

## EFFECT OF SALINE WATER IRRIGATION ON TOLERANT AND SENSITIVE WHEAT VARIETIES UNDER DISPARATE SOIL FERTILITY CONDITIONS

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### ABSTRACT

Improved soil fertility (80 kg ha<sup>-1</sup> each of N and P<sub>2</sub>O<sub>5</sub>) significantly increased the growth and yield of both salt tolerant (Kharchia-65) and sensitive (HD-2009 and HD-4502) wheat varieties under saline water (10 dSm<sup>-1</sup>) irrigation. This improvement of plant performance was associated with increased concentrations and absolute quantities of nitrogen, phosphorus and potassium, decreased concentrations of sodium and chloride in the shoot tissue and reduced Na : K ratios. Nutritional improvement under both normal and saline conditions led to higher concentrations of chlorophyll and soluble protein and increased activity of nitrate reductase in the leaf tissue. However, the adverse effects on growth, yield, nutrient uptake and metabolism, induced by salt stress, were markedly higher in sensitive varieties, HD-4502 and HD-2009 as compared to the tolerant variety, Kharchia-65.

### INTRODUCTION

In semi-arid regions of Rajasthan, the growth of winter wheat is often restricted as the ground waters used for irrigation in many parts are moderate to highly saline (Dhir 1977). Rainy season fallow however, prevents a progressive build up of salinity in light to medium textured soils (Gupta and Abic handani 1970; Dhir 1977). Under this as well as other situations of salinity, fertilizer induced alleviation of growth and yield have been reported for wheat (Luken 1962; Dhir et al. 1975; Garg et al. 1982) and also for certain other crops (Ravikovitch and Porath 1967; Ravikovitch and Yoles 1971; Bernstein et al. 1974). In this regard more attention has been paid to nitrogen and phosphorus (Champagnol 1979; Kafkafi 1984; Feigin 1985) with some emphasis on potassium (Heimann 1958). This phenomenon seems to be crop specific and is believed (Bernstein et al. 1974) to be mediated through elimination of nutritional deficiencies. In wheat cv. Kalyansona fertilizer induced performance improvement under salt stress has been attributed to increased uptake of nitrogen, phosphorus and potassium and reduced chloride levels in the tissue coupled with the induction of better metabolic efficiency (Garg et al. 1982) However, the relative magnitude and complexion of salinity fertility interaction in salt tolerant and sensitive varieties of wheat do not seem to have been fully explored. Therefore, an attempt has been made here to obtain some information on this subject.

## MATERIAL AND METHODS

One salt tolerant (cv. Kharchia-65) and two sensitive (cv. HD-2009 and HD-4502) wheat varieties (Joshi 1976) were grown under high (HF-80 kg ha<sup>-1</sup> of N and P<sub>2</sub>O<sub>5</sub>) and low (LF-no fertilizer application) soil fertility conditions in glazed pots with closed bottom (3 plants per pot) filled with 30 kg loamy sand soil. The soil contained 7.1, 5.9, 63.1 and 24.1 per cent of clay, silt, fine and coarse sand respectively, 0.15 per cent organic carbon, 15 kg ha<sup>-1</sup> available P<sub>2</sub>O<sub>5</sub> and 220 kg ha<sup>-1</sup> available K<sub>2</sub>O. The pH of the soil was 8.1 and E<sub>Ce</sub> 0.088 dSm<sup>-1</sup>. From 15 DAS till maturity, one set of plants under each variety and fertility conditions, was irrigated at weekly intervals with saline waters of 10 dSm<sup>-1</sup> concentration of a composition representing saline ground water of this region (50% NaCl, 15% Na<sub>2</sub>SO<sub>4</sub>, 10% each of NaHCO<sub>3</sub>, CaCl<sub>2</sub> and MgCl<sub>2</sub> and 5% MgSO<sub>4</sub>) while the other set of plants (control) was irrigated with tap water (0.2 dSm<sup>-1</sup>) throughout the growing period. The changes in soil salinity levels were ascertained from measurements of electrical conductivity of 1:2 soil-water extracts at 35, 60, 85 and 110 (harvest) DAS.

