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LONG TERM EFFECT OF GREEN MANURING ON MICRONUTRIENT CONCENTRATION AND UPTAKE OF WHEAT 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 concentration and uptake of wheat in calcareous soil under rice-wheat system. The soil is classified as calciorthant which is deficient in zinc (available Zn 0.73 mg kg^{-1}). Micronutrients Zn, Cu, Fe and Mn concentration of wheat increased considerably by the incorporation of various organic sources like FYM, dhaincha, sunhemp, green gram as green manure crops and it was reflected in higher uptake and responses of micronutrient by the crop. Green gram along with 5 t FYM ha^{-1} every year incorporation was most effective among all treatments with respect to the concentration and uptake of micronutrients in wheat crop. The residual impact of different green manures and FYM alone or in combination exhibited significant result with respect to micronutrients concentration as well as uptake by wheat crop is attributed due to the fact that the availability of cationic metals can be strongly influenced by reactions with organic matter. Addition of natural organic materials such as green manures, compost and wheat straw has increased the soluble and exchangeable Zn, Cu, Fe and Mn can maintain micronutrients nutrition to rice-wheat system.

Key words : *Green manuring, rice-wheat system, calciorthant, concentration, uptake - Zn, Cu, Fe and Mn*

Micronutrients zinc (Zn), copper (Cu), iron (Fe), manganese (Mn) are essential for the normal healthy growth and reproduction of plants, animals and humans and when the supply of plant-available zinc is inadequate, crop yields are reduced and the quality of crop products is frequently impaired. Micronutrients have particular physiological functions in all living systems, such as the maintenance of structural and functional integrity of biological membranes and facilitation of protein synthesis and gene expression. Zinc deficiency appears to be the most widespread and frequent micronutrient deficiency problem in cereal plants worldwide, resulting in severe losses in yield and nutritional quality. This is particularly the case in areas of cereal production. It is estimated that nearly half the soils on which cereals are grown have levels of available micronutrients low enough to cause its deficiency. Since cereal grains have inherently low micronutrients concentrations, growing them on these potentially micronutrients deficient soils further decreases grain and straw Zn, Cu, Fe, Mn concentration.

Rice and wheat are the main staple food cereals exclusively grown for human consumption all over the globe since ancient times. At present, rice and wheat account for over 75 per cent of the total food grain production in the country. The modern agricultural technology emphasizes wide spread use of fertilizers as a source of nutrients. In fact fertilizer use is considered as a barometer of agricultural production. The uses of organics have been advocated because of their ecofriendly nutrients benefits and improvement of soil health (Prasad 1999). Maintenance of organic matter in the soil, therefore, should be one of the management issues for the sustainability of agricultural production system. Dhaincha, FYM, green gram, crop residues sunhemp are important renewable organic sources of nutrients, supplementing the fertilizer for major nutrients, green manure and organic manure are also important in improving soil quality (Bellaki and Badanur, 1994; Mathur, 1997; Swarup *et al*. 1998). Since, green manuring with dhaincha, sunhemp, green gram and FYM incorporation is becoming on increasing important aspects of environmentally sound sustainable agriculture and organic materials hold a great promise due to their local availability, as a source of multiple nutrient and availability to improve soil characteristics. The emergence of zinc deficiency has generally been considered as secondary. The availability of zinc to plants is influenced by its

distribution within the soil profile and other soil characteristics (Singh *et al.* 1989 and 2005).

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 wheat were recorded from a harvest area of 10 m^2. Wheat 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 500C 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 particular 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 : A perusal of data presented in Table-1 showed that Zn concentration in wheat grain and straw varied from 20.0 to 33.3 and 18.7 to 26.7 mg kg^{-1} respectively due to different treatments. The maximum Zn concentration in wheat grain (33.3 mg kg^{-1}) and straw (26.7 mg kg^{-1}) recorded in treatment, T_{10} were 10 kg ha^{-1} Zn is being applied alternate year and the minimum values were obtained under control treatment. Application of green manuring significantly raised the Zn content in wheat grain and straw where the effect of dhaincha was more pronounced. Every year green manuring was found more effective as compared to alternate year. Although, the effect of green manuring every year with green gram was non-significant, but when it was applied along with FYM, the effect was significant in enhancing Zn content in wheat. Farm Yard Manure alone was also effective in enhancing Zn concentration in wheat.

