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CORRELATION COEFFICIENT OF Zn FRACTION WITH VARIOUS SOIL FERTILITY PARAMETERS BY LONG TERM APPLICATION OF INORGANIC FERTILIZERS AND FARMYARD MANURE IN VERTISOL

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ABSTRACT

A field experiment was conducted in *kharif* during 2016-17 to evaluate the correlation coefficient of Zn fraction with different soil properties like pH, EC, OC and $CaCO_3$ and available status of N, P and K in Soybean-Wheat cropping system in Vertisol at the research farm of Department of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur (MP).The 10 treatments were applied in combination of different doses of fertilizer viz., 50% NPK, 100% NPK, 150% NPK and 100%NPK+HW, 100%NPK+Zn, 100%NP, 100%N, 100%NPK+FYM, 100%NPK-S and control with four replications in a randomized block design. The results revealed that the soil pH and EC were remaining unaltered even after continuous application of variable amounts of fertilizers either alone or in combination. The application of fertilizers along with FYM did not affect any significant changes even after a period of four decades of continuous use of inorganic fertilizers. However, continuous use of imbalanced fertilizer (only urea) also did not produce any marked effect on soils pH. This could probably be due to high buffering capacity of these soils and presence of calcium carbonate. The highest content of soil organic matter and $CaCO_3$ were recorded with 100%NPK+ FYM and 150% NPK treatment combination. Similarly, the highest amount of available NPK and Zn were accounted with 100%NPK+ FYM and 150% NPK treatment over control and imbalance application of inorganic fertilizers. Correlation coefficient was computed relating to Zn fraction with respect to soil properties. Among all the soil properties organic carbon content in soil predominantly affected the almost all individual fractions of Zn in soil complex. Furthermore, the residual Zn, organically bound Zn and exchangeable Zn fraction was found to be maximum with available Zn.
(Key words : pH, EC, Organic Carbon, ,$CaCO_3$, FYM , Zn fraction, long-term experiment, Soybean–Wheat sequence)

INTRODUCTION

The optimum plant growth and crop yield depends not only on the total amount of nutrients present in the soil at a particular time but also on their availability which is controlled by physical and chemical properties of soil. Now-a-days, the agricultural productivity declined due to increased removal of micronutrients resulting from adoption of high yielding varieties and intensive cropping to meet the increasing demand of food grains production along with the high analysis NPK fertilizers and limited use of organic manures (Mathur *et al*., 2006; Somasundaram *et al*., 2009; Sharma *et al*., 2009).

Micronutrients namely, zinc (Zn), iron (Fe), copper (Cu), manganese (Mn) and boron (B) are essential nutrients required in very small quantities for normal plant growth which are involved in various enzymes and other physiologically active molecules (Gao *et al*., 2008), although each micronutrient has specific functions in plants and in microbial growth processes. Micronutrient availability is influenced by numerous soil parameters like soil pH, organic content, and other physical, chemical and biological conditions in the rhizosphere zone (Pati and Mukhopadhyay, 2011). The soil Zn fractions are highly dependent on the physicochemical soil properties, such as pH, EC, organic carbon (OC), clay content and cation exchange capacity (CEC). Thus, the chemistry and effect of the aforementioned properties appear to be of major importance in Zn fractions, and therefore improve the available Zn pools. The distribution of Zn fractions among soil particles is vital to supply adequate amounts of Zn needed for crop growth (Panwar *et al*.,2017).But the incidence of zinc nutrient deficiency is adsorption on the surface of $CaCO_3$ could also reduce solution zinc. Adsorption of zinc by clay mineral, Fe/Al-oxides, Organic matter and $CaCO_3$ increases with increase in pH (Chidanandappa, 2003).

