

LONG TERM EFFECT OF MANURE AND FERTILIZERS ON CONCENTRATION AND UPTAKE OF Zn, Cu, Fe AND Mn IN RICE AND WHEAT GRAINS UNDER RICE-WHEAT SYSTEM

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Abstract: Laboratory analysis was made on the plant samples collected (October 2013) from an on-going long-term field experiment (in progress since *Kharif* 2009-10) at Department of Soil Science, PAU, Ludhiana to investigate the effect of manure and chemical fertilizers in rice-wheat system. The organic manure through bio gas slurry (BGS) @ 6 t ha⁻¹ was incorporated along with nitrogen fertilizer (N @ 80 and 120 kg ha⁻¹). The results of our study revealed that the concentration of Zn, Cu, Fe and Mn (26.74, 4.93, 39.18 and 24.60 mg kg⁻¹ respectively) in wheat grains and (27.07, 2.97, 36.72 and 52.28 mg kg⁻¹ respectively) in rice grains was found higher in the treatments where organic manure was added along with chemical fertilizers. Similarly, the uptake of Zn, Cu, Fe and Mn (123.1, 23.6, 189.4 and 112.1 g ha⁻¹ respectively) in wheat grains and (158.4, 17.3, 194.0 and 306.1 g ha⁻¹ respectively) in rice grains were found higher where organic manure was added along with chemical fertilizers.

Keywords: Rice and wheat grains, concentration, uptake, Zn, Cu, Fe and Mn, biogas slurry manure, chemical fertilizers, rice-wheat system

INTRODUCTION

Production of food grains is increasing year after year due to intensive cultivation of land thereby depleting a huge amount of macronutrients along with micronutrients. Relatively, over use of macronutrient fertilizers and decreased use of organic manures have induced secondary and micronutrient deficiencies in the Indo Gangetic Plains. In several areas with intensive cropping, zinc deficiency appeared initially and subsequently the deficiencies of iron (Fe) and manganese (Mn) were observed. Herencia *et al* (2008) reported that with the addition of organic and mineral fertilization, OM-bound fractions of micronutrients increased their availability and uptake in the soil. Dhaliwal and Walia (2008) reported that incorporation of manures increased the availability of the micronutrients like Zn, Cu, Fe and Mn.

Different cropping systems behave differently with respect to the uptake of Zn, Cu, Fe and Mn under different conditions. The uptake of Zn, Cu, Fe and Mn in alkaline condition of soil was higher in rice as compared to wheat in rice-wheat cropping system (Gupta and Mehla 1993). Kulandaivel *et al* (2004) reported that the application of 30 kg ZnSO₄ + 5 kg FeSO₄ha⁻¹ chelating with FYM in sandy clay loam soil with low content of Zn and Fe was found to be the best combination for uptake of micronutrients by rice in rice-wheat cropping system. Singh and Ram (2007) observed the uptake of micronutrients by rice, wheat and cowpea crops under rice-wheat-cowpea cropping system in Mollisol. The effect of different fertilizer on micronutrients uptake by groundnut and wheat crop under groundnut-wheat cropping system was observed by Patel *et al* (2007). Bahera and Singh (2009) conducted an experiment during 2002-06 and reported that the total uptake of Zn, Cu, Fe and Mn ranged from 119.5-2.68.6, 17.0-37.5, 278.3-504.6 and 51.6-108.3 g ha⁻¹ respectively by maize and from 134-324.7, 60.8-149.3, 1030.8-2540.2 and 219.4-466.3 g ha⁻¹ respectively by wheat under different treatments. Li *et al* (2007) reported that the wheat grain had higher concentration of Zn, Cu, Fe and Mn (20.2, 5.0, 31.4 and 21.7 mg kg⁻¹ respectively) than those of corn grain (14.3, 2.7, 22.9 and 3.05 mg kg⁻¹ respectively). Application of manure and chemical fertilizers in combination helped to improve the micronutrient content of wheat and rice grains. Keeping these points in view, the present study was undertaken to investigate the effect of manure and chemical fertilizers on concentration and uptake of Zn, Cu, Fe and Mn in wheat and rice grains.

