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Research Paper

Nutrient Uptake of Aerobic Rice Genotypes as Influenced by Biofertilizer

Aliyu Isah Take-tsaba[1]*, Abdul Shukor Bin Juraimi[2], Mohd Rafii Bin Yusop[3], Radziah Bt Othman[4] and Ajit Singh[5]

[1]Department of Agricultural Education, School of Vocational Education, Federal College of Education (Technical), P. M. B. 1088, Zaria Road Gusau, Zamfara State, Nigeria.
[2]Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia, UPM Serdang 43400, Selangor Darul Ehsan, Malaysia.
[3]Institute of Tropical Agriculture and Food Security, Universiti Putra Malaysia, UPM Serdang 43400, Selangor Darul Ehsan, Malaysia.
[4]Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia, UPM Serdang 43400, Selangor Darul Ehsan, Malaysia.
[5]School of Biosciences/Sciences, The University of Nottingham Malaysia Campus Jalan Broga 43500, Semenyih, Selangor Darul Ehsan, Malaysia.
*Corresponding Author E-mail: aitaketsaba87@yahoo.com

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Biofertilizer, which is prepared with beneficial environment-friendly bacteria and residue of plant material, can be a complement to chemical fertilizer and eventually improve soil productiveness aids in tackling the opposing ecological penalties, energy depletion and imminent dares of food production. Two field experiments were carried out during off and main season at Universiti Putra Malaysia to determine the influence of biofertilizer on nutrient uptake and yield of different aerobic rice genotypes. The experiment consisted of five biofertilizer treatments (chemical fertilizer recommended rate (CFRR) 100% as control, biofertilizer 1 t ha^{-1} + 75% CFRR, biofertilizer 2 t ha^{-1} + 50% CFRR, biofertilizer 3 t ha^{-1} + 25% CFRR and biofertilizer 4 t ha^{-1}) and three aerobic rice genotypes (MRIA1, MR219-4 and MR219-9). Results showed that application of biofertilizer positively affected nutrient uptake and grain yield of aerobic rice. Biofertilizer 1 t ha^{-1} + 75% CFRR application recorded the highest grain yield (4296.70 kg ha^{-1}) while biofertilizer 4 t ha^{-1} recorded the highest N and P uptake (37.88 and 9.59 kg ha^{-1}), respectively in grains in the main season. MR219-4 and MR219-9 recorded the highest and comparable grain yield and nutrient uptake. The study showed that application of biofertilizer 1 t ha^{-1} + 75% CFRR increases grain yield and biofertilizer 4 tons increase nutrient uptake of MR219-4 and MR219-9.

Keywords: Aerobic rice, genotypes, grain yield and nutrient uptake

INTRODUCTION

An anaerobic rice production system is a ground breaking approach to growing rice in well-drained, non-puddled, and non-saturated soils devoid of ponded water (Bouman, 2001). This method uses specified rice cultivars responsive to input and corresponding management practices to attain at least 4-6 t ha^{-1} with only 50-70% of the water necessary for flood irrigated rice production. It is suggested in zones where water is also rare or costly to let traditional irrigated rice cultivation since dwindling water openness looms the sustainability of customary flood-irrigated rice ecology (Anwar *et al.*, 2010). To tackle the impending dares of food production, energy depletion and opposing ecological penalties, biofertilizer, which is prepared with beneficial environment-friendly bacteria and residue of plant material can be a complement to chemical fertilizer and eventually improve soil productiveness. Ngoc *et al.* (2001) established that application of bio and organic fertilizer upturns the growth and yield of rice and able to reduce mineral fertilizer use. The innovative agronomic option is to apply biofertilizer in combination with chemical fertilizers to lessen the chemical fertilizer usage

(Radziah and Panhwar, 2014). Organic acid secretion by PSB (phosphate solubilizing bacteria) aid to liquefy P from unsolvable and permanent forms to the existing form in the plant, while Azotobacter can change nitrogen in the atmosphere into accessible plant form in the soil (Mondal *et al*., 2015). It is anticipated that biofertilizers might offer a prospect for rice farmers to increase yields and productive efficiency. This study was conducted to determine the effect of biofertilizer in combination with chemical fertilizer on nutrient uptake of three aerobic rice genotypes in field condition.

MATERIALS AND METHODS

Experimental site

Two field experiments were conducted at Field 10, Universiti Putra Malaysia (UPM), (latitude 3° 02' N; longitude 101° 42' E and on the altitude of 31 m above sea level) Selangor, Malaysia during the off-season (May to September 2015) and main season (September to December 2015). Sweet corn was previously planted at the experimental site and the debris was cleared off prior to land preparation. At the experimental site, the soil was clay loam with pH value of 6.50 and 6.42, total carbon (C) 0.79 and 0.77%, total nitrogen (N) 0.06 and 0.07%, total sulphur (S) 0.02 and 0.0.2%, phosphorus (P) 84.7 and 165.2 µg g^{-1}, potassium (K) 41.24 and 55.07 µg g^{-1} were recorded in off and main season, respectively (Table 1). The total rainfall received during the experimental periods was 548 and 1438 mm in the off and main season respectively. Maximum and minimum temperatures recorded in the off and main season were 33.5 and 33°C, 25.25 and 24.5°C, average 29 and 28.5°C respectively (Table 2).

Experimental materials

Aerobic rice varieties

Three aerobic rice genotypes namely, MRIA1 a short duration commercial variety obtained from Malaysian Agricultural Research and Development Institute (MARDI) while MR219-4 and MR219-9 obtained from Malaysian Nuclear Agency were used for the experiments.

Preparation of biofertilizer compost

The biofertilizer used constituted a mixed species of nitrogen-fixing bacteria (*Bacillus spp*. Sb35 and 42) and phosphate solubilization bacteria (*Bacillus spp*. PSB16). One liter of each inoculum was diluted in 4 liters of distilled water (H_2O) + molasses. The mixed bacterial culture was then mixed into composted empty fruit bunch (EFB) and peat moss in the ratio of 1:1:1. The prepared biofertilizer compost was stored at ambient room temperature for one month for the bacteria to multiply preceding use.

Treatments and experimental design

The treatments consisted of five biofertilizer treatments (1) control 100% chemical fertilizer recommended rate (CFRR) i.e. 150 N; 60 P_2O_5; 60 K_2O kg ha^{-1}, (2) biofertilizer at 1 ton ha^{-1} + 75% CFRR, (3) biofertilizer at 2 t ha^{-1} + 50% CFRR, (4) biofertilizer at 3 t ha^{-1} + 25% CFRR, and (5) biofertilizer at 4 t ha^{-1}) and three aerobic rice genotypes (MRIA1, MR219-4 and MR219-9). The experiments were laid out in a split-plot arranged in a randomized complete block design (RCBD) with three replicates, with biofertilizer in the main plot and aerobic rice genotypes in the sub-plot.

