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EFFECT OF GYPSUM AND ZINC SOURCES ON YIELD AND ZINC, COPPER MANGANESE AND IRON NUTRITION OF SOYBEAN (*GLYCINE MAX* L.) ON SODIC SOILS

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ABSTRACT

A pot experiment was conducted on a zinc deficient sodic soil to evaluate the effects of 0, 5 and 10 ppm zinc as zinc sulphate ($Zn\,SO_4\,7\,H_2\,O$) and zinc ethyline diamine tetra acetic acid (Zn-EDTA) and four rates of gypsum (G_{25}, G_{50}, G_{75}, G_{100} of gypsum reqirement of soil) on soybean (variety Black Tur). The plants did not survive without gypsum addition to the sodic soil of 56.5 ESP (exchangeable sodium percentage). The dry matter yield of soybean increased with increasing rates of gypsum. Application of zinc sulphate lead to higher yield than that of Zn-EDTA. Application of 5 ppm zinc as zinc sulphate alongwith G_{100} improved the dry matter yield markedly. Zinc concentration incressed with zinc supply, more so when applied as Zn-EDTA. Gypsum upto G_{75} decreased zinc content while zinc uptake increased. Copper uptake increased with zinc application. At G_{25}, G_{75} and G_{100} zinc sulphate increased copper content and its uptake. Uptake of manganese increased and its content decreased with zinc. Gypsum when applied alone increased manganese content, but decreased when zinc and gypsum were applied together. Iron content and its uptake in zinc sulphate treatment was less than those under Zn-EDTA treatment. In general, at higher levels of gypsum, iron uptake decreased, but the iron content decreased consistently with graded levels of gypsum.

INTRODUCTION

Zinc deficiency in sodic soils is quite common due to excessive sodium. high pH, carbonate and bicarbonate ions (Lindsay, 1972). In zinc dificient alkali soils only the application of zinc and not that of gypsum could correct its deficiency (Takkar and Singh, 1978). The present investigation was conducted to study the effect of zinc and gypsum on the yield and zinc, copper, manganese and iron nutrition of soybean on sodic soil.

MATERIAL AND METHODS

Earthen pots lined with polyethelene were filled with 4 kg air dried zinc-deficient soil of 56.5 ESP. Gypsum was added to the pot soil @ 25, 50, 75 and 100 per cent (G_{25}, G_{50}, G_{75} and G_{100} of the soil gypsum requirement) and mixed thoroughly. Three levels of zinc i.e. 0,5 and 10 ppm through both, zinc sulphate and Zn–EDTA (zinc ethyline diamine tetra acetic acid) were superimposed. The experiment in randomised design was replicated thrice. A basal dose of 50 ppm nitrogen and 25 ppm phosphorus in the form of urea and ammonium phosphate was added. All the nutrients in solution form were thoroughly mixed with the soil before sowing. Six plants per pot of soybean variety 'Black Tur' were sown and grown for six weeks. The yield under control treatment (56.5 ESP) was not recorded as there was no germination. After addition of gypsum no leaching was done. After harvesting, the plants were washed in 0.01 normal hydrochloric acid followed by distilled water and deionized water. After drying in oven at 70° C, the shoot yield was recorded. The plant samples were analysed for zinc, copper, managanese and iron by atomic absorption spectrophotometer after digestion in diacid mixture of nitric acid : perchloric acid (5:1). The chemical analysis was done as per Chopra and Kanwar (1976).

RESULTS AND DISCUSSION

Dry matter yield

Application of zinc in a gypsum treated alkali soil significantly increased the shoot dry matter production (37%) over 0 ppm zinc (Table 1). The increase in yield was 42 and 32 per cent with zinc sulphate and Zn-EDTA, respectively, over control. Zinc application at 10 ppm was found slightly better than 5ppm zinc.

The shoot yield of soybean increased with increasing rates of gypsum. However, the difference between the treatment G75 and G100 was non-significant. Gypsum with zinc at 5 ppm improved the shoot yield markedly. At higher gypsum level (G100) the difference in yield due to 10 ppm zinc as compared to 5 ppm zinc was non-significant. The gypsum treatments i.e. G50, G75 and G100 resulted in 28, 60 and 76 per cent increase in yield, respectively over G_{25}. The improvement in the yield due to gypsum application is attributed to reduction in soil pH and increase in calcium supply (Abrol *et. al.* 1972 and Shukla and Mukhi, 1980). The increase in shoot yield of paddy was associated (Bhumbla and Abrol, 1971) with enhanced utilization of zinc and calcium, and decrease in sodium absorption due to gypsum application upto G_{50} zinc concentration and uptake.

