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Effect of kinetin on water relations, photosynthesis, respiration and chlorophyll and nucleic acid contents of wheat (*Triticum aestivum* L.) grown under salinity

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Abstract

The effect of kinetin (10 g m^{-3}) presowing seed soaking treatment on water relations, chlorophyll (Chl) and nucleic acid contents, and photosynthetic and respiration rates in wheat (*Triticum aestivum* L.) grown in a greenhouse under three salinity levels (*i.e.* 0, 6 and 9 dS m^{-1} ECe) was studied. Relative water content and osmotic potential showed a progressive decline with increase in the salinity but there was an increase in chlorophyll (*a*+*b*) content in the leaves. Salinity decreased RNA content and net photosynthetic and respiration rates. Seed soaking either in water or kinetin enhanced the relative water content of leaves but reduced osmotic potential under both saline and non-saline conditions.

Introduction

Biosynthetic mechanisms of plants are disturbed under soil salinity, which may lead to general suppression of growth and reduction in yield under saline conditions (Levitt 1982). The endogenous balance of plant hormones, one of the most important internal factors during almost all the phases of plant development (Letham *et al.* 1978) is also disturbed. A wide variety of synthetic plant hormones have been tried in order to alleviate salt-stress induced physiological effects and maximise crop production. The present investigations studied the effects of kinetin on the water relations, photosynthetic and respiration rates, and chlorophyll and nucleic acid contents of wheat grown under different salinity.

Materials and methods

Wheat (*Triticum aestivum* L. cv. WH-147) plants were grown in earthen pots (30 cm diameter) in a greenhouse using artificially prepared soil (water saturation of 33 %) of three different salinities (*i.e.* 0, 6 and 9 dS m^{-1} ECe) using NaCl, $CaCl_2$ and

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$MgSO_4$ in the ratio of 3:1:1 on meq basis. Each pot was filled with 4.5 kg well-sieved soil. 1500 cm^3 of the salt solution of desired salinity was applied to each pot. During the 2nd week of November, 1987, 10 seeds after an 18 h seed soaking in kinetin (10 g m^{-3}) solutions (T_K) or water (T_W) or unsoaked (T_0) were sown without drying in each pot at uniform depth (7.65 cm below the soil surface) and distance. Each experimental set was replicated three times.

Thinning was done after one week and only four plants per pot of comparable growth were maintained. Irrigation was given at 50 % depletion of the available soil moisture calculated on the basis of daily water loss. The observations were done at 45 d (vegetative stage), 75 d (anthesis) and 105 d (dough stage) after sowing. At each stage three pots containing four plants were sampled from each treatment: two plants were used for physiological observations and the remaining two for biochemical analyses.

The rates of photosynthesis and respiration were measured in the morning (10.00 - 11.00) on the fourth leaf from top using an infra-red gas analyser (IRGA) *ACD 225/2K* (USA).

Relative water content (RWC) was determined in the 3rd leaf from the top. Osmotic potential was determined (10.00 - 12.00) by a *5100-B* Psychrometer (*Wescor*, Longman, USA).

For biochemical estimations fresh tissue of the 3rd leaf blade from the top was used during the vegetative phase and the flag leaf was used during the reproductive phase. Content of chlorophyll (*a*+*b*) was estimated in 80 % acetone by the spectrophotometric method of Arnon (1959). The content of nucleic acids in the leaves was estimated according to Cherry (1962) and Nieman and Poulson (1963), using a *Carl Zeiss* UV spectrophotometer.

The data collected were analysed statistically by the analysis of variance developed by Fisher (1950), and the significance was tested at 5 % level by use of the factorial Complete Randomized Design (CRD).

Results and discussion

Effect of salinity: Both the relative water content and osmotic potential (Table 1) showed a progressive decline with increase in salinity. The decrease in the relative water content by salinity was compensated by the decrease in osmotic potential (Table 1) through an increase in total soluble solids and thereby the pressure potential was maintained. Similar observations have also been made by Hsiao (1973) and Meyer and Boyer (1981). Thus expansion growth which depend directly on pressure potential was maintained even under saline conditions.

Salinity decreased chlorophyll content, disturbed the photosynthetic apparatus, lowered number of leaves per plant and hence reduced photosynthetic production (Downton 1977, Kennedy 1977, Shone and Gale 1983). Both an increase or decrease in the respiration rate of plants grown under saline conditions have been reported (Sarin and Rao 1958). In the present study, the reduction in both the net photosynthetic and respiration rates (Table 2) was observed with increasing salinity. The maximum reduction in the photosynthetic rate was observed at dough stage

(105 d after sowing) when most of the leaves underwent senescence due to other metabolic disturbances as expressed in the reduction in dry matter of various plant parts and in low ultimate plant yield. The increase in respiration rate (Table 2) may be due to excessive oxidation of substrate and increased activity of enzymes of the respiratory metabolism. An increase in the activity of hydrolytic enzymes under NaCl and Na_2SO_4 salinities was observed by Weimberg (1970). A marked reduction in chlorophyll content with the increasing salinity (Table 2) agreed with the findings of Reddy and Das (1978), Divate and Pande (1981), Garg and Garg (1982), *etc.*

Table 1. Effect of different pre-sowing treatments (T_0 - dry, T_W - soaked with water, T_K - soaked with kinetin solution) on relative water content and osmotic potential of the third leaf of wheat grown under different salinity.

