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Comparative Efficiency of Foliar and Soil Application of K on Salt Tolerance in Rice

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Abstract: Artificially salinized soils were used to see the effect of foliar and soil application of K on rice. Results indicated that the number of tillers plant^{-1}, paddy and straw yield and grains to straw ratio significantly decreased with the increase in salinity. All K application methods increased the above parameters significantly at all salinity levels over distilled water spray. Increasing levels of salinity decreased K concentration in shoots and straw, which was increased significantly by foliar and soil application. Both methods of K application remained at par with each other. Sodium concentration increased with increase in salinity in both shoots and straw and decreased by foliar and soil application of K. Foliar application of K proved better than soil application in this respect. The K/Na ratio decreased significantly by the increase of salinity, while this ratio increased significantly by the foliar and soil application of K.

Key words: Potassium application, salinity, rice crop, foliar and soil application.

Introduction

At present about 6.67 million hectares of land is salt affected in Pakistan (Khan, 1998). Out of this about 60% salt affected soils are saline/sodic in nature (Muhammad, 1983). After N and P, K is the third major nutrient required by plants as a macro nutrient. Potassium plays a key role during the growth of plants under saline conditions as it participates in the mechanism of stomatal movement (Rana *et al.*, 1976) photosynthesis, osmoregulatory adaptations of plant to water stress (Nelson, 1978; Bringers and Trolldenier, 1979) and enhances the activity of nitroreductase (Sinha, 1978).

The salt affected soils can be brought under cultivation by the removal of excessive soluble salts and exchangeable sodium through various reclamation techniques. Rice crop is recommended for cultivation during reclamation because it supplies more drainable surplus. Its growth and yield are greatly reduced under extreme saline conditions (Verma and Neue, 1984). Hedge and Joshi (1974) noted that K concentration is decreased and Na is increased in rice with increasing salinity levels . The ratio of K/Na in rice shoots generally decreased with the increase in salinity (Muhammad, 1986). The ability of a cultivar to maintain high K/Na ratio can be a suitable selection criteria for salt tolerance. Foliar application of K is an efficient method of K supply to plants to avoid interaction both antagonistic and synergistic with essential major secondary and micro nutrients (Dibb and Thompson, 1985). Keeping all this in view the present study was undertaken to see the effect of foliar and soil application of K on the growth and chemical composition of rice under saline conditions.

Materials and Methods

A non- saline composite soil sample was collected from field area (ECe 1.65 d Sm^{-1}).It was alkaline in reaction (pH 8.0), deficient in total N (0.036%), low in available P (5.7 mg kg^{-1}) and medium in extractable K (105 mg kg^{-1}). The soil samples were brought to the wire house, air dried, ground, passed through 2 mm sieve and filled in the glazed pots (10 kg pot^{-1}). The following treatment combinations were applied and replicated thrice.

Salinity levels Ece (dSm^{-1})	Foliar spray of distilled water after every 10 days interval. (F_0)	Soil application of K @ 50 mg K Kg^{-1} soil (F_1)	Foliar application of 0.5% K_2SO_4 solution after every 10 days Interval (F_2)	Soil application + foliar spray (F_3)
1.65 (control)	"	"	"	"
6.0	"	"	"	"
12.0	"	"	"	"

A basal dose of N and P_2O_5 @ 50 and 40 mg kg^{-1} soil was applied to all pots. Eight (36 days old) seedlings of rice variety, KS-282 were transplanted in each pot and after 6 days were thinned to four. The salinity level 6.0 dSm^{-1} was developed 6 days after transplanting and ECe of 12.0 dSm^{-1} after 9 days of transplanting, using a mixture of salts($Na_2 SO_4$, NaCl, $CaCl_2$.$2H_2O$ and Mg SO_4. 7 H_2O in the ratio of 10:4:5:1 having Na: Ca: Mg ratio of 14:5:1 and Cl: SO_4 ratio of 9:11 respectively). Calculated amount of each salt was added to pots in solution form and pots were labeled . An additional dose of N @ 40 mg kg^{-1} soil was also applied 28 days after transplanting. For F_2 and F_3 total number of sprays were 9 and the volume of Ist, 2nd, 3rd, 4th and 5th sprays were 30, 40, 50 and 60 ml pot^{-1} (containing 4 plants) while 30 ml of 0.50% K_2SO_4 solution was sprayed in 6th, 7th, 8th and 9th sprays pot^{-1} (containing 2 plants). At maturity the panicles of each plant were harvested separately. The paddy and straw yields, the number of productive tillers plant^{-1} were also recorded. The straw samples along with stubbles were up-rooted separately. The shoots and straw samples were analyzed for K, Na and K/Na ratio.

