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Dry Matter Partitioning and Ion Accumulation in Spring Wheat (*Triticum aestivum* L.) as Affected by Soil Salinity and Growth Regulator (IAA) Spray

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Abstract: In a pot experiment with spring wheat cv. Kohistan-97 and Parwaz-94, the effect of foliar application of IAA and different salinity levels 8, 12 and 16 dS m^{-1} on dry matter partitioning and ion accumulation was studied. With the increase in salt concentration, there was decrease in roots, culms and leaves dry weights. The reduction in dry weights was more in Kohistan-97 than Parwaz-94. The Na^+ and Cl^- contents in roots, culms and leaves increased with increasing salinity while K^+ content decreased. Spraying with IAA proved effective in ameliorating the adverse effect of salinity on dry matter and ion accumulation, whether applied at the time of salinization or 15-days after salt treatment.

Key words: Dry matter partitioning, Ion accumulation, Growth regulator (IAA), NaCl salinity, Wheat.

Introduction

In all arid and semi-arid regions of the world, soil salinity is a major agricultural problem. Pakistan, being an agricultural country, is also confronted with this serious problem. About 6.3 million hectares of agricultural land in Pakistan is affected to various degrees by soil salinity. The excess salts present in the root zone impares the growth of many field crops. The deleterious effects of salinity on plant growth are attributed to a decrease in osmotic potential of the growth medium, specific ion toxicity, nutritional imbalance and reduction in enzymatic and photosynthetic efficiency and other physiological disorders (Ashraf and Khan, 1993; Ashraf *et al.*, 1991; Greenway and Munns, 1980; Khan *et al.*, 1995; Khan, 1993). Although wheat is classified as moderately salt tolerant crop, similar adverse effects of root zone salinity on its plant traits have been reported (Gill *et al.*, 1993; Iqbal, 1991; Rashid, 1986). The proper curve of salt affected soils is ofcourse its reclamation that involves the use of chemical amendments. As plant growth regulators are effective in reducing the adverse effects of salinity, therefore, the present project was undertaken to determine the effect of foliar application of IAA on dry matter and ion accumulation of spring wheat under salt stress.

Materials and Methods

A pot experiment was conducted on wheat crop in the Botanical Garden, University of agriculture, Faisalabad, during winter 1998-99. The earthen pots of 30 cm diameter lined with polythene bags were filled with 10 kg of sandy loam soil, having ECe, 2.12 dS m^{-1}, pH 7.5 and saturation percentage, 28. Seeds of two wheat varieties, Kohistan-97 and Parwaz-94 were obtained from Ayub Agricultural Research Institute (AARI), Faisalabad. The sowing was done on December 2, 1998 and eight seeds were sown 2cm deep in each pot. One hundred and eight pots in total were used, allocating 54 pots to each variety. Tap water was used for irrigation, whenever needed. After germination five plants were maintained in each pot. Three salinity levels (8, 12 and 16 dS m^{-1}) were developed using NaCl solution while normal soil having ECe 2.12 dS m^{-1} was considered as control. The salinity treatment was imposed when seedlings were at hour leaf stage. A single dose of 25 mg L^{-1} of Indole-3-acetic acid (IAA) was sprayed using hand spray pump at two different time intervals. First spray was done at the time of salinization and second fifteen days after the salt treatment. The experiment was laid out in Completely Randomized Design (CRD) with three factors (variety, salinity and growth regulator) having nine treatments for each variety. Each treatment was replicated thrice. Dry weights of roots, culms and leaves were recorded at maturity. For dry weights, roots, culms and leaves of nine randomly selected plants were oven dried at 70 °C for 72 hours to attain constant weight.

Analysis of ions: For the analysis of Na^+, K^+ and Cl^-, healthy plants were selected at booting stage. Leaves, culms and root samples were dried at 70°C for 72h in an oven and 0.5g of ground dried material was taken in a test tube and 10 ml of deionized water was added to it. Then the test tubes were placed in an autoclave at 121 °C for five minutes and the mixture was shaken in warm conditions for 4-5 minutes and filtered on cooling. The volume of the extract was made 50 ml with deionized distilled water. Sodium and potassium contents in the extracts were determined with a flame photometer (Sherwood Scientific Ltd. Cambridge, UK) whereas, chloride content determined with a digital chloride ion meter (Control Kagaku Crop., Japan).