Periodic observations on plant height, root growth and leaf area (Licor LI-3000 Leaf area meter) were recorded alongwith data on final above ground dry matter production and grain yield. Data in all cases were based on means of six replicates (pots) and significance was adjudged through analysis of variance. Nitrogen, phosphorus, potassium, sodium and chloride were analyzed in triplicate from representative samples of dry shoot tissue at 35, 55 and 75 DAS adopting analytical procedures described earlier (Garg et al. 1982). Fresh leaf tissue (two upper most fully expanded leaves) was analysed (Lahiri et al. 1987) at 60 DAS in triplicate, for ascertaining the levels of certain metabolites (free proline, soluble protein, total chlorophyll) and activity of nitrate reductase.

## RESULTS AND DISCUSSION

Observations on soil EC indicated that repeated irrigations with saline water led to a progressive build up of salinity with the advancement of age of all the three varieties. In the initial stages the salinity build up was relatively more under HF-condition (0.82 to 1.34 dSm<sup>-1</sup> at 60 DAS) as compared to LF-condition (0.79 to 0.84 dSm<sup>-1</sup>) but at later growth stages the EC values were more or less comparable under the two fertility conditions. At harvest these were 1.61, 1.40 and 1.58 dSm<sup>-1</sup> for varieties KH-65, HD-2009 and HD-4502 respectively under HF-condition and 1.59, 1.33 and 1.63 dSm<sup>-1</sup> respectively under LF-condition with saline water irrigation. The values ranged between 0.37 to 0.65 dSm<sup>-1</sup> in the controls of both the fertility conditions. The build up of salinity as found here has also been noticed under saline water irrigation of wheat in field condition (Gupta and Abichandani 1968; Dhir 1977).

The saline water induced salt stress reduced dry matter and grain yields in all the varieties under both the soil fertility conditions (Table 1). But tolerant variety Kharchia-65 (KH-65) was affected less adversely as compared to the other two sensitive varieties. However, HF condition significantly alleviated the adverse effects of salt stress in both tolerant and sensitive varieties. Irrespective of the variety the fertilizer induced improvement was obvious from the fact that dry matter and grain yields of salt stressed plants under HF condition were always higher than those of unstressed (control) plants under LF condition. It is interesting to note again that the per cent reductions in dry matter and grain yields due to salt stress were always less under the HF as compared to LF conditions in all the varieties, more so in the tolerant variety KH-65.

The mechanisms of nutritional improvement of plant growth and yield under salt stress have now been fairly explored. Improved soil fertility has been found to increase the concentration of nitrogen, phosphorus and potassium and to decrease the level of chloride in the plant tissue (Garg et al. 1982). Nutritional improvement also has been found to increase the chlorophyll concentration and the activities of enzymes like nitrate reductase, ATPase and alkaline pyrophosphatase in the leaves of wheat under saline water irrigation (Garg et al. 1982). A significant salinity-fertility interaction in mustard particularly with respect to enzymes of nitrogen metabolism such as, NR, GS, GOGAT and GDH has also been reported from this laboratory (Sharma et al. 1989). Furthermore enhanced leaf area and larger root growth under improved soil fertility has been reported to contribute to higher yield in cotton and corn despite salt stress (Khalil et al. 1967).

In the present investigation advantages of soil fertility improvement were obvious from the fact that plant height, leaf area and dry weight of roots at successive growth stages remained consistently higher in HF as compared to LF condition despite salt stress in all the three varieties (Fig. 1). However, tolerant variety KH-65 experienced relatively less growth inhibition while the variety HD-4502 suffered the maximum reductions in plant growth under salt stress.

Although there are some studies which report the absence of significant salinity-fertility interaction (Bernstein et al. 1974; Feigin 1985), a number of investigations (Luken 1962; Ravikovitch and Yoles 1971; Kafkafi 1984) show a real increase in salinity tolerance under improved fertility conditions. The data on various parameters of plant performance obtained in this study also revealed a significant favourable effect of improved soil fertility on both salt tolerant and sensitive wheat varieties.

