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Effect of Integrated Nutrient Management on the Status of Micronutrients in Long term Rice-rice Cropping System of Andhra Pradesh

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ABSTRACT

Soil micronutrient status was assessed under integrated nutrient management in long term rice-rice cropping system in Alfisols of southern Telangana zone of Andhra Pradesh for two consecutive years during 2005-06 and 06-07. The availability of micronutrients *viz*, Zn, Cu, Fe and Mn did not show distinct trend of improvement by the application of different levels of NPK through the fertilizers as compared to control. However, the availability of Zn and Cu enhanced significantly through the addition of FYM or *glyricidia* along with chemical fertilizers as compared to the entire nutrient supplements only through the fertilizers. The soil available Fe was in general on par due to the application of fertilizers alone or in combination with organic sources. The available Mn was not influenced by any treatment.

Key words : Alfisols, Integrated Nutrient Management, Soil micronutrients.

Rice –rice is the most predominant cropping system in southern Telangana zone of Andhra Pradesh state. The micronutrient deficiencies are being recognized in soils intensively cultivated with cereals in several parts of the country. This is aggravated by the continuous application of high analysis fertilizers without replenishing the depleted micronutrients. Depressive effects of continuous cropping, low manuring (Subba Rao and Ghosh, 1981) and use of higher levels of NPK fertilizers (Minhas and Mehta, 1984) on zinc content in soil were reported earlier. While, Bellakki and Badanur (1997) found that the application of organic manures either alone or in combination with fertilizers significantly increased the micronutrient status of the black soils. Therefore, incorporation of organic material is emphasized to supply the micronutrients and thereby maintain the nutrient balance. An investigation was made to assess the effect of integrated nutrient management on the status of micronutrients in Alfisols under continuous rice-rice cropping system.

MATERIAL AND METHODS

The studies were conducted in two consecutive years 2005-06 and 2006-07 at Agricultural College Farm, Rajendranagar, Hyderabad. The experiment was conducted on a sandy clay loam soil on which only rice is grown continuously in both *kharif* and *rabi* seasons since 1988. The experiments were laid out in a randomized block design with 12 treatments (Table 1) in three replications. Rice variety; RNR 23064 was planted adopting a spacing of 20 cm x 10 cm in 59.8 m^2 sized plot. The soil samples were collected with soil augur at random from each treatment plot at 0-15 and 15-30 cm depth before transplanting, panicle initiation and harvesting stages of the crop in each season. The soil samples, except those for enzyme activity, microbial biomass and respiration were dried under shade, powdered using wooden mortar and pestle and then passed through a 2 mm sieve before taking up analysis. Micronutrients (Zn, Cu, Fe and Mn) of soil were determined by the method suggested by Lindsay and Norvell (1978) and their relative change over time *i.e.,* between the end of *kharif* 2005-06 and at the end of *rabi* 2006-07 was observed.

RESULTS AND DISCUSSION

DTPA extractable Zinc

The data indicated that the soil available Zn reduced with advance in crop growth from transplanting to panicle initiation and harvesting in all the treatments in the upper 0-15 cm soil depth (Table 2). The soil continuously nourished with different levels of fertilizer nutrients did not show an appreciable change in the quantity of this micronutrient compared to the unfertilised soil. This trend was persistent at transplanting, panicle initiation and harvesting stage of the crop in the *kharif* and *rabi* season during 2005-06 as well as 2006-07. An appreciable improvement in the availability of this micronutrients during the four seasons was recorded by substituting 50 % N fertilizer with FYM in *kharif* and application of recommended dose of fertilizers in the *rabi* season as compared to the inorganic fertilizers. The substitution of 50 % N fertilizer with *glyricidia* in *kharif* and the application of optimum dose of nutrients through fertilizers in the *rabi* season was also in general more effective to make available more quantity of available Zn in the soil as compared to the application of nutrients only through inorganic sources. However, this improvement was not consistently significant although the crop growth period.

