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Effect of Zinc and FYM application schedule on yield and micronutrient composition under Rice-wheat rotation

Anil Kumar Saxena and Suneeta Singh

Abstract

A field experiment was conducted at Modipuram, District Meerut (U.P.) to evaluate the effects of zinc, farmyard manure and their combined application at two different schedules of application i.e. after two crop cycles or once in three years on yields and micronutrient contents of third year rice and subsequent wheat crops. Application of Zn, FYM and their conjoint applications increased grain and straw yields of both rice and subsequent wheat crop however, no significant effect of treatment application schedule was recorded on yields of any crop. Combined application of 2.5 kg Zn + 5 t FYM/ha increased the grain and straw yield of rice and wheat crops by 39.3, 34.2, 29.5 and 15.0 per cent over control, respectively. Application of Zn alone or in combination with FYM increased Zn concentration in rice straw. Application of treatments after two crop cycles resulted higher Zn concentration in rice grain as compared to treatment application limited to first year rice crop. The interaction effect of treatments and their application schedule significantly influenced concentration of Cu, Fe and Mn in crops. Application of 2.5 kg Zn + 5 t FYM/ha to rice crop can be recommended for rice-wheat rotation on Zn-deficient Ustochrept soils of western Uttar Pradesh.

Keywords: Micronutrient, zinc, FYM, rice-wheat rotation

Introduction

Rice-wheat system is one of the most widely practiced cropping systems of *Tarai* as well as North India. With the development of suitable varieties, the area under rice-wheat is expanding even in many non-traditional areas. Both rice and wheat are exhaustive feeders of nutrients (700 kg NPK/ha/year for 15 tonnes of grain/ha) (Narang *et al.*, 1990) [8]. The cultivation of two cereals year after year has led to declining soil fertility and poor crop yields. With the use of high analysis NPK fertilizers, generally devoid of micronutrients, has no doubt remarkably increased food production but simultaneously put forth a host of problems relating micronutrient deficiencies, particularly of Zn in soil. A proper nutrient management in rice-wheat system is warranted, so as to achieve high and sustainable productivity of the system. Among all micronutrients, zinc is one of the most important micronutrient, for the healthy growth of plant; as it performs several physiological functions in the plant. Zinc is indispensable for normal plant growth and maintains oxidation-reduction potential within the cell (Sommers and Lipman, 1926) [19]. Khaira diseases an expression of Zn deficiency which has become a widespread disorder in lowland rice (Nene; 1966) [10]. Zinc deficiency in soil is widespread throughout the world, especially in rice cropland of Asia (Tisdale *et al.*, 1997) [23] and in soil order of *Entisol, Asidisol, Alfisol, Mollisol* and *Vertisol* (Srivastava and Gupta, 1996) [20].

As Zinc deficiency has been noticed from several parts of India, Zinc application in rice-wheat system has become inevitable. The integrated use of organic and inorganic fertilizers has been found promising not only in maintaining higher productivity, but also in providing maximum stability in terms of crop yield (Nambiar and Abrol, 1989) [7]. Though, FYM is a bulky organic manure containing low concentration most of the essential plant nutrients and its application in rice-wheat cropping system tends to build up the organic matter in wet tropics and improve nutrient contents in soil and improve crop yields (Meelu and Morris, 1988) [6]. Organic manure acts as storehouse of micronutrients (Stevenson, 1982) [21]. The use of application which of even reduced application of zinc to about 50 per cent (Sakal *et al.*, 1985) [15].

Material and methods

To ascertain the effects of frequency of treatment application and of individual and conjoint application of zinc and farmyard manure previously applied to first crop of rice, on yields and micronutrient contents of rice third year and in the following wheat crop, field experiments was conducted at Modipuram (Distt. Meerut).

