The Effectiveness of Local Rhizobacteria Formulations in Increasing The Growth and Production of Rice Plants in Merauke

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Abstract: This study aimed to examine the effectiveness of acetoin-producing rhizobacteria formula in promoting growth and increasing local rice yields in Merauke. This in vitro ponder was conducted at the Biopesticide Research facility, Staff of Horticulture, Udayana College. This think about was carried out within the test cultivate of the Staff of Agribusiness, Udayana College, Denpasar. This think about focused on four rhizobacteria segregates that have been recognized to be tried to fortify the development of rice plants. The rice assortment utilized was the Ciherang assortment, which was frequently developed by cultivating communities in Merauke Rule. The test plan utilized was a Randomized Piece Plan (RBD), comprising of 4 replications. Each replication comprised of 6 medications, to be specific 4 rhizobacteria separates and 2 medicines for comparison. The four rhizobacteria confines were Rg21, Pd13, Pd7, and Bb7. Whereas the 2 medicines as a comparison were Unadulterated Acetoin (Dad) and control. Each treatment was rehashed 10 times so that the whole reiteration was 240 rice plant pots. The pot measure utilized was a surface with a distance across of 30 cm and was filled with developing media. The results of the study showed that the mechanism of action of the rhizobacterial formula in increasing rice yields was the presence of acetoin compounds and derivative compounds such as 2-Butanone, 3-hydroxy, 2,3-butanediol, diacetate, 2,3-Butanediol (CAS), 2-Butanone, 3-acetyloxy, and 1,4-Dioxane. These compounds were produced by rhizobacteria in the rhizosphere, which helped plants achieve acetoin homeostatic conditions so that plants could increase plant height, leaf area, number, number of productive tillers, panicle length, percentage of filled and empty grain, and reduce amylose content. The treatment of Merauke local rhizobacteria formula carried out in a greenhouse with a concentration of 2% was effective in promoting growth and increasing rice yields by adding the weight per plant by 52.83% when compared to the control.

Keyword: *Effectiveness, Local Rhizobacteria, Rice Production*

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1. Introduction

Rice (*Oryza sativa* L.) is an annual plant that belongs to the grass group. Rice has a short life of less than one year. Rice as a food crop is consumed by around 90% of the community as a staple food (Sharma et al., 2021; Dhillon and Tanwar, 2018; Nguyen-Van-Hung et al., 2022; Subash et al., 2015. The increase in public consumption must be balanced with an increase in rice production, supported by production factors, such as the effective use of fertilizers. The irrational utilize of chemical fertilizers and pesticides ceaselessly can cause a heap of buildups that exceeds the environment's carrying capacity and causes soil fertility to decrease (Wang et al., 2022; Qian et al., 2018; Lim et al., 2016; An et al., 2015). As a result, it is unable to provide the expected results and even tends to *level off* the production (Nguyen-Van-Hung

et al., 2022; Abdullaev et al., 2007; Brye et al., 2004).

To expect these issues, it is essential to break through in development innovation utilizing more naturally neighborly strategies so ripeness conditions can be kept up (Rej et al., 2022). Efforts to reduce the use of chemical fertilizers and synthetic pesticides really need to be done in the direction of environmentally friendly, sustainable agriculture (De Ramon N'Yeurt and Iese, 2015).

Currently, many researchers are starting to focus on biological resources in increasing plant resistance through the role of beneficial soil microbes. The technology that is currently developing rapidly is the use of microorganisms (non-pathogenic saprophytic bacteria) explored from the plant rhizosphere and can stimulate plant growth (Le Roux et al., 2021; Wang et al., 2022; Zeng et al., 2017).

Rhizobacteria can colonize the rhizosphere aggressively, and several types of rhizobacteria are able to play dual roles as biological fertilizers and bioprotectants in plants (Muñoz et al., 2021; Hauchhum and Tripathi, 2020; Mayak et al., 1999). Microbes that are beneficial for plants are rhizobacteria from the *Pseudomonas* sp. group because they can fertilize the soil and as an inducer of plant resistance.

Graminae family plants are reported to have the ability to increase the population and activity of microbes in plant roots and also have the ability to be antagonistic bacteria against plant pathogens (Naramoto et al., 2020). Furthermore, bacteria from Graminae plants' roots can break down phosphate compounds, which is around 52.09% of the overall confines tried [20]. The capacity of microbes to break down phosphate compounds can be utilized to extend plant development and encourage the retention of phosphate components by plants (Sugita et al., 2018; Budnik et al., 2016; Chen et al., 2015).