The availability of Zn in the lower soil depth of 15 - 30 cm was less than in the upper layer of 0-15 cm. This trend was similar irrespective of the treatments imposed (Table 3). This micronutrient tended to reduce from transplanting to harvesting stage. Even the substitution of 25 % N fertilizer through FYM in the *kharif* season and the application of 75 % recommended NPK dose through the fertilizers in the *rabi* season also increased the availability of this micronutrient at several sampling stages barring the panicle initiation in *kharif* 2005-06 and at harvesting stage in *rabi* during both the years. The integration of paddy straw as an organic source to substitute 25 or 50 % N fertilizer had no significant impact. However, the integration of 25 or 50 % N fertilizer with *glyricidia* increased the soil available Zn content.

DTPA extractable Copper

The unfertilized soil had 3.52 and 3.79 mg available Cu kg^{-1} soil in 0-15 cm depth of soil at transplanting in the *kharif* season during 2005-06 and 2006-07 respectively (Table 4). At the panicle initiation stage, the soil had 3.50 and 3.78 mg Cu kg^{-1} while it was 3.42 and 3.70 mg kg^{-1} after harvest in *kharif* 2005-06 and 2006-07, respectively. In the *rabi* season the soil had 3.45, 3.42 and 3.40 mg kg^{-1}

Table 1. Details of the treatments .

Sl. No	Kharif	Rabi
T_1	No fertilizers, No organic manures	No fertilizers, No organic manures
T_2	50 Rec. NPK dose through fertilizers	50 Rec. NPK dose through fertilizers
T_3	50 % Rec. NPK dose through fertilizers	100 % Rec. NPK dose through fertilizers
T_4	75 % Rec. NPK dose through fertilizers	75 % Rec. NPK dose through fertilizers
T_5	100 % Rec. NPK dose through fertilizers 120:60:60 kg ha^{-1}	100 % Rec. NPK dose through fertilizers 120:60:60 kg ha^{-1}
T_6	50 % Rec. NPK dose through fertilizers + 50 % N through FYM	100 % Rec. NPK dose through fertilizers
T_7	75 % Rec. NPK dose through fertilizers + 25 % N through FYM	75 % Rec. NPK dose through fertilizers
T_8	50 % Rec. NPK dose through fertilizers + 50 % N through paddy straw	100 % Rec. NPK dose through fertilizers
T_9	75 % Rec. NPK dose through fertilizers + 25 % N through paddy straw	75 % Rec. NPK dose through fertilizers
T_{10}	50 % Rec. NPK dose through fertilizers + 50 % N through glyricidia	100 % Rec. NPK dose through fertilizers
T_{11}	75 % Rec. NPK dose through fertilizers + 25 % N through glyricidia	75 % Rec. NPK dose through fertilizers
T_{12}	Conventional farmers practice 80:50:20 kg ha^{-1} NPK	Conventional (farmers) practice 80:50:20 kg ha^{-1} NPK

Table 2. Influence of integrated nutrient management treatments on soil available Zn (mg kg^{-1}) in rice-rice cropping system at 0-15 cm

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
T_1	1.70	1.60	1.69	1.58	1.65	1.57	1.84	1.78	1.82	1.74	1.80	1.68
T_2	1.72	1.64	1.71	1.61	1.68	1.59	1.90	1.81	1.88	1.75	1.84	1.72
T_3	1.71	1.63	1.69	1.61	1.65	1.60	1.89	1.79	1.89	1.74	1.82	1.73
T_4	1.71	1.65	1.71	1.62	1.68	1.58	1.91	1.80	1.87	1.76	1.84	1.72
T_5	1.71	1.63	1.68	1.61	1.65	1.59	1.91	1.79	1.85	1.72	1.82	1.74
T_6	1.93	1.88	1.90	1.84	1.89	1.81	2.20	2.02	2.15	1.96	2.10	1.98
T_7	1.87	1.80	1.85	1.77	1.82	1.75	2.09	1.94	2.01	1.387	1.98	1.82
T_8	1.85	1.78	1.84	1.76	1.81	1.74	1.94	1.84	1.92	1.82	1.88	1.79
T_9	1.83	1.74	1.81	1.72	1.78	1.69	1.86	1.74	1.81	1.78	1.79	1.71
T_{10}	1.90	1.82	1.87	1.80	1.85	1.78	2.08	1.94	2.09	1.90	1.96	1.85
T_{11}	1.88	1.79	1.86	1.78	1.83	1.75	2.94	1.91	1.96	1.88	1.94	1.83
T_{12}	1.70	1.63	1.68	1.61	1.65	1.58	1.84	1.76	1.81	1.74	1.79	1.72
SE $\pm$	0.07	0.08	0.10	0.08	0.07	0.08	0.09	0.10	0.07	0.09	0.10	0.09
CD at 5 %	0.14	0.16	0.21	0.16	0.14	0.17	0.18	0.22	0.14	0.18	0.21	0.19

