Inoculation of Merapi Indigenous Rhizobacteria as A Substitute Compost for Application in Rice Cultivation on Coastal Sandy Under Drought Stress

10.18196/pt.v10i2.15646

Sarjiyah*, Agung Astuti, Akhmad Bustamil

Department of Agrotechnology, Faculty of Agriculture, Universitas Muhammadiyah Yogyakarta, Jl. Brawijaya, Kasihan, Bantul, Yogyakarta, 55183, Indonesia

**Corresponding author, email:* sarjiyah@umy.ac.id

ABSTRACT

This study aimed to determine the role of the indigenous rhizobacteria from Merapi as a substitute for compost in rice cultivation on coastal sandy land under drought stress. The study was a single-factor experiment, with types and doses of compost as treatments, arranged in a completely randomized design (CRD) consisting of seven treatments and three replications. The seven treatments tested were cow manure compost at doses of 30 and 40 tons/ha, chicken manure compost at doses of 30 and 40 tons/ha, Azolla compost at doses of 20 and 30 tons/ha, and without compost as a control treatment. Each experimental unit consisted of three plants for destructive sampling, three sample plants, and a substitute plant. The application of cow manure compost at a dose of 30 tons/ha to the rice plants inoculated with MB and MD isolates of Merapi indigenous rhizobacteria resulted in the best growth at five weeks after planting, which was not significantly different from that without compost application. This result indicated that the rice plants cv. Segreng Handayani inoculated with Merapi indigenous rhizobacteria, cultivated on coastal sandy soil under drought stress, even without the application of compost, could give the same responses as the plants treated with various types and doses of compost.

Keywords: Coastal sandy, Compost, Indigenous rhizobacteria, Merapi

ABSTRAK

Penelitian ini bertujuan untuk mengetahui peran Rhizobacteri indigenous *Merapi sebagai substitusi kompos pada budidaya padi di lahan pasir pantai yang mengalami cekaman kekeringan. Penelitian ini merupakan eksperimen faktor tunggal yaitu jenis dan takaran kompos yang disusun dalam Rancangan Acak Lengkap (RAL) yang terdiri dari tujuh perlakuan dan tiga ulangan. Ketujuh perlakuan yang diuji adalah kompos kotoran sapi dengan dosis 30 dan 40 ton/ha, kompos kotoran ayam dengan dosis 30 dan 40 ton/ha, kompos Azolla dengan dosis 20 dan 30 ton/ha, dan tanpa kompos sebagai perlakuan kontrol. Setiap satuan percobaan terdiri dari tiga tanaman korban, tiga tanaman sampel, dan satu tanaman pengganti. Aplikasi kompos kotoran sapi dosis 30 ton/ha pada tanaman padi yang diinokulasi MB dan MD isolat Rhizobakteri* indigenous *Merapi menghasilkan pertumbuhan terbaik pada umur lima minggu setelah tanam, yang tidak berbeda nyata dengan tanpa aplikasi kompos. Hasil ini menunjukkan bahwa tanaman padi varietas Segreng Handayani yang diinokulasi dengan Rhizobakteri* indigenous *Merapi yang dibudidayakan di tanah pasir pantai di bawah cekaman kekeringan, bahkan tanpa aplikasi kompos, dapat memberikan respons yang sama dengan tanaman yang diperlakukan dengan berbagai jenis dan dosis kompos.*

Kata kunci: *Pasir pantai, Kompos, Rhizobakteri indigeneus, Merapi*

INTRODUCTION

The rice production in Indonesia in 2017 was 70.61 million tons of dry unhusked rice ready for milling (GKG), which increased by 0.67 million tons (0.94%) compared to rice production in 2016 (BPS, 2017). The improvement of rice production has not been able to keep up with the increasing need for national rice, so efforts are still needed to increase rice production.

Efforts to increase rice production can be achieved through intensification and extensification. Increasing rice production by extensification can be done using marginal lands, including coastal sandy land. The utilization of coastal sandy land to increase rice production is faced with several limiting factors, including low water storage ability, high infiltration and evaporation, very low fertility

open access

Check for updates

Article History
Received: 30 Mar 2022
Accepted: 18 Aug 2022

and organic matter content, and low water use efficiency. Wibisana et al., (2020) found that using filter cake compost at a dose of 5 tons ha^{-1} was more efficient, and it could provide efficiency of 0.097 tons per kg of cane at a dose of 76.76% inorganic fertilizer. Intensification efforts to increase soil fertility and rice yields in coastal sandy land include adding organic fertilizers, using microbial biotechnology in the form of biological fertilizers, and using superior cultivars tolerant to environmental stress (upland rice cv. Segreng Handayani). Kristamtini & Prajitno (2009) stated that the Segreng Handayani cultivar is one of the superior upland rice cultivars tolerant to water stress, but its production has only reached 3-4 tons/ha.

