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Salinity Effects on some Cultivars of Berseem *(Trifolium alexandrinum L.)*

Auswirkungen unterschiedlicher Bodensalzgehalte auf einige Alexandrinerklee-Sorten *(Trifolium alexandrinum L.)*

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1 Introduction

Berseem *(Trifolium alexandrinum L.)* is widely grown for forage in several countries where soil salinity is a major problem for agriculture. In addition to its importance as a fodder crop, it has a considerable nitrogen fixing ability through the bacteria of the genus *Rhizobium* which inhabit their root nodules.

Although it has been categorised among the moderately salt tolerant crops by MAAS and HOFFMAN (1977), and has been found to be more salt tolerant and more efficient Na and Cl excluder than the salt sensitive species *T. pratense* (WINTER and LAUCHLI, 1982) the crop is severely salt tolerant crops by MAAS and HOFFMAN (1977), the crop is severely affected when grown on highly saline soils. In view of the considerable importance of the crop, the improvement of its salt tolerance by screening a large number of genotypes within a single cultivar (ASHRAF, MCNEILLY and BRADSHAW, 1987), and/or by screening a large number of exotic/native cultivars as examplified by the work of KINGSBURY and EPSTEIN, 1984) with wheat, and/or by transferring genes responsible for tolerance from a highly salt tolerant wild relative if present, could be of considerable value. A biological approach to overcoming the problems of soil salinity appears to have considerable value in that it is very economical, and has received considerable attention from many workers (SHANNON, 1985; EPSTEIN, 1985; ASHRAF, MCNEILLY and BRADSHAW, 1986), since it is not economically feasible to modify the environment to suit the plant.

Systematic work to exploring genetic variability for salt tolerance in berseem is still in its infancy. However our previous work on this crop (ASHRAF, MCNEILLY and BRADSHAW,

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1987) clearly shows that there is a considerable amount of appropriate intra-varietal genetic variability. The present work was carried out in order to assess inter-varietal variation in a range of existing cultivars of berseem. Efforts have also been made to draw parallels between tolerance and patterns of ion accumulation in the cultivars examined.

2 Materials and Methods

Seed of the ten berseem cultivars cvs, 3/73, B 18, B 23, P 139, P 178, P 185, Faisalabad Late, Sargodha Bulk 84, Sargodha Early, and Syndhic 1/79 was kindly supplied by the Ayub Agricultural Research Institute, Faisalabad, Pakistan.

In all cultivar seed samples, total germination varied from 96 to 100% when tested in 0.05% $Ca(NO_3)_2$ solution in control conditions. All seed samples were surface sterilized in 0.1% $HgCl_2$ solution for five minutes before experimentation.

Sand Culture Experiment

Ordinary silica sand was washed thoroughly with tapwater, then with distilled deionized water, and finally with full strength Rorison nutrient solution (HEWITT, 1966). Twenty centimeter diameter plastic pots were filled with 4.24 kg dry sand. The concentrations of NaCl used were 0, 75, 150 and 225 mol m^{-3}. The experiment had three blocks, each block having ten cultivars and four concentrations of NaCl. A total of 120 pots was used.

About one hundred and fifty seeds of each cultivar were germinated in Petri dishes, and three days after sowing when germination was complete, six randomly chosen seedlings of each cultivar were transplanted equidistant from each other into each pot.

The experiment was conducted in a greenhouse at 24°C with a 16 h photoperiod. The seedlings were grown for two weeks, irrigated with full strength Rorison nutrient solution (HEWITT, 1966), after which time NaCl treatments were begun by adding aliquots of a 37.5 mol m^{-3} solution of NaCl in 1.5 l of the full strength nutrient solution, on alternate days, until the appropriate NaCl concentrations were reached. Salt treatments continued with addition of 1.5 l of the appropriate solution on alternate days to each pot. This volume was sufficient to wash through solution already present in the sand as determined from the electrical conductivity of the effluent solution from the pots. This enabled the constancy of appropriate treatments throughout the experimental period.

The plants were harvested five weeks after the start of the salt treatments just before flowering. Plant roots were removed carefully from the sand which was already flushed with the solution of appropriate NaCl treatment. The roots were then briefly washed with distilled deionized water. Plant material was dried at 80°C for three days. The dry weight of shoots and roots was measured in each cultivar.

Physiological analysis

Cations: 25 mg shoot and root samples were digested in 1 ml concentrated HNO_3. After digestion was complete the volume of the sample was made up to 20 ml with distilled deionized water. Na^+ and K^+ were determined by flame photometry, and Ca^{2+} by atomic absorption spectrometry.

Chloride: 25 mg subsamples of shoots and roots were extracted by boiling in distilled deionized water for 3 h and the chloride content of the samples determined with Corning Chloride Analyzer.