Table 3. Influence of integrated nutrient management treatments on soil available Zn (mg kg^{-1}) in rice-rice cropping system at 15-30 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	1.65	1.58	1.65	1.56	1.61	1.55	1.80	1.76	1.80	1.72	1.26	1.66
T_2	1.69	1.56	1.66	1.53	1.64	1.51	1.85	1.76	1.80	1.66	1.79	1.64
T_3	1.62	1.54	1.70	1.52	1.64	1.52	1.88	1.76	1.80	1.65	1.81	1.64
T_4	1.66	1.60	1.63	1.58	1.63	1.54	1.86	1.77	1.82	1.71	1.79	1.68
T_5	1.67	1.57	1.83	1.56	1.60	1.53	1.84	1.80	1.79	1.68	1.75	1.68
T_6	1.89	1.85	1.86	1.80	1.85	1.78	2.16	2.10	2.10	1.90	2.05	1.92
T_7	1.82	1.76	1.82	1.73	1.78	1.71	2.02	1.94	1.97	1.84	1.95	1.79
T_8	1.73	1.71	1.78	1.70	1.78	1.68	1.90	1.89	1.85	1.78	1.82	1.75
T_9	1.78	1.69	1.76	1.67	1.73	1.64	1.83	1.70	1.76	1.73	1.74	1.66
T_{10}	1.88	1.81	1.77	1.79	1.74	1.77	2.00	1.90	2.06	1.89	1.86	1.84
T_{11}	1.84	1.74	1.78	1.73	1.75	1.77	2.81	1.86	1.91	1.83	1.83	1.79
T_{12}	1.66	1.59	1.59	1.57	1.63	1.51	1.81	1.72	1.76	1.70	1.77	1.68
SE $\pm$	0.06	0.09	0.04	0.06	0.09	0.10	0.08	0.07	0.09	0.06	0.08	0.08
CD at 5 %	0.14	0.18	0.08	0.13	0.18	0.21	0.16	0.14	0.18	0.12	0.17	0.10

Table 4. Influence of integrated nutrient management treatments on soil available Cu (mg kg^{-1}) in rice-rice cropping system at 0-15 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
T_1	3.52	3.45	3.50	3.42	3.48	3.40	3.79	3.68	3.78	3.64	3.70	3.61
T_2	3.57	3.48	3.56	3.46	3.50	3.42	3.82	3.71	3.80	3.65	3.75	3.60
T_3	35.5	3.46	3.53	3.45	3.51	3.43	3.80	3.61	3.76	3.66	3.73	3.61
T_4	3.57	3.48	3.55	3.49	3.52	3.47	3.79	3.70	3.78	3.65	3.75	3.59
T_5	3.54	3.47	3.51	3.45	3.49	3.44	3.84	3.71	3.81	3.64	3.76	3.54
T_6	3.96	3.89	3.93	3.87	3.90	3.85	4.19	4.02	4.16	3.99	4.10	3.84
T_7	3.84	3.78	3.81	3.77	3.76	3.74	4.02	3.89	3.98	3.85	3.42	3.79
T_8	3.83	3.26	3.80	3.76	3.78	3.73	3.96	3.81	3.92	3.76	3.87	3.71
T_9	3.77	3.69	3.75	3.67	3.71	3.64	3.83	3.74	3.81	3.69	3.78	3.62
T_{10}	3.90	3.81	3.87	3.80	3.85	3.77	4.10	3.91	4.02	3.88	3.96	3.84
T_{11}	3.79	3.71	3.76	3.69	3.73	3.65	4.02	3.87	3.98	3.82	3.90	3.84
T_{12}	3.56	3.47	3.52	3.45	3.50	3.41	3.76	3.65	3.74	3.62	3.68	3.81
SE $\pm$	0.10	0.13	0.09	0.12	0.10	0.15	0.08	0.07	0.08	0.12	0.10	0.12
CD at 5 %	0.21	0.28	0.19	0.23	0.21	0.30	0.17	0.14	0.16	0.24	0.21	0.24

