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CONCENTRATION AND UPTAKE OF NUTRIENTS BY RICE ROOTS AND QUALITY OF RICE GRAINS AS INFLUENCED OF GYPSUM, Zn AND DIFFERENT SALINE ENVIRONMENTS.

Khan, H.R., Faiz, S.M.A., Adachi, T*. and Ahmed, I.U.
Department of Soil Science, University of Dhaka, Dhaka-1000, Bangladesh.
* Faculty of Agriculture, Okayama University, Okayama-700, Japan.

ABSTRACT

The effects of different levels(ECiw=0.60, 8, 16 dSm^{-1})of water salinity, gypsum(G=0, 160kg ha^{-1}) and Zinc(Zn=0, 5kg ha^{-1})on the concentration and uptake of nutrients by rice roots and quality of rice grains were studied in greenhouse. Highly significant($P \leq 0.01$)effect of salinity on the concentration and uptake of nutrients by roots and quality of rice grains was found, the adverse effect being more pronounced on BR 6 rice while the exotic CSR 4 appeared more salt tolerant. The concentration and uptake of Ca, Mg and Zn in roots decreased with an increase in salinity. The concentration of Na, Cl and S increased with an increase in water salinity but the uptake of S and Cl was slightly decreased at 8 dSm^{-1} while 50 per cent yield reduction was at 16 dSm^{-1}. Maximum amount of uptake of Na was at 8 dSm^{-1} followed by that at 16 and 0.60 dSm^{-1} for both the cultivars. Application of gypsum and Zn at the rates of 160 and 5kg ha^{-1} increased the concentration and uptake of Ca, Mg and S, and were effective to decrease the concentration of Na and Cl in rice roots. Salinity significantly reduced the grains and root yields of the rices but G_{160} and Zn_5 had favorable effects on these parameters. Protein contents of the rices varied significantly with the treatments and ranged from 68.8 to 87.5 g kg^{-1} for CSR 4 and 67.5 to 82.5 g kg^{-1} for BR 6. Application of G_{160} and Zn_5 separately or in combination improved the protein contents of rice grains, regardless of salinity.

Key words: concentration of nutrients, gypsum, quality of rice grains, salinity, zinc.

INTRODUCTION

One-fifth of the total area(26,000km^2)of Bangladesh which lies around the northern apex of the Bay of Bengal is seriously affected by saline water intrusion[4]. Electrical conductivity of Betna river (Feni: near northern apex of the Bay of Bengal)waters fluctuated from 2.6 to 29.4 dSm^{-1} with a coefficient of variation 76 per cent[12]. Such saline irrigation has a marked effect on the nutrients availability as well as their translocation in plant. It is well known that salinity lowers the water potential in the soil, consequently lowering the water potential gradient from the soil to the plant cell. Besides, salinity sometimes causes nutrient imbalance due to more Na^+ and Cl^- in soil solution[6] which may also adversely affect the mineral nutrition of the plant[3]. Salt tolerant varieties can be grown in the coastal areas with fresh water irrigation, but as the cost-benefit ratio of irrigation becomes low, farmers are not interested in such an uncertain venture. Hence, for the optimum growth of plants under saline conditions, reclamation and management practices should be done to maintain a balance between the concentration of ions in the immediate environment of root and their uptake.

Plant growth and yield of rice increased by gypsum and it acted as an amending material in saline soil[15]. Application of gypsum along with irrigation suppressed the absorption of sodium ions by soil particles and plants from diluted solutions[24]. It was suggested that application of water with intermediate salinity, gypsum or other amendments with irrigation water would be effective to reclaim saline soil but further research is still needed[5]. Application of Zn enhanced the yield and decreased the adverse effects of salinity and sodicity[23]. The coastal saline soils of Bangladesh are slightly to moderately alkaline in reaction where Zn deficiency is becoming an acute problem [17]. Salinity has a negative effect on the assimilation of N, P and K by rice but the application of gypsum and zinc at the rates of 160 and 5kg ha^{-1}, respectively was significantly effective for the uptake of N, P and K, irrespective of salinity[11]. Based on these backgrounds, we studied the influences of gypsum, zinc and intermittent saline irrigation on the quality of rice grains and uptake of Na, Ca, Mg, S, Cl and Zn by two rice cultivars.

