

Original Research Article

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Effects of PGPR on Micronutrients Availability in Soil and Its Translocation in Rice under Loamy Sand Textured Soil

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ABSTRACT

The field experiment was conducted on effects of PGPR on micronutrients availability in soil and its translocation in rice under loamy sand textured soil during *kharif* season of the year 2018 at Regional Research Station, Anand Agricultural University, Anand. The experiment was laid out in Randomized Block Design, comprising twelve treatment combinations of different levels of Fe and Zn with or without Bio NPK consortium (PGPR) with three replications. The soil of the experimental field was loamy sand in texture, low in organic carbon, medium in available nitrogen and phosphorus, high in available potassium and deficient in available Zn and Fe. The experimental results revealed that the application of RDF + 75% Zn + 75% Fe + Bio NPK consortium (T₁₂) recorded significantly higher grain and straw yield, N uptake by straw, K uptake by grain, S uptake by grain and straw. Maximum Fe content in grain of rice recorded with the application of RDF + 75% Fe + Bio NPK consortium (T₈). Whereas, in case of Fe content in straw and Zn content in grain and straw of rice, significantly higher with the application of RDF + 100% Zn + 100% Fe + Bio NPK consortium (T₁₀). With respect to uptake, significantly higher Fe and Zn uptake by grain and straw, Mn uptake by straw and Cu uptake by grain of rice was observed with the application of RDF + 75% Zn + 75% Fe + Bio NPK consortium (T₁₂). The soil available N, P₂O₅, K₂O, S, Zn and Mn after harvest of rice crop were influenced due to different treatments but did not reach the level of significance. Maximum *Azotobacter*, *Azospirillum*, PSB and KMB population of soil was found in treatment T₁₂ (RDF + 75% Zn + 75% Fe + Bio NPK consortium) over control. Thus, the beneficial effect of PGPR was observed to increase rice yield as well as Fe and Zn content in rice.

Keywords

Rice, Bio NPK consortium (PGPR), micronutrient, Content and uptake

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Introduction

Rice is the most important staple food in several developing countries and chemical fertilizer is the most important input required for rice cultivation. The high-yielding rice variety has resulted in an increase in rice production but requires large amounts of

chemical fertilizers, leading to health hazards and environmental pollution. Globally, rice is grown on about 167.4 m ha with a total production of 759.6 million tonnes annually. Of this, Asia accounts for about 90 per cent of the total production and consumption (Anon., 2017). India is the largest rice growing country, covering an area of about 43.19 m ha

with the production and productivity of 110.15 million tones and 2.55 t/ha of rice, respectively, during the year of 2016-2017 (Anon., 2017). In Gujarat, rice is cultivated on an area of 8.36 lakh ha with total production of 17.90 lakh tonnes per annum and productivity of 2142 kg/ha during 2011-12 (Anon., 2017). This crop is mainly grown during *kharif* and summer season in some districts of South Gujarat beside some districts of middle Gujarat where perennial canal irrigation facilities are available.

The crucial role played by micronutrients in enhancing food-grain production in India is now a well-recognized fact. Widespread micronutrient deficiencies in soil, now being recorded all over the country which resulted in severe losses in crop yield as well as in nutritional quality too. It is estimated that nearly half of the soils on which food crops are grown, are deficient in Zn Next to Zn, B (33%) and Fe (15%) deficiencies are also limiting the crop production to a large extent besides lower contents of these elements. In Gujarat the deficiency of Zn and Fe is about 25 per cent in different soils. In some light textured soils of Gujarat, multi-micronutrient deficiencies are also reported (Anon., 2018). Extensive micronutrient deficiencies lead to decline in factor productivity even with balanced NPK fertilization. Although the crop response to micronutrients application varies with soil type, crops and genotype, agro-climatic conditions and severity of deficiency, an enormous response to micronutrient fertilization has been reported in a wide variety of crops including horticultural crops across the country (Shukla *et al.*, 2012).

In recent years, biofertilizers have been emerged as a supplement to mineral fertilizer and hold a promise to improve the yield of crops. The biofertilizers are found positive contribution to soil fertility, resulting in an increase in crop yield without causing any

environmental, water or soil hazards. N₂ fixer, P solubilizing bacteria and Potassium mobilizing bacteria play an important role in plant nutrition.