The uptake of Zn by wheat grain, straw, and total uptake increased significantly from 72.3 to 130.0, 87.7 to 139.4 and 160.0 to 269.4 g ha^{-1}, respectively due to different treatments. Green manuring with dhaincha, sunhemp and green gram, either alternate or every year addition have significant impact on total uptake of Zn by wheat crop. The effect of dhaincha was superior over sunhemp and green gram but every year green manuring with sunhemp was found statistically similar with alternate year of dhaincha incorporation. Similar to yield and Zn content, the Zn uptake was also found to be more effectively enhanced by green gram + 5 t ha^{-1} FYM applications. Such result was expected due to the fact that organic matter on decomposition resulted in build-up of available Zn which accentuated the Zn uptake by crops. Similar result has been reported by several workers (Babu, 2004).

Per cent total uptake response of wheat crop varied from 13.3 to 68.4 due to different treatments. The lowest per cent total uptake response (13.3%) was recorded with treatment, T_6 where green gram alone was added while, the maximum per cent total uptake response was observed under treatment, T_{10} (68.4%) followed by T_8 (61.9%). The significant effect of green manuring alone or in conjoint with FYM gave support to the finding of Sharad and Verma (2001). It may happened because of lower C : N ratio of green manure which resulted in faster decomposition and more release of Zn to be utilized during the crop growth period leading to higher Zn concentration and uptake by wheat crop (Meelu, 1981).

Copper (Cu) concentration and uptake : Copper concentration and uptake by wheat crop as reported in Table-2 indicated that the Cu concentration of wheat grain and straw varied from 6.5 to 11.5 and 7.3 to 12.3

Table-1 : Zinc concentration and uptake by wheat 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	20.0	18.7	72.3	87.7	160.0	-
T_2 – Sunhemp (every year)	23.7	22.7	90.5	116.6	207.1	29.4
T_3 – Sunhemp (alternate year)	22.0	20.7	82.4	103.7	186.1	16.3
T_4 – Dhaincha (every year)	29.3	23.7	117.1	125.4	242.4	51.5
T_5 – Dhaincha (alternate year)	26.0	21.3	102.1	110.1	212.2	32.6
T_6 – Green gram (every year)	21.7	20.3	79.8	101.5	181.3	13.3
T_7 – Green gram + 2.5t FYM/ha (every year)	28.0	24.7	103.2	124.8	227.9	42.4
T_8 – Green gram + 5t FYM/ha (every year)	31.3	26.0	122.3	136.7	259.0	61.9
T_9 – 10.0 t FYM/ha (every year)	29.7	24.7	114.1	129.3	243.5	52.2
T_{10} – 10 kg Zn/ha (alternate year)	33.3	26.7	130.0	139.4	269.4	68.4
S.Em +	1.52	0.95	4.87	5.54	6.74	
CD (P = 0.05)	4.51	2.82	14.47	16.45	20.02	

Table-2 : Copper concentration and uptake by wheat 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	6.5	7.3	23.6	34.5	58.1	-
T_2 – Sunhemp (every year)	8.0	10.0	30.8	51.3	82.0	41.1
T_3 – Sunhemp (alternate year)	7.0	8.3	26.2	41.8	67.9	16.9
T_4 – Dhaincha (every year)	9.7	12.0	38.7	63.5	102.2	75.9
T_5 – Dhaincha (alternate year)	7.8	8.3	30.9	43.1	74.0	27.4
T_6 – Green gram (every year)	7.3	8.3	26.8	41.3	68.1	17.2
T_7 – Green gram + 2.5t FYM/ha (every year)	9.2	11.0	33.8	55.6	89.4	53.9
T_8 – Green gram + 5t FYM/ha (every year)	11.5	12.3	44.6	64.9	109.5	88.5
T_9 – 10.0 t FYM/ha (every year)	10.2	12.0	39.3	62.5	101.8	75.2
T_{10} – 10 kg Zn/ha (alternate year)	6.8	7.7	26.8	40.0	66.8	15.0
S.Em +	0.55	0.76	2.25	3.36	4.27	
CD (P = 0.05)	1.64	2.26	6.70	10.00	12.70	

mg kg^{-1}, respectively due to different treatments. The maximum Cu concentration of wheat grain and straw were observed to be 11.5 and 12.3 mg kg^{-1} under treatment T_8, receiving green gram + 5 t ha^{-1} FYM. The effect was significantly superior over other treatments except T_9 where 10 t FYM ha^{-1} was applied. This suggests that green gram as green manuring can save at least 5 t FYM ha^{-1}

