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# The Effectiveness Of Multiple Inoculation Of Biodiversity In Improving Soil Biological Properties And Results Of Two Gogo Rice Varieties In Coastal Area

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**ABSTRACT.** This study aims to obtain a combination of biological fertilizers and upland rice varieties that can improve soil biological properties and increase upland rice production in coastal areas. This research was conducted from September to December 2019, in Beringin Raya Village, Muara Bangkahulu District, Bengkulu City. Soil and plant analysis were carried out at the Soil Science Laboratory, Faculty of Agriculture, Bengkulu University. This study used a Completely Randomized Block Design (RAKL). The first factor tested was upland rice varieties consisting of Inpago 10 and Serantan. Furthermore, the second factor is the type of biological fertilizer which consists of control, a combination of P solubilizing bacteria, K solubilizing bacteria, and N2 fixing bacteria, as well as a combination of arbuscular mycorrhizal fungi, K solubilizing bacteria, and N2 fixing bacteria. Each treatment combination was repeated 4 times so that there were 24 experimental units. Each experiment consisted of 50 plants so that the total plant population was 50 x 24 = 1,200 plants. The results showed that the combination of double inoculants of biological fertilizers BPF + BPK + BPN and rice variety Inpago 10 resulted in the highest population of potassium solubilizing bacteria, plant dry weight and weight of pithy grain per clump. Double inoculants of BPF + BPK + BPN biofertilizers resulted in the highest population of potassium solubilizing bacteria, the heaviest plant dry weight and weight of pithy grain per clump. Inpago 10 variety also had a higher population of potassium solubilizing bacteria, and better growth and yield components of rice compared to the serantan variety.

***Keywords:*** *Coastal Area, Upland Rice, Biological Fertilizer*

## INTRODUCTION

Indonesian territory is a very wide archipelago, from the past until now Indonesia is known as an archipelagic country. As we all know that Indonesia has 17,510 islands and the length of the coastline reaches 81,000 km and the sea area covers 70% of the total area of Indonesia (Sartika, 2011). However, until now the coastal area has not been managed and utilized optimally. The coastal area which is dominated by sandy soil makes the area less suitable for agricultural activities. Coastal areas have characteristics that are less conducive to plants, namely: (1) High salt levels cause osmotic pressure to increase (lower or negative water potential in root media) causing plants to experience drought stress, (2) Poisoning of ions such as Cl ions- and Na- in excess, (3) Nutrient imbalance due to inhibition of nutrient absorption, as well as a combination of these factors, has unstable soil properties, low soil moisture, high evapotranspiration, high salt content, organic matter content, low nutrient content (Gorham, 2007) . Therefore, efforts are needed to increase the fertility of coastal areas, one of which is the use of biological fertilizers and organic fertilizers.

Biological fertilizers are active (living) microorganisms that are given in the soil that can help plants provide nutrients. Therefore, by utilizing soil microbes such as arbuscular mycorrhizal fungi, phosphate bacteria. 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). The use of biological fertilizers in this study were Arbuscular Mycorrhizal Fungi (FMA), Phosphate Solubilizing Bacteria (BPF), Potassium Solubilizing Bacteria (BPK), and Azotobacter sp.

Arbuscular mycorrhizal fungi (AMF) are obligate fungi, or must live in symbiosis with their hosts, and are in symbiosis with approximately 90% of land plants. Plants in symbiosis with AMF were able to grow and produce better than non-mycorrhizal plants. This is because AMF is involved in various processes in the soil, for example in soil aggregation, overhauling of organic matter, movement of nutrients and water. In addition, mycorrhizal plants are also more resistant to pathogen attack (Garmendia et al., 2004), drought stress, heavy metals, and salinity (Turkmen et al., 2005). The provision of AMF has been shown to be able to increase upland rice yields (Margarettha et al., 2017). In this study using phosphate solubilizing bacteria that can provide phosphate nutrients.

Phosphate solubilizing bacteria (BPF) are non-pathogenic soil bacteria and are included in the category of plant growth-promoting bacteria. These bacteria produce vitamins, phytohormones and a collection of organic compounds that can improve root growth of tomato plants and increase soil nutrients. Phosphate solubilizing bacteria are bacteria that play a role in soil fertilization because this type of bacteria is able to carry out the mechanism of dissolving phosphate in the soil and improve plant root growth and can also increase nutrient uptake in plants. Phosphate solubilizing bacteria also play a role in providing essential macronutrients for plant growth and providing potassium nutrients (Astuti, 2013).

