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Differential Gynotypic Salt Tolerance of Wheat in Simulated Saline Soils

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ABSTRACT

A green house experiment was conducted during *rabi* 1986 in a big galvanized pot (75 cm x 60 cm x 25 cm) to evaluate 16 varieties of wheat with four salinity levels (S_0-2.0, S_1-4.0, S_2-8.0 and S_3-12.0 ECe dS^{m-1}) in a medium black calcareous soil. The results showed that germination percentage, plant height, straw and grain yield as well as Na & K content and Na/K ratio were severely affected by salinity levels.

Among the varieties, the highest germination percentage, plant height and straw and grain yield were recorded with Kharchia, J-24 and Popatia, which were at par with each other but significantly superior to the rest cultivars. The highest mean salinity index (87.9) was noted with genotype Kharchia, followed by J-24 (86.6) and that of lowest (65.4) was recorded by GW-1 and GW-2. In addition to this a minimum Na content and Na/K ratio in straw were also observed in these varieties.

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INTRODUCTION

Fortunately agricultural crops show marked differences in their ability to grow under saline conditions and a great variability exists among varieties (Epstein, 1972, Maas and Haffman, 1977). Salinity brings physiological, biochemical and morphological changes in plants which reflect on the overall performance of the plant. The significant varietal differences in salt tolerance have been reported in wheat by Giriraj *et al.* (1980) and Kumar (1983). However, the high yielding varieties of wheat grown in Saurashtra region have not been evaluated for their salt tolerance.

In Saurashtra region of Gujarat, the main source for irrigation is well water (80%) and majority of these water are either saline or sodic or bath (Patel *et al.* 1982). However, the farmers of this region grow wheat with these poor quality well water to meet their food and fodder requirement. The present study was, therefore, undertaken to study the relative salt tolerance of different varieties of wheat grow in this region.

MATERIALS AND METHODS

A green house study in big galvanized iron pots (75 cm x 60 cm x 30 cm) containing 120 kg calcareous medium black clay soil

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(Vertisol) was conducted during *rabi* 1986 to evaluate the relative salt tolerance of sixteen wheat varieties (viz., V_1-J-405, V_2-Lok-1, V_3-J-24, V_4-Kalyan Sona, V_5-WH-147, V_6-GW-120, V_7-HD-2236, V_8-HI-1077, V_9-GW-89, V_{10}-Kharchia, V_{11}-Raj-1555, V_{12}-HD-4560, V_{13}-GW-1, V_{14}-GW-2, V_{15}-A-206 and V_{16}-Popatia (Local) using four levels of salinity (Viz., S_0-2.0, S_1-4.0, S_2-8.0 and S_3-12.0 ECe dSm^{-1}) in a completely randomized design with two replications. The soil was clay in texture having pH-8.0, EC-1.05 dSm^{-1}, $CaCo_3$-19.5%, organic carbon-0.75% Olson's available P 12.4 kg/ha and available K 323 kg/ha. The saline waters of 4.0, 8.0 & 12.0 EC dSm^{-1} were prepared by dissolving sulphates and chlorides of Na, Mg and Ca at 15:2:1 and of Cl : SO_4 at 2:1 ratio. The calculated amount of N & P as urea and diammonium phosphate was applied in furrow per pot as basal @ 60 kg N & 60 kg P_2O_5/ha and remaining N was supplied in two equal splits, each of 30 kg N/ha as urea at 20 and 40 days after sowing. Following this, 50 seeds of each variety were sown in line (22.5 cm spacing) in each pot and they were covered with the soil. Fourty two litres of solution of different salts concentration as per the treatments were applied uniformly in each pot in order to attain slightly higher moisture (35%) than that of field capacity. The soil was allowed to attain equalibrium for 48 hrs and then it was checked whether the desired salinity (ECe) in the soil was attained or not. The water content in the pots was maintained within 80-100% available water throughout the growth period by adding distilled water. However, salinity levels (2, 4, 8 & 12 EC dSm^{-1}) of the pots as per respective treatments were maintained constant through out the crop growth by irrigating them with respective saline waters, whenever required. The fourth day after sowing, the daily germination count was recorded periodically but the final counts were considered on eleventh day after sowing. Finally 10 seedlings for each variety were allowed to grow up to maturity. The mean plant height and grain and straw yield at harvest were recorded. The soil analysis was carried out by the standard methods as described by Richards (1954), whereas plant analysis for Na & K as per the method described by Jackson (1973).

