Universal Journal of Agricultural Research 12(2): 321-331, 2024 http://www.hrpub.org
DOI: 10.13189/ujar.2024.120211

# Growth and Yield of Some Wetland Rice Varieties Treated with Microbial Consortium under Washed Saline Soil Conditions

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*Received December 6, 2023; Revised March 6, 2024; Accepted March 25, 2024*

***Cite This Paper in the Following Citation Styles***

***(a):*** *[1] Ubad Badrudin, Munif Ghulamahdi, Bambang S. Purwoko, Etty Pratiwi , "Growth and Yield of Some Wetland Rice Varieties Treated with Microbial Consortium under Washed Saline Soil Conditions," Universal Journal of Agricultural Research, Vol. 12, No. 2, pp. 321 - 331, 2024. DOI: 10.13189/ujar.2024.120211.*

***(b):*** *Ubad Badrudin, Munif Ghulamahdi, Bambang S. Purwoko, Etty Pratiwi (2024). Growth and Yield of Some Wetland Rice Varieties Treated with Microbial Consortium under Washed Saline Soil Conditions. Universal Journal of Agricultural Research, 12(2), 321 - 331. DOI: 10.13189/ujar.2024.120211.*



**Abstract** Saline land is suboptimal land with a high electrical conductivity that can inhibit the growth and production of rice plants. The objectives of the study were to determine 1) changes in the electrical conductivity value of saline soil before and after washing and 2) the growth and yield of rice plants grown on washed saline soil media with the application of microbial consortium and their interactions. The study used a Randomized complete block design with two factors and three replications. The first factor was a microbial consortium consisting of four microbial consortiums, and the second factor was rice variety consisting of three varieties e.i. Pokalli, Biosalin 2 Agritan and IR29. Result showed that washing saline soil with fresh water decreased electrical conductivity from 17 dS $m^{-1}$ to 2.18 dS $m^{-1}$. The Pokkali variety had the highest plant, height biomass components, but the IR29 had the highest number of productive tillers. Microbial consortium B gave the best effect on the variable of the number of empty grains per clump, percentage of open grains, and dry weight of grain per clump. There was no interaction between growth components, plant biomass, and N, P, K, and Na levels. The pokkali variety contains low levels of K and Na in the roots, but high in the shoot, while the IR29 variety has high levels of K and Na in the roots, but low in the shoot. The best results in the variable number of filled grains per clump and grain dry weight per clump were shown by the microbial consortium C treatment and the Biosalin 2 Agritan variety.

**Keywords** Rice, Saline, Microbial Consortium, Conductivity

## 1. Introduction

Rice is a commodity that contains nutrients needed by humans [1], has high economic value, and is consumed as the staple food of most of the world's population [2]. Along with the increasing population growth in Indonesia, the need for rice is increasing [3]. Research reported that the demand for rice in Asia will increase by 70% over the next 30 years because of increasing population growth. Still, the availability of paddy fields is decreasing due to conversion for other purposes, which causes food production to fall [5]. Indonesia's population in 2022 reached 275 million with an annual population growth rate of 1.17% [6], and rice consumption in 2025 predicted will be 130.39 kg per capita per year, so the total rice demand was around 36.5 million tons [7]. Therefore, rice production must consistently be increased to meet the needs of the community.

Increasing rice productivity can be done by intensification, including through the use of superior varieties [8]. The development of excellent types will provide good results because they have the characteristics of being able to adapt to the environment in which they grow [9] and make maximum use of inputs, as well as a shorter lifespan [10]. Another effort that can be maximized is extensification, namely by utilizing marginal land. Such conditions must be developed because many productive rice fields in Indonesia have been converted for other purposes outside of agriculture, namely for transportation facilities, settlements and housing [11], industrial areas, airports, and other public interests [12]. According to [13], wetland conversion occurs for extensive deforestation uses such as peat swamp forests. The transformation of productive paddy fields reached 96,512 $ha.th^{-1}$, so it is projected that paddy fields in 2045 will cover 5.1 million ha, which is a reduction from the current condition of around 8.1 million ha [14] so that the growth of paddy fields in Indonesia has experienced adverse developments [15].

One of the marginal lands that can be utilized is saline land. This land has high potential because, in Indonesia, the area reaches 12.02 million ha [16]. This area provides an opportunity for rice cultivation in order to increase rice productivity. However, the land can inhibit and disrupt plant growth and production [17]. Saline land causes an increase in soil osmotic pressure and causes low soil osmotic potential, an imbalance in the availability of nutrients needed by plants, and toxicity to plants [4]. Research reported that high saline soil causes a decrease in germination percentage, plant height, number of tillers, yield and yield components, and an increase in the rate of empty grain [18]. Biomass and yield are negatively affected by increasing soil salinity. Research results reported that NaCl levels up to 75 mM significantly affected leaf damage, strawweight, grain weight, root weight, and the number of tillers, the availability of K, Ca, Mg, $NH_{4+}$ elements, so that nutrient availability was insufficient [19, 20]. To improve the condition of saline land can be done by washing using fresh water.

