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INFLUENCE OF GREEN MANURING ON MICRONUTRIENTS CONCENTRATION AND UPTAKE OF RICE IN CALCAREOUS SOIL UNDER RICE-WHEAT SYSTEM

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ABSTRACT

A field experiment has been running at Rajendra Agricultural University (RAU), Pusa research farm since Kharif 2000 to see the Long term effect of green manuring on micronutrient Zn, Cu, Fe, Mn concentration and uptake of rice in calcareous soil under rice-wheat system. The soil is classified as light textured calciorthant which is deficient in zinc (available Zn 0.73 mg kg^{-1}). The green manuring treatments were compared with FYM and $ZnSO_4$ application. After completion of 5th rice-wheat cycle (2004-05) the result revealed that zinc concentration and uptake was found maximum in T_{10} where 10 kg ha^{-1} Zn was applied through $ZnSO_4$. The application of FYM or $ZnSO_4$ alone enhanced the Zn concentration in grain and straw of rice significantly compared with green manuring but the concentration and uptake of Cu, Fe, Mn nutrient in rice crop was observed highest in T_4 where dhaincha as green manure was incorporated every year. Green manuring through dhaincha and sunhemp, both each and alternate year application have impressive impact on the concentration and uptake of Cu, Fe, Mn. The effect was statistically at par with every year incorporation of dhaincha and application of either FYM @ 10 t ha^{-1} or 10 kg Zn ha^{-1}.

Key words : *Micronutrient, concentration, uptake, green manuring, FYM, $ZnSO_4$*

About 90% of world's rice is grown in Asia (IRRI, 1989), where it is the staple food and accounts for 50–80% of the calories consumed by the people of the region (Hossain and Pingali, 1998). To meet the expected rice consumption in the world in 2020, a compound growth rate of 1.2% is needed (Rosegrant *et al.,* 1998). This growth rate has to be obtained by increasing productivity, as there is little scope for area expansion. Widespread occurrence of Zn deficiency

in soil has been reported in many parts of our country, particularly where high yielding fertilizer responsive crops are being grown intensively. The calcareous soils of Bihar, occupying a sizeable area, are deficient in micronutrients (Zn) to the extent of 80% of tested soil samples, and symptoms of Zn deficiency are frequently observed in many crops (Sakal and Singh, 1979). Zinc is a vital micronutrient for all the plants involved in a wide range of metabolic processes like, carbohydrate, lipid, protein and nucleic acid synthesis and ruin zinc deficiency is significantly encountered in plants growing in calcareous and sodic soils due to the development of insoluble zinc carbonate which decreases the availability of this cationic micronutrients. Long-term application of zinc and organic manures increased the organic matter content of soil. The conjoint use of zinc and organic manures suggestively increased crop biomass, micronutrients concentration and uptake as well as availability of micronutrients in soils over mineral fertilizer alone. Use of organic manures, including green manuring, is an important strategy to maintain and/or improve soil fertility for sustainable crop production and improved the micronutrient concentration and uptake in rice crop. It has been widely reported in the literature that beneficial effects of organic manures in restoring crop productivity were much larger than those from inorganic fertilizers (Larney and Janzen, 1996; Fageria and Baligar, 2005). It has also been reported that organic matter cycling is related to the agricultural potential of crop (Tissen et al., 1994), and that green manure production and incorporation represents an alternative source of nutrients to mineral fertilizers (Clement *et al.,* 1998). However, it should be kept in mind that green manuring alone cannot supply sufficient essential plant nutrients for maximum or maximum economic crop yields. Hence, the best strategy is to use green manure in conjugation with chemical fertilizers.