Organic fertilizers added to the coastal sandy land can improve the soil's physical, chemical, and biological properties. The role of organic matter in soil physical properties includes stimulating granulation, improving soil aeration, and increasing water retention capacity. The potential organic fertilizers in coastal sandy land include cow and chicken manure and Azolla compost. Mertikawati et al., (1999) and Hasibuan (2015) found that providing compost of cow manure, chicken manure, gliricidia leaves, and angsana leaves at a dose of 30 ton/ha could improve the physical properties (soil moisture, soil porosity, and bulk density) and chemical properties (soil pH, organic C, and soil organic matter) of soil. Ratnasari et al., (2020) found that organic matter significantly increased water availability in the soil, thereby supporting the growth and yield of upland rice. Yovita (2012) reported that chicken manure compost at a dose of 20 tons/hectare showed the best results on the growth and yield of sweet corn plants on peat soil. Meanwhile, the research by Kustiono et al., (2012) showed the application of Azolla at a dose of 6 tons/hectare compost on rice cv. Ciherang on Inceptisol soils produced 8.69 tons/hectare of grain.

Merapi indigenous rhizobacteria isolates have the potential to be used as biological fertilizers, especially for rice plants in fields with limited water. It is supported by the research of Agung Astuti et al., (2014a), reporting that rice plants inoculated with the Merapi indigenous rhizobacteria with a watering frequency of six days gave the same results as rice plants without inoculation with a daily watering frequency. Rhizobacteria isolates can produce growth hormones and osmoprotectants, increasing plant resistance to drought stress and fixing N from the air. Therefore, it is necessary to study the types and doses of compost to be added to the coastal sandy soil to improve soil fertility and increase the yield of rice inoculated with Merapi indigenous rhizobacteria isolates. Applying the inoculum of Merapi indigenous rhizobacteria is expected to reduce the use of organic fertilizer.

MATERIALS AND METHODS

Experimental design

This study used upland rice plants cv. Segreng Handayani (a local variety of Gunung Kidul), MB and MD isolates of Merapi indigenous rhizobacteria (collection of Ir. Agung Astuti, M.Si), LBA (Luria Bertani Agar) platting media, LBC (Luria Bertani Cair) isolate propagation media, cow manure compost, chicken manure compost, Azolla compost, coastal sandy soil for planting media. The study was a single-factor experiment, with types and doses of compost as treatments, arranged in a completely randomized design (CRD). The treatments applied were various types of compost with different doses on Segreng Handayani rice plants that were inoculated with Rhizobacteri indigenous Merapi in drought stress for two days, consisting of seven treatments and three replications. The seven treatments tested were cow manure compost at doses of 30 and 40 tons/ha, chicken manure compost at doses of 30 and 40 tons/ha, Azolla compost at doses of 20 and 30 tons/ha, and without compost (control). Each unit consisted of three plants for destructive sampling, three sample plants, and a substitute plant.

Rhizobacteria were identified and characterized according to Bergey's Manual of Determinative Bacteriology. Colony morphology observations include colony color, diameter, edge shape, internal structure, and elevation. Cell morphology observations include cell shape, gram properties, catalase, and aerobics.

Statistical Analysis

The data were analyzed using analysis of variance (ANOVA) at P≤0.05. The data were then subjected to Duncan's Multiple Range Test (DMRT) at P≤0.05 to determine the difference between treatments.

RESULTS AND DISCUSSION

Identification and characterization

Identification is carried out to ensure that the bacteria used are the same as the bacteria that have been determined. Identification of the indigenous rhizobacteria of Merapi includes colony and cell characterization. Colony characterization was carried out by culturing MB and MD isolates on the LBA medium using the surface platting method.

The identification and characterization of the MB and MD isolates of Merapi indigenous rhizobacteria follow the results of research by Agung Astuti (2016), reporting that the color of the isolates is white (MB) and creamy white (MD). The diameter is 0.4 cm (MB) and 1.4 cm (MD). Meanwhile, the colony form is circular (MB) and amuse (MD) with an edge shape of entire (MB) and filamentous (MD). The elevation is law convex (MB) and convex rugose (MD), and the inner structure is coarsely Granular (MB) and arborescent (MD). The cell's shape is bacillus (MB) ad coccus (MD). Both isolates are negative-Gram bacteria.