MATERIALS AND METHODS

The experiment was conducted with high yielding BR 6 and exotic CSR 4 rices in the greenhouse at the Department of Soil Science, University of Dhaka, Bangladesh. The soil used for this experiment was Hatiya silty clay loam(fine silty, isohyperthermic Aeric Fluvaquent)was collected from coastal saline zone (Table 1). Initially 300 g of 1M HCl washed coarse sand was added to the bottom of each earthen pot and then 8kg of air−dried, ground and 5mm−sieved composite soil was filled in a pot(28/24 cm). Thirty five−day old seedlings at the rate of two per hill and three hills in a pot were transplanted in each pot. The experiment was set up in a factorial randomized design using 3 levels(0.6, 8.0, 16.0 dSm^{-1})of saline water(ECiw), 2 levels(0, 160 kg ha^{-1})of gypsum (G)and 2 levels(0, 5 kg ha^{-1})of zinc (Zn), arranged in three replications with the following treatment combinations;

Table 1 Physio−chemical properties of the original soil(0−15cm depth)on oven dry basis.

Properties	Values
Sand[19]	9.0 %
Silt[19]	61.0 "
Clay[19]	30.0 "
Textural class	Silty clay loam
Water holding capacity[2]	7.1mm cm^{-1}
pH (1:2.5)[9]	7.9
Organic carbon[2]	8.8 g kg^{-1}
Total Nitrogen[9]	0.8 "
Available phosphorus[16]	19.7mg kg^{-1}
Available zinc[10]	1.4 "
Electrical conductivity (ECe)[22]	3.6dSm^{-1}
Exchangeable cations	
Potassium[2]	0.52cmol kg^{-1}
Sodium[2]	3.76 "
Calcium[7]	1.73 "
Magnesium[7]	2.60 "
Water soluble anions	
Chloride[9]	2.66 "
Sulfate[9]	1.25 "
Bicarbonate[22]	0.37 "
Carbonate[22]	0.05 "
Cation exchange capacity[2]	16.87cmol kg^{-1}
Sodium adsorption ratio (SAR)[22]	8.08
Exchangeable sodium percentage (ESP)[22]	23.40

T_1 $EC_{0.6}G_0Zn_0$ fresh water (locally available tap water : ECiw 0.6 dSm^{-1}, pH 6.7, SAR 2.08, Na 2.98, K 0.22, Ca 0.83, Mg 1.13, Cl 2.19, SO_4 0.02, HCO_3 1.30 and CO_3 0.0 mmol L^{-1}) irrigation(6cm/week)without G and Zn.

T_2 $EC_{0.6}G_{160}Zn_0$ fresh water irrigation (6 cm/week)with G at the rate of 160 kg ha^{-1}.

T_3 $EC_{0.6}G_0Zn_5$ fresh water irrigation (6 cm/week)with Zn at the rate of 5 kg ha^{-1}.

T_4 $EC_{0.6}G_{160}Zn_5$ fresh water irrigation (6 cm/week)with G and Zn at the rates of 160 and 5 kg ha^{-1}.

T_5 $EC_8G_0Zn_0$ alternate fresh and saline water (ECiw 8 dSm^{-1})irrigation(6 cm/week)without G and Zn.

T_6 $EC_8G_{160}Zn_0$ alternate fresh and saline water irrigation(6 cm/week)with G at the rate of 160 kg ha^{-1}.

T_7 $EC_8G_0Zn_5$ alternate fresh and saline water irrigation(6 cm/week)with Zn at the rate of 5 kg ha^{-1}.

T_8 $EC_8G_{160}Zn_5$ alternate fresh and saline water irrigation(6 cm/week)with G and Zn at the rates of 160 and 5 kg ha^{-1}.

