ZINC FRACTIONS AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT

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Abstract: *The long-term effect of integrated nutrient management on different forms of zinc in soil and their relationship with wheat yields and zinc uptake in rice-wheat cropping system was studied. A field trial was conducted at Bhadhiarkhar, District Palampur after fifteen years in the ongoing long-term experiment on rice-wheat cropping system with 12 treatments comprising control, farmers' practice, inorganics viz., 50, 75 and 100% NPK; and conjoint use of 50 and 75 % NPK with 50 and 25% N substitution, respectively through FYM/wheat cut straw/dhaincha during kharif followed by 100 and 75%NPK through inorganics in rabi. Results revealed that among Zn fractions non-specifically adsorbed exchangeable Zn (Zn-I), specifically adsorbed exchangeable Zn (Zn-II), organically bound Zn (Zn-III), Mn-oxide bound Zn (Zn-IV) significantly increased with the application of organics along with NPK fertilizers. The highest values were recorded in treatment where 50% NPK through inorganic fertilizers plus 50% N through FYM was applied. Aluminium and Fe oxide bound Zn (Zn-V) decreased significantly both under chemical fertilizers alone and their conjoint use with organics. Total zinc i.e. sum of all the extracted fractions was significantly influenced by the application of different organics along with fertilizers. The highest value was recorded in treatment where 50% NPK through inorganic fertilizers + 25% N through wheat cut straw were applied. The yield and Zn uptake by wheat increased with conjoint application of fertilizers and organic manures. A significant and positive relationship between grain yield and Zn-I, Zn-II, Zn-III, Zn-IV was observed under INM treatments including farmers' practice. Straw yield of wheat was also related to different Zn fractions in similar fashion.*

Key words: *Integrated nutrient management, rice-wheat system, Zn Fractions, wheat yield and zinc uptake.*

Introduction

Rice-wheat being a highly exhaustive cropping system, removes about 384 g ha^{-1} Zinc for each tonne of grain harvested (Vasuki, 2010). High productivity of rice-wheat cropping system cannot be sustained unless the declining trend in soil fertility resulting from the nutrient mining by these crops is replenished. Further, chemical fertilizers alone are unable to maintain the long-term soil health and crop productivity (Subba Rao and Srivastava, 1998) as they lack in secondary and micronutrients. Application of FYM along with recommended level of chemical fertilizer has been found to sustain crop production vis-à-vis maintaining soil health.

Since Zn is one of the most important micronutrients limiting plant growth, an understanding of transformations taking place in its status in different pools after continuous use of organic materials in conjunction with fertilizers is essential for developing management practices that can lead to their more efficient in a particular cropping system.

It is well established fact that it is not only the nutrient status of the soils but also the different chemical pools in which these nutrients occur in soils. These pools play an important role in the process of nutrient uptake and translocation and hence, on the crop growth. Knowledge of the total content of an element in soil is of meager importance as it does not provide information about its chemical behaviour and availability to plants. Crops differ not only in the utilization of native and added fertilizer nutrients but also in the extent of utilization from different chemical pools. Therefore, a trial was conducted to study the effect of integrated nutrient management on soil zinc fractions, crop yields and zinc uptake in rice-wheat cropping system.

Materials and Methods

Long-term field trial was initiated in *kharif* 1990 at *Bhadhiarkhar* Experimental Farm, Department of Agronomy, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during *rabi* 2005-06. The area falls under wet temperate zone with average rainfall of 2500-3000 mm, of which 80 per cent is received during wet season (July-Nov.) the experimental soil (Typic Hapladalf) was silty clay loam with acidic reaction, medium in organic carbon, high in available N, medium in P and K at the initiation of the experiment in 1990. The experiment was started with twelve treatments in Randomised Block Design having four replications. The treatmrnt details for *kharif* and *rabi* are given in table 1. The organics *viz.*, FYM, wheat cut straw and *Dhaincha* green manure are being applied in the specified treatments since inception of the experiment during *kharif* season only. Wheat (HPW-184) was sown at the seed rate of 100 kg ha^{-1} during the period under investigation at spacing of 20 cm. The crop was raised under irrigated conditions. The recommended fertilizer (100% RDF) of N, P and K was 90, 17 and 33 kg ha^{-1}, respectively, for rice and 120, 26 and 28 kg ha^{-1}, respectively for wheat. Half of nitrogen and full amount of P_2O_5 and K_2O as per treatments were applied at the time of sowing of the crop. Remaining nitrogen was applied in two equal splits at tillering and flowering stages. All the recommended cultural practices were followed during the growth of the crop. Crops were harvested at maturity, and grain and straw yields recorded and analyzed for Zn content. After the harvest of wheat (*rabi* 2005-06), composite soil samples (0-0.15 m) were analysed for Zn fractions by sequential fractionation scheme proposed by Mclaren and Crowford (1973) subsequently modified by Iyenger *et al.* (1981). Crop yield and Zn uptake data were correlated by simple correlations.