Potassium solubilizing bacteria (CPC) are bacteria that can provide essential macronutrients for plant growth and development. Potassium solubilizing bacteria that can provide macro nutrients needed in plant metabolic processes. According to Sugumara and Janarthanam (2007) they compared the effectiveness of BPK potassium solubilizing bacteria Bacillus mucilaginosus with microcline, orthoclase and muscovite mica minerals. The results of the study showed that the potassium in muscovite mica had a higher dissolution effectiveness compared to microbes and orthoclase.

Azotobacter sp is one of the rhizobacteria species that has been known as a nitrogen fixing biological agent, diazotroph, which converts dinitrogen to ammonium by reducing electrons and protonation of dinitrogen gas. Air molecules are converted into cell nitrogen freely. Nitrogen associated with the body structure is released in organic form as secretions or after the microorganism dies (Andayaningsih, 2000). Azotobacter has a complete mechanism as a potential microbe, namely providing nitrogen, phytohormones and anti-functions. Azotobacter enhances plant growth through fixation and production of phytohormones. (Vikhe, 2014). In addition, the use of organic fertilizers derived from composted coffee fruit skin waste.

Coffee husk compost is one of the organic materials that can be used as an ingredient for making organic fertilizer. The levels of organic matter and nutrients possessed by coffee husk waste allow it to improve soil properties. C-organic content of coffee rind is 45.3%,

nitrogen content is 2.98%, phosphorus 0.18% and potassium is 2.26%. In addition, coffee rind also contains elements of Ca, Mg, Mn, Fe, Cu and Zn (Pujiyanto, 2007). Coffee husk compost is a substitute for organic matter from manure. The addition of coffee husk compost can help improve soil properties, the content of organic matter in the soil can help the growth of upland rice plants (Oriza sativa L).

Upland rice (Oryza sativa L.) is a rice plant that is cultivated on dry soil, which is drought tolerant or without flooding such as lowland rice. This study used varieties (Inpago) 10, and varieties (Serantan). Where upland rice varieties vary and generally are local and national types of rice. Upland rice is widely cultivated in almost all parts of Indonesia because Upland rice that lives on dry land is a very important food crop because until now rice is still used as a staple food for most of the world's population, especially Asia. In addition, in Indonesia, rice is still seen as a key product for economic and political stability, the most important food crop for the community. This study aims to obtain a combination of biological fertilizers and upland rice varieties that can improve soil biological properties and increase upland rice production in coastal areas.

## MATERIAL AND METHODS

This research was conducted from September to December 2019 in Beringin Raya Village, Muara Bangkahulu District, Bengkulu City. This study used a Completely Randomized Block Design (RAKL), the factors tested were upland rice varieties consisting of Inpago 10 (description attached on page 44 ) (V1) and Serantan (V2) and the type of biological fertilizer consisting of Control (P1), the combination of P solubilizing bacteria, the combination of K solubilizing bacteria, and the combination of N2 (P2), the combination of arbuscular mycorrhizal fungi, the combination of K solubilizing bacteria, and the combination of N2 (P3). Each treatment combination was repeated 4 times so that there were 24 experimental units. Each experiment consisted of 50 plants so that the total plant population was 50 x 24 = 1,200 plants. The data obtained were analyzed using analysis of variance (ANAVA) at 5% level. Significantly different variables were further analyzed with DMRT at 5% level.

The study began with land preparation by clearing weeds, then the soil was processed using a hoe, then plots were made with a size of 1.5 mx 3 m and the distance between plots was 50 cm, while the distance between replicates was 100 cm. Then fertilized with 10 tons ha-1 coffee husk compost, 50 kg ha-1 Urea, 25 kg ha-1 TSP 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 the time of planting.

Upland rice planting is done by making a planting hole using a tugal 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. so that in one experimental unit there are 50 plants. The number of seeds per hole planted is two upland rice seeds. The combination of P solubilizing bacteria + K solubilizing bacteria + N fixing bacteria was carried out by referring to the method developed by Bertham et al. (2016-2018). While AMF

is combined by inserting as much as 2.5 grams of the combination into the planting hole (Nusantara et al., 2012).

