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Influence of integrated nutrient management on crop yield in rainfed rice-niger cropping sequence

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ABSTRACT

Studies on the influence of integrated nutrient management on status of micronutrients and yield of crops in rice-niger cropping sequence revealed that the availability of DTPA extractable Fe, Mn and Zn were significantly higher in the treatment of 50% N (inorganic) + 50% N (FYM) + PK (inorganic and adjusted), followed by 50% of the recommended dose of fertilizer (RDF) + 50% N FYM. Availability of DTPA Cu and hot water soluble B in soil were increased by 37.88 and 47.70% after rice and 41.98 and 50.72% after niger, respectively, over control, when 50% recommended dose of fertilizers were substituted through 50% N through FYM. However, the treatment of 50% RDF + 50% N farm yard manure (FYM) showed the highest uptake of micronutrients (DTPA extractable Fe, Mn, Zn, Cu and HWS-B) by both rice and niger crop. Besides, application of 50% RDF along with 50% N FYM significantly increased the straw (7.05 t ha^{-1}) and grain (4.08 t ha^{-1}) yield of wet season rice and stover (1.96 t ha^{-1}) and seed (0.28 t ha^{-1}) yield of dry season niger over control and RDF.

Key words: *integrated nutrient management,* rice–niger cropping sequence

Rice with 75% area under rainfed condition is the staple food crop in India. With the advantage of wide spread rice fallow and retreating monsoon, rice followed by niger (*Guizotia abyssinica* L.) may be one of the main choice of the farming community of Assam under rainfed condition. However, imbalanced use of nutrients, giving much emphasis to supplement the soil with the macronutrients, may lead to widespread deficiencies of other nutrients, particularly micronutrients under intensive cultivation. The deficiencies of micronutrients have become major constraints to productivity, stability and sustainability of soil (Yadav and Meena, 2009). Besides, it is difficult to provide proper nutrition to meet the crop requirements with bulky organic manure alone. Biofertilizers are low cost and ecofriendly input that have tremendous potential for supplying nutrients which can reduce the chemical fertilizer dose by 25-50% (Vance, 1997). Therefore, there is a need for integrated application of different sources of nutrient for sustaining the desired crop productivity (Tiwari, 2002). The combined use of macro and micro nutrients helps in maintaining yield stability trough correction of nutrient deficiencies, enhancing the effectiveness of applied nutrients and by providing favourable soil physical condition (Banerjee *et al.,* 2006). Although sporadic studies in this regard have been conducted earlier, area specific information is quite meagre. Considering these aspects, an attempt was made to find out the influence of integrated nutrient management on availability and uptake of micronutrients and crop yields in an inceptisol in rainfed rice-niger cropping sequence of Assam.

MATERIALS AND METHODS

The field experiment was conducted during 2007-08 in rice-niger cropping sequence, at Assam Agricultural University (AAU), Jorhat, Assam. The field was under rice-niger rotation from 2004. Initially the soil had a sandy clay texture with bulk density of 1.30 Mg m^{-3}, water holding capacity of 38.25%, mean weight diameter of 0.69 mm, water stable aggregates of 46.34%, pH of 5.01, organic carbon of 0.60%, CEC of 5.20 cmol (p^{+}) kg^{-1}, EC of 0.129 dS m^{-1}, base saturation of 38.01%, available N of 270.05 kg ha^{-1}, available P_2O_5 of 27.59