Results and Discussion

Zinc Fractions

All the zinc fractions except residual zinc (Zn-VI) were affected with the application of different organics and chemical fertilizers (Table 1).

Different zinc fractions viz., non-specifically adsorbed exchangeable Zn (Zn-I), specifically adsorbed exchangeable Zn (Zn-II), organically bound Zn (Zn-III), Mn-oxide bound Zn (Zn-IV) significantly increased with the application of organics along with NPK fertilizers. The highest values were recorded in treatment T_6 where 50% NPK through inorganic fertilizers plus 50% N through FYM was applied.

The application of chemical fertilizers alone resulted in lower contents of non-specifically adsorbed exchangeable Zn (Zn-I), and specifically adsorbed exchangeable Zn (Zn-III). Organically bound Zn and Mn-oxide bound Zn increased under these treatments but increases were comparatively low in comparison to INM treatments as zinc is known to form strong complexes with organic matter in the soil (Himes and Barber 1957, Mandal 1987; Phogat *et al.* 1994, Sharad and Verma 2001).

Aluminium and Fe oxide bound Zn (Zn-V) decreased significantly both under chemical fertilizers alone and their conjoint use with organics. Iron and Al have been reported to form strong complexes with organic matter (Iyenger *et al.* 1981; Mandal and Biswapati Mandal 1987; Phogat *et al.* 1994 and Sharad and Verma 2001). Total zinc *i.e.* sum of all the extracted fractions was significantly influenced by the application of different organics along with chemical fertilizers. The highest value was recorded in treatment T_9 where 50% NPK through inorganic fertilizers + 25% N through wheat cut straw were applied.

Crop Yield

The grain yield of wheat increased significantly with the application of chemical fertilizers alone or in combination with different organics (Table 2). The results indicated that application of 50% N through FYM plus 50% NPK through inorganic fertilizers gave the highest grain yield which was; however, at par with 100% NPK applied plots. Amongst different organics, it was observed that FYM at both the rates was found superior to wheat cut straw and green manures at the respective rates. It was further noted that substitution of 50 per cent of N through any of the organics recorded higher yields as compared to 25% N substitution by these materials.

Application of 50% NPK through inorganic fertilizers + 50% N through FYM resulted in maximum straw yield. The straw yield of wheat increased significantly with the application of organics along with chemical fertilizers over control treatment. Farmers' practice too showed a significant increase over the control, the increase being to the order of 88.3 per cent. FYM, wheat cut straw and green manure added a huge quantity of organic matter to the soil. Organic matter, thus added, in turn mineralized and released nitrogen to the succeeding wheat crop and thereby producing increased grain yield. Similar results were also reported by Sharma and Mitra (1990), Rajput and Warsi (1992) and Tiwari *et al.* (1995).

Zinc Uptake

The range of variation in total Zn uptake was from 70.6 g ha^{-1} under control (T_1) to 205.5 g ha^{-1} under 50% N through FYM (T_6). Application of chemical fertilizers alone or in combination with organic manures resulted in significant increase in Zn uptake over no use of chemical fertiizers or manures (Table 2). Application of 50, 75 and 100% NPK alone significantly increased the total Zn uptake by about 50.2, 96.1 and 131.3%, respectively over the control. The increase in Zn uptake under integrated use of 50% NPK through fertilizers and 50% N through FYM, wheat cut straw and green manure over control were worked out to be 191.2, 138.9 and 138.9%, respectively. The increase in uptake of nutrients may be due to better availability of these nutrients due to added supply of Zn and because of good proliferation of root system and balanced nutrient application, thereby, resulting in better absorption of nutrients (Sharma *et al.* 2001). A further glance at the data revealed that substitution of 25% N either through FYM or wheat cut straw and green manure resulted in lower uptake in comparison to 50% N substitution. The total Zn uptake was also higher in farmers practice over control (T_1).

Relationship of Zinc fractions with crop yield and nutrient uptake

Correlation between the grain and straw yields considering all the treatments with different Zn fractions was not found significant except Zn-V which showed significant but negative relationship with grain and straw yields returning coefficient of correlation values as -0.69 and -0.80 (Table 3). However, when only the INM treatments including farmers' practice were considered for correlation analysis, it was found that there was a significant and positive relationship between grain and straw yields and Zn-I, Zn-II, Zn-III, Zn-IV and available Zn. The respective coefficients of correlation were 0.92, 0.97, 0.81, 0.92 and 0.96. The respective values of coefficients of correlation for straw yield were 0.90, 0.92, 0.81, 0.90 and 0.80. However, Zn-V was also correlated significantly but negatively with grain yield only (r = -0.80). Zn-VI, however, was not correlated significantly with the grain and straw yield.

As regards the Zn uptake, it was further noted that correlation of total zinc uptake with different Zn fractions, considering all the treatments was positive and significant at 5% level of significance only in case of Zn-III (r = 0.63) and available Zn (r = 0.57) while Zn-V was negatively correlated at 5% level of significance with Zn-V (r= -0.80).