Washing with fresh water can reduce the level of salinity and electrical conductivity of the soil [21]. Washing with fresh water can reduce salt concentration in saline soils [22,23,24]. The process of reduction in NaCl levels depends on the volume of water used for leaching [25]. Explained that leaching has a significant influence in controlling both salinity and soil electrical conductivity [26]. Soil salinity and electrical conductivity conditions that can be controlled support plant growth and production increases [27].

An alternative solution to negate the adverse effects of saline land is the use of superior varieties that are tolerant and adaptive. The use of saline soil is very necessary as a way to manage land that has low salinity content [28]. These superior varieties are able to adapt and adjust well to the stressful growing environment conditions. The mechanism of plant adjustment to sub-optimal environments is carried out by producing phytohormones, including ABA, jasmonic acid (JA), gibberellin (GA), Brassinosteroids (BRs), and ethylene. ABA activates SnRK2 to regulate stomatal closure, osmotic homeostasis, and gene expression [28]. JA is required to inhibit root growth as a strategy to survive in saline conditions [29].

Technological innovations can be developed to reduce the problems of saline land by applying microbes. Microorganisms play a positive role in overcoming these conditions by increasing the availability and absorption of nutrients K, Ca, Fe, and Zn by the roots and distributing them to the leaves as well as increasing the number and biomass of roots, efficiency in water use, producing synergistic metabolites and improving osmoregulation [30], synthesis of antioxidant enzymes [31]. The use of microorganisms as biological fertilizers can improve environmental conditions, sustainable crop production and reduce the use of inorganic fertilizers [32]. Types of microorganisms that have the potential to be applied are halophilic bacteria [33] such as *Streptomyces*, *Azospirillum*, *Clostridium*, *Alcaligenes*, *Bacillus*, *Rhizobium*, *Pseudomonas* [34,35], *Thiobacillus*, *Serratia* and *Klebsiella* [34], *Azotobacter* [35].

The purpose of this study was to determine 1) changes in the electrical conductivity value of saline soil before and after washing and 2) the growth and yield of rice plants grown on washed saline soil media with the application of microbial consortium and their interactions.

## 2. Materials and Methods

The research was conducted in an uncontrolled plastic house of the Faculty of Agriculture, Pekalongan University, Pekalongan City Indonesia, from November 2022 to February 2023 at an altitude of 4 meters above sea level with ordinate Lat -6.895074°, Long 109.662577°.

This was a 3x4 factorial experiment with three levels of the variety factor and four levels of the microbial consortium factor. The variety factor consisted of Pokkali (V1), Biosalin 2 Agritan (V2) and IR29 (V3). The microbial consortium factor consisted of no microbial application (M0), microbial consortium A application (M1), microbial consortium B application (M2), and microbial consortium C application (M3). The applied microbial consortiums were listed in Table 1. All the strains were isolated from saline soil in the Slamaran Village, Pekalongan City, Central Java, Indonesia. All the strains selected from 78 strains were isolated. There were three replications. Experimental units were arranged in a randomized block design.

The soil used for growing rice plants was saline soil taken from stagnant sea water flooded saline land. It was air dried, grounded, and sieved using a10-20 mesh sieve. Then it was put into 20 cm diameter and 50 cm high plastic buckets. Each bucket was filled with 8 kg of sieved saline soil.

Washing the saline soil in the buckets was carried out as follows: 8 liters of fresh water was added to the fine saline soil in the bucket, it was stirred evenly by hand then it was left soaking the soil for 24 hours. After 24 hours, the EC of standing water was measured using an EC meter, and the result was recorded. Then the standing water was removed. Then 3 liters of new fresh water was added and was stirred again manually and evenly, then it was left soaking the soil for 24 hours. The next day, the EC of standing water was measured using an EC meter, and the result was recorded. The step was repeated for 14 days.

After washing for 15 days, a soil sample for washed saline soil was taken from all buckets of the washed saline soil and homogenized. Then it was air dried, ground, and sieved. The samples of unwashed soil and washed soil were sent to Soil and Fertilizer Instruments Standardization Testing Agency, Bogor, Indonesia for soil analysis.