RESULTS AND DISCUSSION

Effect on Germination

Salinity : The periodic germination counts showed (Fig.1) that the germination was almost 94 per cent after eleventh day of sowing with control (2.0 ECe dSm^{-1}) followed (88%) by

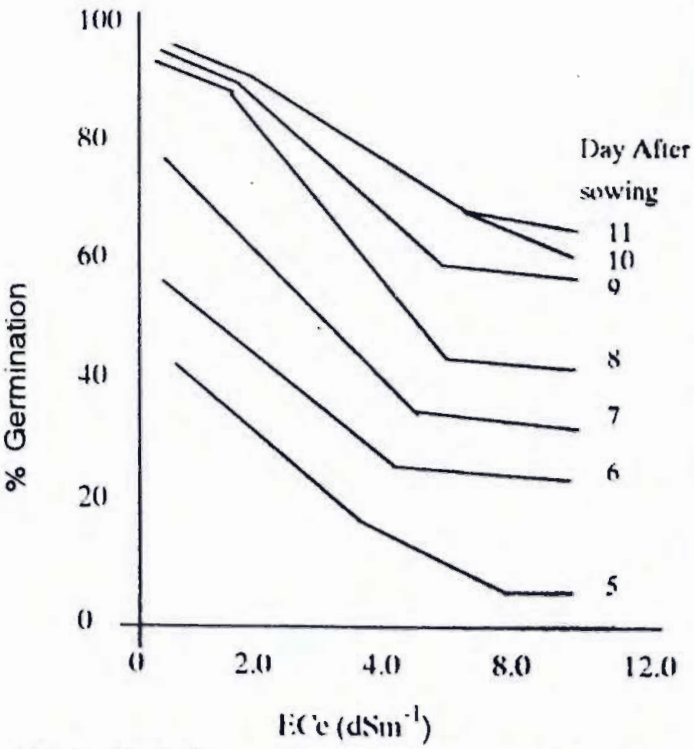


Fig.1 : Periodic germination of wheat as influence by salinity levels.

ECe level of 4.0 dSm^{-1}. The higher salt concentration levels at 8.0 dSm^{-1} and above showed the inhibitory effect and markedly decreased the total germination. Only 56 per cent of total germination was observed at ECe

12 dSm^{-1}. The final germination count was significantly affected by salinity levels and it was decreased with salinity level increased. The linear relationship between salinity level and germination could be expressed by the regression equation y = 101.2 - 3.93 x (r = 0.981). The results are in accordance to Kumar (1983) who reported that germination percentage of wheat varieties were decreased with an increased in salinity levels.

Variety : The result in table 1 showed that the highest mean germination percentage (80.5%) was recorded with variety Popatia, followed by Kharchia (79.0%), J 24 (78.5%), Lok 1 (78.3%), G.W.-2 (77.7) and A 207 (77.5%) in that order which were at par with each other.

Interaction : The interaction effect showed that the highest germination percentage (64%) was noted with variety J 24 followed by G.W.1 and Lok 1 (63.0%) and Kharchia and Popatia (62.0%) at highest salinity level (ECe 12 dSm^{-1}). Nevertheless, the results indicated that most of the varieties have less harmful effect on germination up to 8.0 ECe dSm^{-1} salinity level.

Effect on plant height

Salinity : As salinity level increased the mean plant height significantly from 52.6 to 32.1 cm (Table 1). The linear relationship between salinity levels and average plant height (Table 4) could be expressed by the regression equation y = 57.4 - 2.21 X (r-0.992). The results are in agreement with those reported by Kumar (1983).

Variety : The plant height was also affected significantly by the varieties (Table 1). The maximum mean plant height (52.4 cm) was recorded with variety G.W-2. While the minimum plant height was noted with variety W.H. 147 (34.7 cm), followed by H.D. 2236 (38.9 cm).

Interaction : The significant depression in plant height under the highest saline condition (ECe 12 dSm^{-1}) was minimum with variety Popatia (28.6%), followed by J 24 (29.0%), whereas the highest with G.W-2 (51.3) followed by H.D. 2236 (50.9%). The height of plant was more adversely affected in case of low salt tolerant varieties than those of high salt tolerant once. The depression effect of salinity on plant height might be due to the inhibition effect of presence of soluble salts (Bernstein and Hayward. 1958).

