BRIEF COMMUNICATION

Salinity tolerance in different cultivars of barley (*Hordeum vulgare* L.)

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Abstract

Seven barley (*Hordeum vulgare* L.) cultivars tested varied greatly in their responses to root medium salinity (electrical conductivity of 3, 5, 10, 15 and 20 dS m^{-1}). Plant growth was relatively more adversely affected than seed germination. Dry/fresh mass ratio increased at higher salinity levels in all barley cultivars indicating reduced water uptake. Higher K/Na ratio in plant shoots compared to that in the root medium solution indicated selective uptake of K that seems to be among processes involved in tolerance of cultivars to salinity stress.

Barley is known to be salt tolerant crop (*e.g.* Norlyn and Epstein 1982), however large variation exists among its cultivars (Bhatti *et al.* 1976). The purpose of the present study was to screen germplasm of barley collected from arid and semi-arid areas of Pakistan for salt tolerance.

The effect of different salinity levels [electrical conductivity (E.C.): 3, 5, 10, 15 and 20 dS m^{-1}] on seed germination and growth of seven barley cultivars (Table 1) was studied. Salinity levels of 5 to 20 dS m^{-1} were prepared by the addition of Na_2SO_4, $CaCl_2$, $MgCl_2$, and NaCl in ratio of 10:5:1:4 on equivalent basis (Qureshi *et al.* 1977) to the Hoagland nutrient solution (Arnon and Hoagland 1940) with E.C. of 3 dS m^{-1} used as control. Ten seeds of each cultivar were placed in Petri dishes on filter paper soaked with 5 ml of respective solution, three replicates per treatment.

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Petri dishes were sealed with parafilm and covered with black muslin cloth to avoid evaporation and light. A seed was considered to have germinated when both radicle and plumule had emerged. Percentage of germinated seeds was recorded daily over a period of ten days.

Five seedlings of each barley cultivar, already grown in sand for a week, were transplanted in cement tanks filled with gravel saturated with nutrient solution. One week later, the plants were subjected to salinity levels of 5, 10, 15 and 20 dS m^{-1} by step-wise increases of 2.5 dS m^{-1} every alternate day. The salinity levels were maintained and the solutions were recirculated intermittently for aeration and uniform distribution of salts in the medium. The solutions were completely replaced every two weeks to replenish the nutrient supply. The plants were harvested after 20 weeks at flag leaf stage. Dry mass of plants was recorded. Plant shoots were analysed for Na and K on a flame photometer following wet digestion.

Table 1. Effect of salinity on seed germination [%] of different cultivars of barley

Cultivar	Salinity level [dS m^{-1}] 3	5	10	15	20
PK-30064	76 a	63 a	73 ab	53 a	30 a
PK-30157	73 a	73 a	73 ab	63 ab	70 b
PK-30073	75 a	93 bc	76 ab	73 b	66 b
PK-30082	100 b	100 c	100 c	93 c	90 c
PK-30127	100 b	96 c	80 b	73 b	66 b
PK-30121	100 b	75 ab	75 ab	66 ab	53 b
PK-30112	73 a	60 a	60 a	60 ab	60 b

Values in a column sharing the same letter are not statistically significant.

The seed germination percentage was slightly affected up to salinity level of 10 dS m^{-1}. With further increase in salinity, the germination percentage of all cultivars, except PK-30157 and PK-30112, decreased gradually. The cultivar PK-30082 showed higher germination percentage at each salinity level compared with respective values for other cultivars (Table 1). Reduction in germination due to salinity is known in many species. However, ranking of species or cultivars considering their germination responses only may be misleading as tolerance may increase at later growth stages (Torello and Symington 1984). Further, salinity affects germination and growth differently (Francois *et al.* 1984). Therefore, long-term growth studies are necessary to evaluate species or cultivars for salt tolerance.

Dry mass of each cultivar was little affected by 5 dS m^{-1} level but decreased gradually with further increase in root medium salinity. Dry mass of different cultivars decreased to 24-58 % when salinity increased from 3 to 20 dS m^{-1} (Table 2). The salt tolerance limits (salinity levels causing 50 % yield reduction) for these cultivars ranged from 12.5 to 18.9 dS m^{-1} for green mass yield. For dry mass, 50 % reduction in yield of cultivar PK-30064 was not recorded even at 20 dS m^{-1}

level whereas for other cultivars it ranged from 13.2 to 20 dS m^{-1}. These differences in salt tolerance are likely because of variations in water content of cultivars.

