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DYNAMICS OF MANGANESE FRACTIONS IN CALCAREOUS VERTIC USTOCHREPTS UNDER AICRP-LTFE SOILS

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ABSTRACT

The investigation was carried out under the ongoing AICRP-LTFE with groundnut-wheat cropping sequence at Junagadh Agricultural University, Junagadh, during the year 1999(Initial soil), 2002-03(4th year), 2006-07(8th year) after completion of crop cycle. The study was aimed to find out the effect of continuous application of inorganic fertilizers and organic manure on the distribution of Mn fractions. There was a decline in soil Mn status of LTFE soils. A significant decline in the important forms such as exchangeable Mn, total Mn and residual Mn was observed. Conversion of exchangeable to DTPA-Mn was evident. In light of this, overall mean DTPA available Mn recorded medium values (6.297 ppm) as compared to the critical values. Further the internal turnover of Mn along with other fertilizers could also help avoid the deficiencies of Mn even on a long run. The whole spectrum warranted a need to supply Mn nutrient through suitable sources to stabilize Mn status in the soil. The total form was a predominant component followed by DTPA available Mn. There were inter-conversions from DTPA available as well as total form to the reducible forms in a long run.

KEY WORDS
LTFE's soil
Mn fraction
water soluble-Mn
Exchangeable-Mn

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INTRODUCTION

Micronutrient deficiencies in crop plants are widespread in all over the world because of increased micronutrient demands from intensive cropping practices and adaptation of high-yielding cultivars having higher micronutrient demand. Moreover, enhanced production of crops on marginal soils that contain low levels of essential nutrients, increased use of high analysis fertilizers with low amounts of micronutrient contamination, decreased use of animal manures, composts and crop residues, use of soils that are inherently low in micronutrient reserves and involvement of natural and anthropogenic factors that limit adequate plant availability add to the cause (Fageria *et al.,* 2002). In India, intensive cropping with nutrient exhaustive high-yielding varieties coupled with the use of high analysis fertilizers for enhancing food grain production have catalyzed the rapid depletion of available micronutrients in soil in general (Singh, 2009) and available manganese (Mn) in some areas in particular (Nayyar *et al.,* 1990). 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. To understand the chemical reactions and bioavailability of soil zinc, it is essential to investigate its release behaviour of various fractions in soils Saviour and Stalin (2014). Dhaliwal and Walia (2008) reported that incorporation of manures increased the availability of the micronutrients like Zn, Cu, Fe and Mn. Long-term experiments (LTE) offer a better platform to visualize the status of micronutrients in soil under intensive cropping and their contribution to sustained production. Uptake of manganese by crop plants is determined by soil properties, plant factors, and their interactions at the soil-root interface. Knowledge of the reactions at the interface is basic to the prediction of soil Mn availability and to an understanding of soil-plant-Mn relationships. One aspect of the processes is the quantitative estimation of those fractions of native soil Mn that interact with plant roots and contribute to availability in soil and plant uptake. Medium black soils of Saurashtra region derived from trap basalt, sand stone and lime stone under semi-arid climate have unique properties of calcareousness which affect the physico-chemical properties, nutrient availability and plant growth. Very little or no work was done on Mn nutrition, status and different forms in soils of Saurashtra region so far. Hence, there is a need for depth study of dynamics of different forms of Mn under intensive agriculture, present investigation was carried out.

MATERIALS AND METHODS

Surface soil samples (0-15 cm) were collected from the AICRP-LTFE soils conducted on groundnut-wheat sequence in RBD, replicated four times, at Instructional Farm, Junagadh Agricultural University, Junagadh during the year 1999 (initial), 2002-03 (4th year, after wheat) and 2006-07 (8th year, after wheat).