MATERIALS AND METHODS

In order to achieve the objectives mentioned earlier, laboratory studies were made on the soil samples collected from an on-going long-term experiment on role of manure and fertilizers in rice-wheat cropping system (in progress since *Kharif* 2009-10) at Department of Soil Science, Punjab Agricultural University, Ludhiana. The soil of experiment field was classified as Typic Ustochrept. The experiment was laid out in a split plot design with four main and three sub treatments. The organic manure through bio gas slurry (BGS) @ 6 t ha⁻¹ was incorporated along with nitrogen fertilizer (N @ 80 and 120 kg ha⁻¹), phosphorus fertilizer (P @ 30 kg ha⁻¹) and potassium fertilizer (K @ 30 kg ha⁻¹) were applied to the rice crop. Whereas in wheat crop, nitrogen fertilizer (N @ 120 kg ha⁻¹), different levels of phosphorus fertilizer (P @ 30 and 60 kg ha⁻¹) and potassium fertilizer (K @ 30 kg ha⁻¹) were applied. The soil organic carbon was 0.33%, available nitrogen content was 275 kg ha⁻¹,

available phosphorus was 23 kg ha⁻¹ and available potassium was observed as 184 kg ha⁻¹.

Plant analysis

The grain samples from rice and wheat crops were collected at maturity. These grains were digested in a diacid mixture of HNO₃ and HClO₄ (3:1) for the analysis of total Zn, Cu, Fe and Mn. The concentrations of Zn, Cu, Fe and Mn were determined using atomic absorption spectrophotometry method given by Isaac and Kerber (1971).

Statistical analysis

Critical difference (CD) was used to compare the treatments effects at P<0.05. The statistical analysis was done with the help of method described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Concentration of Zn, Cu, Fe and Mn in wheat grain

The results in Table 1 revealed that Zn in wheat grain ranged from 21.07 to 26.74 mg kg⁻¹ in different treatment combinations. Significantly higher concentration of Zn has been noticed in those treatments where organic manure @ 6 t ha⁻¹ has been added along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ applied to the rice crop as compared to the treatments where only N @ 120 kg ha⁻¹ was applied to the rice crop and no organic manure and P fertilizer were applied. Similarly, significantly higher concentration of Zn was also noticed in the treatments where organic manure @ 6 t ha⁻¹ was added along with N @ 80 kg ha⁻¹ without the application of phosphatic fertilizer as compared to the treatments where no organic manure was applied but N @ 120 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ were applied to the rice crop. The concentration of Cu in wheat grain ranged from 4.42 to 4.93 mg kg⁻¹ in different treatment combinations (Table 1). The application of organic manure @ 6 t ha⁻¹ along with application of N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ to the rice crop did not show any significant results for Cu at this stage as compared to the treatments where N @ 120 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ were applied to the rice crop without incorporating organic manure.

Similarly, the concentration of Fe in wheat grain ranged from 33.67 to 39.18 mg kg⁻¹ in all the treatments combinations. Significantly higher concentrations were observed in the treatments where organic manure @ 6 t ha⁻¹ has been added along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ applied to the rice crop as compared to the treatments where only N @ 120 kg ha⁻¹ was applied to the rice crop without application of organic manure and P fertilizer. Similarly, the treatments where organic manure @ 6 t ha⁻¹ was added along with N

@ 80 kg ha⁻¹ without the application of phosphatic fertilizer showed significant higher concentration of Fe as compared to the treatments where no organic manure was incorporated but N @ 120 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ were applied to the rice crop. Also, the concentration of Mn in wheat grain ranged from 20.20 to 24.60 mg kg⁻¹ in all the treatment combinations.

