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ENHANCEMENT IN ZINC RESPONSE OF RICE BY MAGNESIUM IN ALKALI SOIL

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SUMMARY

Magnesium application enhanced the effect of zinc on growth and grain yield of rice in alkali/sodic soil.Ten kg $MgSO_4$/ha almost doubled the biomass production under normal supply of 25 kg $ZnSO_4$/ ha largely due to increased tillering. It also hastened the process of heading. Magnesium tended to reduce the chaffy grains and thereby increased the filled-grains and grain size leading to yield enhancement significantly. Further, magnesium application resulted in dark green colour of leaves due to increased chlorophylls. The activity of carbonic anhydrase also increased due to magnesium application . Interestingly, Mg application promoted the absorption and translocation of Zn, Ca, P, K and that of Mg itself whereas Na accumulation was inhibited. This study suggested that magnesium can be beneficial, in addition to zinc, in alkali soil.

***Key words*: Carbonic anhydrase, chlorophyll, magnesium sulphate, sodic soil, zinc.**

INTRODUCTION

The rising human population has lately changed the land use pattern in our country and as a result a large chunk of salt-affected soils, hitherto lying barren, are now being brought under cultivation following successful crop technology development for such waste lands (Dargan *et al* 1976, Singh 1981a, b, 1982 a) . One essential component of this crop technology is the soil application of micro-nutrient zinc (Shukla and Prasad 1974, Shukla and Mukhi 1980, Singh 1982 b, 1983). In the present experiment , the effects of various doses of magnesium, were investigated under the influence of uniform supply of zinc from two sources with a view to explore the possibility whether magnesium can be of any use in increasing agro-economic efficiency of applied zinc in sodic soil.

MATERIALS AND METHODS

The present experiment was conducted in partially reclaimed sodic soil at the research farm of N.D.University of Agriculture and Technology, Kumarganj , Faizabad. The field was ploughed by tractor-drawn plough and since the land topography was a bit undulating it had to be properly levelled and strongly bunded from all sides . Soil samples from 0-15 cm depth were drawn from 5 places randomly and analysed for mechanical , chemical and physical properties . The soil was sandy loam with 23.5% clay , 20.2% silt, 54.5% sand with intial pH 10.3, electrical conductivity 2.1 d Sm^{-1}, exchangeable sodium 85% and bulk density 1.61 g/cm^3. The soils had been reclaimed by pyrites in the previous season lowering the pH down to 9.2. Thus, rice and wheat had been grown alternatively prior to this experiment . The experimental design consisted of

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randomized blocks with three replications having plot size 5x4 m each. NPK nutrients were supplied @ 100 kg N, 50 kg P_2O_5 and 30 kg K_2O /ha as per normal agronomic schedule of fertilizer application. Two sources of zinc, i.e. DMCC zinc frit (22.2% Zn) and zinc sulphate (23% Zn) were applied @ 25kg/ha each in combination with three levels of $MgSO_4$,viz. 0, 7.5 and 10 kg/ha at the time of transplanting of rice cultivar Saket-4. Five-week-old seedlings were transplanted @ 4 seedlings/hill at 15x15 cm spacing . Chlorophyll contents (Yoshida *et al.* 1976) and carbonic anhydrase activities (Wilber and Anderson 1948) in fully developed leaves were determined two weeks after transplanting . Observations on growth parameters, yield and yield components and elemental status of composite samples of leaf tissues were recorded at maturity (Yoshida *et al.* 1976). The findings were analyzed statistically (Panse and Sukhatme 1985).

RESULTS AND DISCUSSION

On account of relatively rigorous earth work involved in field levelling for soil reclamation, the production factors particularly soil strength and inherent fertility of experimental field were not conducive to good plant performance in this study. Yet, the zinc sulphate proved superior to DMCC zinc frit in stimulating plant growth under alkali soil conditions . Deficiency of zinc as well as non-supply of magnesium resulted in severe retardation in plant growth(Table 1) . Plant height, root length , tiller production and bio-mass accumulation were all accelerated by zinc combined with magnesium applications which appear to be dose-dependent . Though the application of 10 kg $MgSO_4$ / ha promoted plant height only by 3 cm, root length by 4 cm and tiller production by 5-6 /hill ,but bio-mass accumulation almost doubled with shoot to root ratio being slightly higher on account of magnesium application. Interestingly enough , magnesium promoted exersion of panicles ,which led to early heading by about a week. Magnesium has been reported to enhance quantity and quality of orange fruits (Nan 1996).

Plant supplied with 25 kg $ZnSO_4$ in combination with 10kg $MgSO_4$produced 9 cm long panicles whereas, in cases when magnesium had not been supplied the panicles measured only between 6 to 7 cm (Table 2) . Similarly, the production and growth of primary rachis branches were also reduced drastically in the absence of zinc and magnesium . The source of zinc and the levels of magnesium undoubtedly exerted significant impact on grain formation in rice under alkali soil conditions . The results revealed a decisive role of magnesium in spikelet sterility , cutting down the number of chaffy grains to only 20 against 37 to 45 per panicle in the absence of magnesium. The effects of levels of magnesium on grain size were quite substantial , the difference varying between 2 to 3.4 g/1000 grains. Naturally , magnesium-promoted yield components finally contributed to increased yield . The observed acceleration in overall growth and yield on account of zinc and

Table 1. Effect of magnesium on response of rice to zinc application in alkali soil in terms of growth attributes.

