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Effect of Nutrient Management Practices on Zinc Concentration and Grain, Straw Yield of Paddy

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ABSTRACT

Rice is the predominant staple crop in developing countries in which zinc i.e., one of the essential micronutrients required in small amounts (5-100 mg/kg) in plant is mostly found deficient. The experiment was conducted with different nutrient sources along with microbial inoculants in the *kharif* season, 2016 at the research farm of ICAR research complex for the Northeastern Himalayan region situated at Barapani, Meghalaya in split-plot with three types of nutrient management practices viz,. organic, integrated nutrient management and inorganic (RDF) in the main plot and three microbial inoculants viz., *Azospirillum*, zinc solubilizing bacteria and phosphorus solubilizing bacteria in a subplot in split plot design replicated thrice. Grain yield and Zn uptake was found highest in INM and *Azospirillum*+PSB+ZnSB. On the other hand, Zn content was found highest in organic source and in *Azospirillum*+PSB+ZnSB.

Keywords Biofertilizer, FYM, INM, Microbial inoculants, RDF.

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INTRODUCTION

The most essential staple food crop in majority of developing countries is rice (*Oryza sativa*). Asia is where rice is predominantly cultivated, with China producing most of it. In terms of output, India comes in second place to China (Rathna *et al.* 2019). The area under rice crop is approximately 45 million hectares and production are 177.65 million tonnes (MoA and FW 2022). According to Maclean *et al*. (2002), Rice provides around 21% of the world's energy requirements. According to Hussain *et al.* (2012), 2.7 million people worldwide (roughly one-third of all people) are severely affected by zinc malnutrition, with populations in different countries ranging from 4 to 73% of the total (Hess *et al.* 2009) and of which mostly living in Africa and Asia (Kumssa *et al*. 2015). According to Qaswar *et al.* (2017), Zn deficiency has now become a significant threat to the nutritional security of both plants and people. A proportion of chemical fertilizer must be replaced with microbial inoculants to prevent losses and indiscriminate use of chemical fertilizers. The use of microbial inoculants (biofertilizers) is a method that offers promise for the building of future sustainable agricultural systems, given the rapidly dropping Zinc level and the need to use Zinc more efficiently. In addition to providing nutrients, these organic sources of nutrients and microbial inoculants improve the physical and biological health of the soil (Meena *et al.* 2014, Shahane *et al.* 2013). In light of this, the present experiment was conducted to determine how nutrient management techniques and microbial inoculants affect lowland rice's ability to absorb Zinc in the eastern Himalayas.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in *kharif* 2016 at the research farm of the ICAR Complex for the north-eastern Himalayan area in Umiam (Barapani), Meghalaya, which is located at an elevation of 950 meters above sea level and latitudes of 25 degrees 41 seconds and 91 degrees 55 seconds east. The climate is sub-tropical humid type. The annual maximum temperature ranges from 25–35^{o}C minimum from 15–25^{o}C during the summer with 150-250 cm rainfall. Soil was red lateritic of texture was sandy clay loam. Soil pH was 5.0, Organic carbon 2.51% (Walkley and Black method, Jackson 1973) and available Zn was 2.06 ppm (DTPA extraction, Lindsay and Norvell 1978).

Treatments details

The experiment was undertaken into a split-plot design with 12 treatment combinations having 3 replications with 3 main plot treatments viz., 1. 100% organic, 2. 100% inorganic (recommended dose of fertilizer) and 3. INM (75% RDF+ 25% FYM) and 4 subplot treatments comprising of different microbial inoculation viz., 1. control, 2. *Azospirillum,* 3. *Azospirillum* with PSB, 4. *Azospirillum* with PSB and ZnSB in subplots. In the organic treatment, nutrient supplementation was provided using farmyard manure (FYM) applications. For the inorganic nutrient management approach, Urea, SSP, and MOP were used in the ratios of 80: 60: 40 kg/ha each to apply nitrogen (N), phosphorus (P), and potassium (K). In the organic plot, the nutrient requirement was fulfilled by farm yard manure and rock phosphate. However, in the INM plots, the nutrient application consisted of a 75% RDF (recommended dose of fertilizer) combined with 25% FYM. The seedlings' roots were submerged in the solution after the biofertilizers had been dissolved in water at the required concentration. The experiment was done on a popular local rice variety known as 'Shahsarang 1'.