**Table 1.** Microbial consortium applied

| Microbial consortium | Bacterial community | Strain |
|---|---|---|
| A (M1) | Endofit | *Stenotrophomonas maltophilia* |
| | | *B. aryabhattai* |
| | Rhizosfer | *Bacillus marisflavi* |
| | | *Bacillus aerius* |
| B (M2) | Endofit | *Stenotrophomonas maltophilia* |
| | | *B. aryabhattai* |
| | Rhizosfer | *Bacillus aerius* |
| | | *Bacillus firmus* |
| C (M3) | Endofit | *B. aryabhattai* |
| | | *B. flexus MPVK* |
| | Rhizosfer | *Bacillus marisflavi* |
| | | *Bacillus firmus* |

Rice seeds were surface sterilized by soaking the seeds in 0.5% NaOCl for 6 minutes, then the NaOCl was removed and the seeds were washed with sterilized water three times. The surface sterilized seeds were sown on the surface of paper in a tray at room temperature for 2 days. The germinated seeds with approximately radicle grown 0.2 cm long were immersed in the microbial consortium according to the treatment for 1 hour. The treated seeds were sown on non saline nursery beds. The size of each nursery bed was 1 m x 1 m. The nursery bed was prepared 1 week before sowing. 2 kg of chicken manure was applied per plot 1 day before sowing.

One day before transplanting, 8 g of chicken manure was applied per pot. Transplanting of the seedlings was carried out 30 days after sowing. Seedlings were transferred to the prepared planting media 3 seedlings per pot. 1 g urea, 0.4 g SP36, 0.4 g KCl, and 5 liters of 100 times dilution of the microbial consortium were applied three days after transplanting. The planting medium was inundated with fresh water to a height of $\underline{+}2$ cm for 7 days after planting. Then flooded with fresh water to a height of $\underline{+}10$ cm until harvest. If the inundation decreased, then additional fresh water was added to a level of $\underline{+}10$ cm. Rice was harvested when 90-95 % of the grain turned yellow.

Observed variables were plant height and number of productive tillers, panicle length, number of filled grains per clump, number of empty grains per clump, percentage of empty grains, wet weight of grain per clump, dry weight of grain per clump, root length, root wet weight, root dry weight, shoot wet weight, shoot dry weight, N, P, K, Na contained in roots and shoot.

ANOVA of the observed data was carried out using DSAASTAT version 1.514 programe. If the F test indicated that there was a significant effect of the treatments, the Tukey's test at a 5% significance level was carried out for multiple means comparison.

# 3. Results and Discussion

### 3.1. Soil Test Results

Table 2 showed the data of unwashed and washed saline soil. The soil texture did not change by washing. It was classified as clay soil; soil pH also did not change by washing; the EC of unwashed saline soil was 17 dS $m^{-1}$. The soil EC value of 17 dS $m^{-1}$ was far above the soil EC value of 4 dS $m^{-1}$ which was classified as saline soil. Very high soil EC value resulted in no tested rice varieties, including the pokkali variety that was classified as saline tolerant rice cultivar, could grow and all varieties died on this soil. By washing the soil 15 times with fresh water, the EC reduced to 2.18 dS $m^{-1}$ which resulted in all tested varieties growing and producing grains.

This was in line with research that washing with fresh water can reduce the electrical conductivity value of soil [36]. Furthermore reported that waterlogging of rice plants throughout the season can remove salt from the root zone through leaching or dilution [37]. Such conditions are very supportive, suitable, and safe for the growth and production of rice plants. The soil whose electrical conductivity value (EC) is below the range of 2.18 dS $m^{-1}$ is safe and suitable for plant growth [38]. The research explained that the soil is categorized as saline when the saturated paste extract has an EC value greater than 4 dS $m^{-1}$ [39]. Then mentioned that soils with EC values of 7.2-7.4 dS $m^{-1}$ caused rice yield losses of 50% (508 g $m^{-2}$) because rice plants have a tolerance to saline conditions around 3 dS $m^{-1}$ that soil with a salinity of 3.5 dS $m^{-1}$ caused a yield loss of 10% [40,41,42].

