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EFFECT OF Mg APPLICATION ON Zn UPTAKE BY MAIZE AND ON ITS (Zn) AVAILABILITY IN ALKALINE CALCAREOUS SOILS

F. HUSSAIN, RAHMATULLAH* and A. RASHID

Soil Science Division, Nuclear Institute for Agriculture and Biology, Faisalabad

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Abstract. A pot culture experiment with different Mg and Zn levels indicated Mg to have little effect on Zn availability to maize (*Zea mays* L., cv. BS-I) grown on an alkaline calcareous soil. A soil incubation study with different Mg and Zn levels applied to two alkaline calcareous soils supported the results of the pot culture experiment. Zinc additions were found to enhance the dry matter yield of maize plants appreciably. The present study was indicative of the probable existence of Mg deficiency in light textured soils as Mg increments increased the dry matter yield of maize plants significantly.

Introduction

Zinc deficiency in many crops has recently been reported in Pakistan.[1, 2] Rice and maize have been observed to be suffering more widely and severely with Zn deficiency.[3, 4] As most of the soils of Pakistan are alkaline and calcareous in nature, fixation of Zn is suspected to be a major problem in these soils.[1, 5] Magnesium under these conditions is one of the most abundantly occurring earth cations. Since Mg and Zn have similar ionic radii (0.78°Å and 0.83°Å respectively), they have been reported to interact with each other in exchange reactions on various colloidal fractions of soils.[6-11] Zinc availability in this way may be affected through the release or fixation process.[7, 10] Some studies have revealed an enhanced Zn uptake by plants when Mg was applied to the soils.[6, 10, 12] Some other workers obtained a depressing effect of Mg increments on the uptake of Zn by plants.[8, 13]

Literature reported on this aspect of plant nutrition is contradictory and most of the studies reported have been conducted under acid soil conditions. The present studies were envisaged to obtain information on the effect of Mg on Zn availability using maize as an indicator crop grown on an alkaline calcareous soil.

Materials and Methods

Pot culture study. A surface calcareous soil to a depth of 15 cm was collected from the experimental farm of the Institute. It was air-dried, crushed in a wooden mortar, passed through a 2-mm plastic sieve and analyzed for various physico-chemical properties. The soil (pH 7.7, EC_e 1.34 mmhos/cm) was loamy sand and contained 4.5% $CaCO_3$, 0.31% organic matter, 10.7 ppm NaHCO3-extractable P and 0.46 ppm DTPA (diethylenetriaminopentaacetic acid) extractable Zn. Soil portions of 4 kg were filled in polyethylene-lined plastic pots of 20-cm surface dia. and 23-cm height. The basal fertilizer dressing consisted of 100 ppm N as urea and 50 ppm P_2O_5 as KH_2PO_4. Treatments were 0, 5, 25 ppm Zn (as $ZnSO_4.7H_2O$) and 0, 60, 120 ppm Mg (as $MgSO_4.7H_2O$). The treatments in factorial combination were imposed in triplicate. All the salts were applied as their aqueous solutions before planting. Eight seeds of maize soaked in water for 24 hr. were sown in each pot and the stand later thinned to four healthy plants. The soil in pots was brought to field capacity every day by the addition of deionized water.

Maize plants were harvested by cutting at ground level 21 days after sowing, rinsed thoroughly in two baths of deionized water, dried in paper sacs at 70° and ground in a Wiley mill fitted with stainless steel blades and other internal parts of the cutting chamber. One g portions of the ground material were digested with 25 ml diacid mixture (redistilled HNO_3 and $HClO_4$ at 4:1). Zinc in the diluted digest was determined by atomic absorption spectroscopy. Total Zn contents were calculated by multiplying their concentration with plant dry matter yields.

Soil incubation study. An incubation study was carried out using two alkaline calcareous soils (0-15 cm) collected from the Thikriwala and Kamalia towns of the Faisalabad district. Physico-chemical properties of the soil have been detailed previously.[14] The treatments in factorial combination included 0, 2.5, 5.0, 10.0 ppm Zn (as $ZnSO_4.7HO_2$) and 0, 60, 120 and 480 ppm Mg (as $MgSO_4.7H_2O$). All the salts were applied as their aqueous solutions by adjusting the amount of water to bring the soil in each vessel to its 75% field capacity. The soils maintained at this moisture level were incubated at $30\pm1°$ for 13 days, a period found sufficient for maximum fixation of Zn.[17] At the end of the incubation period, the soil samples were extracted with 0.005M

*Now Graduate student in Department of Agronomy, Pennsylvania State University, University Park, Pennsylvania, USA.