Treatments

Treatments*:		
Main Plots :	M_1 :	Application on alternate years
	M_2 :	Application once in three years
Sub-plot :		
	T_1	Control (No zinc application)
	T_2	FYM @ 5t/ha
	T_3	2.5 kg Zn as $ZnSO_4$/ha
	T_4	3.75 kg Zn as $ZnSO_4$/ha
	T_5	5.00 kg Zn as $ZnSO_4$/ha
	T_6	2.5 kg Zn as $ZnSO_4$/ha + FYM @ 5 t/ha
	T_7	3.75 kg Zn as $ZnSO_4$/ha + FYM@ 5 t/ha
* Treatments limited to rice crop only.		
Experimental Design:	Split plot RBD	

Chemical analysis of plant and soil samples
The samples of grains and straw of both rice and wheat collected from each plot were washed thoroughly first in tap water, then in 0.1 N HCl and finally distilled water before drying them in an electric oven at 60 °C. Finely ground samples (0.5–1 g) of grains and straw were digested in di-acid (HNO_3:$HClO_4$, 3:1 v/v) and analyzed for micronutrients by atomic absorption spectrophotometer.

Results & Discussion
It is evident from the data contained in Table 1 that the grain and straw yields of rice and grain yield of subsequent wheat crop were not significantly affected by main plots i.e. frequency of treatment application however, the straw yield of wheat was significantly higher where treatment application was made in the first year alone as compared to case where treatment application was repeated after two crop cycle.
The effect of subplots on yields of both grain and straw of rice and subsequent wheat crop was significant. Application of 2.5, 3.75 and 5 kg Zn/ha significantly increased the grain yield of rice crop by 28.1, 27.1 and 39.2 per cent and rice straw yield by 22.1, 19.4 and 27.0 over control, respectively. Application of 5 t FYM/ha also significantly increased rice grain yield by 14.9 per cent and straw yield by 14.5 per cent over control. Singh *et al.*, (2018) [1], Jaga *et al.*, (2011) [2] and Kumar *et al.*, (2010) [5] reported similar to these findings. Application of 5 t/FYM together with 2.5 or 3.75 kg Zn/ha significantly increased rice grain yield by 39.3 and 38.7 per cent and rice straw yield by 31.6 and 34.2 per cent over control, respectively. Singh (1999) [17] also reported that application of Zn to first crop rice had significantly increased grain yields of rice. A favorable effect of FYM application on yields of third crop of rice has been recorded earlier. (Chaterjee *et al.* 1978). Sakal *et al.* (1995) [16] also reported that application of Zn and compost to first crop rice significantly increased yields of third crop of rice.
Zinc application @ 2.5, 3.75 and 5.0 kg Zn/ha to rice crop had a significant residual effect on yields of subsequent third year wheat crop and the recorded increase in grain yield and straw yield was 17.2, 27.1 and 28.0 per cent and 8.8, 17.1 and 16.7 per cent over control, respectively. Application of farmyard manure alone or in combination with 2.5 and 3.75 kg Zn/ha to rice crop also had significant residual effect on grain and straw yields of wheat and wheat grain and straw yields were increased by 12.0, 29.5 and 31.1 per cent and 8.52, 15.0 and 14.6 over control, respectively. Patidar and Mali (2002) [12] reported that higher yield of wheat under FYM treatment was owing to better plant growth and higher yield attributes of wheat as a result of improvement in soil physical and chemical properties with FYM application. Sakal (2001) have reported that application of Zn at the rate of 10 kg/ha brought a significant yield increase for the next three crops of rice-wheat system. Prasad *et al.* (1989) [13] also observed that the residual effect of Zn applied through organic sources persisted even after the harvest of the fourth crop of wheat and rice.

Micronutrient composition
Effect of different treatments and frequency of their application on micronutrient concentration in grain and straw of rice and subsequent wheat crop in third year are presented in Table 3 and 4.

Zinc
As shown in Table 2 and 3, the zinc concentration in grain of rice significantly higher where treatment application was repeated after two crop cycle as compared to the case where treatment application was made in the first year alone. The effect of sub-plots on zinc concentration was only significant in straw of rice. Application of 2.5 kg Zn/ha and 5.0 kg Zn/ha significantly increased zinc concentration by 25.6 and 23.0 per cent over control. Application of 5 t FYM with 2.5 kg Zn/ha also increased zinc concentration in straw of rice by 24.0 per cent over control. Khan *et al.* (1992) [3]; Kumar *et al.* (1999) [4] reported that zinc application increased the concentration of zinc in both grain and straw of rice. Increasing levels of zinc increased zinc content in grain and straw of wheat (Narendra *et al.* 1988) [9].