3 Results

3.1 Mean fresh weight per plant

The data for fresh weight per plant of 10 berseem cultivars at different salt concentrations are given in Fig. 1. Analysis of variance of the data (Tab. 2) showed that addition of salt significantly reduced mean fresh weight per plant ($p \leq 0.001$) in all cultivars. Different cultivars had significantly different fresh biomass ($p \leq 0.01$) in response to the increasing salt concentration. The Cultivar X Concentration interaction was non-significant. Although statistically non-significant, cvs Faisalabad Late, P 139, and P 185 had higher fresh biomass than the other cultivars did not show any marked difference from one another. When the mean data were expressed as percent of control, Faisalabad Late again had about two to three times higher values of fresh weight at the highest salt concentration than the other cultivars.

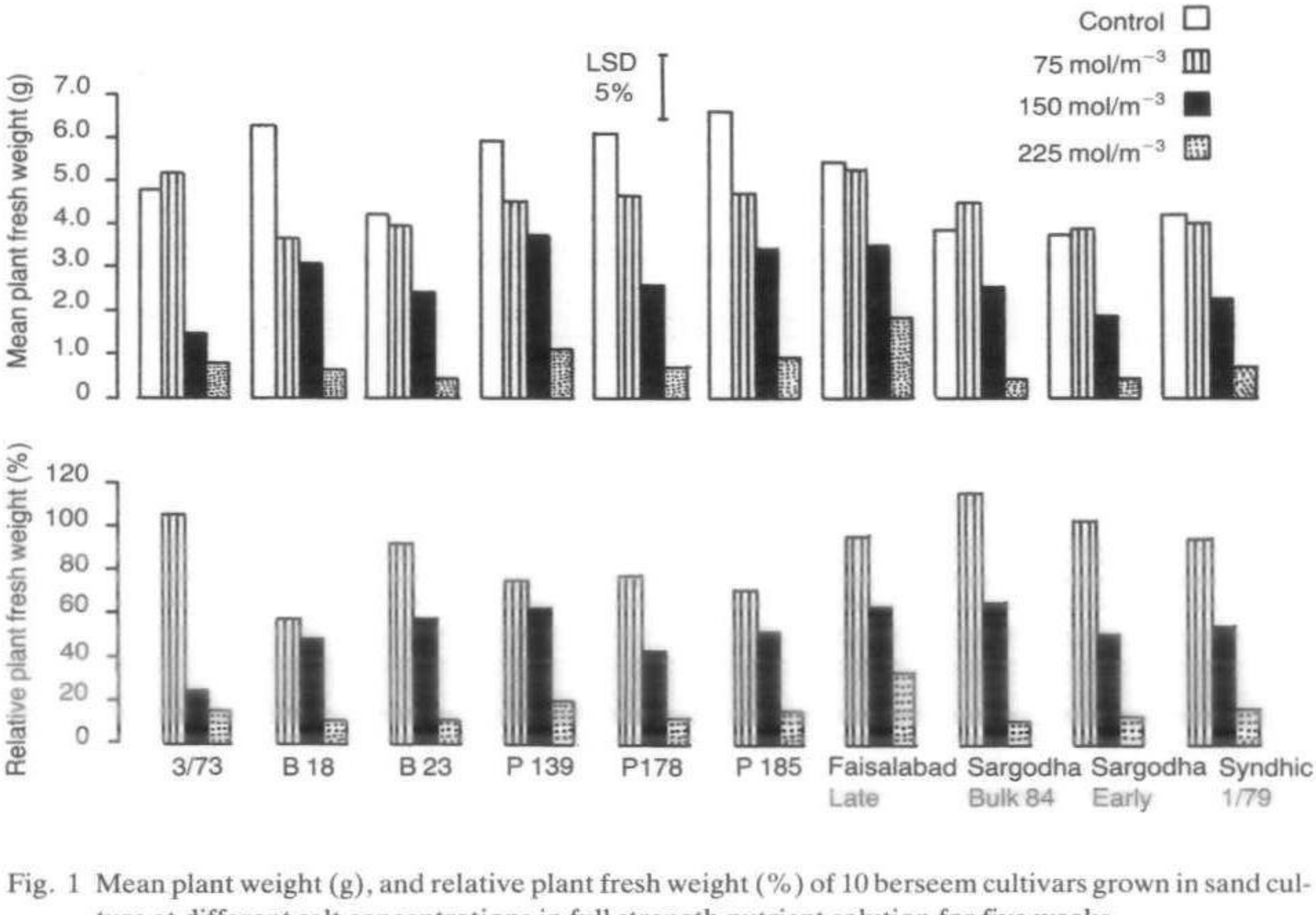

Fig. 1 Mean plant weight (g), and relative plant fresh weight (%) of 10 berseem cultivars grown in sand culture at different salt concentrations in full strength nutrient solution for five weeks.