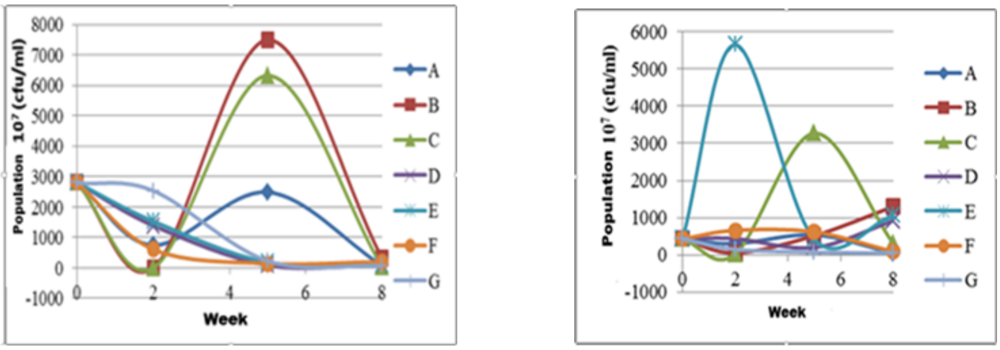
The MB and MD isolates of Merapi indigenous rhizobacteria were Gram-negative. It means that the indigenous rhizobacteria of Merapi can accumulate glycine betaine. Glycine betaine is a compound accumulated by Gram-negative bacteria under drought stress. According to Brock (1997), the characterization of rhizobacteria cells is Gram-negative with a diameter of 0.5 to 0.9 μm long 1.2 - 3.0 μm, without spores. It follows this study's gram characteristics of the Merapi indigenous rhizobacteria isolates.

The population dynamics of Merapi indigenous rhizobacteria

The population dynamics of Merapi indigenous rhizobacteria were observed in the starter mixture and nursery as well as at 2, 5, and 8 weeks after planting. The number of colonies was counted using the Total Plate Count (TPC) method. The population of Merapi indigenous rhizobacteria, both MB and MD isolates, increased from the time of the starter mixture to the nursery phase in the Greenhouse (Figure 1). It is assumed that the population of MB and MD isolates experienced a growth phase, and they were able to pass the environmental adaptation phase in the nursery.

The Merapi indigenous rhizobacteria in the starter mixture reached 48.33x107 CFU/ml (MB and MD). In the nursery planting media (in the Greenhouse), the MB isolate population increased to 2796x107 CFU/ml, and the MD isolates increased to 426.67x107 CFU / ml. Meanwhile, the population of other bacteria in the soil was 196x107 CFU/ml, so the total bacteria in the nursery was 3418.67x107 CFU/ml (Figure 1).

MD isolates had a faster adaptation ability compared to MB isolates. This result is consistent with the research of Agung_Astuti et al., (2014a), reporting that the development of MD isolates in the first



(a) (b)

Figure 1. (a) MB isolates and (b) MD isolates of Merapi indigenous *Rhizobacteria* inoculated in rice plants cv. Segreng Handayani. A: Cow manure compost 30 ton/ha, B: Cow manure compost 40 ton/ha, C: Chicken manure compost 30 ton/ha, D: Chicken manure compost 40 ton/ha, E: Azolla compost 20 ton/ha, F: Azolla compost 30 ton/ha, G: Control (without compost/only inoculated with indigenous rhizobacteria).

week was faster than that of MB isolates. It proves that MD isolates can adapt to week 2, and the population decreases until week 8. The population growth of MD isolates in treating Azolla compost at 20 tons/ha was very good initially. Meanwhile, the population growth in the treatment of chicken manure compost at 30 tons/ha was very good in the end, but the growth of the isolates was slow. In the treatment of cow manure 30 and 40 tons/ha, the growth of MD isolates was low until the 5th week, then increased, while in Azolla compost, 30 tons/ha, the growth of isolates was prolonged and did not even develop.

From week 2 to week 5, the population of Merapi indigenous rhizobacteria experienced a log phase. The increase in the population of MB isolates is supported by the research of Agung Astuti et al., (2014b), mentioning that the MB and MD isolate experienced development from weeks 4 to 6.

The population of Merapi indigenous rhizobacteria in the treatment of Azolla 20 ton/ha experienced exponential growth from week 0 to week two so that it could pass the adaptation phase. This increase was dominated by the MD isolate colony of Merapi indigenous rhizobacteria, which was 5656.67x107 CFU/ml (Figure 1b).

In the span of week 2 to week 5, the MB isolates experienced a log phase in the treatment of cow manure compost at 30 and 40 tons/ha, while in the treatment of 30 tons/ha of chicken manure compost, both MB and MD isolate experienced a log phase (Figure 1a and 1b). Thus, MD isolates had a faster adaptation ability compared to MB isolates.

The root growth of rice plants cv. Segreng Handayani

Roots are important in supporting plants to grow upright and absorb nutrients and water for plant metabolic processes. Root growth is influenced by environmental conditions, such as soil texture and type, air, and soil cultivation (Gardner et al., 1991).