Agronomic practices

Land was ploughed and rotovated to obtain a fine tilt and then marked out into required plot sizes with 1.0 m space between blocks and 0.50 m spacing between plots. The gross and net plot sizes were 2.5 m × 1.5 m (3.75 m^2) and 2.0 m × 1.0 m (2.0 m^2), respectively constituting 6 rows in the gross plots and 4 rows in the net plots, respectively. Sown seeds were apparently treated with 70% chlorox (5.25% sodium hypochloride solution) for 30 min then rinsed with sterile water (Amin *et al*., 2004). Seed sowing was done on 24th May 2015 and 3rd September 2015 at an intra and inter-row spacing of 25 cm × 25 cm.

Ten dry treated rice seeds were sown $hole^{-1}$ that was later thinned to 5 seedlings $hill^{-1}$ at 14 days after sowing (DAS). To control weeds, 'Butachlor' herbicide (1.2 kg a.i ha^{-1}) was sprayed 2 DAS in main season only while 'Basagran' herbicide (bentazone 0.8 kg a.i ha^{-1} and MCPA 0.12 kg a.i ha^{-1}) was sprayed in both seasons at 21 and 28 DAS in off and main season, respectively followed by manual weeding throughout the growing seasons.

A day before crop establishment biofertilizer was incorporated into the soil. Compound fertilizer (NPK 15:15:15) was applied at the rate of 400 kg ha^{-1} as basal; and Urea at the rate of 196 kg ha^{-1} in two split doses by side placement at 28 and 56 DAS to supply total recommended nutrients of 150 N; 60 P_2O_5; 60 K_2O kg ha^{-1}. Both were applied as prescribed by the treatments. The crop was grown rain-fed but supplemental irrigation was carried out using a sprinkler to keep the soil at field capacity throughout the growing season. The field was netted to prevent birds' damage to the grains. Other pests were controlled following standard practices.

Table 1. Soil physico-chemical properties (0-20 cm) at field 10 Universiti Putra Malaysia collected prior to the onset of the experiment.

	Physical properties			Soil Texture Class	Chemical properties						Extractable (µg/g)							
	Sand	Silt	Clay		pH	EC (µS/cm)	CEC (cmol/kg)	Total C (%)	Total N (%)	Total S (%)	P	K	Ca	Mg	Cu	Fe	Mn	Zn
Off season	37.36	37.36	29.88	clay loam	6.5	58	5.05	0.79	0.06	0.02	84.7	41.24	876.7	62.7	1.595	168.0	5.95	1.72
Main season	40.46	40.46	28.99	clay loam	6.42	113.9	5.01	0.77	0.07	0.02	165.2	55.07	955.9	106.6	1.54	145.4	11.1	2.54

Table 2. Monthly precipitation and temperature from May - December 2015 at field 10 Universiti Putra Malaysia.

Off season					Main season				
Month	Precipitation (mm)	Temperature (°C)			Month	Precipitation (mm)	Temperature (°C)		
		Maximum	Minimum	Average			Maximum	Minimum	Average
May	34	34	25	29	September	98	33	25	29
June	125	33	26	29	October	411	33	25	29
July	65	34	25	29	November	426	33	24	28
August	324	33	25	29	December	503	33	24	28
Average		33.5	25.25	29	Average		33	24.5	28.5
Total	548				Total	1438			

Rice grain yield, straw yield and root dry weight measurement

At harvest, panicles from sixteen (16) hills (1 m^{-2}) in each plot were harvested, threshed, winnowed to remove the chaff and for root dry weight, three rice hills root were carefully uprooted, washed and oven dried at 70°C for 72 h. The samples were weighed using weighing balance and the grain yield and straw yield and root dry weight was converted to kg ha^{-1}.

Plant nutrient analysis

After harvest, samples of plant were collected from each treatment; the samples were separated into the straw (above ground plant parts excluding the grains), root and grains after which they were oven dried at 70°C for 72 h. Oven dried samples were ground in the laboratory using a Wiley Hammer Mill with 1 mm mesh size. The samples were analyzed for total nitrogen (N), phosphorus (P) and potassium (K). The nutrients were determined using acid wet digestion method (Enders and Lehmann, 2012). For the digestion process, ground samples of 0.25 g were transferred to clean 100 ml digestion flask and 5 ml concentrated sulphuric acid (H_2SO_4) was added to each flask. The samples were allowed to stand for 2 h after which 2 ml 50% hydrogen peroxide (H_2O_2) was added. The flasks were heated for 45 min at 285°C, and then allowed to cool. This process was repeated twice to let the digestion be cleared (colorless). The flasks were then removed from the digestion block, cooled at room temperature and made up to 100 ml of distilled water filtered through filter paper (Whatman no.1). The digested samples were stored in plastic vials before analysis for N, P and K. Nitrogen and potassium were determined with Auto Analyzer (AA) (Lachat instrument, USA), while potassium was determined using Automatic Absorption Spectrometer (ASS) (Perkin Elmer, 5100, USA). Nutrient content was expressed as the percent of tissue dry weight. Nutrient (N, P, and K) uptake was determined by multiplying nutrient content by a dry matter of the respective plant part (straw, grains, or root).

Statistical analysis

The data collected were subjected to analysis of variance (ANOVA) in order to decide any

Table 3. Grain yield, straw yield, and root dry weight of aerobic rice as influenced by biofertilizer, genotypes and their interactions during off and main season.

Treatments	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Root dry weight (kg ha^{-1})	
	Off season	Main season	Off season	Main season	Off season	Main season
Biofertilizer (B)						
CFRR 100%	4252.20a	3571.10a	5140.60a	4563.20a	2746.67a	1159.29b
Biofertilizer 1 ton + 75% CFRR	4296.70a	3766.70a	4691.00ab	3940.4ab	2549.33b	1307.02a
Biofertilizer 2 tons + 50% CFRR	3733.30a	3227.40a	4410.00bc	3549b	1840.36c	1105.60c
Biofertilizer 3 tons + 25% CFRR	3925.60a	3294.80a	4533.50a-c	3227.80b	1692.98d	1106.13c
Biofertilizer 4 tons	2945.60b	3082.20a	3895.60c	3201.80b	1714.13d	909.33d
Genotypes (G)						
MR219-4	5020.00a	3840.00a	4462.50ab	4150.30a	3021.87a	1287.04b
MR219-9	4626.70a	3860.00a	4081.50b	4134.40a	2440.53b	1365.97a
MRIA1	1845.30b	2465.30b	5058.40a	2804.60b	863.68c	699.41c
Significance level						
B	*	ns	*	*	***	***
G	***	***	**	***	***	***
B × G	ns	ns	ns	ns	***	***
SEM						
B	238.269	284.633	201.452	264.280	21.765	6.064
G	156.165	161.330	214.649	174.142	15.418	4.125
B × G	349.196	360.745	479.970	389.394	34.476	9.225
Mean	3830.67	3388.45	4534.13	3696.45	2108.69	1117.48
CV (%)	15.79	18.44	18.34	18.25	2.83	1.43

Means in a column for each factor followed by the same letter(s) are not significantly different at P≤0.05 using Duncan's new multiple range tests (DNMRT), *, **, *** represent significant at P≤0.05, P≤0.01 and P≤0.001 respectively, ns = not significant at P>0.05, CFRR = chemical fertilizer recommended rate, SEM = standard error of mean.

significant differences between treatments using the SAS Software Program (Version 9.4), and treatment means were compared using Duncan's New Multiple Range Test (DNMRT) at 0.05 probability level.