3.2 Mean dry weight per plant

Although increasing salt concentration caused reduction in the absolute plant dry weight (Fig. 2) of all ten cultivars ($p \leq 0.001$), there were significant differences in absolute dry biomass of the different cultivars ($p \leq 0.05$). Faisalabad Late had consistently greater weight at all salt concentrations than the other cultivars, although this difference was statistically non-significant because of Cultivar X Concentration intercation being non-significant. Cvs B 18, B 23, Sargodha Bulk 84, and Sargodha Early had lower dry biomass than the other cultivars at the highest salt concentration.

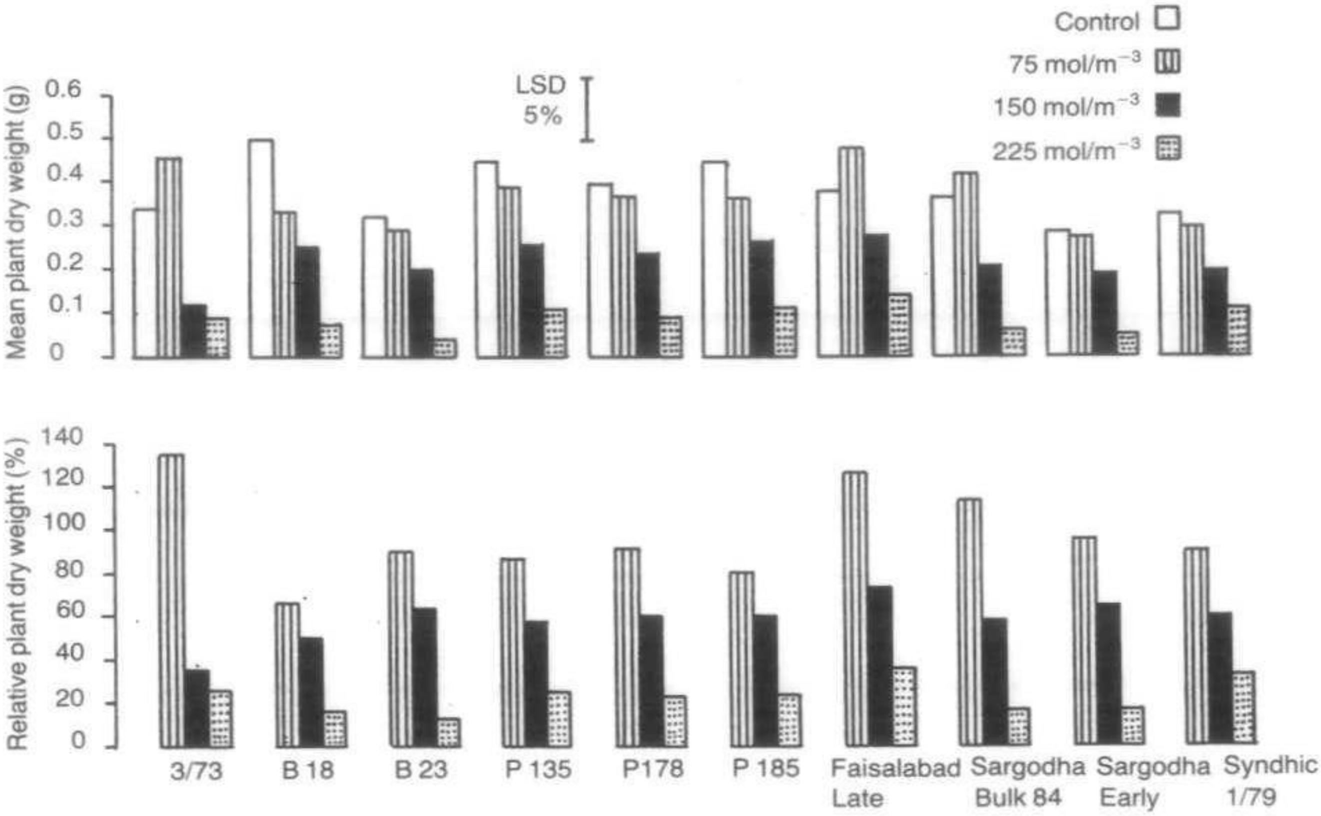

Fig. 2 Mean plant dry weight (g), and relative dry weight (%) of 10 berseem cultivars grown in sand culture at different salt concentrations in full strength nutrient solution for five weeks.

Relative dry weight data did not show any consistent difference between all the cultivars except in Faisalabad Late, which showed consistently better performance at all the salt concentrations.

3.3 Mean percent plant water content

The data for mean percent plant water content are given in Tab. 1. The increasing NaCl concentration significantly reduced plant water content in all cultivars ($p \leq 0.001$). Cultivars also differed significantly in response to increasing salt concentration ($p \leq 0.05$). Cultivar X Concentration interaction was non-significant.

