significantly different from the Inpago 10 variety inoculated with biological fertilizers, both double inoculants AMF + BPK + BPN and BPF + BPK + BPN (Table 6). The results indicated that genetically the Inpago 10 variety was better than the Benar variety. The nature of each genetic and environment where the lines and varieties grow will affect the grain density of each panicle, the number of grains per panicle will also affect the amount of filled grain formed (Idawanni, 2016; Suryanugraha *et al.,* 2017).

Table 6. The interaction effect of varieties and types of fertilizers on grain weight per clump

Type of Fertilizer	Varieties	Pulp Weight per Clump (g)
BPF + BPK + BPN	Inpago 10	18.64 a
FMA + BPK + BPN	Inpago 10	17.74 a
Inorganic Fertilizer Recommendation	Inpago 10	11.45 b
BPF + BPK + BPN	Sunggo	10.85 b
FMA + BPK + BPN	Sunggo	9.74 b
Inorganic Fertilizer	Sunggo	9.05 b

Note: numbers followed by the same letter in the same column means that it is not significantly different in the DMRT follow-up test at 5% level

. In addition, microbial activity has the effect of increasing nutrient uptake and nutrient availability in the soil, resulting in an increase in rice yields. Plants will grow well and produce high if all the nutrients provided are available in sufficient quantities. Nitrogen serves to improve plant vegetative growth (plants that grow in soil with sufficient nitrogen will turn green) and help the process of protein formation (Sonbai *et al.,* 2013). The element N has an important role in the growth and development of all living tissues. Furthermore, phosphorus is very useful for the formation of new cells in growing tissues, stimulates root growth, is a basic material for protein, strengthens plant stems and helps assimilation and respiration (Liferdi, 2010). Phosphorus also functions to accelerate and strengthen the growth of young plants into mature plants in general, accelerate the flowering and ripening of fruits and seeds, and can increase grain production (Sutedjo, 2002). Potassium nutrients function to increase the synthesis and translocation of carbohydrates, thereby accelerating the thickening of cell walls and rigidity of stems/fruits/branches (Taiz and Ziger, 2002).

The highest rice yield in this study was obtained on the Inpago 10 variety fertilized with double inoculants BPF + BPK + BPN which produced the heaviest grain weight per clump, which was 18.64 g or equivalent to 1.66 tons/ha. This result is still far below the average upland rice yield based on the description of the Inpago 10 variety, which is 4 tons/ha (Appendix 2). Furthermore, for local variety Sunggo, the highest grain weight per clump was 10.85 g or equivalent to 0.96 ton/ha. This result is also still below the average productivity according to farmers, which is ±1.66 tons/ha. This shows that the treatment given is still not able to increase soil fertility according to the location used to determine the description of the variety. In addition, in this study the Inpago rice variety was only tested in coastal areas, so it still takes time to adapt to the environment which causes crop yields to not be maximized.

CONCLUSION

Based on the results of the study, it can be concluded that the use of biological fertilizers in upland rice cultivation in coastal areas is more efficient in increasing the N, P, and K nutrient status, growth and yield of upland rice compared to recommended fertilizers. Upland rice varieties suitable for coastal land are Inpago 10 with fertilizers in the form of biological fertilizers a combination of Phosphate Solubilizing Bacteria + K Solvent Bacteria + N Fixing Bacteria..

REFERENCES

Achmad, S.R. dan Y.B.S. Aji. 2016. Pertumbuhan tanaman karet belum menghasilkan di lahan pesisir pantai dan upaya pengelolaan lahannya. *Jurnal Warta Perkaretan*. 35(1) : 11-24. https://doi.org/10.22302/ppk.wp.v35i1.76

Alavan, A., R. Hayati dan E. Hayati. 2015. Pengaruh pemupukan terhadap pertumbuhan beberapa varietas padi gogo (*Oryza sativa* L.). *Jurnal Floratek*. 10: 61–68

Aquilanti L, Favilli F, Clementi F. 2004. Comparison of different strategies for isolation and preliminary identification of Azotobacter from soil samples. *Soil Biology and Biochemistry*. 36(9): 1475-1483 https://doi.org/10.1016/j.soilbio.2004.04.024

Badan Pusat Statistik Provinsi Bengkulu. 2014. Produksi Padi dan Palawija Provinsi Bengkulu tahun 2014.