There was a significant effect of rhizobacteria inoculation with the addition of various types and doses of compost on the proliferation, length, fresh weight, and dry weight of the roots of rice plants cv. Segreng Handayani was cultivated on coastal sandy soil under drought stress at week 5 with each P-value of 0.0032, 0.0203, 0.0003, and 0.0040, respectively (Table 1), but not at week 8 (Table 2) with a P-value higher than 0.05. The application of cow manure compost at 30 ton/ha and 40 ton/ha, Azola compost at 20 ton/ha, and without compost (only inoculation of MB and MD isolates) under drought stress resulted in the higher proliferation and longer roots compared to other treatments at

Table 1. Effect of types and doses of compost on the root proliferation, root length, root fresh weight, and root dry weight at week 5

Treatments	Root proliferation (+)	Root length (cm)	Root fresh weight (g)	Root dry weight (g)
A	3.00 a	46.00 a	42.48 a	7.16 a
B	2.67 a	45.00 ab	25.80 a	4.46 ab
C	1.00 c	22.63 bcd	0.75 b	0.30 c
D	1.33 bc	20.83 cd	2.19 b	0.60 c
E	2.33 ab	33.33 abcd	9.15 b	2.13 bc
F	1.00 c	11.67 d	0.25 b	0.11 c
G	3.00 a	39.97 abc	26.24 a	5.69 ab

Remarks: Means followed by the same letters in the same column are not significantly different according to DMRT at P≤0.05. A: Cow manure compost 30 ton/ha, B: Cow manure compost 40 ton/ha, C: Chicken manure compost 30 ton/ha, D: Chicken manure compost 40 ton/ha, E: Azolla compost 20 ton/ha, F: Azolla compost 30 ton/ha, G: Control (without compost/only inoculated with indigenous rhizobacteria).

Table 2. Effect of types and doses of compost on the root proliferation, root length, root fresh weight, and root dry weight at week 8

Treatments	Root proliferation (+)	Root length (cm)	Root fresh weight (g)	Root dry weight (g)
A	4.00 a	55.33 a	55.41 a	8.70 a
B	3.67 a	44.00 a	49.37 a	7.35 a
C	3.33 a	37.17 a	52.24 a	7.12 a
D	3.67 a	47.33 a	50.54 a	6.91 a
E	3.00 a	35.67 a	31.75 a	4.17 a
F	3.00 a	34.00 a	34.74 a	5.50 a
G	4.00 a	39.50 a	52.55 a	7.02 a

Remarks: Means followed by the same letters in the same column are not significantly different according to ANOVA at P≤0.05. A: Cow manure compost 30 ton/ha, B: Cow manure compost 40 ton/ha, C: Chicken manure compost 30 ton/ha, D: Chicken manure compost 40 ton/ha, E: Azolla compost 20 ton/ha, F: Azolla compost 30 ton/ha, G: Control (without compost/only inoculated with indigenous rhizobacteria).

week five. Meanwhile, the application of cow manure compost at both doses and without compost resulted in higher fresh and dry weight of the roots.

The application of cow manure compost at 30 and 40 tons/ha, Azolla compost at 20 tons/ha, and without compost significantly increased the proliferation, length, and fresh and dry weight of roots. It is suspected that mixed MB + MD isolates can stimulate root development with these treatments, thereby increasing soil fertility and improving plant growth. In addition, the development of root proliferation is also influenced by IAA produced by rhizobacteria in the roots. According to Agung Astuti (2014 a), MB isolates have a strong ability to break down NH_4^+ to Nitrite (NO_2^-) or Nitrate (NO_3^-) and to break down organic or inorganic N into ammonia, besides also having resistance to very high osmotic pressure (NaCl> 2.75M). Meanwhile, MD isolate is very strong in dissolving phosphate and resistant to osmotic pressure (NaCl> 2.75M). However, at week 8, the roots' proliferation, length, and fresh and dry weight were the same in all treatments. This result is because, from weeks 5 to 8, there was an increase in the population of rhizobacteria, especially MD isolates. Chavez et al., (2019) 's research results stated that soil fertility strongly influenced plant microbiota.

The shoot growth of rice plants cv. Segreng Handayani

Plants experience biomass growth in forming their body parts. Plant biomass includes all plant materials from photosynthesis (Sitompul and Guritno, 1995 in Apriyanti, 2007). The effect of

Table 3. Effect of types and doses of compost on the plant height, shoot fresh weight, shoot dry weight at week 5 and number of tillers

Treatments	Plant height (cm)	Shoot fresh weight (g)	Shoot dry weight (g)	Number of tillers
A	51.81 a	44.32 a	9.86 a	23.78 a
B	50.22 a	31.68 ab	7.10 a	18.78 a
C	45.33 ab	4.73 c	1.37 c	14.33 a
D	39.39 bc	6.23 c	1.42 c	16.17 a
E	50.53 a	18.38 bc	4.21 bc	18.55 a
F	29.95 c	1.28 c	0.46 c	6.56 a
G	52.48 a	40.61 a	10.32 a	18.56 a

Remarks: Means followed by the same letters in the same column are not significantly different according to DMRT at P≤0.05. A: Cow manure compost 30 ton/ha, B: Cow manure compost 40 ton/ha, C: Chicken manure compost 30 ton/ha, D: Chicken manure compost 40 ton/ha, E: Azolla compost 20 ton/ha, F: Azolla compost 30 ton/ha, G: Control (without compost/only inoculated with indigenous rhizobacteria).