Although statistically non-significant, cvs 3/73, B 23, P 139, P 178, P 185, Faisalabad Late, and Sargodha Early contained higher plant water content at the highest salt concentration than Sargodha Bulk 84. At the same concentration cvs Syndhic 1/79, and B 18 had almost same amount of water as in cv Sargodha Bulk 84. Cvs 3/73, and Sargodha Bulk 84 had lower plant water content than the other cultivars at 150 mol m^{-3} NaCl.

3.4 Ion content

Sodium: Sodium content of shoots and roots of the 10 berseem cultivars are presented in Tab. 3. Analysis of variance of the data showed that increasing NaCl concentration had significantly increased the Na^+ content in both shoots and roots in all the cultivars ($p \leq 0.001$). Cvs B 23, Faisalabad Late, and Sargodha Early contained significantly higher Na^+ content in the shoots at 75 mol m^{-3} NaCl than the other cultivars ($p \leq 0.05$). At 150 mol m^{-3} NaCl, cvs P 185, and Faisalabad Late had higher Na^+ content in the shoots than in the other cultivars. The root Na^+ contents in Faisalabad Late, P 139, B 18, and 3/73 were significantly greater than in the other cultivars at the highest NaCl concentration. The cultivars did not differ significantly for shoot Na^+ content at 225 mol m^{-3} NaCl.

In general Faisalabad Late had higher Na^+ content in both shoots and roots at all the NaCl concentrations as compared to the other cultivars. The other cultivars did not show any consistency in the Na^+ content with respect to the increasing salt concentration.

Chloride: The data for Cl^- content of different plant parts of the 10 berseem cultivars are presented in Tab. 4.

Cvs Sargodha Early, and P 178 had significantly greater shoot Cl^- content ($p \leq 0.05$) than in the other cultivars at 75 mol m^{-3}NaCl. By contrast Faisalabad Late had significantly greater root Cl^- content than in all the other cultivars except Syndhic 1/79. At 150 mol m^{-3} NaCl, cvs B 18, P 139, and Sargodha Early had higher shoot Cl^- than most of the other cultivars. At the same NaCl concentration, Faisalabad Late, and Sargodha Bulk 84 contained greater root Cl^- than in the other cultivars. Cvs 3/73 and Sargodha Early had the lower shoot Cl^- content and cvs B 18, and P 139 had greater Cl^- content than in the other cultivars at 225 mol m^- NaCl.

Potassium: Addition of NaCl in the rooting medium significantly affected ($p \leq 0.001$) the K^+ content of cvs Faisalabad Late, Syndhic 1/79, and B 18 reduced significantly at 75 mol m^{-3} NaCl as compared to their respective control values, but the shoot K^+ content of the other cultivars remained unaffected. The shoot K^+ content of cv 3/73 reduced about 38% at the highest salt level but this reduction was quite drastic in the other cultivars i.e. 49% in Sargodha Early and more than 50% in all the other cultivars. The cultivars differed significantly in root K^+ content at the control treatment but they did not differ significantly at any of the other salt treatments. Faisalabad Late was the least K^+ accumulator in the roots.

Calcium: The Ca^{2+} content (Tab. 6) in the shoots of cv 3/73 reduced as compared to its control, but the shoot content of all the other cultivars remained unaffected at 75 mol m^{-3} NaCl. In cvs B 18, P 139, P 185, Faisalabad Late, and Sargodha Early the shoot Ca^{2+} content was almost unaffected at the highest salt concentration. Similarly the root Ca^{2+} content of cvs 3/73, P 139, P 185, and Syndhic 1/79 remained unaffected at 225 mol m^{-3} NaCl.

Na^+/K^+ ratio: The shoot Na^+/K^+ ratio (Tab. 7) of B 18 and Syndhic 1/79 was lower at 150 and 225 mol m^{-3} NaCl than in the other cultivars. Cvs Faisalabad Late, and Sargodha Bulk 84 had greater root Na^+/K^+ ratio than in the other cultivars.

4 Discussion

The data for plant fresh weight and dry weight clearly show that a large amount of variation does exist, even within the small number of cultivars examined in this study. Cv Faisalabad Late had 2–3 times more fresh and dry biomass than the other cultivars at the highest salt concentration. This cultivar had a very consistent response at all the salt treatments. Cvs P 139, and P 185 also performed better than the other seven cultivars with respect to fresh and dry biomass. The other cultivars did not show any consistent correlation between the two indices, fresh and dry biomass e.g. Cv Syndhic 1/79 was comparatively moderate in fresh weight, but it was as good as Faisalabad Late in the relative dry weight data (33.33%) at the highest salt concentration).

From an exploitation viewpoint any cultivar which gives a high yield in saline soil would be of great value whether it has real tolerance or not. However, the cv Faisalabad Late showed comperatively better performance in both absolute terms, and relative biomass production.