Treatment Detail

T_1- 50 % NPK of recommended doses in G'nut-Wheat sequence,

T_2- 100 % N P K of recommended doses in G'nut -Wheat sequence,

T_3 -150 % N P K of recommended doses in G'nut -Wheat sequence,

T_4 -100 % N P K of recommended doses in G'nut -Wheat sequence + $ZnSO_4$ @ 50 kg ha^{-1} once in three year to G'nut only (i.e. '99, 02, 05 etc), T_5 - N P K as per Soil Test,

T_6 - 100 % N P of recommended doses in G'nut -Wheat sequence,

T_7 - 100 % N of recommended doses in G'nut -Wheat sequence,

T_8 - 50 % N P K of recommended doses + FYM @ 10 t ha^{-1} to G'nut and 100 % N P K to Wheat,

T_9 - Only FYM @ 25 t ha^{-1} to G'nut only,

T_{10} - 50 % N P K of recommended doses + Rhizobium + PSM to G'nut and 100 % N P K to Wheat,

T_{11} - 100 % N P K of recommended doses in G'nut -Wheat sequence (P as SSP) and

T_{12} – Control.

Manganese Fractionation method

The sequential extraction technique employed to separate the various forms of manganese was Tessier's procedure by Jackson (1973) and Viets (1962) as water soluble, exchangeable, DTPA available, and reducible form. Total Mn status was determined by digesting the soil using HF: $HClO_4$ (5:1). These extracts were analyzed for their Mn content on Atomic Absorption Spectrophotometer. Residual form of Mn was calculated by deducting water soluble + exchangeable + DTPA available + reducible (i.e available total) from the total Mn status of the soil. The per cent available Mn status was calculated as available total of the total Mn status of the soil.

RESULTS AND DISCUSSION

Mn - Water Soluble

The water soluble Mn showed significant difference among

Table 1: Status of different forms of manganese in soils of LTFE experiment in 1st, 4th and 8th year

Treat.	Mn water soluble from in soil (ppm)				Mn exchangeable form in soil (ppm)			
	1st year	4th year	8th year	pooled	1st year	4th year	8th year	pooled
T1	0.480	0.312	0.794	0.529	2.312	1.667	1.734	1.904
T2	0.460	0.273	0.769	0.501	2.529	2.226	1.641	2.132
T3	0.499	0.291	0.785	0.525	2.643	3.214	1.448	2.435
T4	0.459	0.275	0.834	0.522	2.418	1.566	1.423	1.802
T5	0.496	0.365	0.798	0.553	2.403	1.360	1.535	1.766
T6	0.466	0.258	0.782	0.502	2.346	1.481	1.280	1.702
T7	0.494	0.353	0.817	0.555	2.712	1.365	1.239	1.772
T8	0.482	0.425	0.767	0.558	2.016	2.129	1.622	1.922
T9	0.446	0.345	0.805	0.532	2.510	3.234	2.249	2.664
T10	0.456	0.260	0.791	0.502	2.025	2.061	1.449	1.845
T11	0.452	0.373	0.777	0.534	2.130	1.538	1.388	1.685
T12	0.458	0.242	0.771	0.490	2.148	1.490	1.236	1.625
SEm ±	0.025	0.033	0.026	0.016	0.229	0.258	0.175	0.213
CD at 5%	NS	0.095	NS	0.045	NS	0.742	0.505	0.624
C.V.%	10.490	21.000	6.480	10.670	19.460	26.500	23.070	23.030
Mean	0.471	0.314	0.791	0.525	2.349	1.944	1.520	1.938
Y * T	S.Em.±	0.028	C.D. at 5 %	NS	S.Em.±	0.223	C.D. at 5 %	0.627

