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Accumulation of iron and zinc under intensive cropping with long term fertilizer application in calcareous vertic ustocrepts soils

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Abstract
A long term fertilizer experiment (LTFE) was started in the year 1999 at Instructional Farm, College of Agriculture, Junagadh Agricultural University at Junagadh to know the effect of continuous application of fertilizers (0, 50, 100 and 150% recommended dose of N, P, K with and without Rhizobium and PSM) and manure (FYM @ 10 and 25 t/ha) on accumulation of iron (Fe) and zinc (Zn) under groundnut-wheat sequence. After harvesting of wheat crop, the soil samples were drawn at the interval of 1st, 4th, 8th and 12th years and analysed for Fe and Zn Result revealed that the DTPA available Fe was significantly increased with application of FYM and fertilizer at 4th, 8th and 12th years after harvesting of wheat crop. The application of FYM @ 25 t ha^{-1} significantly improved Zn content at 8th and 12th years over control. While, in case of the DTPA available Fe after 8th and 12th years were recorded highest with the application of 100% NPK of recommended doses in G'nut-Wheat sequence (P as SSP). The Y x T interaction effect of Fe and Zn was observed significant in pooled analysis after 12th years harvesting of wheat crop. The Y x T interaction effect clearly indicated that the continuous cropping (G'nut-Wheat sequence) with and without fertilizer treatments after a span of 12 years, the accumulation of Fe and Zn, were increased 136% and 42%, respectively over initial year of the experimentation. These results clearly showed that the application of FYM with fertilizer increased availability of Fe and Zn in the soil and above the maximum permissible limit.

Keywords: LTFE, fertilization, DTPA-available iron and zinc

Introduction
The long term experiments are of immense value in assessing the sustainability of agricultural systems and practices. Our aim is to study the trend of the micronutrients in long run. Considering future strategy of soil fertility and its management only achieved with scientific information generated via different soil micronutrients like Fe and Zn over a periods of time. We are continuously mining soil nutrients since decades and centuries while farming the soil. Whatever we are adding as a fertilizer or manure may not be sufficient or suitable for propelling the dynamics of nutrients in the soil. This is particularly so in case of micronutrients because they are in minute quantity and are indispensable for the crop plants. Micronutrients are important for maintaining soil health and also increasing productivity (Rattan *et al.*, 2009) [12]. Based on interview with farmers and the information available at different agricultural centers, the application of fertilizers in this area is more than land requirements, which can result in high concentration of micronutrients in the soil. The aim of this work is to investigate the effect of different fertilizers on the micronutrients in soil under groundnut-wheat sequence.

Materials and Methods
The long term fertilizer experiment was started in the year 1999 at Instructional Farm, College of Agriculture, Junagadh Agricultural University at Junagadh to know the effect of continuous application of fertilizers (NPK) and manure (FYM) on accumulation of iron and zinc under groundnut-wheat sequence. The RDF of Groundnut and Wheat was 12.5: 25:0 and 120:60:60 kg/ha NPK respectively. The soils of following treatments were given in table no (1). The Soil Samples collected periodically of four periods (0, 4th, 8th and 12th years) at following intervals. (1) Initial soil (1999 - before groundnut) (2) 2002-03, 4th year (2003 - after wheat) (3) 2006-07, 8th year (2007 - after wheat) (4) 2010-11, 12th year (2011- after wheat).

Collection and preparation of Soil Samples (LTFE)

The soil samples were collected after harvesting of groundnut and wheat crops. Collected soil samples were air dried in shade, powdered with wooden mortar and passed through 2 mm sieve. The bulk soil samples were stored in polyethylene bags for analyses of DTPA-extractable method (Lindsay and Norvell, 1978) [6] of micronutrient such as Fe and Mn.

Table 1: Treatment Details.

T_1	50% NPK of recommended doses in groundnut-wheat sequence
T_2	100% NPK of recommended doses in groundnut-wheat sequence
T_3	150% NPK of recommended doses in groundnut-wheat sequence
T_4	100% NPK of recommended doses in groundnut-wheat sequence + $ZnSO_4$ @ 50 kg ha^{-1} once in three year to groundnut only (i.e. '99, 02, 05 etc)
T_5	NPK as per soil test
T_6	100% NP of recommended doses in groundnut-wheat sequence
T_7	100% N of recommended doses in groundnut-wheat sequence
T_8	50% NPK of recommended doses in groundnut-wheat sequence + FYM @ 10 t ha^{-1} G'nut and 100% NPK to wheat
T_9	FYM @ 25 t ha^{-1} to groundnut only
T_{10}	50% NPK of recommended doses in groundnut-wheat sequence + *Rhizobium* + PSM to G'nut and 100% NPK to wheat
T_{11}	100% NPK of recommended doses in groundnut-wheat sequence (P as SSP)
T_{12}	Control