In general the data for ion content do not show any clear correlation with the fresh and dry weight data for any of the cultivars examined. However the more tolerant cv Faisalabad Late had higher Na^+ content in both shoots and roots, and higher Cl^- content in the roots as compared to the other cultivars. The response of cv Faisalabad Late to saline environments may have been due to the accumulation of high concentrations of electrolytes and water to maintain its turgor (ELZAM and EPSTEIN, 1969; GREENWAY and MUNNS, 1980). The second highest biomass producing cvs P 139, and P 185 did not show any correlation between their ion content and biomass data.

The results for ion contents of different plant parts of the cultivars examined are less easy to explain, and may not be useful to use as selection criterion based on survival/whole plant performance seems appropriate to select for salt tolerance in berseem as already proposed for different crops by many workers (millet, ASHRAF and MCNEILLY, 1987:

wheat, KINGSBURY and EPSTEIN, 1984: and ASHRAF and MCNEILLY, unpublished data; tomato, RUSH and EPSTEIN, 1981; barley, EPSTEIN and NORLYN, 1977).

Our previous work on this crop (ASHRAF, MCNEILLY and BRADSHAW, 1987) and the present work clearly show that there is a lot of intra- and intervarietal genetic variation in this crop which can be exploited through conventional selection and breeding techniques to enhance its tolerance.

Cultivars such as Faisalabad Late could be of direct use in moderately saline soils, provided it has also considerable adaptation to other environmental factors, because an increase in yield of only 1% on saline soils could be worth millions of pounds. It is highly likely that screening a wide range of germplasm of this crop may provide even more tolerant cultivar/line than Faisalabad Late.

5 Summary

Salt tolerance of the ten berseem *(Trifolium alexandrinum)* cultivars 3/73, B 18, B 23, P 139, P 178, P 185, Faisalabad Late, Sargodha Bulk 84, Sargodha Early, and Syndhic 1/79 was assessed using a sand culture technique at different NaCl concentrations, after five weeks growth. Cvs Faisalabad Late, P 139, and P 185 produced greater fresh and dry biomass than the other cultivars. No consistent correlation was found between the biomass data and ion content of any of the cultivars examined, except Faisalabad Late which contained higher shoot and root Na^+ and higher root Cl^-, and also had a greater plant water content than in the other cultivars.

Since no clear pattern of ion distribution emerges for any of the cultivars, a selection criterion based on whole plant performance for assessment of salt tolerance in berseem is proposed.

Key words: Berseem, Salt tolerance, screening, *Trifolium alexandrinum, variability.*

Zusammenfassung

Die 10 Alexandrinerkleesorten *(Trifolium alexandrinum)*: 3/73, B 18, B 23, P 139, P 178, P 185, Faisalabad Late, Sargodha Bulk 84, Sargodha Early und Syndhic 1/79 wurden auf ihre Salztoleranz hin untersucht. Durchgeführt wurde dies nach der Sandkulturmethode (HEWITT, 1966) mit drei verschiedenen NaCl Konzentrationen (75, 150 und 225 mol m^{-3}), die Analyse erfolgte nach fünf Wochen Wachstum.

Die Sorten Faisalabad Late, P 139 und P 185 hatten einen höheren Frisch- und Trockenmassewert als die anderen Sorten.

Keine übereinstimmende Korrelation konnte zwischen den Biomassewerten und den Ionengehalten der untersuchten Sorten festgestellt werden, ausgenommen Faisalabad Late, die einen höheren Na-Gehalt im Stengel und Wurzel und einen höheren Gehalt an

Cl in den Wurzeln hatte. Ferner hatte diese Sorte einen höheren Wassergehalt als die anderen Sorten.

Da kein klares Muster der Ionenverteilung für eine der Sorten hervorgeht, wird ein Selektionskriterium ausgehend von der ganzen Pflanze für die Abschätzung von Salztoleranz bei Alexandrinerklee vorgeschlagen.

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Tab. 1: Mean percent plant water content (fresh weight basis) of 10 berseem cultivars grown in sand culture at different salt concentrations in full strength nutrient solution.

Cultivars	NaCl concentrations (mol m^{-3})			
	0 (control)	75	150	225
1. 3/73	85.90(2.54)*	81.89(1.89)	79.93(1.58)	79.15(2.32)
2. B 18	83.93(1.92)	82.31(2.56)	83.15(3.28)	75.79(1.68)
3. B 23	83.30(2.12)	85.01(0.78)	83.93(1.86)	84.14(3.20
4. P 139	85.14(3.11)	83.28(3.05)	86.34(2.46)	78.86(2.64)
5. P 178	86.95(1.19)	82.69(0.87)	81.39(0.82)	80.14(0.68)
6. P 185	86.14(2.67)	84.92(1.84)	84.29(1.78)	77.95(2.56)
7. Faisalabad Late	85.98(1.78)	81.55(2.14)	83.94(0.98)	82.15(2.42)
8. Sargodha Bulk 84	80.87(1.95)	81.64(0.68)	79.24(2.02)	71.19(3.68)
9. Sargodha Early	84.49(2.84)	85.29(2.34)	81.25(1.62)	77.71(1.21)
10. Syndhic 1/79	84.30(0.94)	85.06(1.65)	81.97(2.58)	74.00(1.46)
Cultivar × Concentration = N.S.				