DTPA and the concentrations of Zn in the soil extracts were determined by atomic absorption spectrophotometery.[15]

Results and Discussion

Pot culture study

(*a*) *Dry matter yield.* Application of 5 ppm Zn appreciably increased the dry matter yield over control ($P<0.05$, Table 1). Magnesium application at the rate of 60 ppm also increased the plant yield significantly ($P<0.01$, Table 1). Higher dose of either Zn or Mg did not increase the dry matter yield when compared with their respective preceding levels; rather, a decrease was observed. As the interaction of Zn and Mg was found to be non-significant (Table 1); therefore, it seems that their levels might have exhibited an antagonistic effect on the absorption of some other elements. The plants receiving 60 ppm Mg + 5 ppm Zn were quite vigorous and healthier with more dark green colour and broader leaf blades.

(*b*) *Zinc concentration and total Zn contents in maize plants.* Increasing doses of Zn progressively increased both the concentration and contents of Zn in plants ($P<0.01$, Table 1). In general, application of Mg resulted in a slight increase in Zn concentration as well as total Zn contents in plants. These results do not coincide with the earlier reports indicating a depressed uptake of Zn by plants when Mg was applied to the soils.[8, 13]

TABLE 1. EFFECT OF Mg AND Zn ON DRY MATTER YIELD AND CONCENTRATION AND TOTAL CONTENTS OF Zn IN MAIZE TOPS.

Applied		Dry matter yield	Zn concentration	Total Zn contents
Zn	Mg			
ppm		g/pot	ppm	µg/pot
0	0.0	2.40	4.39	10.51
	60.0	3.18	3.33	10.63
	120.0	2.98	4.39	13.07
5	0.0	3.10	26.04	78.93
	60.0	4.33	31.94	138.11
	120.0	2.93	29.86	86.67
25	0.0	3.25	45.13	149.03
	60.0	3.33	47.92	160.65
	120.0	2.98	54.86	163.58
LSD (0.05) (Mg means)	..	0.41	NS	NS
LSD (0.05) (Zn means)	..	0.41	11.25	67.78
LSD (0.05) (Mg × Zn means)	..	NS	NS	NS

Soil incubation study. Addition of increasing amounts of Zn markedly increased the availability of Zn over control in both soils ($P<0.01$, Table 2). Mg. application up to 480 ppm exhibited no effect on the extractability of Zn from either soil used. These results thus presented an evidence for little effect of Mg on Zn availability in alkaline calcareous soils.

TABLE 2. DTPA-EXTRACTABLE Zn IN TWO SOILS AS INELUENCED BY VARIOUS LEVELS OF Mg AND Zn AND INCUBATED FOR 13 DAYS AT 30±1° AND 75% FIELD CAPACITY.

Applied		0.005 M DTPA-extractable Zn	
Zn	Mg	Thikriwala soil	Kamalia soil
ppm		ppm	
0	0	0.37	0.58
	60	0.31	0.53
	120	0.29	0.46
	480	0.24	0.47
2.5	0	2.04	2.19
	60	1.95	2.25
	120	1.95	2.31
	480	2.07	2.19
5.0	0	4.02	4.23
	60	4.02	4.08
	120	4.02	4.20
	480	4.14	4.20
10.0	0	6.96	7.20
	60	6.90	7.46
	120	6.90	7.32
	480	6.90	7.32
LSD (0.05) (Mg means)	..	NS	NS
LSD (0.05) (Zn means)	..	0.06	0.09
LSD (0.05) (Mg × Zn means)	..	NS	NS

General Discussion

The present data on soil and plant analyses clearly showed Mg as having little effect on the availability of Zn to maize. The results are contrary to the findings of Seatz[6] and Merrill, *et al.*[10] in which soil treatment with Mg increased Zn contents of some upland crops. Magnesium deficiency is most likely to occur in acid soils with a sandy loam, loamy sand or sand ploughlayer with subsoil coarse or coarser.[16] Although the soil used in the current pot culture experiment was a loamy sand, little evidence exists for Mg deficiency in the soils of Pakistan which are mostly alkaline and calcareous. It was, however, interesting to note that Mg application to the current soil caused a highly significant increase

in the dry matter yield of maize plants. Furthermore, the plant yield was generally maximum in pots receiving 60 ppm Mg in combination with either dose of Zn. Thus there are indications in the pot culture study that Mg deficiency may exist in the coarse textured soils of Pakistan. Further systematic investigations in this respect are warranted. Based on the results of the present studies, it seems that either native or applied Mg in the foreseeable future may have little bearing on Zn availability to maize and likely to other upland crops grown on alkaline calcareous soils of Pakistan.

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