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Growth and Ionic Relations of Six Triticale Cultivars as Affected by Salinity

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Abstract. Growth and ionic relations were studied in six triticale cultivars of different geographical origins grown in a greenhouse in nutrient solution with or without the addition of 100 mM NaCl. In 21 d old plants of all the six cultivars growth was little affected in the salt treatment, whereas in the subsequent three harvests during vegetative phase (after 31, 38 and 45 d), growth reduction effects of salinity were progressively pronounced. Generally, shoots of all the six cultivars accumulated relatively more K^+ as compared to Na^+ or Cl^-. Differential accumulation of K^+, Na^+ and Cl^- by various cultivars was coupled with variable rates of Na^+ and Cl^- transport from root to shoot which were – to some extent – related to cultivar differences in growth in saline root media. Chloride content of shoots of the six cultivars was negatively correlated with the relative growth reduction due to salinity at the four harvests.

Triticale (× *Triticosecale* WITTMACK), a cross between the genera *Triticum* and *Secale* is recognized as the first successful 'man-made' cereal. Since it combines yield and other critical characteristics equal or superior to those of wheat with the tolerance of drought and poor soil and resistance to disease typical of rye, it may occupy a very important place in marginal agricultural environments. Higher grain yields of triticale compared to those of wheat have been reported by many authors in different regions, *e.g.* in Mexico (WOLF 1976), in Australia (BROUWER 1977), in Pakistan (TAHIR 1978).

The drought resistance of triticale has been studied by various workers (FISCHER and MAURER 1978, SUTTON and DUBBELDE 1980). However, the response of triticale to salinity has not been so extensively studied and reported in the literature. The effect of various concentrations of different salts on germination has been reported by SZABO (1972) and the effects of soil salinity on growth and content of nitrogen, chloride and phosphate have been reported by MASHHADY *et al.* (1982), NORLYN and EPSTEIN (1984) and TOURAINE and AMMAR (1985). In the present study, six cultivars of triticale from different geographical regions were surveyed for growth responses and K^+, Na^+ and Cl^- contents throughout seedling growth in 1/2 Hoagland solution without or with 100 mM NaCl in the root medium.

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MATERIALS AND METHODS

The following six cultivars of triticale were used:

A — Drira (Mexico)
B — 8-A-432 (China)
C — AT-7-76 (Australia)
D — 634-3-113 (France)
E — A-689 (Mexico)
F — 2038 (Canada)

Seedlings of all cultivars were germinated and raised in control 1/2 Hoagland solution (*cf.* SALIM and PITMAN 1983 for details). Five-day-old seedlings were transferred to plastic buckets containing 9 l of continuously aerated control solution. Four seedlings were held with polythene foam plugs through formica sheet lid in each bucket. When the seedlings were 15 d old, salinization was started with 10 mM NaCl after every 3 h and a maximum of 50 mM NaCl in 24 h. Thus the salt treatment of 100 mM NaCl was complete when the plants were 16 d old. Twenty four seedlings of each cultivar were grown in 6 buckets in control solution and at each salt level. Four harvests, 6 plants of each cultivar at each salt level, were taken when the plants were 21, 31, 38 and 45 d old. The final harvest was taken just before the booting stage.

The experiment was conducted in a glasshouse under day/night temperature of 22 °C to 28 °C/19 °C to 23 °C, and mean relative humidity of 35 % /90 %. Irradiance varied during the day from 300 to 1400 μmol m^{-2}s^{-1}. The nutrient solutions were completely changed after every 7 d in all the treatments.

At each harvest, fresh and dry (80 °C for 74 h) masses of shoots and roots were determined, the root samples being washed in distilled water for 30 s to remove surface contaminations and blotted. For inorganic analyses, dried samples were digested with boiling 1 M HNO_3 followed by two extractions

TABLE 1

Dry matter [g per plant] of six triticale cultivars grown in nutrient solutions without and with 100 mM NaCl at three harvests (21, 31 and 38 d old, plants)

Cultivar	NaCl in root medium [mM]	Plant age [d]		
		21	31	38
A	0	0.50	1.94	4.17
	100	0.59	1.57	3.13
B	0	0.64	2.64	6.31
	100	0.53	1.71	3.34
C	0	0.44	1.83	4.31
	100	0.45	1.42	2.94
D	0	0.34	1.65	3.40
	100	0.36	0.88	2.17
E	0	0.69	3.03	5.74
	100	0.57	2.00	3.50
F	0	0.46	1.92	4.54
	100	0.52	1.27	2.62

TABLE 2

Growth responses of six cultivars of triticale grown in nutrient solutions without and with 100 mM NaCl at harvest 4 (45 d old plants)