Table 1: Effect of manure and fertilizers on Zn, Cu, Fe and Mn concentration in wheat grain

Treatments to rice	Rates of P applied to wheat (kg P ₂ O ₅ ha ⁻¹)			Mean
	P ₀	P ₃₀	P ₆₀	
Zn (mg kg⁻¹)				
M ₀ N ₁₂₀ P ₀	23.80	23.04	22.33	23.06
M ₆ N ₈₀ P ₃₀	25.25	24.63	24.12	24.67
M ₀ N ₁₂₀ P ₃₀	22.25	21.52	21.07	21.61
M ₆ N ₈₀ P ₀	26.74	25.65	25.41	25.93
Mean	24.51	23.71	23.23	-
LSD (<i>p</i> <0.05)	R=0.52, W=0.48, R×W=NS			
Cu (mg kg⁻¹)				
M ₀ N ₁₂₀ P ₀	4.79	4.76	4.73	4.76
M ₆ N ₈₀ P ₃₀	4.86	4.82	4.80	4.83
M ₀ N ₁₂₀ P ₃₀	4.92	4.42	4.45	4.59
M ₆ N ₈₀ P ₀	4.93	4.92	4.90	4.92
Mean	4.87	4.73	4.72	-
LSD (<i>p</i> <0.05)	R=NS, W=NS, R×W=NS			
Fe (mg kg⁻¹)				
M ₀ N ₁₂₀ P ₀	35.83	34.63	33.67	34.71
M ₆ N ₈₀ P ₃₀	38.23	38.78	39.18	38.73
M ₀ N ₁₂₀ P ₃₀	37.87	36.26	36.23	36.79
M ₆ N ₈₀ P ₀	36.20	35.92	37.20	36.44
Mean	37.03	36.40	36.57	-
LSD (<i>p</i> <0.05)	R=0.21, W=0.46, R×W=0.93			
Mn (mg kg⁻¹)				
M ₀ N ₁₂₀ P ₀	21.25	21.13	21.03	21.14
M ₆ N ₈₀ P ₃₀	22.48	22.17	21.60	22.08
M ₀ N ₁₂₀ P ₃₀	21.33	20.35	20.20	20.63
M ₆ N ₈₀ P ₀	24.60	23.33	23.00	23.65
Mean	22.42	21.75	21.46	-
LSD (<i>p</i> <0.05)	R=0.73, W=0.41, R×W=NS			

Significantly higher concentration was observed in the treatments where organic manure @ 6 t ha⁻¹ has been added along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ applied to the rice crop as compared to the treatments where only N @ 120 kg ha⁻¹ was applied without addition of organic manure to the rice crop and also no P fertilizers was applied. Similar results were obtained by Dhaliwal and Walia (2008).

Uptake of Zn, Cu, Fe and Mn in wheat grain

The data presented in Table 2 indicated that Zn uptake in wheat grain ranged from 95.2 to 123.1 g ha⁻¹ in all the treatments. Significantly higher Zn uptake (102.7 to 117.3 g ha⁻¹) was recorded in the treatments where organic manure @ 6 t ha⁻¹ was added along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ as compared to the treatments where no organic manure was added.

Table 2: Effect of manure and fertilizers on uptake of Zn, Cu, Fe and Mn in wheat grain