Table 4. Effect of types and doses of compost on the plant height, shoot fresh weight, shoot dry weight at week 8, number of tillers, and anthesis period

Treatments	Plant height (cm)	Shoot fresh weight (g)	Shoot dry weight (g)	Number of tillers	Anthesis period (days)
A	65.49 a	100.69 a	22.77 a	29.67 a	63.67 cd
B	55.72 ab	84.16 a	18.42 a	24.22 a	69.33 bc
C	53.59 ab	84.40 a	18.28 a	26.11 a	71.00 b
D	48.17 bc	90.08 a	19.75 a	23.11 a	70.50 b
E	63.16 ab	53.18 a	11.66 a	31.11 a	68.33 bcd
F	37.03 c	54.71 a	11.35 a	9.00 a	77.00 a
G	62.56 ab	85.56 a	18.56 a	22.77 a	63.00 d

Remarks: Means followed by the same letters in the same column are not significantly different according to DMRT at P≤0.05. A: Cow manure compost 30 ton/ha, B: Cow manure compost 40 ton/ha, C: Chicken manure compost 30 ton/ha, D: Chicken manure compost 40 ton/ha, E: Azolla compost 20 ton/ha, F: Azolla compost 30 ton/ha, G: Control (without compost/only inoculated with indigenous rhizobacteria).

rhizobacteria inoculation with the addition of various types and doses of compost on plant height was in line with the effect on the root development (proliferation, root length, fresh root weight, and root dry weight) because the better the root development, the more water and nutrient absorbed, thereby resulting in optimum plant growth. The nutrients in cow manure compost at 30 and 40 tons/ha can increase the biomass weight of the rice plants. Besides, the treatment can provide energy and nitrogen for the indigenous rhizobacteria to fertilize the plants. According to Rao (1994), the roots of rice plants can provide exudates in the form of organic compounds needed for soil microorganisms.

There was a significant effect of rhizobacteria inoculation with the addition of various types and doses of compost on the plant height and the shoot fresh and dry weight at week 5, but no significant effect on the number of tillers (Table 3). The application of cow manure compost at 30 and 40 tons/ha, chicken manure compost at 30 tons/ha, Azolla compost at 20 tons/ha, and control (without compost) produced higher plants compared to the application of chicken manure compost at 40 ton/ha and Azolla compost at 30 ton/ha. The shoot fresh and dry weight of plants treated with cow manure compost at 30 and 40 tons/ha and of control (without compost) plants were significantly higher than those treated with other treatments. Meanwhile, at week 8, the application of cow manure compost at 30 and 40 tons/ha, chicken manure compost at 30 tons/ha, Azolla compost at 20 tons/ha, and control produced significantly higher plants compared to the application of chicken manure and Azolla compost at 40 and 30 ton/ha, respectively (Table 4).

Conversely, the treatments had no significant effect on the fresh and dry weight of the shoots at week 8. This result is in line with the development of the roots that were not significantly affected by the treatments because shoot growth is influenced by the root's ability to absorb water and nutrients for growth. The results of the research by Khalimi et al., (2014) also showed that the application of PGPR could stimulate plant growth and increase plant resistance to pathogenic fungi.

There was no significant effect of the inoculation of rhizobacteria with the addition of various types and doses of compost on the number of tillers in week 5 (Table 3) as well as at week 8 (Table 4). However, all treatments resulted in a higher number of tillers compared to the description of the cultivar (9 - 11) due to the role of the indigenous rhizobacteria that can produce phytohormones such as IAA. Organic materials from cow manure, chicken manure, and Azolla compost can be used as nutrients that help the growth of indigenous rhizobacteria in the roots so that they can fertilize plants. Research by Agung Astuti et al., (2014b) reported that inoculation of Merapi indigenous rhizobacteria (MB + MD isolates) produced a higher number of tillers, reaching 12-16 tillers, compared to those without inoculation, producing only 9.27 tillers (Utami et al., 2009).

There was no significant effect of the inoculation of rhizobacteria with the addition of various types and doses of compost on the anthesis period (Table 4). The control treatment resulted in an earlier anthesis period. However, it was not different from the application of cow manure compost at 30 tons/ha (63.67 days) and Azolla compost at 20 tons/ha (68.33 days). This result is because the different types of compost have different levels of ability to bind water, especially in coastal sandy soil, which has a high porosity. Hence, the soil is prone to drought. Drought can affect morphology, physiology, and activities at the molecular level of rice plants, such as delayed anthesis, reduced distribution and allocation of dry matter, reduced photosynthetic capacity due to stomata closure, restriction in metabolism, and damage to chloroplasts (Farooq et al., 2009).