MATERIALS AND METHODS

A long-term field experiment was started in Kharif 2000 in light textured highly calcareous soil deficient in

available zinc at Rajendra Agricultural University, Bihar, Samastipur, research farm, Pusa. The experimental soil had pH 8.40, EC 0.32 dSm $^{-1}$, OC 3.80 g kg^{-1}, CEC 8.2 [cmol (p^{+}) kg^{-1}], Free $CaCO_3$ 34.40% and available Zn 0.73 mg kg^{-1}. The experiment was laid out in a RBD with following treatment details as T_1-control, T_2-Sunhemp every year, T_3-sunhemp alternate year, T_4-Dhaincha every year, T_5- Dhaincha alternate year, T_6- Green gram every year, T_7- Green gram + 2.5 t FYM ha^{-1} every year, T_8-Green gram + 5.0 t FYM ha^{-1} every year, T_9-10 t FYM ha^{-1} every year and T_{10}-10 kg Zn ha^{-1} alternate year. These were mixed thoroughly in the respective experimental plot one week prior to transplanting of rice. After completion of 5th rice-wheat cycle (2004-05) grain and straw yield of rice were recorded from a harvest area of 10 m^2. Rice plant samples were first washed with running tap water followed by washing with 0.01 N HCl and finally with double distilled water. After that, plant samples were dried in a hot air oven at 50^{0}C for 48 hours till the constant weight was achieved. After drying, the samples were ground to fine powder by using stainless steel grinder for further analysis. The zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn) content of the plant samples were analyzed in aqueous extracts prepared after wet-digestion with a di-acid mixture of HNO3 and HClO4 (9:4 ratio) using Atomic Absorption Spectrophotometer (Perkin Elmer A Analyst-100). The uptake of Zn, Cu, Fe and Mn were calculated by the multiplication of concentration of respective element and yield of crop. The statistical analysis of variance (ANOVA) of the measured parameters was performed by windows based Statistical Package namely SPSS (ver. 9.3) and the least significant difference (LSD) test was applied to evaluate the significance of the differences between the variables and treatments.

RESULTS AND DISCUSSION

Zinc (Zn) Concentration and uptake : The concentration of Zn varied from 16.7 to 29.0 mg kg^{-1} in rice grain and 18.3 to 34.7 mg kg^{-1} in rice straw as influenced by different treatments (Table 1). The minimum Zn concentration in grain (16.7 mg kg^{-1}) and straw (18.3 mg kg^{-1}) were recorded in treatment, T_1 (Control) whereas, it was found maximum i.e. 29.0 And 34.7 mg kg^{-1} in grain and straw, respectively under treatment, T_{10} where 10 kg ha^{-1} Zn was applied through $ZnSO_4$. The Zinc concentration was more in straw than grain in general. The effect of green manuring through Sunhemp and Dhaincha was found significant whether applied each year or alternate year. Incorporation of green gram alone as green manuring did not provide significant increment in Zn concentration, however, green gram when applied along with FYM, the impact was significant. Application of FYM or $ZnSO_4$ alone improved the Zn concentration in grain and straw of rice significantly. Such increment of Zn concentration may be due to application of Zn through incorporation of dhaincha, sunhemp, green gram and FYM. The addition of Zn through different organic sources along with exploitation of native Zn in soil by organic acids produced on decomposition of organic manures. Increased Zn utilization by crop due to organic matter addition was also reported by Shukla *et al*. (1978), Duraiswamy *et al*. (1988), Singh and Sakal (1982).

The Zn uptake by rice straw was about two times higher as compared to Zn uptake by rice grain. The variation in Zn uptake due to different treatments as reported in Table 1 was found to be from 50.6 to 109.4 g ha^{-1} by rice grain, 89.8 to 215.1 g ha^{-1} by rice straw and 140.4 to 324.6 g ha^{-1} total uptake by rice. It is apparently visualized that impact of green manures, FYM, alone or in combination with green gram and $ZnSO_4$ were found similar to that in Zn concentration of rice grain and straw. The significant increase in total Zn uptake by rice crop may be due to better utilization of applied as well as native zinc by crops. Green manures and FYM incorporation on decomposition might have increased the Zn use efficiency of applied Zn as well as partially dissolved the comparatively insoluble form of Zinc by the decomposition products of organic matter as reported by Singh *et al*. (1998).