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MATERIALS AND METHODS

The present investigation is a part of an ongoing All India Coordinated Research Project on long-term fertilizer experiment with soybean-wheat cropping sequence which was initiated during 1972 at the Research Farm of the Department of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur. The experiment consisted of 10 treatments replicated four times in a randomized block design consist of gross plot size 17x10.8 m with 1 m spacing between plots and 2 m spacing between the replications. The recommended fertilizer dose (100% NPK) for the crop was estimated on the basis of soil test value. The soil under experiment represent a medium deep black soil classified as very fine, belonging to Kheri series of fine *montmorillonitic hyperthermic* family of Typic *Haplustert.* At the initiation of this experiment in 1972, pooled soil sample was collected before application of the treatments. The samples were drawn from the surface layer (0–15 cm) and sub surface (15-30 cm depth) prior to the application of fertilizers and manures. The samples were mixed and a composite representative sample was taken and analyzed for different soil properties. For the present study, soil samples were collected with the help of tube auger from the each plot of the above mentioned treatments from the plough layer (20 cm) from the long-term fertilizer experiment on a permanent site at the Experimental Research Station of J.N. Krishi Vishwa Vidhyalaya, Department of Soil Science and Agricultural Chemistry, Jabalpur (M.P.).Composite representative soil samples were obtained from these samples for each plot. Each composite sample consisted of a mixture of four sub samples from different locations of each plot to secure representative sample of the plot selected for sampling. The mass of each collected sample was reduced to about 500 g by adopting the technique of quartering. These soil samples were cleaned, air-dried, crushed by wooden pestle and mortar passed through 2 mm stainless steel sieve and stored in polythene bags at room temperature until analysis. These soil samples were used for analysis.

Soil pH was determined in a 1:2.5 soil water suspension by glass electrode pH meter (Piper, 1950). The soil suspension used for pH determinations were allowed to settle down and conductivity of supernatant liquid was determined by using conductivity meter (Piper, 1950). The results are expressed in dSm^{-1} at 25°C. Next to this, determination of organic carbon was analyzed by Walkley and Black's rapid titration method (1934) as described by Piper (1950) and the $CaCO_3$ content was determined by method of rapid titration and expressed as % free $CaCO_3$ content (Black,1965).Thereafter, available nitrogen in soil sample was determined by adapting the alkaline permanganate method of Subbiah and Asija (1956) and the phosphorus content of soil was estimated by extraction procedure as described by Olsen *et al.,* (1954). Soil available phosphorus was extracted using 0.5 M $NaHCO_3$ (pH 8.5) and determination was done by ascorbic acid method as described by Millar and Keeney (1982). The transmittance or absorbance of the blue colour so developed was read after 10 minutes, on spectrophotometer at 660 nm wavelength. After that the available potassium was extracted with neutral normal ammonium acetate and was estimated with flame photometer (Muhr *et al.,* 1963) and the available Zn was estimated by Lindsay and Norvell's procedure (1978) using an extractant consisting of 0.005M Diethylene triamine penta-acetic acid (DTPA), 0.1M C_aCl_2 and 0.1M triethanol-amine adjusted to pH 7.3.

RESULTS AND DISCUSSION

Physico-chemical Properties of experimental soil

1) Soil pH value

Table 1 illustrated that the soil pH (0 to 15 cm) recorded after more than four decades of continuous application of fertilizer and manures to Soybean - Wheat rotation ranged between 7.49 to 7.62 in soil before sowing while, pH value was found to be unaltered even at lower depth (15-30) which ranged between 7.50 to 7.63.It has been established use of chemical fertilizer; possessed net residual acidity could not created significant alteration in the pH of the experimental site (Swarup and Yaduvanshi, 2000 and Singh *et al*., 2011). This effect appears to have been controlled by the presence of calcium carbonate. Tomar (2003) and Sudhir *et al*., (2002) similarly no marked variation was observed in the soil pH at surface layer (0-15cm depth) as well as at sub surface soil (15-30 cm). Thakur *et al*., (2011) have been reported that the use of chemical fertilizer could not marked adverse effect on the soil physicochemical properties due to its high buffering capacity from long-term fertilizer experiment being conducted in Vertisol.

2) Soil electrical conductivity value

The result from table 1 revealed that the EC value of the soil at 0-15 cm depth recorded after four decades of continuous addition of fertilizer and manure in Soybean - Wheat rotation ranged between 0.15 to 0.19 dSm^{-1} at surface soil. While, EC value was found to be unchanged even at down profile which ranged between 0.15 to 0.20 dSm^{-1}, indicated that imposition of fertilizer and manure had unaltered the soluble salt deposition in soil. The values of EC did not show remarkable alternation and this could be attributed to the low residual effect of applied inputs concluded with high buffering capacity of soil. Sharad and Verma (2001) have also been reported that no significant increase in EC of surface soil after harvest.