RESULTS

Grain yield, straw, and root dry weight

There was significant ($p<0.05$) effect of biofertilizer and genotypes on grain yield, straw yield and root dry weight in both seasons except for the effect of biofertilizer on grain yield in the main season. The interactions effect on root dry weight in both seasons was also found to be significant ($p<0.05$) (Table 3). The highest grain yield (4296.70 kg ha^{-1}) in off season and root dry weight (1307.02 kg ha^{-1}) in main season were recorded in biofertilizer 1 ton + 75% CFRR while the highest straw yield (5140.60 and 4563.20 kg ha^{-1}) in both off and main season, respectively and root dry weight (2746.67 kg ha^{-1}) in off season was recorded in CFRR 100%. Biofertilizer 4 tons recorded the lowest grain yield, straw yield, and root dry weight in both seasons except root dry weight in off season where biofertilizer 3 tons + 25% CFRR recorded the lowest (1692.98 kg ha^{-1}). MRIA1, MR219-4, and MR219-9 recorded the highest (5058.40, 3021.87 and 1365.97 kg ha^{-1}) straw yield in off season, root dry weight in both off and main season, respectively. MR219-4 and MR219-9 were similar in grain yield in both seasons and straw yield in the main season. MRIA1 recorded the lowest grain yield and root dry weight in both seasons, straw yield in the main season. The interaction between biofertilizer × genotypes on root dry weight is presented in (Table 4). In off-season, MR219-9 recorded the highest (3637.33 kg ha^{-1}) root dry weight different from the other genotypes in CFRR 100%, MR219-4 recorded the highest (3680.00, 2752.00 and 3424.00 kg ha^{-1}) in biofertilizer 1 ton + 75% CFRR, biofertilizer 2 tons + 50% CFRR and biofertilizer 4 tons respectively, different from the other genotypes but at par with MR219-9 in biofertilizer 3 tons + 25% CFRR. In main season, MR219-4 recorded the highest (1589.87 and 1524.80 kg ha^{-1}) in CFRR 100% and biofertilizer 2 tons + 50% CFRR respectively while MR219-9 recorded the highest (1539.73, 1691.20 and 1030.93 kg ha^{-1}) in biofertilizer 1 tons + 75% CFRR, biofertilizer 3 tons + 25% CFRR and biofertilizer 4 tons different from the other genotypes. MRIA1 recorded the lowest values in both seasons and in all biofertilizer treatments.

N content in grains, straw, and root

There was significant ($p<0.05$) effect of biofertilizer, genotypes and all the interactions effect in both seasons on N content in grains, straw, and root except genotypes in root and interaction in grains in the main season (Table

Table 4. Root dry weight (kg ha^{-1}) of aerobic rice as influenced by interaction between biofertilizer, genotypes and their interactions during off and main season.

Treatments	BF0	BF1	BF2	BF3	BF4
Off season					
MR219-4	3168.00b	3680.00a	2752.00a	2085.33a	3424.00a
MR219-9	3637.33a	2373.33b	2506.67b	2256.00a	1429.33b
MRIA1	1434.67c	1594.67c	262.40c	737.60b	289.07c
Main season					
MR219-4	1589.87a	1461.33b	1524.80a	956.80b	902.40b
MR219-9	1482.67b	1539.73a	1085.33b	1691.20a	1030.93a
MRIA1	405.33c	920.00c	706.67c	670.40c	794.67c

Means in a column for each season followed by the same letter are not significantly different at P≤0.05 using Duncan's new multiple range test (DNMRT), BF0 = CFRR 100%, BF1 = biofertilizer 1 ton + 75% CFRR, BF2 = biofertilizer 2 tons + 50% CFRR, BF3 = biofertilizer 3 tons + 25% CFRR, BF4 = biofertilizer 4 tons, CFRR = chemical fertilizer recommended rate.

Table 5. N content (%) in grains, straw, and root of aerobic rice as influenced by biofertilizer, genotypes and their interactions during off and main season.

Treatments	Grains		Straw		Root	
	Off season	Main season	Off season	Main season	Off season	Main season
Biofertilizer (ha^{-1}) (B)						
CFRR 100%	1.39ab	1.00b	1.31a	1.15ab	1.02b	1.31bc
Biofertilizer 1 ton + 75% CFRR	1.42a	0.86b	1.37a	1.13ab	0.90c	1.33b
Biofertilizer 2 tons + 50% CFRR	1.13b	0.91b	1.12b	1.06b	1.10b	1.18c
Biofertilizer 3 tons + 25% CFRR	1.46a	0.87b	1.12b	1.09b	1.20a	1.48a
Biofertilizer 4 tons	1.66a	1.26a	1.12b	1.21a	1.21a	1.38ab
Genotypes (G)						
MR219-4	1.52a	0.90b	1.11b	1.15a	1.15a	1.35a
MR219-9	1.36b	0.98a	1.40a	1.09b	1.04b	1.33a
MRIA1	1.35b	1.06a	1.12b	1.14a	1.06b	1.33a
Significance level						
B	*	***	***	*	***	**
G	*	***	***	*	*	ns
B × G	**	ns	***	***	***	***
SEM						
B	0.081	0.042	0.019	0.030	0.027	0.041
G	0.050	0.026	0.017	0.015	0.027	0.023
B × G	0.111	0.059	0.037	0.033	0.060	0.052
Mean	1.41	0.98	1.21	1.13	1.08	1.34
CV (%)	13.63	10.38	5.27	5.07	9.53	6.68

Means in a column for each factor followed by the same letter(s) are not significantly different at P≤0.05 using Duncan's new multiple range tests (DNMRT), *, **, *** represent significant at P≤0.05, P≤0.01 and P≤0.001 respectively, ns = not significant at P>0.05, CFRR = chemical fertilizer recommended rate, SEM = standard error of mean.

5). In both seasons, in grains, straw and root, biofertilizer 4 tons recorded the highest values except in straw and root in off and main season where biofertilizer 1 ton + 75% CFRR and biofertilizer 3 tons + 25% CFRR recorded the highest (1.37 and 1.48%) in straw and root in off and main season respectively while biofertilizer 1 ton + 75% CFRR and biofertilizer 2 tons + 50% CFRR recorded the lowest (0.90 and 1.18%) in root in off and main season respectively. MR219-4 recorded the highest (1.52 and 1.15%) in grains and root respectively in off season while MR219-9 recorded the highest and the lowest (1.40 and 1.09%) in straw in off and main season, respectively. MR219-4 and MRIA1 were similar in straw in both seasons while MR219-9 and MRIA1 were similar in grains in both seasons and root in off season. The interaction effect between biofertilizer × genotypes on N content in the grains in off season, straw and root for off and the main season is presented in (Table 6). In grains

Table 6. N content (%) in grains, straw and root of aerobic rice as influenced by interaction between biofertilizer × genotypes during off and main season.

