International Journal of Agricultural Technology 2021Vol. 17(2):433-442
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Utilization of some *in-situ* micro-organism for improving the growth and result of organic gogo rice (*Oryza sativa* L.) in Bengkulu coastal area

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Bertham, Y. H., Nusantara, A. D., Arifin, Z. and Anandyawati, A. (2021). Utilization of some in-situ micro-organism for improving the growth and result of organic gogo rice (*Oryza sativa* L.) in Bengkulu coastal area. International Journal of Agricultural Technology 17(2):433-442.

Abstract Gogo rice varieties with a high level of adaptation, and ascertain the ability of *in-situ* micro-organisms to increase the carrying capacity of coastal areas were investigated from July - December 2019 in Beringin Raya Village, Muara Bangkahulu District, Bengkulu City. Therefore threegogo rice varieties were obtained from BPTP Bengkulu, which are Inpago 10, Serantan and Sungggu. The results showed that the Inpago 10 had the highest adaptability compared to Serantan and Sunggu. It showed that the rhizosphere of Inpago produced Azotobacteria populations, Mycorrhizae, P-solvent and K-solvent bacteria. Furthermore, in-situmicro-organisms with double inoculation improved the rice rhizosphere characteristics and yield components compared to control.

Keywords: Gogo rice, In-situ microorganisms, Coastal area

Introduction

Indonesia is one of the archipelagic countries with a coastline of about ± 81 thousand km, which is a large extent. However, the region has been marginalized and under-empowered due to its less profitable land characteristics. This is because coastal land has sand-textured soil, withahigh salt content and low nutrient and organic matter. However, coastal soils generally have high levels of dissolved salts or Na+ / K+ ratios and Na+ and Cl- ions (Yamaguchi and Blumwald, 2006). Therefore, a reduced photosynthetic efficiency is caused by stomata closure and low protein content (Sibole III *et al.*, 2002). It is also caused by long duration ofsaltstress (Mishra *et al.*, 1991). Therefore, it is necessary to improve the carrying capacity of these areas towards agricultural cultivation. This can be achieved using the right technological approach.

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Rice is a staple food commodity in Indonesia, and the increase in population is accompanied by a high demand. However, local production has not met this increase, therefore rice is still being imported. An effort to improve the level of local productivity is the extensification to coastal areas, but the growth and production will experience changes in the soils. The use of organic materials, such as biocomposts, and biological fertilizers are thought to improve rice adaptability. In fact, the use of biofertilizers in Bengkulu's coastal ocean area was proven to improve the growth and yield of soybeans (Bertham*et al.*, 2019; Nusantara *et al.*(2019a), peanuts (Bertham and Nusantara, 2018), chili (Bertham *et al.*, 2016) and edamame (Nusantara *et al*., 2019b).

Meeting nutritionalrequirements, especially N, P, and K through fertilization is very necessary in increasing carrying capacity. However, the use of synthetic fertilizers is not appropriate because this area is pivot, which makes nutrients leach easily. Therefore, other inputs are needed in order to fulfil the need of plants. The nutrientssupply can be obtained from local micro-organisms such as arbuscular mycorrhiza, potassium and phosphate solvent bacteria, as well as azotobacterial.

Arbuscular mycorrhiza are obligate fungi thatexhibit a symbiotic relationship with their host plant (about 90% terrestrial) (Smith and Read, 2008). Therefore, plants that are symbiotic with AMF grow and produce better yield. This is because FMA is involved in various processes, such as soil aggregation (Miller and Jastro, 2000), overhaul of organic matter, movement of nutrient and water (Smith and Read, 2008). Besides, the mycorrhizal plants are more resistant to pathogens attack (Garmendia *et al.,* 2004), drought stress, heavy metals, and Salinity (Turkmen *et al.,* 2005). Meanwhile, FMA has been proven to increase Gogo rice yield (Syamsiyah *et al.,* 2014 ; Margarettha *et al.,* 2017). Phosphate solubilizing bacteria is one of the soil micro-organisms thatdissolves P ions and converts them to absorbable forms (Keneni *et al.,* 2010). These bacteria secrete enzymes that play a role in the hydrolysis of organic P into inorganic P and also produce growth regulators (Purwaningsih, 2003). Astuti *et al.* (2013) demonstrated that phosphate solubilizing bacteria (BPF) increased the wet weight, nitrogen content (N), and phosphorus levels (P) of tomato plants in acidic soil.

Also, potassium solvent microbes dissolve P from insoluble bonds in a medium to form new cells leading to immobilization (Basak and Biswas, 2009). Azotobacter is a gram-negative bacterium that binds nitrogen using anitrogenaseholoenzyme which has iron sulfate molybdenum cluster as an active site (Chiu *et al.,* 2001). This bacterium produces IAA hormones (Widiastuti*et al.,* 2016). Furthermore, it lives free as a saprophyte in soil, freshwater, marine and other natural habitats, and has been utilized as an effective inoculum to enhance plant growth and pest control (Aquilanti*et al.,* 2004).