Rhizobacteria from the *Bacillus* sp. and *P. seudomonas* sp. are able to dissolve phosphate. Meanwhile, the *Serratia* sp. group, apart from increasing the availability of P., can also fix nitrogen. *Bacillus* sp. isolate is also reported to be able to synthesize the growth hormone IAA. *P. fluorescens* isolate is able to produce IAA, gibberellins, and cytokinins (Sub et al., 2019). Similarly, *Serratia* sp. isolate is reported to be able to synthesize IAA. Rhizobacteria can be isolated from the rhizosphere of various types of plants, including cabbage, apples, and soybeans.

Several microorganisms that can progress plant and soil quality are Pantoea agglomerans GTA24, Aeromonas hydrophila KDTBA1, Paesturella multocida Mimo, Enterobacter gergoviae Pi8, and Enterobacter cloacae EG. Furthermore, these microscopic organisms are able to deliver acetoin (3-hydroxybutan-2-butanone) and the protein urease. Acetoin could be a unstable compound created by bacteria that capacities as a trigger within the handle of invigorating plant development. Meanwhile, according to, acetoin plays an vital part in invigorating the method of plant organogenesis (morphogenesis) so that the arrangement of plant organs is quicker, so plant development is quicker. Detailed that acetoin is able to extend the development of Arabidopsis thaliana plants. In expansion, acetoin can moreover initiate plant resistance and increment the arrangement of the number of branches, roots, and blossoms so that acetoin can increment plant efficiency.

The rhizobacteria used as plant growth promoters are rhizobacteria that can produce phytohormones such as the hormone indole acetic acid or IAA, Gibberellins, and ethylene. reported that synthesizing various phytohormones by rhizobacteria does not

function as a hormone for the bacterial cell itself, but there is a mutually beneficial relationship between the bacteria and the plant itself. Plants use hormones to support the growth process, while bacteria utilize metabolites resulting from carbon fixation by plants, such as root exudates. This is because root exudates contain the amino acid tryptophan, which can be converted to IAA by rhizobacteria (Bilal et al., 2018; Schürch, 2017). Cell elongation and enlargement is the mechanism of action in promoting growth and increasing plant yields (Bakhoum et al., 2019). Cell elongation mainly occurs in the area of the stem tip and root tip. Cell elongation at the tip of the stem causes the plant height and number of leaves to increase (Tsubota et al., 2014). Microbial exploration for various purposes, especially in agriculture, has been widely developed, not only microbes in the rhizosphere but also microbes in plants (endophytes), which have the potential as growth promoters to increase plant growth.

Endophytic bacteria such as *Azospirillum, Enterobacter cloacae, Alcaligenes, Acetobacter diazotrophicus, Herbaspirillum seropedicae, Ideonella dechlorantans*, and *Azoarcus* sp. have been shown to increase N-fixation in rice plants. Endophytic bacteria found in the roots and stems of sugarcane plants produce the growth-promoting hormone IAA (Indole Acetic Acid), and the population of endophytic bacteria is found to be higher in the roots. Isolates obtained from the genera *Burkholderia, Pantoea, Pseudomonas,* and *Microbacterium* (Mehrasa et al., 2022; Wang et al., 2022; Lòpez-fernàndez and Compant, 2016)**.**

2. Problem Formulation

This in vitro consider was conducted at the Biopesticide Research facility, Workforce of Horticulture, Udayana College. This think about was carried out within the exploratory cultivate of the Staff of Agribusiness, Udayana College, Denpasar. The recognizable proof of acetoin compounds by Gas Chromatography-Mass Spectroscopy (GC-MS) was carried out at the Bali Police Measurable Research facility. The distinguishing proof of rhizobacteria segregates by analyzing the 16S rRNA quality was conducted at the Virology Research facility, Division of Plant Assurance, Bogor Agrarian College, whereas the Filtering Electron Magnifying lens (SEM) investigation was carried out at the LPPT Research facility of Gadjah Mada College, Yogyakarta.

The apparatuses utilized in this ponder were Petri dishes, Erlenmeyer jars, test tubes, becker glasses, measuring mugs, micropipettes, magnifying lens slides, mixing spoons, gas stoves, computerized scales, computerized cameras, magnifying lens laminar stream cabinet aluminum thwart, cotton, cover, millimeter piece paper, sticker paper, autoclave, and stationery. The materials utilized in this consider were rice seeds, rhizobacteria separate confined from the Gramineae plant rhizosphere, 70% clean liquor, Supplement Agar (NA), Nystatin, molasses, agar, potato, Benomyl 10 g, compares, NPK fertilizer, potato peptone glucose agar (PPGA), polybags and compost.

