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ALLEVIATION OF SALINITY EFFECTS USING PLANT GROWTH REGULATORS IN WHEAT

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SUMMARY

A field experiment was conducted to study the harmful effects of salinity and their amelioration by the application of plant growth regulators, viz. cycocel, maleic hyderazide, benzyladenine and mixtalol on physiological, biochemical and yield attributes of wheat (*Triticum aestivum* L.). Salinity was found to significantly decrease photosynthetic rate, total chlorophyll content, cell membrane stability, reducing sugar content, plant height, leaf area index, test weight, number of grains/ear, number of tillers, grain and straw yield compared to non saline field. Application of plant growth regulators ameliorated the effect of salinity on these physiological parameters. A significant increase in grain nitrogen and protein contents was observed. Maximum increase in above parameters was recorded by the use of benzyladenine at 75 mg l^{-1} as compared to other concentrations and other plant growth regulators.

Key words: **PGRs, physiological attributes, salinity, wheat.**

INTRODUCTION

Salt stress is one of the major wide spread environmental stress that limits growth and development of plant (Greenway and Munns 1980). Salinity adversely affects plant growth, through osmotic and ion toxicity. Extra expenditure of energy for osmotic adjustment under salt stress causes growth reduction (Pasternak 1987). Reclamation of salt affected land by the common practices such as leaching and drainage are expensive or impracticable in many cases. A possible approach to increase the productivity of such areas is to improve salt tolerance in plants. Plant growth retardants have been used effectively to increase the tolerance of plants under water deficit conditions. Such compounds have been used to increase the yield by retarding the plant senescence (Sairam *et al*. 1991). Cycocel inhibit GA biosynthesis and in turn favours the availability of substrate like cytokinins (Fletcher and Arnold 1986). Plant growth promoters (PGRs) have been used to reverse the salinity induced deleterious effects (Singh 1977).

Present investigation was carried out to examine the response of plant growth regulators in alleviating the deleterious effect of salt stress on physiological, biochemical traits, growth and yield of wheat.

MATERIALS AND METHODS

The field experiment was conducted during the *rabi* season of 2004-2005 on saline (EC 7.8 d Sm^{-1}) and non-saline field (EC 1.2 dSm^{-1}) at S.K.N.College of Agriculture, Jobner. The saline and non-saline field was maintained by using sodium chloride salt. The EC level of both the field during experiment were maintained by applying saline and non saline irrigation water. EC value was measured in soil samples taken after 5 days of every

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irrigation (1:2, ratio of soil and distilled water) using conductivity meter. The soil of experimental field was sandy loam. The experiment was laid out in randomized block design (RBD) with three replications. The seeds of wheat var. KRL1-4 were soaked for 10 hrs. in cycocel (CCC), maleic hyderazide (MH), mixtalol (MXT) solution of 750 and 1500 mg l^{-1} and benzyladenine (BA) at 75 and 150 mg l^{-1} concentration in laboratory before sowing in the field. The plot size was 2 x 2 meter and there were nine treatments, viz. (1) Control (seed were soaked in distilled H_2O) (2) CCC_{750} (3) CCC_{1500} (4) MH_{750} (5) MH_{1500} (6) BA_{75} (7) BA_{150} (8) MXT_{750} (9) MXT_{1500} mg l^{-1}. CCC and MH are the plant growth retardants and BA and MXT are plant growth promoters. Seeds soaked in the solution of these plant growth regulators and were sown @ 100kg / ha. with 22.5 cm row to row and 5cm plant to plant distance, on 25th November, 2004.

The crop received six irrigations up to maturity. The data were recorded at 60 and 90 days after sowing. Photosynthetic and transpiration rates of upper leaf was measured with the help of C1-301 CO_2 gas analyzer. The amount of total chlorophyll content estimated as method suggested by Arnon (1949) and cell membrane stability index following Sullivan (1972). Plant height, number of tillers/meter row, leaf area index (Watson 1952), number of grains/ear and 1,000 grain weight were determined for each treatment. The estimations of protein content in leaf (Lowry *et al.* 1951), reducing sugar content in leaf (Nelson 1944) and nitrogen and protein content in grain (Kjel-Tek N_2 analyser instrument) were done. The crude protein content in grain was calculated by multiplying the per cent nitrogen with a constant factor of 6.25 as suggested by Gupta *et al*. (1972). The grain and straw yield was determined at maturity.

