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Effect of levels and frequency of zinc sulphate application on yied and DTPA - Zn availability in maize-sunflower cropping system

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Abstract : Five cycles of field experiments involving maize followed by sunflower were conducted during 1996-2001 in a clay loam soil at Agricultural College and Research Institute, Coimbatore. The results indicated that application of zinc sulphate @ 37.5 kg ha^{-1} to first crop of maize followed by 12.5 kg ha^{-1} to all alternate sunflower crops increased the total yield of maize and sunflower together, showing beneficial resident effect of applied zinc to previous crop, which received cumulatively 25% less zinc sulphate as compared to 12.5 kg ha-1 fo zinc sulphate applied to every crop in a sequence covering ten crops despite comparable yield were recorded among themselves. There was a build up of DTPA-Zn in the post harvest soil due to application of zinc sulphate, irrespective of levels, either to every crop or alternate crop over a period of time as against depletion of zinc observed in the treatments receiving only once and no zinc in the sequential experimentation.

Key words : Maize, sunflower cropping sequence, Zinc sulphate and DTPA-Zn.

Introduction

Continuous cropping with high yielding varieties and improved package of practices depletes the soil nutrients through increased production. Of the various micronutrients, Zn is the most limiting because of its wide spread deficiency. Zinc is essential for synthesis of proteins and auxing in plants and it activates many enzymes such as proteinase and peptidases. In view of importance of Zn in crop production, it is normally applied to cereals and oilseed crops. But Zn dose and frequency has not been studied for a cereal oilseed cropping sequence. There are reports that stating application of zinc to cotton-sorghum cropping system at various levels is beneficial to crop growth and yield increase and 25kg ha^{-1} of $ZnSO_4$ once in a year was found to be effective (Anonymous, 1990). In some cases, residual effect of applied Zn was found to persist in the soil even after harvest of the 4th crop (Gupta *et al.* 1986) and residual effect of applied Zn was beneficial in rice-rice cropping system (Hoque and Jahiruddin, 1994). Keeping the above points in view, a series of field experiments involving maize-sunflower crops in sequence were undertaken to study the direct and residual effects of applied zinc on DTPA-Zn abailability and yield of crops.

Materials and Methods

Field experiments with maize var.CO.1 in rabi season followed by sunflower var CO.2 in *kharif* season in a sequence were conducted during 1996-2001, at Eastern Block of Agricultural College and Research Institute, Coimbatore. There were 12 treatments comprising various frequency of zinc sulphate application at 12.5 and 25.0 kg ha^{-1} for every and alternate crops, 37.5 kg ha^{-1} to the first crop followed by 12.5 kg ha^{-1} to all subsequent crops and to sunflower crop alone, once in three crops, as well as lump sun quantum to the crop alone. Treatments were replicated thrice in randomized block design.

The experimental soil was loam in texture and it had following characteristrics; pH 8.0, EC 0.2 dSm^{-1} and organic carbon 0.43%. Available micronutrients extracted by DTPA were Zn - 1.01 ppm, Fe 18 ppm, Cu 1.4 ppm and Mn 2.8 ppm. The recommended N, P_2O_5 and K_2O @

Table 1. Impact of $ZnSo_4$ application on straw (t ha^{-1}) and gram yield (kg ha^{-1}) of maize and stover (k ha^{-1}) and seed yield (kg ha^{-1}) sunflower.

Treatments / $ZnSo_4$ Kg ha^{-1}			I - Maize		II - Sunflower		III - Maize		IV - Sunflower		V - Maize	
	Maize	Sunflower	Grain	Straw	Seed	Stover	Grain	Straw	Seed	Stover	Grain	Straw
T_1	0	0	2489	7.38	952	3.05	2571	8.30	1330	4.06	1891	10.0
T_2	12.5	- (First crop alone)	3245	8.96	1358	3.49	3571	8.50	1618	4.37	1966	10.2
T_3	25.0	- (First crop alone)	3422	11.3	1502	3.61	3809	8.90	1714	4.65	2023	10.6
T_4	37.5	- (First crop alone)	3600	9.99	1640	3.86	3928	9.10	1741	4.71	2080	11.3
T_5	50.0	- (First crop alone)	4756	9.90	1750	3.88	4047	9.20	1761	4.71	2136	11.5
T_6	12.5	12.5 (every crop)	3289	8.96	1810	3.68	3857	9.40	2015	4.71	2250	11.4
T_7	12.5	-(all maize)	3334	9.36	1458	3.61	4000	9.60	1714	4.37	2200	11.5
T_8	37.5	12.5 (all subsequent crops)	4134	11.9	1890	3.88	4095	9.70	1999	4.64	2245	11.4
T_9	25.0	- (all maize)	3757	9.99	1650	3.05	4196	9.70	1777	4.55	2240	11.6
T_{10}	25.0	- (every 3rd crop)	3778	10.76	1690	3.16	3880	9.30	1967	4.71	2148	10.9
T_{11}	37.5	25 for 5th and 9th crop	4311	10.86	1790	3.61	3904	9.90	1634	4.79	2248	11.3
T_{12}	37.5	12.5 (Sunflower crop)	4042	10.70	1920	3.94	3952	9.90	1952	4.89	2170	11.3
CD (P=0.05)			430	2.30	140	0.48	223	1.60	240	0.52	104	1.43