During the research, plant maintenance was carried out in the form of watering, replanting, weeding, hoarding, and pest control. Watering of plants is carried out evenly on the surface of the plot of land, carried out every morning and evening when it is not raining or according to environmental conditions. Embroidery is done when there are seeds that do not grow or grow abnormally, weeding is done manually and mechanically using a sickle. Weeding was done every two weeks during the study. Pembumbunan will be done at 4 weeks after the plant by using Kored. Bumping is done by loosening the soil around the plant and the soil is backfilled at the base of the plant stem so that the plant becomes stronger. Pest control was carried out using the insecticide Curacron (active ingredient profenofos 500 g/L) to control armyworms, grasshoppers, and stink bugs. Control of bird pests using nets, is done by waiting for plants from bird attacks.

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). Harvesting in the generative phase was carried out, namely 85% of rice panicles were golden yellow, flag leaves and 90% of rice grains had turned yellow, rice panicles bowed, and the grain was hard when pressed by hand and left no marks. Harvesting is done by cutting the base of the panicle using scissors. Then put it in an envelope for observation.

## RESULT AND DISCUSSION

### The results of the analysis

of upland rice varieties had a significant effect on plant height, total tiller number, plant dry weight, population of potassium solubilizing bacteria, number of pithy grain per clump, total number of pithy grain per clump, and weight of pithy grain per clump. not significant for the AMF population, BPF population, total number of tillers, and number of panicles per clump. Meanwhile, the type of fertilizer and the interaction between varieties and types of fertilizers only had a significant effect on potassium solubilizing bacteria, plant dry weight, and weight of pithy grain per clump. In addition, the results of the analysis of variance showed that the block had no significant effect on almost all of the observed variables (Table 1). This indicates that the diversity between groups or experimental blocks is relatively low.

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Table 1. Summary of Variance Analysis Results

| Observation Variables | F-count | | | | KK (%) |
|---|---|---|---|---|---|
| | Block | Varieties | Types of Fertilizer | Interaction | |
| Plant Height | 0.52 ns | 192.88* | 1.18 ns | 0.46 ns | 11.13 |
| Total Tillers | 1.21 ns | 72 ,68* | 0.96 ns | 0.05 ns | 16.75 |
| Plant Dry Weight | 0.50 ns | 35.64* | 4.18* | 25.31* | 11.90 |
| AMF population | 1.00 ns | 0.02 ns | 0.83 ns | 0.15 ns | 39.59 |
| Phosphate Solubilizing Bacteria Population | 0.21 ns | 0.14 ns | 0.07 ns | 0.79 ns | 37.67 |
| Potassium Solubilizing Bacteria Population | 1.68 ns | 18.65* | 28.27* | 7.41* | 31.99 |
| Number of Fully Grain Per Clump | 1.04 ns | 6.06* | 1.33 ns | 0.51 ns | 16.78 |
| Total Number of Grain Per Clump | 1.79 ns | 7.56* | 0.81 ns | 0.58 ns | 11, 13 |
| Number of panicles per clump | 7.65* | 4.18 ns | 1.08 ns | 0.26 ns | 14.23 |
| Weight of pithy grain per clump | 3.07* | 63.61* | 11.39* | 4.29* | 16.88 |

Note : * = significant effect, ns = no significant effect, KK = coefficient of diversity.

**Research Results**

**Upland**

Rice Varieties Inpago 10 varieties have better growth and yield components and a higher population of potassium solubilizing bacteria than the Serantan variety. This can be seen from Table 2 which shows that plant height, plant dry weight, number of pithy grain per clump, total number of grains per clump and weight of pithy grain per clump on Inpago 10 variety were better than the serantan variety. The Inpago 10 variety produced a plant height of 102.27 cm, plant dry weight of 69.39 g, a population of potassium solubilizing bacteria of 76.09, the number of pithy grain per clump was 94.80 grain, the total number of grain per clump was 119.31 grain and weight of pithy grain per clump was 15.57 g. While the Serantan variety produced plant height as high as 53.47 cm, plant dry weight of 53.84 g, population of potassium solubilizing bacteria of 47.67, number of pithy grain per clump as much as 87.13 grain, total number of pithy grain per clump as much as 110, 96 grain and the weight of pithy grain per clump is 10.24 g. The population of potassium solubilizing bacteria in the Inpago 10 variety was 76.09 while the Serantan variety was 47.67 (Table 2). Based on these data, it can be stated that the Inpago 10 variety is more suitable to be developed in coastal areas than the Serantan variety.