The per cent total uptake of Zn varied from 33.8 to 131.2 per cent. Although the highest per cent total uptake was noted under treatment, T_{10} where 10 kg ha^{-1} Zn was applied through $ZnSO_4$ however the effect was statistically at par with treatment, T_8 (green gram + 5 t FYM ha^{-1}). Such results have also been reported by Shukla *et al*. (1978).

Copper (Cu) Concentration and uptake : The concentration of Cu along with its uptake by rice grain and straw as influenced by different green manures, FYM and Zinc are presented in Table 2. The copper concentration varied from 4.6 to 5.9 and 6.2 to 8.4 mg kg^{-1} in rice grain and straw, respectively. The minimum Cu. concentration was recorded in treatment, T_1 (Control) whereas, it was found maximum under treatment, T_4 where dhaincha as green manure was incorporated every year. Green manuring through dhaincha and sunhemp, both each and alternate year

Table-1 : Zinc concentration and uptake by rice as influence by green manuring under rice-wheat system.

Treatments	Zn Concentration (mg/kg)		Zn uptake (g/ha)			Total uptake response (%)
	Grain	Straw	Grain	Straw	Total	
T_1-Control	16.7	18.3	50.6	89.8	140.4	-
T_2-Sunhemp (every year)	21.7	25.7	75.1	144.6	219.7	56.5
T_3-Sunhemp (alternate year)	20.3	23.3	67.7	127.5	195.2	39.0
T_4-Dhaincha (every year)	22.3	29.0	84.2	177.1	261.4	86.2
T_5-Dhaincha (alternate year)	20.3	25.0	73.3	146.1	219.4	56.3
T_6-Green gram (every year)	18.0	23.0	60.1	127.7	187.8	33.8
T_7-Green gram + 2.5t FYM/ha (every year)	23.0	27.7	87.6	171.2	258.8	84.3
T_8-Green gram + 5t FYM/ha (every year)	26.3	30.3	106.6	198.6	305.2	117.4
T_9-10.0 tFYM/ha (every year)	26.7	29.3	102.3	183.8	286.1	103.8
T_{10}-10 kgZn/ha (alternate year)	29.0	34.7	109.4	215.1	324.6	131.2
S.Em +	0.84	1.03	4.37	7.98	10.97	
CD (P=0.05)	2.51	3.06	12.98	23.72	32.61	

Table-2 : Copper concentration and uptake by rice as influence by green manuring under rice-wheat system.

Treatments	Cu Concentration (mg/kg)		Cu. uptake (g/ha)			Total uptake response (%)
	Grain	Straw	Grain	Straw	Total	
T_1-Control	4.6	6.2	13.9	30.20	44.1	-
T_2-Sunhemp (every year)	5.6	7.3	19.5	41.4	60.9	38.0
T_3-Sunhemp (alternate year)	5.5	7.3	18.4	39.7	58.1	31.7
T_4-Dhaincha (every year)	5.9	8.4	22.4	51.4	73.8	67.1
T_5-Dhaincha (alternate year)	5.5	7.8	19.8	45.6	65.4	48.1
T_6-Green gram (every year)	5.0	7.2	16.8	39.6	56.4	27.7
T_7-Green gram + 2.5t FYM/ha (every year)	5.5	7.9	21.0	48.7	69.7	57.8
T_8-Green gram + 5t FYM/ha (every year)	5.9	8.2	24.0	53.4	77.3	75.2
T_9-10.0tFYM/ha (every year)	5.5	7.2	21.3	45.0	66.2	50.1
T_{10}-10kg Zn/ha (alternate year)	5.2	7.4	19.4	45.7	65.1	47.5
S.Em +	0.16	0.18	0.86	1.61	2.18	
CD (P = 0.05)	0.48	0.52	2.55	4.78	6.48	

application have impressive impact on Cu. concentration but the effect of every year incorporation of green gram were not noted significant. Conjoint application of green gram and FYM significantly increased the Cu concentration. Application of either FYM or $ZnSO_4$ was found to improve the Cu concentration of rice grain and straw significantly. Such types of results have also been reported by Duraiswamy *et al*. (1988).