The yield of rice plants cv. Segreng Handayani

The productivity of rice plants is affected by the interaction between genetic factors and the environment (Yoshida, 1981). According to the Analysis of Variance, there was no significant effect of the inoculation of rhizobacteria with the addition of various types and doses of compost on the harvesting age, the number of panicles and weight of seeds per hill, the weight of 1000 seeds, and the grain yield of rice plants cv. Segreng Handayani in coastal sandy soil under drought stress (Table 5) with a P value> 0.05. However, the application of cow manure compost at 30 tons/ha, Azolla compost at 20 tons/ha, and control tended to result in earlier harvesting age, a higher number of panicles and weight of seeds per hill, and higher grain yield compared to other treatments. The application of cow manure compost at 30 tons/ha resulted in a higher number of panicles per hill (29.11), although it was not different compared to other treatments (Table 5). This result is in line with the anthesis period in the application of cow manure compost at 30 tons/ha and control (without compost), which was earlier than other treatments. Besides, the root growth (root proliferation, root length, and fresh and dry weight of roots) and shoot growth (plant height and fresh and dry weight) at week 5 were higher. According to Purwaningsih and Kristamtini (2009), the harvesting age of rice plants cv. Segreng Handayani is 109 days after planting. It is suspected that the application of cow manure compost at 30 tons/ha can improve growth because the nu-

Table 5. Effect of types and doses of compost on the harvest age, number of panicles per hill, the weight of seeds per hill, the weight of 1000 seeds, and grain yield (ton/ha)

Treatments	Yield				
	Harvest age (days)	Number of panicles per hill	Weight of seeds per hill (g)	Weight of 1000 seeds (g)	Grain yield (ton/ha)
A	104.67 a	29.11 a	17.46 a	20.65 a	4.25 a
B	107.33 a	24.33 a	14.90 a	17.03 a	3.63 a
C	109.00 a	23.72 a	15.59 a	18.01 a	3.80 a
D	107.00 a	25.34 a	15.59 a	20.50 a	3.90 a
E	107.33 a	27.83 a	17.21 a	18.64 a	4.19 a
F	111.00 a	22.50 a	8.38 a	17.64 a	2.04 a
G	104.67 a	27.89 a	16.93 a	20.50 a	4.13 a

Remarks: Means followed by the same letters in the same column are not significantly different according to ANOVA at P≤0.05. A: Cow manure compost 30 ton/ha, B: Cow manure compost 40 ton/ha, C: Chicken manure compost 30 ton/ha, D: Chicken manure compost 40 ton/ha, E: Azolla compost 20 ton/ha, F: Azolla compost 30 ton/ha, G: Control (without compost/only inoculated with indigenous rhizobacteria).

trients are absorbed optimally, thereby providing sufficient energy and nitrogen for the indigenous rhizobacteria of Merapi so that the plants can be harvested earlier.

Meanwhile, the inoculation of Merapi indigenous rhizobacteria with the addition of cow manure and Azolla compost at 30 and 20 tons/ha, respectively, and without the addition of compost resulted in a higher seed weight per hill, the weight of 1000 seeds and grain yield compared to other treatments. Merapi indigenous rhizobacteria can produce NO_3^- and NH_4^+ ions through a mineralization process to form complex materials, such as amino acids and nucleic acids, that plants can directly absorb and use. In addition, Merapi indigenous rhizobacteria can fertilize plants because they can produce IAA to become biological fertilizers for plant growth (Agung Astuti, 2014a). This result is also supported by the research results of Chaves et al., (2019), stating that of the 41 strains of rhizobacteria studied, 86% can produce IAA, and only 14% are high phosphorus solubilizing bacteria. This is in line with research results by Tuhuteru et al., (2019), mentioning that PGPR isolates BrSG.5 (*Burkholderia seminali)s* tested could produce IAA 41.41 mg kg-1, isolate BP25.2 (*Bacillus methylotrophicus*) was effective at producing N (0.05%), while isolate BP25.7 (*Bacillus subtilis*) was effective at producing residue P (0.22 ppm).