Table 2. Effect of upland rice varieties on plant height (TT), plant dry weight (BKT), population of potassium solubilizing bacteria (P.BPK), number of pithy grains per clump (JBBPR), total number of grains per clump (JBTPR) and weight pithy grains per clump (BBBPR)

| Varieties | TT (cm) | BKT (g) | P. BPK | JBBPR | JBTPR | BBBPR (g) |
|---|---|---|---|---|---|---|
| Inpago 10 | 102.27 a | 69.39 a | 76.09 a | 94.80 a | 119.31 a | 15.57 a |
| Serantan | 53.47 b | 53.84 b | 47.67 b | 87.13 b | 110.96 b | 10.24 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 level 5%

**Type of Fertilizer**

The results showed that the double combination of BPF + BPK + BPN also produced the heaviest plant dry weight which was significantly different from the double combination of AMF + BPK + BPN and control. While the lowest plant dry weight was produced by the control although it was not significantly different from the dual combination of AMF + BPK + BPN, but it was significantly different from the double combination biological fertilizer BPF + BPK + BPNThe dry weight of the plant in the dual BPF + BPK + BPN biofertilizer was 68.51 g, while the dry weight of the plant in the control was 58.13 g (Table 3).

Table 3. Effect of fertilizer type on CPC population, plant dry weight, and grain weight per clump

| Type of Fertilizer | Plant Dry Weight (g) | Population CPC Population | Weight per Clump (g) |
|---|---|---|---|
| Control | 58.13 b | 18.37 b | 9.97 b |
| BPF + BPK + BPN | 68.51 a | 89.68 a | 14.75 a |
| FMA + BPK + BPN | 58.22 b | 77.60 a | 12.84 ab |

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

. The double combination of BPF + BPK + BPN biofertilizers produced the largest population of potassium solubilizing bacteria which was not significantly different from the dual combination of AMF + BPK + BPN, but significantly different from the control. While the control resulted in the lowest population of potassium solubilizing bacteria which was significantly different from the combination of biological fertilizers BPF + BPK + BPN and AMF + BPK + BPN. The population of potassium solubilizing bacteria in the dual BPF + BPK + BPN was 89.68, while in the control it was 18.37 (Table 3).

Combination biofertilizer produced the highest grain weight per plant, although it was not significantly different from the double combination of AMF + BPK + BPN, but it was significantly different from the control. While the control produced the lowest weight of pithy grain per clump although it was not significantly different from the dual combination of AMF + BPK + BPN, but it was significantly different from biological fertilizers BPF + BPK + BPN. The weight of pithy grain per clump on the double combination of BPF + BPK + BPN biofertilizer was 14.75 g, while the control was 9.97 g (Table 3).

Journal of Tropical Mycorrhiza
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Vol. 1 No. 2 October 2022

**Interaction of Varieties and Types of Fertilizers**

Combination dual BPF + BPK + BPN resulted in the heaviest dry weight of Inpago 10 rice varieties which was significantly different from the double combination of AMF + BPK + BPN and the control which resulted in the lowest plant dry weight. Meanwhile, the dry weight of Serantan variety showed no significant difference between the dual combination of BPF + BPK + BPN and FMA + BPK + BPN, but it was significantly different from the control which produced the lowest plant dry weight. On the other hand, the Inpago 10 variety produced the heaviest plant dry weight if given BPF + BPK + BPK biofertilizer, but if it was not given biofertilizer, the dry weight of the plant in the Serantan variety was heavier (Table 4).

Table 4. The effect of the combination of varieties and types of fertilizers on plant dry weight

| Fertilizer Types | Rice Varieties | |
|---|---|---|
| | Inpago 10 | Serantan |
| Control | 53.67 b<br>C | 62.60 a<br>A |
| BPF + BPK + BPN | 87.62 a<br>A | 49.40 b<br>B |
| FMA + BPK + BPN | 66.90 a<br>B | 49.53 b<br>B |

Note: the numbers followed by the same capital letter in the same column mean that they are not significantly different in the DMRT follow-up test at 5% level, the numbers followed by the same lowercase letter are the same line means that there is no significant difference in the 5% level DMRT follow-up test,

Application of combination of biological fertilizers in the form of BPF + BPK + BPN and FMA + BPK + BPN resulted in a population of potassium solubilizing bacteria that was not significantly different but higher than the control when combined with Inpago 10 variety. Meanwhile, the Serantan variety showed that the double combination of BPF + BPK + BPN produced the most potassium solubilizing bacteria which was significantly different compared to the double combination of AMF + BPK + control BPN which produced a population of potassium solubilizing bacteria. Lowest. On the other hand, the Inpago 10 variety produced the largest population of potassium solubilizing bacteria when given biological fertilizers, but if not given biological fertilizers the population of potassium solubilizing bacteria was higher in the Serantan variety (Table 5).