However, when only INM treatments were considered, total Zn uptake was found to correlate positively and significantly with Zn-I, Zn-II, Zn-IV and available Zn at 1% level of significance while Zn-III, the coefficient of correlation was significant at 5% level of significance. On the other hand, Zn-V was highly but negatively correlated with Zn uptake (r = -0.86). Zn uptake was not found to be affected by Zn-VI as correlation coefficient was quite low and non significant.

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Table 1: Effect of organic manures and fertilizers on zinc fractions (mg kg^{-1})

	Treatment		Zn-I	Zn-II	Zn-III	Zn-IV	Zn-V	Zn-VI	Total Zn
	Kharif	***Rabi***							
T_1	Control	Control	0.155	0.656	18.174	2.544	22.210	40.328	84.067
T_2	50% NPK	50% NPK	0.152	0.651	18.186	2.547	22.115	40.322	83.974
T_3	50% NPK	100% NPK	0.151	0.649	18.192	2.548	22.109	40.329	83.977
T_4	75% NPK	75% NPK	0.148	0.648	18.183	2.550	22.112	40.322	83.963
T_5	100% NPK	100% NPK	0.146	0.642	18.216	2.554	22.106	40.313	83.976
T_6	50% NPK+50% N through FYM	100% NPK	0.189	0.677	18.439	2.590	21.885	40.347	84.127
T_7	75% NPK+25% N through FYM	75% NPK	0.179	0.669	18.406	2.590	21.994	40.339	84.177
T_8	50% NPK+50% N through wheat cut straw	100% NPK	0.185	0.671	18.435	2.589	21.963	40.318	84.111
T_9	75% NPK+25% N through wheat cut straw	75% NPK	0.170	0.665	18.400	2.589	22.076	40.317	84.216
T_{10}	50% NPK+50% N through green manure *(Dhaincha)*	100% NPK	0.181	0.672	18.380	2.561	21.989	40.320	84.103
T_{11}	75% NPK+25% N through green manure *(Dhaincha)*	75% NPK	0.167	0.664	18.350	2.569	22.116	40.341	84.207
T_{12}	Farmers' practice (40% NPK+5t FYM ha $^{-1}$)	Farmers' practice (40% NPK)	0.164	0.658	18.260	2.550	22.019	40.308	83.958
CD (P=0.05)			0.006	0.012	0.007	0.009	0.004	NS	0.040

Zn-I: Non-specifically adsorbed exchangeable Zn, **Zn-II**: specifically adsorbed exchangeable Zn, **Zn-III**: organically bound Zn, **Zn-IV**: Mn-oxide bound Zn, **Zn-V**: Al and Fe-oxide bound Zn and **Zn-VI:** residual zinc

Table 2: Effect of organic manures and fertilizers on yield (q/ha) of wheat and Zn uptake

	Treatment		**Yield (q/ha)**		**Total zinc Uptake**
	Kharif	***Rabi***	Grain	Straw	**(g ha^{-1})**
T_1	Control	Control	12.5	21.4	70.6
T_2	50% NPK	50% NPK	16.1	36.7	106.0
T_3	50% NPK	100% NPK	26.7	51.0	161.9
T_4	75% NPK	75% NPK	22.5	44.9	138.5
T_5	100% NPK	100% NPK	29.3	51.6	163.3
T_6	50% NPK+50% N through FYM	100% NPK	31.7	55.4	205.5
T_7	75% NPK+25% N through FYM	75% NPK	26.4	46.6	161.1
T_8	50% NPK+50% N through wheat cut straw	100% NPK	25.5	54.0	168.7
T_9	75% NPK+25% N through wheat cut straw	75% NPK	23.3	47.9	146.2
T_{10}	50% NPK+50% N through green manure *(Dhaincha)*	100% NPK	26.6	54.8	168.7
T_{11}	75% NPK+25% N through green manure *(Dhaincha)*	75% NPK	22.1	44.4	128.6
T_{12}	Farmers' practice (40% NPK+5t FYM ha $^{-1}$)	Farmers' practice (40% NPK)	19.7	40.2	123.1
CD (P=0.05)			5	11.4	30.6

Table 3: Correlation coefficients (r) relating Zn fractions with wheat yield and Zn uptake

		Zn-I	**Zn-II**	**Zn-III**	**Zn-IV**	**Zn-V**	**Zn-VI**
Grain yield	Overall	0.42	0.31	0.54	0.46	-0.69*	0.24
	INM treatments	0.92**	0.97**	0.81*	0.92**	-0.80**	0.62
Straw yield	Overall	0.46	0.35	0.59*	0.33	-0.71**	0.07
	INM treatments	0.90**	0.92**	0.81*	0.90**	-0.67	0.25
Zn Uptake	Overall	0.55	0.45	0.63*	0.46	-0.80**	0.25
	INM treatments	0.95**	0.96**	0.80*	0.95**	-0.86*	0.48

* Significance at 5% level

** Significance at 1% level