The variation in Cu uptake due to different treatments were recorded to be 13.9 to 24.0 g ha^{-1} by rice grain, 30.2 to 53.4 g ha^{-1} by rice straw and 44.1 to 77.3 g ha^{-1} total Cu uptake by rice. It is apparently visualized from the result that incorporation of dhaincha, sunhemp (every and alternate year) and green gram were found significant. The effect of dhaincha incorporation was obtained significantly superior over green manuring through sunhemp and green gram. The data also revealed that application of green gram alongwith FYM or use of FYM and $ZnSO_4$ alone augmented significantly the Cu uptake by rice crop.

The per cent total uptake response of copper by rice crop ranged between 27.7 to 75.2 per cent due to different treatments. Although, the highest total uptake response was noted under treatment T_8, where green gram was incorporated alongwith 5 t FYM ha^{-1} application of green manuring each year appears to be superior over its alternate year application. The significant effect of green manuring alone or in conjoint

Table-3 : Iron concentration and uptake by rice as influence by green manuring under rice-wheat system.

Treatments	Fe Concentration (mg/kg)		Fe uptake (g/ha)			Total uptake response (%)
	Grain	Straw	Grain	Straw	Total	
T_1-Control	52.3	179.0	159	877	1035	-
T_2-Sunhemp (every year)	60.3	196.3	209	1107	1316	27.1
T_3-Sunhemp (alternate year)	58.0	185.7	194	1015	1208	16.7
T_4-Dhaincha (every year)	77.7	224.7	292	1369	1662	60.6
T_5-Dhaincha (alternate year)	69.7	216.7	252	1271	1521	47.0
T_6-Green gram (every year)	59.0	193.0	197	1067	1264	22.1
T_7-Green gram + 2.5t FYM/ha (every year)	72.0	241.0	274	1484	1758	69.8
T_8-Green gram + 5t FYM/ha (every year)	76.3	256.3	308	1676	1984	91.7
T_9-10.0 t FYM/ha (every year)	65.7	191.0	251	1197	1448	39.9
T_{10}-10 kg Zn/ha (alternate year)	51.3	179.7	193	1115	1309	26.5
S.Em +	1.72	3.72	11.2	31.8	39.4	
CD (P=0.05)	5.12	11.06	33.1	94.3	117.0	

Table-4 : Manganese concentration and uptake by rice as influence by green manuring under rice-wheat system.

Treatments	Mn Concentration (mg/kg)		Mn uptake (g/ha)			Total uptake response (%)
	Grain	Straw	Grain	Straw	Total	
T_1-Control	39.3	65.0	119.2	318.3	437.5	-
T_2-Sunhemp (every year)	47.0	84.0	163.4	473.1	636.5	45.5
T_3-Sunhemp (alternate year)	44.7	80.7	149.2	440.3	589.5	34.7
T_4-Dhaincha (every year)	49.7	93.3	186.7	569.8	756.5	72.9
T_5-Dhaincha (alternate year)	47.0	86.7	169.4	508.3	677.6	54.9
T_6-Green gram (every year)	45.0	67.7	150.1	374.9	525.0	20.0
T_7-Green gram + 2.5t FYM/ha (every year)	49.3	80.3	186.9	496.0	682.9	56.1
T_8-Green gram + 5t FYM/ha (every year)	49.0	87.3	197.5	571.3	768.8	75.7
T_9-10.0 t FYM/ha (every year)	43.7	81.0	167.8	508.1	676.0	54.5
T_{10}-10 kg Zn/ha (alternate year)	41.3	73.0	155.4	457.3	612.8	40.1
S.Em +	1.97	2.12	8.63	20.37	23.61	
CD (P = 0.05)	5.86	6.29	25.65	60.53	70.16	

with FYM might be due to increases yield and concentration. The organic materials are rich in micro-nutrients which can be used as sources of micro-nutrients and complexing agents (Prasad, 1999).