Zn concentration and uptake in plant samples

According to the method outlined by Prasad *et al.* (2006), the amount of Zn in the dry matter of the grains and straw of the rice crop was determined. Zn absorption in rice grains and straw was estimated by dividing the yield in g/ha of rice grains and straw by the corresponding concentrations. By combining the amounts of Zn taken up by grains and straw for each treatment, the total Zn uptake was calculated.

Statistical analysis

The analysis of variance (ANOVA) method was used to investigate the acquired data, and the "F" test was used to determine its significance (Gomez and Gomez 1984). At the 5% level of significance, the Least Significant Difference (LSD) and Standard Error of Means (SEm+) were computed for each parameter.

RESULTS AND DISCUSSION

Zinc concentration in grains and straw

Zinc (Zn) concentration in grains and straws of rice as affected by nutrient management practices and microbial inoculants are presented in Table 1. The highest concentrations of Zn in grain (18.65 ppm) and straw (61.53 ppm) were recorded in the organic method of nutrient management it was significantly higher over both inorganic treatment and INM. Among the microbial inoculants, the highest concentration of Zn in grain (19.16 ppm) and straw (62.21 ppm) was recorded in the *Azospirillum*+ PSB+ ZnSB treatment. Except for *Azospirillum*, remaining both inoculation treatments recorded significantly higher Zn concentrations over control treatment in grains as well as straw. The interaction effects of nutrient management

Table 1. Zn content and uptake in grain and straw.

Treatments	Zn concentration Grain (ppm)	Straw (ppm)	Zn uptake Grain (g/ha)	Straw (g/ha)	Total (g/ha)
Nutrient management practices					
Organic	18.65	61.53	58.35	315.78	373.24
Inorganic	15.92	54.85	74.96	365.38	441.17
INM	17.50	57.95	76.48	372.94	451.13
SEm ±	0.13	0.82	1.37	7.74	8.24
CD (p=0.05)	0.50	3.19	5.41	30.43	32.40
Microbial inoculants					
Control	16.39	55.51	61.27	316.78	376.87
Azospirillum	16.77	56.46	66.24	335.50	401.75
Azospirillum + PSB	17.10	58.26	70.33	360.59	430.93
Azospirillum + PSB + ZnSB	19.16	62.21	81.86	392.60	477.85
SEm±	0.14	0.86	0.90	8.18	9.08
CD (p=0.05)	0.42	2.57	2.68	24.28	26.96
Interaction	NS	NS	NS	NS	NS

Table 2. Grain, straw and biological yield at different stage in rice crop under different nutrient application practices.

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)
Nutrient management practices			
Organic	3.65	5.69	9.34
Inorganic	4.08	6.06	10.15
INM	4.27	6.28	10.55
SEm±	0.08	0.09	0.16
CD (p=0.05)	0.34	0.36	0.63
Microbial inoculants			
Control	3.72	5.62	9.34
Azospirillum	3.94	5.94	9.89
Azospirillum+ PSB	4.10	6.17	10.27
Azospirillum+ PSB+ ZnSB	4.25	6.31	10.56
SEm±	0.05	0.10	0.11
CD (p=0.05)	0.17	0.31	0.33
Interaction	S	S	S

practices and microbial inoculants were nonsignificant both in grains and straw. Singh (2006) observed a similar result of the higher total uptake of Zn in rice under INM practice. Similar results have been observed by Bhattacharyya *et al.* (2005).

Zn uptake in grains and straw

Zn uptake by grains, straw and total uptake by rice as affected by nutrient management practices and microbial inoculants are presented in Table 1. In nutrient management practices both inorganic and INM showed significantly higher Zn uptake in grains, straw and total uptake over the organic treatment. But the difference between inorganic fertilization and INM was *at par*. The highest value of Zn uptake in grain (76.48 g/ha), straw was (372.94 g/ha) and total uptake and (451.13 g/ha) was recorded in INM. Among the microbial inoculants, the highest value of Zn uptake in grains, straw and total uptake was recorded in *Azospirillum*+ PSB+ ZnSB treatment. The total uptake of Zn was significantly higher due to the microbial inoculation treatments over control. The highest Zn uptake values in grain (381.86 g/ha), straw (392.60 kg/ha) and total uptake (477.85 g/ha) were recorded with *Azospirillum*+ PSB+ ZnSB treatment. No significant interaction effect on Zn uptake in grains and straw was observed due to the nutrient management practices and inoculation with microbial inoculants.