Cultivar	NaCl in root medium [mM]	Plant dry matter [g per plant]	Shoot FM/DM	Root FM/DM	Shoot DM/ root DM
A	0	16.28 ± 1.34	8.9 ± 0.73	21.9 ± 2.13	2.18 ± 0.22
	100	8.23 ± 0.77	6.4 ± 0.58	19.2 ± 1.97	1.37 ± 0.11
B	0	18.33 ± 0.97	8.4 ± 0.70	20.8 ± 2.35	1.90 ± 0.17
	100	10.09 ± 0.46	6.5 ± 0.61	20.0 ± 1.77	1.19 ± 0.09
C	0	13.84 ± 0.81	7.5 ± 0.47	22.0 ± 1.69	1.59 ± 0.14
	100	7.50 ± 0.93	5.9 ± 0.49	21.5 ± 1.88	1.26 ± 0.08
D	0	12.62 ± 1.39	9.2 ± 1.11	23.2 ± 2.61	1.92 ± 0.17
	100	7.69 ± 0.67	6.4 ± 0.70	20.2 ± 2.20	1.02 ± 0.07
E	0	18.26 ± 1.17	8.8 ± 0.78	20.7 ± 1.73	2.27 ± 0.32
	100	11.96 ± 1.81	6.3 ± 0.55	19.9 ± 1.58	1.02 ± 0.16
F	0	12.85 ± 1.40	8.1 ± 0.39	22.6 ± 2.07	1.93 ± 0.22
	100	6.96 ± 0.21	5.5 ± 0.28	18.6 ± 1.88	1.49 ± 0.08

with boiling distilled water. In this extract, K^+, Na^+, Ca^{++} and Mg^{++} were determined by atomic absorption spectrophotometry, and Cl^- by coulombic titration (see SALIM and PITMAN 1983 for details).

RESULTS AND DISCUSSION

At the first harvest, in some cultivars slight improvement in growth was observed in 100 mM NaCl treatment whereas in others there was no effect of salt application in root media on plant growth (Table 1). Slight plant growth improvements with relatively low salt concentration in the root media have also been reported by GREENWAY and MUNNS (1980). However, the growth retarding effects of 100 mM NaCl could be observed in the second harvest and was more pronounced in the third harvest (Table 1). The fourth

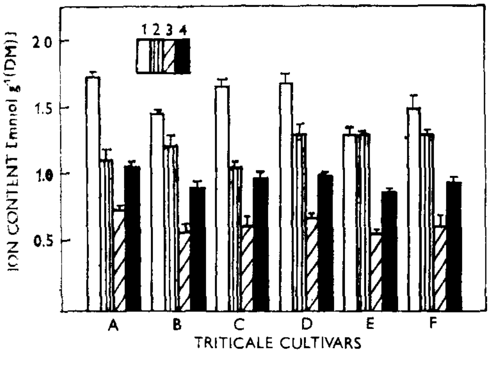

Fig. 1. Content of K^+, Na^+ and Cl^- in shoots of the six triticale cultivars at harvest 4 (45 d old plants). The column 1 represents K^+ content in controls whereas bars 2, 3 and 4 represent K^+, Na^+ and Cl^- contents of 100 mM NaCl grown-plants, respectively.

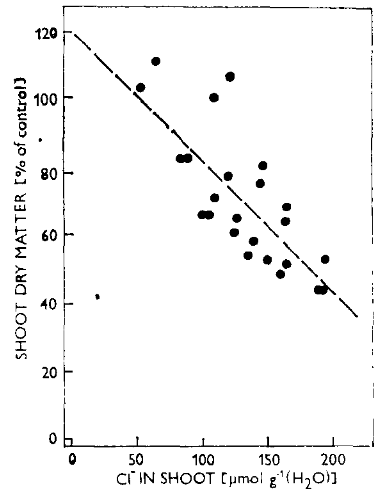

Fig. 2. Relationship between chloride concentration in shoots and shoot dry matter expressed as % of control ($r = -0.761$). Data for the six triticale cultivars.

harvest of the 45-d old plants was made before the booting stage. The plants had developed the maximum number of tillers which was significantly larger in the control plants as compared to those in 100 mM NaCl grown plants. Plant dry matter yields at 100 mM NaCl treatment ranged from 50 % to 65 % of the control plant yield (Table 2). Salinity level of around 100 mM NaCl (electrical conductivity of root zone solution = 1.3 S m^{-1}) appears to be the salt tolerance limit of some cultivars studied, which is close to the salt tolerance limits of some cultivars of wheat (QURESHI *et al.* 1980). The yield of cv. A-689 (Mexico) at 100 mM NaCl (11.96 g per plant) was the highest among the six cultivars indicating its highest salt tolerance. Such differential salt tolerances of cultivars of other cereals, like barley and wheat, have also been reported (GREENWAY 1965, STOREY and WYN JONES 1978, QURESHI *et al.* 1980).