The trends of concentration of N, P, K, Na and Cl in the shoot tissue were similar at 35, 55 and 75 DAS. From the data of 55 DAS (others avoided for the purpose of brevity) it may be found that concentrations of N, P and K were consistently more in HF as compared to LF plants, under both normal and saline conditions

Table 1. Influence of soil fertility on the above ground dry matter production and grain yield of wheat varieties grown under normal and saline water irrigation

Variety	Salinity level (dSm <sup>-1</sup> )	Dry weight shoot (g plant <sup>-1</sup> )			Grain yield (g plant <sup>-1</sup> )		
		HF	LF	Mean	HF	LF	Mean
KH-65	0.2	14.48	7.28	10.88	6.67	3.53	5.10
	10	10.98	4.03	7.49	4.92	1.60	3.26
HD-2009	0.2	12.18	6.39	9.26	5.16	2.71	3.93
	10	8.47	2.08	5.28	3.62	0.95	2.28
HD-4502	0.2	12.97	5.44	9.20	5.44	1.63	3.53
	10	8.11	2.03	5.07	2.87	0.56	1.71
Mean	—	11.18	4.54	—	4.86	1.80	—
LSD		0.05		0.01	0.05		0.01
Variety (V)		0.76		1.08	0.45		0.64
Salinity (S)		1.55		2.13	0.75		1.04
Fertility (F)		0.52		0.70	0.33		0.45
F x S		0.73		0.99	0.47		0.64
V x S		NS		NS	NS		NS
F x V		NS		NS	NS		NS
F x V x S		NS		NS	NS		NS

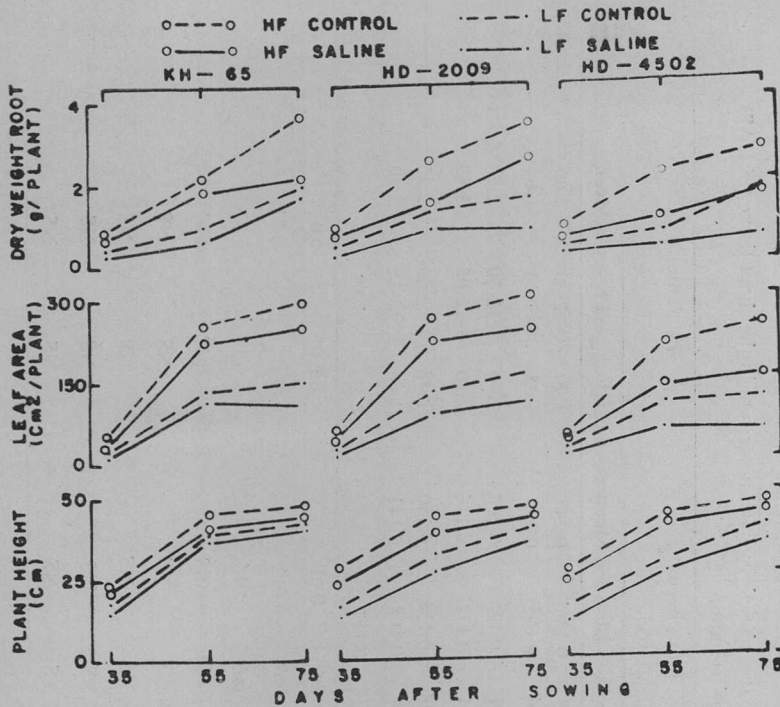


Fig. 1 Influence of soil fertility on plant height, leaf area and dry weight of root of three wheat varieties grown under normal and saline water irrigation.