The inspecting was carried out from the rhizosphere of four sorts of plants having a place to the Graminae family that developed in Merauke Locale, Merauke Regency, Papua Province, to be specific rice (Oryza sativa L.), reeds (Imperata round and hollow L. Brauv), elephant grass (Pennisetum purpureum), and bamboo (Schizostachum mosum). This think about focused on 4 segregates of rhizobacteria that were distinguished to be tried to fortify the development of rice plants. The rice assortment utilized was the Ciherang assortment, which was regularly developed by the rancher community in Merauke Regency.

The experimental design used was a Randomized Block Design (RBD), consisting of 4 replications. Each replication consisted of 6 treatments, namely 4 rhizobacteria isolates and 2 treatments for comparison. The four rhizobacteria isolates were Rg21, Pd13, Pd7, and Bb7. While the 2 treatments as a comparison were pure Acetoin (AM) and control. Each treatment was repeated 10 times so that the total repetition was 240 rice plant pots. The size of the pot used was a surface with a diameter of 30 cm and was filled with growing media in the form of a top layer of paddy soil (taken to a depth of 20 cm from the soil surface) and compost.

The treatment of rhizobacteria was carried out by seed treatment, namely soaking the germinated rice seeds with rhizobacteria suspension for 2 hours before sowing on the nursery tray. Nursery soil on trays was also treated with 10 ml of rhizobacterial suspension per tray (tray size 40 cm x 30 cm). The bacterial density was 108 CFU/ml. The rhizobacterial formulation treatment used for each isolate was Pd13 (240 ml), Bb7 (160 ml), Pd7 (240 ml), and Rg21 (80 ml). This treatment was based on the wet weight of the soil per pot, which was 8,000 gr (8kg).

The parameters observed in this study included growth parameters and yield components, namely:

2.1. Growth Parameters

1. Leaf Area and Leaf Number

Leaf area (cm) and leaf number (strands) were measured when the plant was 60 days after planting. The leaf area measurement used the method of measuring leaf length times leaf width (Pearce et al., 1988).

2. Plant height

The measurement of plant height was carried out since the plant was 2 MST, and further measurements were carried out every two weeks until the plant was pregnant.

3. Number of tillers per clump

The number of tillers per clump was counted from the age of 2 WAP and then counted every 2 weeks until the plants entered the maximum tillering phase.

4. Number of productive tillers per clump

The number of productive tillers per clump was counted at harvest.

2.2. Observation of plant yield components

1. Panicle Length

Panicle length was measured from the final book to the grain at the conclusion of the panicle. The perception is made after the conclusion of the consider by measuring the length of the panicle on each plant in polybags.

2. Number of pithy grain per panicle (seed)

The number of filled grains per panicle was done by calculating the number of pointed grains per panicle at gather time.

3. Percentage of filled and empty grain

The percentage of pithy grain and empty grain per plant was calculated after the end of the study, which was to separate the filled grain by immersion. The sinking grain was included in the filled grain category, and the floating grain was classified as an empty grain. To discover the rate of filled or purge grain, the weight of filled or purge grain was separated by the whole weight of unhulled rice increased by 100%.

4. Bacterial infection of rice plants was analyzed using the Scanning Electron Microscope (SEM) method.

2.3. Data Analysis

All data obtained in this study were analyzed quantitatively using the analysis of variance (ANOVA) and the F test. If F showed

a significant effect, then to compare the average value between treatments, Duncan's Multiple Range test was used at the 5% level.

3. Problem Solution

The test results of the effectiveness of rhizobacteria formula in increasing the growth and yield of rice plants in the greenhouse showed that the treatment of 4 rhizobacteria significantly ($P<0.05$) increased the relative growth rate (LPR), net assimilation rate (LAB), leaf area, base weight, and stover dry weight, root base weight and root dry weight, plant height, number of tillers, leaf chlorophyll, root dry weight, stover weight, number of productive tillers, panicle length, number of pithy grain, percentage of filled and empty grain, weight of 1000 seeds, grain yield per plant, amylose content and macronutrient content.

Table 1. The effect of rhizobacteria on average leaf area, average leaf chlorophyll content at 60 DAP, average leaf number per plant, average leaf base weight per plant and average leaf dry weight per plant at age 60 HST

Treatment	Leaf area	Leaf number (strands)
Control	84,72 e*	7,00 a
Rg21	101,22 d (19,47%)**	8,00 a (14,28%)
Pd13	108,30 b (27,83%)	8,01 a (14,42%)
Pd7	106,02 c (25,14%)	8,60 a (22,85%)
Bb7	109,80 a (29,60%)	8,02 a (14,57%)
Am	106,40 c (25,59%)	8,01 a (14,42%)

The rhizobacteria treatment increased the plant's leaf area from 19.47% to 29.60% compared to the control. M.odoratimimus Bb7 treatment increased leaf area by 29.60%, M.odoratimimus Pd13 treatment increased leaf area by 27.83%, Am treatment increased leaf area by 25.59%, S. marcescens Pd7 treatment increased leaf area by 25, 14%, and P. vermicola Rg21 treatment increased leaf area by 19.14% when compared to the control.