Table 5. Effect of the combination of varieties and types of fertilizers on the population of potassium solubilizing bacteria

| . Types of Fertilizers | Rice Varieties | |
|---|---|---|
| | Inpago 10 | Serantan |
| Control | 12.80 b<br>B | 23.93 a<br>C |
| BPF + BPK + BPN | 108.33 a<br>A | 71.02 b<br>A |
| FMA + BPK + BPN | 107.13 a<br>A | 48.07 b<br>B |

Note: the numbers followed by the same capital letter in the same column mean that they are not significantly different in the DMRT follow-up test at 5% level, the numbers followed by the same lowercase letter on the same line means that the difference is not significantly different in the DMRT follow-up test at 5% level.

The double combination of biological fertilizers consisting of BPF + BPK + BPN produces pithy grain weight per upland rice plant, Inpago 10 variety and the heaviest serantan, although the difference is not significant with multiple combinations. FMA + BPK + BPN, but significantly different when compared to the control. On the other hand, the Inpago 10 rice variety which was not combined with biological fertilizers produced the heaviest grain weight per plant compared to the Serantan variety (Table 6).

Table 6. varieties and types

| fertilizers | grains | |
|---|---|---|
| | pithy | clump |
| per | weight | the |
| | of | of |
| on | The | 6. |
| | combination | effect |
| TableBPK + BPN | 17.34 a<br>A | 10.67 b<br>A |

Note: the numbers followed by the same capital letter in the same column mean that they are not significantly different in the 5% level DMRT follow-up test, the numbers followed by lowercase letters are the same on the same line means that there is no significant difference in the DMRT follow-up test at 5% level

**Discussion**

The results showed that the Inpago 10 variety had a population of more potassium solubilizing bacteria than the serantan variety. This was presumably because the root exudates in the Inpago 10 variety were more compatible with potassium-solventing bacteria than the Serantan variety, so that their development was better. According to Purwaningsih

(2012)the soil microbial population varies greatly in each plant root, This is due to the development of micro-organisms in the soil is strongly influenced by the activity metabolism of plant roots that secrete exudate. The composition of the exudate in each plant is different. This exudate is released by plant roots into the soil which will be utilized by microbes in the soil in order to survive and reproduce, so that it will affect the population and diversity of microorganisms in the soil.

In addition to producing a higher population of potassium solubilizing bacteria, the Inpago 10 variety also has better growth and yield components than the Serantan variety. This can be seen from Table 2 which shows that plant height, plant dry weight, population of potassium solubilizing bacteria, number of pithy grain per clump, total grain per clump and pithy grain weight per clump on Inpago 10 variety were better than the Serantan variety. This is because the Inpago 10 variety has a better level of adaptation to the environment when compared to the Serantan variety. According to Nazirah and Damanik (2015) that differences in genetic composition are one of the factors that cause the appearance of plants to vary. Inpago 10 varieties that have better adaptation to the environment will provide better growth and yield performance.

The average plant height of upland rice varieties as a result of the study was as high as 102.27 cm, 1.73 cm lower or 1.66% when compared to the plant description, which was 104 cm. This is because the research was conducted in coastal areas and during the dry season, so that although watering has been carried out, the plants still lack water. With dry conditions, the water provided and can be stored in the soil is also very low to meet the water needs of plants. As a result, the nutrients that can be absorbed by plant roots are also low and reduce plant growth. The research of Sabetfar *et al*. (2013) showed that the growth of rice plants was more susceptible to drought during the tillering and panicle initiation phase, compared to the 50% flowering age phase. Davatgar*et al.*(2009) reported that drought in the vegetative phase inhibited the growth of plant height, the development of the number of tillers and leaves.

