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RESPONSE OF RICE TO VARIOUS SOURCES OF NITROGEN IN A SALT-AFFECTED SOIL

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The efficiency of different N fertilizers and their mixture under two salinity levels i.e. control (EC_e = 1.7 dS m^{-1}) and EC_e = 10 dS m^{-1} was compared by recording the number of tillers, straw and paddy yields of rice variety KS 282. Nitrogen was applied @ 60 and 80 mg kg^{-1} of soil as urea, ammonium sulphate and a mixture of urea + ammonium sulphate in 1:1 ratio. Significant reduction in number of tillers and straw, paddy yields was observed due to salinity. Nitrogen application increased N concentration, N uptake and decreased K^+, Na^+ and Cl^- concentration in straw and paddy. Nevertheless, application of N in the form of ammonium sulphate or its mixture with urea in 1:1 ratio produced statistically better yields than the straight N application as urea. At lower dose, the mixture was found as efficient as the high dose of straight fertilizers.

INTRODUCTION

Economic use of salt-affected soils requires reclamation through leaching of salts and use of amendments like gypsum and sulphur, etc. But on account of certain limitations, such as insufficient supply of canal water, low soil permeability, use of brackish groundwater, etc., these practices are not fully applicable. This has led to suggestions for the use of essential plant nutrients, including N, on moderately salt-affected soils for establishing economical farming. Under saline and sodic soil conditions, the N requirement for optimum yields might increase because adverse soil conditions modify the nature and extent of N transformation (Bhardwaj and Abrol, 1976). Biswas *et al.* (1985) advocated that crops grown on sodic soils require 14-20% more N compared to that for normal soils.

Under high salinity, growth and yield of rice is drastically reduced but with proper soil and fertilizers management, it can give better production (Aslam *et al.*, 1989). The present investigation was, therefore, undertaken to assess the performance of rice and relative efficiency of different N sources under two salinity levels.

MATERIALS AND METHODS

The experiment was conducted in glazed pots having 30 cm diameter. Each pot was filled with 10 kg of non-saline sandy clay loam soil having pH 7.9, EC_e 1.7 dS m^{-1}, total N 0.06% and CEC 7.9 me 100 g^{-1}. There were two salinity levels, one control (EC_e = 1.7 dS m^{-1}) and the other of EC_e 10 dS m^{-1}. Salinity level of EC_e 10 dS m^{-1} was imposed artificially using appropriate amounts of NaCl. The various sources of N and their doses were as under:

T_0 = Control (No nitrogen)
T_1 = 60 mg N kg^{-1} as urea
T_2 = 80 mg N kg^{-1} as urea
T_3 = 60 mg N kg^{-1} as ammonium sulphate
T_4 = 80 mg N kg^{-1} as ammonium sulphate

T_5 = 60 mg N kg^{-1} as urea + ammonium sulphate (1:1)

T_6 = 80 mg N kg^{-1} as urea + ammonium sulphate (1:1)

Half of the N dose was applied at the time of seedling transplanting and the remaining half was top dressed 45 days after transplanting. A basal dose of P, K and Zn @ 40, 25 and 5 mg kg^{-1} as SSP, SOP and $ZnSO_4$, respectively was applied in all the pots including control at the time of seedling transplanting. Canal water was applied throughout the growth period of the crop. Tillering was recorded at panicle initiation and plant samples were collected for chemical analysis. The crop was harvested at maturity for recording the paddy and straw yields. Dried and ground plant material was analysed for N, K^+, Na^+ and Cl^- concentrations. Data were analysed statistically by ANOVA technique following Completely Randomized Design (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Number of tillers: On the average reduction of 33% in tillers was observed with the salt treatment (Table 1). Nevertheless, with the application of N, the number of tillers increased even at high salinity and was the highest in T_4 and T_6. Similar results have been presented by Pearson *et al.* (1966).

Straw and paddy yield: The use of N fertilizers under both non-saline and saline conditions increased yield significantly (Table 1). Maximum average straw yield was produced by T_6 followed by T_4 and T_2. About 94 to 141% increase in yield was observed with various fertilizer treatments over the control. Similar results were reported by Verma and Neue (1984). The average paddy yield was reduced by about 67% at EC_e 10 dS m^{-1} as compared to that from the normal soil. There were number of reasons as to why yield decreases under saline conditions (Aslam *et al.*, 1991). Maximum paddy yield was produced by T_6 among all the treatments. The yield with T_4 and T_2 were similar followed by T_5 and T_3. The yields of T_5, T_3 and T_1 were significantly better compared to that from the control. Thus the use of mixture of urea + ammonium sulphate (1:1) @ 80 mg N kg^{-1} than straight application of ammonium sulphate or urea was found to be superior. The reason may be the minimum losses of N from mixture application. Zia (1969) and Biswas (1987) also found similar results.