The rhizobacteria treatment formula increased the number of plant leaves ranging from 14.42% to 22.85%. The S. marcescens Pd7 treatment increased the number of leaves by 22.85%, the M.odoratimimus Bb7 treatment increased the number of leaves by 14.57%, M.odoratimimus Pd13 treatment increased the number of leaves by 14.42%, AM treatment increased the number of leaves by 14.42% and P. vermicola Rg21 treatment was 14.28 when compared to the control.

The rhizobacteria treatment increased the leaf base weight from 44.03% to 63.87%. *S. marcescens* Pd7 treatment increased leaf base weight by 63.87%, *M.odoratimimus* Bb7 treatment increased leaf base weight by 58.06%, *P. vermicola* Rg21 treatment increased leaf base weight by 50.00%, *M.odoratimimus* Pd13 treatment increased leaf base weight was 46.77%, and Am increased leaf base weight by 44.03% when compared to the control.

The rhizobacteria formula treatment increased the dry weight of the plants ranging from 44.11% to 68.52%. *S. marcescens* treatment Pd7 increased plant dry weight by 68.52%, *M.odoratimimus* Bb7 treatment increased plant dry weight by 66.47%, *M.odoratimimus* Pd13 treatment increased plant dry weight by 50.88%, *P. vermicola* Rg21 treatment increased plant dry weight by 50.00% and Am increased plant dry weight by 44.11% when compared to the control.

The rhizobacterial formula treatment could increase plant height growth ranging from 6.20% to 19.30% in rice plants aged 2 WAP compared to controls (Table 2). The treatment of *P vermicola* .Rg21, synthetic auxin Am, *M. odoratimimus* Pd13, *S. marcescens* Pd7, and *M. odoratimimus* Bb7, increase plant height growth by 19.30%, 13.47%, 10.44%, 6.92%, and 6.20% respectively compared to control. At the age of 4 MST, rhizobacteria increased plant height growth ranging from 2.73 to 29.68% compared to the control, but *M. odoratimimus* Pd13 and *M. odoratimimus* Bb7 treatments did not increase plant height at 4 MST. The treatment of *S. marcescens* Pd7, synthetic auxin Am and P vermicola Rg21 increased plant height by 29.68%, 5.63%, and 2.73%, respectively, compared to the control. At the age of 6 WAT 4, rhizobacteria increased plant growth from 10.61% to 20.96% compared to control. The treatment of *M. odoratimimus* Bb7, *P vermicola* Rg21, *S. marcescens* Pd7, synthetic auxin Am and *M. odoratimimus* Pd13 increased plant height growth by 20.96%, 16.22%, 15.98, 11.26% and 10.61% when compared to controls. At the age of 8 WAT 4, rhizobacteria could increase plant height ranging from 3.80% to 4.89%, but at this age, each treatment did not experience a significant increase in plant height compared to the control. The Pd7, Rg21, Pd113, Bb7, and Am treatments were respectively 4.89%, 4.74%, 4.74%, 4.00%, and 3.80% when compared to the control.

Table 2. The effect of rhizobacteria on the average increase in height of rice plants at various ages (cm)

Treatment	Plant height at age			
	2 MST	**4 MST**	**6 MST**	**8 MST**
Control	46,61 c*	56,77 b	75,02 b	98,92 a
Rg21	55,61 a (19,30%)**	58,32 ab (2,73%)	87,19 ab (16,22%)	103,61 a (4,74%)
Pd 13	51,48 ab (10,44%)	55,55 b (-)	82,98 ab (10,61%)	103,62 a (4,75%)
Pd7	49,84 bc (6,92%)	73,62 a (29,68%)	87,01 ab (15,98%)	103,76 a (4,89%)
Bb7	49,50 bc (6,20%)	56,85 b (-)	90,75 a (20,96%)	102,88 a (4.00%)
Am	52,89 ab, (13,47%)	59,97 ab (5,63%)	83,47 ab (11,26%)	102,68 a (3,80%)

Figure 1. Developmental performance of treated rice plants; A. Rg21 treatment, B. Pd13 treatment, C. Pd7 treatment, D. Bb7 treatment, and E. Pure acetoin treatment and F. Control treatment

The rhizobacterial formula treatment could increase the growth of the number of tillers ranging from 22.18% to 68.79% in rice plants aged 2 WAP compared to the control (Table 3). The synthetic Acetoin (Am) treatment increased the number of tillers by 68.79%, *P. vermicola* Rg21 treatment increased the number of tillers by 59.77%, *M. odoratimimus* Pd13 treatment increased the number of tillers by 40.97%), *S. marcescens* Pd7 treatment increased the number of tillers by 25.97%, and *M. odoratimimus* Bb7 treatment increased the growth of the number of tillers by 22.79% when compared to the control.