Genotypes	BF0		BF1		BF2		BF3		BF4	
	Off season	Main season	Off season	Main season	Off season	Main season	Off season	Main season	Off season	Main season
Grains										
MR219-4	1.45ab	-	1.38a	-	1.15a	-	1.51a	-	2.13a	-
MR219-9	1.17b	-	1.38a	-	1.20a	-	1.41a	-	1.62b	-
MRIA1	1.56a	-	1.49a	-	1.04a	-	1.43a	-	1.22b	-
Straw										
MR219-4	1.35a	1.37a	1.19b	0.92b	0.94b	1.08b	0.86b	1.17a	1.19a	1.20a
MR219-9	1.26a	1.07b	1.71a	1.42a	1.33a	0.94c	1.58a	0.90b	1.14a	1.13a
MRIA1	1.33a	1.02b	1.22b	1.05b	1.08b	1.17a	0.93b	1.19a	1.03b	1.29a
Root										
MR219-4	0.97a	1.28a	0.81b	1.41a	1.25a	1.22a	1.46a	1.34b	1.24a	1.48a
MR219-9	1.06a	1.43a	1.10a	1.21b	0.83b	1.15a	0.96b	1.42b	1.24a	1.45a
MRIA1	1.01a	1.21a	0.79b	1.39a	1.20a	1.19a	1.17b	1.67a	1.16a	1.20b

Means in a column for each plant part followed by the same letter(s) are not significantly different at P≤0.05 using Duncan's new multiple range test (DNMRT), BF0 = CFRR 100%, BF1 = biofertilizer 1 ton + 75% CFRR, BF2 = biofertilizer 2 tons + 50% CFRR, BF3 = biofertilizer 3 tons + 25% CFRR, BF4 = biofertilizer 4 tons, CFRR = chemical fertilizer recommended rate.

in off season, MR219-4 recorded the highest (2.13%) in biofertilizer 4 tons at par with MR219-9 in CFRR 100% where MRIA1 recorded the highest (1.56%). In straw, MR219-9 recorded the highest in biofertilizer 1 ton + 75% CFRR in both seasons, biofertilizer 2 tons + 50% CFRR and biofertilizer 3 tons + 25% CFRR in off season; and the lowest in biofertilizer 3 tons + 25% CFRR in the main season. MR219-4 recorded the highest (1.37%) in CFRR 100% in the main season while MRIA1 recorded the highest and the lowest (1.17 and 1.03%) in biofertilizer 2 tons + 50% CFRR and biofertilizer 3 tons + 25% CFRR in main and off season, respectively. In root, MR219-4 recorded the highest (1.25 and 1.46%) in biofertilizer 2 tons + 50% CFRR and biofertilizer 3 tons + 25% CFRR in off season. MR219-9 recorded the highest and the lowest (1.10 and 1.21) in biofertilizer 1 ton + 75% CFRR in off and main season, respectively while MRIA1 recorded the highest and the lowest (1.67 and 1.20%) in biofertilizer 3 tons + 25% CFRR and biofertilizer 4 tons, respectively in the main season.

P content in grains, straw, and root

There was no significant ($p>0.05$) effect of biofertilizer, genotypes and all interactions on P content in the grains and root in off season, staw in both seasons but there was significant ($p\leq0.05$) effect of biofertilizer and interaction between biofertilizer × genotypes in both grains and root, genotypes in grains in main season (Table 7). The highest P content in grains (0.31%) was recorded in biofertilizer 4 tons and in root, the highest value (0.16%) was recorded in biofertilizer 1 ton + 75% CFRR comparable with biofertilizer 3 tons + 25% CFRR while in grains, the least (0.10%) was recorded in biofertilizer 1 ton + 75% CFRR. In root, the least (0.13%) was recorded in the other three biofertilizer treatments. MR219-4 recorded the highest P content in grains (0.17%) at par with MR219-9 while MRIA1 recorded the least (0.16%) in main season at par with MR219-9. The interaction between biofertilizer × genotypes on P content in grains and root in main season is presented in Table 8. MR219-4 recorded the highest (0.18%) while MR219-9 recorded the least (0.11%) P contents in grains at par with MRIA1 in biofertilizer 2 tons + 50% CFRR. In terms of P content in the root, MR219-4 and MR219-9 were similar in biofertilizer 1 ton + 75% CFRR but different in biofertilizer 3 tons + 25% CFRR. MRIA1 recorded the lowest and the highest (0.15 and 0.17%) in biofertilizer 1 ton + 75% CFRR and biofertilizer 3 tons + 25% CFRR, respectively.

K content in grains, straw, and root

There was significant ($p\leq0.05$) effect of biofertilizer on K content in straw in main season, genotypes in straw and root in both seasons and interaction between biofertilizer × genotypes in shoot in both seasons and in root in the main season (Table 9). The highest (1.82%) K content in the straw was recorded in biofertilizer 2 tons + 50% CFRR while the least (1.49%) was recorded in biofertilizer 3 tons + 75% CFRR at par with biofertilizer 4 tons. MRIA1 recorded the highest (0.35, 1.98 and 1.75%) in grains in off seasons, in straw in both seasons, respectively and the lowest (0.27%) in grains in the main season. MR219-4 and MR219-9 were at par in grains and straw in both seasons. Also higher than MRIA1 in grains in the main season. The interaction between biofertilizer × genotypes on K content in straw for off and the main season is presented in Table 10. In the off-season, MRIA1 recorded the highest (2.02 and 2.08%) while MR219-4 and MR219-9 recorded the least (1.69 and 1.64%) in biofertilizer 2 tons + 50% CFRR and in biofertilizer 3 tons

Table 7. P content (%) in grains, straw and root of aerobic rice as influenced by biofertilizer, genotypes and their interactions during off and main season.

Treatments	Grains		Straw		Root	
	Off season	Main season	Off season	Main season	Off season	Main season
Biofertilizer (ha^{-1}) (B)						
CFRR 100%	0.11a	0.13bc	0.11a	0.12a	0.11a	0.13b
Biofertilizer 1 ton + 75% CFRR	0.10a	0.10d	0.10a	0.11a	0.10a	0.16a
Biofertilizer 2 tons + 50% CFRR	0.12a	0.14b	0.10a	0.11a	0.11a	0.13b
Biofertilizer 3 tons + 25% CFRR	0.09a	0.11cd	0.10a	0.10a	0.11a	0.15a
Biofertilizer 4 tons	0.09a	0.31a	0.11a	0.10a	0.12a	0.13b
Genotypes (G)						
MR219-4	0.10a	0.17a	0.10a	0.11a	0.11a	0.14a
MR219-9	0.11a	0.16ab	0.10a	0.11a	0.11a	0.14a
MRIA1	0.09a	0.15b	0.10a	0.11a	0.11a	0.14a
Significance level						
B	ns	***	ns	ns	ns	***
G	ns	*	ns	ns	ns	ns
B × G	ns	**	ns	ns	ns	**
SEM						
B	0.016	0.006	0.004	0.008	0.005	0.003
G	0.004	0.005	0.002	0.004	0.002	0.002
B × G	0.010	0.011	0.004	0.010	0.004	0.005
Mean	0.10	0.16	0.10	0.11	0.11	0.14
CV (%)	16.93	11.46	7.32	15.37	6.19	5.74

Means in a column for each factor followed by the same letter(s) are not significantly different at P≤0.05 using Duncan's new multiple range tests (DNMRT), *, **, *** represent significant at P≤0.05, P≤0.01 and P≤0.001 respectively, ns = not significant at P>0.05, CFRR = chemical fertilizer recommended rate, SEM = standard error of mean.

