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EFFECTS OF SODIUM CHLORIDE ON THE GROWTH AND ION CONTENT OF BARLEY

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Abstract. The effect of five concentrations of NaCl (0.05, 0.1, 0.3, 0.5 and 1.0%) on the growth of three varieties of barley, Nos. FAO 11941, FAO 11940 and 3329, were studied. High concentration of NaCl depressed seed germination in all the three varieties. Germination was depressed about 56% in No. 3329, 98% in No. 11940, and no seeds germinated in No. 11941. The 2nd and the 3rd leaves in plants in No. 3329 appeared ahead of those in No. 11941 and No. 11940.

Dry weights of tops in all the varieties decreased in high concentration of NaCl such that the dry weights were little different from each other. Dry weights of roots in Nos. 11941 and 3329 decreased at high salt concentration while there was little effect in No. 11940. However, weights of roots in No. 3329 were generally higher than the weights of roots in No. 11941 as well as No. 11940 at all concentrations of NaCl. The concentration of Na and Cl in plant tops in No. 3329 were similar to those in Nos. 11941 and 11940. It is suggested that No. 3329 is somewhat more salt tolerant than Nos. 11941 and 11940.

Pakistan has long been suffering from food shortage due to lower yields of crops. Among the large number of factors contibuting towards lower yield, the salinity and waterlogging in the canal colonies and the scarcity of irrigation water in dry areas are the most important ones. The extent of salinity problem can be visualized by the fact that out of a total of 48 million cultivated acres of land of Pakistan, 17 million acres are affected with salinity to varying degrees.[5] About 0.1 million acres of land are going out of cultivation annually. Consequently, Pakistan is loosing about 145 million rupees every year because of the loss of agricultural productivity. All efforts are being made to check further deterioration of land and reclaim those areas which already have gone out of cultivation due to salinity and waterlogging.

Various reclamation projects have been started in the country to improve the saline soils. Considerable success has been achieved in this respect. However, the light to moderately saline areas can be used by various agronomic projects. Growing of the salt-tolerant plants is one approach.

The present experiment was designed to compare three varieties of barley for their tolerance to NaCl in pots.

Materials and Methods

Three barley varieties Nos. FAO 11941, FAO 11940, and 3329 were grown at different concentrations of NaCl in soil. The experiment was conducted in polythene-lined plastic pots containing soil taken from the field. The soil was air-dried, ground, and passed through 2 mm sieve. The soil was homogeneously mixed and the pots filled with 14.8 pounds soil. The latter had a field capacity of 25%.

The soil was artificially salinized with 1-litre solutions of 0.05, 0.1, 0.3, 0.5, and 1.0% NaCl each containing a basal nutrient of the following composition (μM) 500 K_2SO_4, 1000, $CaSO_4$ $2H_2O$, 1000 $MgSO_4.7H_2O$,10 $MnSO_4.4H_2O$,1 $CuSO_4.5H_2O$,3.5 $ZnSO_4.7H_2O$, 3.5 $(NH_4)_6$ $Mo_7O_{24}.4H_2O$, 3.5 H_3BO_3, 2.0 $CoSO_4.7H_2O$, 15Fe citrate, 400 NH_4NO_3, 500 $Ca(H_2PO_4)_2.H_2O$.

Fifteen seeds per pot were sown about an inch deep (day 0) and on emergence were thinned to 12. Treatments were replicated thrice and were block randomized. Data were collected for germination (day 5), emergence of leaves and dry weights of tops and roots (day 34). Since plant material in most treatments was too small for analyses, sodium and chloride concentrations were determined only on selected plant material using an EEL flame photometer and potentiometric microtitration apparatus EJ-930.

Results

Seed Germination. Five days after seeding 44.4% seeds of barley variety No. 3329 germinated while only 2.2% and none of Nos. 11940 and 11941, respectively, germinated when seeded in soil treated with a solution of 1.0% NaCl (Table 1). NaCl added to the soil at a concentration of 0.05 - 0.5% had no effect on the germination of the three varieties of barley.

Emergence of Leaves. At 1% NaCl, the appearance of the second leaf in plants in all the three varieties was delayed. The effect of treatment in delaying the appearance of the second leaf was more pronounced in No. 11940 than in No. 3329, where the appearance of second leaf was delayed by three days only. Increasing the concentration of NaCl from 0.05 to 0.5% delayed the appearance of 3rd leaves by 2 - 5 days in all the varieties. At high concentration, however, the appearance of 3rd leaf was delayed by 10 days in No. 3329; 3rd leaf did not develop in Nos. 11941 or 11940. Thus the depressive effects of high NaCl treatment on the appearance of younger leaves paralelled the initial effects of treatment on germination.