Time after sowing [d]	Salinity	Relative water content [%] treatments			mean	Osmotic potential [MPa] treatments			mean
		T_0	T_W	T_K		T_0	T_W	T_K	
45	S_0	83.25	86.33	91.43	87.00	-0.930	-1.016	-1.100	-1.012
	S_6	78.85	82.14	85.91	82.30	-1.123	-1.180	-1.210	-1.171
	S_9	69.41	76.42	77.05	74.29	-1.220	-1.310	-1.360	-1.300
	mean	71.17	81.63	84.80	81.20	-1.091	-1.168	-1.223	-1.161
	C.D. at 5 % LS for	S=1.12	T=1.12	S×T=2.10		S=0.92	T=0.927	S×T=0.160	
75	S_0	87.76	91.23	94.28	91.09	-0.860	-0.940	-1.020	-0.940
	S_6	81.42	85.18	89.43	85.34	-1.250	-1.090	-1.160	-1.166
	S_9	77.58	79.43	81.78	79.59	-1.606	-1.360	-1.913	-1.626
	mean	82.25	85.28	88.50	85.34	-1.238	-1.113	-1.364	-1.244
	C.D. at 5 % LS for	S=1.47	T=1.47	S×T=2.55		S=NS	T=NS	S×T=0.1485	
105	S_0	72.55	78.61	82.89	78.01	-1.040	-1.110	-1.080	-1.076
	S_6	66.51	69.01	74.16	69.80	-1.690	-1.773	-1.710	-1.724
	S_9	59.42	61.26	69.31	63.33	-1.813	-2.050	-2.185	-2.016
	mean	66.16	69.62	75.45	70.44	-1.514	-1.644	-1.658	-1.605
	C.D. at 5 % LS for	S=1.08	T=1.08	S×T=2.01		S=0.065	T=0.065	S×T=0.113	

A quantitative decrease in RNA content with the increased salinity was accompanied by a steady DNA content (Table 3). Salt stress reduces the rates of synthesis of both RNA and DNA and increases rates of their degradation (Rauser and Hanson 1966, Tal 1977) and also accelerates the activity of RNase and DNase in a root and shoot (Sheoran 1975).

Table 2. Effect of different pre-sowing treatments (T_0 - dry, T_W - soaked with water, T_K - soaked with kinetin solution) on rates of net photosynthesis and shoot respiration and chlorophyll content of wheat grown under different salinity.

Time after sowing	Salinity	Photosynthetic rates [mg(CO_2) kg^{-1}(d.m.) s^{-1}]				Respiration rates [mg(CO_2) kg^{-1}(d.m.) s^{-1}]				Chl (*a*+*b*) [g kg^{-1}(f.m.)]			
		treatments			mean	treatments			mean	treatments			mean
[d]		T_0	T_W	T_K		T_0	T_W	T_K		T_0	T_W	T_K	
45	S_0	5.45	5.60	6.16	5.74	1.01	1.06	1.12	1.07	2.86	2.90	3.11	2.95
	S_6	4.86	5.16	5.91	5.31	0.85	0.93	1.06	0.95	2.65	2.79	2.95	2.81
	S_9	3.96	4.25	4.76	4.33	0.74	0.79	0.90	0.81	1.73	1.89	2.03	1.88
	mean	4.76	5.00	5.61	5.12	0.88	0.92	1.03	0.94	2.41	2.59	2.81	2.60
	C.D. at 5 % LS for												
		S=NS	T=1.18	S×T=2.35		S=NS	T=0.6	S×T=NS		S=NS	T=NS	S×T=0.02	
75	S_0	10.97	11.36	13.77	12.03	3.81	3.92	4.17	3.96	2.94	3.10	3.17	3.07
	S_6	9.01	10.11	10.51	9.88	3.49	3.68	3.99	3.72	2.76	2.89	3.02	2.89
	S_9	7.11	7.06	7.54	7.33	3.11	3.47	3.73	3.47	2.20	2.31	2.43	2.31
	mean	9.03	9.60	10.61	9.74	3.47	3.72	3.96	3.72	2.63	2.76	2.87	2.75
	C.D. at 5 % LS for												
		S=0.08	T=2.58	S×T=5.02		S=0.84	T=0.84	S×T=1.69		S=0.02	T=0.02	S×T=0.05	
105	S_0	2.27	2.60	3.19	2.72	4.47	5.30	5.94	5.24	3.12	3.34	3.42	3.29
	S_6	1.58	1.70	2.14	1.81	3.94	4.30	4.52	4.25	2.93	3.14	3.27	3.11
	S_9	0.96	1.26	1.43	1.21	3.76	4.03	4.38	4.16	2.63	2.68	2.76	2.69
	mean	1.60	1.88	2.25	1.91	4.06	4.54	4.95	4.51	2.89	3.05	3.15	3.03
	C.D. at 5 % LS for												
		S=0.81	T=0.81	S×T=1.62		S=1.41	T=1.41	S×T=2.81		S=0.02	T=0.02	S×T=0.05	