Table 1. *Contd..*

Treatments / ZnSO4 Kg ha-1			VI - Sunflower		VII - Maize		VIII - Sunflower		IX - Maize		X - Sunflower	
	Maize	Sunflower	Seed	Stover	Grain	Straw	Seed	Stover	Grain	Straw	Seed	Stover
T_1	0	0	1190	3.0	3000	8.39	1152	2.60	2512	7.60	1170	1.90
T_2	12.5	- (First crop alone)	1204	3.0	3047	8.57	1216	2.61	2605	7.80	1210	1.89
T_3	25.0	-(First crop alone)	1219	3.1	3095	9.04	1258	2.68	2605	8.00	1208	1.90
T_4	37.5	-(First crop alone)	1238	3.0	3047	9.38	1260	2.70	2645	8.00	1223	1.92
T_5	50.0	-(First crop alone)	1238	3.1	3095	9.52	1260	2.69	2640	8.10	1220	1.91
T_6	12.5	12.5 (every crop)	1479	3.3	3714	10.4	1446	2.74	2800	8.30	1331	1.96
T_7	12.5	- (all maize)	1309	3.2	3523	10.4	1309	2.74	2770	8.20	1230	1.91
T_8	37.5	12.5 (all subsequent crops)	1428	3.2	3720	9.65	1430	2.75	2810	8.20	1334	1.94
T_9	25.0	- (all maize)	1304	3.3	3619	9.16	1296	2.73	2805	8.30	1248	1.90
T_{10}	25.0	- (every 3rd crop)	1290	3.1	3333	9.44	1290	2.70	2610	8.00	1241	1.92
T_{11}	37.5	25 for 5th and 9th crop	1285	3.1	3280	9.54	1285	2.72	2690	8.20	1245	1.93
T_{12}	37.5	12.5 (Sunflower crop)	1476	3.2	3285	9.52	1401	2.73	2698	8.30	1332	1.95
CD (P=0.05)			95	NS	217	0.94	57	NS	92	NS	42	NS

Table 2. Effect of levels and frequency of Zinc sulphate application on the total economic yield and dry matter yield (Maize and Sunflower)

	Treatments / $ZnSO_4$ (kg ha^{-1})		Total Economic yield ($t\ ha^{-1}$)	Dry matter yield ($t\ ha^{-1}$)
	Maize	Sunflower		
T_1	0	0	17.9	56.2
T_2	12.5	- (First crop alone)	20.5	59.3
T_3	25.0	- (First crop alone)	21.8	63.7
T_4	37.5	- (First crop alone)	22.3	63.9
T_5	50.0	- (First crop alone)	22.8	64.5
T_6	12.5	12.5 (every crop)	23.9	64.4
T_7	12.5	-(all maize)	22.8	64.8
T_8	37.5	12.5 (all subsequent crops)	25.0	66.4
T_9	25.0	-(all maize)	23.1	64.9
T_{10}	25.0	- (every 3^{rd} crop)	23.2	63.9
T_{11}	37.5	25 for 5^{th} and 9^{th} crop	23.6	65.8
T_{12}	37.5	12.5 (Sunflower crop)	24.1	2.60
		CD (P=0.05)	1.18	65.5

135:62.5:50 and 40:20:20 kg ha^{-1} for maize and sunflower crops, respectively, was applied to all the plots. The zinc sulphate was applied as per the treatments for all crops. Standard package of practices were carried out during the crop growth. Postharvest soil samples collected from each experiment were analysed for DTPA-Zn. The yield of both crops was recorded at maturity. The yield data and DTPA-Zn were analysed statistically. The preparation of field for every crop was done without disturbing the plots. The DTPA-Zn was assessed as per the procedure outlined by Lindsay and Norbell (1978).