Table 3. The effect of rhizobacteria on the average increase in the number of tillers of rice plants at various ages

Treatment	Number of tillers at various ages			
	2 MST	**4 MST**	**6 MST**	**8 MST**
Control	2,66 b	9,50 b	16,33 b	29,24 b
Rg21	4,25 a (59,77%)	15,30 a (61,05%)	24,08a (47,45%)	43,49 a (48,73%)
Pd 13	3,75 ab (40,97%)	13,08 ab (37,68%)	24,66a (51,01%)	41,58 a (42,20%)
Pd7	3,33 ab (25,18%)	13,16ab (38,52%)	27,66a (69,38%)	40,91 a (39,91%)
Bb7	3,25 ab (22,18%)	13,90 ab (46,31%)	26,91a (64,78%)	37,66 ab (29,79%)
Am	4,49 a (68,79%)	16,08 a (69,26%)	25,49a (56,09%)	41,08 a (40,49%)

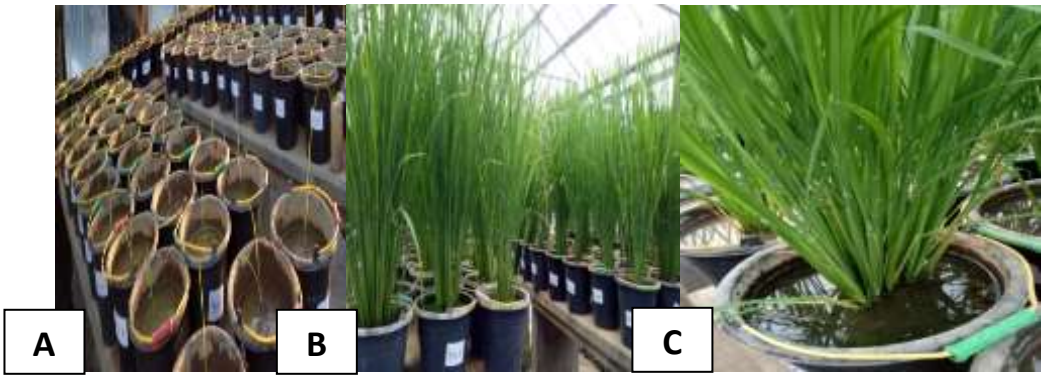

Figure 2. Plant performance at 0 weeks (A) and number of tillers at 6 WAP (B, C)

The rhizobacterial formula treatment increased the growth of tillers at the age of 4 MST ranging from 69.26% to 37.68% compared to the control. The Synthetic Acetoin (Am) treatment increased tiller growth by 69.26%, *P. vermicola* Rg21 treatment increased tiller growth by 61.05%, *M. odoratimimus* Bb7 treatment increased tiller growth by 46.31%, *S. marcescens* Pd7 treatment increased the number of tillers by 38.52%, and *M. odoratimimus* Pd13 treatment increased the growth of tillers by 37.68% when compared to the control.

The rhizobacterial formula treatment increased the growth of tillers ranging from 69.38% to 47.45% at the age of 6 WAT. *S. marcescens* Pd7 treatment increased tiller growth by 69.38%, *M. odoratimimus* Bb7 treatment increased tiller growth by 64.78%, synthetic Acetoin (Am) treatment increased tiller growth by 56.09%, *M. odoratimimus* Pd13 treatment increased tiller growth by 51.01% and *P. vermicola* Rg21 treatment increased the growth of tillers by 47.45% when compared to the control.

At the age of 8 MST, the rhizobacterial formula treatment experienced an increase in the growth of tillers ranging from 48.73% to 29.79%. *P. vermicola* Rg21 treatment increased tiller growth by 48.73%, *M. odoratimimus* Pd13 treatment increased tiller growth by 42.20%, Synthetic Acetoin (Am) treatment increased tiller growth by 40.49%, *S. marcescens* Pd7 treatment increased tiller growth by 39.91%, and *M. odoratimimus* Bb7 treatment increased the growth of tillers by 29.79% when compared to the control.