Treatments to rice	Rates of P applied to wheat (kg P ₂ O ₅ ha ⁻¹)			Mean
	P ₀	P ₃₀	P ₆₀	
Zn uptake (g ha⁻¹)				
M ₀ N ₁₂₀ P ₀	95.2	99.0	108.7	100.9
M ₆ N ₈₀ P ₃₀	102.7	117.3	116.6	112.2
M ₀ N ₁₂₀ P ₃₀	88.9	93.2	100.6	94.2
M ₆ N ₈₀ P ₀	106.9	123.1	122.0	117.3
Mean	98.4	108.1	111.9	-
LSD (<i>p</i> <0.05)	R=10.95, W=7.18, RxW=NS			
Cu uptake (g ha⁻¹)				
M ₀ N ₁₂₀ P ₀	19.2	20.4	23.1	20.9
M ₆ N ₈₀ P ₃₀	19.8	23.0	23.2	22.0
M ₀ N ₁₂₀ P ₃₀	19.7	19.2	21.2	20.0
M ₆ N ₈₀ P ₀	19.7	23.6	23.6	23.3
Mean	19.6	21.6	22.8	-
LSD (<i>p</i> <0.05)	R=NS, W=2.03, RxW=NS			
Fe uptake (g ha⁻¹)				
M ₀ N ₁₂₀ P ₀	143.3	149.0	163.9	152.1
M ₆ N ₈₀ P ₃₀	155.6	184.9	189.4	176.6
M ₀ N ₁₂₀ P ₃₀	151.6	157.2	172.6	160.5
M ₆ N ₈₀ P ₀	144.8	172.5	178.5	165.3
Mean	148.8	165.9	176.1	-
LSD (<i>p</i> <0.05)	R=13.84, W=12.64, RxW=NS			
Mn uptake (g ha⁻¹)				
M ₀ N ₁₂₀ P ₀	84.9	91.0	102.3	92.8
M ₆ N ₈₀ P ₃₀	91.3	105.6	104.5	100.5
M ₀ N ₁₂₀ P ₃₀	85.3	88.2	96.2	89.9
M ₆ N ₈₀ P ₀	98.4	112.1	110.5	107.0
Mean	90.0	99.2	103.4	-
LSD (<i>p</i> <0.05)	R=10.15, W=6.95, RxW=NS			

Significantly higher Zn uptake was observed in the treatments where organic manure @ 6 t ha⁻¹ was added along with N @ 80 kg ha⁻¹ without P₂O₅ application to the rice crop as compared to the treatment where N @ 120 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ were applied

without organic manure. These results are in accordance with those obtained by Nayyar *et al*, (1990).

The perusal of the data (Table 2) revealed that Cu uptake in wheat grain ranged from 19.2 to 23.6 g ha⁻¹ in all the different treatment combinations. The treatments where organic manure @ 6 t ha⁻¹ was added along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹, showed significantly higher Cu uptake as compared to the treatments where no organic manure was added. Similarly, the Fe uptake in wheat grains varied from 143.3 to 189.4 g ha⁻¹ in different treatment combinations (Table 2). The maximum Fe uptake was recorded in the treatments where organic manure @ 6 t ha⁻¹ was added along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ was applied and another where organic manure @ 6 t ha⁻¹ was applied along with N @ 80 kg ha⁻¹ without P₂O₅ application to the rice crop as compared to the treatments where no organic manure was applied. The data in Table 2 further revealed that Mn uptake by wheat grain ranged from 84.9 to 112.1 g ha⁻¹ in all different treatment combinations. The maximum Mn uptake was registered (91.3 to 105.6 g ha⁻¹) in the treatments where organic manure @ 6 t ha⁻¹ was added along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ was applied as compared to the treatments where no organic manure was added and only N @ 120 kg ha⁻¹ was applied without P₂O₅ application.

Concentration of Zn, Cu, Fe and Mn in rice grain

Significantly higher concentration of Zn (Table 3) has been noticed in those treatments where organic manure @ 6 t ha⁻¹ has been incorporated along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ applied to the rice crop as compared to the treatments where only N @ 120 kg ha⁻¹ was applied to the rice crop and no organic manure and no P fertilizer were applied. The data presented in Table 3 illustrated that the concentration of Cu in rice grain at maturity ranged from 2.66 to 2.97 mg kg⁻¹ in different treatment combinations. The incorporation of organic manure @ 6 t ha⁻¹ along with application of N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ to the rice crop did not show any significant results for Cu at this stage as compared to the treatments where N @ 120 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ were applied to the rice crop without incorporating organic manure. The concentration of Fe in rice grain at maturity ranged from 29.88 to 36.72 mg kg⁻¹ in all the treatment combinations. Significantly higher concentrations were observed in the treatments where organic manure @ 6 t ha⁻¹ has been incorporated along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ applied to the rice crop as compared to the treatments where only N @ 120 kg ha⁻¹ was applied to the rice crop without application of organic manure and P fertilizer application.