Copper
It is evident from Table 2 and 3, copper concentration of straw of rice was not significantly affected by main plot i.e. frequency of treatment application however, Cu concentration in grain of rice was significantly lower, in case of treatment application once in 3 years as compared to treatment application after two crop cycles. Copper concentration in grain and straw of subsequent wheat crop was, however, significantly higher with treatment application made in the first year alone as compared to case where treatment application was repeated after two crop cycle. The effect of sub-plot on copper concentration of grain and straw of both rice and subsequent wheat crop was significant. Application of 2.5 and 5.0 kg Zn/ha significantly decreased copper concentration in grain and straw of rice over control. There was also a significant decrease in copper concentration due to application of 5 t FYM with 2.5 or 3.75 kg Zn/ha in grain and straw of rice crop. Application of 5 t FYM with 3.75 kg Zn/ha significantly decreased copper concentration in straw of wheat. The interaction effect of main plot × sub-plot significantly influenced Cu concentration in rice and wheat grains. In rice grains the treatment application at both frequencies i.e. after 2 crop cycles and 3 crop cycles significantly decreased Cu concentration in comparison to control except for the treatment receiving 5 t FYM/ha after three crop cycles. The concentration of Cu in rice grain for control treatment under 3 crop cycles frequency was significantly lower than that under 2 crop cycle frequency.
Under 3 crop cycle frequency the application of 5 t FYM/ha and 5.0 kg Zn/ha treatments significantly decreased the Cu concentration in wheat grain. In general, Cu concentration in wheat grain under different sub-plots with 3 crop cycle

frequency was higher than under 2 crop cycle frequency except for 5 t FYM/ha treatment.

Iron

As shown in Table 2 and 3, iron concentration in grain and straw of rice crop was significantly higher where treatment application was repeated after two crop cycle as compared to treatment application was made in the first year alone. The effect of sub-plots on iron concentration of both grain and straw of rice and subsequent wheat crop was significant. Application of 2.5 kg Zn and 5.0 kg Zn/ha significantly decreased iron concentration in grain and straw of rice in comparison to control, respectively. Application of 2.5 kg Zn + 5 t FYM/ha significantly decreased iron concentration in grain of rice over control. Application of 3.75 kg Zn + 5 t FYM/ha also significantly decreased the concentration in straw of rice in comparison to control. These findings indicated an antagonistic relationship between zinc and iron in rice (Subramaniyam and Mehta, 1974; Rahmatullah *et al.*, 1976) [22, 14].

In subsequent wheat crop, the residual effects of all zinc levels alone or in combination with FYM were effective in decreasing iron concentration of wheat grain in comparison to control. Application of 3.75 kg Zn/ha significantly increased iron concentration of wheat straw in comparison to control. The interaction effect of main plot × sub-plot significantly influenced Fe concentration in grain and straw of rice and subsequent wheat crop. Application of treatments after two crop cycles decreased Fe concentration in rice grain in comparison to control except for 3.75 kg Zn + 5 t FYM/ha. Significant decrease in Fe concentration recorded under 2.5 and 5 kg Zn/ha treatment. Application of 5 t FYM/ha, 2.5 kg Zn/ha and 3.75 kg Zn + 5 t FYM/ha after two crop cycles significantly decreased Fe concentration in rice straw in comparison to control. On the other hand, application of 2.5 kg Zn + 5 t FYM/ha after three crop cycle was only effective to significantly decrease Fe concentration in rice straw in comparison to control. For subsequent wheat crop, application of 5 t FYM/ha, 3.75 kg Zn/ha and 2.5 kg Zn + 5 t FYM/ha to rice crop after two crop cycles significantly increased Fe concentration in wheat grain as compared to control. All treatment applied to rice crop in the first year (after three crop cycle frequency) significantly decreased Fe concentration in wheat grain comparison to control. Iron concentration in wheat straw was significantly increased over control under 3.75 kg Zn/ha treatment applied after two crop cycles, while both, 2.5 kg Zn/ha and 3.75 kg Zn + 5 t FYM/ha applied to rice crop in the first year significantly decreased it in comparison to control. Iron concentration in wheat straw under 3.75 kg Zn/ha treatment applied to first year rice crop was significantly higher over control.