Table 5. Influence of integrated nutrient management treatments on soil available Cu (mg kg^{-1}) in rice-rice cropping system at 15-30 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	3.50	3.41	3.48	3.41	3.45	3.48	3.75	3.66	3.74	3.60	3.68	3.57
T_2	3.51	3.45	3.50	3.40	3.46	3.36	3.75	3.63	3.75	3.58	3.67	3.55
T_3	3.46	3.44	3.45	3.40	3.45	3.37	3.75	3.52	3.76	3.61	3.68	3.60
T_4	3.51	3.41	3.49	3.42	3.43	3.42	3.74	3.65	3.77	3.64	3.70	3.4
T_5	3.48	3.42	3.46	3.40	3.41	3.38	3.79	3.66	3.75	3.59	3.70	3.50
T_6	3.91	3.82	3.82	3.80	3.85	3.76	4.15	3.99	4.09	3.90	4.06	3.76
T_7	3.80	3.71	3.76	3.69	.72	3.71	3.91	3.82	3.94	3.82	3.38	3.75
T_8	3.79	3.21	3.74	3.70	3.71	3.67	3.90	3.76	3.88	3.70	3.81	3.69
T_9	3.72	3.60	3.70	3.61	3.65	3.59	3.75	3.69	3.75	3.61	3.66	3.57
T_{10}	3.86	3.75	3.81	3.71	3.84	3.72	4.00	3.90	3.95	3.78	3.92	3.75
T_{11}	3.74	3.76	3.69	3.62	3.68	3.60	3.93	3.82	3.92	3.80	3.86	3.78
T_{12}	3.50	3.43	3.55	3.40	3.43	3.38	3.71	3.60	3.68	3.60	3.64	3.76
SE $\pm$	0.14	0.12	0.13	0.12	0.13	0.10	0.08	0.08	0.10	0.12	0.11	0.08
CD at 5 %	0.28	0.23	0.27	0.24	0.26	0.21	0.17	0.19	0.21	0.24	0.22	0.17

Table 6. Influence of integrated nutrient management treatments on soil available Fe (mg kg^{-1}) in rice-rice cropping system at 0-15 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
T_1	18.32	18.25	18.29	18.23	18.27	18.20	19.10	18.95	19.10	18.92	19.02	18.59
T_2	18.41	18.36	18.39	18.35	18.35	18.31	19.20	19.02	19.12	19.86	19.06	18.61
T_3	18.47	8.39	18.46	18.39	18.42	18.37	19.21	18.96	19.14	18.94	19.10	18.64
T_4	18.49	18.40	18.47	18.37	18.41	18.35	19.24	18.96	19.16	18.99	19.10	18.59
T_5	18.41	18.32	18.38	18.30	18.31	18.27	19.18	18.21	19.15	18.96	19.08	18.84
T_6	19.10	18.96	19.08	18.95	18.26	18.91	19.84	19.50	19.26	18.42	19.78	19.31
T_7	18.82	18.74	18.81	18.72	18.79	18.68	19.70	19.50	19.61	19.31	19.59	19.02
T_8	18.83	18.78	18.81	18.75	18.78	18.72	19.12	19.21	19.35	19.15	19.31	19.10
T_9	18.71	18.65	18.69	18.64	18.62	18.63	19.31	19.09	19.28	19.02	19.23	18.95
T_{10}	18.90	18.82	18.89	18.80	18.85	18.77	19.53	19.40	19.51	19.36	19.45	19.28
T_{11}	18.80	18.71	18.79	18.70	18.75	18.68	19.48	19.30	19.44	19.28	19.42	19.20
T_{12}	18.39	18.31	18.39	18.30	18.34	18.27	19.20	19.30	19.56	18.92	19.11	18.87
SE $\pm$	0.33	0.24	0.31	0.37	0.39	0.25	0.46	0.22	0.18	0.31	NS	0.29
CD at 5 %	0.70	0.49	0.64	NS	NS	0.52	NS	NS	NS	0.64	0.33	0.61