RESULTS AND DISCUSSION

Salinity was found to decrease the photosynthetic rate, transpiration rate, total chlorophyll content, cell membrane stability, leaf area index, protein content, reducing sugar content in leaf , plant height, test weight, number of grains /ear, number of tillers / meter row length, grain and straw yield with a significant increase in nitrogen and protein content in grain (Tables 1, 2 and 3).

The per cent decrease in grain and straw yield was recorded 20.65, 20.04 over control field because salinity causes non availability of water, nutrient imbalances and ion toxicity in plants (Pasternak 1987).Salts within plants reduces the growth by causing premature senescence of old leaves and reduced the supply of assimilates to the growing region (Narayana and Rao 1987) .Salinity is also known to causes destruction of chl-a molecule which is more sensitive to salinity than chlorophyll-b molecule (Reddy and Vora 1986).

The use of CCC up to 1500 mg l^{-1} concentration was found to increase the photosynthetic rate, total chlorophyll content, cell membrane stability, reducing sugar content, protein content in leaf, test weight, number of grains/ ear, number of tiller/ meter row length, nitrogen and protein content in grain, grain and straw yield, because H_2O_2 have been reported to be involved in the enhancement of senescence in leaves, CCC minimized the H_2O_2 content in leaves under salinity by increasing the level of catalase activity thus maintain high metabolic status (Saha and Gupta 1999). A significant increase in nitrogen and protein content in grain also recorded by the use of CCC because it enhances the transport of metabolites from vegetative parts to the developing grains (Uprety and Yadava 1985). Cycocel also decreased the vegetative growth and regulate better translocation of photosynthates into grains (Phulekar *et al*. 1998).It could be deduced from the data of photosynthesis might be a major factor for increased grain and straw yield in our case. These results.colaborate with the results of Asici and Briggs (1973).Who observed that although declined leaf area but leaf thickness increased resulting in stacking of mesophyll and bundle sheath cells in wheat While a significant decrease in plant height, transpiration rate and in leaf area index was recorded, because the CCC inhibits the biosynthesis of gibberellins in plant (Corcoran 1975) .It promotes synthesis of proline, glycine, betaine, which may affect the membrane that lead to reduced K^+ in guard cells, thereby causing stomatal closure, which results in decreased transpiration rate of leaves (Govil 1985). A significant increase in cell membrane stability of leaves was also recorded by the use of CCC as evidenced by present study (Table 1).

Table 1. Effect of plant growth regulators on physiological traits in wheat grown under non saline and saline field conditions.

Treatments (mg l^{-1})	Photosynthesis rate (μmol CO_2 m^{-2} s^{-1})				Transpiration rate (mmol H_2O m^{-2} s^{-1})				Chlorophyll content (mg g^{-1} fw)				Cell membrane stability			
	60 DAS		90 DAS		60 DAS		90 DAS		60 DAS		90 DAS		60 DAS		90 DAS	
	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1
Control	14.17	11.18	15.24	12.41	4.08	3.24	4.21	3.88	2.78	2.44	2.93	2.66	83.02	69.51	75.43	62.80
CCC_{750}	15.43	12.47	16.40	13.52	3.49	3.09	3.62	3.36	3.00	2.68	3.06	2.79	86.12	73.21	79.32	65.91
CCC_{1500}	16.37	13.21	17.40	14.57	3.29	3.58	3.50	3.24	3.08	2.88	3.20	2.94	88.42	74.65	82.29	68.32
MH_{750}	15.29	12.33	16.27	13.48	3.44	3.07	3.60	3.34	2.91	2.63	3.00	2.77	83.72	71.00	77.24	64.29
MH_{1500}	14.24	11.34	15.43	12.62	3.26	2.57	3.48	3.22	2.90	2.60	2.94	2.75	81.46	70.35	76.60	62.54
BA_{75}	16.57	13.59	17.57	15.08	3.55	3.11	3.99	3.40	3.18	2.78	3.26	3.00	91.35	77.28	85.72	71.96
BA_{150}	15.62	12.65	16.62	14.11	3.32	2.58	3.53	3.27	3.05	2.60	3.12	2.84	89.13	75.43	83.46	69.51
MXT_{750}	16.43	13.46	17.42	14.63	3.50	3.10	3.64	3.38	3.18	2.74	3.23	2.98	88.66	75.43	83.46	69.51
MXT_{1500}	15.49	12.50	16.48	14.11	3.28	2.56	3.51	3.25	2.99	2.57	3.07	2.80	86.42	73.65	81.29	67.32
MEAN	15.51	12.53	16.54	13.84	3.46	2.87	3.68	3.37	3.00	2.66	3.09	2.84	86.48	73.39	80.53	66.91
C.D. at 5%	0.57	1.22	0.52	1.11	0.167	0.355	0.176	0.375	0.08	0.17	0.06	0.13	2.24	4.77	2.40	5.11