The table above shows that at the age of 30 DAP, the rhizobacterial formula treatment increased the leaf chlorophyll content from 10.07% to 2.21% compared to the control. The *M. odoratimimus* Bb7 treatment increased the chlorophyll content by 10.07%, *S. marcescens* Pd7 treatment increased the chlorophyll content by 6.15%, *M. odoratimimus* Pd13 treatment increased the chlorophyll content by 5.92%, the synthetic Acetoin (Am) treatment increased the chlorophyll content by 4.79%, and *P. vermicola* Rg21 treatment increased the chlorophyll content by 2.21% when compared to the control.

The rhizobacterial formula treatment increased the base weight of the stems from 72.15% to 14.45%. *M. odoratimimus* Bb7 treatment increased the wet weight of stems by 72.15%, *P. vermicola* Rg21 treatment increased the wet weight of the stems by 53.36%, *M. odoratimimus* Pd13 treatment increased the wet weight of the stems by 46.00%, *S. marcescens* Pd7 treatment increased wet stem weight by 41.10%, and synthetic Acetoin (Am) treatment increased

wet stem weight by 14.45% when compared to control.

The rhizobacterial formula treatment increased the dry weight of the stover between 69.96% to 17.95%. *S. marcescens* Pd7 treatment increased the dry weight of the stover by 69.96%, *P. vermicola* Rg21 treatment increased the dry weight of the stover by 56.80%, *M. odoratimimus* Bb7 treatment increased the dry weight of the stover by 53.92%, *M. odoratimimus* Pd13 treatment increased the dry weight of the stover was 40.19%, and the synthetic Acetoin (Am) treatment increased the dry weight of the stem by 17.95% when compared to the control.

The rhizobacteria formula treatment increased the wet weight of the roots ranging from 89.97% to 3.54%. *M. odoratimimus* Bb7 treatment increased the wet weight of the roots by 89.97%, *M. odoratimimus* Pd13 treatment increased the wet weight of the roots by 80.58%, *P. vermicola* Rg21 treatment increased the wet weight of the roots by 69.42%, *S. marcescens* Pd7 treatment increased root wet weight by 35.19%, and synthetic Acetoin (Am) treatment increased root wet weight by 3.54% when compared to control.

The rhizobacteria formula treatment increased the dry weight of the roots ranging from 72.19% to 12.98%. *S. marcescens* Pd7 treatment increased root dry weight by 72.19%, *M. odoratimimus* Bb7 treatment increased root dry weight by 49.09%, synthetic Acetoin (Am) treatment increased root dry weight by 17.75%, *P. vermicola* Rg21 treatment increased root dry weight by 12.98%, *M. odoratimimus* Pd13 treatment increased root dry weight by 8.96%, compared to control. Chatterjee et al. (2011) reported that the consortium treatment between *Bacillus Firmus* KUCr1 and *Cellulosimicrobium cellulans* KUCr3 bacteria in spinach plants increased root dry weight by 77.54% when compared to control. This increase was higher when compared to treatment without a consortium, where the increase in root dry weight in the *B. Firmus* KUCr1 treatment was 37.78%, and *C. cellulans* KUCr3 treatment was 56.68% when compared to the control.

Table 4. The effect of rhizobacteria formula on the average wet weight of stover (stem), dry weight of stover, wet weight of roots and dry weight of roots per plant clump

Treatment	Wet stove weight (g)	Dry stove weight (g)	Root wet weight (g)	Root dry weight (g)
Control	326,25 f	56,10	101,67 f	55,20 d
Rg21	500,35 b	87,97 b	172,25 c	62,37 c
	(53,36%)	(56,80%)	(69,42%)	(12,98%)
Pd13	476,35 c	78,65 c	183,60 b	60,15 cd
	(46,00%)	(40,19%)	(80,58%)	(8,96%)
Pd7	460,37 c	95,35 a	137,45 d	95,05 a
	(41,10%)	(69,96%)	(35,19%)	(72,19%)
Bb7	561,65 a	86,35 b	193,15 a	82,30 b
	(72,15%)	(53,92%)	(89,97%)	(49,09%)
Am	373,42 e	66,17 d	105,27 e	65,00 c
	(14,45%)	(17,95%)	(3,54%)	(17,75%)

Figure 3. Root performance of rice plants treated with rhizobacteria formula; A. Control treatment, B. Rg21 treatment, C. Pd13 treatment, D. Pd7 treatment, E. Bb7 treatment and F. AM treatment

The rhizobacteria formula treatment increased the number of productive tillers ranging from 34.90% to 28.80%. The synthetic acetoin (Am) treatment increased the number of productive tillers by 34.90%, *M. odoratimimus* Bb7 treatment increased the number of productive tillers by 31.32%, *M. odoratimimus* Pd13 treatment increased the number of productive tillers by 30.79%, %, *S. marcescens* treatment Pd7 increased the number of tillers by 28.84%, and *P. vermicola* treatment Rg21 increased the number of productive tillers by 28.80% when compared to the control. Wuriesyliane et al. (2013) reported that the treatment of *Azospirillum* bacteria and endophytic bacteria grown with a density of 108 cells ml-1 resulted in the highest number of productive tillers by 10.82% when compared to the control. A study conducted by Syaiful et al. (2012) reported that the application of biological fertilizers containing *Azotobacter* combined with N-fertilizer had a very significant effect on the number of productive tillers compared to controls.