Copper uptake by wheat grain and straw as well as total uptake by wheat crop increased significantly as influenced by different treatment and ranged between 23.6 to 44.6, 34.5 to 64.9 and 58.1 to 109.5 g ha^{-1}, respectively. Akin to Cu concentration, total uptake of Cu by wheat crop also followed same trend with highest total uptake under treatment T_8 (109.5 g ha^{-1}). While, the minimum total Cu uptake (58.1 g ha^{-1}) was noted under control. The effect of green manuring through dhaincha both alternate and every year was found significant whereas, green manuring with green gram and alternate year sunhemp failed to produce significantly higher total Cu uptake. However, green gram when applied along with FYM the effect was significant. Incorporation of FYM alone @ 10 t ha^{-1} was found to improve the total Cu uptake by wheat crop significantly. But the sole application of Zn through $ZnSO_4$ did not show any effect on Cu content and uptake in wheat. These results corroborated with findings of Das, 2002.

Table-3 : Iron concentration and uptake by wheat 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	48.7	198.7	176.0	934.1	1110.0	-
T_2 – Sunhemp (every year)	65.0	248.0	249.4	1273.0	1522.0	37.1
T_3 – Sunhemp (alternate year)	54.0	227.7	201.9	1142.0	1344.0	21.1
T_4 – Dhaincha (every year)	77.3	258.3	309.2	1369.0	1678.0	51.2
T_5 – Dhaincha (alternate year)	65.7	239.0	258.1	1234.0	1493.0	34.5
T_6 – Green gram (every year)	55.3	224.0	202.8	1116.0	1319.0	18.8
T_7 – Green gram + 2.5t FYM/ha (every year)	70.7	253.7	261.9	1186.0	1548.0	39.5
T_8 – Green gram + 5t FYM/ha (every year)	73.3	267.0	286.0	1406.0	1692.0	52.4
T_9 – 10.0 t FYM/ha (every year)	60.3	238.3	233.5	1247.0	1480.0	33.3
T_{10} – 10 kg Zn/ha (alternate year)	48.7	199.7	189.7	1045.0	1234.0	11.2
S.Em +	1.89	2.43	11.62	37.15	46.26	
CD (P = 0.05)	5.62	7.22	34.52	110.38	137.46	

Table-4 : Manganese concentration and uptake by wheat 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	23.3	42.3	85.0	198.8	283.0	-
T_2 – Sunhemp (every year)	26.0	52.7	99.0	271.1	370.4	30.9
T_3 – Sunhemp (alternate year)	25.0	46.7	93.0	234.3	327.5	15.7
T_4 – Dhaincha (every year)	30.0	58.0	120.6	306.8	426.5	50.7
T_5 – Dhaincha (alternate year)	27.0	52.3	106.0	270.0	376.1	32.9
T_6 – Green gram (every year)	25.3	46.7	93.0	232.8	325.8	14.8
T_7 – Green gram + 2.5t FYM/ha (every year)	29.0	47.7	107.0	241.7	348.9	23.3
T_8 – Green gram + 5t FYM/ha (every year)	32.0	59.3	125.0	312.2	437.4	54.5
T_9 – 10.0 t FYM/ha (every year)	28.7	54.7	111.0	285.8	397.0	40.3
T_{10} – 10 kg Zn/ha (alternate year)	24.3	44.3	95.0	231.5	326.2	15.3
S.Em +	1.14	1.79	5.06	11.28	12.29	
CD (P = 0.05)	3.39	5.31	15.05	33.53	36.52	

The per cent total uptake response varied from 15.0 to 88.5 per cent due to different treatments. Although, the highest per cent total uptake response was noted under treatment, T_8 where green gram was incorporated along with 5 t FYM ha^{-1} but the effect was statistically at par with treatments T_4 and T_9.

Iron (Fe) concentration and uptake : A perusal of data in Table-3 indicated that Fe concentration in wheat grain and straw enhanced significantly from 48.7 to 77.3 and 198.7 to 267.0 mg kg^{-1}, respectively due to different treatments. The minimum Fe-concentration of wheat grain (48.7 mg kg^{-1}) and straw (198.7 mg kg^{-1}) noted with treatment T_1 (control) which were augmented to the maximum value as 77.3, 258.3 and 267.0 mg kg^{-1} in wheat grain and straw due to two different treatments T_4 and T_8 where dhaincha and green gram + 5 t FYM ha^{-1} were incorporated, respectively.