* figures in parantheses are standard errors

Tab. 2: Analyses of variance of different growth paramenters of 10 cultivars of *Trifolium alexandrinum* L. grown in sand culture at different salt concentrations in half strength nutrient solution for five weeks.

		Fresh weight		Dry weight		Water content	
Source of Variation	Degrees of freedom	Mean squares	Probab.	Mean squares	Probab.	Mean squares	Probab.
Blocks	2	0.034	N.S.	0.0001	N.S.	15.40	N.S.
C	3	28.122	***	0.5860	***	238.41	***
V	9	0.908	**	0.0190	*	34.98	*
C × V	27	0.252	N.S.	0.0060	N.S.	13.70	N.S.
Residual	78	0.191		0.0070		14.96	

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq$; N.S. Not significant

Tab. 3: Mean Na^+ contents (mmol kg^{-1}) in dry shoot and root material of 10 berseem cultivars grown in sand culture at different NaCl concentrations in full strength nutrient solution for five weeks.

Cultivar	NaCl concentrations (mol m^{-3}) 0 (Control) Shoots	0 (Control) Roots	75 Shoots	75 Roots	150 Shoots	150 Roots	225 Shoots	225 Roots
1. 3/73	28.0(2.8) a*	92.0(3.1) d**	608.0(8.4) a	752.0(12.4)a	995.0(16.8) ab	880.0(13.8) ab	1524.0(24.7) a	824.0(11.7) a
2. B 18	64.0(3.2) a	56.0(2.3) d	608.0(7.4) a	536.0((7.6) b	940.0(14.7) ab	824.0(11.6) ab	1602.0(21.8) a	840.0(10.6) a
3. B 23	28.0(1.4) a	28.0(1.1) a	880.0(9.8) b	880.0(13.7) ac	920.0(12.8) a	892.0(15.8) a	1498.0(17.4) a	520.0(7.9) b
4. P 139	24.0(2.2) a	86.0(2.6) d	680.0(6.9) ac	724.0(9.8) ad	937.0(15.6) ab	746.0(9.8) ab	1566.0(24.2) a	840.0(13.5) a
5. P 178	22.0(1.8) a	56.0(1.9) d	680.0(7.1) ac	796.0(11.6) ac	876.0(18.7) a	896.0(10.7) a	1545.0(20.1) a	608.0(9.7) b
6. P 185	18.0(0.9) a	20.0(0.8) a	680.0(4.5) ac	724.0(10.8) ad	1015.0(21.3) ab	760.0(8.9) ab	1470.0(27.2) a	536.0(10.3) b
7. Faisalabad Late	64.0(3.8) d	56.0(2.7) d	908.0(11.4) b	926.0(14.7)c	1096.0(18.7) b	896.0(15.5) a	1634.0(25.7) a	968.0(12.6) a
8. Sargodha Bulk 84	28.0(1.1) a	80.0(2.9) d	536.0(6.2) a	692.0(9.6) a	945.0(16.3) ab	784.0(14.9 ab	1536.0(20.4) a	664.0(8.6) b
9. Sargodha Early	28.0(1.7) a	92.0(3.8) d	824.0(9.3) bc	608.0(8.6) b	879.0(11.9) a	806.0(12.5) ab	1621.0(26.6) a	536.0(7.9) b
10. Syndhic 1/79	56.0(2.9) d	89.0(3.8) d	680.0(7.4) ac	680.0(12.9) bd	860.0(13.7) a	736.0(9.2) b	1576.0(18.4) a	576.0(9.4) b

* Means followed by different letters are statistically different at $\alpha = 0.05$ by the Duncan's multiple range test.

** figures in parantheses are standard errors.

Tab. 4: Mean Cl^- contents (mmol kg^{-1}) in dry shoot and root material of 10 berseem cultivars grown in sand culture at different NaCl concentrations in full strength nutrient solution for five weeks.