Results and Discussion

Fe – DTPA Available

The DTPA available iron was significant when pooled over year and also Y x T interaction was significant (Table 2). Most of the treatments have higher significant value as compared to control in pooled results. The highest values was recorded in application of 100% NPK of recommended doses in G'nut -wheat sequence (P as SSP) (T_{11}), followed by T_8 under pooled. The highest values was recorded in application of 100% NPK of recommended doses in G'nut -wheat sequence (P as SSP) (T_{11}), followed by T_9 and T_{10} after 12th year and also higher value observed under application of 100% NPK of recommended doses in G'nut -wheat sequence (P as SSP) (T_{11}) after 8th year and the higher value observed under application of FYM @ 25 t ha^{-1} to G'nut only (T_9) followed by T_8 after 4th year. Application of FYM increase the availability of Fe may be formation of organic chelates, which decreased their susceptibility to adsorption, fixation and precipitation resulting in their enhanced availability in soil (Kher 1993) [5]. Increase in available Fe with increasing dose of fertilizer may be due to lowering of pH which is known to increase the solubility of metallic element. The substantial amount of Fe seems to have been contributed by SSP and FYM which are reported to contain variable amounts of this element, the normal range being 50-10000 mg kg^{-1} for SSP and 40-93 mg kg^{-1} for the FYM (Sachan 1994) [13]. Overall mean value was increased over a long period. Prasad and Singh (1980) [9] reported that available Fe increased considerably with continuous use of chemical fertilizers and particularly FYM. Nemath *et al.* (1987) [8] reported that application of FYM @ 37.4 to @ 69.4 tonnes per ha significantly increased the iron content of soil after harvest of wheat crop. Rajeev *et al.* (1993) [10] noticed that available Fe level in soil declined in all treatments except FYM treated soil.

The DTPA-available Fe were significantly increased by the application 50% NPK of recommended doses in G'nut -wheat sequence + *Rhizobium* + PSM to G'nut and 100% NPK to wheat (T_{10}) after 12th year may be due to it increased the retention and speciation of Fe in soil. This observation are in agreement with the earlier finding of Huang, *et al*. (2004) [4] who reported that as compared with the control, the retention of total Fe in red soil increased by 28%, respectively, in the presence of *rhizobia.* Akbari, *et al.* (2010) [1] reported that Fe were increased with advancement in maturity period of composting and their highest values were observed with RP @ 1% P_2O_5+MI (compost culture-*Azotobacter*, PSM) @ 500 g t^{-1} + urea @ 0.5%+Pyrite @ 5% on weight basis of crop residues. Duraisami and Mani (2001) [3] reported that supplementation of composted coirpith either alone or combined with *Azospirillum* improved availability of Fe. Chaudhary, *et al.* (2011) [2] observed that inoculation of fly-ash-tolerant Rhizobium increased the accumulation of Fe in different tissues. Zein, *et al.* (2005) [5] reported that *Rhizobia*, *rhizobia+Azotobacter* and *rhizobia+Azotobacter*+farmyard manure treatments were significantly increased availability of DTPA extractable Fe.

Zn –DTPA Available

The Zn-DTPA available form did not differed significantly when pooled over years but Y x T interaction was found significant (Table 3). The highest value was recorded in application of FYM @ 25 t ha^{-1} to G'nut only (T_9) followed by T_4, T_8 and T_{10} after 12th year and 8th year. Similarly the higher value observed under application of 50% NPK of recommended doses in G'nut -wheat sequence (T_1) followed by application of FYM @ 25 t ha^{-1} to G'nut (T_9), T_4 and T_7 after 4th year. Thus, the FYM recorded the highest value of Zn as compare to other treatments at the 4th year 8th year and 12th year. The data are also graphically presented in Fig. 4.1.3. This may be due to formation of organic chelates, which decreased their susceptibility to adsorption, fixation and precipitation resulting in their enhanced availability in soil (Kher 1993) [5]. Increase in available Zn with increasing dose of fertilizer may be due to lowering of pH which is known to increase the solubility of metallic element. The substantial amount of Zn seems to have been contributed by SSP and FYM which are reported to contain variable amounts of this element, the normal range being 50-1000 mg kg^{-1} for SSP and 43-244 mg kg^{-1} for the FYM (Sachan, 1994) [13]. Overall mean value of Zn increased with time span (Table 3). Sharma and Meelu (1975) [14] found that application of 15 tonnes FYM per ha to every crop increased the available zinc of the soil from initial status of 0.62 ppm to 1.09 ppm after six seasons of cropping. Rajeev *et al.* (1993) [10] noticed that available Zn level in soil declined in all treatments except FYM treated soil. Similarly, FYM application for five years increased the Zn content in the Vertisols of Akola (Rao and Dakhore, 1994) [11]. Application of FYM significantly increased available zinc of soil compared to RDF and other treatments (Mathur, 1997) [7].