Table 7. Influence of integrated nutrient management treatments on soil available Fe (mg kg^{-1}) in rice-rice cropping system at 15-30 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	17.23	17.05	17.08	17.38	17.00	16.90	17.63	17.59	17.26	17.92	17.79	17.36
T_2	17.14	17.62	17.23	17.63	17.32	17.18	17.85	17.10	17.64	17.76	17.91	17.62
T_3	17.75	17.22	17.36	17.46	17.26	17.24	17.18	17.15	17.70	17.90	17.96	17.71
T_4	17.93	17.15	17.22	17.14	17.27	17.18	17.42	17.26	17.83	17.95	18.00	17.48
T_5	17.28	17.00	17.22	17.18	17.12	17.67	17.48	17.68	17.76	17.92	17.95	17.65
T_6	18.48	17.33	17.85	17.35	17.12	17.45	17.24	18.00	17.82	17.36	18.75	18.19
T_7	17.34	17.27	17.18	17.35	17.25	17.18	18.29	18.25	17.95	17.31	18.57	18.05
T_8	17.17	17.78	17.23	17.41	17.57	17.26	18.75	18.10	17.38	17.95	18.42	18.00
T_9	17.80	17.66	17.33	17.22	17.29	17.12	18.56	18.10	17.19	18.16	18.36	18.05
T_{10}	17.70	17.25	17.25	17.45	17.28	17.12	18.36	18.00	17.45	18.15	18.48	18.26
T_{11}	17.25	17.17	17.75	17.38	17.23	17.10	18.60	18.00	17.35	18.09	18.40	18.18
T_{12}	17.15	17.13	17.48	17.14	17.40	17.35	18.10	17.56	17.45	17.77	18.19	17.46
SE $\pm$	0.18	0.31	0.28	0.31	0.42	0.21	0.16	0.18	0.25	0.32	0.41	0.44
CD at 5 %	0.38	0.58	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 8. Influence of integrated nutrient management treatments on soil available Mn (kg ha^{-1}) in rice-rice cropping system at 0-15 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
T_1	10.50	10.41	10.48	10.39	10.42	10.35	10.78	10.51	10.76	10.45	10.64	10.41
T_2	10.52	10.45	10.50	10.43	10.49	10.40	10.81	10.49	10.79	10.52	10.65	10.50
T_3	10.51	10.44	10.50	10.41	10.43	10.35	10.79	10.56	10.81	10.52	10.72	10.16
T_4	10.50	10.42	10.49	10.41	10.47	10.40	10.42	10.61	10.41	10.54	10.38	10.40
T_5	10.51	10.43	10.51	10.42	10.48	10.40	10.53	10.59	10.52	10.56	11.65	10.50
T_6	10.92	10.84	10.90	10.88	10.87	10.77	11.84	10.52	11.78	11.49	11.39	11.36
T_7	10.81	10.76	10.79	10.75	10.76	10.70	11.56	10.30	11.51	11.22	11.41	11.18
T_8	10.80	10.72	10.81	10.70	10.79	10.69	11.56	11.21	11.49	11.10	11.36	11.01
T_9	10.74	10.69	10.72	10.66	10.70	10.62	11.32	11.00	11.26	10.99	11.21	10.92
T_{10}	10.90	10.81	10.87	10.80	10.81	10.76	11.70	11.41	11.68	11.36	11.62	11.28
T_{11}	10.85	10.78	10.82	10.75	10.81	10.71	11.50	11.29	11.41	11.21	11.34	11.15
T_{12}	10.51	10.46	10.49	10.42	10.47	10.39	10.81	10.56	10.70	10.49	10.6	10.45
SE $\pm$	0.48	0.31	0.26	0.81	0.49	0.68	0.96	0.83	0.91	1.20	1.32	1.21
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 9. Influence of integrated nutrient management treatments on soil available Mn (kg ha^{-1}) in rice-rice cropping system at 15-30 cm.