All the analyses were done according to methods given in hand book No.60 (U.S.Salinity Lab. Staff, 1954) except total N by Jackson (1962) and available P by Watnabe and Olsen (1965). All the data were statistically analyzed using factorial CRD (Steel and Torrie, 1980).

Results and Discussion

Number of tillers plant^{-1}: Data regarding number of tillers plant^{-1} at 6 weeks after transplanting (WAT), 9WAT and maturity are given in Tables 1 a, 1 b and 1 c respectively. The results showed that at all three stages number of tillers plant^{-1} increased significantly by the Application of potassium over control. Maximum numbers were produced where K was applied through soil application as well as foliar application (F_3). This treatment was found superior than alone soil application or foliar sprays. Similar results were also obtained by Farooq (1989) and Javed and Muhammad (1992).

The number of tillers Plant^{-1} were significantly decreased by the increase of salinity levels and minimum values were noted at ECe of 12.1 dSm^{-1} at all growth stages. The decrease in number might be due to limited supply of metabolites to young growing tissues. Similar results were also reported by Farooq (1989) and Javed and Muhammad (1992).

The interaction between salinity levels and K application methods was non-significant at all the three growth stages(Tables 1 a, 1 b and 1 c).

Paddy and straw yield (g plant^{-1}): Paddy and straw yield data

Table 1a: Effect of foliar sprays and soil application of K on rice tillers plant^{-1} grown on saline soils (6 WAT)

	Potassium applications				
Ece (dS m^{-1})	F_0	F_1	F_2	F_3	Means
1.65(Control)	9.6	9.3	10.1	10.3	9.9 a
6.0	8.3	9.3	9.6	9.9	9.3 b
12.1	7.4	8.0	8.4	9.0	8.2 c
Means	8.4 c	9.0 b	9.3 ab	9.7 a	

Table 1b: Effect of foliar sprays and soil application of K on rice tillers plant^{-1} grown on saline soils (9 WAT)

	Potassium applications				
Ece (dS m^{-1})	F_0	F_1	F_2	F_3	Means
1.65 (Control)	10.7	11.2	11.5	12.3	11.4 a
6.0	9.3	10.0	10.3	10.7	10.1 b
12.1	8.7	9.5	9.8	10.3	9.6 c
Means	9.6 c	10.2 b	10.5 b	11.0 a	

Table 1c: Effect of foliar sprays and soil application of K on rice tillers plant^{-1} grown on saline at maturity (12 WAT).

ECe (dS m^{-1})	F_0	F_1	F_2	F_3	Means
1.65(Control)	10.8	11.3	11.5	12.7	11.6 a
6.0	9.7	10.2	10.8	11.5	10.5 b
12.1	8.8	10.0	10.2	10.8	9.9 c
Means	9.8 c	10.5 b	10.8 b	11.7 a	

Table 2: Effect of foliar sprays and soil application of K on paddy yield(g plant^{-1}) of rice grown on saline soils.

	Potassium applications				
Ece (dS m^{-1})	F_0	F_1	F_2	F_3	Means
1.65 (Control)	21.2	24.3	24.9	29.4	24.9 a
6.0	15.0	17.1	21.1	23.2	19.1 b
12.1	13.7	15.5	16.7	18.3	16.1 c
Means	16.6d	19.0 c	20.9 b	23.6a	

Table 3: Effect of foliar sprays and soil application of K on straw yield (g plant-1) of rice grown on saline soils.

	Potassium applications				
Ece (dS m^{-1})	F_0	F_1	F_2	F_3	Means
1.65 (Control)	21.7	22.1	22.1	24.7	22.6 a
6.06.0	20.9	21.1	21.7	23.6	21.8 b
12.1	16.7	20.2	20.0	21.5	19.6 c
Means	19.8 c	21.1 b	21.3 b	23.3 a	

Table 4: Effect of foliar sprays and soil application of K on grain straw ratio of rice grown on saline soils.