The DTPA-available Zn were significantly increased by the application 50% NPK of recommended doses in G'nut -wheat sequence + *Rhizobium* + PSM to G'nut and 100% NPK to wheat (T_{10}) after 8th and 12th year may be due to it increased the retention and speciation of Zn in soil. These observations are in agreement with the earlier finding of Chaudhary, *et al.* (2011) [2] who observed that inoculation of fly-ash-tolerant *Rhizobium* increased the accumulation of Zn in soil. Akbari, *et al.* (2010) [1] reported that Zn were increased with advancement in maturity period of composting and their highest values were observed with RP @ 1% P_2O_5+MI (compost culture-*Azotobacter*, PSM) @ 500 g t^{-1} + urea @ 0.5%+Pyrite @ 5% on weight basis of crop residues. Huang, *et al*. (2004) [4] reported that as compared with the control, the retention of total Zn in red soil increased by 28%, respectively, in the presence of *rhizobia*. Duraisami and Mani (2001) [3] reported that supplementation of composted coir pith either alone or combined with *Azospirillum* improved availability of Zn. Zein, *et al.* (2005) [5] reported that *Rhizobia*, *rhizobia+Azotobacter* and *rhizobia+Azotobacter*+farmyard manure treatments were significantly increased availability of DTPA extractable Zn.

Conclusion

The Y x T interaction effect of Fe and Zn was observed significant in pooled analysis after 12th years harvesting of wheat crop. The Y x T interaction effect clearly indicated that the continuous cropping (G'nut-Wheat sequence) with and without fertilizer treatments after a span of 12 years, the accumulation of Fe and Zn, were increased 136% and 42%, respectively over initial year of the experimentation. These results clearly showed that the application of FYM with fertilizer increased availability of Fe and Zn in the soil and above the maximum permissible limit.

Table 2: DTPA available Fe in soils of LTFE experiment after 1st, 4th, 8th and 12th year

Treat.	DTPA available iron (Fe) in soil (ppm)				
	1st year	4th year	8th year	12th year	Pooled
T_1	4.086	5.234	9.135	10.599	7.264
T_2	4.418	5.477	8.257	10.294	7.112
T_3	4.312	4.466	7.964	10.659	6.850
T_4	4.944	4.873	8.619	10.552	7.247
T_5	4.466	5.232	8.638	10.538	7.219
T_6	4.764	5.365	8.757	9.748	7.159
T_7	4.114	4.864	8.156	9.739	6.718
T_8	4.612	6.176	9.853	11.635	8.069
T_9	4.628	6.320	7.849	11.853	7.662
T_{10}	4.954	5.439	9.052	11.730	7.422
T_{11}	4.735	5.463	10.492	12.294	8.246
T_{12}	4.483	5.018	8.578	9.406	6.871
SEm±	0.272	0.316	0.483	0.566	0.273
CD at 5%	NS	0.909	1.391	1.629	0.785
C.V.%	12.0	11.9	11.0	10.5	11.6
Mean	4.543	5.327	8.779	10.754	7.371
Y * T	S.Em.±	0.43	C.D. at 5%	1.18	

Table 3: DTPA available Zn in soils of LTFE experiment after 1st, 4th, 8th and 12th year

Treat.	DTPA available zinc (Zn) in soil (ppm)				
	1st year	4th year	8th year	12th year	Pooled
T_1	0.903	1.496	1.082	1.754	1.309
T_2	0.819	1.083	1.461	2.636	1.500
T_3	0.826	0.737	1.286	2.338	1.297
T_4	0.913	1.257	2.176	3.174	1.880
T_5	0.757	0.975	1.412	2.465	1.402
T_6	0.731	1.091	2.148	2.924	1.723
T_7	0.751	1.141	1.681	2.733	1.576
T_8	0.675	1.078	2.121	3.174	1.762
T_9	0.834	1.451	2.663	3.766	2.179
T_{10}	0.820	0.862	2.097	2.436	1.375
T_{11}	0.912	0.761	1.502	2.554	1.432
T_{12}	0.860	0.747	1.215	2.267	1.272
SEm±	0.101	0.126	0.198	0.279	0.151
CD at 5%	NS	0.364	0.570	0.804	0.434
C.V.%	24.7	23.9	22.8	20.5	24.2
Mean	0.817	1.057	1.737	1.162	1.178
Y * T	S.Em.±	0.19	C.D. at 5%	0.52	

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