**Table 2.** Analytical results of stagnant saline soil samples with leaching and without leaching with fresh water

| Component | Yield | |
|---|---|---|
| | washing with fresh water | without washing with fresh water |
| Texture (%) | | |
| Sand | 17 | 14 |
| Silt | 24 | 40 |
| Clay | 59 | 46 |
| pH ($H_2O$) | 6.7 | 6.4 |
| pH (KCl) | 5.7 | 5.7 |
| EC(dS/m) | 2.18 | 17 |
| Salinity (mg/l) | 138 | 1061 |
| C (%) | 1.88 | 1.57 |
| N (%) | 0.17 | 0.14 |
| C/N | 11 | 11 |
| $P_2O_5$ (mg/l) | 79 | 48 |
| $K_2O$ (mg/l) | 396.9 | 506 |
| KTK (cmolc/kg) | 21.87 | 22.1 |
| Fe (%) | 5.79 | 8.54 |
| Al (%) | 12.81 | 8.51 |
| Ca (%) | 0.66 | 1.27 |
| Mg (%) | 0.52 | 0.53 |
| Na (%) | 0.2 | 0.34 |
| S (mg/l) | 10 | 10 |
| Mn (mg/l) | 331 | 244 |

### 3.2. Plant Growth

The results of statistical analysis showed that there was no interaction between the treatment of microbial consortium and rice varieties on plant growth components. Still, the single factor in the treatment of rice varieties differed between treatments, including plant height and number of productive tillers. Pokkali variety is the tallest compared to Biosalin 2 Agritan and IR 29 varieties; the results are 206.38 cm, 122.6 cm, and 98.59 cm, respectively, but for the variable number of productive tillers the highest marks are shown by the IR 29 variety followed by the Biosalin 2 Agritan variety and the least number is shown by the Pokkali variety, respectively 46.75 stems, 39.25 stems, and 28.83 stems, then the single factor for the microbial consortium treatment has the same effect for all treatments (Table 3). Microbial consortiums originate from stagnant saline environments.

The pokkali variety shows the tallest plants compared to the other two types because the description of the Pokkali variety is indeed taller plants, namely 180 cm, and has properties very tolerant of saline conditions and flooding compared to the Biosalin 2 Agritan variety as high as 109 cm and IR 29 as high as 97 cm [43,44,45,46,47]. Research wrote that genetic factors and different traits of each variety cause this difference [48,49]. The rice plants respond differently to salt stress depending on the nature and characteristics of each type [50]. Rice plants that are resistant to stress will overgrow from the salt-sensitive stage and gradually adapt to the stressed environment. At the same time, salinity-sensitive strains will grow slowly and gradually dry out like burning and eventually die [50]. Plants have tolerance limits and adaptation to changes in environmental conditions such as fluctuations in salinity concentrations [51].

The best results on the number of productive tillers were shown by the IR 29 variety (46.75 stems), then Biosalin 2 Agritan (39.25 branches), and the minor variety of Pokkali (28.83 stems). This is in line with research that reported that plant height and leaf area tended to increase under mild stress, but the number of tillers, number of panicles, and grain yield decreased [52]. The plant height has a direct negative effect on grain yield [53]. They stated that tall plants require more nutrients and water for growth, so the ability to form tillers becomes less and vice versa [54].

**Table 3.** Mean plant height and number of productive tillers with microbial consortium treatment and rice varieties

| Treatment | Plant height (cm) | Number of productive tillers (stem) |
|---|---|---|
| microbial consortium | | |
| without microbial consortium | 142.94a | 37.78a |
| microbial consortium A | 141.33a | 38.67a |
| microbial consortium B | 141.21a | 38.11a |
| microbial consortium C | 144.60a | 38.56a |
| Rice varieties | | |
| Pokkali variety | 206.38a | 28.83c |
| Biosalin 2 Agritan variety | 122.6b | 39.25b |
| IR 29 variety | 98.59c | 46.75a |

Remark: numbers followed by the same letter in the same column indicate not significantly

### 3.3. Plant Biomass

The results showed that there was no interaction between the microbial consortium treatment and rice varieties on plant biomass variables, namely root length, root wet weight, root dry weight, shoot wet weight, and shoot dry weight, as well as on the single factor of microbial consortium treatment showed the same results (Table 4).

**Table 4.** Mean plant biomass with microbial consortium and rice variety treatments

| Treatment | root length (cm) | root wet weight (g) | root dry weight (g) | shoot wet weight (g) | shoot dry weight (g) |
|---|---|---|---|---|---|
| microbial consortium | | | | | |
| without microbial consortium | 34.92a | 90.49a | 18.87a | 536,56a | 95,83a |
| microbial consortium A | 35.20a | 97.72a | 18.21a | 495,68a | 94,26a |
| microbial consortium B | 35.01a | 99.52a | 21.84a | 474,69a | 90,41a |
| microbial consortium C | 33.98a | 94.63a | 19.64a | 539,88a | 96,52a |
| Rice varieties | | | | | |
| Pokkali variety | 36,9a | 133,5a | 31,11a | 798,99a | 145,7a |
| Biosalin 2 Agritan variety | 35,43a | 69,92b | 13,65b | 412,40b | 77,65b |
| IR29 variety | 31,9b | 83,28b | 14,1b | 323,71c | 59,39c |