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kg ha^{-1}, available K_2O of 140.00 kg ha^{-1}, exchangeable Ca of 1.21 cmol(p^+) kg^{-1}, exchangeable Mg of 0.60 cmol(p^+) kg^{-1}, available sulphur of 9.37 kg ha^1, available Fe of 8.50 mg kg^{-1}, available Mn of 1.15 mg kg^{-1}, available Zn of 1.43 mg kg^{-1}, available Cu of 1.32 mg kg^{-1} and available B of 0.30 mg kg^{-1}. The experiment with seven treatments (Table 1) was laid out in randomized block design and was replicated thrice with individual plot sizes of 4mx6m. The recommended level (100%) of N, P_2O_5 and K_2O (60, 20 and 40 kg ha^{-1} for rice and 20, 10 and 10 kg ha^{-1} for niger) were applied in the form of urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. On the basis of nitrogen content, the amount of FYM as organic source needed for a particular treatment was calculated and applied as per the treatments except in biofertilizer based integrated nutrient management (INM) package. In the last two treatments, recommended dose of P and K was adjusted after subtracting their contribution through FYM. Biofertilizer culture *i.e. Azospirillium* + Phosphate Solubilizing Bacteria (PSB) dual culture, developed by Biofertilizer Section of AAU, Jorhat, was applied @ 3 kg ha^{-1} before transplanting of wet season rice following root dip treatment, and *Azotobacter* + PSB dual culture was applied at the same rate following seed treatment in niger crop for about 2 hours before sowing. The treatment of biofertilizer based INM package was also added with FYM @ 3 t ha^{-1}, rock phosphate (RP) @ 50 percent of recommended dose of P_2O_5 and MOP @ 100 percent of recommended dose of K_2O for both the crops. Half of urea, whole of SSP, RP and MOP were broadcasted at the time of transplanting of wet season rice. The remaining urea was applied (sharing equally) as top dressing at tillering stage and panicle initiation stage of rice crop. Whole of urea, SSP, RP and MOP were applied as basal to the soil at the time of sowing of niger. The rice crop (cv. Basundhara) was transplanted in 20 cmx15 cm spacing and the niger (cv. NG-1) was sown in 20 cm rows to maintain the plants at 5 cm. The other crop management practices were performed as per standard recommendation of the region. Soil and plant samples were collected after harvest of the rice and niger from each plot. The collected soil samples (from effective root zone depth of 0-30 cm) were air dried, ground, passed through a 2 mm sieve and kept in polythene bags for analysis. The available Fe, Mn, Cu and Zn were determined by Atomic Absorption Spectro photometer using DTPA method (Lindsay and Norvell, 1978). For determination of available B, it was extracted by boiling soil-water suspension (1:2) for five minutes and determined by curcumin method (Hatcher and Wilcox, 1950). The uptake of micronutrients by the crops was determined by Atomic Absorption Spectrophotometer (for Fe, Mn, Cu and Zn) and curcumin method (for B), digesting the plant samples by the wet ashing (tri acid digestion) method. At prevailing market rate of different commodities during 2007-08 the economics and rice equivalent yield were computed.

RESULTS AND DISCUSSION

Different treatments of INM had a significant variation on micronutrient status of soil *viz.,* DTPA-extractable Fe, Mn, Zn and Cu and hot water soluble-B (HWS-B) after harvest of rice and niger crop (Table 1). Such increase in DTPA micronutrients (Zn, Cu, Fe and Mn) and HWS-B attributed to the integration of organic and inorganic sources of nutrients may be due to beneficial effects of FYM, which helps in supplying micronutrients in readily available form. Kumar *et al.* (2008) found that available contents of Fe, Mn, Zn and Cu content in soil increased with the application of FYM as compared with recommended dose of fertilisers in rice-wheat cropping system.

The effect of different treatments on DTPA-Fe was found to be statistically significant and data ranged from 8.28 to 12.98 mg kg^{-1} and 7.00 to 10.82 mg kg^{-1} after the harvest of rice and niger crop, respectively (Table 1). Treatment of 50% N (inorganic)+50% N (FYM)+PK (inorganic and adjusted) registered highest DTPA-Fe followed by the treatment of 50% RDF+50% N FYM and biofertilizer based INM package after the harvest of both the crops. This higher availability of DTPA-Fe might be due to formation of soluble complexes of Fe with FYM and increased production of acids that led to higher solubility of soil– Fe under low pH. This observation confirms the earlier findings of Basumatary *et al*. (2000).

The treatment 50% N (inorganic)+50% N (FYM)+PK (inorganic and adjusted) showed the highest DTPA-Mn (4.58 mg kg^{-1}) in soil, followed by 50% RDF+50% N FYM treatment (3.71 mg kg^{-1}) after the

Table 1. Effect of integrated nutrient management on available micronutrients in soil under rainfed rice-niger sequence

Treatments	Availability of micro nutrient after rice (mgkg^{-1})					Availability of micro nutrient after niger				
	Fe	Mn	Zn	Cu	B	Fe	Mn	Zn	Cu	B
Control	8.28	1.00	0.83	0.82	0.182	7.00	0.88	0.68	0.76	0.170
Recommended dose of Fertilizers (RDF)	9.94	2.84	1.24	1.20	0.218	8.20	1.24	1.20	1.18	0.200
Biofertilizer based INM package	10.58	2.98	2.49	1.27	0.339	10.10	1.09	2.29	1.25	0.338
50% RDF + 50% N (FYM)	10.74	3.71	3.63	1.32	0.348	10.42	1.38	3.56	1.31	0.345
75% RDF + 25% N (FYM)	9.98	2.69	2.14	1.25	0.290	9.94	1.03	1.88	1.22	0.287
50% N (inorganic) + 50% N (FYM) + PK (inorganic and adjusted)	12.98	4.58	3.98	1.31	0.293	10.82	1.89	3.75	1.28	0.289
75% N (inorganic) + 25% N (FYM) + PK (inorganic and adjusted)	10.66	2.91	1.23	0.99	0.224	9.98	1.60	1.18	0.87	0.220
S.Em(±)	0.732	0.254	0.055	0.062	0.018	0.402	0.108	0.130	0.065	0.017
CD (P=0.05)	2.26	0.78	0.11	0.19	0.05	1.24	0.33	0.40	0.20	0.05
CV (%)	12.14	14.48	4.34	9.20	11.93	7.34	14.36	10.91	9.95	11.54