Overall, the effects of the inoculation of Merapi indigenous rhizobacteria added with various types and doses of compost on rice plants cv. Segreng Handayani cultivated on coastal sand soil under drought stress were observed on the root proliferation, root length, root fresh and dry weight, plant height, shoot fresh and dry weight, and anthesis period. The application of cow manure compost at 30 tons/ha and control (without compost) resulted in better responses than other treatments. Meanwhile, the treatments had no significant effect on the grain yield. Nevertheless, the application of cow manure and Azolla at 30 and 20 tons/ha, respectively, and control (without compost) tended to produce higher grain yield than other treatments. It is suspected that the application of cow manure compost at 30 tons/ha can improve vegetative and generative growth more quickly because nutrients are absorbed optimally, thereby providing energy and nitrogen for the indigenous rhizobacteria of Merapi so that the photosynthesis process runs optimally. In addition, the indigenous rhizobacteria of Merapi can fertilize plants because they can produce IAA. According to Agung Astuti (2014a), rhizobacteria isolates have the potential to be used as biological fertilizers. It can be seen from their ability to produce growth hormones and osmoprotectants that can increase plant resistance to drought stress and fix N from the air. The application of Azolla compost at higher doses tends to enhance the denitrification process. Denitrification is the process of reducing nitrogenous oxides, especially nitrite and nitrate, to nitrogen, N_2O, and N_2 (Tiedje, 1988 in Picone et al., 2014). Besides, the research site's environmental temperature (volatilization) is quite high, thereby releasing N and ammonium in the soil into the air as gases. Volatilization is the change of ammonium to ammonia gas, and this process occurs mostly in soils with a pH greater than 7.5 with a sand texture (Budiyanto, 2009). Control treatment (without compost) was found to give the same effect as the application of cow manure compost at 30 ton/ha. The coastal sandy soil used in this research may already contain sufficient organic matter for developing rhizobacteria to develop and play a role in increasing soil fertility, growth, and yield of rice plants. This is in line with the research results of Ningrum et al., (2017), reporting that the combination of treatments without composting rabbit manure and 30 ml of PGPR were able to replace the combination treatment of 10 tons ha-1 of rabbit manure compost and 20 ml on the yield of cobs per hectare.

CONCLUSION

Applying 30 tons/ha of cow manure compost to rice plants inoculated with Merapi indigenous rhizobacteria isolates MB+MD in coastal sandy soil gave the best growth at week five and was not significantly different from that without compost. The provision of various types and doses of compost did not significantly affect the rice yield inoculated by Merapi indigenous rhizobacteria in coastal sandy soil. The inoculation of the indigenous rhizobacteria Merapi can substitute the application of compost in rice cultivation on coastal sandy soil under drought stress.

REFERENCES

Agung_Astuti. (2016). Identifikasi dan Karakterisasi Isolat *Rhizobacteri* Osmotoleran dari Merapi. *PLANTA TROPIKA: Jurnal Agrosains (Journal of Agro Science)*, 4(1), 32-36. https://doi.org/10.18196/pt.2016.054.32-36

Agung_Astuti, Sarjiyah, & Haryono. (2014a). Uji potensi *rhizobacteri indigenous* lahan pasir vulkanik Merapi untuk dikembangkan sebagai pupuk hayati di lahan marginal. *Prosiding Seminar Nasional Pemanfaatan Lahan Marginal Berbasis Sumberdaya Lokal untuk Mendukung Ketahanan Pangan Nasional, HITI-UNSOED Purwokerto, Indonesia*.

Agung_Astuti, Sarjiyah, Haryono, & Habibi. (2014b). Compatibility test of indigenous rhizobacterial isolate of Merapi with rice varieties under drought stress. *Proceeding of International Biotechnology Conference (IBC), Palembang, Indonesia*.

Apriyanti. (2007). Pengujian Bentuk Dan Takaran Inokulum Terhadap Aktivitas Infeksi Dan Nodulasi Akar Tanaman Kerandang (*Pueraria phaseoloides sp.*) Di Tanah Pasir Pantai [Skripsi]. Universitas Muhammadiyah Yogyakarta.

BPS. (2017). Statistik Pertanian 2017. Sekretaris Jendral Departemen Pertanian R.I. http://epublikasi.setjen.pertanian.go.id

Brock. (1997). *Biology of Microorganisms*. Illinois: Southern Illinois University-Carbondale Prentice Hall International, Inc.

Budiyanto, G. (2009). *Bahan Organik dan Pengelolaan Nitrogen Lahan Pasir*. Unpad Press.

Chaves, E.I.D., Gumaraes, V.F., Vendruscolo, E.C.G., Santos, M.F., Oliveira, F.F., Abreu, J.A.C., Camargo, M.P., Schneider, V.S., Souza, E.M., Cruz, L.M., & Vasconcelos, E.S. (2019). Interactions between endophytic bacteria and their effects on poaceae growth performance in different inoculation and fertilization conditions. AJCS, 13 (01), 69-79. https://doi.org/10.21475/ajcs.19.13.01.p1249

Farooq, M., Wahid, A., Lee, D.J., Ito, O., & Siddique, K.H.M. (2009). Advances in drought resistance of rice. *Critical Reviews in Plant Sciences*, 28 (4), 199. https://doi.org/10.1080/07352680902952173

Gardner, F. P., Pearce, R. B., & Mitchell, R.L. (1991). *Fisiologi Tanaman Budidaya*. UI Press.