T_9 $EC_{16}G_0Zn_0$ alternate fresh and saline water (ECiw 16 dSm^{-1})irrigation(6 cm/week)without G and Zn.

T_{10} $EC_{16}G_{160}Zn_0$ alternate fresh and saline water irrigation(6 cm/week)with G at the rate of 160 kg ha^{-1}.

T_{11} $EC_{16}G_0Zn_5$ alternate fresh and saline water irrigation(6 cm/week) with Zn at the rate of 5 kg ha^{-1}.

T_{12} $EC_{16}G_{160}Zn_5$ alternate fresh and saline water irrigation(6 cm/week) with G and Zn at the rates of 160 and 5 kg ha^{-1}.

Recommended basal doses of N, P_2O_5, and K_2O were applied at the rate of 80, 60 and 40 kg ha^{-1} as urea, triple superphosphate(TSP) and muriate of potash(MP), respectively. The whole amounts of TSP, gypsum and zinc oxide were applied at the time of pot preparation. The whole of MP and half of urea were applied before transplantation, followed by top dressings of the remaining urea in two equal splits, at the active tillering and the panicle initiation stages of rice. Initially all pots were irrigated with tap water(Table 2) to bring the soil at complete submergence for 7 days after transplanting(DAT). On the 8th DAT, the desired concentrations of saline water in relation to the Betna river(coastal river that affects the soil under investigation) water were prepared by adding the required amounts of salts, viz. NaCl, Na_2SO_4, Na_2CO_3, $CaCl_2$ and $MgCl_2$ in the ratio of 3:2:1:4:1 dissolved in tap water. The solutions were then applied at the rate of 1 liter per pot per week, in addition to tap water and a level of 6 cm of water above the soil surface was maintained. Intercultural operations were performed as required. The soil solutions were collected anaerobically at different growth stages of rice. The soil solutions were drawn through a sampling tube fitted at the bottom of each pot and allowed to flow by gravity to fill a 150 ml Erlenmeyer flasks which was previously flushed with nitrogen gas. Soil solutions were analyzed for their pH[9], EC and SAR[22] (Table 2). The grain yields and plant roots (oven dried at 65℃) were measured after harvesting the crops at maturity. The roots were separated by soaking the soil of each pot with tap water and then spraying with a stream of tap water over fine mesh screen and finally washed with distilled water[14].

Protein content and composition of rice roots :

Protein content of the rice grains was determined from per cent N[9] concentration in the grains multiplied by 6.25. The contents of Na, K(flame photometry[2]), S(Spectrophotometrically at 420 mμ wave length after developing turbidity with

Table 2 Characteristics of tap water used, soil solution (leachate) after 90 days of submergence (CSR 4), protein contents of rice grains, grain and root yields as influenced by gypsum, Zn and different EC waters.

Treatment		*EC	pH	SAR	Grain(g/pot)		Root wt.(g/pot)		Protein(g/kg)	
No.	Combination	(dSm^{-1})			CSR 4	BR 6	CSR 4	BR 6	CSR 4	BR 6
T_1	$EC_{0.6}G_0Zn_0$	2.7	7.70	4.6	16.61	11.60	4.47	2.38	85.0	80.6
T_2	$EC_{0.6}G_{160}Zn_0$	2.7	7.50	4.2	18.29	13.40	5.30	2.74	86.3	81.9
T_3	$EC_{0.6}G_0Zn_5$	2.7	7.70	4.5	18.53	13.65	5.10	2.60	85.6	81.3
T_4	$EC_{0.6}G_{160}Zn_5$	2.6	7.50	4.0	22.00	17.35	6.13	3.12	87.5	82.8
T_5	$EC_8G_0Zn_0$	3.9	7.90	6.2	4.18	2.30	3.15	1.24	76.3	73.1
T_6	$EC_8G_{160}Zn_0$	3.7	7.60	5.9	4.20	2.35	3.62	1.40	77.5	73.8
T_7	$EC_8G_0Zn_5$	3.8	7.85	6.1	4.29	2.41	3.48	1.34	76.9	73.3
T_8	$EC_8G_{160}Zn_5$	3.7	7.60	5.8	4.49	3.35	3.96	1.57	78.8	74.4
T_9	$EC_{16}G_0Zn_0$	5.2	8.05	9.1	0.42	0.22	1.36	0.55	68.8	67.5
T_{10}	$EC_{16}G_{160}Zn_0$	4.9	7.70	8.4	0.48	0.24	1.52	0.60	70.6	68.8
T_{11}	$EC_{16}G_0Zn_5$	5.0	7.85	8.8	0.45	0.26	1.44	0.58	70.0	68.1
T_{12}	$EC_{16}G_{160}Zn_5$	4.7	7.75	8.3	0.51	0.31	1.70	0.69	72.5	70.0
Tap water		0.6	6.70	2.1						