The results showed that the combination of biofertilizers produced the largest population of potassium solubilizing bacteria compared to the control. This indicated that the potassium-solventing bacteria given were able to multiply well, so the number was higher and different from the control based on the DMRT follow-up test at 5% level. The increasing population of potassium solubilizing bacteria is one indication of the increasing quality of soil biological characteristics which has an impact on increasing soil fertility so that plant growth takes place better and crop yields increase. This is evident from the results of the study which showed that in addition to producing the highest population of potassium solubilizing bacteria, the double combination of BPF + BPK + BPN was not significant with AMF + BPK + BPN which resulted in the heaviest plant dry weight and the heaviest weight of pithy grain per plant. This is because the biofertilizer given is able to increase nutrient uptake for plants, especially P by BPF (Noor, 2005), K by BPK (Prajapati *et al.*, 2013), and N by BPN (Babalola, 2010). This is in accordance with the statement of Samuel and Muthukkaruppan (2011) that the increase in growth and production component variables is due to an increase in nitrogen, phosphate, and potassium elements in the soil which are the main elements needed by plants.

The results showed that the heaviest plant dry weight was found in the double combination of biological fertilizers BPF + BPK + BPN and Inpago 10 rice variety, which was 87.62 g. This is because the given biological fertilizer can increase the availability of nutrients for plants. In addition, the dry weight of the plant was heavier in the combination of double inoculant biofertilizer BPF + BPK + BPN and the Inpago 10 rice variety because it produced the largest population of potassium solubilizing bacteria so that the availability of element K was higher. According to Simanungkalit (2001) that biological fertilizers are live microorganisms that are given into the soil as inoculants to help plants facilitate or provide certain nutrients for plants. The results of the research of Isawa*et al.*, (2010) showed that the plant biomass increased between 6-12% greater than the control plants. Microbial colonies have increased plant height and biomass, this is thought to occur due to increased cell metabolic activity.

A better combination between BPF, BPK, and BPN as well as the compatibility with the root exudates of Inpago 10 plants increased the development of potassium solubilizing bacteria, resulting in a higher population. In addition to playing a role in taking nutrients and anchoring plants into the soil, roots also actively secrete various compounds called root exudates into the soil environment. Root exudates mediate the interaction between plants and microbes in the rhizosphere (Badri and Vivanco, 2009).Root exudate is a food source and the main energy for organisms that live in rhizosphere(Zhuang*et al.*2013). Root exudates are very dependent on the type of plant (*plant species-specific*), then will affect the specific microbial community for the host plant. Different types of plants will produce different types and amounts of root exudates, the difference will be even greater when the plant kinship relationship is lower (Hockenga*et al.*2006). The difference in root exudate production will result in different interactions with microbes. This is because a root exudate composition will form a different rhizosphere community as well.

The increase in growth and population of potassium solubilizing bacteria was followed by an increase in crop yields. This is evident from the results of the study which showed that inoculation of BPF + BPK + BPN biofertilizers on the Inpago 10 rice variety produced the heaviest grain weight per clump, which was 18.11 g. This is because microbial activity has the effect of increasing nutrient uptake and nutrient availability in the soil, resulting in increased rice yields.

## CONCLUSION

The combination of double inoculant biofertilizer BPF + BPK + BPN and rice variety Inpago 10 resulted in the highest population of potassium solubilizing bacteria, plant dry weight and heaviest weight of pithy grain per clump. Double inoculants of BPF + BPK + BPN biofertilizers resulted in the highest population of potassium solubilizing bacteria, the heaviest plant dry weight and weight of pithy grain per clump. Inpago 10 variety also had a higher population of potassium solubilizing bacteria, and better growth and yield components of rice compared to the serantan variety.

## REFERENCES

Andayaningsih P. 2000. Pengaruh takaran molase terhadap perkembangan Azotobacter sp. Indigenus podsolik merah kuning asal subang pada media gambut. Jurnal Bionatura. 2: 66-74.

Astuti.Y.W, L.U. Widodo dan I. Budisantosa. 2013. Pengaruh bakteri pelarut fosfat dan bakteri penambat nitrogen terhadap pertumbuhan tanaman tomat pada tanah masam. Biosfera A Scientific Journal. 30(3) : 134-142.

Babalola, O. 2010. Beneficial bacteria of agricultural importance. Biotechnol. Lett. 32(11):1559-15570.

Badri, D.V. dan J.M. Vivanco. 2009. Regulation and function of root exudates. Plants, Cells and Evironment. 32:666-681.

Davatgar, N., M.R. Neishabouri, A.R. Sepaskhah, A. Soltani. 2009. Physiological and morphological responses of rice (Oriza sativa L.) to varying water stress management strategies. Int. J. Plant Prod. 3(4):19-31.