Table 8. P content (%) in grains and root of aerobic rice as influenced by interaction between biofertilizer × genotypes during main season.

Genotype	BF0	BF1	BF2	BF3	BF4
Grains					
MR219-4	0.13a	0.11a	0.18a	0.12a	0.30a
MR219-9	0.14a	0.09a	0.11b	0.12a	0.34a
MRIA1	0.1a	0.10a	0.13b	0.10a	0.30a
Root					
MR219-4	0.13a	0.17a	0.13a	0.15ab	0.12a
MR219-9	0.12a	0.167a	0.13a	0.14b	0.13a
MRIA1	0.13a	0.15b	0.13a	0.17a	0.13a

Means in a column for each plant part followed by the same letter(s) are not significantly different at P≤0.05 using Duncan's new multiple range test (DNMRT), BF0 = CFRR 100%, BF1 = biofertilizer 1 ton + 75% CFRR, BF2 = biofertilizer 2 tons + 50% CFRR, BF3 = biofertilizer 3 tons + 25% CFRR, BF4 = biofertilizer 4 tons, CFRR = chemical fertilizer recommended rate.

+ 25% CFRR respectively and were at par to each other. In main season, MR219-4 recorded the highest (1.95%) in biofertilizer 2 tons + 50% CFRR and the least (1.61 and 1.41%) in CFRR 100% and in biofertilizer 1 ton + 75% CFRR. MR219-9 recorded the highest (1.59%) in biofertilizer 3 tons + 25% CFRR while MRIA1 recorded the highest (1.87 and 2.05%) in CFRR 100% and in biofertilizer 1 ton + 75% CFRR, respectively and the least (1.32%) in biofertilizer 3 tons + 25% CFRR.

N uptake in grains, straw, and root

There was significant (p<0.05) effect of biofertilizer in straw and root in both seasons, genotypes in grains, straw and root in both seasons except in straw in off season, and all the interactions effect except in grains in main season and in straw in off season on N uptake (Table 11). In both off and main season, the highest N uptake in straw (67.86 and 53.24 kg ha^{-1}) was by plants

Table 9. K content (%) in grains, straw and root of aerobic rice as influenced by biofertilizer, genotypes and their interactions during off and main season.

Treatments	Grains		Straw		Root	
	Off season	Main season	Off season	Main season	Off season	Main season
Biofertilizer (ha^{-1}) (B)						
CFRR 100%	0.31b	0.29b	1.87a	1.70ab	0.85a	0.71a
Biofertilizer 1 ton + 75% CFRR	0.31b	0.28b	1.85a	1.71ab	0.88a	0.70a
Biofertilizer 2 tons + 50% CFRR	0.32ab	0.30ab	1.87a	1.82a	0.85a	0.74a
Biofertilizer 3 tons + 25% CFRR	0.35a	0.30b	1.84a	1.49c	0.86a	0.70a
Biofertilizer 4 tons	0.34ab	0.36a	1.97a	1.60bc	0.88a	0.72a
Genotypes (G)						
MR219-4	0.31b	0.32a	1.82b	1.63b	0.85a	0.70a
MR219-9	0.32b	0.33a	1.85b	1.60b	0.88a	0.71a
MRIA1	0.35a	0.27b	1.98a	1.75a	0.86a	0.73a
Significance level						
B	ns	ns	ns	***	ns	ns
G	**	***	**	***	ns	ns
B × G	ns	ns	*	***	ns	ns
SEM						
B	0.010	0.019	0.039	0.035	0.022	0.020
G	0.008	0.009	0.036	0.019	0.022	0.014
B × G	0.018	0.019	0.080	0.043	0.049	0.031
Mean	0.33	0.31	1.88	1.66	0.86	0.71
CV (%)	9.40	10.77	7.37	4.51	9.78	7.62

Means in a column for each factor followed by the same letter(s) are not significantly different at P≤0.05 using Duncan's new multiple range tests (DNMRT), *, **, *** represent significant at P≤0.05, P≤0.01 and P≤0.001 respectively, ns = not significant at P>0.05, CFRR = chemical fertilizer recommended rate, SEM = standard error of mean.

Table 10. K content (%) in straw of aerobic rice as influenced by interaction between biofertilizer × genotypes during off and main season.

Treatment	BF0	BF1	BF2	BF3	BF4
Off season					
MR219-4	1.74a	1.93a	1.69b	1.80b	1.92a
MR219-9	1.95a	1.84a	1.90ab	1.64b	1.91a
MRIA1	1.93a	1.80a	2.02a	2.08a	2.09a
Main season					
MR219-4	1.61b	1.41c	1.95a	1.55a	1.64a
MR219-9	1.63ab	1.67b	1.52b	1.59a	1.58a
MRIA1	1.87a	2.05a	1.94a	1.32b	1.57a

Means in a column for each season followed by the same letter(s) are not significantly different at P≤0.05 using Duncan's new multiple range test (DNMRT), BF0 = CFRR 100%, BF1 = biofertilizer 1 ton + 75% CFRR, BF2 = biofertilizer 2 tons + 50% CFRR, BF3 = biofertilizer 3 tons + 25% CFRR, BF4 = biofertilizer 4 tons, CFRR = chemical fertilizer recommended rate.

in CFRR 100% at par with biofertilizer 1 ton + 75% CFRR. The other biofertilizer treatments were all similar recording the least. In the case of root, there was higher uptake by plants in CFRR 100% in off season different from the other biofertilizer treatments. Similar to straw, the other biofertilizer treatments were all similar recording the least. Biofertilizer 1 ton + 75% CFRR recorded the highest (17.31 kg ha^{-1}) at par with biofertilizer 3 tons + 25% CFRR in main season while biofertilizer 4 tons recorded the least (12.63 kg ha^{-1}) at par with biofertilizer 2 tons + 50% CFRR. MR219-4 recorded the highest (74.67 and 33.61 kg ha^{-1}) N uptake in grains and root respectively in off season while MR219-9 recorded the highest (18.25 kg ha^{-1}) N uptake in root in the main season. MR219-4 and MR219-9 were similar in grains and straw in the main season. MRIA1 recorded different and lowest N uptake in grains, straw, and root in both seasons.

Table 11. N uptake (kg ha^{-1}) in grains, straw and root of aerobic rice as influenced by biofertilizer, genotypes and their interactions during off and main season.