From the data, it is clear that reduction in paddy yield due to salinity was severe as compared to tillering and straw yield indicating that vegetative phase is less affected by salt stress than the reproductive phase. Similar conclusions were drawn by Akbar (1985) and Aslam *et al.* (1988).

Chemical composition of rice straw and paddy

Nitrogen: The data indicated that treatments T_6, T_4 and T_2 were statistically similar compared to the rest of the treatments (Table 2). Minimum N concentration was recorded in control plants. In the fertilizer treatments, increase in N concentration was obviously due to the better supply of this nutrient in soil associated with relatively higher uptake by plants. This increase in N concentration at higher salinity may be attributed to reduction in dry matter yield. Maximum N uptake was found @ 80 mg N kg^{-1} as ammonium sulphate or mixture of urea + ammonium sulphate. Less uptake of N in case of urea than ammonium sulphate or mixture of urea + ammonium sulphate could be due to volatilization losses of urea under saline environment (Hamid and Ahmed, 1988).

Table 1. Effect of nitrogen sources and salinity on number of tillers, straw and paddy yields

Rate of N (kg^{-1} of soil)	Number of tillers pot^{-1}			Straw yield g pot^{-1}			Paddy yield g pot^{-1}		
	S_0	S_1	Mean	S_0	S_1	Mean	S_0	S_1	Mean
T_0 Control (No N)	18.3	9.0	13.7 e	33.3	16.8	25.1 e	26.5 e	8.9 h	17.7 e
T_1 60 mg as urea	29.0	18.3	23.7 d	54.3	33.6	43.9 d	46.3 d	17.8 g	32.1 c
T_2 80 mg as urea	37.3	25.0	31.2 bc	68.6	44.2	56.4 bc	64.8 b	19.4 fg	42.1 b
T_3 60 mg as A/s	34.6	22.6	28.6 cd	60.7	40.3	50.5 c	46.7 c	18.2 fg	32.5 c
T_4 80 mg as A/s	41.0	30.3	35.6 a	67.7	50.0	58.9 b	61.7 b	20.2 fg	40.9 b
T_5 60 mg as U + A/s (1:1)	33.0	21.0	27.0 d	61.5	41.5	51.5 c	57.8 bc	18.6 fg	38.2 bc
T_6 80 mg as U + A/s (1:1)	37.6	28.0	32.8 ab	76.4	56.3	66.4 a	69.5 a	22.1 f	45.7 a
Mean	33.0 A	22.0 B		60.4 A	40.4 B		54.4 A	17.9 B	

Values followed by same letter(s) are statistically similar at P = 0.01.
A/s = Ammonium sulphate and U + A/s = Urea + ammonium sulphate (1:1) ratio.
S_0 = EC_e 1.7 and S_1 = EC_e = 10 dS m^{-1}.

Table 2. Chemical composition of rice variety KS 282 as affected by soil salinity and nitrogen fertilizers

Rate of N (kg^{-1} of soil)	N (g kg^{-1})						N uptake (g pot^{-1})		
	Straw			Paddy			(Straw + Paddy)		
	S_0	S_1	Mean	S_0	S_1	Mean	S_0	S_1	Mean
T_0 Control (No N)	4.6 f	5.6 e	5.1 c	9.9 g	10.4 f	10.2 d	0.43 f	0.19 g	0.31 e
T_1 60 mg as urea	5.9 de	6.8 b	6.4 b	16.0 e	16.7 d	16.4 c	1.06 c	0.52 ef	0.79 d
T_2 80 mg as urea	6.5 bc	7.2 ab	6.8 a	17.4 c	18.2 ab	17.8 a	1.47 a	0.67 de	1.07 b
T_3 60 mg as A/s	5.8 de	6.9 b	6.4 b	15.9 e	17.7 bc	16.8 bc	1.27 b	0.60 e	0.94 c
T_4 80 mg as A/s	6.3 cd	7.3 ab	6.8 a	17.3 c	18.3 ab	17.8 a	1.49 a	0.73 de	1.11 ab
T_5 60 mg as U + A/s (1:1)	6.1 cde	7.1 ab	6.6 ab	16.1 de	17.9 ab	17.0 b	1.32 b	0.63 e	0.97 bc
T_6 80 mg as U + A/s (1:1)	6.4 bcd	7.4 a	6.9 a	18.1 bc	18.4 a	17.9 a	1.60 a	0.82 d	1.21 a
Mean	10.8 A	14.5 A		15.7 B	16.8 A		1.23 A	0.59 B	