Garmendia, I., N. Goicoechea, dan J. Aguirreolea. 2004. Effectiveness of three Glomus species in protecting pepper (Capsicum annuum L.) against Verticillium wilt. Biological Control, 31(3) : 296–30.

Gorham, J. 2007. Sodium. p. 569-575. In Barker, A.V and D.J Pilbeam (eds). Handbook of Plant Nutrition. Taylor & Francis. 631 pages.

Hockenga, M.A., L.G. Maron, dan M.A. Pineros. 2006. AtAMLTI which encodes a malate transporter as one od aluminium tolerance in Arabidopsis. Plant Physiology 132:936-948.

Isawa, T., M. Yashuda, H. Awazaki, K. Minasiwa, S. Sinozaki, and H. Nakashita. 2010. Azospirillum sp. strain b510 enhances rice growth and yield. Microbes Environ. 25(1): 58–61.

Margarettha, M. Syarif, dan H. Nasution. 2017. Efektivitas fungi mikoriza arbuskular indigen untuk padi Gogo di lahan kering marjinal. Jurnal Ilmiah Ilmu Terapan Universitas Jambi, 5(1), 83–96.

Nazirah, L. dan B.S.J. Damanik. 2015. Pertumbuhan dan hasil tiga varietas padi gogo pada perlakuan pemupukan. Jurnal Floratek. 10(1):54-60.

Noor A. 2005. Peranan fosfat alam dan kombinasi bakteri pelarut fosfat dengan pupuk kandang dalam meningkatkan serapan hara dan hasil kedelai. Jurnal Tanah dan Lingkungan. 7(2):41-47.

Prajapati K, Sharma MC, Modi HA. 2013. Growth promoting effect of potassium solubilizing microorganisms on Abelmoscus esculantus. International Journal of Agriculture Science. 3(1):181-188.

Pujiyanto, 2007. Pemanfaatan kulit buah kopi dan bahan mineral sebagai amelioran tanah alami. Pelita perkebunan. 23 (2) : 159-172.

Purwaningsih, P. 2012. Isolasi, populasi dan karakterisasi bakteri pelarut fosfat pada daerah perakaran dan tanah dari Bengkulu, Sumatra. J.Tek. Ling. 13 (1): 101 – 108. https://doi.org/10.29122/jtl.v13i1.1410

Sabetfar, S., M. Ashouri, E. Amiri, and S. Babazadeh. 2013. Effect of drought stress at different growth stages on yield and yield component of rice plant. Persian Gulf Crop Protection 2(2):14-18.

Samuel S, dan S.M. Muthukkaruppan. 2011. Characterization of plant growth promoting rhizobacteria and fungi associated with rice, mangrove and effluent contaminated soil. Current Botany. 2(3): 22-25.

Sartika, I. 2011. Evaluasi kebijakan pemberdayaan nelayan. Jurnal Ilmu Adminitrasi Negara. 11(2) : 111-124. http://dx.doi.org/10.46730/jiana.v11i02.592

Simanungkalit, R.D.M., D.A. Suriadikarta, R.Saraswati, D. Setyorini dan W.Hartatik. 2006. Pupuk Organik dan Pupuk Hayati. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian, Bogor.

Sudaryono. 2001. Pengaruh Pemberian Bahan Pengkondisi Tanah Terhadap Sifat Fisik Dan Kimia Tanah Pada Lahan Marginal Berpasir. Jurnal Teknologi Lingkungan, 2(1), 106–112.

Sugumaran P, Janarthanam B. 2007. Solubilization potassium containing minerals by bacteria and their effect on plant growth. World J Agric Sci. 3(1): 350 – 355.

Turkmen, O., R, S. D., E. Suat, dan D. Atilla. 2005. Effects of Arbuscular Mycorrhizal Fungus and Humic Acid on the Seedling Development and Nutrient Content of Pepper Grown under Saline Soil Conditions. Journal of Biological Sciences, 5(4) : 568-574.

Vikhe P.S. 2014. Azotobacter species as a Natural Plant Hormone Synthesizer. Research Journal on Recent Science. 3 (IVC):59-63.

Zhuang, X., J. Gao, M. Ma, S. Fu, dan G. Zhuang. 2013. Review bioactive molecules in soil ecosystems: Masters of the Underground. Int. J. Mol. Sci. 14: 8841-8868.