Statistical analysis of data: The data for all the parameters was analysed statistically using ANOVA (Completely Randomized Design) according to Steel and Torrie (1980) and least significant differences between mean values were calculated following Duncan's New Multiple Range (DMR) test.

Results

Analysis of variance of data for dry weights of roots, culms and leaves of both wheat varieties as effected by salinity and IAA are presented in Table 1. Root dry weight decreased significantly with increasing salinity in both varieties (Fig. 1) but more adverse effects of salinity were found on Kohistan-97. Application of growth regulator had a significant effect in reducing the effect of salinity on root dry weight. Fig.1 showed that salinity had a significant effect on culm dry weight in both varieties of wheat i.e. it decreased with increasing salinity. But the growth regulator treatments had significant effect on culm dry weight at all salinity level in reducing the salinity effect whether it was applied at the time

Table 1: Analysis of variance summaries (mean squares) of data dry matter partitioning into root, culm and leaf of wheat as affected by salinity and IAA-spray

S.O.V.	D.F.	Dry weight of root	Dry weight of culm	Dry weight of leaf
Salinity (S)	2	0.102**	0.056**	0.084**
Growth Regulator (GP)	2	0.025**	0.009**	0.013**
Varieties (V)	1	0.037**	0.158**	0.023**
V x S	2	0.008**	0.001*	0.001**
V x GR	2	0.000^{NS}	0.002**	0.000^{NS}
S x GR	4	0.000^{NS}	0.001*	0.000^{NS}
V x S x GR	4	0.000^{NS}	0.001*	0.001**
Error	36	0.001	0.002	0.000
Total	53			

NS = Non-significant * = Significant, ** = Highly significant, at 5 and 1% level of probability

Table 2: Analysis of variance summaries (mean squares) of data for root and culm Na+, K+ and Cl^- concentrations in wheat as affected by salinity and IAA-spray

S. O. V.	D. F.	Root Na^+ conc.	Culm Na^+ conc.	Root K^+ conc.	Culm K^+ conc.	Root Cl^- conc.	Culm Cl^- conc.
Salinity (S)	2	1053.20**	247094.57**	296.54**	1449.18**	323.68**	6457.82**
Growth Regulator (GR)	2	653.73**	31411.29**	79.30**	769.59**	1241.70^{NS}	7167.28**
Varieties (V)	1	1769.99**	7351.86**	20.58**	3518.19**	494.19**	58323.87**
V x S	2	31.00**	13777.48**	9.63**	390.89**	1.03**	246.52**
V x GR	2	67.14**	8282.27**	5.96**	7.43**	0.59^{NS}	120.64**
S x GR	4	20.29**	1101.60**	6.77**	16.60**	9.39**	311.57**
V x S x GR	4	10.28*	164.39**	2.13**	22.95**	3.22**	127.52**
Error	36	2.66	126.30	0.73	0.85	0.77	2.76
Total	53						

NS = Non-significant * = Significant, ** = Highly significant, at 5 and 1% level of probability

Table 3: Analysis of variance summaries (mean squares) of data for leaf Na^+, K^+ and Cl^- concentrations in wheat as affected by salinity and IAA-spray

S. O. V.	D. F.	Leaf Na^+ concentration	Leaf K^+ concentration	Leaf Cl^- concentration
Salinity (S)	2	5205.20**	19336.98**	731.35**
Growth Regulator (GR)	2	10193.80**	16779.37**	727.60^{NS}
Varieties (V)	1	983.46**	17849.12**	40811.65**
V x S	2	199.88**	11667.37**	19.54**
V x GR	2	27.65^{NS}	13174.11**	2352.09**
S x GR	4	339.40**	12644.24**	1223.18**
V x S x GR	4	50.77**	12175.21**	285.21**
Error	36	90.18	0.73	13.82
Total	53			

of salt treatment or after fifteen days of salinity treatment. By contrast, Parwaz-94 had significantly greater culm dry weight than Kohistan-97 in all treatments. A similar adverse effect of salinity was found on leaf dry weight (Fig.1). It decreased significantly in both wheat varieties with increase in salt concentration in the growth medium. Both the growth regulator treatments proved beneficial in alleviating the salinity effect on leaf dry weight as compared to control (no-growth regulator). However, growth regulator treatment, applied at the time of salinization, proved more beneficial than that applied 15-days after salt treatment because leaf dry weight in this growth regulator treatment was relatively greater at all salinity levels compared with the latter growth regulator treatment.