Iron (Fe) Concentration and uptake : The data of iron concentration and uptake in rice are given in Table 3. Iron concentration of rice grain and straw significantly increased from 51.3 to 77.7 and 179.0 to 256.3 mg kg^{-1}, respectively due to application of green manures through dhaincha, sunhemp and green gram or FYM. The effect of every year dhaincha application was found statistically at par with sunhemp and green gram (both alternate and every year) treatments. Conjoint use of green gram and FYM or FYM alone also increased Fe-content significantly in rice grain and straw, whereas application of $ZnSO_4$ alone, failed to enhanced Fe-concentration significantly which might be due to antagonistic effect of Zn on Fe as suggested by several workers like Das *et al.* (1993).

The Fe-uptake by rice grain and straw and total Fe-uptake varied from 159 to 308, 877 to 1676 and 1035 to 1984 g ha^{-1}, respectively (Table 3) as influenced by different treatments. The minimum total Fe uptake by rice crop was recorded as 1035 g ha^{-1} under treatment, T_1 (Control) whereas, the maximum total Fe-uptake was obtained as 1984 g ha^{-1} in treatment, T_8 where green gram alongwith 5 t FYM ha^{-1} was incorporated. Green manuring both in alternate and every year through dhaincha, sunhemp as well as

green gram, enhanced significantly the total Fe-uptake by rice crop. Every year green manuring of dhaincha, was noted significantly superior over all the green manuring treatments. Significant effect was also observed when conjoint use of green gram + FYM or FYM alone was done.

Per cent response of total uptake was noted maximum (91.7%) under treatment, T_8 where green gram as green manure and 5 t FYM ha^{-1} was applied while minimum per cent total uptake response (16.7 %) was recorded with treatment T_3. Such increment in Fe-concentration and uptake has also been reported earlier which might be due to application of organic manures. After decomposition, organic manures release various organic acids which solubilize the native Fe and made more available. These results are in conformity with the findings of Singh and Pathak (2003).

Manganese (Mn) Concentration and uptake : Manganese concentration in rice grain and straw was significantly affected by dhaincha and sunhemp green manuring (Table 4). Highest Mn concentration of rice grain and straw was found under the treatment, T_4 (49.7 & 93.3 mg kg^{-1}), respectively and the lowest was observed (39.3 & 65.0 mg kg^{-1}), respectively under treatment, T_1 (control). The effect of green manuring with dhaincha and sunhemp applied each year was more effective than alternate year application. The effect of dhainchha was superior over sunhemp incorporation. Application of green gram, FYM and $ZnSO_4$ alone failed to significantly enhanced Mn concentration in rice grain but Mn concentration of rice straw was enhanced significantly under the treatment FYM and $ZnSO_4$, alone application.

Manganese uptake by rice grain and straw ranged between 119.2 to 197.5 and 318.3 to 571.3 g ha^{-1}, respectively. While total uptake of Mn by rice crop ranged between 437.5 to 768.8 g ha^{-1} due to different treatments (Table 4). The lowest Mn total uptake was noted to be 437.5 g ha^{-1} at control treatment and the highest was observed (768.8 g ha^{-1}) at treatment receiving green gram as green manure crop + 5 t FYM ha^{-1}. Green manuring both alternate and every year with dhaincha, sunhemp and green gram, significantly augment the total Mn uptake by rice crop. However, the application of green gram + FYM or alone application of FYM and $ZnSO_4$ have also impressive impact on total uptake of manganese.

The per cent total uptake response of manganese varied from 20.0 to 75.7 per cent. Although, the highest per cent total uptake response was recorded under treatment, where green gram was incorporated alongwith 5 t FYM ha^{-1} but the effect was statistically at par with treatment T_4 (dhaincha as green manuring every year).

CONCLUSIONS

Application of FYM or $ZnSO_4$ alone enhanced the Zn concentration in grain and straw of rice significantly compared with green manuring but the concentration and uptake of Cu, Fe, Mn nutrient in rice crop was observed highest in T_4 where dhaincha as green manure was incorporated every year. Green manuring through dhaincha and sunhemp, both each and alternate year application have impressive impact on the concentration and uptake of Cu, Fe, Mn. Thus, long-term application of organic manures increased micronutrient nutrition under rice-wheat cropping system in calcareous soil.

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