*EC=Electrical conductivity of soil solution (leachate).

$BaCl_2$ and gum accacia[9]), $Cl^{[9]}$, Ca, Mg and Zn(atomic absorption spectrophotometry[7])were determined after HNO_3-HClO_4 acid (2:1)digestion.

RESULTS AND DISCUSSION

Yield of rice : Root dry matter and grain yields were reduced significantly($p \leqq 0.01$)with the increase in ECiw but the application of gypsum and Zn increased the yields of both the varieties (Table 2). The root dry matter and grain yield of CSR 4 rice cultivar remained higher than those of the BR 6 rice, irrespective of salinity and the increased yields by different treatments were more pronounced for CSR 4 rice which is presumably due to the genetic properties of CSR 4 rice grown under different saline environments. Reduction in yields were 30(root)and 75(grain)per cent for CSR 4; 48(root)and 80(grain)per cent for BR 6 at 8 dSm^{-1}, and 70(root)and 97(grain)per cent for CSR 4 ; 77(root)and 98(grain)per cent for BR 6 at 16 dSm^{-1} level compared to the treatments with non−saline(0.6 dSm^{-1})irrigation.

Protein contents of rice grains : Protein contents of the rice grains varied significantly($p \leqq 0.05$)with the treatments and ranged from 68.8 to 87.5 g kg^{-1} for CSR 4, and 67.5 to 82.5 g kg^{-1} for BR 6(Table 2). Protein contents of the rice grains decreased with each increment of salinity and the marked reductions were observed at the highest salinity level for both the cultivars. Application of gypsum at the rate of 160 kg ha^{-1} was ranked second in order of protein contents in rice grains of both the varieties, regardless of salinity. But the combined application of G_{160} and Zn_5 was more effective to improve protein contents of the rice grains. The results of the present investigation are similar to the findings reported by Rahman et al.[21]. They reported that protein contents of BR 3 rice grains ranged between 68 and 84 g kg^{-1} in saline−acid sulfate soils and can be improved by the application of liming materials($CaCO_3$ and basic slag). Protein contents of IR 8 rice grains under saline environment varied[8] from 76 to 86 g kg^{-1} with an average of 82 g kg^{-1}.

Na, Ca, Mg, S, Cl and Zn in rice roots : Sodium concentration increased with each increment of salinity and followed the sequence : $EC_{16} > EC_8 > EC_{0.6}$. This increase of Na concentration in roots might be due to the increase of Na ions in the soil as well as in the applied irrigation water. The Na concentration was the highest for T_9 and the lowest with T_4 while the control(T_1)treatment obtained the fourth lowest value of Na concentration (Table 3). Gypsum was effective to decrease Na concentration which might have been due to the supply of excess Ca from gypsum that hindered the absorption of Na ions[24]. Similar results had also been reported[15]. The single effect of Zn to reduce Na concentration in rice roots which might be due to the counter−effects of Zn on sodium[23]. The present investigation revealed that the combined application of G_{160} and Zn_5 was more effective than their separate application though the uptake of Na increased with gypsum and Zn for both the cultivars regardless of salinity. The maximum amount of uptake of Na was obtained in 8 dSm^{-1} level, followed by 16 and 0.60 dSm^{-1} saline phases for both the varieties (Fig. 1).