Treat.	Mn DTPA available form in soil (ppm)				Mn reducible form in soil (ppm)			
	1st year	4th year	8th year	pooled	1st year	4th year	8th year	pooled
T1	5.168	5.895	6.856	5.973	44.95	44.37	45.51	44.94
T2	5.977	5.805	6.919	6.233	44.77	44.76	44.68	44.74
T3	5.821	6.145	6.059	6.008	44.85	45.44	45.51	45.27
T4	5.804	5.187	6.324	5.772	45.38	45.41	46.15	45.64
T5	5.512	5.659	6.891	6.021	44.92	45.76	45.77	45.48
T6	5.713	5.162	6.965	5.947	46.55	45.26	48.43	46.75
T7	6.328	6.610	7.043	6.660	45.36	44.95	45.93	45.42
T8	6.400	5.964	8.342	6.902	45.42	44.60	47.02	45.68
T9	6.797	7.373	8.793	7.655	45.29	46.95	44.63	45.62
T10	5.566	5.979	7.536	6.360	45.50	45.94	45.80	45.75
T11	6.161	6.398	6.709	6.423	45.01	46.14	45.50	45.55
T12	5.663	5.558	5.626	5.616	44.52	44.67	45.21	44.80
SEm ±	0.394	0.376	0.427	0.231	0.61	0.51	0.64	0.34
CD at 5%	NS	1.082	1.230	0.648	NS	1.46	1.84	0.95
C.V.%	13.350	12.570	12.200	12.690	2.70	2.23	2.79	2.59
Mean	5.909	5.978	7.005	6.297	45.21	45.36	45.85	45.47
Y * T	S.Em.±	0.400	C.D. at 5 %	NS	S.Em.±	0.59	C.D. at 5 %	NS

Table 2: Status of total, residual, percentage available and available total form of manganese in 1st, 4th and 8th year in the LTFE soils

Treat.	Mn total form in soil (ppm)				Mn residual form in soil (ppm)			
	1st year	4th year	8th year	pooled	1st year	4th year	8th year	pooled
T1	242.76	232.64	225.99	233.80	189.86	180.40	171.09	180.45
T2	241.99	233.58	225.93	233.83	188.25	180.51	171.91	180.23
T3	241.18	228.89	224.03	231.37	187.36	173.80	170.23	177.13
T4	249.98	228.59	240.73	239.77	195.92	176.15	186.00	186.03
T5	246.31	233.79	229.80	236.64	192.99	180.65	174.81	182.82
T6	248.20	231.19	228.75	236.05	193.13	179.03	171.29	181.15
T7	256.89	229.19	243.10	243.06	201.99	175.91	188.07	188.66
T8	259.98	236.66	245.34	247.32	205.66	183.53	187.59	192.26
T9	258.81	248.37	256.09	254.42	203.77	190.47	199.61	197.95
T10	250.61	232.42	230.46	237.83	197.06	178.18	174.88	183.37
T11	247.82	231.18	219.54	232.84	194.06	176.72	165.16	178.65
T12	243.59	229.23	203.30	225.37	190.80	177.26	150.46	172.84
SEm ±	4.46	3.10	6.74	2.88	4.52	3.29	6.65	2.90
CD at 5%	12.84	8.93	19.40	8.10	NS	NS	19.14	8.14
C.V.%	3.58	2.66	5.83	4.20	4.64	3.66	7.56	5.47
Mean	249.01	232.98	231.09	237.69	195.07	179.39	175.93	183.46
Y * T	S.Em. ±	5.00	C.D. at 5 %	NS	S.Em. ±	5.01	C.D. at 5 %	NS

Treat.	Percentage available of Mn in soil				Total available forms of Mn in soil (ppm)			
	1st year	4th year	8th year	pooled	1st year	4th year	8th year	pooled
T1	21.84	24.31	24.45	23.53	52.91	52.24	54.89	53.35
T2	22.22	23.95	23.95	23.37	53.74	53.07	54.01	53.61
T3	22.32	24.17	24.21	23.57	53.81	55.09	53.80	54.23
T4	21.64	22.77	22.77	22.40	54.06	52.44	54.73	53.74
T5	21.67	23.96	23.96	23.20	53.33	53.14	54.99	53.82
T6	22.22	25.16	25.16	24.18	55.08	52.16	57.45	54.90
T7	21.39	22.66	22.82	22.29	54.90	53.28	55.03	54.40
T8	20.90	23.70	23.70	22.77	54.32	53.12	57.75	55.07
T9	21.27	22.09	22.09	21.81	55.04	57.90	56.48	56.47
T10	21.38	24.17	24.17	23.24	53.55	54.24	55.58	54.46
T11	21.70	24.79	24.79	23.76	53.75	54.45	54.37	54.19
T12	21.62	26.00	26.00	24.54	52.79	51.96	52.85	52.53
SEm ±	0.49	0.72	0.72	0.38	0.76	0.77	0.74	0.66
CD at 5%	NS	2.07	2.08	1.06	NS	2.21	2.13	1.92
C.V.%	4.50	5.99	6.02	5.62	2.83	2.86	2.69	2.79
Mean	21.68	23.98	24.00	23.22	53.94	53.59	55.16	54.23
Y * T	S.Em. ±	0.65	C.D. at 5 %	NS	S.Em. ±	0.76	C.D. at 5 %	2.13

