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EFFECT OF ZINC AND MAGNESIUM APPLICATIONS ON THE AVAILABILITY OF NATIVE CALCIUM TO WINTER MAIZE IN CALCAREOUS SOIL

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Addition of Zn significantly increased the dry matter yield of maize roots, stem, leaf sheath and leaf blade whereas Mg decreased their yields. In no Zn treatment, the application of Mg at 60 ppm reduced the total dry matter yield to 35% and in presence of 5 ppm Zn the magnitude of reduction was only 12%. The depressing effect of Mg on the concentration of Ca was much higher as compared to Zn. Incorporation of Mg reduced the uptake of Ca in roots to 62% and in aerial organ to 76% which revealed an inhibited translocation of Ca from root to shoot. Application of Zn reduced the soil available Ca to 27% whereas Mg reduced it to 39% showing thereby the higher depressing effect of Mg on the availability of Ca as compared to the effect of Zn.

Widespread deficiency of Zn has been noticed on several crops being grown in calcareous soils of North Bihar (Sakal and Singh, 1979). Winter maize is relatively more susceptible to Zn deficiency than the spring and monsoon ones. In some pockets of calcareous belt incipient Mg deficiency on maize has also been observed. Zinc and Mg application is advocated to mitigate this problem. But their effects on the availability of Ca to maize in such highly calcareous soil are not clearly under-

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stood. The present investigation was, therefore, undertaken to find out the effect of Zn and Mg application on the availability of native Ca to maize crop.

MATERIALS AND METHODS

The experiment was conducted in polythene lined pots under green house each containing 4 kg sandy loam textured soil. The pH, E. C., free $CaCO_3$, organic carbon, available Zn, available Mg and Ca of the experimental soil were 8.3, 0.24 mmhos/cm, 30.5%, 0.42%, 0.48 ppm 2.4 and 10.8 m.e/100 g soil respectively. Available Zn was extracted with DTPA-$CaCl_2$ (Lindsay and Norvell, 1978) and estimated with an atomic absorption spectrophotometer. Available Mg and Ca were extracted with neutral N-NaC1 and estimated by EDTA titration method (Heald, 1965). Other soil characteristics were estimated as per procedure of Jackson (1967).

A basal dose of 100 ppm N, 50 ppm P_2O_5 and 50 ppm K_2O was applied through urea, KH_2PO_4 and and KC1, respectively in each pot. Zinc was applied 0, 5 and 10 ppm as zinc sulphate and Mg @ 0, 15, 30, 45 and 60 ppm as magnesium sulphate in all possible combinations. Treatments were replicated three times in a CRD. Winter maize variety 'Lakshmi composite' was taken as test crop. Four plants in each pot were allowed to grow for 50 days. Pots were irrigated with deionised water.

The plants were taken out from each pot and separated into leaf blade, leaf sheath, stem and root portions. These were thoroughly washed in acidified detergent solution and dried in hot air oven at 65°C. The oven-dry weight of these plant parts was recorded and analysed for total Ca in tri-acid digest by EDTA titration method (Heald, 1965). The soil samples drawn from each pot at harvest were analysed for available Ca

RESULTS AND DISCUSSION

Dry matter Yield:- The maximum dry matter yield of all the plant parts due to Zn application was recorded at 5 ppm Zn level. At this Zn level the dry weight of roots, leaf sheath and leaf blade was increased by 22, 42, and 28%, respectively over their corresponding controls (Table 1). Application of Mg significantly reduced the average dry matter yield of roots, stem, leaf sheath and leaf blade by 31, 46, 49 and 38%, respectively. The beneficial effect of Zn was more or less supressed when Mg was applied at 15 ppm or more. In absence of Zn, the application of Mg @ 60 ppm reduced the total dry matter yield to a tune of 35% and at 5 ppm Zn level it reduced to 12% only. This indicates that Zn resists the reduction in dry matter yield brought about by the application of Mg.

Calcium concentration and uptake :- Increasing levels of Mg progressively decreased the Ca concentration in all the plant parts (Table 2). It decreased the average Ca concentration in roots, stem, leaf sheath and leaf blade from 1.08 to 0.60, 0.38 to 0.19, 0.46 to 0.22, and 0.66 to 0.42%, respectively The antagonism between Ca and Mg has been reported by several wor-

Table 1. Effect of zinc and magnesium application on dry matter yield maize plant parts (g/pot).

Plant parts	Zinc levels ppm	Magnesium levels (ppm) 0	15	30	45	60	Mean	C. D. at 5% for Zn	Mg	Zn x Mg
Root	0	5.10	5.90	4.90	3.40	3.27	4.31	0.09	0.12	0.20
	5	5.80	5.33	5.20	5.00	4.87	5.24			
	10	6.87	5.03	4.70	4.43	4.00	5.01			
	Mean	5.92	5.09	4.93	4.28	4.05	—			
Stem	0	1.60	1.53	1.47	137	1.33	1.46	0.12	0.14	0.23
	5	1.97	1.47	1.17	1.13	0.90	1.33			
	10	2.53	1.50	1.27	1.19	1.03	1.49			
	Mean	2.03	1.50	1.03	1.20	1.09	—			
Leaf Sheath	0	1.60	1.47	1.33	1.30	1.17	1.37	0.12	0.14	0.26
	5	2.63	1.97	1.83	1.70	1.63	1.95			
	10	3.57	1.57	1.50	1.33	1.13	1.82			
	Mean	2.60	1.67	1.55	1.44	1.31	—			
Leaf Blade	0	5.53	4.47	4.43	3.33	3.17	4.21	0.14	0.17	0.20
	5	6.70	5.53	5.20	4.83	4.73	5.40			
	10	6.90	5.47	4.57	4.33	3.83	5.02			
	Mean	6.38	5.12	4.73	4.16	3.91	—			

kers (Coffman and Miller, 1973). The magnitude of reduction in Ca concentration of plant parts brought about by Mg application was much higher than the Zn application. This shows the preponderance of Mg over Zn in decreasing the Ca concentration in plants.