Note: the same letter indicates not significantly

The results of statistical analysis showed that the treatment of rice varieties differed between treatments on all plant biomass variables. The Pokkali variety showed the best results, and the IR29 variety had the lowest marks. The variables of root length, root wet weight, root dry weight, shoot wet weight, and shoot dry weight in Pokkali varieties were 36.96 cm, 133.57 g, 31.11 g, 798.99 g, and 145.74 g, respectively. In contrast, IR29 varieties in the variables of root length, shoot wet weight, and shoot dry weight yielded 31.94 cm, 323.71 g, and 59.39 g, respectively. Still, the variables of root wet weight and root dry weight between Biosalin 2 Agritan and IR 29 varieties were not significantly different (Table 4). Pokkali is a highly saline-tolerant variety, but IR29 is sensitive to salty conditions [55,56]. Pokkali can adapt to stressful situations; when grown under normal conditions, the results are better [57]. The Pokkali produces better biomass compared to other varieties in saline conditions [56]. The Pokkali variety grown under low saline conditions showed better biomass compared to higher saline conditions [58]. The characters of root length, root wet weight, root dry weight, shoot wet weight, and shoot dry weight with 6 dS $m^{-1}$ salinity resulted in 15.5 cm, 77.7 mg, 26 mg, 153.23 mg, 34.1 mg, respectively, while at 12 dS $m^{-1}$ salinity the figures were 10 cm, 19.1 mg, 11.77 mg, 63.1 mg, 16.6 mg respectively [58]. This is possible due to the condition of the growth medium washed with fresh water, which shows decreased electrical conductivity decreased (EC = 2.18 dS $m^{-1}$). The level of N and $P_2O_5$ is respectively by 0.17% and 79 mg/l (Table 2). The rice plants in desalination grow very well [59]. Rice plants can grow for a limit of less than 3 dS $m^{-1}$ for nutrient support [42].

### 3.4. N, P, K, and Na levels

The results of the statistical analysis provide information that there is no interaction between the treatment of microbial consortium and rice varieties on the variables of N, P, K, and Na levels in both roots and shoots.

The results showed that the treatment of rice varieties differed between treatments on the variable levels of K and Na both in the roots and shoot, but the levels of N in the roots and shoot had no effect, while the levels of P in the shoot were different varieties. K and Na levels in the roots with low values are in Pokkali types, while the highest in IR 29 types. The abundance of P, K, and Na was highest in the Pokkali variety and lowest in the IR 29 variety. Singly for the treatment of microbial consortium does not affect the variable levels of N, P, K, and Na both in the roots and shoot (Table 5).

Pokkali variety shows the lowest K and Na levels in the roots, which are 0.116% and 0.488%, respectively, while the largest is in the IR 29 variety, which is 0.275% and 0.828%, respectively. In that saline conditions reduce plant growth and are associated with salt accumulation both in the roots and shoots [60]. This is in line with research which reported that saline-tolerant plants reduce $Na^+$ and $K^+$ uptake, which causes low levels of $Na^+$ and $K^+$ in the roots, while saline-sensitive varieties cannot translocate some $Na^+$ and $K^+$ to the shoots so that $Na^+$ and $K^+$ levels in the nodes become low [61]. Wild rice plants have properties that are more tolerant of saline stress and show higher $Na^+$ content in the shoot and lower in the roots [62]. Regulation of $Na^+$ and $K^+$ is crucial in rice plants in adjusting to saline stress. Dissolved nutrients such as Na+ and K+ are the main elements of rice plants [62].

**Table 5.** Test results of N, P, K, Na levels in roots and shoot with microbial consortium treatment and rice varieties

| Treatment | Roots | | | | Shoot | | | |
|---|---|---|---|---|---|---|---|---|
| | N(%) | P(%) | K(%) | Na(%) | N(%) | P(%) | K(%) | Na(%) |
| Microbial consortium | | | | | | | | |
| without microbial consortium | 0.727a | 0.157a | 0.176a | 0.703a | 1.752a | 0.21a | 2.01a | 0.064a |
| microbial consortium A | 0.679a | 0.174a | 0.184a | 0.636a | 1.751a | 0.191a | 2.067a | 0.067a |
| microbial consortium B | 0.679a | 0.163a | 0.228a | 0.637a | 1.867a | 0.188a | 2.013a | 0.062a |
| microbial consortium C | 0.651a | 0.193a | 0.163a | 0.663a | 1.693a | 0.182a | 1.948a | 0.067a |
| Rice varieties | | | | | | | | |
| Pokkali variety | 0.709a | 0.164a | 0.116c | 0.488c | 1.615a | 0.218a | 2.156a | 0.081a |
| Biosalin 2 Agritan variety | 0.678a | 0.192a | 0.173b | 0.663b | 1.824a | 0.183b | 1.888b | 0.058b |
| IR29 variety | 0.665a | 0.16a | 0.275a | 0.828a | 1.858a | 0.178b | 1.984b | 0.055b |

Notes: numbers followed by the same letter in the same column indicate not significantly

### 3.5. Crop Yield Components

The results showed that the interaction between the microbial consortium and rice varieties significantly affected the number of filled grains per hill, the number of empty grains per hill, the percentage of empty grains, and the dry weight of grain per hill (Table 7).