Results and Discussions

Yield

The yield data of individual crops are furnish in Table 1. Analysis of yield data of dividual crops revealed that application of zinc sulphate at higher levels to first crop resulted in higher crop yield. For instance, crop that received zinc sulphate @ 50 kg ha^{-1} to first crop of maize registered statistically highest yield (4756 kg ha^{-1}) and plots receiving zinc sulphate to first crop @ 37.5 kg ha^{-1} (T8, T11 and T12) registered comparable yield among themselves. This could be due to direct effect of applied zinc as Zn status of soil was below critical level. The results are in conformity with the findings of Islam et al. (1997). The yield data of first three crops in the sequence indicated that none of the treatments maintained consistently higher crop in the sequence indicated that none of the treatments maintained consistently higher crop yields. Also, those treatments that received zinc sulphate @ 25.0 or 37.5 kg ha^{-1} to the first crop, recorded comparable yield in the succeeding crops. This is due to the fact that residual effect of applied zinc may have been observed in succeeding crop

Table 3. Influence of Zinc sulphate applied on DTPA-Zn content in the post harvest soil of Maize - Sunflower cropping sequence.

	Treatments / $ZnSO_4$ kg ha^{-1}		DTPA-Zn in the post harvest soil (ppm)									
			I		II		III		IV		V	
	Maize	Sunflower	Maize	Sunflower	Maize	Sunflower	Maize	Sunflower	Maize	Sunflower	Maize	Sunflower
T_1	0	0	0.96	0.88	0.81	0.80	0.78	0.76	0.73	0.75	0.67	0.64
T_2	12.5	- (First crop alone)	1.88	1.70	1.68	1.66	1.60	1.10	1.20	1.10	1.00	0.95
T_3	25.0	- (First crop alone)	2.06	1.90	1.82	1.76	1.70	1.10	1.40	1.40	1.10	0.94
T_4	37.5	- (First crop alone)	2.12	2.01	2.00	1.98	1.60	1.20	1.40	1.30	1.10	0.96
T_5	50.0	- (First crop alone)	2.41	2.11	2.05	1.95	1.70	1.30	1.50	1.40	1.20	1.04
T_6	12.5	12.5 (every crop)	1.53	2.09	2.25	2.90	2.20	1.80	2.10	2.90	3.00	3.00
T_7	12.5	-(all maize)	1.59	1.97	2.10	1.96	1.90	1.30	2.00	3.00	3.00	2.60
T_8	37.5	12.5 (all subsequent crops)	2.09	2.24	2.35	2.80	2.30	2.10	2.20	3.00	3.10	3.10
T_9	25.0	-(all maize)	1.93	1.73	2.20	1.86	2.00	1.40	2.20	3.00	3.10	2.80
T_{10}	25.0	- (every 3rd crop)	2.00	1.80	1.86	2.96	2.00	1.40	2.20	2.40	2.70	2.60
T_{11}	37.5	25 for 5th and 9th crop	2.15	1.86	1.99	1.80	1.90	1.50	1.90	2.30	3.10	2.80
T_{12}	37.5	12.5 (Sunflower crop)	2.18	2.22	2.18	2.80	2.00	1.80	1.80	2.80	2.80	3.10
		CD (P=0.05)	0.12	0.08	0.11	0.10	0.26	0.23	0.40	0.40	0.52	0.39

which in turn would have improved the crop yield which is in line with the findings of Gupta et al (1986). However, it is interesting to note that from the fourth crop (Sunflower) onwards treatments receiving zinc sulphate either @ 12.5 kg ha^{-1} to every crop (T6) or 37.5 kg ha^{-1} of Zn to the first crop followed by 12.5 kg ha^{-1} to all subsequent crops recorded the highest economic yield in most of the crops in the sequence and they were found on par with plots receiving zinc sulphate @ 37.5 kg ha^{-1} to the first crop (maize) followed by 12.5 kg ha^{-1} to alternate crop (sunflower) in seven out of ten experiments conducted. The continuous and alternate applications of zinc sulphate at lower level (12.5 and 25.0 kg ha^{-1}) may have accentuated in built up of zinc in the soil which enhanced the availability of Zn to the crop over a period of time as evidenced on the crop yield and DTPA-Zn recorded for treatments T6, T8 and T12. This was also supported by Deb (1997) who observed 98 to 99% of applied zinc remains in soil and is available to the succeeding crops.