S_0=Non saline field, S_1= saline field, DAS=Days after sowing

Table 2. Effect of plant growth regulators on biochemical traits of wheat grown under non saline and saline field conditions.

Treatments (mg l^{-1})	Protein content (mg/g fw)				Leaf area index				Reducing sugar content (mg/g fw)				Plant height (cm)			
	60 DAS		90 DAS		60 DAS		90 DAS		60 DAS		90 DAS		60 DAS		90 DAS	
	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1
Control	10.21	6.71	12.73	8.46	2.88	2.32	3.23	2.47	3.77	2.83	3.13	2.53	35.34	31.29	64.34	60.28
CCC_{750}	11.20	7.30	14.00	9.88	2.57	1.89	2.80	2.09	3.86	3.16	3.35	2.73	33.37	28.20	62.51	57.12
CCC_{1500}	12.27	7.90	15.87	11.32	2.22	1.70	2.50	1.82	4.00	3.30	3.60	2.85	33.11	27.13	60.29	52.21
MH_{750}	10.80	7.10	13.67	9.86	2.40	1.72	2.70	1.78	3.82	3.00	3.20	2.62	33.17	27.17	61.53	56.18
MH_{1500}	10.54	6.90	13.27	8.86	2.28	1.60	2.40	1.60	3.55	2.85	3.10	2.60	31.08	24.14	59.30	50.13
BA_{75}	12.54	8.97	16.80	11.25	3.59	2.94	3.94	3.18	4.30	3.85	4.12	3.05	39.27	35.61	69.61	65.67
BA_{150}	12.07	8.50	15.67	10.27	3.30	2.78	3.68	3.06	4.00	3.67	3.80	2.90	38.43	34.19	67.29	63.20
MXT_{750}	12.34	8.50	16.00	10.87	3.46	2.80	3.82	3.06	4.21	3.71	3.95	2.90	37.21	34.13	68.47	64.42
MXT_{1500}	11.67	8.10	15.27	10.47	3.20	2.66	3.57	2.90	3.85	3.62	3.65	2.66	36.27	33.16	66.47	63.10
MEAN	11.52	7.78	14.81	10.14	2.88	2.27	3.18	2.44	3.92	3.33	3.54	2.76	35.25	30.56	64.42	59.15
C.D. at 5%	0.36	0.78	0.48	1.03	0.14	0.30	0.18	0.38	0.10	0.22	0.11	0.23	1.16	2.48	1.14	2.42

S_0=Non saline field, S_1= saline field, DAS=Days after sowing

Table 3. Effect of plant growth regulators on yield attributes, yield and grain quality of wheat grown under non saline and saline field conditions.