RDF-Recommended dose of fertilizers of N, P_2O_5 and K_2O (60, 20 and 40 kg ha^{-1} for rice and 20, 10 and 10 kg ha^{-1} for niger), FYM-Farm yard manure

harvest of rice crop. Same trend was also observed for niger crop, which showed 53.44 and 36.23% increase in DTPA Mn due to application of 50% N (inorganic)+50% N (FYM)+PK (inorganic and adjusted) and 50% RDF+50% N FYM, respectively. Such increase in Mn might be explained by the process of mineralization of organic sources of nutrients that led to increased accumulation of exchangeable and water soluble Mn in soil. Sharma *et al*. (2007) reported that organic matter provides chelating agents for complexation of Mn, which reduces its adsorption, oxidation and precipitation into unavailable form. The addition of organic matter creates reducing conditions with fine textured soil, such as the soil in this study.

The availability of DTPA-Zn in soil varied significantly due to integrated treatments of varying sources of nutrients after harvest of both wet season rice and dry season niger crop. Higher DTPA-Zn was observed in the treatment 50% N (inorganic)+50% N (FYM)+PK (inorganic and adjusted) followed by 50% RDF+50% N FYM and biofertilizer based INM package for both the crops. Due to integrated treatments maximum of 79.15 and 81.87% DTPA-Zn increase in soil over control was recorded, after harvest of wet season rice and dry season niger, respectively. Such increase owing to application of FYM along with NPK fertilizers might be due to formation of organic chelates of higher stability, as Zn is known to form relatively stable chelates with organic ligands which decrease their susceptibility of precipitation. Mineralization of organically bound form of Zn present in organic residues and also possible addition of Zn *via* SSP might have resulted an improvement of DTPA-Zn over control treatment. This result corroborated the findings of Jagtap *et al.* (2007). Almas *et al.* (2000) reported that the addition of exogenous organic matter with functional groups that have the ability to form stable complexes, promotes Zn availability in soils.

Data revealed a significant variation of DTPA-Cu in soil from 0.82 to 1.32 mg kg^{-1} after wet season rice and 0.76 to 1.31 mg kg^{-1} after dry season niger as a result of different treatments of INM (Table 1). The highest DTPA-Cu was recorded in the treatment receiving 50% of RDF along with 50% N through FYM, followed by 50% N (inorganic)+50% N (FYM)+PK (inorganic and adjusted) and biofertilizer based INM package, with lowest value in control after the harvest of both the crops. This increase in DTPA-Cu as a result of combined application of inorganic and organic sources of nutrients over control might be due to formation of Cu-humus complex that decreased its susceptibility to fixation or precipitation in the soil. Kumar and Yadav (1995) and Basumatary *et al.*, (2000) have reported such increase in availability of Cu with the application of FYM.

After the harvest of wet season rice, the HWS-B content of soil ranged from 0.182 to 0.348 mg kg^{-1} and it varied from 0.170 to 0.345 mg kg^{-1} after the harvest of dry season niger (Table 1). The highest HWS-B content of soil was recorded in the treatment of 50% RDF+50% N FYM followed by biofertilizer based INM package which were at par with one another. Half the recommended dose of fertilizers substituted through FYM (N based) showed 47.70 and 50.72% increase in HWS-B over control after rice and niger crop, respectively. The increase in availability of B may be due to addition of FYM as organic source. Decomposition of FYM and enhanced microbial population may break down the organic complex, which reduces fixation of B on clay minerals, and ultimately increased the availability of B in soil. This result supported the findings of Arora and Chahal (2007) and of Borkakati and Takkar (2000) in soils of Assam.

There was a significant effect of combined application of organic and inorganic sources of nutrients on total micronutrient uptake by wet season rice and dry season niger in the sequence (Table 2). The highest uptake of total micronutrients was observed in the treatment receiving 50% of RDF+50% N through FYM, which increased the Fe, Mn, Zn, Cu and B uptake in rice crop by 66.33, 70.53, 77.08, 73.14 and 87.36%, respectively. This might be due to the combined use of chemical fertilizers and FYM, where FYM in addition to being a store house of almost all the nutrients required for plant growth, improved the soil environment by way of improving the physico-chemical properties of soil. Uptake of Fe, Mn, Zn, Cu and B in niger crop showed maximum of 89.10, 87.57, 94.44, 87.23 and 96.42% increase, respectively over control when 50% recommended dose of fertilizers was replaced by FYM (N based). Higher uptake of micronutrients with addition of FYM might be due to chelating action of organic compounds released during decomposition of manures and prevention of these cations from fixation, precipitation, oxidation and leaching. The vigorous root proliferation along with higher biomass production also contributed towards higher uptake of micronutrients from the integrated treatments.