Analysis of variance of data for Na^+, K^+ and Cl^- contents in roots, culms and leaves are presented in Table 2 and 3. Root Na^+ and Cl^- concentrations (Fig. 2) of both wheat varieties increased significantly ($P<0.01$) with increasing supply of NaCl to the growth medium. Varieties differed significantly in root Na^+ and Cl^- concentration. Kohistan-97 had significantly greater Na^+ and Cl^- concentration in root at all salinity level than that in PAR-94. Root K^+ concentration of both varieties decreased significantly ($P<0.01$) with increasing salinity (Fig. 2). Parwaz-94 had a significantly greater ($P<0.01$) root K^+ concentration than Kohistan-97. Both growth regulator treatments had a significant effect ($P<0.05$) in checking the high accumulation of Na^+ and Cl^- and enhancing root K^+ concentration in both varieties at all the salinity levels but the more pronounced effect was of the growth regulator treatment which was applied at the time of salt treatment.

Culm Na^+ and Cl^- concentrations (Fig. 2) increased, while K^+ concentrations decreased significantly ($P<0.01$) with increasing salinity. The varieties differed significantly ($P<0.01$) in ion accumulation. Accumulation of Na^+ and Cl^- was higher in Kohistan-97 than Parwaz-94. Whereas K^+ concentration was significantly greater in Parwaz-94 than Kohistan-97. However, in both varieties, application of growth regulator had

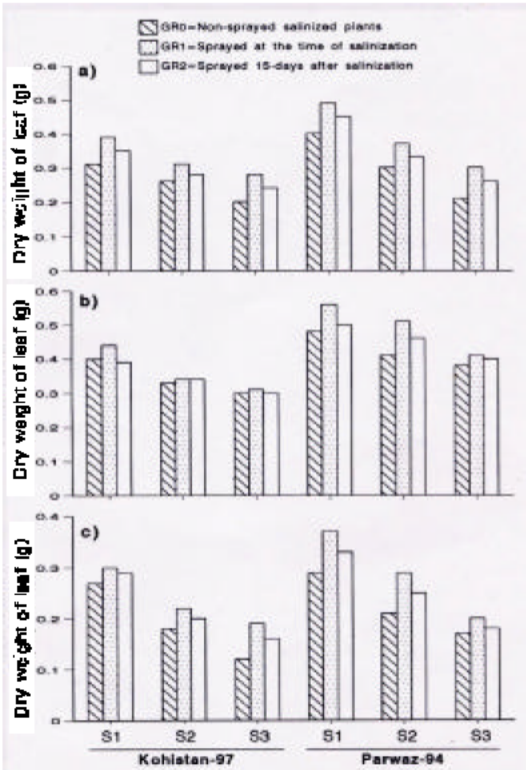

Fig. 1: (a) Dry weight of root (b) Culm © Leaf of two spring wheat varieties grown at varying salt treatments and IAA- spray at maturity

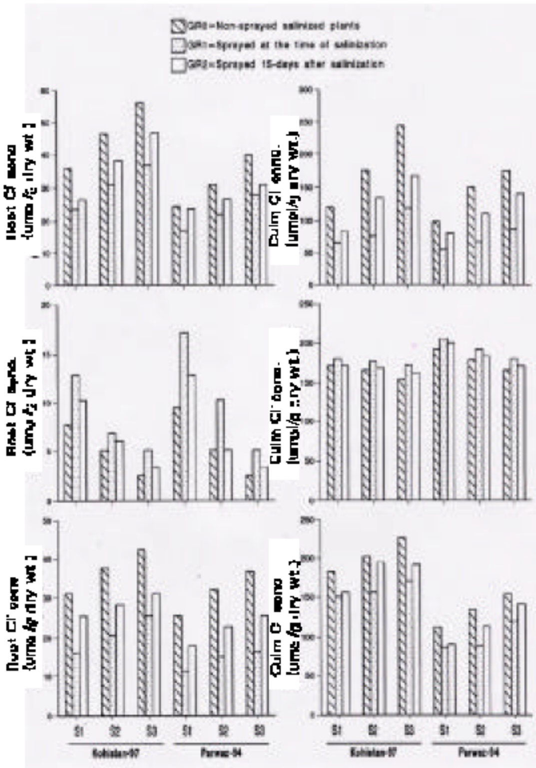

Fig. 2: Concentrations of Na+, K+ and Cl⁻ in root and culm of two spring wheat varieties grown at varying salt treatment and IAA-spray at adult stage