Sources of zinc	$MgSO_4$ (kg/ha)	Plant height (cm)	Root length (cm)	Productive tillers/ hill	Non-productive tillers/hill	Total tillers /hill	Shoot weight (g/hill)	Root weight (g/hill)	Total weight (g/hill)	Shoot: root ratio
DMCC zinc frit @ 25kg/ha	None	31.5	15.4	6.7	6.2	12.9	36.5	14.1	50.6	2.59
“ “ “ “	7.5	33.0	17.1	7.7	8.3	16.0	47.2	18.7	65.9	2.52
“ “ “ “	10.0	34.6	19.6	9.3	9.1	18.4	66.8	23.5	90.3	2.84
Zinc sulphate @ 25kg/ha	None	33.7	16.7	6.5	7.1	13.6	38.5	15.1	53.6	2.55
“ “ “ “	7.5	35.3	18.4	7.3	9.3	16.6	54.5	20.9	75.4	2.61
“ “ “ “	10.0	36.6	20.4	8.9	10.8	19.7	82.5	27.2	109.7	3.03
Control (without zinc)	None	29.2	12.7	5.2	4.7	9.9	31.4	11.5	42.9	2.73
	LSD (0.05)	2.2	1.7	1.4	1.1	2.1	4.7	2.1	6	0.51

Table 2. Effect of magnesium on response of rice to zinc application in alkali soil in terms of yield and yield components.

Sources of zinc	$MgSO_4$ (kg/ha)	Delay in heading (days)	Panicle length (cm)	Rachis branches/ panicle	Filled grains/ panicle	Chaffy grains/ panicle	Spikelet sterility (%)	Grain size (g/1000 grains)	Grain yield (q /ha)
DMCC zinc frit @ 25kg/ha	None	7.7	6.4	6.5	23.1	45.3	66.2	10.4	1.8
“ “ “ “	7.5	6.5	6.8	7.5	25.7	37.1	59.1	11.8	3.0
“ “ “ “	10.0	5.3	7.4	7.7	28.9	30.1	51.0	12.4	6.5
Zinc sulphate @ 25kg/ha	None	6.6	6.6	6.8	22.9	37.1	61.8	10.5	2.0
“ “ “ “	7.5	4.4	7.9	7.2	29.5	23.6	44.4	12.3	3.4
“ “ “ “	10.0	None	9.1	8.4	34.6	20.3	36.9	13.9	7.5
Control (without zinc)	None	9.9	6.1	4.8	18.8	54.3	74.3	7.9	1.3
	LSD (0.05)	1.3	0.4	0.6	0.7	3.3	2.0	0.5	0.9

magnesium may be expected as both the chlorophyll and carbonic anhydrase activities were higher under these conditions (Table 3) probably resulting in high photosynthetic rates (Thomas and Howarth 2000). Apparently , the carbonic anhydrase activity which catalyses the hydration and dehydration of carbonic acid was inhibited by alkalinity and the inhibition was ameliorated by zinc and magnesium as zinc is the constituent of this enzyme. The role of magnesium in making leaves darker is also obvious as magnesium is constituent of chlorophyll (Bose and Mishra 2001).

The application of zinc and magnesium increased the accumulation of Zn , Ca , Mg , P & K in leaf tissues on the one hand, and reduced the content of Na on the other (Table 3) . The maximum increase took place in the concentration of Zn followed by other elements in the manner Zn>K>Mg>Ca>P. The concentration of Zn increased 2.7 times whereas that of K, Ca, Mg and P increased by about 49, 40, 39 and 17% respectively. Na content reduced by about 24% in which zinc and magnesium contributed about equally. Reduction in Na which is harmful when accumulates, must have improved

Table 3. Effect of magnesium on response of rice to zinc application in alkali soil in terms of chlorophyll, carbonic anhydrase and elemental composition of leaves.

Sources of zinc	$MgSO_4$ (kg/ha)	Chlorophyll (mg/g)	Carbonic anhydrase*	Zn (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	P (%)	K (%)
DMCC zinc frit @ 25kg/ha	None	8.2	310	22.7	1672	1505	1679	0.193	2.07
“ “ “ “	7.5	8.9	317	24.2	1720	1650	1580	0.200	2.21
“ “ “ “	10.0	9.3	321	26.4	1820	1770	1512	0.205	2.32
Zinc sulphate @ 25kg/ha	None	8.3	313	23.8	1681	1562	1579	0.194	2.16
“ “ “ “	7.5	9.3	330	26.2	1769	1661	1480	0.209	2.37
“ “ “ “	10.0	10.2	336	28.6	1844	1793	1386	0.215	2.45
Control (without zinc)	None	6.1	288	10.6	1326	1279	1827	0.184	1.64
	LSD (0.05)	0.3	2.3	0.6	53.6	40.5	41.2	0.017	0.16

* Carbonic anhydrase activity expressed in terms of mg CO_2/100mg dry wt./10min.

plant growth (Qadar 1995, Velu and Srivastava 2000) . Though the ionic radius of Mg is less than that of Zn and also the Mg has antagonistic effect on the uptake of Zn and vice-versa, how exactly the application of Mg increased the concentration of Zn is obscure.However, application of magnesium in addition to zinc, does appear beneficial for rice crop in alkali/sodic soil.

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