(Table 2). HF condition reduced the Na and Cl concentrations in the shoot tissue of vars. KH-65 and HD-4502 under salt stress. But the effects on var. HD-2009 were not very obvious (Table 3). Our earlier investigation (Garg et al. 1982) also indicated that Cl concentration in shoot and grains of wheat (cv. Kalyansona) was reduced under high as compared to low fertility condition. A similar observation was made by Feigin (1985) in melon shoot. But it seems that fertility induced adjustments in chloride level in the shoot tissue may be dependent on varietal trait. Furthermore the Na : K ratios (Table 4) generally remained relatively higher in the sensitive var. HD-4502 as compared to the other two varieties. It is often suggested (Joshi et al. 1980) that wheat genotypes tolerant to salinity and sodicity were characterized by lower Na : K values in contrast to the sensitive ones. However, in the present study it is interesting to observe that Na : K ratio under saline condition remained markedly less in HF as compared to LF plants in all the three varieties at all stages of growth (Table 4). This is a pointer towards a positive salinity-fertility interaction in tolerant as well sensitive wheat varieties.

Fig. 2 indicates that the absolute quantities of nitrogen, phosphorus and potassium per plant (i.e. NPK uptake) increased with the advance of growth and their levels were markedly more in HF as compared to LF plants under both normal and saline conditions. It is noteworthy that their levels were always higher in salt

Table 2. Influence of soil fertility on the concentrations of nitrogen, phosphorus and potassium in the shoot tissue (55 DAS) of wheat varieties grown under normal and saline water irrigation

Variety	Salinity level (dSm <sup>-1</sup> )	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
		HF	LF	Mean	HF	LF	Mean	HF	LF	Mean
KH-65	0.2	3.21	2.82	3.01	0.358	0.136	0.247	2.90	2.30	2.60
	10	3.00	2.78	2.89	0.326	0.095	0.210	2.05	1.23	1.64
HD-2009	0.2	3.14	2.34	2.74	0.289	0.125	0.207	2.70	2.30	2.50
	10	2.92	2.40	2.66	0.241	0.112	0.176	2.10	1.08	1.59
HD-4502	0.2	3.20	2.47	2.93	0.176	0.124	0.150	2.48	2.03	2.25
	10	2.75	2.63	2.69	0.174	0.108	0.141	1.65	1.16	1.40
Mean	—	3.04	2.61	—	0.260	0.117	—	2.31	1.68	—
LSD		0.05	0.01		0.05	0.01		0.05	0.01	
Variety (V)		0.16	NS		0.007	0.012		0.13	0.21	
Salinity (S)		0.14	NS		0.009	0.014		0.15	0.22	
Fertility (F)		0.14	0.22		0.013	0.019		0.12	0.17	
F x V		0.11	0.15		0.026	NS		NS	NS	
F x S		0.13	0.18		NS	NS		NS	NS	
V x S		NS	NS		NS	NS		NS	NS	
F x V x S		NS	NS		NS	NS		NS	NS	

stressed plants under HF condition as compared to control plants under LF condition. Similar observations have also been made by Sharma and Lal (1975) and Garg et al. (1982). It is again interesting to find that the uptake of N, P and K were more in var. KH-65 followed by var. HD-2009 and HD-4502. Furthermore the Na and Cl levels, particularly at 75 DAS were maximum in sensitive var. HD-4502 followed by var. HD-2009 and KH-65. However, a higher uptake of Na and Cl by HF-Plants under salt stress generally occurred as a result of higher dry matter production.

Table 5 indicates that the levels of chlorophyll and soluble protein declined under salt stress but HF condition increased their levels in all the varieties under stress. The level of proline increased due to stress under both

Table 3. Influence of soil fertility on the concentrations of sodium and chloride in the shoot tissue (55 DAS) of wheat varieties grown under normal and saline water irrigation

Variety	Salinity level (dSm <sup>-1</sup> )	Sodium (%)			Chloride (%)		
		HF	LF	Mean	HF	LF	Mean
KH-65	0.2	0.20	0.23	0.21	0.31	0.33	0.32
	10	1.00	1.45	1.22	1.25	1.74	1.50
HD-2009	0.2	0.28	0.21	0.25	0.37	0.29	0.33
	10	1.05	1.00	1.02	1.08	0.98	1.03
HD-4502	0.2	0.93	0.93	0.93	1.02	1.00	1.01
	10	2.05	2.50	2.27	2.05	2.55	2.30
Mean		0.92	1.05	—	1.01	1.15	—
LSD		0.05		0.01	0.05		0.01
Variety (V)		0.13		0.21	0.16		0.27
Salinity (S)		0.10		0.16	0.09		0.14
Fertility (F)		NS		NS	0.13		NS
F x S, F x V, V x S		NS		NS	NS		NS
F x V x S		NS		NS	NS		NS

