Indian Journal of Agronomy 63 (3): 377—399 (September 2018)

**Research Communication**

# Influence of promising rice (*Oryza sativa*) varieties and nutrient-management practices on micronutrient biofortification and soil fertility in Eastern Himalayas

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Received : November 2017; Revised accepted : March 2018

## ABSTRACT

An experiment was conducted during the rainy season (*kharif*) of 2016 at Barapani, Meghalaya, to study the influence of promising rice (*Oryza sativa* L.) varieties and nutrient-management practices on plant nutrient acquisition and soil fertility. The experiment was laid out in split-plot design, replicated thrice, consisting 12 treatment combinations, viz. 4 nutrient-management practices [100% organic, 100% inorganic recommended dose of fertilizer (RDF), integrated nutrient management (INM) (50% RDF + 50% FYM) and control] in main plot, and 3 promising rice varieties ['Shahsarang 1', 'Lumpnah' and 'Megha' Semi-Aromatic 2'] in subplots. The results showed that rice grain yield was significantly higher in INM practice, followed by inorganic and organic practice. Among the varieties, grain yield was significantly higher in 'Shahsarang 1' followed by 'Lumpnah' and 'Megha' SA 2. The INM practice also resulted in highest Fe, Mn, Cu content in rice grains, while the organic practice showed the highest grain Zn. Among the varieties, 'Megha SA 2' had highest grain Fe, Mn and Zn content, while 'Shahsarang 1' exhibited the highest grain Cu. Micronutrient uptake in rice grains followed the similar trend as that of nutrient-management practices and rice varieties. There was an improvement in available NPK over initial status with higher available NPK in INM practice and higher soil organic carbon in organic practice.

***Key words :*** Biofortification, Lowland rice, Micronutrients, Nutrient management practices, Rice varieties, Soil fertility

Rice is the staple food in eastern Himalayan region of India. About an 80% of the total cultivated area in north-eastern hilly region (NEHR) is occupied by rice. It is cultivated in an area of about 3.47 million ha in north-eastern states of India (DAC, 2016), which accounts for about 7.8% of the total rice acreage of the country and contributes about 6.5% of the country's total rice production. The productivity of rice in the region is about 2.14 t/ha compared to national average of 2.39 t/ha (DAC, 2016). The north-eastern (NE) region of India is still in deficit of about 12% of foodgrains which includes about 1 million tonnes of rice. The major reasons for low productivity of rice in NEHR are non-adoption of high-yielding varieties (HYVs), low fertilizer use and poor crop-management practices besides poor socio-agro-economic conditions of the north-eastern hill farmers who ill-afford recommended agricultural inputs for better crop management (Choudhary, 2016; Kumar *et al*., 2016). At the same time, the rural masses of north-eastern India face micronutrient deficiencies due to poor quality nutrition (Sikdar, 2015). Therefore, there is a dire need to increase both productivity and quality especially micronutrient biofortification in rice grains on a sustainable basis using efficient nutrient and soil fertility management technology. Keeping in view these facts, an attempt was made to assess the crop productivity and micronutrient (Fe, Mn, Zn, Cu) acquisition capacity of promising rice varieties at different nutrient-management practices besides their influence on soil fertility in eastern Himalayas.

The experiment was conducted at the 'Lowland Rice Research Block' of the Experimental Farm of ICAR–RC–NEHR, Barapani, (25°30' N, 91°51' E, 950 m above mean sea-level), Meghalaya (in Eastern Himalayas), India. The soil of the experimental site was acidic with sandy-clay loam texture, *p*H 4.8, Walkley-Black C (oxidizable-SOC) 2.45%, alkaline $KMnO_4$-oxidizable-N 236 kg/ha, 0.5 M $NaHCO_3$-extractable-P 6.3 kg/ha and 1 N $NH_4OAc$-extractable-K 293.4 kg/ha. Thus, the soil was high in soil

Based on a part of M.Sc. Thesis of the first author, submitted to ICAR-Indian Agricultural Research Institute, New Delhi in 2017 (unpublished)