The microbial consortium treatment differed between treatments on the number of empty grains per clump, percentage of open grains, and dry weight of grain per clump. In contrast, the variables of panicle length per panicle, number of filled grains per clump, and wet weight of grain per clump had no effect. The best results were shown by microbial consortium B, and the lowest was demonstrated by the treatment without microbial consortium. Microbial consortium B for the number of empty grains per clump, the percentage of open grains, and the dry weight of grain per clump were 646 grains, 13.08%, and 99.14 g, respectively, while the lowest results were in the treatment without microbial consortium with values on these variables being 1054.22 grains, 21.09%, and 89.28 g, respectively (Table 6).

The results showed that the single factor for the treatment of rice varieties was different for all variables, namely panicle length per panicle, number of filled grains per clump, number of empty grains per clump, percentage of open grains, wet weight of grain per clump, dry weight of grain per clump. The Pokkali variety gave the best yield on the variable panicle length, then the Biosalin 2 Agritan variety on the number of filled grains per clump, grain wet weight per clump, and grain dry weight per clump, and IR 29 on the number of empty grains per clump and percentage of open grains (Table 6).

The results of statistical analysis showed that the interaction between the microbial consortium and rice varieties differed between treatments on the number of filled grains per clump, the number of empty grains per clump, the percentage of open grains, and the dry weight of grain per clump, while the variables of panicle length and wet weight of grain per clump had no effect.

The grain dry weight per clump of Biosalin 2 Agritan without bacterial inoculation was not significantly higher than that of Biosalin 2 Agritan inoculated with bacterial consortium A, B, or C, that of Pokkali inoculated with bacterial consortium A, B, or C, but it was significantly higher than that of Pokkali without bacterial inoculation, IR29 without inoculation, IR29 inoculated with bacterial consortium A, B or C. The grain dry weight per clump of IR29 without bacterial inoculation was the lowest, but it was not significantly different from the grain dry weight per clump of IR29 inoculated with bacterial consortium C.

The highest number of filled grains per clump was produced by Biosalin 2 Agritan inoculated with bacterial consortium C. The lowest number of filled grains per clump was produced by Pokkali without bacterial inoculation. However, the number of filled grains of Biosalin 2 Agritan inoculated with bacterial consortium C was not significantly higher than that of Biosalin 2 Agritan without bacterial inoculation or inoculated with bacterial consortium A or B. The number of filled grains per clump was produced by Biosalin 2 Agritan without inoculation or inoculated with bacterial consortium A, B or C significantly higher than that of Pokkali without bacterial inoculation or inoculated with bacterial consortium A, B, or C. The number of filled grains per clump was produced by Biosalin 2 Agritan without inoculation or inoculated with bacterial consortium A, B, or C significantly higher than that of IR29 without bacterial inoculation or inoculated with bacterial consortium C (Table 7). This information can also be seen in Figure 1.