The results in the Table 3 illustrated that the concentration of Mn in rice grain at maturity ranged from 42.28 to 52.28 mg kg⁻¹ in all the treatment combinations. Significantly higher concentration of Mn was observed in the treatments where organic manure @ 6 t ha⁻¹ has been incorporated along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ applied to the rice crop as compared to the treatments where only N @ 120 kg ha⁻¹ was applied without addition of organic manure to the rice crop and also no P fertilizers was applied.

Table 3: Effect of manure and fertilizers on Zn, Cu, Fe and Mn concentration in rice grain

Treatments to rice	Rates of P applied to wheat (kg P ₂ O ₅ ha ⁻¹)			Mean
	P ₀	P ₃₀	P ₆₀	
Zn (mg kg⁻¹)				
M ₀ N ₁₂₀ P ₀	23.18	22.68	21.13	22.33
M ₆ N ₈₀ P ₃₀	24.05	24.37	22.05	23.49
M ₀ N ₁₂₀ P ₃₀	22.35	21.72	20.46	21.51
M ₆ N ₈₀ P ₀	27.07	25.10	23.77	25.31
Mean	24.16	23.47	21.85	-
LSD (<i>p</i> <0.05)	R=0.34, W=0.52, R _x W=NS			
Cu (mg kg⁻¹)				
M ₀ N ₁₂₀ P ₀	2.84	2.78	2.77	2.79
M ₆ N ₈₀ P ₃₀	2.87	2.85	2.83	2.85
M ₀ N ₁₂₀ P ₃₀	2.70	2.68	2.66	2.68
M ₆ N ₈₀ P ₀	2.97	2.93	2.88	2.93
Mean	2.84	2.81	2.79	-
LSD (<i>p</i> <0.05)	R=NS, W=NS, R _x W=NS			
Fe (mg kg⁻¹)				
M ₀ N ₁₂₀ P ₀	29.88	30.57	31.44	30.63
M ₆ N ₈₀ P ₃₀	34.94	35.55	36.72	35.74
M ₀ N ₁₂₀ P ₃₀	31.68	31.67	32.60	31.98
M ₆ N ₈₀ P ₀	31.47	32.95	33.98	32.80
Mean	31.99	32.68	33.68	-
LSD (<i>p</i> <0.05)	R=0.78, W=0.56, R _x W=NS			
Mn (mg kg⁻¹)				
M ₀ N ₁₂₀ P ₀	45.19	44.80	44.73	44.91
M ₆ N ₈₀ P ₃₀	49.47	48.88	48.43	48.93
M ₀ N ₁₂₀ P ₃₀	43.22	43.00	42.28	42.83
M ₆ N ₈₀ P ₀	52.28	51.23	49.20	50.91
Mean	47.54	46.98	46.16	-
LSD (<i>p</i> <0.05)	R=0.37, W=0.34, R _x W=0.68			

Uptake of Zn, Cu, Fe and Mn in rice grain

The data indicated that the Zn uptake by rice grain increased significantly in the treatments where chemical fertilizers were applied along with organic manure (Table 4). The

data indicated that Zn uptake in rice grain ranged from 94.7 to 158.4 g ha⁻¹ in all the treatments. Significantly higher uptake of Zn was recorded in the treatment where organic manure @ 6 t ha⁻¹ was incorporated along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ was applied as compared to the treatments where no organic manure was incorporated and only N @ 120 kg ha⁻¹ was applied without P₂O₅ application. The Cu uptake in rice grain ranged from 12.3 to 17.3 g ha⁻¹ in all the different treatment combinations.