Further, the microbes are potential alternate that could cater plant zinc and iron requirement by solubilizing the complex zinc in soil. Several bacteria living in plant rhizosphere promote plant growth directly or indirectly, such bacteria are generally designated as PGPR (plant-growth-promoting rhizobacteria) or also called 'Plant Probiotics'. Examples of direct plant growth promotion are (a) bio fertilization by nutrient acquisition, (b) stimulation of root growth, (c) rhizoremediation and (d) plant stress management - biotic and abiotic. Mechanisms of biological control by which rhizobacteria can promote plant growth indirectly, *i.e.*, by reducing the level of disease and pests which include antibiosis, induction of systemic resistance and competition for nutrients and niches. Many scientists world over have supported consortium (multiple microbial community) approach for bio fertigation and biological control. Study of biodiversity of PGPR from agricultural land is need to be taken up for benefit of farmers through Enumeration, Quantitative and Qualitative analysis of agriculturally beneficial bacteria (Subhashini *et al.*, 2016).

Materials and Methods

For achieving the objective of present investigation, a field experiment entitled, Effects of PGPR on micronutrients availability in soil and its translocation in rice under loamy sand textured soil during the *kharif* season of the year 2018. The experiment was conducted at Regional Research Station, Anand Agricultural University, Anand. The experiment consists of twelve treatments *i.e.* T₁- Control, T₂- RDF + 100% Zn, T₃- RDF + 100% Fe, T₄- RDF + Bio NPK Consortium

(PGPR), T₅- RDF + 100% Zn + Bio NPK Consortium (PGPR), T₆- RDF + 75% Zn + Bio NPK Consortium (PGPR), T₇- RDF + 100% Fe + Bio NPK Consortium (PGPR), T₈- RDF + 75% Fe + Bio NPK Consortium (PGPR), T₉- RDF + 100% Zn + 100% Fe, T₁₀- RDF + 100% Zn + 100% Fe + Bio NPK Consortium (PGPR), T₁₁- RDF + 75% Zn + 75% Fe, T₁₂- RDF + 75% Zn + 75% Fe + Bio NPK Consortium (PGPR). The experimental field was ploughed and cross cultivated by tractor drawn cultivar. Then after, field was leveled with the help of wooden plank. Field was allowed to water logged condition by excess irrigation and puddling was done using tractor drawn puddler. After constant levels of water height in the field, Blocks were prepared perpendicular to fertility gradient and separate plots were formed by raising bunds on outer side of plots to avoid mixing of water and fertilizer. After preparing individual plots, transplanting was done using 25 DAS seedling at specified spacing (20 cm x 15 cm) in each plots. The common application of recommended dose of fertilizer was applied on plot basis. For basal application 50% of nitrogen in each plot i.e. 50 kg/ha in form of urea after transplanting was applied. Remaining 50% of nitrogen (50 kg/ha) was applied in the form of urea after 30 days transplanting. The nutrient content and uptake by paddy was recorded after harvesting. Representative composite soil sample from 0-15 cm depth were collected initially from the entire experimental site and from each plot after the harvest of rice crop. For better representation, soil samples were prepared by mixing the soil collected from five-six spots from the plots randomly. The soil samples were air-dried and grounded to pass through 2 mm sieve. The soil samples were labeled and stored in polythene lined cotton bags for further analysis. The soil of the experimental field was *Typic Ustochrepts*, loamy sand in texture and had pH_{1:2.5}-7.32, EC_{1:2.5}-0.31 dS/m, organic carbon-0.34%, available N- 250

kg/ha, available P₂O₅- 28 kg/ha, available K₂O- 242 kg/ha, available S- 10.11 mg/kg, available Fe- 2.35 mg/kg, available Zn- 0.12 mg/kg, available Mn- 6.62 mg/kg, available Cu- 0.96 mg/kg and analysis methods are given in Table 1. Whole biomass of rice grain and straw from each replication were sampled separately for recording dry biomass and analyzing nutrient content *viz.*, N, P, K, S, Fe, Mn, Zn and Cu from grain and straw. The collected samples were washed with distilled water and dried in oven at 65±70°C till constant weight achieved. Subsequently, the dried samples were powdered using Willey mill and stored in clean polythene zip-bags for chemical analysis. All the data recorded during the study period were statistically analyzed by using standard methods as suggested by Steel and Torrie (1982).