A decreased fresh/dry matter ratio in shoots and a decreased shoot/root ratio was found in 100 mM NaCl treatment (Table 2) which is a typical response of glycophytes to salinity (GREENWAY and MUNNS 1980). However,

TABLE 3

Rates of net Na^+ and Cl^- transport from root to shoot of six triticale cultivars grown under 100 mM NaCl. Values are averages and standard mean errors for the rates of net transport between all harvests

Cultivar	Rate of net transport [μmol g^{-1} (root FM) h^{-1}]	
	Na^+	Cl^-
A	0.60 ± 0.05	0.87 ± 0.11
B	0.45 ± 0.06	0.71 ± 0.08
C	0.54 ± 0.04	0.75 ± 0.08
D	0.53 ± 0.05	0.80 ± 0.07
E	0.40 ± 0.05	0.65 ± 0.06
F	0.61 ± 0 07	0.89 ± 0.10

the fresh/dry matter ratios of roots remained unchanged with salinity as reported for mung bean by SALIM and PITMAN (1983). Relative growth rates (RGR) between the four harvests seemed to vary in different cultivars but the differences were insignificant. In general, RGR for control plants ranged between 0.12 to 0.14 g g^{-1} d^{-1} and for 100 mM NaCl grown plants between 0.08 to 0.10 g g^{-1} d^{-1} between the four harvests of various cultivars. However, for both control and salt grown plants RGR gradually decreased with the age of plants due to plant development (SALIM and PITMAN 1983).

Some differences in various ion contents (K^+, Na^+, Ca^{2+}, Mg^{2+}, Cl^-) in root and shoot samples of the six cultivars at the four harvests were observed. However, data on K^+, Na^+ and Cl^- are more important for discussion (Fig. 1). Potassium was the principal cation in the control plant shoots in all cultivars. However, cultivars B and E had the lowest K^+ contents but both these cultivars had the highest plant dry matter yields (Table 2, above). Rather low K^+ contents of these two cultivars may have been partly due to the growth dilution effect (GREENWAY and MUNNS 1980). When root zone solution contained 100 mM NaCl, K^+ in plant shoots decreased with exception of cultivar E. Na^+ contents of shoots of the six cultivars were lower than the respective K^+ contents. In fact in cultivars B, E and F, shoot Na^+ contents were around 50 % of the K^+ contents of shoot whereas in the root medium the ratio of Na : K concentrations was 20 : 1. This high selectivity of K^+ in cereal shoots is an important physiological mechanism for plant survival in saline environment (WYN JONES *et al.* 1979). In cultivars B and E, Na^+ contents of shoot were the lowest among the six cultivars which were presumably due to low rates of net Na^+ transport from roots to shoots (Table 3). Similarly among the six cultivars the lowest shoot Cl^- content of cultivar E was associated with the lowest net rates of Cl^- transport from shoot to root.

In 100 mM Na Cl grown plants Cl^- concentration in shoot tissue water in all cultivars at the four harvests was negatively linearly correlated ($r = -0.761$) with dry matter expressed as % of the control. This clearly indicates the significant plant growth retarding effects of Cl^- load in plant shoots and supports the earlier report of SALIM and PITMAN (1983) on mung bean.

Data discussed above indicate the existence of differential salt tolerance in different triticale cultivars of different origins like in many other plant species. In general, different triticale cultivars are as salt tolerant as some cultivars of wheat. The cultivar A 689 proved to be the best biomass yielding in saline root media followed by the cultivar 8-A-432. Comparatively higher salt tolerance of these two cultivars seemed to be due to relatively higher K^+ selectivity against Na^+ in their shoot and their ability to control Na^+ and Cl^- flows.

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BOOK REVIEW

ELAGIN, I. N. (ed.): PRODUKTIVNOST' LESNYKH FITOTSENOZOV. [PRODUCTIVITY OF FOREST PHYTOCOENOSES.] — Institut Lesa i Drevesiny sib. Otd. Akad. Nauk SSSR, Krasnoyarsk 1984. 149 pp. Rbl. 0.55. [In Russian].

The paperback booklet contains 15 articles in which the structure, growth and productivity of forest phytocoenoses including the lower forest strata are investigated. Stands of different ages and various tree composition (mainly *Pinus, Picea, Betula, Larix, Cedrus*) at diverse localities, the effects of climatic and soil factors and burning of forests on productivity, and on the mineral composition of biomass are studied. Mushroom variety and productivity in artificial coenoses of different tree composition are described.

Individual articles are illustrated, contain a lot of tables and lists of references. The booklet is written only in Russian without any foreign-language abstracts or summaries. It is of interest to research workers in forestry, forest production, geobotany and ecology.

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