Effect of seed soaking in water: Seed soaking in water (T_W) enhanced the relative water content of leaves (Table 1) both under saline and non-saline conditions but reduced their osmotic potential (Table 1). The water-soaking enhanced both the photosynthetic and respiration rates (Table 2) and chlorophyll (*a*+*b*) content of the leaves (Table 3). The water-soaking also leads to an increased RNA content (Table 3). DNA content (Table 4) was not significantly affected.

Effect of kinetin: Both the relative water content and osmotic potential (Table 1) showed a progressive significant increase as a result of seed soaking in the kinetin solution. On the contrary, treatment with kinetin led to a decrease in the water content in two halophytes grown under NaCl salinity (Boucaud and Ungar (1976) or did not improve the reduction in water content of roots and shoots of salt-stressed guar plants (Varshney 1980).

Table 3. Effect of different pre-sowing treatments (T_0 - dry, T_W - soaked with water, T_K - soaked with kinetin solution) on RNA and DNA content in leaf of wheat grown under different salinity.

Time after after sowing [d]	Salinity	RNA [g kg^{-1}(f.m.)]				DNA [g kg^{-1}(f.m.)]			
		treatments			mean	treatments			mean
		T_0	T_W	T_K		T_0	T_W	T_K	
45	S_0	1.35	1.62	1.81	1.59	0.209	0.197	0.217	0.208
	S_6	1.22	1.40	1.45	1.35	0.225	0.210	0.220	0.218
	S_9	1.10	1.25	1.39	1.25	0.273	0.256	0.248	0.259
	mean	1.22	1.42	1.55	1.40	0.235	0.221	0.228	0.228
	C.D. at 5 % LS for S=0.013 T=0.013 S×T=0.228					S=NS T=NS S×T=NS			
75	S_0	1.55	1.69	1.34	1.52	0.121	0.136	0.149	0.135
	S_6	1.34	1.48	1.25	1.35	0.156	0.171	0.161	0.162
	S_9	1.13	1.05	1.45	1.21	0.183	0.196	0.208	0.195
	mean	1.34	1.41	1.34	1.36	0.153	0.167	0.172	0.167
	C.D. at 5 % LS for S=0.117 T=0.117 S×T=0.202					S=NS T=NS S×T=NS			
105	S_0	1.18	1.27	1.20	1.22	0.173	0.181	0.190	0.181
	S_6	1.03	0.98	1.16	1.05	0.202	0.209	0.214	0.208
	S_9	0.94	0.96	1.25	1.04	0.228	0.218	0.231	0.225
	mean	1.05	1.07	1.20	1.11	0.201	0.202	0.211	0.204
	C.D. at 5 % LS for S=0.010 T=0.010 S×T=0.018					S=NS T=NS S×T=NS			

In the present experiment, kinetin treatment enhanced photosynthetic rates (Table 2) at all the stages of observations both under saline and non-saline conditions. These results are in agreement with the results of experiments with chloroplasts of *Phaseolus vulgaris* (Treharne *et al.* 1970) and *Nicotiana rustica* (Katz *et al.* 1978). Enhanced rates of photosynthesis in radish seedlings at application of kinetin were substantiated by increasing photosynthetic unit, amount of plastoquinone and phyllo-quinone (Buschmann and Lichtenthaler 1977); such changes promote a high level of CO_2 fixation.

Both under non-saline and saline conditions kinetin treatment enhanced the rate of shoot respiration (Table 2); this agrees with the findings of Goswami and Srivastava (1985) who observed that zeatin alleviated the adverse effects of salinity on respiration possibly by lowering the stomatal resistance.

The chlorophyll (*a*+*b*) content in the leaves (Table 2) was increased significantly by kinetin pre-treatment. Similarly, Bessonova *et al.* (1984) reported that kinetin applied to the leaves of tobacco partially or completely reversed the effect of salinity on leaf chlorophyll content. Similar results were reported by Fadl and El-Deen (1980) and Singh and Jain (1982).

RNA content (Table 3) was increased both under saline and non-saline conditions as a result of kinetin treatment; the changes in DNA content were not statistically significant. Similarly, Naito *et al.* (1978) found that benzyladenine (BA) treatments of intact primary leaves of beans elevated the level of DNA, RNA and protein as well as the activities of corresponding hydrolases; in the case of RNA and protein BA positively influenced the ratio of their synthesis /decomposition.

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