Treatments	Grains		Straw		Root	
	Off season	Main season	Off season	Main season	Off season	Main season
Biofertilizer (ha^{-1}) (B)						
CFRR 100%	57.72a	35.13ab	67.86a	53.24a	27.99a	15.48b
Biofertilizer 1 ton + 75% CFRR	60.13a	32.26ab	64.12a	44.86ab	22.75b	17.31a
Biofertilizer 2 tons + 50% CFRR	42.93b	28.99b	48.47b	37.68bc	19.52c	13.14c
Biofertilizer 3 tons + 25% CFRR	56.54a	28.88b	49.49b	34.44c	20.21c	16.03ab
Biofertilizer 4 tons	53.13ab	37.88a	43.31b	38.28bc	21.19bc	12.63c
Genotypes (G)						
MR219-4	74.67a	34.30a	49.48b	47.96a	33.61a	17.16b
MR219-9	62.13b	37.59a	57.80a	45.46a	24.97b	18.25a
MRIA1	25.48c	25.99b	56.68ab	31.69b	8.43c	9.35c
Significance level						
B	ns	ns	***	**	***	***
G	***	**	ns	***	***	***
B × G	*	ns	ns	**	***	***
SEM						
B	3.75	2.49	2.42	2.95	0.74	0.42
G	2.739	2.060	2.617	1.933	0.679	0.304
B × G	6.123	4.607	5.852	4.322	1.518	0.681
Mean	54.09	32.63	54.65	41.70	22.33	14.92
CV (%)	19.61	24.46	18.55	17.95	11.78	7.90

Means in a column for each factor followed by the same letter(s) are not significantly different at P≤0.05 using Duncan's new multiple range tests (DNMRT), *, **, *** represent significant at P≤0.05, P≤0.01 and P≤0.001 respectively, ns = not significant at P>0.05, CFRR = chemical fertilizer recommended rate, SEM = standard error of mean.

Table 12. N uptake (kg ha^{-1}) in grains, straw and root of aerobic rice as influenced by interaction between biofertilizer × genotypes during off and main season.

Treatments	BF0		BF1		BF2		BF3		BF4	
	Off season	Main season	Off season	Main season	Off season	Main season	Off season	Main season	Off season	Main season
Grains										
MR219-4	87.19a	-	73.76a	-	56.72a	-	68.47a	-	87.21a	-
MR219-9	54.84b	-	73.73a	-	54.91a	-	67.97a	-	59.20b	-
MRIA1	31.14b	-	32.91b	-	17.16b	-	33.19b	-	12.98c	-
Straw										
MR219-4	-	70.81a	-	40.99ab	-	45.07a	-	41.65a	-	41.25a
MR219-9	-	54.94b	-	60.50a	-	35.47a	-	35.02a	-	41.35a
MRIA1	-	33.96c	-	33.08b	-	32.51a	-	26.65a	-	32.24a
Root										
MR219-4	30.86b	20.40a	29.66a	20.61a	34.54a	18.59a	30.45a	12.81b	42.54a	13.37a
MR219-9	38.64a	21.16a	26.04a	18.59b	20.87b	12.44b	21.60b	24.07a	17.68b	15.00a
MRIA1	14.48c	4.89b	12.55b	12.74c	3.15c	8.38c	8.60c	11.197b	3.35c	9.52b

Means in a column for each plant part followed by the same letter(s) are not significantly different at P≤0.05 using Duncan's new multiple range test (DNMRT), BF0 = CFRR 100%, BF1 = biofertilizer 1 ton + 75% CFRR, BF2 = biofertilizer 2 tons + 50% CFRR, BF3 = biofertilizer 3 tons + 25% CFRR, BF4 = biofertilizer 4 tons, CFRR = chemical fertilizer recommended rate.

The interaction between biofertilizer × genotypes on N uptake in grains, straw, and root is presented in (Table 12). In N uptake in grains, MR219-4 and MR219-9 were similar in all biofertilizer treatments except in CFRR 100% and biofertilizer 4 tons in which MR219-4 recorded the highest (87.19 and 87.21 kg ha^{-1}), respectively. MR219-9 was at par with MRIA1 in CFRR 100% but different in biofertilizer 4 tons. In terms of N uptake in straw, MR219-4 recorded the highest (70.81 kg ha^{-1}) in CFRR 100% in the main season different from the other genotypes while in biofertilizer 1 ton + 75% CFRR, MR219-9 recorded the highest (60.50 kg ha^{-1}). The genotypes differed from each other in N uptake in root in both season except in biofertilizer 1 ton + 75% CFRR in off season, in CFRR100%

Table 13. P uptake (kg ha^{-1}) in grains, straw and root of aerobic rice as influenced by biofertilizer, genotypes and their interactions during off and main season.

Treatments	Grains		Straw		Root	
	Off season	Main season	Off season	Main season	Off season	Main season
Biofertilizer (ha^{-1}) (B)						
CFRR 100%	4.42a	4.66b	5.62a	5.65a	2.98a	1.41c
Biofertilizer 1 ton + 75% CFRR	4.47a	3.97b	4.84b	4.49b	2.53b	2.16a
Biofertilizer 2 tons + 50% CFRR	4.55a	4.67b	4.54bc	3.91b	1.92c	1.40c
Biofertilizer 3 tons + 25% CFRR	3.41a	3.85b	4.57bc	3.28b	1.85c	1.67b
Biofertilizer 4 tons	2.59a	9.59a	4.14c	3.31b	1.95c	1.17d
Genotypes (G)						
MR219-4	5.01a	6.36a	4.70ab	4.60a	3.27a	1.82a
MR219-9	4.89a	6.05a	4.27b	4.47a	2.56b	1.88a
MRIA1	1.77b	3.63b	5.26a	3.32b	0.91c	1.00b
Significance level						
B	ns	***	**	**	***	***
G	***	***	**	**	***	***
B × G	ns	ns	ns	ns	***	***
SEM						
B	0.771	0.591	0.174	0.354	0.106	0.041
G	0.290	0.341	0.218	0.274	0.046	0.023
B × G	0.648	0.763	0.487	0.612	0.102	0.051
Mean	3.89	5.35	4.74	4.13	2.25	1.56
CV (%)	28.87	24.70	17.78	25.67	7.87	5.67

Means in a column for each factor followed by the same letter(s) are not significantly different at P≤0.05 using Duncan's new multiple range tests (DNMRT), *, **, *** represent significant at P≤0.05, P≤0.01 and P≤0.001 respectively, ns = not significant at P>0.05, CFRR = chemical fertilizer recommended rate, SEM = standard error of mean.

and biofertilizer 4 tons in main season in which MR219-4 and MR219-9 were at par. In biofertilizer 3 tons + 25% CFRR in the main season, MR219-4 and MRIA1 were comparable. MR219-9 recorded the highest (38.64 and 24.07 kg ha^{-1}) in CFRR 100% in off and biofertilizer 3 tons + 25% CFRR in the main season respectively while MR219-4 recorded the highest in the remaining biofertilizer treatments in both seasons. MRIA1 recorded the least in both biofertilizer treatments in both seasons.