treatment, when pooled over years and also in 4th year (Table 1). Highest value was observed in T_8 (0.558 ppm) followed by T_7, T_5, T_{11}, T_8, T_1, T_3 and T_4. Interaction between treatment and year was found no significant. Komisarek *et al.* (1991) stated that increasing lime rates decreased water soluble Mn. Mehra and Baser (1982) observed that water soluble Mn ranged from traces to 3.82 ppm. The water soluble Mn fraction constituted a very small fraction of total Mn (Sharma *et al.*, 1997).

Mn - exchangeable

The exchangeable Mn showed significant difference among treatment when pooled over years. The highest value was recorded under application of FYM @ 25 t/ha to G'nut only (2.664 ppm) followed by application of 150 % N P K of recommended doses in G'nut -Wheat sequence (2.435 ppm) and 100 % N P K of recommended doses in G'nut -Wheat sequence (2.132 ppm). Interaction between treatment and year was also significant. In long term, there seems to be decrease over the year. The level of exchangeable Mn in first year was highest as compared to 4 and 8 year, that signified that application of chemical fertilizer in particular enhanced utilization of this form of Mn by the plants vis-à-vis in a long term changing mobilization of Mn to this particular form from other forms (Table 1). Looking to the spectrum of DTPA available Mn there seems to be conversion of this form into exchangeable form, particularly under chemical fertilizers treatments. Komisarek *et al.* (1991) stated that increasing lime rates decreased exchangeable Mn. Mehra and Baser (1982) observed that exchangeable Mn averaged 2.07 ppm. The exchangeable Mn fraction of total Mn accounted for 13 per cent (Sharma *et al.*, 1997).

Mn - DTPA available

The DTPA available form of Mn differed significant, when pooled over years and highest value was observed under application of FYM @ 25 t ha^{-1} to G'nut(7.655 ppm), while Y x T interaction were non significant (Table 1). Mean values did not showed any significant changes after 4th year but after 8th year slight increase was in mean value. The chemical fertilizer appeared to maintain the high utilization of DTPA available Mn by the plants through out as well as conversion of DTPA available form into the exchangeable form. Zhang and Zhang (1984) reported that in calcareous soils chelated and exchangeable Mn were of little importance in the nutrient status of soil and easily reducible Mn markedly affects the soil Mn supply for plants. Sharma *et al.* (1997) reported that reducible and exchangeable Mn fraction constituted 30.4 and 13 per cent of the total Mn, respectively.

Mn - reducible

Reducible form of Mn was significant, when pooled over years and highest value was observed under application of 100 % NP of recommended doses in G'nut -Wheat sequence (46.75 ppm), while Y x T interaction were non significant (Table 1). Overall mean value did not show any significant changes over time but chemical fertilizers, in general increased the reducible Mn after 8th year compared to control and FYM. This supported the contention that chemical fertilizer enhanced utilization of reducible Mn also. Mehra and Baser (1982) observed that reducible Mn ranged 22-109 ppm. Reducible Mn fraction constituted 30.4 per cent of the total Mn as reported by Sharma *et al.* (1997).

Mn - total

The pooled differences were significant, however Y x T interaction was non significant. The highest value observed with application of FYM @ 25 t ha^{-1} to G'nut (254.42 ppm) followed by under application of 50 % N P K of recommended doses in G'nut -Wheat sequence + FYM @ 10 t/ha G'nut and 100 % N P K to Wheat (247.32 ppm). Overall mean values registered a decrease in the total Mn content on the long run basis. There is a possibility of replenishing Mn in the soil by fertilizer application. The utilization of Mn by the plants also appears to increase by the fertilizer application which was quite evident from the significant treatment differences over the years (Table 2).