Treatments (mg l^{-1})	Test weight (g)		No. of grains/ear		No. of tillers/ meter row length		Grain yield (q/ha)		Straw yield (q/ha)		Nitrogen content (%) in grain		Protien content (%) in grain	
	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1	S_o	S_1
Control	37.29	35.15	47.36	35.25	128.19	121.72	32.40	25.42	47.16	37.39	1.42	1.48	8.87	9.23
CCC_{750}	38.80	37.14	50.66	37.66	133.44	125.96	37.68	29.54	54.25	43.16	1.48	1.51	9.25	9.45
CCC_{1500}	39.94	38.20	52.77	39.55	136.55	128.55	41.14	32.42	58.99	46.89	1.54	1.55	9.61	9.66
MH_{750}	38.92	36.08	49.26	36.45	131.12	124.15	34.36	27.38	49.70	39.93	1.47	1.50	9.19	9.40
MH_{1500}	38.00	35.82	48.55	35.99	129.33	122.44	33.55	26.15	48.67	38.31	1.46	1.50	9.15	9.36
BA_{75}	40.51	38.49	56.99	43.88	140.77	132.88	42.58	34.32	60.61	49.05	1.54	1.56	9.65	9.76
BA_{150}	40.30	38.27	53.88	40.77	138.66	130.77	39.15	31.24	55.91	44.84	1.52	1.54	9.52	9.63
MXT_{750}	39.98	38.32	54.88	41.77	138.66	130.77	41.75	33.53	59.65	48.14	1.54	1.55	9.62	9.73
MXT_{1500}	39.82	38.16	52.77	39.66	137.55	129.66	38.62	30.75	55.37	44.35	1.52	1.53	9.50	9.62
MEAN	39.28	37.29	51.90	39.00	134.92	127.43	37.91	30.08	54.48	43.56	1.50	1.53	9.37	9.54
C.D. at 5%	0.81	1.74	1.32	2.80	2.38	5.07	2.19	4.67	2.41	5.13	0.032	0.068	0.155	0.329

S_0=Non saline field, S_1= saline field

The significant increase in photosynthetic rate, total chlorophyll content, cell membrane stability, reducing sugar content, protein content in leaves, test weight, number of grains/ ear, number of tiller/ meter row length, nitrogen and protein content in grain, grain and straw yield was not seen by the use of MH as compared to other plant growth regulators, while a significant decrease was recorded in transpiration rate, leaf area index and in plant height. Similar results were also reported by Govil (1985).

The use of BA at 75 mg l^{-1} concentration was found to increase the photosynthetic rate of leaf due to increase in photosynthetic pigments content (Siva Kumar and Nath 2000). Significant decrease in transpiration rate of leaf recorded by the use of BA at this concentration (Table 1). Benzyl adenine was also found to enhance the cell membrane stability of leaf cells, This increase in membrane stability is related to, benzyl adenine alleviating the damaging effect of high temperature by increasing the volume of inter cellular air spaces and decreased leaf temperature, which results in increased cell membrane stability (Quing 1998). Significantly increase in grain and straw yield was also observed at both the concentration of BA over control in both the fields due to delay in leaf senescence and extended grain formation period offering considerable potential for increasing grain yield (Ray and Choudhary 1981).

Significant increase in total chlorophyll content, reducing sugar content, protein content in leaves, plant height, test weight, number of grains/ ear, number of tillers / meter row length, nitrogen and protein content in grain were also recorded by the use of BA at 75 mg l^{-1} concentration over control and 150 mg l^{-1} BA concentration. The maximum increase in grain and straw yield were recorded under 75 mg l^{-1} than 150 mg l^{-1}. A significant increase in total chlorophyll content and photosynthetic rate of wheat leaf was recorded by the use of MXT only at 750 mg l^{-1} concentration under both the fields over control. Prolonged leaf longevity increased leaf area (Zhou *et al*. 1992) and increase in active iron uptake (Kadam *et al*. 1988) which seemed to be the major factor for increased chlorophyll content, photosynthetic rate and grain and straw yield. A significant decrease in transpiration rate was also seen by the application of MXT at only 750 mg l^{-1} concentration. Mixtalol is a triacontanol based growth regulator containing a mixture of long chain aliphatic alcohol (C_{24}-C_{34}), it increases plant growth and yield by way of increasing protein content, reducing sugar content, plant height, test weight, number of grains/ear, number of tillers/meter row length, nitrogen and protein content in grain and reduces the rate of photorespiration in plant (Menon and Srivastava 1984). Mixtalol at 750 mg l^{-1} concentration was also observed to increase the cell membrane stability as evidenced by the finding of Zhou *et al*. (1990). Interactive effect of soil salinity and plant growth regulators was found non-significant.

The present study concludes that the adverse effect of salinity on physiological, biochemical traits ,growth, grain and straw yield of wheat cv. KRL1-4 can be ameliorated by the use of benzyladenine (75 mg l^{-1}), mixtalol (750 mg l^{-1}) and cycocel (1500 mg l^{-1}) as pre-sowing seed soaking treatment for 10 hours. These ameliorants could be effectively used under saline conditions (up to EC 7.8 dSm^{-1}) for growing wheat crop successfully.

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