significant ($P<0.01$) effect in restricting the high accumulation of Na^+ and Cl^- and increasing the accumulation of K^+ in culm compared with control salt treatment (no growth regulator). Similar effect off salinity and IAA was observed on leaf Na^+, Cl^- and K^+ concentrations (Table 3 and Fig.3). Leaf Na^+ and Cl^- concentrations increased significantly ($P<0.01$) with increasing salinity in both wheat varieties, whereas K^+ concentrations decreased, varieties differed significantly. Application of growth regulator had significant effect ton leaf Na^+ and K^+ but statistically non-significant on Cl^- concentration. However their interactive effective was significant.

Discussion

The results of the present study revealed that dry weights of roots, culms and leaves of both wheat varieties decreased with increasing salinity levels of the growth medium. Both the growth regulator treatments proved effective in ameliorating the adverse effect of salinity on dry weights. These findings are parallel to those of Stark and Roth (1991), Maas *et al.* (1977) and Maliwal (1997) who also found that increasing salinity in the growth medium reduced the plant growth in terms of all the above mentioned parameters, in wheat, barley, rice and maize. However, growth regulator treatment mitigated the adverse effects of salinity on all these parameters. The decrease in root, culm and leaf dry weights due to salinity could be due to shrinkage of cell contents, reduced development and differentiation of vascular tissues (Strogonov, 1962), unbalanced nutrition, Hagazi *et al.* (1995), damage of membrance and distrubed avoidance mechanism (Storey and Wyn Jones, 1978).

The crops, however, differed markedly in the amount of ion uptake and also in their distribution in different plant parts. In our study, Na^+ and Cl^- concentrations increased with increasing salinity, whereas K^+ concentration decreased in both wheat lines. However, Kohistan-97 accumulated higher concentration of Na^+ and Cl^- compared with Parwaz-94. Both the growth regulator treatments proved effective in checking the high accumulation of Na^+ and Cl^- and enhancing K^+ accumulation in roots, culm and leaves. Growth regulator treatment applied at the time of salinization was more effective than the other applied 15-days after salinization.

+The increase in Na^+ and decease in K^+ concentration under saline conditions may be related to the antagonistic effect of Na^+ on K^+ uptake. This leads to an ionic imbalance in plant system and increased Na^+/K^+ ratio (Datta *et al.*, 1996; Shannon and Noble, 1995; Sharma, 1990). These results are

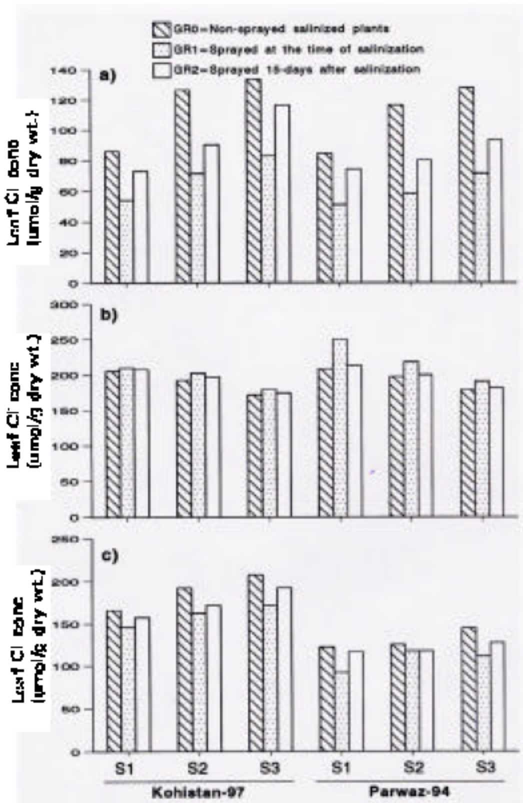

Fig. 3: Concentration of (a) Na+ (b) K+ (c) Cl^- in leaf of two spring wheat varieties grown at varying salt treatments and IAA-spray at maturity

in close conformity with the earlier findings in wheat (Chhipa and Lal, 1993; Khan *et al.*, 1999), rice (Prakash and Prathapasenan, 1988), and maize (Datta *et al.*, 1996) in which salinity decreased K^+ and increased Na^+ and Cl^- contents in roots, stems and leaves but the application of different growth regulators increased K^+ and decreased Na^+ and Cl^- contents under salt stress.

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