Table 2. Effect of salinity on dry mass yield [g $plant^{-1}$] and dry/fresh mass ratios in shoots of barley cultivars

Cultivar	Salinity level [dS m^{-1}] 3	5	10	15	20
PK-30064	12.3 ab	15.9 ab	8.9 ab	9.1 a	7.2 a
	(0.09)	(0.09)	(0.09)	(0.10)	(0.12)
PK-30157	17.4 ab	16.5 b	21.0 d	16.5 b	8.8 a
	(0.09)	(0.10)	(0.12)	(0.13)	(0.15)
PK-30073	17.3 ab	19.0 b	14.4 bc	12.8 ab	7.4a
	(0.10)	(0.10)	(0.12)	(0.11)	(0.13)
PK-30082	18.4 b	19.5 bc	10.2 ab	11.6 ab	5.7 a
	(0.12)	(0.11)	(0.11)	(0.12)	(0.13)
PK-30127	11.6 a	8.8 a	8.0 a	10.0 a	4.1 a
	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)
PK-30121	26.5 c	25.5 c	19.5 cd	16.3 b	6.3 a
	(0.12)	(0.12)	(0.14)	(0.15)	(0.16)
PK-30112	16.5 ab	17.3 b	10.0 ab	7.4 a	4.0 a
	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)

The values sharing same letters in a column are not significantly different. Values in parentheses are dry/fresh mass ratios.

The dry/fresh mass ratio is a measure of water uptake; the ratio being inversely related to water content (Naidoo 1985). Dry/fresh mass ratios for different cultivars were little affected up to 15 dS m^{-1} level whereas they increased slightly at higher salinity (Table 2). Moreover, these ratios were not affected to the same extent for different cultivars indicating variations in their ability for water uptake and osmotic adjustment under saline conditions.

The sodium concentrations were significantly higher in saline treatments compared to control for each cultivar and were of the order about ten-fold at the 20 dS m^{-1} salinity level (Table 3). It may be noted that sodium concentrations were relatively lower in more salt tolerant cultivars than in those low in tolerance. However, no consistent relationship existed between sodium concentrations and tolerance limits of the cultivars.

Potassium concentrations decreased 2 to 3 times as the root medium salinity increased from 3 to 20 dS m^{-1}. The cultivars differed significantly in their potassium concentrations except at 20 dS m^{-1} level (Table 3). The K/Na ratios in shoots of barley cultivars decreased with increasing salinity. K/Na ratios in plant tissue were always higher than those in respective external solutions indicating selective uptake of K over Na. Such selectivity for K over Na has been reported for other species (Bhatti *et al.* 1983, Mahmood and Malik 1987). Highly salt tolerant species (halophytes) are capable of K uptake even though Na/K ratio in the external solution may be higher than 100 (Black 1960) and K in the tissue is not depressed beyond minimal level. Selective K uptake seems one of the processes helping the cultivars tolerate salinity stress.

Table 3. Sodium and potassium concentrations and K/Na ratios in shoots of different barley cultivars grown at different salinity levels.

	Cultivar	Salinity level [dS m^{-1}] 3	5	10	15	20
Sodium concentration [mg g^{-1}]	PK-30064	0.203 a	1.10 a	1.73 bc	1.81 ab	1.86 a
	PK-30157	0.263 a	1.26 ab	1.58 ab	1.86 abc	2.55 cd
	PK-30073	0.215 a	1.33 ab	1.81 bc	1.98 bc	2.24 b
	PK-30082	0.215 a	1.26 ab	1.78 bc	1.96 bc	2.24 b
	PK-30127	0.274 a	1 43 b	1.72 bc	2.28 d	2.64 d
	PK-30121	0.262 a	1.15 a	1.36 a	1.63 a	2.21 b
	PK-30112	0.215 a	1.25 ab	1.89 c	2.11 cd	2.34 bc
Potassium concentration [mg g^{-1}]	PK-30064	1.87 c	1.65 c	1.17 b	0.98 b	0.68 a
		(9.24)	(1.50)	(0.68)	(0.54)	(0.37)
	PK-30157	1.82 bc	1.27 a	1.04 ab	0.84 ab	0.69 a
		(6.90)	(1.00)	(0.66)	(0.45)	(0.27)
	PK-30073	1.88 c	1.45 abc	0.90 a	0.87 ab	0.67 a
		(8.80)	(1.09)	(0.50)	(0.44)	(0.30)
	PK-30082	1.85 bc	1.37 ab	0.92 a	0.89 ab	0.70 a
		(8.63)	(1.09)	(0.52)	(0.45)	(0.31)
	PK-30127	1.83 bc	1.53 bc	1.04 ab	0.92 ab	0.79 a
		(6.66)	(1.07)	(0.61)	(0.41)	(0.30)
	PK-30121	1.54 a	1.27 a	0.83 a	0.73 a	0.64 a
		(5.88)	(1.11)	(0.61)	(0.45)	(0.29)
	PK-30112	1.65 ab	1.34 ab	0.87 a	0.80 ab	0.67 a
		(7.67)	(1.10)	(0.46)	(0.38)	(0.29)
K/Na in solution		(10.09)	(0.23)	(0.11)	(0.08)	(0.06)

The values followed by the same letters in a column are not significantly different. Values given in parentheses are K/Na ratios.

The present studies have shown that most of the tested cultivars are reasonably tolerant to salinity with tolerance limits above 15 dS m^{-1}. These cultivars may be grown on marginal soils or be used as secondary colonizers in plant succession scheme (Sandhu and Malik 1975) for economical utilization of salt-affected lands. Further, this germplasm offers wide genetic variability which could be used in programme of breeding for salt tolerance.

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