When compared with 0 ppm zinc (Table 2.) the increase in zinc content due to zinc sulphate and Zn-EDTA was 58 and 350 per cent, respectively. Without zinc application, addition of gypsum, irrespective of gypsum requirement, caused significant reduction in zinc concentration in plant tissues which increased upto G_{75}, and decreased significantly at G_{100} when no zinc was applied. Takkar and Singh (1978) also observed similar results in rice. Application of higher levels of gypsum caused reduction in zinc content which is attributed to interaction between calcium and zinc (Shukla and Mukhi, 1980) and formation of insoluble calcium zincate complex.

The uptake of zinc increased with zinc application regardless of zinc sources, being higher in Zn-EDTA treatments. Application of gypsum without zinc resulted in a marginal increase in zinc uptake upto G_{75}. The depression in zinc uptake at G_{100} was probably due to very

Table 1. Effect of gypsum, sources and levels of zinc on the dry matter yield (g/pot) of soybean plant

Gypsum added	Control	Zn as Zinc sulphate			Zn as Zn EDTA			Mean
(per cent G.R.)	0 ppm	5 ppm	10 ppm	Mean	5 ppm	10 ppm	Mean	
G_{25}	0.83	1.04	1.28	1.16	0.99	1.11	1.05	1.05
G_{50}	1.02	1.42	1.51	1.47	1.20	1.55	1.38	1.34
G_{75}	1.34	1.87	1.84	1.86	1.65	1.72	1.69	1.68
G_{100}	1.46	2.05	2.08	2.07	1.80	1.87	1.84	1.85
Mean	1.16	1.60	1.68	1.64	1.41	1.56	1.53	—

C.D. at 5%	
Zn sources	0.14
Gypsum requirement	0.20
Zn control vs. Zn application	0.22
Zn levels	NS
Zn sources x Zn levels	NS
Zn sources x Gypsum requirement	NS
Zn level x Gypsum requirement	NS

Table 2. Effect of gypsum, sources and levels of zinc on the concentration and uptake of zinc by soybean plant

Gypsum added	Control	Zn as Zinc sulphate			Zn as Zn–EDTA			Mean
(per cent G.R.)	0 ppm	5 ppm	10 ppm	Mean	5 ppm	10 ppm	Mean	
				Zn concentration (ppm)				
G_{25}	22.6	33.8	51.1	42.4	83.5	137.0	111.2	66.41
G_{50}	22.4	29.7	38.0	33.8	81.5	124.8	103.1	59.69
G_{75}	24.4	26.5	37.7	32.1	70.4	122.2	96.3	56.26
G_{100}	15.6	22.4	33.3	27.9	65.9	94.8	80.4	46.40
Mean	21.2	28.1	40.0	34.3	75.3	119.7	97.7	
				Zn uptake (ug/pot)				
G_{25}	18.8	37.4	66.1	51.8	84.7	152.1	118.4	71.8
G_{50}	24.9	42.2	57.5	49.9	97.8	192.8	145.3	83.0
G_{75}	33.0	49.6	69.5	59.6	116.6	209.6	163.1	95.7
G_{100}	22.6	46.0	70.9	58.5	119.1	177.3	148.2	87.2
Mean	24.8	43.8	66.0	54.9	104.6	183.0	143.8	

C.D. at 5%	for concentration	for uptake
Zn sources	1.4	8.6
Zn levels	1.4	8.6
Zn sources x Zn levels	1.98	12.2
Gypsum requirement	1.98	12.2
Zn sources x Gypsum requirement	2.8	17.3
Zn levels x gypsum requirement	2.8	NS
Zn sources x Zn levels x Gypsum requirement	3.96	NS
Zn control vs. Zn application	2.21	13.6

low zinc concentration in tissues. When zinc was supplemented with gypsum, the zinc uptake by soybean shoot was not affected significantly (Takkar and Singh, 1978). Uptake of zinc increased and its content decreased as the gypsum levels were raised except at G_{100} in zinc treated pots which may largely be due to the dilution effect of enhanced growth. The increase in growth can be associated with the enhanced zinc utilization by plants, decrease in sodium utilization due to zinc and enhanced uptake of calcium, calcium/sodium ratio and other plant nutrients due to application of gypsum (Shukla and Mukhi, 1980).

Iron concentration and uptake

Zinc application lowered the iron concentration of shoot by 15.4 per cent over that of control (Table 3). The effect of zinc sulphate in the reduction of iron (20%) was more than that of Zn-EDTA (11%).