P uptake in grains straw and root

There was significant (p<0.05) effect of biofertilizer and genotypes in P uptake in grains, straw, and root in both seasons except biofertilizer in grains in off season. Interactions effect on P uptake in root in both seasons was also found to be significant (p<0.05) (Table 13). In the off-season, the highest P uptake in straw and root (5.62 and 2.98 kg ha^{-1}) was by plants in CFRR 100% while the lowest (4.14 and 1.85 kg ha^{-1}) was recorded by plants in biofertilizer 4 tons and biofertilizer 3 tons + 25% CFRR, respectively. In main season, the highest (9.59, 5.65 and 2.16 kg ha^{-1}) was by plants in biofertilizer 4 tons, CFRR 100% and biofertilizer 1 ton + 75% CFRR in grains, straw, and root, respectively. While the lowest (3.85 and 3.28 kg ha^{-1}) was recorded by biofertilizer 3 tons + 25% CFRR in grains and in the root, the lowest (1.17 kg ha^{-1}) was from biofertilizer 4 tons. In the off-season, MRIA1 and MR219-4 recorded the highest (104.52 and 64.04 kg ha^{-1}) while in off season, MR219-9 and MRIA1 recorded the lowest (5.62 and 3.27 kg ha^{-1}) P uptake in straw and root respectively. MR219-4 and MR219-9 were similar in P uptake in grains while MRIA1 recorded different and lowest values in all (grains, straw, and root) in both seasons except in straw in the main season.

The interaction between biofertilizer × genotypes on P uptake in the root is presented in (Table 14). In off-season, MR219-9 recorded the highest (3.95 kg ha^{-1}) P uptake in root different from the other genotypes in CFRR 100% while in the other biofertilizer treatments, MR219-4 recorded the highest values different from the other genotypes in biofertilizer 1 ton + 75% CFRR and biofertilizer 4 tons but at par with MR219-9 in biofertilizer 2 tons + 50% CFRR and biofertilizer 3 tons + 25% CFRR. In main season, MR219-4 recorded the highest (2.02 and 1.98 kg ha^{-1}) in CFRR 100% and biofertilizer 2 tons + 50% CFRR while MR219-9 recorded the highest (2.45 and 1.35 kg ha^{-1}) in biofertilizer 3 tons + 25% CFRR and biofertilizer 4 tons but at par with MR219-4 in biofertilizer 1 ton + 75% CFRR. In both seasons and biofertilizer treatments, MRIA1 recorded the lowest and different values.

Table 14. P uptake (kg ha^{-1}) in root of aerobic rice as influenced by interaction between biofertilizer × genotypes during off and main season.

Treatments	BF0	BF1	BF2	BF3	BF4
Off season					
MR219-4	3.46b	3.71a	2.88a	2.42a	3.90a
MR219-9	3.94a	2.34b	2.59a	2.32a	1.62b
MRIA1	1.55c	1.54c	0.28b	0.82b	0.34c
Main season					
MR219-4	2.02a	2.51a	1.98a	1.46b	1.13b
MR219-9	1.70b	2.57a	1.35b	2.45a	1.35a
MRIA1	0.51c	1.40b	0.88c	1.12c	1.04b

Means in a column for each season followed by the same letter are not significantly different at P≤0.05 using Duncan's new multiple range test (DNMRT), BF0 = CFRR 100%, BF1 = biofertilizer 1 ton + 75% CFRR, BF2 = biofertilizer 2 tons + 50% CFRR, BF3 = biofertilizer 3 tons + 25% CFRR, BF4 = biofertilizer 4 tons, CFRR = chemical fertilizer recommended rate.

Table 15. K uptake (kg ha^{-1}) in grains, straw and root of aerobic rice as influenced by biofertilizer, genotypes and their interactions during off and main season.

Treatments	Grains		Straw		Root	
	Off season	Main season	Off season	Main season	Off season	Main season
Biofertilizer (ha^{-1}) (B)						
CFRR 100%	12.77a	10.59a	96.43a	76.24a	23.54a	8.23b
Biofertilizer 1 ton + 75% CFRR	13.10a	10.76a	87.32ab	65.80ab	22.49a	9.16a
Biofertilizer 2 tons + 50% CFRR	11.84ab	10.00a	82.73ab	64.11ab	15.95b	7.95b
Biofertilizer 3 tons + 25% CFRR	13.57a	10.12a	84.29ab	49.00c	14.55b	7.63b
Biofertilizer 4 tons	9.60b	11.04a	77.00b	51.56bc	14.41b	6.51c
Genotypes (G)						
MR219-4	15.53a	12.04a	80.86b	67.82a	25.75a	8.95b
MR219-9	14.53a	12.78a	75.55b	66.15a	21.34b	9.67a
MRIA1	6.46b	6.69b	100.25a	50.05b	7.48c	5.07c
Significance level						
B	ns	ns	ns	**	***	***
G	***	***	**	***	***	***
B × G	ns	ns	ns	ns	***	***
SEM						
B	0.910	1.003	4.042	4.383	0.660	0.213
G	0.537	0.574	4.718	3.094	0.560	0.174
B × G	1.200	1.283	10.549	6.918	1.251	0.389
Mean	12.18	10.50	85.55	61.34	0.52	7.90
CV (%)	17.07	21.15	21.36	19.53	11.91	8.54

Means in a column for each factor followed by the same letter(s) are not significantly different at P≤0.05 using Duncan's new multiple range tests (DNMRT), *, **, *** represent significant at P≤0.05, P≤0.01 and P≤0.001 respectively, ns = not significant at P>0.05, CFRR = chemical fertilizer recommended rate, SEM = standard error of mean.

K uptake in grains shoots and roots

There was significant (p<0.05) effect of biofertilizer on K uptake in grains in main season and in root in both seasons, genotypes in grains, straw and root in both seasons and interaction effect between biofertilizer × genotypes on K uptake in root in both seasons (Table 15). The highest K uptake in straw (76.24 kg ha^{-1}) was by plants in CFRR 100% while the lowest (49.00 kg ha^{-1}) was recorded by plants in biofertilizer 3 tons + 25% CFRR, at par with biofertilizer 4 tons. Plants in CFRR 100% and biofertilizer 1 ton + 75% CFRR recorded the highest (23.54 and 9.16 kg ha^{-1}) K uptake in root in off and main season respectively. Biofertilizer 4 tons recorded the lowest (14.14 and 6.51 kg ha^{-1}) in off and main season, respectively. MRIA1, MR219-4,and MR219-9

Table 16. K uptake (kg ha^{-1}) in root of aerobic rice as influenced by interaction between biofertilizer × genotypes during off and main season.

Treatments	BF0	BF1	BF2	BF3	BF4
Off season					
MR219-4	26.82b	33.07a	24.22a	17.45a	27.18a
MR219-9	32.22a	19.70b	21.51a	19.85a	13.41b
MRIA1	11.58c	14.70c	2.12b	6.37b	2.64c
Main season					
MR219-4	11.58a	9.65b	10.00a	6.77b	6.73ab
MR219-9	10.21a	11.62a	8.27b	11.32a	6.94a
MRIA1	2.90b	6.21c	5.57c	4.78c	5.87b

Means in a column for each season followed by the same letter(s) are not significantly different at P≤0.05 using Duncan's new multiple range test (DNMRT), BF0 = CFRR 100%, BF1 = biofertilizer 1 ton + 75% CFRR, BF2 = biofertilizer 2 tons + 50% CFRR, BF3 = biofertilizer 3 tons + 25% CFRR, BF4 = biofertilizer 4 tons, CFRR = chemical fertilizer recommended rate.