Calcium status of the original soil was low in comparison to Na and Mg concentrations(Table 1), which might be due to ion competition between Na and Ca in saline environment[6]. The application of G_{160} and Zn_5 separately or in combination increased the concentration(Table 3)and uptake(Fig. 1)of Ca in the rice roots. This results agreed well with the earlier findings[13]. Calcium concentration and uptake decreased with increasing salinity and the results can be supported by the observation of Patil et al.[18]. They observed that the uptake of Ca and Mg by rice roots decreased with an increase of salinity.

The concentration(Table 3)and uptake(Fig. 1)of Mg decreased with each increment of salinity. The concentration and uptake of Mg was the highest with T_4 and the lowest with T_9 treatments for both the cultivars. The separate application of G_{160} and Zn_5 was better but their combined application had significant($p \leqq 0.05$)effects to increase the concentration and uptake of Ca and Mg regardless of salinity.

The peak value of S concentration was found at

Table 3 Comparison of nutrient contents(g kg^{-1})in rice roots at maturity as influenced by gypsum, Zn and different EC waters.

Cultivar CSR 4

a) Sodium : G X Zn X ECiw

G/ECiw	Zn_0	Zn_5	G-mean
0 kg gypsum(G) ha^{-1}			9.0 a
0.6	3.5 c	3.3 c	
8	9.9 b	9.2 b	
16	14.2 a	13.7 a	
160 kg gypsum ha^{-1}			8.3 b
0.6	3.4 c	3.1 c	
8	8.8 b	8.2 b	
16	13.6 a	12.8 a	

Zn−mean 8.9 A 8.4 B
L.S.D. (5%)=0.32

b) Calcium : G X Zn X ECiw

G/ECiw	Zn_0	Zn_5	G-mean
0 kg gypsum ha^{-1}			3.9 b
0.6	4.8 a	4.9 a	
8	3.8 b	3.9 b	
16	2.8 c	2.9 c	
160 kg gypsum ha^{-1}			4.2 a
0.6	5.1 a	5.4 a	
8	4.0 b	4.2 b	
16	3.1 c	3.3 c	

Zn−mean 3.9 A 4.1 A
L.S.D. (5%)=0.24 (5%)

c) Magnesium : G X Zn X ECiw

G/ECiw	Zn_0	Zn_5	G-mean
0 kg gypsum ha^{-1}			2.3 a
0.6	2.9 a	3.0 a	
8	2.2 b	2.3 b	
16	1.8 c	1.8 c	
160 kg gypsum ha^{-1}			2.5 a
0.6	3.0 a	3.3 a	
8	2.4 b	2.6 b	
16	1.9 c	2.0 c	

Zn−mean 2.4 A 2.5 A
L.S.D. (5%)=0.31

d) Sulfur : G X Zn X ECiw

G/ECiw	Zn_0	Zn_5	G-mean
0 kg gypsum ha^{-1}			0.35 b
0.6	0.25 a	0.28 a	
8	0.34 b	0.37 b	
16	0.43 c	0.45 c	
160 kg gypsum ha^{-1}			0.42 a
0.6	0.31 a	0.35 a	
8	0.40 b	0.46 b	
16	0.48 c	0.52 c	

Zn−mean 0.37 B 0.41 A
L.S.D. (5%)=0.02

e) Chloride : G X Zn X ECiw

G/ECiw	Zn_0	Zn_5	G-mean
0 kg gypsum ha^{-1}			4.3 a
0.6	3.3 c	3.2 c	
8	4.5 b	4.3 b	
16	5.6 a	5.1 a	
160 kg gypsum ha^{-1}			4.0 b
0.6	3.1 c	2.9 c	
8	4.2 b	4.0 b	
16	5.3 a	4.7 a	