Ece (dS m^{-1})	F_0	F_1	F_2	F_3	Means
1.65 (Control)	0.95	1.10	1.12	1.22	1.10 a
6.0	0.72	0.81	0.97	0.99	0.87 b
12.1	0.69	0.77	0.83	0.84	0.78 c
Means	0.79 d	0.89 c	0.97 b	1.02 a	

Table 5: Effect of foliar sprays and soil application of K on Na concentration (mmol Kg^{-1}) in shoots of rice grown on saline soils.

	Potassium applications				
Ece (dS m^{-1})	F_0	F_1	F_2	F_3	Means
1.65 (Control)	30.4	27.5	26.9	24.6	27.4 c
6.0	39.1	36.2	35.4	32.6	35.8 b
12.1	47.8	47.1	46.4	43.5	46.2 a
Means	39.1a	36.9 b	36.2 b	33.6 c	

Table 6: Effect of foliar sprays and soil application of K on Na concentration (mmol Kg^{-1}) in straw of rice grown on saline soils.

ECe (dS m^{-1})	F_0	F_1	F_2	F_3	Means
1.65(Control)	55.0	50.7	50.7	46.4	50.7 c
6.0	54.3	68.1	66.6	60.1	62.3 b
12.1	103.4	84.0	82.6	80.4	87.1 a
Means	70.9 a	67.6 b	66.6 b	62.3 c	

Table 7: Effect of foliar sprays and soil application of K on Na concentration (mmol Kg^{-1}) in shoots of rice grown on saline soils.

	Potassium applications				
Ece (dS m^{-1})	F_0	F_1	F_2	F_3	Means
1.65(Control)	456.5	486.4	494.1	584.5	505.4 a
6.0	420.0	472.8	478.9	560.8	483.1 b
b12.1	319.8	335.9	335.9	429.3	365.2 c
Means	398.8 c	438.4 b	442.9 b	524.9 a	

Table 8: Effect of foliar sprays and soil application of K on Na concentration (mmol Kg^{-1}) in straw of rice grown on saline soils.

	Potassium applications				
Ece (dS m^{-1})	F_0	F_1	F_2	F_3	Means
1.65 (Control)	360.9	404.5	412.1	419.8	399.3 a
6.0	250.2	381.4	386.5	399.3	354.4 b
12.1	204.8	245.8	250.8	260.0	240.4 c
Means	272.0 c	343.9 b	349.8 b	359.7 a	

Table 9: Effect of foliar sprays and soil application of K on K: Na ratio in rice shoots grown on saline soils.

	Potassium applications				
Ece (dS m^{-1})	F_0	F_1	F_2	F_3	Means
1.65(Control)	15.0	18.0	18.7	23.9	18.9 a
6.0	10.8	13.8	14.1	17.2	14.0 b
12.1	6.9	7.8	7.9	10.2	8.2 c
Means	10.9 c	13.2 b	13.6 b	17.1 a	

Table 10: Effect of foliar sprays and soil application of K on Na ratio in rice straw grown on saline soils.

	Potassium applications				
Ece (dS m^{-1})	F_0	F_1	F_2	F_3	Means
1.65 (Control)	6.5	8.5	8.5	9.1	8.2 a
6.0	4/3	6.7	6.5	6.8	5.8 b
12.1	2.5	3.0	3.3	4.5	3.3 c
Means	4.4 c	5.7 b	6.1 b	6.8 a	

(Table 2 & 3) showed that these were significantly decreased by the increase of salinity levels and minimum yields were recorded at ECe 12.1 (dSm^{-1}). The decrease in paddy and straw yield with increasing soil salinity might be due to reduced growth of rice plants as a result of reduced uptake of water and nutrients (higher osmotic pressure and nutritional imbalance and specific ion effect)(Flower *et al.*, 1991). It may also be due to limited supply of metabolites to young growing tissues, interference of NaCl with the production of proteins and damage to the enzymatic proteins exposed to cover water potential. Similar results were also reported by Chaudhry (1989) and Javed and Muhammad (1992). Applying K either through rooting media or foliar sprays over control significantly increased paddy and straw yield. Maximum paddy yield was noted in F_3 where K was applied through rooting media + foliar spray and was superior to alone soil application or foliar spray. This increase in paddy and straw yield suggested that the yields of rice could be increased under saline conditions by K application.