Effect on yields

Salinity : The straw and grain yield were severely affected by salinity (Table 2). The reduction in straw (7.2, 27.7 and 46.1%) and grain (9.4, 27.2 and 38.4%) yield were found at low (S_1), medium (S_2) and high (S_3) salinity level, respectively. The results are in accordance with Sharma *et al.* (1981), who observed that 50% reduction in yield of wheat at EC of 16 dSm^{-1} of water in black soil. Such decreases in the yield of wheat were reported by Kumar and Singh (1980) and Kumar *et al.* (1981). In present investigation, a considerable reduction in grain (b = 0.112, r = 0.997***) and straw (b = -0175, r = 0- 998***) of wheat were noticed when the soil salinity levels increased from 8 to 12 dSm^{-1}. Our results are in agreement with Balakrishnarao *et al.* (1981) Magar *et al.* (1982) and Kadum *et al.* (1983). The reduction of yield might be due to lower photosynthesis and hence, disturbed carbohydrates and nitrogen metabolism in salt stress condition leading to poor yield (Strognov. 1964).

TABLE 1

Effect of salinity levels on germination percentage and plant height of different varieties of wheat.

Varieties	Salinity level (dSm^{-1})					Salinity level (dSm^{-1})					
	Control	4.0	8.0	12.0	Mean	Control	4.0	8.0	12.0	Mean height	Per cent height decline at 12 EC level
	Germination percentage					Plant height (cm)					
J - 405	92.0	80.0	70.0	60.0	75.5	51.6	50.0	35.4	30.5	41.8	41.0
Lok - 1	94.0	87.0	69.0	63.0	78.3	49.6	45.6	36.4	32.3	40.9	35.0
J - 24	94.0	87.0	69.0	64.0	78.5	50.0	49.5	38.8	35.5	43.5	29.0
K.Sona	93.0	89.0	65.0	60.0	76.8	51.8	50.0	37.4	32.9	43.0	36.5
W.H.147	93.0	86.0	58.0	45.0	70.5	44.8	40.0	29.0	25.0	34.7	44.2
G.W.120	96.0	95.0	59.0	54.0	76.0	56.0	49.0	39.0	31.2	43.5	44.3
H.D.2236	92.0	92.0	65.0	54.0	75.7	49.5	45.7	36.3	24.3	38.9	50.9
H.I.1077	96.0	87.0	62.0	46.0	72.7	52.5	51.2	38.0	29.6	42.8	43.6
G.W.89	93.0	87.0	58.0	53.0	72.7	53.8	50.8	39.0	30.8	43.6	42.8
Kharchia	96.0	89.0	69.0	62.0	79.0	50.5	48.8	40.1	34.2	43.4	32.3
Raj-1555	86.0	82.0	71.0	54.0	73.2	53.5	52.2	39.0	30.6	43.8	42.7
H.D.4560	90.0	90.0	60.0	46.0	71.5	52.8	52.0	40.0	30.2	43.8	42.8
G.W.1	91.0	86.0	63.0	63.0	75.8	55.0	51.1	38.6	29.0	43 4	47.2
G.W.2	95.0	92.0	64.0	60.0	77.7	63.6	62.2	52.0	31.8	52.4	51.3
A - 206	96.0	90.0	64.0	60.0	77.5	52.1	51.2	36.1	35.5	43.7	31.8
Popatia	96.0	94.0	70.0	62.0	80.5	53.8	45.3	41.2	38.4	44.7	28.6
Mean	93.3	88.3	64.8	56.6		52.6	49.7	38.5	32.1		
CD (0.05)	S=1.6	V=3.0	S x V = 6.2			S=0.8	V=1.6	S x V = 3.1			

TABLE 2

Effect of salinity levels on grain and straw yield of different varieties of wheat.