Table 4: Effect of manure and fertilizers on uptake of Zn, Cu, Fe and Mn in rice grain

Treatments to rice	Rates of P applied to wheat (kg P ₂ O ₅ ha ⁻¹)			Mean
	P ₀	P ₃₀	P ₆₀	
Zn uptake (g ha⁻¹)				
M ₀ N ₁₂₀ P ₀	120.7	116.1	102.1	112.9
M ₆ N ₈₀ P ₃₀	127.4	132.7	109.1	123.1
M ₀ N ₁₂₀ P ₃₀	113.9	108.8	94.7	105.8
M ₆ N ₈₀ P ₀	158.4	136.1	123.4	139.4
Mean	130.1	123.4	107.4	-
LSD (<i>p</i> <0.05)	R=5.08, W=6.17, R _x W=NS			
Cu uptake (g ha⁻¹)				
M ₀ N ₁₂₀ P ₀	14.8	14.2	13.4	14.1
M ₆ N ₈₀ P ₃₀	15.2	15.6	14.0	14.9
M ₀ N ₁₂₀ P ₃₀	13.8	13.5	12.3	13.2
M ₆ N ₈₀ P ₀	17.3	15.8	14.9	16.0
Mean	15.3	14.8	13.7	-
LSD (<i>p</i> <0.05)	R=1.47, W=1.15, R _x W=NS			
Fe uptake (g ha⁻¹)				
M ₀ N ₁₂₀ P ₀	155.5	156.5	151.8	154.6
M ₆ N ₈₀ P ₃₀	185.0	194.0	181.8	186.9
M ₀ N ₁₂₀ P ₃₀	161.4	159.0	150.8	157.1
M ₆ N ₈₀ P ₀	184.2	178.7	176.7	179.9
Mean	171.5	172.1	165.3	-
LSD (<i>p</i> <0.05)	R=11.06, W=NS, R _x W=NS			
Mn uptake (g ha⁻¹)				
M ₀ N ₁₂₀ P ₀	235.1	229.4	216.1	226.9
M ₆ N ₈₀ P ₃₀	262.1	266.6	239.7	256.1
M ₀ N ₁₂₀ P ₃₀	220.3	215.9	195.9	210.7
M ₆ N ₈₀ P ₀	306.1	277.7	255.8	279.8
Mean	255.9	247.4	226.9	-
LSD (<i>p</i> <0.05)	R=13.52, W=13.59, R _x W=NS			

The treatments where organic manure @ 6 t ha⁻¹ was incorporated along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ was applied showed significantly higher Cu uptake as compared to the treatments where no organic manure was incorporated and only N @ 120 kg ha⁻¹ was applied without P₂O₅ application. The Fe uptake in rice grain varied from 150.8 to

194.0 g ha⁻¹ in different treatment combinations (Table 4). The maximum Fe uptake was recorded in the treatments where organic manure @ 6 t ha⁻¹ was incorporated along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹. On the other hand, in wheat crop no significant results pertaining to Fe uptake were indicated where different levels of phosphatic fertilizer were applied. Increased Fe uptake with organic manure may be ascribed to increased availability of Fe because of their favourable impact on oxidation-reduction regime during rice crop.

Similarly, the Mn uptake in rice grain ranged from 195.9 to 306.1 g ha⁻¹ in all different treatment combinations. The maximum Mn uptake was registered in the treatments where organic manure @ 6 t ha⁻¹ was incorporated along with N @ 80 kg ha⁻¹ and P₂O₅ @ 30 kg ha⁻¹ was applied as compared to the treatments where no organic manure was incorporated and only N @ 120 kg ha⁻¹ was applied without P₂O₅ application. Walia *et al* (2008) reported similar results pertaining to uptake of Zn, Cu, Fe and Mn in rice-wheat system.

CONCLUSION

The results of our investigation revealed that concentration and uptake of Zn, Cu, Fe and Mn in rice and wheat grains is higher in the treatments where organic manure was applied along with chemical fertilizers.

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