Table 5. The effect of rhizobacteria on the number of productive tillers, panicle length, number of pithy grain per panicle, 1000 seed weight, filled grain, empty grain, and grain weight per plant

Treatment	Productive tillers (clump)	Panicle length(cm)	Rice grain per panicle (seed)	Grain content (%)	Empty grain (%)
Control	24,58	23,68 b	89,61	71,07 a	28,91 a
Rg21	31,66 ab	27,63 a	97,06 ab	79,49 a	18,91 a
Pd13	(28,80%)	(16,68%)	(8,31%)	(11,84%)	(1,79%)
Pd7	32,15 a	26,89 a	97,02 ab	78,45 a	21,55 ab
Bb7	(30,79%)	(13,55%)	(8,29%)	(10,31%)	(25,45%)
Am	31,67 ab	25,87 ab	104,65 a	78,40 a	21,60 ab
	(28,84%)	(9,24%)	(16,78%)	(10,31%)	(25,28%)
	31,32 ab	27,08 a	98,44 ab	79,80 a	20,19 ab
	(27,42%)	(14,35%)	(9,85%)	(12,28%)	(30,16%)
	33,16 a	26,87 a	96,94 ab	76,94 a	23,05 ab
	(34,90%)	(13,47%)	(8,17%)	(8,25%)	(20,26%)

The rhizobacteria formula treatment increased the panicle length of rice ranging from 16.78% to 8.17%. *S. marcescens* Pd7 treatment increased the rice panicle length by 16.78%, *P. vermicola* Rg21 treatment

increased the rice panicle length by 16.68%, *M. odoratimimus* Bb7 treatment increased the rice panicle length by 9.85%, *M. odoratimimus* Pd13 increased the rice panicle length by 8.29% and Am increased the length of rice panicle by 8.17% when compared to the control.

The rhizobacteria formula treatment increased the pithy grain per panicle ranging from 16.78% to 8.17*%. S. marcescens* Pd7 treatment increased the pithy grain per panicle by 16.78%. *M. odoratimimus* Bb7 treatment increased pithy grain per panicle by 9.85%, *P. vermicola* Rg21 treatment increased rice grain per panicle by 8.31%, *M. odoratimimus* Pd13 increased rice grain per panicle by 8.29% and AM increased the pithy grain per panicle 8.17% when compared to the control.

The rhizobacteria formula treatment increased the percentage of weight of 1000 seeds ranging from 1.13% to 8.17%. The Am treatment increased the weight of 1000 seeds by 8.17%, *P. vermicola* Rg21 treatment increased the weight of 1000 seeds by 4.19%, *M. odoratimimus* Pd13 increased the weight of 1000 seeds by 2.36%, *S. marcescens* Pd7 treatment increased the weight of 1000 seeds by 2.36%, *M. odoratimimus* Bb7 treatment increased the weight of 1000 seeds by 1.13% when compared to the control.

The rhizobacteria formula treatment increased the percentage of grain content ranging from 8.25% to 12.78%. *M. odoratimimus* Bb7 treatment increased the grain content by 12.78%, *P. vermicola* Rg21 treatment increased the grain content by 11.84%, *M. odoratimimus* Pd13 treatment increased the grain content by 10.31%, *S. marcescens* Pd7 treatment increased the grain content by 10.31%, the Am treatment increased the grain content by 8.25% when compared to the control.

The rhizobacteria formula treatment could reduce the percentage of empty grain ranging from 1.79% to 30.16%. *M. odoratimimus* Bb7 treatment was able to reduce the empty grain by 30.16%, *M. odoratimimus* Pd13 treatment was able to reduce the empty grain by 25.45%, *S. marcescens* Pd7 treatment was able to reduce the empty grain by 25.28%, the AM treatment was able to reduce the empty grain vacuum by 20.26%, and *P. vermicola* Rg21 treatment was able to reduce the empty grain by 1.79% when compared to the control.