**Table 6.** Mean numbers of single factor treatments of microbial consortium and rice variety

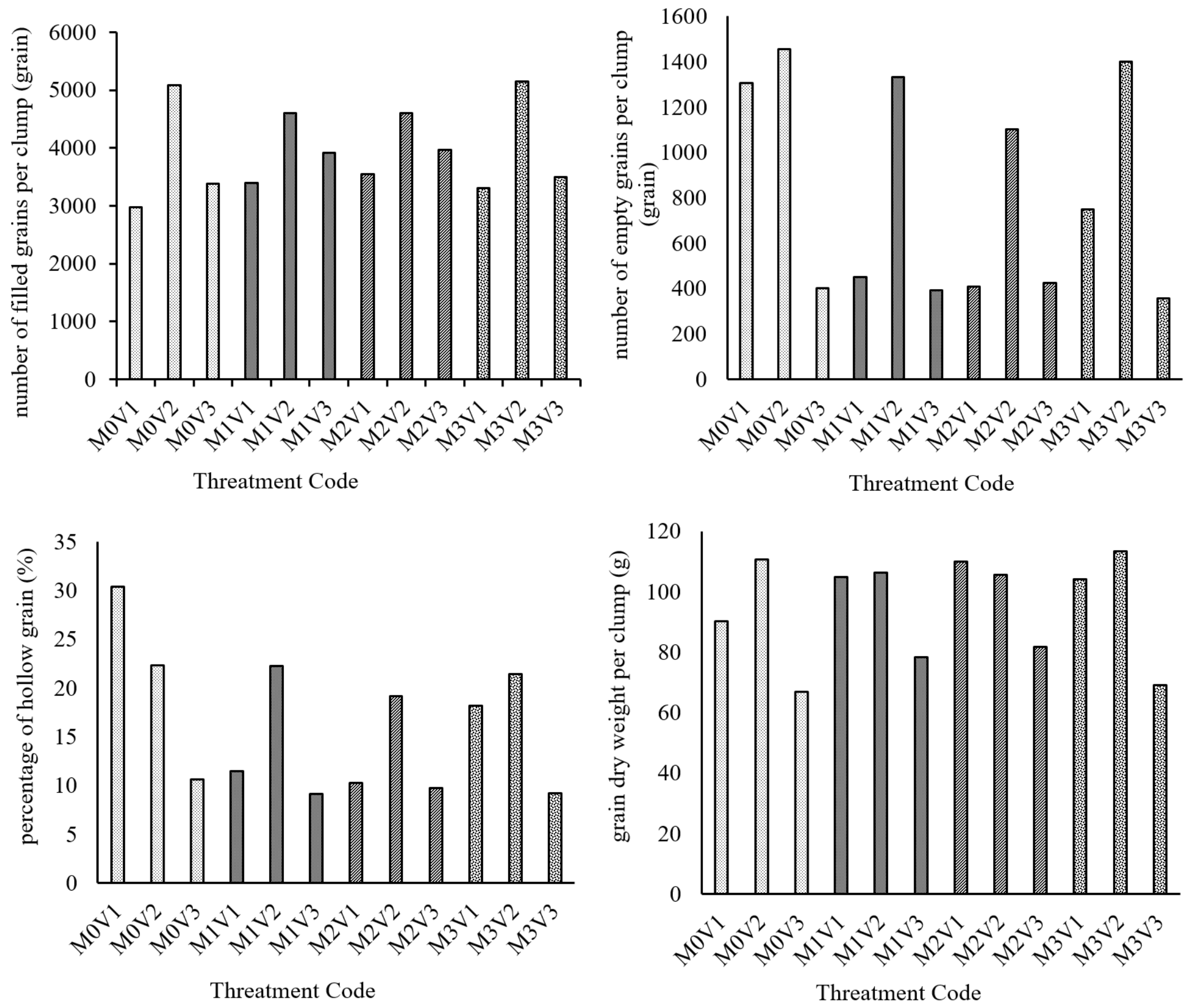
| Treatment | panicle length (cm) | number of filled grains per clump (grain) | number of empty grains per clump (grain) | percentage of hollow grain (%) | wet weight of grain per clump (g) | grain dry weight per clump (g) |
|---|---|---|---|---|---|---|
| microbial consortium | | | | | | |
| without microbial consortium | 24.27a | 3816.78a | 1054.22b | 21.09b | 104.25a | 89.28b |
| microbial consortiumA | 24.17a | 3973a | 725.56a | 14.28a | 127.31a | 96.53ab |
| microbial consortium B | 23.86a | 4035.67a | 646a | 13.08a | 114.12a | 99.14a |
| microbial consortium C | 23.86a | 3984.67a | 834.78ab | 16.28ab | 109.35a | 95.57ab |
| rice varieties | | | | | | |
| Pokkali variety | 28.17a | 3307.67b | 728.17b | 17.57b | 110.06ab | 102.35a |
| Biosalin 2 Agritan variety | 24.07b | 4858.58a | 1323c | 21.29b | 134.55a | 108.10a |
| IR29 variety | 19.88c | 3691.33b | 394.25a | 9.69a | 96.66b | 74.04b |

Notes: numbers followed by the same letter in the same column indicate not significantly