3) Soil organic carbon content

The perusal of data (Table 1) represented that soil organic carbon content at 0-15 cm has found to be successively increased with increasing levels of fertilizer application. The lowest value was observed in control (5.60 g kg^{-1}) which was increased to 6.30 and 7.23 g kg^{-1} due to application of sub optimal and optimal dose of 50% NPK and 100% NPK. However, the highest value (8.85g kg^{-1}) was recorded with 100% NPK+FYM treatment which was significantly higher than 150% NPK, 100% NPK, 50% NPK and imbalanced dose of fertilizer. The Organic carbon content amongst the 100%NPK, 150%NPK, 100%NPK – S and 100%NPK+Zn were found to be at par. However, a progressive decline in organic carbon was found with down profile (15-30 cm).It was found to be significantly higher with 100%NPK + FYM (6.93 g kg^{-1}) over recommended optimal dose (5.80g kg^{-1}) which indicate a high deposition of organic matter on surface soil. Organic carbon in the surface soil with an initial value of 5.6 g kg^{-1} had increased significantly and attained a maximum level of 8.85 g kg^{-1} in the treatment that received 100% NPK+FYM. This could be ascribed to the contribution from organic manure used. Vasanthi and Kumarswamy (2000), Verma *et al*.(2012-), Swarup and Yaduvanshi (2000), Verma and Subehi (2005), Santhy *et al*. (2001) and Tomar (2003) have also been observed that increasing levels of fertilizer application had also assisted in increasing the organic carbon content, due to increased contribution from the decomposing of plant residue.

4) Content of calcium carbonate in soil

The data (Table 1) illustrated that the calcium carbonate contents observed from the surface layer after 44 years of continuous application of fertilizers and organic manure ranged between 35.35g kg^{-1} (control) to 46.60 g kg^{-1} (100% NPK+FYM). The values of lower layer ranged between 37.30 g kg^{-1}to51.03gkg^{-1}.The lowest content was associated with control (35.35 g kg^{-1}) and 100% N (37.18 g kg^{-1}) and the highest value (46.60 g kg^{-1}) was observed with 100% NPK + FYM which was significantly higher than 100% NPK-S (40.33 g kg^{-1}). The Calcium carbonate content amongst the 50% NPK, 100%NPK and 150%NPK were found to be at par. Similar trend was followed in lower depth. Sharma *et al*. (2004) and Choudhari *et al*.(2005) were reported that there was also no appreciable alteration in its content was marked at lower depths.

5) Available - N content in soil

The data presented in table 2 revealed that available N content in soil was increased successively and significantly higher from 178 kg ha^{-1} (control) to 220, 265 and 290 kg ha^{-1} with addition of higher fertilizer dose (50%, 100%, and 150% NPK, respectively). The highest content (325 kg ha^{-1}) was noticed with optimal NPK+FYM treatment which was significantly higher than imbalanced dose of fertilizer. While, 100% NP, 100% NPK – S,100% NPK+Zn and 100% NPK+HW treatments were almost equal and at par. However, lowest content of available N was observed in 100% N treatment (210 kg ha^{-1}) as well as without fertilizer addition (control)(178 kg ha^{-1}). The available content at 15-30 cm was also found significantly higher in super optimal dose i.e. 150% NPK (255 kg ha^{-1}) over control (140 kg ha^{-1}) followed by sub optimal dose i.e. 50% NPK (190 kg ha^{-1}) and optimal dose i.e. 100% NPK (210 kg ha^{-1}). There was significantly maximum available status of nitrogen was confined on surface and decline with depth. Singh *et al*. (2011) and Singh *et al*. (2012) also reported that the available N status could only be maintained through integration of fertilizer and manure for increasing the nutrients use efficiency of N over imbalance fertilizer use.

6) Available - P content in Soil

The data (Table 2) indicated that available P content in soil at surface had increased significantly from 29.10 kg ha^{-1}(100% NPK) to 34.60 (150% NPK kg ha^{-1}) over 8.40 kg ha^{-1} (control). However, the maximum content (36.60 kg ha^{-1}) was recorded in 100% NPK+FYM treatment which was significantly higher than imbalanced dose of fertilizer. Available P content in 100% NP, and 100% NPK - S treatments were almost equal as that obtained in 100% NPK, 100% NPK+HW and 100% NPK+Zn treatments. Available P content in 150% NPK and 100% NPK+FYM treatments were found to be statistically at par. A similar trend in available P status was also found at lower depth (15-30). Garg and Mikha (2010), Dwivedi *et al*. (2007) and Thakur *et al*. (2011) were reported that lower values of available P content was recorded at lower depth while higher P content was confined on surface of the experimental soil.