Zn−mean 0.43 A 0.40 B
L.S.D. (5%)=0.30

f) Zinc : G X Zn X ECiw

G/ECiw	Zn_0	Zn_5	G-mean
0 kg gypsum ha^{-1}			0.010B
0.6	0.010a	0.014a	
8	0.009b	0.012b	
16	0.008c	0.010c	
160 kg gypsum ha^{-1}			0.012A
0.6	0.011a	0.017a	
8	0.010b	0.014b	
16	0.009c	0.012c	

Zn−mean 0.009B 0.013A
L.S.D. (5%)=0.002

continued……

Table 3(continued)

Cultivar BR 6

a) Sodium : G X Zn X ECiw

G/ECiw	Zn_0	Zn_5	G-mean
0 kg gypsum ha^{-1}			7.5 a
0.6	2.6 c	2.3 c	
8	7.9 b	7.3 b	
16	13.0 a	11.8 a	
160 kg gypsum ha^{-1}			7.0 b
0.6	2.4 c	2.2 c	
8	7.5 b	6.7 b	
16	12.3 a	10.9 a	
Zn−mean	7.6 A	6.9 B	

L.S.D. (5%)=0.32

b) Calcium : G X Zn X ECiw

G/ECiw	Zn_0	Zn_5	G-mean
0 kg gypsum ha^{-1}			3.4 b
0.6	4.4 a	4.5 a	
8	3.4 b	3.4 b	
16	2.4 c	2.4 c	
160 kg gypsum ha^{-1}			3.7 a
0.6	4.6 a	5.1 a	
8	3.5 b	3.7 b	
16	2.6 c	2.9 c	
Zn−mean	3.5 A	3.6 A	

L.S.D. (5%)=0.23

c) Magnesium : G X Zn X ECiw

G/ECiw	Zn_0	Zn_5	G-mean
0 kg gypsum ha^{-1}			2.1 b
0.6	2.7 a	2.8 a	
8	2.0 b	2.1 b	
16	1.6 c	1.7 c	
160 kg gypsum ha^{-1}			2.4 a
0.6	2.9 a	3.1 a	
8	2.2 b	2.4 b	
16	1.8 c	2.0 c	
Zn−mean	2.2 A	2.4 A	

L.S.D. (5%)=0.28

d) Sulfur : G X Zn X ECiw

G/ECiw	Zn_0	Zn_5	G-mean
0 kg gypsum ha^{-1}			0.31 B
0.6	0.20 c	0.22 c	
8	0.30 b	0.31 b	
16	0.41 a	0.43 a	
160 kg gypsum ha^{-1}			0.36 A
0.6	0.24 c	0.28 c	
8	0.33 b	0.36 b	
16	0.45 a	0.48 a	
Zn−mean	0.32 B	0.35 A	

L.S.D. (5%)=0.02

e) Chloride : G X Zn X ECiw

G/ECiw	Zn_0	Zn_5	G-mean
0 kg gypsum ha^{-1}			3.4 a
0.6	2.8 c	2.6 c	
8	3.5 b	3.2 b	
16	4.2 a	4.0 a	
160 kg gypsum ha^{-1}			3.2 a
0.6	2.6 c	2.5 c	
8	3.2 b	3.2 b	
16	4.0 a	3.6 a	
Zn−mean	3.4 A	3.2 A	

L.S.D. (5%)=0.30

f) Zinc : G X Zn X ECiw

G/ECiw	Zn_0	Zn_5	G-mean
0 kg gypsum ha^{-1}			0.008 b
0.6	0.008 a	0.011 a	
8	0.007 b	0.010 b	
16	0.006 c	0.009 c	
160 kg gypsum ha^{-1}			0.010 a
0.6	0.009 a	0.013 a	
8	0.008 b	0.012 b	
16	0.007 c	0.011 c	
Zn−mean	0.007 B	0.011 A	

L.S.D. (5%)=0.002

In a column and row, means followed by a common letter are not significantly different at 5 per cent level.