Results and Discussion

Yield

The different treatments significantly influenced the grain and straw yield (kg/ha) of rice. The maximum grain (5821 kg/ha) and straw (4973 kg/ha) yield recorded under T₁₂ (RDF + 75% Zn + 75% Fe + Bio NPK consortium) was on par with the treatments T₁₀ and T₁₁ in grain yield but in case of straw yield it was statistically similar with T₈, T₉, T₁₀ and T₁₁. The results indicated that the application of 75% dose of Zn and Fe found beneficial to improve the rice yield. Similar findings have been reported by Kaz Ali *et al.*, (2017) found that *Azospirillum lipoferum* inoculation increased rice tiller numbers and subsequently the grain yield. Thus it is hypothesized that these bacterial inoculations could also lead to improve the grain yield (Kaz Ali *et al.*, 2017). The coinoculation of PGPR microorganisms and their synergistic effect on plant growth by increased nutrients uptake lead to the yield increase when compared to the control plants. Similar result

was obtained by the Ahmed *et al.*, (2013) and Vaid *et al.*, (2014) in their experiments. The significant effect of the treatment in increasing grain and straw yield of rice might be due to positive effect of treatments on growth parameters and yield attributes during growth period. This might be due to the inoculation of nitrogen fixer, P solubilizer and plant growth promoting substances producing organisms and their role in the increased availability of nutrients to the crop plants. Similar result was reported by the Sadaghiani *et al.*, (2014), Ahmed *et al.*, (2013) and Ashrafuzzaman *et al.*, (2009).

Nutrient content and uptake

The application of different treatments does not affect significantly on N, P, K, S, Mn and Cu content in rice grain and straw. Treatment T₁₂ (RDF + 75% Zn + 75% Fe + Bio NPK Consortium) significantly resulted higher nitrogen uptake by straw (36.70 kg/ha) However, it remained at par with T₅, T₈, T₉, T₁₀ and T₁₁. In addition to enhancement of plant growth and yield, PGPR are directly involved in increased concentration and uptake of nitrogen and synthesis of phytohormones. This may be correlated with their ability to fulfill the N requirement of the rice crop and the application of single species may have failed to meet nitrogen requirement as mentioned by Vaid *et al.*, (2014) and Sharma *et al.*, (2014). Significantly higher phosphorus uptake (9.03 kg/ha) by rice straw was observed in T₁₀ (RDF + 100% Zn + 100% Fe + Bio NPK consortium). However, it remained at par with treatment T₉ and T₁₂. Its might be due to increased availability of P₂O₅ which was added in the soil through resources by *Azotobacter* and phosphate solubilizing bacteria. Similar results were found by Gooma *et al.*, (2015) and Yadav *et al.*, (2014). Whereas, in case of K uptake (18.78 kg/ha) by grain significantly higher with application of RDF + 75% Zn + 75% Fe + Bio

NPK consortium (T₁₂) and remained on par with T₁₀ and T₁₁. While K uptake by straw, significantly higher with application of RDF + 100% Zn + 100% Fe + Bio NPK consortium (T₁₀) (70.78 kg/ha), it remained statistical comparable with T₂, T₇, T₈, T₉, T₁₁ and T₁₂. Its might be due to the application of Bio NPK consortium which helps in mobilization of K in plant. Similar results were found by Biari *et al.*, (2008) and Mathews *et al.*, (2006). The maximum S uptake by grain (18.35 kg/ha) and straw (19.22 kg/ha) of rice was observed with application of RDF + 75% Zn + 75% Fe + Bio NPK consortium (T₁₂) remained statistically at par T₁₀ and T₁₁ in grain and T₅ to T₁₁ in straw. The reason could be due to combined application Zn and Fe with PGPR which ultimately enhanced its absorption by plants because of fair availability of sulphur in the soil resulting in increased uptake of S by rice. These findings all in accordance with Kalhapure *et al.*, (2014).