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organic carbon (SOC), low in available-N and available-$P_2O_5$ but high in available-$K_2O$. The total rainfall during the growing season was 1,622.6 mm. The experiment consisted of 12 treatment combinations and was laid out in split-plot design with 3 replications. The treatments consisted of 4 main-plot treatment, viz. 100% organic through FYM, 100% inorganic (recommended dose of fertilizer-RDF), integrated nutrient management (INM) (50% RDF+50% FYM) and absolute control, while in the sub-plots the 3 varieties, viz. 'Shahsarang 1', 'Lumpnah' and 'Megha SA 2' were taken and transplanted on 16 July 2016 with plant spacing of 20 cm × 20 cm. Mineral N, P and K were applied through urea, single superphosphate and muriate of potash @ 80 : 60 : 40 kg/ha, respectively, for inorganic nutrient management. While nutrients in organic plots were applied through FYM and rockphosphate. In INM plots, it was applied through 50% RDF and 50% FYM and remaining through rockphosphate. For absolute control, nothing was applied for entire crop season. Observations on grain yield, micronutrient content (ppm) in rice grains their uptake (g/ha), soil *p*H, SOC, available NPK in soil were assessed using standard procedures (Rana *et al*., 2014).

The rice grain yield was significantly higher in integrated nutrient management (INM) practice (4.18 t/ha), followed by inorganic and organic practice and the least in the control treatment (Table 1). The INM, inorganic and organic practices were significantly different and superior to the control treatment. The grain yield was significantly, increased under INM practice to the tune of 56.5% over the control. Among the varieties, 'Shahsarang 1' was the highest yielder, followed by 'Lampnah' which is an average yielder among 3 varieties. The lowest yield was recorded for 'Megha SA 2', and all these varieties differed significantly from each other. The trend in grain yield for different nutrient-management practices was: INM > inorganic > organic > control respectively. And the trend in grain yield for rice varieties was in order of 'Shahsarang 1' > 'Lumpnah' > 'Megha SA2' respectively. No significant interaction effect was found for grain yield between different nutrient-management practices and rice varieties (Table 1). Better performance of rice varieties under INM practice was probably because of good crop establishment and better anchorage of roots (Choudhary and Suri, 2009; Paul *et al*., 2014). It is widely recognized that neither sole use of organic manures alone nor sole use of chemical fertilizers helps in achieving the sustainability of crop yields at desired level. Thus, combined use of organic manures and inorganic fertilizers help in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients, enhancing efficiency of applied nutrients by providing favourable soil conditions (Paul *et al*., 2014). Similarly in our study, the INM practice exhibited higher grain yield than their respective counterparts i.e. inorganic, organic and control treatments.

Data pertaining to micronutrient (Fe, Mn, Zn, Cu) content in rice grains (Table 1) revealed that, in general, the INM practice the reported the highest grain Fe, Mn, Cu content (ppm). The organic practice resulted in the highest grain Zn (18.58 mg/kg), while control treatment exhibited the lowest grain micronutrient (Fe, Mn, Zn, Cu) content; however, organic and inorganic practices exhibited intermediate grain micronutrient concentrations in general. Further, micronutrient (Fe, Mn, Zn, Cu) uptake in grains

**Table 1.** Effect of nutrient-management practices and rice varieties on crop productivity, nutrient acquisition of micro-nutrients in rice grains, and soil chemical properties at harvesting of rice crop