Bertham.Y.H. 2002. Respon tanaman kedelai (*Glycine Max* (L) Merill) terhadap pemupukan fosfor dan kompos jerami pada tanah Ultisol. *Jurnal Ilmu Pertanian Indonesia*. 4(2):78-83

Bertham, Y.H., Z. Arifin, dan A.D. Nusantara. 2019. The Improvement of Yield and Quality of Soybeans in a Coastal Area Using Low Input Technology Based on *Biofertilizers*. *International Journal on Advanced Science Engineering Information Technology*. 9(3) : 787-791. http://dx.doi.org/10.18517/ijaseit.9.3.6247

Don, N, T., dan C.N. Diep. 2014. Isolation, characterization and identification of phosphate and potassium solubilizing bacteria from weathered materials of granite rock mountain, That Son, an Giang province, Vietnam. *American Journal of Life Sciences*. 2(5):282-291. https://doi.org/10.11648/J.AJLS.20140205.16

Fitria, E, dan M.N Ali. 2014. Kelayakan usaha tani padi gogo dengan pola Pengelolaan Tanaman Terpadu (PTT) di Kabupaten Aceh Besar, Provinsi Aceh. *Widyariset*. 17(3): 425–434. http://dx.doi.org/10.14203/widyariset.17.3.2014.425-434

Garg, N dan S. Chandel. 2010. Arbuscular Mycorrhizal Networks: Process and Function. A Review. *Agronomy for Sustainable Development*. 30:581–599. http://dx.doi.org/10.1051/agro/2009054

Herawati, R. E. Inoriah, Rustikawati, dan Mukhtasar. 2017. Genetics diversity and agronomic characters of F3 lines selected by recurrent selection for drought tolerance and blast resistance of bengkulu local rice varieties. *International Journal on Advance Science Engineering Information Technology*.7(3) : 922-927. http://dx.doi.org/10.18517/ijaseit.7.3.1641

Herawati, R., B.S. Purwoko, dan I.S. Dewi. 2009. Keragaman genetik dan karakter agronomi galur haploid ganda padi gogo dengan sifat-sifat tipe baru hasil kultur antera. *J. Agron. Indonesia*., 37 (2) : 87 – 94. https://doi.org/10.24831/jai.v37i2.1399

Herawati, R., Masdar And Alnopri. 2019. Genetic analysis of grain yield of F4 populations for developing new type of upland rice. *SABRAO Journal of Breeding and Genetics*. 51(1) : 68-79.

Idawanni, Hasanuddin, dan Bakhtiar. 2016. Uji adaptasi beberapa varietas padi gogo diantara tanaman kelapa sawit muda di Kabupaten Aceh Timur. *Jurnal Floratek*. 11 (2):88-95

Ikhwani dan T. Rustiati. 2018. Respons varietas padi dengan beras berkarakter khusus terhadap pemupukan dan cara tanam. *Penelitian Pertanian Tanaman Pangan*. 2(1) : 17-24

Liferdi, L. 2010. Efek pemberian fosfor terhadap pertumbuhan dan status hara pada bibit manggis. *Jurnal Hort*. 20(1) : 18-26

Morrissey, J.P., J.M. Dow, G.L. Mark, dan F. O'Gara. 2004. Are microbes at the root of a solution to world food production?. *EMBO Reports*. 5(10): 922-926.

Nurmas, A., Nofianti, A. Rahman dan A. Khaeruni. 2014. Eksplorasi dan karakteristik Azotobacter *Indigenous* untuk pengembangan pupuk hayati tanaman padi gogo lokal di lahan marjinal. *Jurnal Agroteknos*. 4(2) : 128-134.

Nurhidayati. T, K.I Purwani, dan D. Ermavitalini. 2010. Isolasi Mikoriza Vesikular Arbuskular pada lahan kering di Jawa Timur. *Berkala Penelitian Hayati*. (4) : 43-46.

Nusantara, A.D., Y.H Bertham, A. Junedi, H. Pujiwati, dan Hartal. 2019. Pemanfaatan mikroba untuk meningkatkan pertumbuhan dan hasil kedelai di tanah pesisir. *JIPI*. 21(1) : 37-43 https://doi.org/10.31186/jipi.21.1.37-43

Nusantara AD, Y.H Bertham, dan I. Mansur. 20. *Bekerja dengan Fungi Mikoriza Arbuskula*. SEAMEO BIOTROP dan IPB Press. Bogor.