In general, Fe concentrations in grain and straw of both rice and wheat crop under treatment application after two crop cycles were higher than those under treatment application after three crop cycles.

Manganese

It is depicted from the data in Table 2 and 3, the effect of sub-plots on Mn concentration of grain and straw of subsequent wheat crop was significant. Application of 5 t FYM alone significantly increased manganese concentration of grain and straw of wheat by 10.9 and 29.2 per cent over control. Application of 2.5 kg Zn + 5 t FYM/ha significantly increased manganese concentration of wheat grain by 11.5 per cent over control. The interaction effect of main plot × sub plot significantly influenced Mn concentration in grain and straw of wheat crop. Manganese concentration in wheat grain was increased significantly over control under treatments receiving 5 t FYM/ha, 2.5 kg Zn/ha, 5.0 kg Zn/ha and 2.5 kg or 3.75 kg Zn + 5 t FYM/ha applied to rice crop after two crop cycles however. Manganese concentration in wheat straw was increased significantly over control under 5 t FYM/ha and 3.75 kg Zn + 5 t FYM/ha applied to rice crop after two crop cycles. Similarly, application of 5 t FYM/ha and 3.75 kg Zn/ha to first year rice crop was effective in increasing Mn concentration of wheat straw significantly over control. However, application of 2.5 kg Zn/ha to first year rice crop decreased Mn concentration in wheat straw significantly over control.

In general, Mn concentrations in wheat grain and straw under treatment application after two crop cycles frequency were at par with those under treatment application to first year rice crop alone. However, Mn concentration in wheat grain and straw under combined application of Zn + FYM to rice after two crop cycle frequency were higher. Nutrient composition influenced by the application of FYM alone or in combination gave the similar findings. (Pathan *et al.*, 2010 and Sisodia *et al.*, 2010) [11, 18].

Thus, based on the results of third year rice and wheat crop, it could be concluded that treatment application schedule had no significant effect on grain and straw yield of rice and grain yield of wheat. Application of 2.5 kg Zn + 5 t FYM/ha gave yields either at par with or slightly higher than those obtained with application of 5 kg Zn/ha. Both treatment application schedule and treatments influenced the concentration of micronutrient cations other than Zn. Application of 2.5 kg Zn + 5 t FYM/ha to rice crop can be recommended for rice-wheat rotation on Zn deficient Ustochrept soils of Western Uttar Pradesh.

Table 1: Effect of different Zn treatments and frequency of their application on grain and straw yield of rice and wheat in third year

Main Plot	Sub-plot Treatments	Yield (Q/ha)			
		Rice		Wheat	
		Grain	Straw	Grain	Straw
After 2 crop cycles	Control	31.53	44.03	31.61	76.16
	5 t FYM/ha	36.96	52.36	35.89	83.30
	2.5 kg Zn/ha	41.65	54.50	37.37	82.24
	3.75 kg Zn/ha	41.29	53.31	41.17	90.44
	5.00 kg Zn/ha	44.98	57.12	41.65	87.47
	2.5 kg Zn + 5 t FYM/ha	45.22	59.50	42.06	85.09
	3.75 kg Zn + 5 t FYM/ha	45.03	60.69	42.57	83.97
	Mean	40.95	54.50	38.90	84.09
After 3 crop cycles	Control	32.13	46.41	32.92	77.35
	5 t FYM/ha	36.22	51.17	36.34	83.30