Without zinc, the gypsum treatments G_{50} and G_{75} increased the iron content of plant over G_{25}. This is in agreement with the finding of Olsen and Watanabe (1979). Depression was, however, observed at higher gypsum level i.e., G_{100}. Application of gypsum together with zinc caused significant reduction in iron content. It is probable that effectiveness of gypsum and zinc in suppressing sodium absorption may be decreased when applied together (Shukla and Mukhi, 1979). Application of 10 ppm zinc through both the sources of zinc resulted in higher iron content of plant compared with 5 ppm zinc at all levels of gypsum. It is evident from data (Table 3) that 10 ppm zinc, irrespective of zinc sources, lead to marked improvement in iron uptake. Application of zinc enhanced iron uptake upto G_{75} but the increase was not significant.

Copper concentration and uptake

Application of zinc sulphate at 5 ppm level increased copper concentration more than the Zn-EDTA treatment. Both the sources were however, equally effective at 10 ppm zinc level (Table 4). Application of zinc resulted in 47 per cent increase in the copper uptake as compared to 0 ppm zinc. The magnitude of increase was 60 per cent in zinc sulphate and 35 per cent in Zn EDTA treatments. The increasing levels of gypsum had a depressing effect on copper content in the plant.

No marked difference between gypsum levels was noticed on the uptake of copper which improved significantly with G_{75} level. At higher gypsum levels, zinc sulphate was significantly superior than Zn-EDTA in increasing copper uptake. At lower levels of gypsum, both the sources of zinc were, however, equally effective.

Manganese concentration and uptake

The data (Table 5) revealed that in the absence of zinc, increasing rates of gypsum caused marked improvement in manganese content. The reduction in manganese content was evident at gypsum levels G_{75} and G_{100}. Olsen and Watanabe (1979) also reported similar trends in sorghum.

Table 3. Effect of gypsum, sources and levels of Zinc on the concentration and uptake of iron by soybean plant

Gypsum added	Control	Zn as Zinc sulphate			Zn as Zn–EDTA			Mean
(per cent G.R.)	0 ppm	5 ppm	10 ppm	Mean	5 ppm	10 ppm	Mean	
				Pe concentration (ppm)				
G_{25}	133.3	113.3	143.3	128.3	123.3	133.3	128.3	129.3
G_{50}	146.6	110.0	130.0	120.0	108.3	150.0	129.1	129.0
G_{75}	150.0	85.0	91.6	83.3	88.3	116.6	102.5	106.3
G_{100}	80.0	71.6	78.0	74.8	91.6	91.6	91.6	82.6
Mean	127.5	95.0	110.7	102.8	102.9	122.9	112.9	
				Fe untake (ug/pot)				
G_{25}	110	119	185	152	122	150	136	137
G_{50}	151	156	195	176	130	232	181	175
G_{75}	200	159	169	164	146	201	174	175
G_{100}	117	147	163	155	165	171	168	153
Mean	145	145	178	162	141	189	165	

C.D. at 5%	for concentration	for uptake
Zn sources	3.60	NS
Zn levels	3.60	15
Zn sources x Zn levels	NS	NS
Gypsum requirement	5.09	21
Zn sources x Gypsum requirement	7.20	NS
Zn levels x Gypsum requirement	7.20	NS
Zn sources x Zn levels x Gypsum requirement	10.18	NS
Zn control vs. Zn application	5.69	24

Table 4. Effect of gypsum, sources and levels of zinc on the concentration and uptake of copper by soybean plant

Gypsum added (percent G.R.)	Control	Zn as Zinc sulphate			Zn as Zn-EDTA			Mean
	0 ppm	5 ppm	10 ppm	Mean	5 ppm	10 ppm	Mean	
				Cu concentration (ppm)				
G_{25}	22.6	26.6	24.0	25.3	22.6	25.3	24.0	24.2
G_{50}	20.0	18.6	20.0	19.3	22.6	24.0	23.3	21.0
G_{75}	21.3	21.3	28.0	24.6	18.6	22.6	20.6	22.4
G_{100}	20.0	24.0	24.0	24.0	18.0	20.6	19.3	21.3
Mean	21.0	22.7	24.0	23.3	20.5	23.2	21.8	
				Cu uptake (ug/pot)				
G_{25}	18.9	27.8	30.8	29.3	22.5	28.1	25.3	25,6
G_{50}	20.5	26.4	30.1	28.3	27.6	37.1	32.4	28.3
G_{75}	28.2	39.9	51.5	45 7	31.1	39.1	35.1	38.0
G_{100}	29 3	49 2	49.9	49.7	32.4	39.5	36.0	40.1
Mean	24.2	35.8	40.6	38.4	28.4	36.0	32.2	