Safrida, N. Ariska dan Yusrizal. 2019. Respon beberapa varietas padi lokal (*Oryza sativa* L.) terhadap amelioran abu janjang sawit pada lahan gambut. *Jurnal Agrotek Lestari*, 5(1) : 28-38 https://doi.org/10.35308/jal.v5i1.1964

Singh G, D. R. Biswas, dan T. S. Marwah. 2010. Mobilization of potassium from waste mica by plant growth promoting rhizobacteria and its assimilation by maize (Zea mays) and wheat (Triticum aestivum L). *Journal of Plant Nutrition*. 33(8):1236-1251. https://doi.org/10.1080/01904161003765760

Sonbai, J.H.H., D. Prajitno., dan A. Syukur. 2013. Pertumbuhan dan hasil jagung pada berbagai pemberian pupuk nitrogen di lahan kering regosol. *Ilmu Pertanian* 16 (1) : 77-89. http://dx.doi.org/10.35726/jp.v20i2.20

Sriwahyuni, P dan P. Parmila. 2019. Peran bioteknologi dalam pembuatan pupuk hayati. *Agro Bali*, 2(1) : 46-57. https://doi.org/10.37637/ab.v2i1.408

Sudaryono. 2001. Pengaruh pemberian bahan pengkondisi tanah terhadap sifat fisik dan kimia tanah pada lahan marginal berpasir. *Jurnal Teknologi Lingkungan*, *2*(1), 106–112.

Suete, F., S. Samudin dan U. Hasanah. 2017. Respon pertumbuhan padi gogo (*Oryza sativa*) kultivar lokal pada berbagai tingkat kelengasan tanah. *e-J. Agrotekbis*, 5 (2) : 173 – 182 http://jurnal.faperta.untad.ac.id/index.php/agrotekbis/article/view/121

Suharno, dan S. Sufaati. 2009. Efektivitas pemanfaatan pupuk biologi Fungi Mikoriza Arbuskular (FMA) terhadap pertumbuhan tanaman matoa (Pometia pinnata Forst.). *SAINS*. 9(1): 81-36.

Sunar, T.R Gustina, dan Nikmah. 2021. Respon pertumbuhan, produksi dan kandungan seng (Zn) tanaman padi (*Oryza sativa* l.) Terhadap teknik pemberian dan dosis pupuk zink sulfat. *Jurnal Agrisia*, 14(1) : 1-13

Suptiningsih, E. 2007. Peningkatan produktivitas tanah pasir untuk pertumbuhan kedelai dengan inokulasi Mikoriza dan Rhizobium. *Jurnal Bioma*. 9 (2) : 58-61. https://doi.org/10.14710/bioma.9.2.58-61

Suryanugraha, W.A., Supriyanta, dan Kristamtini. 2017. Keragaan sepuluh kultivar padi lokal (*Oryza sativa* L.) Daerah IstimewaYogyakarta. *Vegetalika*. 6(4): 55-70 https://journal.ugm.ac.id/jbp/article/view/30917/18734

Sutedjo, M.M. 2002. Pupuk dan cara pemupukan. Rineka Cipta. Jakarta

Taiz, L., and E. Zeiger. 2002. Plant physiology. Sinauer Associates, Inc., Publisher. Sunderland, Massachusetts

Widyati, E. 2017. Memahami komunikasi tumbuhan-tanah dalam areal rhizosfir untuk optimasi pengelolaan lahan. *Jurnal Sumberdaya Lahan*. 11(1) : 33-42 http://dx.doi.org/10.21082/jsdl.v11n1.2017.33-42

Wuriesyliane. 2017. Pengaruh konsorsium Azospirillum, Azotobacter dan Bakteri Pelarut Fosfat terhadap pertumbuhan tanaman padi. *Klorofil*. 12(1) : 43 – 46. https://doi.org/10.32502/jk.v12i1.614

Zuhry, E. dan F. Puspita. 2008. Pemberian Cendawan Mikoriza Arbuskular (CMA) pada tanah podsolik merah kuning terhadap pertumbuhan dan produksi kedelai (*Glycine max* (L) Merill. *Jurnal Sagu*. 7(2):25-29. http://dx.doi.org/10.31258/sagu.v7i2.1107