The rhizobacteria formula treatment could increase grain weight per plant from 28.55% to 52.53%. *P. vermicola* Rg21 treatment increased grain weight per plant by 52.53%, *S. marcescens* Pd7 treatment increased grain weight per plant by 48.90%, *M. odoratimimus* Bb7 treatment increased grain weight per plant by 45.34%, *M. odoratimimus* Pd13 treatment increased grain weight per plant by 42.89% and AM treatment increased grain weight per plant by 28.55% when compared to control.

The Observation of Rhizobacteria Colonization on Rice Plant Roots using Scanning Electron Microscope (SEM)

The results of observations of rice roots using SEM showed that the rhizobacteria formula in the *P.vermicola* Rg21 treatment, *M.odoratimimus* Pd13 treatment, *S.marcescens* Pd7 treatment, and M.*odoratimimus* Bb7 treatment appeared to colonize in the form of biofilms on the roots of rice plants. The observations of rhizobacteria colonization in roots using SEM have been reported by several researchers, such as the results of the study reported by Kim and Kremer (2005) that the bacteria *Bradyrhizobium japonicum* GD3, *Pseudomonas putida* GD4, and *Bacillus megaterium* GP4 are seen to colonize and associate in the roots of *Ipomoea* spp. after being observed with SEM

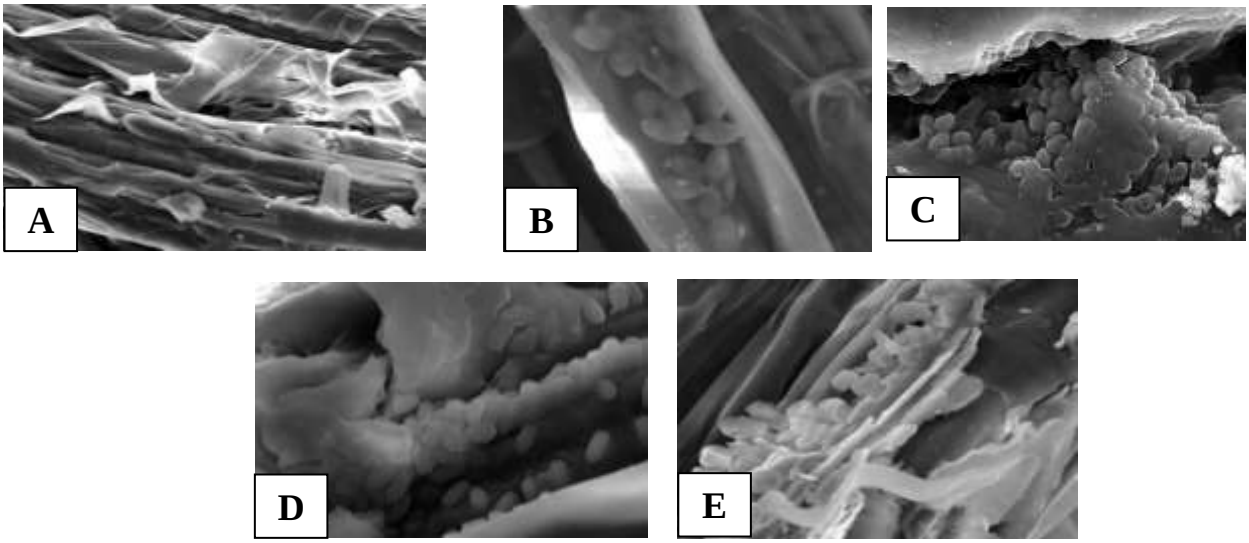

Figure 4. The results of rhizobacterial colonization observations

The results of the study of rhizobacteria work effectiveness test on the growth of rice plants significantly increased the development of rice tillers compared to the control. This proved that the mechanism of action of rhizobacteria was very effective, especially in rhizobacteria that produced acetoin compounds that were able to interact with plant roots. This was evident in the treatment of 4 rhizobacteria tested in the field; the number of tillers expanded by an normal of 40.15% when compared to the control, while the pure Acetoin treatment as a comparison also increased the number of tillers by 40.49% when compared to the control.

4. Conclusion

The mechanism of action of rhizobacterial formula in increasing rice yields is the presence of acetoin compounds and derivatives of acetoin such as 2-Butanone, 3-hydroxy, 2,3-butanediol, diacetate, 2,3-Butanediol (CAS), 2-Butanone, 3-acetyloxy, 1,4-Dioxane produced by rhizobacteria in the rhizosphere and helps plants achieve acetoin homeostatic conditions. Thus, plants can increase plant height, number of leaves, leaf area, number of tillers, panicle length, percentage of filled grain, and empty grain. The treatment of Merauke local rhizobacteria formula carried out in a greenhouse with a concentration of 2% is effective in promoting growth and increasing rice yields by adding the weight per plant by 52.83% when compared to the control.

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Conflicts of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.