7) Available-K content in Soil

Data clearly showed that (Table 2) content of available K in soil was found to be increased successively and significantly from control (236 kg ha^{-1}) to 50% and 100% NPK treatments (253 and 290 kg ha^{-1}) respectively. The maximum value (317 kg ha^{-1}) of available K was recorded when 100% NPK was applied with FYM which was significantly higher than imbalanced dose of fertilizer. Whereas, 150% NPK and 100% NPK+FYM were at par with each other. However, lower value of available K content was recorded in 100%N treatment as well as in control which was significantly lower than 150% NPK. A similar trend in available K status was also found at lower depth (15-30). Dixit and Gupta (2000), Sharma *et al*. (2005) and Yadhuvanshi and Swarup (2006) justified that there was significant difference at 15-30 cm in over surface soil (0-15 cm) which was found to be slightly decline in similar trend as obtained at surface soil. Therefore, higher soil K was found on surface soil.

8) Available - Zn content in Soil

The perusal of the data (Table 2) illustrated that available Zn content in soil was found to be increased with fertilizer addition over control (0.320 mg kg^{-1}). Highest available Zn content (1.19 mg kg^{-1}) was recorded in 100% NPK+Zn treatment instead of without application of Zn. On the other hand available Zn content in 100% NPK treatment (0.82 mg kg^{-1}) was significantly lower than 100% NPK+Zn (1.19 mg kg^{-1}) and 100% NPK+FYM(1.08 mg kg^{-1}) treatments. However, there was no appreciable change in available Zn content in soil even at 15-30 cm depth.

4.3 Correlation coefficient of Zn fractions with soil properties

The inter relationship between various soil fertility parameter with Zn fractions at various depth were computed. Amongst the various soil properties the organic carbon content and available Zn status affected Zn fractions. Correlation coefficient analysis was undertaken taking into account the Zn fraction values obtained from the soils. Correlation coefficient was computed relating to Zn fractions with respect to soil properties. In this context, the significant r values obtained with all the soil properties showed that Organic carbon content in soil predominantly affected the almost all individual fractions of Zn fraction in soil complex. Whereas, amongst the various soil properties Soil pH, Soil EC, and available K did not affect Zn fraction. The highest value of Zn fraction, in case of Organic carbon and $CaCO_3$ found in organically bound Zn. However, the direct contribution of Zn and complexes Zn fraction were recorded to be minimum with available N and P. Moreover, the direct contribution of Residual-Zn, Organically bound-Zn and Exchangeable-Zn fraction were found to be maximum (0.974, 0.941, 0.913 respectively)with available Zn.This indicate that dynamic equilibrium of organically bound-Zn was found amongst the Zn fractions with the Zn availability in soil for plant utilization.

Table 1. Effect of continuous application of fertilizers and manure on soil pH, soil EC, soil organic carbon content and soil calcium carbonate content in soil

Treatments		Soil pH		EC (dSm^{-1})		OC ($g\ kg^{-1}$)		$CaCO_3$ ($g\ kg^{-1}$)	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	50%NPK	7.51	7.50	0.16	0.16	6.30	4.78	40.52	41.75
T_2	100%NPK	7.58	7.57	0.16	0.17	7.23	5.80	43.10	43.55
T_3	150%NPK	7.62	7.61	0.19	0.20	7.45	6.87	44.10	45.70
T_4	100%NPK+HW	7.59	7.63	0.16	0.17	7.18	5.60	42.80	44.20
T_5	100%NPK+Zn	7.60	7.61	0.18	0.18	7.15	5.85	42.50	43.48
T_6	100%NP	7.54	7.60	0.16	0.17	6.65	5.20	42.18	42.78
T_7	100%N	7.49	7.52	0.15	0.15	6.10	4.24	37.18	37.75
T_8	100%NPK+FYM	7.53	7.52	0.18	0.18	8.85	6.93	46.60	51.03
T_9	100%NPK – S	7.56	7.55	0.17	0.16	7.10	5.30	40.33	42.10
T_{10}	Control	7.50	7.51	0.16	0.15	5.60	4.60	35.35	37.30
SEm(±)		0.10	0.06	0.013	0.0110.011	0.31	0.32	2.20	3.60
CD (p=0.05)		-	-	-	-	0.89	0.94	6.25	7.44