recorded the highest (100.25, 25.75 and 9.67 kg ha^{-1}) in straw in off season, in root in off and main season, respectively. MR219-4 and MR219-9 were similar in grains and straw in both seasons while MRIA1 recorded different and lowest values in grains and root in both seasons, in straw in the main season. The interaction between biofertilizer × genotypes on K uptake in the root is presented in (Table 16). In off-season, MR219-9 recorded the highest (32.22 kg ha^{-1}) P uptake in root different from the other genotypes in CFRR 100% while in biofertilizer 1 ton + 75% CFRR and biofertilizer 4 tons, MR219-4 recorded the highest (33.07 and 27.18 kg ha^{-1}), respectively different from the other genotypes but at par with MR219-9 in biofertilizer 2 tons + 50% CFRR and biofertilizer 3 tons + 25% CFRR. In main season, MR219-9 recorded the highest (11.62 and 11.32 kg ha^{-1}) in biofertilizer 1 ton + 75% CFRR and biofertilizer 3 tons + 25% CFRR respectively while MR219-4 recorded the highest (10.00 kg ha^{-1}) in biofertilizer 2 tons + 50% CFRR different from the other genotypes. MR219-4 and MR219-9 were similar in CFRR 100% and biofertilizer 4 tons. In both seasons and biofertilizer treatments, MRIA1 recorded the lowest.

DISCUSSION

The highest grain yield and root dry weight recorded in biofertilizer 1 ton + 75% CFRR might be that in this treatment macro nutrient elements such as Nitrogen, Phosphorus and Potassium were readily available to plants at earlier stages of plant growth then followed by atmospheric N fixation and solubilization of insoluble Phosphorus by microorganisms contained in the biofertilizer. Habibi *et al.* (2011) intensely advocated the use of combined strains (biofertilizers) in combination with half amount of chemical fertilizers and organic in medicinal pumpkin have led to the highest grain yield and oil yield. These researchers publicized that about 50% of the nitrogen and phosphorus fertilizers requirement can be substituted by organic and biofertilizers because organic and biofertilizers enhanced use efficiency of the suggested nitrogen and phosphorus fertilizers and abridged cost of the chemical fertilizers, furthermore stopped polluting the environment with the broad use of chemical fertilizers. It was reported by Radhakrishnan, (1996) that *Azospirillum* and phosphor-bacteria inoculation have caused root biomass to be higher and added number of bolls in cotton. Tran *et al.* (2006) stated that Bradyrhizobia and PSB (*Pseudomonas* sp) application in the soybean crop led to a considerable improvement in a nodules number and dry weight, yield contributing characters, grain yield, availability and uptake of soil nutrient.

Application of biofertilizer influenced the nutrients content in rice grain. There was greater variation in nutrient content in the grains, straw and root tissues between the treatments. The highest grains, straw and root nutrients content found in biofertilizer 4 tons and biofertilizer 1 ton + 75% CFRR treatments might probably be owing to added fixation of nitrogen by the N fixing bacteria causing superior use of all other nutrients by the plants. Biofertilizer application had been found to generally enhance the tissue N content than P and K. These findings support those of Dubey *et al.* (2012). Alternatively, it might be that the main role of soil P mobilization and increased P bioavailability by bacteria used in the biofertilizer were properly executed (Panhwar *et al.*, 2015a; Zhang *et al.*, 2009; Panhwar, *et al.*, 2015b) with decreasing P adsorption owing to struggle for enthusiastic sites in adsorption and dissolution of unsolvable P compounds like Ca, Fe and Al phosphates (Bolan *et al.*, 1994; Storm *et al.*, 2002). Radziah and Panhwar (2014) testified that PSB application plays an important role in providing P to developing plants. Applying PSB strains aids in solubilization of P which is higher than soil and plant absorption significantly increase yield in aerobic rice. The significant higher phosphorus content recorded in biofertilizer 2 tons + 50% CFRR and in biofertilizer 4 tons than the other treatments in rice grains and straw could be elucidated by an increase in P availability to plant due to the application of phosphate bacteria. Due to better shielding capability of biofertilizer for initial moisture hassle and improving phosphorus accessibility to plants thereby higher phosphorus content in plants was also expected (Rizvi *et al*., 2013). Nitrogen fertilization of rice upsurges the cation exchange (CEC) of root capability, permitting them to absorb more nitrogen from the soil, therefore N and later, P may have been used in larger quantities due to its availability (Nadeem *et al*., 2004). Usage of greater dosage of nitrogen in CFRR 100% might have aided in promoting good vegetative growth and root system, which improved the greater N uptake by plants (Paikaray *et al*., 2001; Mhaskar and Thorat, 2005; Sharma *et al*., 2007). Also, a significant increase in nutrient uptake observed with application of CFRR 100% might be due to minimum losses and maximum increase in plant growth and might be due to application of nitrogen to equalize the crop request at diverse physiological phases and reflected in recording the higher nutrient uptake and recovery fraction of applied nutrients due to the minimum loss of nitrogen. PSB inoculation and oxalic acid application increased P uptake in aerobic rice (Panhwar *et al*., 2013). Generally, there was high nutrient content and uptake in off season of low rainfall than the main season. This might be due to some microorganisms exert their actions in either aerobic or anaerobic condition. Yadava *et al.* (2014) reported that Azotobacter fixes N under aerobic conditions, while Azospirillum fixes N under anaerobic condition and cumulatively, they showed significant effect on uptake of P and N by rice crop Increase in K content and uptake might be due to it synergistic correlation with N and P. The helpful effect of PSB and Azotobacter, either alone or in combination has been advocated by Singh *et al.* (2008) in rice-wheat cropping system. The resultant increase in P uptake above control could be due to the bacterial solubilization of insoluble phosphate in the soil. These bacteria exhibited an effective starring role in P uptake and growth advancement of plants by dissolution of inorganic insoluble phosphate as also reported by Narula *et al*. (2000). Other scientist reported that the effect of the inoculation of a assortment of numerous free-living rhizobacteria; Azotobacter, Bacillus, Enterobacter, and Xanthobacter have significantly enhanced nitrogen accumulation, growth and grain yield of rice plants (Mirzai *et al*., 2010; Bal *et al*., 2013). Numerous researchers stated that PGPR (plant growth promoting rhizobia) and PSB strains were used as proficient bio-inoculants for increasing growth characteristic, yield and nutrient content of rice crops (Khalid *et al*., 2009; Singh *et al*., 2011; Manivannan, 2011). Rodgers and Barneix, (1988) also ascribed genotypic dissimilarities in nitrate uptake to their discrepancy in growth rates. Hence, for the rate of uptake, the 'demand factor' is one of the essential bases, as the greater the growth rate, the greater the N uptake.

Conclusion

The combination of a microbial consortium of nitrogen-fixing bacteria conglomeration (*Bacillus sp*. Sb35 and 42) and bacteria for the solubilization of phosphate (*Bacillus sp*. PSB16) could be salvaged as adept bi-inoculants for integrated nutrient management for sustainable aerobic rice production. It is eco-friendly and substitute for chemical fertilizer for aerobic rice production as well as improves the soil productiveness and wellbeing. It can be concluded that application of biofertilizer 1 ton + 75% CFRR increases grain yield and biofertilizer 4 tons increase nutrient uptake of MR219-4 and MR219-9.

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