**Table 7.** Mean number of interactions between microbial consortium and rice varieties on yield component variables

| Treatment | Number of filled grains per clump (grain) | number of empty grains per clump (grain) | percentage of hollow grain (%) | grain dry weight per clump (g) |
|---|---|---|---|---|
| M0V1 | 2980.33d | 1306.33d | 30.38c | 90.26b |
| M0V2 | 5085.33a | 1455.67d | 22.29b | 110.60a |
| M0V3 | 3384.67cd | 400.67ab | 10.6a | 66.97e |
| M1V1 | 3398.00cd | 449.67ab | 11.45a | 104.95a |
| M1V2 | 4603.67ab | 1333.33d | 22.25b | 106.40a |
| M1V3 | 3917.33bc | 393.67ab | 9.13a | 78.23cd |
| M2V1 | 3542.00cd | 409.33ab | 10.28a | 109.96a |
| M2V2 | 4598.33ab | 1103.33cd | 19.19b | 105.68a |
| M2V3 | 3966.67bc | 425.33ab | 9.77a | 81.78bc |
| M3V1 | 3310.33cd | 747.33bc | 18.19b | 104.24a |
| M3V2 | 5147.00a | 1399.67d | 21.41b | 113.30a |
| M3V3 | 3496.67cd | 357.33a | 9.24a | 69.17de |

Notes: numbers followed by the same letter in the same column indicate not significantly; M0V1 = without microbial consortium and Pokkali variety; M0V2 = without microbial consortium and Biosalin 2 Agritan variety; M0V3 = without microbial consortium and IR29 variety; M1V1 = microbial consortium A and Pokkali variety; M1V2 = microbial consortium A and Biosalin 2 Agritan variety; M1V3= microbial consortium A and variety IR29; M2V1= microbial consortium B and variety Pokkali; M2V2= microbial consortium B and variety Biosalin 2 Agritan; M2V3= microbial consortium B and variety IR29; M3V1= microbial consortium C and variety Pokkali; M3V2= microbial consortium C and variety Biosalin 2 Agritan; M3V3= microbial consortium C and variety IR29.




**Notes:** M0V1 = without microbial consortium and Pokkali variety; M0V2 = without microbial consortium and Biosalin 2 Agritan variety; M0V3 = without microbial consortium and IR29 variety; M1V1 = microbial consortium A and Pokkali variety; M1V2 = microbial consortium A and Biosalin 2 Agritan variety; M1V3= microbial consortium A and variety IR29; M2V1= microbial consortium B and variety Pokkali; M2V2= microbial consortium B and variety Biosalin 2 Agritan; M2V3= microbial consortium B and variety IR29; M3V1= microbial consortium C and variety Pokkali; M3V2= microbial consortium C and variety Biosalin 2 Agritan; M3V3= microbial consortium C and variety IR29.

**Figure 1.** Complete information on the interactions between microbial consortium and rice varieties on yield component variables

Biosalin 2 Agritan is a salinity tolerant rice variety and has a potential yield of 9.06 tons $ha^{-1}$ with an average yield of 7.62 tons $ha^{-1}$ [62], while the pokkali is a salinity resistant rice variety and has [55, 63, 64], productivity at 2000-3500 kg $ha^{-1}$ [65, 66], thus the biosalin 2 agritan variety shows higher yields compared to pokkali.

Values of all observed variables of rice plant varieties treated with microbial consortium were similar to those of untreated rice plant varieties. These indicated that indigenous microbial community of the soil has similar abilities to the applied consortium microbial. In many cases plants treated with indigenous microbia were performed better than that with non indigenous micobia, since indigenous microbia already adapted to the local condition. In addition there was a possibility that non indigenous microbia could not compete with local microbial communities. The effect of microbial consortium showed the same results presumably because the microbial consortium has the ability and character that is relatively the same as the microbes that exist and live in the planting media used. Microbes derived from local soil can increase plant growth better than newly applied microbes, because soil microbes have great potential to adapt quickly to the soil conditions encountered [67]. Interactions between microbes can have an impact on the behavior of these microbes and plant growth [68].

## 4. Conclusions

Based on the research that has been carried out, it can be concluded that 1) saline soil washed with fresh water decreased the electrical conductivity from 17 dS $m^{-1}$ to 2.18 dS $m^{-1}$, making it suitable for the growth and production of rice plants. 2) The Pokkali variety produced the highest plant height biomass component, but the IR 29 variety showed the highest number of productive tillers. 3) Microbial consortium B gave the best effect on the variables of the number of empty grains per clump, percentage of empty grains, and dry weight of grain per clump. 4) there was no interaction between growth components, plant biomass, and levels of N, P, K, and Na. 5) The Pokkali variety contained low levels of K and Na in the roots but high levels of P, K, and Na in the crown, while the IR29 variety contains high levels of K and Na in the roots, while in the crown. 6) The best results in the variable number of filled grains per clump and dry weight of grain per clump were shown by the treatment of microbial consortium C and Biosalin 2 Agritan varieties.


# Acknowledgements

On this occasion the author would like to express his thanks to all colleagues who have helped with the research and observation process in the field and laboratory.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