Hasibuan, A.S.Z. (2015). Pemanfaatan bahan organik dalam perbaikan beberapa sifat tanah pasir pantai selatan Kulonprogo. *PLANTA TROPIKA: Jurnal Agrosains (Journal of Agro Science)*, 3 (1), 34 – 40. https://doi.org/10.18196/pt.2015.037.31-40

Khalimi, K., Gusti Ngurah A.S.W. (2012). Pemanfaatan Plant Growth Promoting Rhizobacteria (PGPR) untuk Biostimulants dan Bioprotektans. *ECOTROPHIC: Jurnal Ilmu Lingkungan (Journal of Environmental Science)*, 4 (2), 131-135.

Kristamtini, & Prajitno, A.L. (2009). Karakterisasi padi beras merah segreng varietas unggul lokal Gunungkidul. *Jurnal Ilmu Ilmu Pertanian*, 5 (1), 45-51. http://dx.doi.org/10.55259/jiip.v5i1.299

Kustiono, G, Indarwati & Jajuk Herawati. (2012, June). Kajian Aplikasi Kompos Azolla dan Pupuk Anorganik untuk meningkatkan hasil padi sawah (*Oryza sativa* L.) [Seminar Nasional]. Seminar Nasional 2012, Kedaulatan Pangan dan Energi, Fakultas Pertanian Universitas Trunojoyo Madura. https://nanopdf.com/download/kajian-aplikasi-kompos-azolla-dan-pupuk-anorganik_pdf

Mertikawati, I., Suyono, A.D., & Djakasutami, S. (1999). Pengaruh

Berbagai Pupuk Organik Terhadap Beberapa Sifat Fisika dan Kimia Vertisol dan Ultisol Serta Hasil Padi Gogo. Proceeding of Konggres Nasional VII, HITI Bandung, Indonesia.

Ningrumm, W.A., Karuniawan, P.W., & Setyono, Y.T. (2017). Pengaruh Plant Growth Promoting Rhizobacteria (PGPR) dan Pupuk Kandang Kelinci terhadap Pertumbuhan dan Produksi Tanaman Jagung Manis (Zea mays saccharata). Jurnal Produksi Tanaman, 5(3), 433-440. https://doi.org/10.21776/397

Picone, L.I., Cecilia, V. , Calypso, L.P., Fernando, O.G., & Roberto, H.R. (2014). Denitrification in a Soil under Wheat Crop in the Humid Pampas of Argentina. *Open Journal of Soil Science*, 4 (9). https://doi.org/10.4236/ojss.2014.49033

Purwaningsih, Heni, & Kristamtini. (2009). Potensi Pengembangan Beras Merah sebagai Plasma Nutfah Yogyakarta. *Jurnal Penelitian dan Pengembangan Pertanian,* 28 (3), 88-95.

Rao, N.S.S. (1994). Mikroorganisme Tanah dan Pertumbuhan Tanaman. UI press.

Ratnasari, P., Tohari, T., Eko, H., & Priyono, S. (2020). Effect of Trenches with Organic Matter and KCl Fertilizer on Growth and Yield of Upland Rice in Eucalyptus Agroforestry System. *PLANTA TROPIKA: Jurnal Agrosains (Journal of Agro Science),* 8 (2), 114 – 125. https://doi.org/10.18196/pt.2020.121.114-125

Tuhuteru, S., Endang, S., & Arif, W. (2019). Aplikasi *Plant Growth Promotingm Rhizobacteria* dalam MeningkatkanProduktivitas Bawang Merah di Lahan Pasir Pantai. Jurnal Agronomi Indonesia, 47(1), 53-60. https://dx.doi.org/10.24831/jai.v47i1.22271

Utami D.W., Kristamtini, Prajitno, KS. (2009). Karakterisasi Plasma Nutfah Padi Beras Merah Lokal Asal Propinsi Daerah Istimewa Yogyakarta Berdasarkan Karakter Morfo-Agronomi dan Marka SSRs. *Zuriat*, 20(1). https://doi.org/10.24198/zuriat.v20i1.6644

Wibisana, D.L., Purwono, & Sudirman, Y. (2020). The Application of Filter Cake Compost to Improve The Efficiency of Inorganic Fertilizer in Upland Sugarcane (*Saccharum officinarum* L.) Cultivation. *PLANTA TROPIKA: Jurnal Agrosains (Journal of Agro Science)*, 8 (2), 93 – 102. https://doi.org/10.18196/pt.2020.119.93-102

Yoshida, S. (1981.) Fundamentals of Rice Crop Science. *The International Rice Research Institute*.

Yovita. (2012). Pengaruh Pemberian Tiga Jenis Pupuk Kompos dan Dosis NPK terhadap Pertumbuhan dan Hasil Tanaman Jagung Manis di Tanah Gambut Pedalaman [Magister Thesis]. Universitas Lambung Mangkurat. http://repository.ut.ac.id/2725/