	2.5 kg Zn/ha	39.86	55.93	38.27	84.73
	3.75 kg Zn/ha	39.58	54.69	40.82	89.25
	5.00 kg Zn/ha	43.62	57.72	40.91	91.63
	2.5 kg Zn + 5 t FYM/ha	43.43	59.50	41.51	91.39
	3.75 kg Zn + 5 t FYM/ha	43.27	60.69	41.98	92.01
	Mean	39.73	55.16	38.97	87.09
Mean Sub-plot	Control	31.83	45.22	32.26	76.76
	5 t FYM/ha	36.59	51.77	36.12	83.30
	2.5 kg Zn/ha	40.76	55.22	37.82	83.49
	3.75 kg Zn/ha	40.44	54.00	41.00	89.85
	5.00 kg Zn/ha	44.30	57.42	41.28	89.55
	2.5 kg Zn + 5 t FYM/ha	44.33	59.50	41.78	88.24
	3.75 kg Zn + 5 t FYM/ha	44.15	60.69	42.28	87.99
C.D.(p=0.05)	Main plot	NS	NS	NS	2.87
	Subplot	3.17	3.42	1.6	5.98
	Subplots within main plot	NS	NS	NS	NS
	Subplots across the main plot	NS	NS	NS	NS

Table 2: Effect of different Zn and FYM treatments and frequency of their application on micronutrient concentration in grain and straw of rice in third year.

Main Plot	Sub-plot Treatments	Rice							
		Zn (mg/kg)		Cu (mg/kg)		Fe (mg/kg)		Mn (mg/kg)	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
After 2 crop cycles	Control	21.76	17.05	10.19	6.97	147.3	314.02	27.45	116.05
	5 t FYM/ha	20.89	19.94	8.86	9.60	121.40	261.40	33.31	123.68
	2.5 kg Zn/ha	17.75	20.84	5.20	5.98	73.37	181.97	27.18	86.28
	3.75 kg Zn/ha	25.01	20.71	6.00	7.06	108.02	304.52	31.86	106.25
	5.00 kg Zn/ha	25.50	21.64	6.15	5.35	78.20	279.60	28.15	122.55
	2.5 kg Zn + 5 t FYM/ha	24.20	22.05	5.68	6.48	93.30	363.90	29.91	104.31
	3.75 kg Zn + 5 t FYM/ha	28.72	20.76	6.03	5.95	139.95	239.50	27.20	92.60
	Mean	23.40	20.43	6.87	6.77	106.79	277.56	29.29	107.39
After 3 crop cycles	Control	17.96	17.34	7.62	7.20	92.00	245.55	27.71	107.39
	5 t FYM/ha	18.59	18.35	7.81	8.93	98.78	209.68	28.23	113.20
	2.5 kg Zn/ha	15.27	22.36	5.15	5.59	69.11	203.10	25.30	102.95
	3.75 kg Zn/ha	17.96	19.88	5.57	7.36	106.25	224.33	26.45	101.93
	5.00 kg Zn/ha	14.52	20.67	4.32	6.16	70.67	210.55	23.45	99.97
	2.5 kg Zn + 5 t FYM/ha	17.66	20.59	5.09	6.72	81.93	189.50	30.34	91.73
	3.75 kg Zn + 5 t FYM/ha	19.24	20.51	5.90	6.73	92.42	224.38	29.62	106.26
	Mean	17.32	19.96	5.92	6.96	87.3	215.30	27.30	103.35
Mean Sub-plot	Control	19.86	17.20	8.91	7.08	119.65	279.78	27.58	111.72
	5 t FYM/ha	19.74	19.15	8.33	9.26	110.09	235.54	30.78	118.44
	2.5 kg Zn/ha	16.51	21.60	5.17	5.78	71.24	192.53	26.24	94.61
	3.75 kg Zn/ha	21.49	20.30	5.79	7.21	107.14	264.43	29.16	104.09
	5.00 kg Zn/ha	20.01	21.16	5.24	5.76	74.44	245.08	25.80	111.26
	2.5 kg Zn + 5 t FYM/ha	20.93	21.32	5.39	5.60	87.62	276.70	30.12	98.02
	3.75 kg Zn + 5 t FYM/ha	23.98	20.64	5.96	6.34	116.18	230.94	28.41	99.42
C.D.(p=0.05)	Main plot	5.51	NS	0.91	NS	21.23	44.22	NS	NS
	Subplot	NS	3.59	0.81	0.69	13.32	34.17	NS	NS
	Subplots within main plot	NS	NS	1.15	NS	18.85	48.32	NS	NS
	Subplots across the main plot	NS	NS	1.33	NS	25.59	59.59	NS	NS