Varieties	Salinity level (dSm^{-1})					Salinity level (dSm^{-1})				
	Control	4.0	8.0	12.0	Mean	Control	4.0	8.0	12.0	Mean
	Grain yield g plant $^{-1}$					Straw yield g plant $^{-1}$				
J-405	3.25	2.90	2.40	2.00	2.64	3.80	3.60	2.65	2.00	3.01
Lok-1	3.05	2.85	2.55	1.95	2.60	3.95	3.75	2.85	2.15	3.18
J-24	3.10	2.95	2.70	2.40	2.78	3.80	3.75	3.15	2.50	3.30
K. Sona	3.05	2.90	2.65	2.15	2.70	3.65	3.50	2.75	2.10	3.00
W.H.147	3.00	2.65	2.05	1.55	2.31	3.40	3.10	2.40	1.60	2.63
G.W.120	3.09	2.85	2.50	1.85	2.56	3.75	3.55	2.90	1.80	3.00
H.D.2236	3.10	2.80	2.45	1.75	2.53	3.45	3.05	2.55	1.65	2.68
H.I.1077	3.15	2.55	2.00	1.65	2.34	3.75	3.45	2.35	1.85	2.85
G.W.89	2.80	2.40	2.05	1.30	2.14	3.65	3.25	2.55	1.65	2.78
Kharchia	3.10	3.00	2.70	2.48	2.81	3.55	3.45	3.15	2.63	3.20
Raj-1555	3.13	2.85	2.15	1.70	2.46	3.95	3.65	2.35	1.90	2.96
H.D.4560	3.05	2.85	2.35	1.80	2.51	4.18	3.80	2.95	2.00	3.23
G.W. 1	2.55	2.05	1.75	1.20	1.89	3.55	3.15	2.20	1.70	2.65
G.W. 2	2.55	2.10	1.65	1.25	1.89	3.75	3.55	2.45	1.95	2.93
A-206	2.65	2.55	2.45	1.75	2.35	3.40	3.05	2.75	1.90	2.78
Popatia	3.05	2.85	2.55	2.33	2.70	4.40	4.05	3.55	3.00	3.75
Mean	2.97	2.69	2.31	1.83		3.75	3.48	2.71	2.02	
		(9.4)	(22.2)	(38.4)			(7.2)	(27.7)	(46.1)	
C D (0.05)	S = 0.08	V = 0.16		S x V = 0.31		S = 0.070	V = 0.14		S x V = 0.28	

Note : Figures in perantheses are showed the percentage over control.

Variety : Irrespective of salinity levels, the highest mean grain yield were recorded with Kharchia (2.31 g plant^{-1}), followed by J 24 (2.78 g plant^{-1}), Kalyansona and Popatia (2.70 g plant^{-1}) which were at par with each other but they were significantly superior to the rest cultivars. The local variety Popatia, significantly out yielded the rest in case of straw yield (3.75 g plant^{-1}). The next varieties in decreasing order were J 24 (3.30). Raj 1555 (3.23) and G.W. 89 (3.20 g plant^{-1}) which were at par but significantly superior to the rest of the cultivars (Table 2).

The mean grain yield for salinity levels followed the similar trend recording the highest mean salinity index (89.9) with variety Kharchia followed by J 24 (86.6) and Popatia and Kalyansona (84.4). The results (Table 3) further revealed that for 50% yield decline was expected with the highest EC (26.2 dSm^{-1}) for Kharchia, of 24.4 dSm^{-1} for J 24 and that of 22.7 dSm^{-1} for Popatia. Whereas that of the lowest value 11.4 dSm^{-1} for GW 1 and GW 2 indicating comparatively less salt tolerance. The rest of cultivars were expect the 50 per cent yield decline even below 20 dSm^{-1} salinity. Considering the reduction in grain yield at the highest salinity level (EC 12 dSm^{-1}), the minimum reduction (20.3%) was noted with Kharchia, followed by J 24 (22.5%) and Popatia (23.9%) .on the other hand, cultivar GW 89 recorded the highest reduction (53.6%). The lowest negative regression co-efficient (b) -0.064 with variety Kharchia indicate the less sensitive to decline the yield with increasing the salinity. The high yielding variety J 24 has also the almost the same regression co-efficient (b) -0.069 indicating equivalent to Kharchia in salt tolerance. The following varieties were Popatia (b = -0.071), A 206 (b = -0.084) and Kalyansona (b = -0.088) also possed lower regression co-efficient. Contrary to this, variety Raj 1555 recorded the highest regression slope (b = -0.146) indicating more sensitive to salinity. On same line, Giriraj *et al.* (1980) reported that the varieties Kharchia and A 206 showed higher tolerance to salinity.