Uptake of Iron by wheat grain and straw varied from 176.0 to 309.2 and 934.1 to 1406.0 g ha^{-1}, respectively and total Fe uptake increased from 1110.0 to 1692.0 g ha^{-1} due to application of dhaincha, sunhemp, green gram, FYM and $ZnSO_4$ treatments. The maximum total Fe uptake (1692.0 g ha^{-1}) was recorded with treatment T_8 which was significantly superior over minimum value of 1110 g ha^{-1} noted in control.

The effect of different green manuring sources like dhaincha, sunhemp and green gram were found significant. The effect of dhaincha was superior over

sunhemp and green gram although the effect of alternate year sunhemp application was at par with every year green manuring with green gram. Conjoint application of green gram and FYM and alone application of FYM significantly augmented total Fe-uptake by wheat crop but sole application of $ZnSO_4$ did not exhibit any improvement in Fe as well as uptake by wheat crop. Zn^{2+} inhibit, Fe^{2+} uptake possibly because of competition for the same carrier site (Tisdale *et al*. 2002, Chavan and Banerjee, 1980 and Pathak *et al*. 1975).

Per cent total uptake response of Iron by wheat crop ranged between 11.2 to 52.4 per cent due to different green manuring, FYM and $ZnSO_4$ treatments. However, the highest per cent total uptake response i.e. 52.4 per cent was recorded with treatment T_8 which was significantly superior over treatment showing lowest per cent total uptake response (10 kg Zn ha^{-1}). Green manuring and application of FYM increased organic matter content of soil which supplies chelating agents that help in maintaining the solubility of micronutrients and increase Fe availability to plant (Tisdale *et al*. 2002).

Manganese (Mn) concentration and uptake : Scanning the data summarised in Table-4 revealed that Mn concentration of wheat grain and straw increased significantly from 23.3 to 32.0 and 42.3 to 59.3 mg kg^{-1}, respectively because of different treatments. It was further observed that among the green manuring treatments, dhaincha green manuring both alternate and every year significantly increased the Mn concentration of wheat grain and straw while every year green manuring with sunhemp has significant effect on Mn concentration of wheat straw. However, application of green gram with FYM had also significant impact on Mn concentration of wheat grain and straw. It is apparent from the data that the impact of $ZnSO_4$ on Mn concentration was non-significant while alone application of FYM, significantly increased the Mn concentration in wheat grain and straw.

Residual effect of dhaincha, sunhemp, FYM and green gram were found to affect the Mn uptake significantly which varied from 85.0 to 125.0, 198.8 to 312.2 and 283.0 to 437.4 g ha^{-1} in grain, straw as well as total Mn uptake, respectively (Table 12). The maximum total Mn uptake was obtained (437.4 g ha^{-1}) under green gram + FYM treatment combination. The effect of green manuring of alternate and every year through dhaincha and sunhemp were found significant. Application of FYM along with green gram or FYM alone, impressibly enhanced total uptake of Mn by wheat crop while, $ZnSO_4$ failed to show any improvement in total uptake of Mn by wheat crop. These results corroborated with the findings of Ragini (2003).

The total uptake response of Mn by wheat crop varied from 14.8 to 54.5 per cent due to different treatments. Application of green gram along with FYM recorded maximum total uptake response of 54.5 per cent which was followed by every year dhaincha incorporation and FYM alone. The impact of different green manures, and FYM alone or in combination exhibited significant result with respect to Mn concentration as well as uptake by wheat crop is attributed due to the fact that the availability of Mn^{2+} can be strongly influenced by reactions with organic matter. Addition of natural organic materials such as green manures, compost and wheat straw have increased the soluble and exchangeable Mn (Tisdale *et al*. 2002).

CONCLUSIONS

Under rice-wheat system, micronutrients zinc (Zn), copper (Cu), iron (Fe), manganese (Mn) concentration of wheat increased considerably by the incorporation of various organic sources like dhaincha, sunhemp, green gram as green manure crops and FYM in calcareous soil under rice-wheat system and it was reflected in higher uptake of micronutrient by the crop. Zinc sulphate application also resulted in higher uptake of zinc by the crop. 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}. This result indicates that green gram incorporation along with 5 t ha^{-1} FYM could substitute 10 kg Zn ha^{-1}. Similarly green gram incorporation could save 5 t ha^{-1} FYM.

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