Table 3: Effect of different Zn and FYM treatments and frequency of their application on micronutrient concentration in grain and straw of wheat in third year.

Main Plot	Sub-plot Treatments	Wheat							
		Zn (mg/kg)		Cu (mg/kg)		Fe (mg/kg)		Mn (mg/kg)	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
After 2 crop cycles	Control	27.77	19.15	5.49	3.69	25.68	106.62	21.22	18.20
	5 t FYM/ha	31.17	21.49	5.64	3.28	34.58	119.88	24.24	22.93
	2.5 kg Zn/ha	28.67	22.26	5.63	4.05	28.30	115.33	24.36	21.73
	3.75 kg Zn/ha	30.80	23.32	5.44	4.48	40.98	133.33	20.93	16.63
	5.00 kg Zn/ha	28.97	23.50	6.13	4.51	29.28	88.42	23.83	17.89
	2.5 kg Zn + 5 t FYM/ha	31.63	23.72	5.65	3.87	34.93	110.63	25.35	21.70
	3.75 kg Zn + 5 t FYM/ha	29.15	22.37	5.98	3.11	30.89	118.15	25.01	23.01
	Mean	29.74	22.26	5.71	3.86	30.67	113.19	23.56	20.30
After 3 crop cycles	Control	29.75	19.52	6.48	5.00	43.65	106.67	22.34	18.56
	5 t FYM/ha	32.13	20.13	5.53	4.70	20.05	92.78	24.06	24.58
	2.5 kg Zn/ha	29.95	23.93	6.61	4.18	27.55	65.92	22.18	13.58

	3.75 kg Zn/ha	32.53	22.02	6.36	4.71	23.03	137.98	22.58	23.63
	5.00 kg Zn/ha	30.98	21.69	5.04	4.66	25.85	93.42	21.83	18.40
	2.5 kg Zn + 5 t FYM/ha	32.28	21.69	6.85	4.08	29.78	108.05	23.20	17.06
	3.75 kg Zn + 5 t FYM/ha	32.20	23.15	6.08	3.86	26.00	79.82	21.41	15.54
	Mean	31.40	22.01	6.13	4.46	27.99	97.80	22.42	18.76
Mean Sub-plot	Control	28.76	19.34	5.95	4.35	34.67	106.64	21.78	18.38
	5 t FYM/ha	31.65	20.81	5.59	3.99	22.32	106.33	24.15	23.75
	2.5 kg Zn/ha	29.31	23.09	6.12	4.11	27.93	90.62	23.27	17.65
	3.75 kg Zn/ha	31.67	22.67	5.90	4.59	32.01	135.66	21.76	20.13
	5.00 kg Zn/ha	29.98	22.59	5.58	4.59	27.57	90.92	22.50	18.15
	2.5 kg Zn + 5 t FYM/ha	31.95	23.67	6.25	3.97	32.36	109.34	24.28	19.38
	3.75 kg Zn + 5 t FYM/ha	30.68	22.76	6.03	3.49	28.45	98.98	23.21	19.28
C.D.(p=0.05)	Main plot	NS	NS	0.34	0.58	NS	NS	NS	NS
	Subplot	NS	NS	0.46	0.58	4.13	18.15	1.74	2.88
	Subplots within main plot	NS	NS	0.65	NS	5.84	25.67	2.46	4.08
	Subplots across the main plot	NS	NS	0.67	NS	7.36	27.93	2.93	4.59

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