Cultivars	NaCl concentrations (mol m^{-3}) 0 (Control) Shoots	0 (Control) Roots	75 Shoots	75 Roots	150 Shoots	150 Roots	225 Shoots	225 Roots
1. 3/73	17.1(2.1) a*	41.6(3.2) a**	612.0(13.2) a	397.0(6.3) a	1640.0(20.1) ab	528.7(8.6) a	2353.8(80.4) a	584.5(9.2) a
2. B 18	62.0(4.6) a	60.5(4.7) a	544.0(8.7) a	481.3(5.6) ab	1805.4(27.6) a	681.6(7.2) a	2888.0(82.4) bc	800.1(10.6) b
3. B 23	41.2(4.1) a	66.1(5.3) a	614.4(9.4) a	580.6(8.7) b	1514.2(28.9) ab	597.8(11.1) a	3142.1(115.6) b	568.7(8.7) ac
4. P 139	67.0(5.2) a	81.3(4.8) a	734.8(5.4) ab	467.0(6.3) ab	1830.0(45.8) a	705.6(12.2) a	2696.3(96.6) c	822.8(11.4) b
5. P 178	59.3(3.4) a	83.1(5.9) a	974.0(12.2) b	660.4(8.7) b	1782.3(41.2) a	725.0(9.2) a	2991.0(105.8) bc	645.9(7.8) ab
6. P 185	15.4(2.2) a	47.5(3.2) a	530.4(10.6) a	629.0(9.0) b	1639.0(29.9) ab	667.2(8.7) a	2704.0(112.8) c	660.5(12.7) ab
7. Faisalabad Late	20.3(1.8) a	52.5(2.8) a	542.5(8.7) a	869.2(12.3) c	1609.1(18.5) ab	807.3(10.2) b	2840.0(88.1) bc	642.4(18.3) ab
8. Sargodha Bulk 84	81.9(3.99) a	13.9(0.7) a	653.3(12.1) a	623.2(11.9) b	1414.9(21.2) b	816.2(11.6) b	2691.8(72.9) c	642.7(15.1) ab
9. Sargodha Early	40.7(2.7) a	86.0(4.3) a	1036.0(16.1) b	561.3(8.1) b	1937.5(34.7) a	714.0(8.9) a	2413.9(74.1) ac	403.0(8.8) c
10. Syndhic 1/79	82.0(4.1) a	92.3(6.1) a	660.6(12.9) a	735.8(7.5) bc	1526.9(26.6) ab	763.2(10.2) a	2779.0(92.7) bc	594.8(9.2) a

* Means followed by different letters are statistically different at $\alpha = 0.05$ by the Duncan's multiple range test.

** figures in parantheses are standard errors.

Tab. 5 Mean K^+ contents (mmol kg^{-1}) in dry shoot and root material of 10 berseem cultivars grown in sand culture at different NaCl concentrations in full strength nutrient solution for five weeks.

Cultivars	NaCl concentrations (mol m^{-3})							
	0 (Control)		75		150		225	
	Shoots	Roots	Shoots	Roots	Shoots	Roots	Shoots	Roots
1. 3/73	796.0(12.6) a*	856.0(21.8) ab**	796.0(32.1) a	424.0(8.2) a	516.0(11.1) a	424.0(16.7) a	500.0(21.1) a	192.0(9.2) a
2. B 18	1232.0(86.4) b	836.0(42.2) ab	988.0(39.2) ab	368.0(22.1) a	868.0(21.5) bc	328.0(12.6) a	516.0(18.9) a	220.0(6.5) a
3. B 23	1040.0(55.6) ab	708.0(25.9) ab	1132.0(75.3) b	424.0(12.2) a	672.0(15.6) abc	404.0(18.1) a	480.0(12.6) a	120.0(22.2) a
4. P 139	1132.0(44.2) b	836.0(36.5) ab	1172.0(81.1) b	384.0(8.7) a	852.0(21.7) bc	404.0(23.2) a	568.0(19.6) a	212.0(13.7) a
5. P 178	1112.0(35.7) b	796.0(32.3) ab	1172.0(54.2) b	480.0(15.1) a	796.0(22.9) bc	440.0(11.2) a	424.0(12.7) a	160.0(12.1) a
6. P 185	1092.0(38.3) b	968.0(46.1) a	1092.0(41.4) ab	480.0(23.7) a	724.0(18.2) abc	460.0(15.2) a	424.0(13.5) a	180.0(9.2) a
7. Faisalabad Late	1212.0(58.2) b	652.0(12.2) b	1096.0(42.7) ab	440.0(24.5) a	572.0(9.7) a	384.0(18.1) a	436.0(29.1) a	184.0(11.2) a
8. Sargodha Bulk 84	1060.0(61.2) ab	762.0(23.6) ab	1004.0(50.5) ab	460.0(18.1) a	700.0(23.9) abc	368.0(10.2) a	404.0(17.2) a	120.0(6.7) a
9. Sargodha Early	968.0(26.8) ab	744.0(28.3) ab	1076.0(41.8) ab	424.0(21.0) a	572.0(15.6) a	500.0(19.1) a	500.0(22.8) a	160.0(5.9) a
10. Syndhic 1/79	1252.0(44.8) b	836.0(30.1) ab	960.0(49.0) ab	500.0(9.2) a	952.0(42.5) c	368.0(11.2) a	572.0(26.3) a	140.0(8.7) a

* Means followed by different letters are statistically different at $\alpha = 0.05$ by the Duncan's multiple range test.