Total economic yield

The effect of applied zinc on the economic produce of crops in the sequence, the yield data of maize and sunflower together were pooled for entire five cycles and statistically analysed (Table 2). As observed in the individual experiments, there was a significant different between the treatments due to application of zinc sulphate either to every crop or alternate crop or once in three crops. The

total economic yield of maize and sunflower together was found to be the highest (25 t ha^{-1}) for the application of zinc sulphate @ 37.5 kg ha^{-1} to first crop followed by 12.5 kg ha^{-1} to all subsequent crops (T8) Which was comparable with treatments T12 (24.0 t ha^{-1}) and T6 (23.9 t ha^{-1}) in the sequence. Application of zinc sulphate to the first crop alone as lump sum quantum at various levels (T1 to T5) registered significantly lower yield of both the crops together which is due to the fact that that removal of Zn by succeeding crops may have restricted the availability of zinc to crops as evidenced in the available zinc status sulphate @ 12.5 and 25.0 kg ha^{-1} to alternate maize crops (T7 and T9), 25.0 kg ha^{-1} (T10) once in three crops and once in four crops (T11) were comparable among themselves.

On comparing the cumulative zinc sulphate applied in relation to yield obtained in T6, T8 and T12, nearly 25 and 33.3% of zinc sulphate could be saved when it was applied @ 37.5 kg ha^{-1} to the first crop followed by 12.5 kg ha^{-1} to alternate sunflower crop (T12) than that of T6 and T8 which cumulatively received 125 and 150 kg Zn ha^{-1}, respectively.

Dry matter yield

Four out of five experiments conducted on maize have shown significantly higher dry matter yield for the application of zinc sulphate @ 12.5 kg ha^{-1} to all crops and 25.0 kg ha^{-1} to alternate maize crops. (Table 1) However, there was not much significant influence on the dry matter yield of sunflower with three out of five field experiments results showing non-significant effect. Analysis of maize and sunflower dry matter together showed the highest total dry matter yield of 66.7 t ha^{-1} for the application of zinc sulphate @ 37.5 kg ha^{-1} to the first crop followed by 12.5 kg ha^{-1} to all subsequent crops (T8) which was found on par with all other treatments except T1, T2 and T3 (Table 2).

DTPA-Zn

Application of zinc sulphate at different levels with various frequencies showed significant effect on the content of DTPA-Zn in postharvest soil of each experiment (Table 3). The treatments that received $ZnSO_4$ irrespective of the levels either for every crop or alternate crops maintained DTPA-Zn values with increasing $ZnSO_4$ doses as well as with application of $ZnSO_4$ to every crop. The removal of zinc by both the crops in the sequence is attributed to the gradual depletion of zinc content of the soil in the treatments (T2 to T5) that received $ZnSO_4$ once in the beginning of the experiment that is to the first crop alone which resulted in the lower available zinc which was below the critical level at the end of the tenth experiment. This is in agreement with the findings of Dangarwala (1983). Also, it was observed that application of $ZnSO_4$ @ 12.5 and 25.0 kg ha^{-1} to every crop and alternate crops respectively maintained DTPA-Zn content above critical limit (1.2 ppm). Application of $ZnSO_4$ cumulatively @ 150 kg ha^{-1} having a frequency of 37.5 kg ha^{-1} to first crop followed by 12.5 kg ha^{-1} to every crop over a period of five years resulted in the built up of DTPA-Zn to 3.1 ppm (T8). However, it was comparable with those treatments that received $ZnSO_4$ @ 12.5 kg ha^{-1} to every crops and 25.0 kg ha^{-1} to alternate crops and once in three crops. With one lump sum quantity of ZnSo4 @ 12.5 to 50 kg ha^{-1} for the treatments T2 to T5, the DTPA-Zn status was the lowest over a period time due to consistent removal of Zn by crops. The decline in DTPA-Zn was observed from 2.41 ppm to 1.04 ppm at the end of tenth experiment by the addition of highest level of Zn @ 50.0 kg ha^{-1} to first crop and similar trend was observed for treatments T2, T3 and T4. The highest DTPA-Zn content was recorded for the application of $ZnSO_4$ @ 37.5 kg ha^{-1} to first crop followed by 12.5 kg ha^{-1} to all subsequent crops (T8) which in most cases was comparable with T6 and T12.As most of the applied Zn remains in the soil (Deb, 1997) the