Mn - Residual

The pooled differences were significant, but Y x T interaction was non significant, highest significant value was observed under application of FYM @ 25 t ha^{-1} to G'nut (197.95 ppm) followed by under application of 50 % N P K of recommended doses in G'nut -Wheat sequence + FYM @ 10 t/ha G'nut and 100 % N P K to Wheat (192.26ppm). Maximum depletion was observed in control treatment after 8th year. Overall mean registered a decrease in the residual Mn content on long run basis (Table 2).

Mn - Percentage Availability

The percentage available Mn in soil is largely reflected by DTPA available and reducible form of Mn. Although pooled difference differed significantly, the Y x T interaction was not significant. The untreated control recorded the highest values compare to fertilized treatment after 4th and 8th years. Thus chemical fertilizer not only favoured conversion to available form but also enhanced utilization of Mn content (Table 2).

Mn Available Total

The total available Mn also differed significantly when years pooled and also in Y x T interaction. Like wise other forms highest value was observed by T_9 (56.47 ppm)followed by T8 (55.07 ppm) and T6 (54.90 ppm). Overall mean value slight decline after 4th year but after 8th year it was the higher values numerically as compared to other year, suggesting the faster replenishment from total Mn content (Table 2).

REFERENCES

Dhaliwal, S. S. and Walia, S. S. 2008. Integrated nutrient management for sustaining maximum productivity of rice-wheat system under Punjab conditions, *J. Research Punjab Agricultural University*. **45:** 12-16.

Fageria, N. K., Baligar, V. C. and Clark, R. B. 2002. Micronutrients in crop production. *Advances in Agronomy*. **77:** 185-250.

Herencia, J. F., Ruiz, J. C., Melero, M. S., Villaverde, J. and Maqueda, C. 2008. Effects of organic and mineral fertilization on micronutrient availability in soil, *Soil Science*. **173:** 69-80.

Jackson, M. L. 1973. Soil chemical analysis. *Prentice Hall of Indian Pvt. Ltd.,* New Delhi. pp. 388-415.

Komisarek, J., Kocialkowski, W. Z., Rachwal, L. and Sienkiewicz, A. 1991. Effect of CaCO3 on the content of various forms of Cu, Zn and Pb in contaminated soils. Panstwowe Wydawnictwo Naukowe. p. 53-62.

Mehra, R. K. and Baser, B. L. 1982. Distribution of manganese in saline alkali soils of Bhilwara District (Rajasthan). *Trans. Indian Soc. Desert Technol., Univ. Cent. Desert Stud.* **7(1):** 41-4.

Nayyar, V. K., Takkar, P. N., Bansal, R. L., Singh, S. P., Kaur, N. P. and Sadana, U. S. 1990. Status of micronutrients in Soils of Punjab.Research Bulletin, Department of soils, Punjab Agricultural University, Ludhiana. p. 146.

Saviour, M. N. and Stalin, P. 2014. Release behavior of zinc fractions for varying levels of added Zn in sandy loam soils, *The Bioscan*. **8(3&4):** 235-240.

Singh M. V. 2009. Effect of trace element deficiencies in soil on human and animal health. *Bulletin of the Indian Society of Soil* Science. **27:** 75-101.

Sharma, B. L., Rathore, G. S. and Bapat, P. N. 1997. Status of different forms of manganese and their relationship with physico-chemical properties of Entisols. *J. Indian Soc. Soil Sci.* **45:** 390.

Viet, F. G. Jr. 1962. Chemistry and availability of micronutrient in soils.*J. Agric. Food chem.* **10:** 165-178

Zhang, W. and Zhang, N. 1984. Study on the manganese nutrient in calcareous soil. III Transformation of manganese II Sulfate and changes of content of manganese of different forms in soils. *TurangXuebao*, **21(4):** 382-6.