| Treatment | Grain yield (t/ha) | Micronutrient content in grains (ppm) | | | | Micronutrient uptake in grains (g/ha) | | | | Soil *p*H | SOC (%) | Available nutrient status (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fe | Mn | Zn | Cu | Fe | Mn | Zn | Cu | | | N | P | K |
| *Nutrient-management practices* | | | | | | | | | | | | | | |
| Organic | 3.74 | 82.20 | 23.24 | 18.58 | 9.36 | 307.5 | 86.9 | 69.1 | 35.0 | 4.6 | 2.53 | 323.3 | 8.95 | 288.2 |
| INM | 4.18 | 83.86 | 23.88 | 18.22 | 9.39 | 350.4 | 99.8 | 76.2 | 39.3 | 4.7 | 2.48 | 332.2 | 10.21 | 339.9 |
| Inorganic | 4.02 | 80.25 | 23.41 | 17.13 | 9.16 | 322.3 | 94.1 | 68.8 | 36.9 | 4.7 | 2.44 | 328.7 | 9.08 | 292.5 |
| Control | 2.26 | 77.25 | 22.55 | 15.97 | 9.10 | 174.1 | 50.8 | 36.0 | 20.5 | 4.8 | 2.42 | 218.6 | 6.26 | 274.1 |
| SEm± | 0.06 | 0.26 | 0.24 | 0.13 | 0.04 | 5.0 | 1.4 | 0.9 | 0.6 | 0.02 | 0.01 | 4.4 | 0.32 | 13.0 |
| CD (P=0.05) | 0.21 | 0.89 | 0.83 | 0.44 | 0.14 | 17.3 | 5.0 | 3.0 | 2.2 | NS | 0.02 | 15.4 | 1.12 | 44.9 |
| *Rice varieties* | | | | | | | | | | | | | | |
| 'Shahsarang 1' | 3.86 | 80.83 | 23.10 | 17.40 | 9.28 | 313.2 | 89.5 | 67.8 | 35.9 | 4.6 | 2.47 | 314.1 | 9.18 | 301.4 |
| 'Lumpnah' | 3.60 | 80.67 | 23.35 | 17.07 | 9.27 | 292.7 | 84.5 | 62.0 | 33.5 | 4.7 | 2.46 | 302.2 | 8.47 | 298.8 |
| 'Megha SA 2' | 3.19 | 81.17 | 23.37 | 17.96 | 9.21 | 259.9 | 74.7 | 57.8 | 29.4 | 4.7 | 2.47 | 285.7 | 8.23 | 296.6 |
| SEm± | 0.05 | 0.62 | 0.14 | 0.164 | 0.03 | 3.3 | 1.2 | 0.9 | 0.5 | 0.02 | 0.01 | 7.2 | 0.30 | 7.5 |
| CD (P=0.05) | 0.15 | NS | NS | 0.49 | 0.11 | 9.9 | 3.6 | 2.8 | 1.5 | NS | NS | 21.7 | NS | NS |

SOC, soil organic carbon; INM, integrated nutrient management; NS, non-significant (g/ha) were again significantly higher in INM practice, followed by inorganic and organic practice and control, respectively, owing to better crop nutrition and crop productivity (Choudhary and Suri, 2009; Paul *et al*., 2014). On an average, higher micronutrient (Fe, Zn, Cu, Mn) addition in soil under organic and INM practices might have resulted in significant variation in nutrient accumulation in rice grains from the nutrient sources as well as its acquisition through improved root parameters (Choudhary and Suri, 2009). Among the varieties, 'Megha SA 2' revealed the highest grain Fe, Mn and Zn content, while 'Shahsarang 1' the highest Cu content in rice grains (9.28 mg/kg). Further, Fe, Mn, Zn and Cu uptake in rice grains was significantly higher in 'Shahsarang 1', followed by 'Lumpnah' and 'Megha SA2', respectively, owing to higher productivity in 'Shahsarang1' followed by 'Lumpnah' and 'Megha SA 2' (Table 1), as nutrient uptake is the resultant of grain yield as well as respective nutrient concentrations (Paul *et al.,* 2014). Besides this, the differential macro and micronutrient acquisition behaviour of various rice cultivars depends on their genetic ability as well as varying response to nutrient-management practices which might have led to variation in resultant micronutrient uptake (Table 1), as also reported by Dass *et al*. (2015, 2017). Thus, our study revealed that INM practice as well as rice variety 'Shahsarang 1' were the best performers in terms of micronutrient biofortification in the NEHR.

Data on soil chemical properties (Table 1), determined at crop harvesting, revealed that irrespective of the nutrient-management practice there was an improvement in available nutrient status (NPK) over the initial content, but with non-significant effect on soil *p*H. It was found that soil organic carbon (SOC) was the highest in organic practiced plots (2.53%), while available NPK (332.2, 10.21, 339.9 kg/ha) were the highest in INM plots; however, the control treatment exhibited the lowest SOC and soil NPK build-up. The higher organic matter additions under INM and organic nutrient-management practices might have been the appropriate triggering force for improved SOC and NPK build-up in the present study (Choudhary and Suri, 2009, 2014; Paul *et al*., 2014).

Thus, it is concluded that INM practice is the best nutrient-management technique over other nutrient-management practices to harness the highest grain yield with better biofortified rice grains with micronutrients (Fe, Mn, Zn, Cu) besides improving soil fertility status in Eastern Himalayas. Likewise, among the varieties, 'Shahsarang 1' was the best performer in terms of grain yield and micronutrient (Fe, Mn, Zn, Cu) biofortification of rice grains in eastern Himalayas.

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