Based on the background above, this study aimed to obtain Gogo rice varieties that have a high level of adaptation, and ascertain the abilitiesof local micro-organismstointensify thecapacity of coastal areas.

Materials and methods

This study was conducted from July 2019 to February 2020 inBeringin Raya Village, Muara Bangkahulu District, Bengkulu City. The production of biological fertilizer inoculants was carried out at the Soil Biology Laboratory, Faculty of Agriculture, Bengkulu University. Meanwhile, themeasurement of plant dry weight, initial and final soil analysis, and tissue nutrient content were carried out at the Soil Science Laboratory. The experimental design was a split plot type.Therefore, 3 Gogo rice varieties were obtained from BPTP Bengkulu which were Inpago 10 (V1), Serantan (V2), and Sunggu (V3). Meanwhile, the subplots are fertilizer inputs, which are Formula I (microbial solvent P + microbial solvent K + microbial fixator N), Formula II (arbuscular mycorrhizal fungi + microbial solvent K + microbial fixator N), as well as control (inorganic fertilizer recommended by BPTP which are 200 kg Urea ha^{-1}, 100 kg SP36 ha^{-1}, 100 kg KCl ha^{-1}). The microbes used in this study were microbes obtained through isolation fom coastal lands. The inoculum was applied with the zeolite carrier. Its application is carried out when planting seedlings in the experimental field.

These two factors are combined, therefore there were 9 treatment combinations and repeated 4 times, leadingto 36 experimental units. The obtaineddata were analyzed using analysis of variance (ANAVA) at 5% level. Also, significantly different variables were further analyzed with DMRT at 5%.

Results

Laboratory test results showed that the soil contained 0.19% N which is classified as low, 0.23% C as moderate, 0.28 me 100 g^{-1} of soil K_2O as low, 6.23 ppm P_2O5 as low. Also, the pH of water was 6.2 which is slightly acidic, KCl was 5.8, KTK of soil was 5.2 which is classified as low. Based on these data, it can be concluded that the soil wasmarginal with the problem of nutrient content, organic matter, andrelatively low KTK, as well as sour pH.

Soil biological characteristics

The results of the variance analysis showed there were no real interaction between fertilizer inputs and rice varieties on soil biological characteristics and yields. This indicated that they gave the same response to fertilizer inputs. However, the single factor of the input has a significant effect on azotobacterial and BPK population, the number and percentage of puffed grains, weight per clump and per plot. Meanwhile, Gogorice varieties have a significant effect on azotobacterial, BPK, and BPF population, the number of piths per panicle, weight of 1000 seeds, grain weight per clump and per plot.

The inoculants in Formula I produced the highest azotobacterial population of 21.55 colonies g^{-1} which was not significantly different from the double inoculants in Formula II which was 14.44 colonies g^{-1}. However, this is different from the recommendation fertilizer which produced the lowest azotobacterial population of 6.11 colonies g^{-1}. Thedouble inoculants in Formula I increased the azotobacterial population by 252.65%. Meanwhile, those in Formula II increased the population by 136.39% compared to the recommended fertilizer, which was 100.18 colonies g^{-1}. Furthermore, it increased by 505.68% compared to therecommended, which produced a BPK of 16.54 colonies g^{-1}. Whereas Formula II biofertilizer inoculants produced a BPK of 94.06 colonies g^{-1}, withan increase of 468.68% (Table 1).

Table 1. The impact of fertilizer input on the soil microbes population

Observation Variable	Fertilizer Input	Value	Increasing (%)
Azotobacter population (Colonyg^{-1})	Formula I	21,55 a	252,65
	Formula II	14,44 a	136,39
	Recommendation	6,11 b	0,00
FMA Population (colonyg^{-1})	Formula I	135,81	2,55
	Formula II	162,18	22,46
	Recommendation	132,44	0,00
BPF Population (Colonyg^{-1})	Formula I	137,86	2,44
	Formula II	148,80	10,58
	Recommendation	134,57	0,00
BPK Population (colonyg^{-1})	Formula I	100,18 a	505,68
	Formula II	94,06 a	468,68
	Recommendation	16,54 b	0,00

The results showed that the Inpago 10 variety produced more azotobacteric, BPF, and BPK populations than the Serantan and Sunggu (Table 2).

Table 2. The impact of varietyon the soil microbe population

Variety	Azotobakter population (colonyg^{-1})	FMA population (Colonyg^{-1})	BPF population (colonyg^{-1})	BPK population (colonyg^{-1})
Inpago 10	16,59 a	138,46	150,90 a	83,73 a
Serantan	12,07 b	146,99	132,65 b	43,93 b
Sunggu	13,44 b	149,83	137,69 b	83,12 a

Rice production

The number of pithy grains were produced by double inoculants in Formula I were not significantly different from II, but different from chemical recommendations (Table 3). Also, those in Formula I produced 93.67per panicle, which increased by 11.41% more than the recommendationswhich produced 84.00. Meanwhile, the inoculants in Formula II produced 91.33 pithy grains per panicle, which is8.73% higher than the recommendations. Those in Formula I produced the highest pithy grains weight per clump and plot, although it was not significantly different from II, but different from chemical fertilizer recommendations. Also, the weight of pithy grains per clump in a double inoculant in Formula I was 14.34 g, which increased by 36.44% than chemical recommendations, which produced a weight per clump of 10.51g. Meanwhile, those in Formula II produced a weight of 13.61gperclump. The weight per plot in Formula I was 0.74kg, which increased by 46.45% than the recommendation of chemical fertilizers, while the double inoculant in Formula II produced a weight of 0.66 kg per plot.