Table 2. Effect of continuous application of fertilizers and manure on available NPK and Zinc content in soil

Treatments		Available N ($kg\ ha^{-1}$)		Available P ($kg\ ha^{-1}$)		Available K ($kg\ ha^{-1}$)		Available Zn ($mg\ kg^{-1}$)	
		0-15 cm	15-30cm	0-15 cm	15-30cm	0-15 cm	15-30cm	0-15 cm	15-30cm
T_1	50%NPK	220	190	18.90	9.80	253.00	240.00	0.673	0.508
T_2	100%NPK	265	210	29.10	17.20	290.00	270.00	0.825	0.558
T_3	150%NPK	290	255	34.60	21.60	315.00	290.00	0.915	0.808
T_4	100%NPK+HW	260	205	27.40	16.80	284.00	267.00	0.650	0.602
T_5	100%NPK+Zn	263	208	26.20	16.10	289.00	268.00	1.188	1.130
T_6	100%NP	250	205	25.83	15.73	220.00	212.00	0.805	0.543
T_7	100%N	210	170	8.83	4.70	215.55	209.43	0.480	0.425
T_8	100%NPK+FYM	325	240	36.70	20.80	317.00	300.00	1.085	1.065
T_9	100%NPK – S	258	200	27.80	16.50	286.00	269.00	0.585	0.530
T_{10}	Control	178	140	8.40	4.10	236.00	228.00	0.320	0.280
SEm(±)		11.12	8.56	1.34	1.11	25.230	16.210	0.043	0.041
CD (p=0.05)		32.27	24.84	3.90	3.22	8.694	5.586	0.125	0.120

Table 3. Effect of long term application of fertilizers and manure on correlation coefficient values between soil properties and Zn fractions at 0 to 15 cm depths

Soil properties	Various Zn Fraction (0-15 cm)m						
	Water solubl Zn	Exchang eable-Zn	Complexed Zn	Organically bound-Zn	Occluded Zn	Residual Zn	Total-Zn
Soil pH	0.575	0.423	0.423	0.679*	0.575	0.609	0.610
Soil Ec	0.733*	0.701*	0.701*	0.678*	0.733*	0.757*	0.757*
Soil Oc	0.740*	0.686*	0.686*	0.780**	0.740*	0.662*	0.671*
Soil $CaCo_3$	0.816**	0.641*	0.641*	0.865**	0.816**	0.739*	0.747*
Available N	0.778**	0.654*	0.654*	0.810**	0.778**	0.719*	0.726*
Available P	0.739*	0.561	0.561	0.779**	0.739*	0.678*	0.685*
Available K	0.633*	0.630	0.630	0.698*	0.633*	0.591	0.599
Available Zn	0.746*	0.913**	0.913**	0.941**	0.813**	0.974**	0.978**

Table 4. Effect of long term application of fertilizers and manure on correlation coefficient values between soil properties and Zn fractions at 15 to30 cm depths

Soil properties	Various Zn Fraction (15-30 cm)m						
	Water solubl Zn	Exchang eable-Zn	Complexed Zn	Organically bound-Zn	Occluded Zn	Residual Zn	Total-Zn
Soil pH	0.373	0.240	0.236	0.509	0.383	0.341	0.356
Soil Ec	0.751*	0.598	0.600	0.736*	0.752*	.781**	0.784**
Soil Oc	0.783**	0.659*	0.663*	0.770**	0.785**	0.776**	0.782**
Soil $CaCo_3$	0.782**	0.662*	0.666*	0.792**	0.785**	0.651*	0.667*
Available N	0.729*	0.545	0.547	0.717*	0.731*	0.652*	0.661*
Available P	0.698*	0.541	0.542	0.719*	0.701*	0.585	0.599
Available K	0.698*	0.631	0.632*	0.716*	0.701*	0.659*	0.669*
Available Zn	0.738*	0.964**	0.965**	0.943**	0.798**	0.938**	0.948**

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