Interaction : The data given in table 2 showed that though the variety J 405 noted highest grain yield (3.25 g plant^{-1}) at normal condition but at highest salinity level (12 EC dSm^{-1}) variety Kharchia has recorded the highest grain yield (2.48) follwed by J 24 (2.40) and Popatia (2.33 g plant^{-1}) which were at par with each other but were significantly superior to J 405. Whereas, significantly lower grain yield was recorded with variety G.W-1 and G.W-2 and G.W. 89 at almost all salinity levels. In case of straw yield, variety Popatia out yielded at almost all sanility levels. However, variety Kharchia and J 24 also recorded the significantly higher straw yield (2.63 and 2.50 g plant^{-1}, respectively) over the rest of the cultivars. Thus it can be concluded that at medium salinity level (8.0 EC dSm^{-1}) the different wheat varieties follow the order Kharchia J 24 > Kalyansona > Popatia = A 206, while at higher salinity level (12.0 EC dSm^{-1}) that was Kharchia = J 24 > Popatia > Kalyansona.

Sodium, potassium content and its ratio

Effect of salinity : Salinity had significant effect on Na, K content and Na/K ratio in straw (Table 4). As soil salinity levels increased Na content and Na/K ratio in straw gradually increased from 35.2 to 84.5 (me%) and 1.47 to 5.86, respectively. The reverse was true in case of K content (23.9 to 14.8 me%).

TABLE 3

Relative salt tolerance of wheat varieties based on grain (yield).

Varieties	*Mean** grain yield (g)*	*Reduction at ECe 12 dSm^{-1} over control (%)*	*Mean** salinity index (%)*	*Salinity level for 50 % yield decline (dSm^{-1})*	*Regression of yield on salinity*
J-405	2.43	38.5	74.9	14.7	Y = 3.43 -0.123 X (r = -0.983)
Lok-1	2.45	36.1	80.3	16.5	Y = 3.29 -0.107 X (r = -0.966)
J-24	2.68	22.5	86.6	24.4	Y = 3.23 -0.069 X (r = -0.946)
K.Sona	2.58	28.5	84.4	19.6	Y = 3.25 -0.088 X (r = -0.949)
W.H.147	2.08	48.3	69.4	12.2	Y = 3.25 -0.144 X (r = -0.994)
G.W.120	2.40	39.3	78.7	15.4	Y = 3.32 -0.117 X (r = -0.990)
H.D.2236	2.33	43.5	75.3	14.0	Y = 3.36 -0.129 X (r = -0.982)
H.I.1077	2.06	47.6	65.6	11.9	Y = 3.27 -0.143 X (r = -0.919)
G.W.89	1.91	53.6	68.5	11.7	Y = 3.06 -0.142 X (r = -0.971)
Kharchia	2.72	20.3	87.9	26.2	Y = 3.23 -0.064 X (r = -0.976)
Raj-1555	2.23	45.7	71.3	12.6	Y = 3.40 -0.146 X (r = -0.972)
H.D.4530	2.33	41.0	76.6	14.3	Y = 3.33 -0.126 X (r = -0.964)
G.W.1	1.66	52.9	65.4	11.4	Y = 2.70 -0.125 X (r = -0.959)
G.W.2	1.66	50.9	65.4	11.4	Y = 2.70 -0.125 X (r = -0.948)
A-206	2.25	33.9	84.0	18.8	Y = 2.90 -0.084 X (r = -0.862)
Popatia	2.58	23.9	84.4	22.7	Y = 3.16 -0.071 X (r = -0.948)

* Grain yield across salinity levels

** Mean salinity index = $\frac{\text{Mean of 4, 8 and 12 EC}}{\text{Control yield}} \times 100$

TABLE 4

Effect of salinity levels and varieties on sodium, potassium content and Na/K ratio in wheat straw.