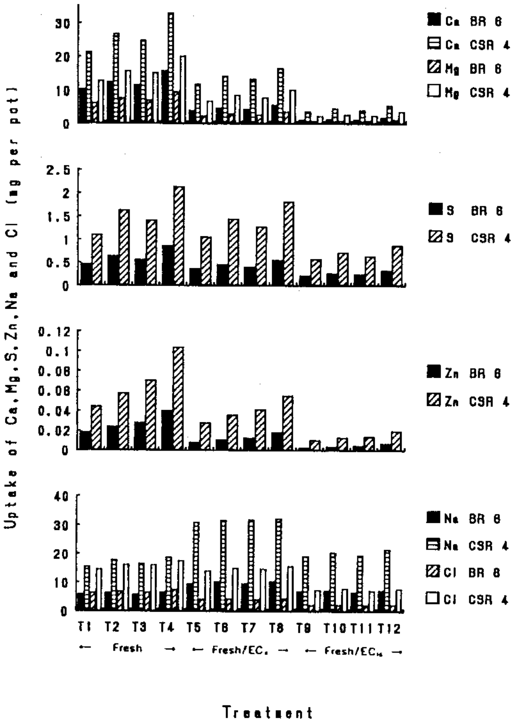

Fig. 1 Nutrient uptake by rice roots at maturity as influenced of gypsum, Zn and different EC waters.

the highest salinity(16 dSm^{-1}) with G_{160} and Zn_5 treatments which progressively declined at 8 and 0.6 dSm^{-1} salinity(Table 3). The effects of separate application of gypsum and Zn were found to increase S status in roots but their interactive effect was positively significant($p \leq 0.05$) with the increased S concentration in rice roots. Zinc enhanced the concentration and uptake of S even at the highest saline irrigation. The maximum(0.52 g kg^{-1} in CSR 4 ; 0.48 g kg^{-1} in BR 6)and minimum(0.25 g kg^{-1} in CSR 4; 0.20 g kg^{-1} in BR 6)concentration of S was obtained with T_{12} and T_1 treatments, respectively for both the cultivars. Whereas maximum and minimum uptake of S was with T_4 and T_9 treatments(Fig. 1). The improved uptake of S with G_{160} and Zn_5 might have been due to the synergistic effect of S of gypsum and zinc[20].

Chloride concentration increased with increasing ECiw for both the varieties but the application of G_{160} and Zn_5 separately or in combination decreased Cl concentration (Table 3). The peak value of Cl concentration was obtained with T_9 treatment(5.6 g kg^{-1} in CSR 4 ; 4.2 g kg^{-1} in BR 6)and the lowest with T_4 treatment(2.9 g kg_{-1} in CSR4 ; 2.5 g kg^{-1} in BR 6). The findings were quite similar with the results reported by Ahmed et al.[1]. Chloride uptake was negatively affected by salinity but G_{160} and Zn_5 had additive effect on Cl uptake regardless of salinity(Fig. 1).

Zinc concentration in rice roots decreased with increasing salinity(Table 3). The highest and lowest concentration(Table 3)and uptake(Fig. 1)of Zn were obtained with T_4 and T_9 treatments, respectively for both the cultivars. Combined application of G_{160} and Zn_5 was found effective to increase the concentration and uptake of Zn by rice roots even under saline phases. The results are partially agreed with the findings of some researchers[16,23].

SUMMARY

The present investigation on the concentration and uptake of nutrients by rice roots and quality of rice grains as influenced by gypsum, Zn and different saline environments concludes that salinity affected negatively the grains, roots, Ca, Mg and Zn but induced an increase in Na, Cl and S concentration and uptake by rice roots. This effect was more pronounced at the highest salinity (ECiw 16dSm^{-1}). However, gypsum and Zn separately or in combination improved these characteristics. Protein contents of the rice grains decreased with increased salinity but gypsum and Zn improved the protein contents of rice grains regardless of salinity. The rice variety CSR 4 appeared better tolerant to salinity and further trails should be conducted for confirming the present results.

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