Table 4. Influence of soil fertility on the sodium potassium ratio (Na:K) in the shoot tissue of wheat varieties grown under normal and saline water irrigation

Variety	Salinity level (dSm <sup>-1</sup> )	Na : K ratio at indicated DAS					
		35		55		75	
		HF	LF	HF	LF	HF	LF
KH-65	0.2	0.08	0.08	0.07	0.10	0.09	0.10
	10	0.83	0.91	0.49	1.17	0.48	1.17
HD-2009	0.2	0.10	0.14	0.10	0.09	0.15	0.10
	10	0.45	0.59	0.50	0.93	0.69	0.87
HD-4502	0.2	0.33	0.47	0.38	0.46	0.41	0.49
	10	1.59	2.31	1.24	2.16	2.25	2.50

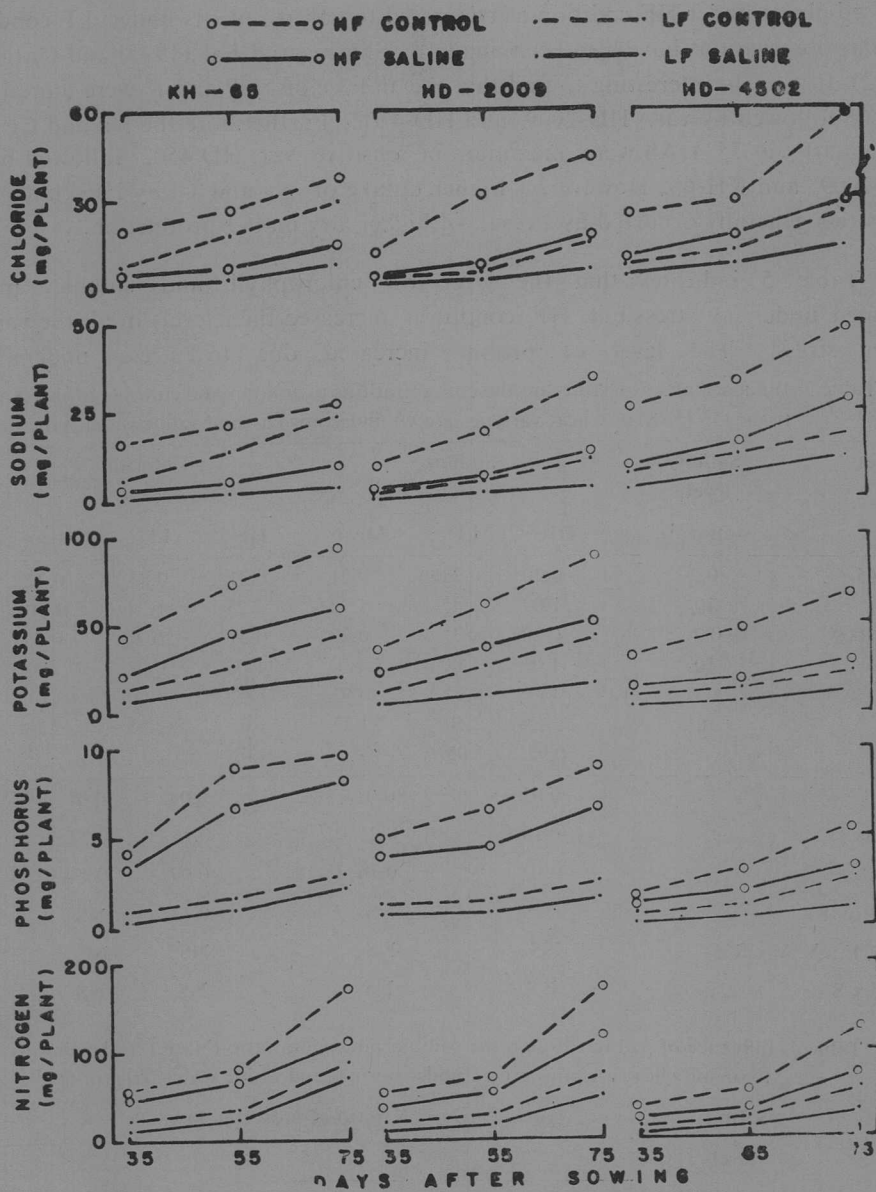


Fig. 2. Influence of soil fertility on nitrogen, phosphorus, potassium, sodium and chloride (mg per plant) in the shoot tissue of wheat varieties grown under normal and saline water irrigation.

Table 5. Influence of soil fertility on the levels of certain leaf metabolites and activity of nitrate reductase (60 DAS) of wheat varieties grown under normal and saline water irrigation

Variety	Salinity level (dSm <sup>-1</sup> )	Total chlorophyll (mg g <sup>-1</sup> dw)			Soluble protein (mg g <sup>-1</sup> dw)			Free proline (mg g <sup>-1</sup> dw)			Nitrate reductase ( $\mu\text{g NO}_2 \text{ g}^{-1} \text{ dwh}^{-1}$ )		
		HF	LF	Mean	HF	LF	Mean	HF	LF	Mean	HF	LF	Mean
		KH-65	0.2	4.51	4.29	4.40	296.3	200.0	248.0	0.62	0.33	0.47	209.5
	10	3.92	3.41	3.66	277.0	142.0	209.5	0.84	0.42	0.63	156.3	115.3	135.8
HD-2009	0.2	4.21	4.10	4.15	191.5	163.7	177.6	0.77	0.53	0.65	254.1	208.5	231.3
	10	3.46	3.15	3.30	165.3	90.7	128.0	1.23	0.69	0.96	159.9	90.9	125.4
HD-4502	0.2	4.17	3.93	4.05	156.3	122.8	139.5	0.76	0.32	0.54	231.0	164.8	197.9