Fe content in grain and straw of rice showed significant effect of different treatments. Application of RDF + 75% Fe + Bio NPK consortium (T₈) recorded significantly higher Fe content (53.10 mg/kg) in grain of rice. It was statistically comparable with treatment T₃, T₇, T₉, T₁₀, T₁₁ and T₁₂. Whereas, in case of Fe content in straw of rice (217.3 mg/kg), significantly higher with the application of RDF + 100% Zn + 100% Fe + Bio NPK consortium (T₁₀). It was statistically at par with T₃, T₇, T₈, T₉, T₁₁ and T₁₂. With respect to Fe uptake, significantly higher Fe uptake by grain (225.4 g/ha) and straw (1075.3 g/ha) of rice was observed with the application of RDF + 75% Zn + 75% Fe + Bio NPK consortium (T₁₂). Its might be due to the application of bio consortium helped during easily growth stage which might have mobilized iron in root zone and thus easily availability of Fe. Application of bio consortium may affect nutrient mobilization. Similar result was found by Lal and Sharma (2013). Significantly higher Zn

content in grain (31.46 mg/kg) and straw (38.0 mg/kg) of rice were registered with application of RDF + 100% Zn + 100% Fe + Bio NPK consortium (T₁₀). However, it remained at par with T₂, T₅, T₆, T₉, T₁₁ and T₁₂ in grain and straw. With respect to Zn uptake, significantly higher Zn uptake by grain (133.1 g/ha) and straw (187.5 g/ha) of rice observed with the application of RDF + 75% Zn + 75% Fe + Bio NPK consortium (T₁₂). It could be due to biofertilizer application with increased the growth and yield parameters which influence and increase water and nutrition absorption causing better

plant growth. Similar results are also reported by Biari *et al.*, (2008). Application of Fe and Zn fertilizers either to soil or foliar application considerably increases Fe and Zn concentration in grain and straw of rice. These findings are in line with those reported by Patel *et al.*, (2015) and Yadav *et al.*, (2011). Maximum Mn uptake by straw (151.7 g/ha) and Cu uptake by grain (12.89 g/ha), it was significantly higher with the application of RDF + 75% Zn + 75% Fe + Bio NPK consortium (T₁₂). Similar results were also reported by Biari *et al.*, (2008) and Mathews *et al.*, (2006).

Table.1 Methods used for initial soil, after harvest of soil and plant analysis

Sr. No.	Parameters	Method	Reference
1.	pH (1:2.5 soil: water)	Potentiometry	Jackson (1973)
2.	EC (1:2.5 soil: water)	Conductometry	
3.	Organic carbon (OC)	Wet oxidation method	Walkley and Black (1934)
4.	Available N	Alkaline KMnO ₄ method	Subbiah and Asija (1956)
5.	Available P ₂ O ₅	Spectrophotometry method (0.5 M NaHCO ₃ extractable)	Olsen <i>et al.</i> , (1954)
6.	Available K ₂ O	Flame photometry (1 N NH ₄ OAc extractable)	Jackson (1973)
7.	Available S	Turbidimetry (CaCl ₂ extractable)	Williams and Steinbergs (1959)
8.	Available micronutrients (Fe, Mn, Zn, Cu)	DTPA extractable Atomic Absorption Spectroscopy	Lindsay and Norvell (1978)
C.	Plant analysis		
1.	Total N (%)	Kjeldahl's method	Tandon (1995)
2.	Total P (%)	Vanadomolybdo phosphoric acid yellow colour method (Spectrophotometry)	Jackson (1973)
3.	Total K (%)	Flame photometry	Jackson (1973)
4.	Total S (%)	Turbidimetry	Choudhary and Cornfield (1966)
5.	Total Fe, Mn, Zn and Cu (mg/kg)	Atomic Absorption Spectrophotometry	Lindsay and Norvell (1978)

Available nutrient status

The soil available N, P₂O₅, K₂O, S, Fe, Zn, Mn and Cu after harvest of rice crop were failed to any significant influence of different treatments.

Microbial population

Data revealed that all the treatments significantly superior over control at both the locations as well as on pooled basis. Maximum *Azotobacter* population

(9.10×10^6 and cfu/g of soil), *Azospirillum* population (9.03×10^6 cfu/g of soil), population of PSB (10.02×10^7 cfu/g of soil) and KMB population (9.98×10^7 cfu/g of soil) was found in samples with treatment T₁₂ (RDF + 75% Zn + 75% Fe + Bio NPK consortium) in soil, which were statistically at par with T₄, T₅, T₆, T₇, T₈, T₁₀ and T₁₁. This may be due to the availability of high root exudates and nutrients in rhizospheric soil of rice crop by Sharma *et al.*, (2014) and Abdullahi *et al.*, (2013).

The agronomic approach for optimum rice yield and enhancement of micronutrients concentration could be better accomplished with the supplementation of 75% Fe and Zn along with Bio NPK consortium (PGPR) was found comparable with 100% dose of Fe and Zn.

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