The interaction effect of organic and inorganic sources of nutrients on yields of rice and niger crop turned out to be significant in the present investigation. The grain and straw yield of wet season rice varied from 2.50 to 4.08 and 4.14 to 7.05 t ha^{-1}, respectively (Table 3), due to different INM treatments. The grain and straw yield of rice increased by 38.73% and 41.28% respectively, when 50% recommended dose of fertilizers were substituted by FYM (N based). This significant increase in yield might be to decomposition of added FYM, which favoured better nutrient availability throughout the crop growth period. Kumar *et al.* (2008) also recorded more grain and straw yield of rice than control plot by applying FYM along with 50 percent NPK in rice-wheat cropping system. In niger

Table 2. Effect of integrated nutrient management on total micronutrient uptake (g ha^{-1}) by rice and niger in rice-niger sequence

Treatments	Rice					Niger				
	Fe	Mn	Zn	Cu	B	Fe	Mn	Zn	Cu	B
Control	372.00	269.00	243.00	22.18	2.52	21.70	17.10	6.90	2.14	0.16
Recommended dose Fertilizers (RDF)	663.00	525.40	470.00	43.14	10.05	63.90	49.70	30.30	6.57	1.29
Biofertilizer based INM package	649.00	565.80	516.00	48.41	12.60	89.30	67.20	60.30	10.18	2.35
50% RDF + 50% N (FYM)	1105.00	912.90	1060.00	82.59	19.93	199.10	137.60	124.00	16.76	4.47
75% + 25% N (FYM)	833.00	502.99	784.00	52.75	14.04	124.10	80.50	85.60	11.05	2.04
50% N (inorganic) + 50% N (FYM) + PK (inorganic and adjusted)	961.00	757.70	983.00	79.05	16.14	126.90	104.4	109.40	15.82	2.68
75% N (inorganic) + 25% N (FYM) + PK (inorganic and adjusted)	511.00	506.50	494.00	38.72	10.24	62.60	45.30	45.90	9.76	1.08
S.Em(±)	10.683	13.863	13.060	3.224	1.046	2.415	2.382	2.619	0.531	0.113
CD (P=0.05)	32.92	42.72	40.25	9.93	3.22	7.44	7.34	8.07	1.64	0.35
CV (%)	2.60	4.06	3.48	10.66	14.83	4.26	5.75	6.87	6.29	9.72

Table 3. Yield of crops and rice equivalent yield (REY) as affected by integrated nutrient management in rice-niger sequence Treatments.

	Rice (t ha^{-1})		Niger (t ha^{-1})		REY (t ha^{-1})
	Grain yield	Straw yield	Seed yield	Stover yield	
Control	2.50	4.14	0.06	0.58	0.18
Recommended dose of Fertilizers (RDF)	3.07	5.16	0.15	1.15	0.41
Biofertilizer based INM package	2.89	4.62	0.17	1.24	0.47
50% RDF + 50% N (FYM)	4.08	7.05	0.28	1.96	0.78
75% RDF + 25% N (FYM)	3.67	6.01	0.23	1.43	0.64
50% N (inorganic) + 50% N (FYM) + PK (inorganic and adjusted)	3.79	6.58	0.23	1.50	0.64
75% N (inorganic) + 25% N (FYM) + PK (inorganic and adjusted)	3.36	5.39	0.15	1.13	0.41
S.Ed(±)	0.293	0.62	0.012	0.078	0.042
CD (5%)	0.64	1.35	0.03	0.17	0.10
CV (%)	10.74	13.62	7.86	7.40	-

also the same trend followed, and the treatment of 50% RDF + 50% N (FYM) showed significant increase in seed (78.57%) and stover (70.41%) yield over control. Such results confirm the findings of Baishya and Thakur (1997) from Assam.

In general, niger yield was lower, which may be due to medium low land situation of rice field and late sowing of niger. Delayed drying of rice field after the harvest of rice crop delayed the sowing of niger to 27 November during 2007. The rice equivalent yield in the treatments involving the combine application of organic and inorganic sources of nutrients along with RDF and control followed the order of 50% RDF + 50% N (FYM) > 75% RDF + 25% N (FYM) at par with 50% N (inorganic) + 50% N (FYM) + PK (inorganic and adjusted) > biofertilizer based INM package > 75% N (inorganic) + 25% N (FYM) + PK (inorganic and adjusted) at par with recommended dose of fertilizers (RDF) > control (Table-3). Maximum 76.92 and 47.44% increase in rice equivalent yield were recorded due to 50% RDF + 50% N FYM treatment, over control and RDF, respectively. This could be attributed to the fact that soil fertility and soil productivity of the plots receiving both inorganic and organic (FYM) source of nutrients were better as compared to control and chemical fertilizer alone.

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