Varieties	*Salinity levels (dSm^{-1})*					*Salinity levels (dSm^{-1})*					*Salinity levels (dSm^{-1})*				
	Control	*4.0*	*8.0*	*12.0*	*Mean*	*Control*	*4.0*	*8.0*	*12.0*	*Mean*	*Control*	*4.0*	*8.0*	*12.0*	*Mean*
	Na me (%)					*K me (%)*					*Na/K ratio*				
J-405	33.5	40.7	60.4	86.1	55.2	22.4	21.3	17.5	14.2	18.8	1.50	1.91	3.45	6.06	3.23
Lok-1	32.0	37.5	56.2	84.0	52.4	22.2	21.3	17.7	14.8	19.0	1.45	1.77	3.16	5.68	3.02
J-24	33.0	35.8	50.1	61.5	45.1	23.9	22.0	19.7	17.5	20.9	1.38	1.63	2.39	3.51	2.23
K.Sona	32.3	37.7	54.3	66.5	47.8	22.5	20.5	17.7	15.2	19.0	1.44	1.84	3.06	4.36	2.68
W.H.147	34.3	43.0	70.8	91.2	59.8	22.5	21.7	18.0	13.5	18.9	1.53	1.98	3.92	6.76	3.55
G.W.120	32.5	38.7	68.6	87.0	57.2	23.5	21.3	18.2	13.7	19.2	1.39	1.82	3.76	6.48	3.37
H.D.2236	37.0	46.5	74.0	91.2	62.4	25.5	24.0	19.5	14.7	20.9	1.45	1.94	3.79	6.20	3.34
H.I.1077	36.0	41.3	67.7	91.0	59.0	25.2	24.0	18.7	14.5	20.6	1.43	1.72	3.61	6.27	3.26
G.W.89	36.2	43.5	70.8	85.5	59.0	23.1	20.0	18.5	12.7	18.6	1.56	2.17	3.84	6.72	3.58
Kharchia	33.5	38.0	49.0	57.0	44.4	23.9	22.5	20.7	18.5	21.4	1.39	1.69	2.36	3.08	2.13
Raj.1555	36.8	46.0	74.0	99.0	63.9	25.9	23.2	19.1	13.6	20.4	1.42	1.99	3.87	7.25	3.63
H.D.4530	36.7	46.0	75.0	101.0	64.7	25.3	22.0	16.7	13.6	19.4	1.45	2.10	4.58	7.40	3.86
G.W.1	37.5	47.2	67.7	99.0	62.9	25.1	22.0	18.0	13.0	19.7	1.49	2.15	3.78	7.34	3.69
G.W.2	36.0	45.7	68.0	100.0	62.4	25.6	24.0	17.5	14.5	20.4	1.39	1.91	3.88	6.90	3.52
A-206	38.0	43.0	62.3	79.0	55.5	22.5	21.7	18.5	16.0	19.7	1.68	1.98	3.37	4.95	2.99
Popatia	38.5	45.0	62.4	78.0	55.9	24.3	23.7	19.7	16.0	20.9	1.59	1.98	3.24	4.87	2.90
Mean	35.2	37.8	64.5	84.5		23.9	22.2	18.5	14.8		1.47	1.91	3.50	5.86	
C D (0.05)	S = 0.22	V = 0.43		S x V = 0.61		S = 0.25	V = 0.52		S x V = 0.72		S = 0.10	V = 0.21		S x V = 0.42	

Effect of variety : The varietal differences in sodium and potassium absorption were significant in straw. The highest Na content in straw was recorded with variety H.D. 4560 (64.7 me%) followed by Raj. 1555 (63.9), G.W-1 (62.9) and G.W-2 and H.D. 2236 (62.4 me %). Variety G.W 1, G.W 2 and H.D. 2236 were at par with each other. Contrary to this, Kharchia has noted the lowest Na content (44.4 me%) followed by J 24 (45.1 me %). On the other hand, significantly highest K content in straw was noted by variety Kharchia (21.4 me 100 g^{-1}) followed by J 24, Popatia and H.D. 2236 (20.9) and H.I. 1077 (20.6 me%). These varieties were at par with each other. This results are inconformity with Gill and Dutt (1987). Absorption of Na was minimum in Kharchia, J 24, Kalyansona, Popatia and A 206 varieties with comparision to all salinity levels, which showed less reduction in yield as well as higher tolerance limit as compared to Raj. 1555, H.D. 2236 and H.D.4560. Reverse was true in case of K content.

Sodium, potassium content in straw and Na/K ratio has been found to be suitable parameter to adjust relative salt tolerance. Variety Kharchia (2.13), J 24 (2.33), Kalyansona (2.68) and Popatia (2.90) have been found low Na/K ratio as compared to other cultivars in all salinity levels. Variety Kharchia, J 24, Popatia and Kalyansona gave higher yield with low Na/K ratio, while Raj. 1555, H.D. 2236 and H.D. 4560 were sensitive giving lower yield with higher Na/K ratio. The present finding confirmed the earlier work of Rana *et al.* (1976).

Besides variety Kharchia, variety J 24 could be considered tolerant among the 16 cultivars under test, as this variety has least yield decline under increasing salinity level.

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