Inpago 10 variety produced number of grains per panicle, weight of 1000 seeds, weight per clump and plot, whichishigher than Serantan and Sunggu (Table 4). It showed this variety had better ability to adapt to coastal conditions than the others in research finding. In addition, it is noticed that it had a good level of compatibility with soil micro-organisms more than other varieties, leading to a better performance in supplying nutrients. This is proven in Table 2 which showed that the microbial population in Inpago 10 was greater than in Serantan and Sungguh.

Table 3. The impact offertilizer input on the rice production

Observation Variable	Fertilizer Input	Value	Increasing (%)
Amount of pithy grains per panicle (bulir)	Formula I	93,67 a	11,51
	Formula II	91,33 a	8,73
	Recommendation	84,00 b	0,00
Percentage of pithy grains (%)	Formula I	78,63	9,13
	Formula II	78,81	9,39
	Recommendation	72,05	0,00
Weight of 1000 seeds (g)	Formula I	22,05	7,54
	Formula II	21,75	6,08
	Recommendation	20,51	0,00
Weight of grains per clump (g)	Formula I	14,34 a	36,44
	Formula II	13,16 a	25,15
	Recommendation	10,51 b	0,00
Weight of grains per plot (kg)	Formula I	0,74 a	46,45
	Formula II	0,66 a	30,76
	Recommendation	0,51 c	0,00

Table 4. The impact of varietyon rice production

Varietas	Amount of pithy grains per panicle (bulir)	Percentage of pithy grains (%)	Weight of 1000 seed (g)	Weight of grains per clump (g)	Weight of grains per plot (kg)
Inpago 10	96,33 a	79,74	23,95 a	16,01 a	0,80 a
Serantan	81,00 b	76,02	18,73 b	9,16 c	0,45 c
Sungguh	91,67 a	73,73	21,63 a	12,84 b	0,65 b

Discussion

Result showed the inoculants improved the plant rhizophere conditions, leading to the growth of soil microbes and optimal development. Thisresults are in accordance with Javorekov á*et al.* (2015) that biological fertilizers diversifiedsoil micro-organisms and population. Besides increasing the quantity and quality of organic matter, soil pH, macro and micro elements, it also improvedthe physical properties of soil. The positive impact of this application on microbial population was also reported by Antralina *et al.* (2015) Bertham *et al*. (2019) and Louis Mary *et al.* (2015).

In general, the results showed the population of soil microbes increased with the application of biological fertilizers than the recommendation types. It indicated that, the application of chemical fertilizers damage the rhizosphere, even though it provides nutrient. Although they provide direct nutritional needs, excessive doses have a negative impact on microbial environment. This is because chemical fertilizers increase the concentration of salt in the soil solution, leading to an imbalance of the rhizosphere ecosystem. According to Yunus *et al*. (2017), land use of synthetic fertilizers resultsina decreased population of soil micro-organisms. Meanwhile, Triyono *et al.* (2013) showed that the continuous administration of inorganic fertilizers increased soil acidity, which has a negative impact on micro-organisms. This decreases the natural fertility of the soil over time.

Result indicated that the quality of exudate it produces is better than the others. Also, the population and development of soil microbes is influenced by energy sources in the soil due to the metabolic activity of plant roots that emit exudate (Sorensen *et al.,* 1997; Walker *et al.,* 2003). Therefore, microbes use it to multiply and survive. In addition, the other factors that influence microbial activity are quality and quantity of organic matter, pH, oxygen availability, temperature, season, humidity, inorganic fertilizers, and the presence of inhibitors (Oyewole andKalejaiye, 2012).

The inoculants in both Formula I and II produced all components of plant yields better than the recommendation of chemical fertilizers. The results of this study are in accordance with Mulyaningsih *et al.* (2015) that showed biofertilizer increased upland rice yield than synthetic recommendations. This is because the land used was a coastal area that has a texture dominated by sand fractions. Therefore, the use of synthetic fertilizers cannot maximize crop yields because during rainy season, the nutrients are leached. Also, during hot weather, the temperature of the soil increases, which burns the fertilizer. However, the application of inoculants improved plant nutrients, especially N, P, and K. Thismakes unavailable nutrients to become available for plants through a breakdown process in the rhizosphere environment. Therefore, nutrients supply is continuous as long as the ecosystem is optimum.

Acknowledgements

We would like to thank to University of Bengkulu for supporting the research through Unggulan Universitas Scheme.

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(Received: 27 July 2020, accepted: 15 February 2021)