Grain yield

Both main and subplot treatments had a substantial impact on the rice crop's grain yield (Table 2). INM had the grain yield (4.27 t/ha) that was significantly higher over inorganic (4.08 t/ha) and organic (3.65 t/ha) treatments. INM and inorganic management differed significantly from organic management in terms of yield. Inorganic and INM management had a yield advantage over organic management of 12% and 17%, respectively. In the microbial inoculation treatments, combined inoculation with *Azospirillum*+ PSB+ ZnSB, *Azospirillum*+ PSB. The *Azospirillum*+ PSB+ ZnSB yielded highest (4.25 t/ha) and control yielded the lowest (3.72 t/ha) grain yields treatments. When compared to the control treatment, the inoculation with *Azospirillum* alone, *Azospirillum*+ PSB, and *Azospirillum*+ PSB+ ZnSB had yield advantages of 5.91%, 10.21%, and 14.24%. The interaction effect due to the nutrient management practices and inoculation of microbial inoculants was found to be significant. Shah and Kumar, (2014) also reported, application of either 50% RDF with 50% RDN through MOC (mustard oil cake) or 75% RDF with 25% RDN through MOC and biofertilizer exhibited better grain yields of 20.2% to 33.8% and higher straw yields of 11.0% to 33.3%

Straw yield

INM had the highest straw yield (6.28 t/ha), followed by inorganic (6.06 t/ha), and organic (5.09 t/ha). There was a substantial difference between INM and inorganic management compared to organic management. The lowest straw yield (5.69 t /ha) was recorded in organic treatment. Among the microbial inoculants, combined inoculation with *Azospirillum*+ PSB+ ZnSB, *Azospirillum*+ PSB and sole inoculation with *Azospirillum* gave significantly higher straw yield over the control. Straw yields were highest in the *Azospirillum*+ PSB+ ZnSB treatments (6.31 t/ ha) and lowest in the control treatments (5.62 t/ha). Comparing the inoculation with *Azospirillum* alone, Azospirillum with PSB, and *Azospirillum* with PSB and ZnSB to the control treatment, there was a yield advantage of 5.69%, 9.78%, and 12.27%. On straw yield, it was discovered that there was a strong interaction impact caused by the nutrient management practices and the inoculation of microbial inoculants which was lined with the findings of Bahadur *et al.* (2012).

Biological yield

Nutrient management techniques and microbial inoculants also had a big impact on rice's biological yield, which included grain and straw yields (Table 2). In nutrient management practices both inorganic and INM gave significantly higher biological yield over organic treatment. The highest (10.55 t/ha) biological yields were recorded under INM and lowest (9.34 t/ha) with organic plots. In terms of the microbial inoculants, sole inoculation with *Azospirillum* and mixed inoculation with *Azospirillum*+ PSB+ ZnSB and *Azospirillum*+ PSB considerably increased the biological yield compared to the control. The interaction effect due to the nutrient management practices and inoculation of microbial inoculants on straw yield was found to be significant. Vaid *et al.* (2014) also found that rice plant inoculated with Zn solubilizing bacteria enhances the biological yield as well as availability from soil.

Table 3. Available nutrients in paddy soil after harvest as affected by nutrient management practices.

Treatments	Available Zn (kg/ha)	SOC in soil (%)
Control	2.65	2.55
Azospirillum	2.66	2.55
Azospirillum+ PSB	2.69	2.57
Azospirillum+ PSB+ ZnSB	2.74	2.58
SEm±	0.04	0.03
LSD (p=0.05)	NS	NS
Interaction	NS	NS

Status of Zn in soil after harvest

The availability of zinc in soil at the harvesting stage of rice as influenced by different nutrient management practices is presented in Table 3. The availability of Zn was found to be highest in INM practice preceded by inorganic and organic, respectively. The value recorded for Zn were 2.72 kg/ha. Available Zn was found statistically *at par* in main plot treatments and sub-plot treatments. No significant interaction effect on the availability of nutrients was observed due to the nutrient management practices and inoculation with microbial inoculants. Bahadur *et al.* (2012) also reported that integrated nutrient management enhances the availability of zinc in soil which is similar to the finding of this experiment.

CONCLUSION

The available nutrient status of the Zinc in the soil at the harvesting stage was found to be highest in integrated nutrient management practice followed by inorganic and organic management respectively. The value recorded for Zn was 2.72 kg/ha. All three of the microbial inoculation treatments greatly outperformed the control in terms of available Zn.

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