Values followed by same letter(s) are statistically similar at P = 0.01.
A/s = Ammonium sulphate and U + A/s = Urea + ammonium sulphate (1:1) ratio.
S_0 = EC_e 1.7 and S_1 = EC_e = 10 dS m^{-1}.

Table 3. Effect of nitrogen sources and salinity on K^+, Na^+ and Cl^- concentration in straw of rice variety KS 282

Rate of N (kg^{-1} of soil)	K^+ ($g\ kg^{-1}$)			Na^+ ($g\ kg^{-1}$)			Cl^- ($g\ kg^{-1}$)		
	S_0	S_1	Mean	S_0	S_1	Mean	S_0	S_1	Mean
T_0 Control (No N)	11.2 a	8.0 e	9.6 a	2.9 f	4.5 a	3.8 a	5.3 f	13.4 a	9.4 a
T_1 60 mg as urea	10.6 c	7.9 f	9.3 d	2.5 h	3.8 d	3.2 c	4.4 f	10.4 bc	7.4 b
T_2 80 mg as urea	10.5 d	7.7 g	9.1 e	2.1 k	3.6 e	2.8 d	3.3 fg	7.5 d	5.4 d
T_3 60 mg as A/s	11.1 b	7.9 f	9.5 b	2.6 g	4.2 c	3.4 b	3.0 cd	9.6 c	6.6 c
T_4 80 mg as A/s	10.4 d	6.9 j	8.7 g	2.4 i	3.7 e	2.8 d	3.0 g	6.0 e	4.5 e
T_5 60 mg as U + A/s (1:1)	11.1 b	7.7 g	9.4 c	2.4 i	4.3 b	3.4 b	4.4 f	11.4 b	7.9 b
T_6 80 mg as U + A/s (1:1)	10.5 c	7.1 h	8.8 f	2.2 j	4.2 c	3.2 c	3.9 f	8.5 d	6.2 c
Mean	10.8 A	7.6 A		2.4 B	4.1 A		3.9 B	9.5 A	

Values followed by same letter(s) are statistically similar at P = 0.01.
A/s = Ammonium sulphate and U + A/s = Urea + ammonium sulphate (1:1) ratio.
S_0 = EC_e 1.7 and S_1 = EC_e = 10 dS m^{-1}

Potassium: Maximum K^+ concentration was found in control plants which was significantly superior to all the other fertilizer treatments (Table 2). There was maximum K^+ concentration in plant grown at EC_e 1.7 dS m^{-1} and it decreased by about 29% with increase in salt stress in the rooting medium. Low concentration of K^+ in T_4 may be attributed to the growth dilution effect. Decrease in K^+ concentration with salinity may be related to an increase in the uptake of Na^+ as against K^+ from the rooting medium having high Na:K ratio (Aslam *et al.*, 1992).

Sodium: Maximum Na^+ concentration was found in the control plants. The data (Table 3) showed that increasing rate of N further lowered the concentration of Na^+ in plants. With salinity, the Na^+ concentration of plants increased by approximately 40% of that in normal soil. The results are in agreement to those reported by Kaddah *et al.* (1975) and Aslam *et al.* (1992).

Chloride: Maximum Cl^- concentration was found in control plants while increasing the rate of N decreased it. The minimum concentration of this ion was found in the case of T_4 may be due to more and rapid growth resulting in less accumulation of this ion in plant tissues. Soil salinity has a positive and highly significant relationship with the Cl^- concentration. The data on Cl^- concentration followed the same trend as that of Na^+ (Table 3) i.e., the concentration increased with the increasing level of soil salinity while N material and its rates had depressive effect on the Cl^- concentration in plant tissues. Kaddah *et al.* (1975) and Aslam *et al.* (1992) have documented similar results.

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