This increase in paddy and straw yield might be due to the participation of K in mechanism of stomatal movement, photosynthesis and osmoregulatory adaptation of plants to water stress in saline sodic soils (Nelson, 1978 and Flower *et al.*, 1991). The results also showed that foliar application of K was better than soil application in case of paddy yield which was in contrast to Aslam *et al.*(1998). Potassium absorption by plant leaves is possible under saline conditions (Jurgens, 1976) and K absorbed under such conditions might help the plants for regulating stomatal opening and closing. Similar explanation for foliar application was given by Skeema and Salam (1989).

The interaction between salinity levels and K application methods were found non significant in both paddy and straw yields.

Grain to Straw ratio: The results indicated that there was a significant decrease in grain to straw ratio with progressive increase in salinity levels(Table-4). This concludes that grain development is more adversely affected by salinity than straw production, and the Coarse rice is more salt tolerant at vegetative stage than at reproductive stage. Similar findings were reported by Muhammad (1986).

Potassium application significantly increased the grain to straw ratio over control. Maximum ratio was recorded in F_3 where K was applied through soil application + foliar spray followed by foliar spray and least in soil K application (F_1) (Table-4). This means that foliar application of K is better than soil application to increase the grain production because plants absorbed K through the leaves when its supply through rooting media is inadequate under adverse conditions. (Jurgens, 1976 and Aslam *et al.*,1998). Similar findings were reported by Farooq (1989).

Sodium concentration (mmol Kg^{-1}) in rice shoots and straw: Sodium concentration (Tables 5 & 6) in shoots and straw was significantly increased with increasing salinity levels. Maximum Na Concentration in both shoots and straw was recorded at ECe 12.1 (dSm^{-1}). The increase in Na concentration with increasing salinity might be due to its increasing concentration in rooting media. In addition to this it may also be due to reduced growth. The results are in line with those of Girdhar (1988) and Javed and Muhammad (1992). Foliar & soil application of K decreased Na concentration in shoots and straw significantly. Maximum reduction was noted in F_3 where K was applied through foliar + soil application. This treatment was found superior than alone soil (F_1)or foliar application (F_2) of K. Alone soil and foliar application of K differed non significantly. Similar results were reported by Aslam *et al.*(1998) . This indicates that K application through rooting media or by foliar application plays a key role in reducing the Na concentration in rice shoots and straw.

Potassium concentration (mmol Kg^{-1}) in rice shoots and straw: The potassium concentration (Tables 7 & 8) in shoots and straw significantly decreased with the increase in salinity levels. This might be due to competition between K^+ and Na^+ and a resultant increase in the uptake of Na^+ at the cost of K^+ (Aslam and Muhammad 1972 ; Tahir, 1987 and Aslam *et al.*, 1998). The application of K increased the K concentration significantly in both rice shoots and straw over control. The maximum K concentration was noted in F_3 where K was applied by both methods i.e. soil + foliar. Soil and foliar application of K was non significant with each other. The increase in K concentration with soil application of K was due to higher concentration of K in the rooting medium whereas increase in K concentration with foliar spray of K was due to absorption of the sprayed K under saline conditions (Jurgen, 1976 and Javed and Muhammad 1992).

Potassium to sodium ratio in rice shoots and straw: The results are depicted in Tables 9 & 10. It is clear that K/Na ratio in shoots and straw decreased significantly with the increase in salinity levels. It might be due to decrease in K concentration and increase in Na concentration with increasing salinity as given in (Tables 5 & 6 and 7 & 8). Similar results were also reported by Tahir (1987) ; Javed and Muhammad (1992) and Aslam *et al.* (1998). The application of K increased the K/Na ratio significantly over control in both shoots and straw which was maximum in F_3 where K was applied by soil + foliar. Soil and foliar K application methods were non significant with each other. Similar results were reported by Javed and Muhammad (1992)and Aslam *et al.* (1998). The interactions between salinity levels and K application methods were non significant in shoots and straw of rice.

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