Incorporation of Mg markedly decreased the uptake of Ca in different parts of maize plant (Table 3). It decreased the average Ca uptake in roots, stem, leaf sheath and leaf blade from 63.40 to 23.89, 7.43 to 2.05, 11.64 to 2.83 and 42.09 to 16.54 mg/pot, respectively. A reduction in Ca uptake of roots by 62% and of leaf sheath by 75% due to Mg application infers the inhibited translocation of Ca from root to shoot. Maximum Ca uptake due to Zn application was recorded at 5 ppm Zn level.

Availability of Ca in soil :- The available Ca in soil was decreased by Zn and Mg application (Table 4). Zinc decreased it from 4.65 to 3.39 m.e./100 g soil with a 27% reduction over control whereas Mg decreased it from 5.06 to 3.09 m.e/100 g soil with a 39% reduction in its avai-

Table 2. Concentration of Ca (%) in different parts of maize plant as influenced by zinc and magnesium application.

Plant Parts	Zinc levels (ppm)	Magnesium levels (ppm						C. D. at 5% for		
		0	15	30	45	60	Mean	Zn	Mg	Zn x Mg
Root	0	1.13	0.97	0.87	0.78	0.69	0.89			
	5	1.07	0.93	0.75	0.63	0.57	0.79	0.02	0.03	N. S.
	10	1.03	0.87	0.70	0.61	0.	0.75			
	Mean	1.08	0.92	0.77	0.67	0.60	—			
Stem	0	0.40	0.36	0.32	0.24	0.20	0.30			
	5	0.38	0.34	0.28	0.21	0.19	0.28	0.01	0.01	N. S.
	10	0.35	0.32	0.26	0.20	0.17	0.26			
	Mean	0.38	0.34	0.29	0.22	0.19	—			
Leaf Sheath	0	0.50	0.41	0.37	0.32	0.26	0.37			
	5	0.45	0.38	0.33	0.24	0.21	0.32	0.01	0.01	N. S.
	10	0.42	0.35	0.30	0.23	0.19	0.30			
	Mean	0.46	0.38	0.33	0.26	0.22	—			
Leaf Blade	0	0.69	0.60	0.53	0.50	0.46	0.56			
	5	0.67	0.57	0.48	0.45	0.43	0.52	0.01	0.01	N. S.
	10	0.63	0.54	0.47	0.43	0.38	0.49			
	Mean	0.66	0.57	0.49	0.46	0.42	—			

Table 3: Uptake of Ca (mg/pot) by different parts of maize plant as influenced by zinc and magnesium application.

Plant Parts	Zinc levels (ppm)	Magnesium levels (ppm)						C. D. at 5% for		
		0	15	30	45	60	Mean	Zn	Mg	Zn x Mg
Root	0	57.77	47.69	42.79	26.53	22.43	39.44			
	5	61.88	49.59	39.19	31.69	27.91	42.45	1.62	2.11	3.64
	10	70.55	43.60	32.92	27.19	21.33	39.12			
	Mean	63.40	46.96	38.30	28.47	23.89	—			
Stem	0	6.38	5.52	4.69	3.32	2.61	4.50			
	5	7.49	2.00	3.22	2.40	1.79	3.98	0.35	0.43	0.78
	10	8.41	4.38	3.30	2.20	1.76	4.01			
	Mean	7.43	4.97	3.74	2.64	2.05	—			

Zinc levels (ppm)		Magnesium levels 0	15	30	45	60	Mean	C. D. at 5% for Zn	Mg	Zn x Mg
Leaf	0	7.95	6.07	5.00	4.11	2.98	5.22			
Sheath	5	11.86	7.42	6.08	4.07	3.35	6.56	0.46	0.61	1.04
	10	15.10	5.48	4.50	3.04	2.15	6.05			
	Mean	11.64	6.32	5.19	3.74	2.83	—			
Leaf	0	38.35	27.39	23.36	16.67	14.58	24.07			
Sheath	5	44.48	31.74	25.14	21.75	20.51	28.72	0.87	1.13	1.96
	10	43.45	27.90	21.32	18.89	14.53	25.58			
	Mean	42.09	29.61	23.27	19.10	16.54	—			

Table 4. Effect of zinc and magnesium applications on soil available Ca (m. e./100 g soil)

zinc levels (ppm)	MagneSium levels (ppm) 0	15	30	45	60	Mean	C. D. at 5% for Zn	Mg	Zn x Mg
0	6.10	4.98	4.40	4.02	3.77	4.65			
5	4.77	3.76	3.33	3.14	2.78	3.56	0.05	0.07	0.11
10	4.30	3.72	3.28	2.92	2.73	3.39			
Mean	5.06	4.15	3.67	3.36	3.09	—			

lability over control. This shows that the suppressing effect of Mg on the availability of Ca is higher than Zn. The Ca and Mg antagonistic relationship in soil has been reported by several workers (Loew and May, 1901; Bear and Toth, 1948; Hunter, 1949).

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