Treatments	2005-06						2006-07					
	Transplanting		Panicle initiation		Harvesting		Transplanting		Panicle initiation		Harvesting	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	9.18	9.05	9.15	9.10	9.13	9.06	9.36	9.15	9.33	9.12	9.26	9.15
T_2	9.52	9.36	9.40	9.34	9.41	9.32	9.42	9.12	9.37	9.19	9.29	9.18
T_3	9.25	9.40	9.46	9.35	9.38	9.30	9.37	9.15	9.40	9.21	9.34	9.10
T_4	9.46	9.36	9.43	9.42	9.46	9.37	9.35	9.30	9.34	9.25	9.40	9.16
T_5	9.38	9.40	9.46	9.34	9.40	9.35	9.45	9.51	9.44	9.27	9.51	9.19
T_6	9.96	9.75	9.82	9.70	9.70	9.61	10.30	9.78	10.28	10.14	10.05	10.00
T_7	9.82	9.70	9.76	9.70	9.71	9.65	10.12	9.26	10.06	10.00	10.13	10.00
T_8	9.75	7.67	9.74	9.63	9.69	9.60	10.15	9.73	10.06	9.98	10.10	10.00
T_9	9.85	9.70	9.74	9.68	9.72	9.65	10.24	9.84	10.20	9.82	10.15	10.00
T_{10}	10.05	9.89	9.93	9.85	9.86	9.81	10.31	9.87	10.56	10.28	10.45	10.00
T_{11}	9.90	9.76	9.82	9.76	9.81	9.72	10.33	9.78	10.35	10.16	10.29	10.00
T_{12}	9.36	9.25	9.36	9.28	9.33	9.26	9.62	9.37	9.76	9.36	9.45	9.29
SE $\pm$	0.83	1.20	1.00	1.35	1.62	1.68	0.95	0.94	1.22	1.64	1.80	1.76
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

available Cu ha^{-1} at transplanting panicle initiation and harvesting stage in 2005-06. The quantity was 3.68, 3.64 and 3.60 mg available Cu kg^{-1} during the corresponding stages of the crop growth in *rabi* during the second year. These trends were not disturbed by the application of optimum dose, different proportions of optimum fertilizer need of the crop or the farmers practice at any stage during the four seasons. But the integrated nutrient management of rice in the *kharif* season increased the soil available Cu content. The substitution of 50 % recommended N fertilizer with FYM or *glyricidia* in the *kharif* season and growing the crop with recommended dose of fertilizers in the *rabi* season was promising. The soil available Cu content was significantly more than the fertilized or unfertilized soils throughout the crop growth period during the two cycles of rice-rice cropping system. The substitution of 25 % N fertilizer with these organic sources in *kharif* season and fertilizing the crop with 75 % recommended level of fertilizers was also effective to enhance the availability of this micronutrient *albeit* this benefit was not consistent at every stage of crop growth. The substitution of paddy straw in general had no significant effect on the availability of this micronutrient.

The soil available Cu content was relatively low in the 15-30 than in the 0-15 cm depth of the soil in all the treatments (Table 5). The quantity of this micronutrient in the lower depth was also influenced by the application of the fertilizers compared to the unfertilized treatment. The effect of conjunctive use of nutrients by substituting 50 % fertilizer N with FYM or *glyricidia* in the *kharif* season and application of recommended dose of fertilizers in the *rabi* season also had a significant influence to increase the available quantity of Cu in the soil significantly even in this low depth as in the surface.

DTPA extractable Iron

The unfertilized soil had 18.32 mg kg^{-1} available Fe at transplanting in *kharif* and 18.25 mg kg^{-1} in *rabi* during 2005-06 (Table 6). In the subsequent year, the available Fe content was 19.10 and 18.95 mg kg^{-1}. It remained almost similar with least reduction in the later stages until harvest during both the years. There was no remarkable change in the available quantity of this nutrient by the application of different proportions of fertilizer application. A significant increase in the availability of this micronutrient was estimated at transplanting in the *kharif* and *rabi* season only during the first year due to the substitution of 50 %N fertilizer with FYM in the *kharif* season and the application of recommended dose of fertilizers in the *rabi* season. This improvement was consistent during rest of the cropping cycle. The other integrated nutrient management treatments did not show any appreciable change in the available quantity of Fe at any stage in *kharif* or *rabi* during the two years compared to the unfertilized soil.