C. D. at 5%	for concentration	for uptake
Zn sources	0.94	2.9
Zn levels	0.94	2.9
Zn sources x Zn levels	1.33	4.1
Gypsum requirement	1.33	4.1
Zn sources x Gypsum requirement	1 88	5.7
Zn levels x Gypsum requirement	1.88	5.7
Zn sources x Zn level x Gypsum requirement	2.65	8.1
Zn control vs. Zn application	1.48	4.5

Table 5. Effect of gypsum, sources and levels of zinc on the concentration and uptake of manganese by soybean plant

Gypsum added (per cent G. R.)	Control	Zn as zinc sulphate			Zn as Zn-EDTA			Mean
	0 ppm	5 ppm	10 ppm	Mean	5 ppm	10 ppm	Mean	
				Mn concentration (ppm)				
G_{25}	166.7	205.5	200.0	202.7	200.0	250.0	225.0	204.4
G_{50}	216.7	188.9	205.5	197.2	166.6	186.1	176.4	192.7
G_{75}	200.0	169.4	173.5	171·5	133.3	191.6	162.5	173.6
G_{100}	191.6	161,1	163.9	162,5	147.2	183.3	165.3	169 5
Mean	193.7	181.2	185.7	183.5	161.8	202.7	182.3	—
				Mn uptake (ug/pot)				
G_{25}	138	214	256	235	198	279	239	217
G_{50}	222	268	310	289	199	288	244	257
G_{75}	267	318	319	319	220	328	274	291
G_{100}	280	330	341	336	266	344	305	312
Mean	227	282	307	295	221	310	266	—

C. D. at 5%	for concentration	for uptake
Zn sources	NS	22
Zn levels	3.36	22
Zn sources x Zn levels	5.45	31
Gypsum requirement	5.45	31
Zn sources x Gypsum requirement	7.71	NS
Zn levels x Gypsum requirement	NS	NS
Zn sources x Zn levels x Gypsum requirement	10.91	NS
Zn control vs. Zn application	6.10	35

In the presence of applied zinc, increasing levels of gypsum suppressed manganese content upto G_{75} and only slightly at G_{100}. At higher levels of gypsum calcium supperssed the activity of zinc and consequently increased the activity of sodium which decreased manganese concentration. Uptake of manganese increased with zinc application as compared to no zinc application. The magnitude of increase was 30 and 17 per cent in zinc sulphate and Zn-EDTA, respectively. All the levels of zinc except 5 ppm supplied through Zn-EDTA were significantly superior to 0 ppm zinc. With each increment of gypsum, there was significant increase in the manganese uptake. This may be due to increase in yield with gypsum application.

REFERENCES

Abrol, I.P., Dargan, K.S. and Milap Chand 1972. Add zinc to obtain higher profit from saline-alkali soils. *Indian Fmg. 21* (11) : 15-18.

Bhumbla, D. R. and Abrol, I. P. 1971. Use of gypsum for getting good yields from sodic soils. *Indian Fmg. 21* : 11-13.

Chopra, S. L. and Kanwar, J.S. 1976. *Analytical agricultural chemistry.* Kalyani Publishers, Ludhiana.

Lindsay, W.L. 1972. Inorganic phase equilibria of micronutrients in soils p. 41-58. In *Micronutrient in Agriculture.* Managing Editor Richard C. Dinauer Soil Sci. Am. Inc. Madison, Wisconsin, U.S A.

Olsen, S. R. and Watanabe, F. S. 1979. Interaction of added gypsum in alkaline soils with uptake of iron, molybdenum, manganese and zinc by sorghum. *Soil Sci. Soc. Am. J. 43* : 125–130.

Shukla, U.C. and Mukhi, A.K. 1979. Sodium potassium and zinc relationship in corn (*Zea mays L.*) *Agron J. 71* : 235–237.

Shukla, U.C. and Mukhi, A.K. 1980. Ameliorative role of zinc, potassium and gypsum on maize (*Zea mays L.*) growth under alkali soil conditions. *Agron J. 72* : 85–88.

Takkar, P.N. and Singh, T. 1978. Zinc nutrition of rice as influenced by rates of gypsum and Zn fertilization of alkali soil. *Agron J. 70* : 447-450.