** figures in parantheses are standard errors.

Tab. 6: Mean Ca^{2+} contents (mmol kg^{-1}) in dry shoot and root material of 10 berseem cultivars grown in sand culture at different NaCl concentrations in full strength nutrient solution for five weeks.

Cultivars	NaCl concentrations (mol m^{-3})							
	0 (Control)		75		150		225	
	Shoots	Roots	Shoots	Roots	Shoots	Roots	Shoots	Roots
1. 3/73	560.0(28.7) a*	310.0(8.7) ab**	490.0(9.2) a	410.0(21.2) a	380.0(23.2) a	360.0(23.2) a	330.0(19.1) a	340.0(20.2) ab
2. B 18	450.0(18.8) a	300.0(10.1) ab	580.0(12.3) ab	340.0(18.2) ab	580.0(20.6) b	300.0(1832) ab	400.0(21.2) a	260.0(7.8) a
3. B 23	540.0(30.1) a	320.0(12.6) ab	530.0(13.2) ab	320.0(13.6) ab	500.0(18.7) ab	300.0(23.6) ab	340.0(18.1) a	270.0(16.5) a
4. P 139	530.0(24.6) a	250.0(6.8) a	640.0(6.8) b	280.0(12.1) b	520.0(23.2) b	320.0(26.1) ab	570.0(12.6) b	340.0(12.6) ab
5. P 178	530.0(15.7) a	370.0(8.6) b	576.0(21.6) ab	310.0(21.2) ab	510.0(30.2) b	300.0(9.2) ab	410.0(21.2) a	270.0(13.7) a
6. P 185	480.0(18.6) a	390.0(5.7) b	590.0(24.8) ab	270.0(19.2) b	610.0(34.1) b	380.0(8.1) a	410.0(22.6) a	400.0(19.6) b
7. Faisalabad Late	576.0(23.2) a	360.0(9.9) b	590.0(15.6) ab	270.0(19.2) b	420.0(22.6) a	350.0(9.6) ab	550.0(18.6) b	260.0(12.7) a
8. Sargodha Bulk 84	550.0(18.9) a	350.0(8.6) b	610.0(30.1) ab	300.0(12.2) b	600.0(18.7) b	360.0(21.2) a	370.0(19.2) a	250.0(13.6) a
9. Sargodha Early	480.0(14.1) a	380.0(12.1) b	500.0(22.8) a	410.0(19.2) a	470.0(19.2) ab	250.0(1539) b	430.0(23.9) a	290.0(11.6) a
10. Syndhic 1/79	520.0(21.8) a	230.0(7.6) a	530.0(15.7) b	230.0(6.6) b	460.0(24.1) ab	250.0(18.7) b	430.0(12.2) a	290.0(12.6) a

* Means followed by different letters are statistically different at $\alpha = 0.05$ by the Duncan's multiple range test.

** figures in parantheses are standard errors.

Tab. 7: Mean Na^+/K^+ ratio of shoots and roots of 10 berseem cultivars grown in sand culture at different salt concentrations in full strength nutrient solution for five weeks.

Cultivars	NaCl concentrations ($mol\ m^{-3}$) 0 (Control)		75		150		225	
	Shoots	Roots	Shoots	Roots	Shoots	Roots	Shoots	Roots
1. 3/73	0.04 a*	0.11 a	0.76 a	1.87 a	1.93 a	2.08 a	3.05 a	4.29 ab
2. B 18	0.05 a	0.07 a	0.62 a	1.46 a	1.08 a	2.51 a	3.10 a	3.81 ab
3. B 23	0.03 a	0.04 a	0.78 a	2.08 a	1.37 a	2.21 a	3.12 a	4.30 ab
4. P 139	0.02 a	0.10 a	0.58 a	1.89 a	1.10 a	1.85 a	2.76 b	3.96 ab
5. P 178	0.02 a	0.07 a	0.58 a	1.66 a	1.10 a	2.04 a	3.63 a	3.80 ab
6. P 185	0.02 a	0.02 a	0.62 a	1.51 a	1.40 a	1.65 a	3.47 a	2.98 b
7. Faisalabad Late	0.05 a	0.09 a	0.82 a	2.10 a	1.92 a	2.33 a	3.75 a	5.26 ab
8. Sargodha Bulk 84	0.03 a	0.08 a	0.53 a	1.50 a	1.33 a	2.13 a	3.80 a	5.53 a
9. Sargodha Early	0.03 a	0.12 a	0.77 a	1.43 a	1.54 a	1.61 a	3.24 a	3.35 b
10. Syndhic 1/79	0.04 a	0.11 a	0.71 a	1.36 a	0.90 b	2.00 a	2.76 b	4.11 ab

* Means followed by different letters are statistically different at $\alpha = 0.05$ by the Duncan's multiple range test.