The available Fe content in the 15-30 cm depth was invariably low in all the treatments compared to the upper 0-15 cm layer (Table 7). Fertilizer application in different proportion of the optimum and the integrated nutrient management by substituting 25 or 50 % recommended N with FYM, paddy straw or *glyricidia* did not influence the availability of Fe remarkably.

DTPA extractable Manganese

The soil available Mn in rice-rice cropping system continuously grown without application of fertilizers remained almost constant at different stages of crop growth during the two year cycle (Table 8). The application of fertilizers did not influence the available quantity of this micronutrient remarkably. The substitution of 25 or 50 % fertilizer N with FYM, paddy straw or *glyricidia* also did not influence the availability of this micronutrient. There was no appreciable reduction of this micronutrient at panicle initiation and harvesting stage of the crop even at 15-30cm soil depth (Table 9). These trends were similar even in the fertilized soil supplied with variable proportion of N, P, K through fertilizers and their combination with organic sources during the two years.

The available Zn and Cu in the fertilized soil was on par with the unfertilized soil at different stages of crop growth during the two year rice-rice cropping sequence. The co-application of 50 per cent recommended dose of NPK through fertilizers and FYM or *glyricidia* equivalent 50 per cent N fertilizer in the *kharif* season followed by the recommended dose of fertilizers in the *rabi* season significantly enhanced the availability of Fe both in the surface 0-15 and lower soil depth of 15-

30 cm. The substitution of 25 per cent N fertilizer with these organic materials in the *kharif* season and application of 75 per cent recommended dose of fertilizers in *rabi* season also enriched the soil with more quantity of available Zn. On the other hand, the availability of Mn was not influenced by the application of fertilizers or the conjunctive use of nutrients through organic and inorganic sources. Rajeev Kumar *et al.,* (1993), Bellakki and Badanur (1997), Singh *et al.,* (1999), Hegde (1996) reported that the incorporation of organic sources in the soil along with the fertilizers increased the available micronutrients. The magnificent responses of integrated nutrient management treatments in leaving behind larger quantities of copper sustained the crop requirement in sufficient quantity. The availability of Zn increased by the co application of FYM by substituting 25 or 50% N fertilizer. Nonetheless, the site of present experiment continuously cropped with rice-rice cropping sequence for the past 17 years contained much higher quantities than the critical limit of 0.6 mg kg^{-1} Zn, 0.2 mg kg^{-1} Cu, 4 mg kg^{-1} Fe, and 3 mg kg^{-1} Mn even in the unfertilized control. Not complacent with the data so achieved, it would be a wise step to substitute 50 per cent N fertilizer with FYM or *glyricidia* to averse the likely depletion of these micro but essential elements for crop growth in the years to come.

LITERATURE CITED

Bellakki and Badanur 1997 Long term effect of integrated nutrient management on properties of vertisol under dry land agriculture. *Journal of Indian Society of Soil Science,* 45: 438-442.

Hegde 1996 Long term sustainability of productivity in an irrigated sorghum what system through integrated nutrient supply. Field crops Research 48: 167-175.

Lindsay W L and Norvell W A 1978 Development of DTPA soil test for ascertaining available iron, copper, manganese and zinc. *Soil Science Society of American Journal,* 42: 421-428.

Minhas, R S and Mehta R L 1984 Effect of continuous application of fertilizers on crop yield and some soil chemical properties under wheat – maize rotation. *Journal of Indian Society of Soil Science,* 32: 250-256.

Rajeev Kumar, Singh K P and Sarkar A K 1993 Cumulative effects of cropping and fertilizer use on the status of micronutrients in soil and crop. Fertilizer News. 38(11):13-17.

Singh N P, Sachan R S, Pandey P C and Bisht P S 1999 Effect of a decade long fertilizer and manure application on soil fertility and productivity of rice – wheat system in a Mollisol. *Journal of Indian Society of Soil Science,* 48:72-79.

Subba Rao and Ghosh, 1981 Effect of intensive cropping and fertilizer use on the crop removal of sulphur and zinc and their availability in soil. *Fertilizer research,* 2: 303-308

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