	10	3.45	3.04	3.24	131.8	66.4	99.1	1.62	0.60	1.11	110.1	61.6	85.9
Mean	—	3.95	3.65	—	203.0	130.9	—	0.97	0.48	—	186.8	135.2	—
LSD		0.05	0.01	0.05	0.05	0.01		0.05		0.01	0.05		0.01
Variety (V)		0.10	0.17	10.5	17.4			0.18		NS	15.9		26.4
Salinity (S)		0.12	0.19	19.9	30.2			0.06		0.10	12.0		18.2
Fertility (F)		0.10	0.14	9.8	13.7			0.06		0.08	13.2		18.6
V x S		NS	NS	NS	NS			0.12		0.18	20.8		31.5
F x V		NS	NS	16.9	23.8			0.08		0.12	NS		NS
F x S		0.17	NS	13.8	19.4			0.10		0.14	NS		NS
F x V x S		NS	NS	NS	NS			NS		NS	NS		NS

HF and LF conditions. The nitrate reductase activity declined with salt stress in all cases but remained markedly higher under HF-condition. The aforesaid trends suggest that HF condition imparted a relatively better metabolic efficiency to plants under salt stress as compared to LF condition. Again, it was found that the magnitude of metabolic derangements under salt stress were less in var. KH-65 as compared to HD-4502 and HD-2009.

Evidences presented here indicate that improvement of soil fertility condition could favourably influence the concentrations and absolute quantities of NPK, reduce the concentrations of Na and Cl in the tissue, lower the Na:K ratio and improve the metabolism despite salt stress. All this led to higher dry matter production and grain yield. Although nutrient mediated alleviation of adverse effect of salt stress was found in all the three varieties of wheat studied here, the favourable effects were less in the tolerant variety as compared to the sensitive ones.

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