TABLE 1. EFFECT OF NaCl TREATMENTS ON GERMINATION OF THREE VARIETIES OF BARLEY (PERCENTAGE GERMINATION AT DAY 5)

NaCl%	Varieties		
	FAO No. 11941	FAO No. 11940	FAO No. 3329
0.05	100.00	100.00	100.00
0.1	100.00	100.00	100.00
0.3	100.00	100.00	100.00
0.5	97.33	97.33	95.55
1.0	00.00	2.28	44.44

tion of Na in plant tops parallels the effects of said treatments on dry weights of tops (Table 2).

Chloride. Higher concentration (0.5%) of NaCl in the soil increased Cl concentrations in plant tops (Table 3). At each concentration of NaCl i.e. 0.3% and 0.5%, the concentrations of Cl in plant tops were higher than the concentrations of Na. This is consistent with the findings in other varieties of barley.[3] However, the concentration of Cl in plant tops in all the three varieties were similar. This effect of treatments on chloride concentration paralleled the effect of treatments on dry weights of plants tops (Table 2).

TABLE 2. EFFECT OF NaCl TREATMENTS ON DRY WEIGHT OF PLANT (WT IN G PLANT AT DAY 34)

NaCl%	Varieties					
	FAO No 11941		FAO No 11940		No 3329	
	Tops	Roots	Tops	Roots	Tops	Roots
0.05	0.068	0.029	0.083	0.015	0.091	0.021
0.1	0.069	0.017	0.087	0.022	0.082	0.020
0.3	0.065	0.015	0.072	0.016	0.073	0.020
0.5	0.066	0.014	0.057	0.015	0.069	0.018
1.0	0.036	0.014	0.031	0.015	0.034	0.017

TABLE 3. EFFECT OF NaCl TREATMENTS ON ION CONTENT OF PLANT TOPS.

NaCl	Varieties					
	FAO No. 11941		FAO No. 11940		No. 3329	
	Na	Cl	Na%dry	wt. Cl	Na	Cl
0.3	1.73	2.77	1.52	2.51	1.78	2.53
0.5	2.16	3.23	2.36	3.04	2.08	3.24

Dry Weights. Increasing salt concentration from 0.05 to 0.5% in the soil had little effect on the dry weights of plant tops in No. 11941, but the same decreased dry weights of tops generally in No. 11940 as well as No. 3329. High concentation, however, decreased the weights of plant tops substantially in all the three varieties (Table 2). Only in No. 3329 did plant weights decrease as the salt concentrations in soil increased. However, weights of plant tops in No. 3329 were generally higher than the weights of tops in other varieties at all levels of salt concentrations. Thus, at all levels of NaCl, the effects of treatment on dry weights in No. 3329 could be ascribed to the combined effect of treatments on the number of leaves emerged as well as the photosynthetic efficiency of the leaves.

As regards the effects of treatments on roots, increasing concentration of NaCl in the soil generally decreased dry weights of roots in varieties Nos. 11941 and 3329 (Table 2). The dry weights of roots in No. 11940 remained generally unaffected.

Concentrations. Sodium. Higher concentration (0.5%) of NaCl in the soil increased Na concentrations in plant tops (Table 3). At each concentration of NaCl, i.e. 0.3% and 0.5%, the concentrations of Na in plant tops among the three varieties were, however, similar. This effect of treatment on the concentra-

Discussion

Of the three varieties of barley which were tested in the present experiment, variety No. 3329 seemed to tolerate higher concentration of NaCl in the soil. The varietal difference was well marked in the germination of seeds at high salt concentration and clearly demonstrates a superiority of the former over Nos. 11941 and 11940. In addition, the appearance of the 2nd and 3rd leaves in No. 3329 ahead of those in rest of the varieties also supports the suggestion that the plants in No. 3329 grew better in high salt concentrations.

Whereas the dry weights of plant tops in both the varieties Nos. 3329 and 11940 were higher at lower salt concentrations (i.e. 0.05 and 0.1% salt in the soil) than those in No. 11941, the weights of tops in all the varieties at higher salt concentrations (0.3 and 0.5%) were little different from each other. The weights of roots at these concentrations were, however, larger in No. 3329 than those in other varieties thus giving a high root - top ratio. Such effect of salt on the growth of root is characteristic of salt tolerance in many plants.[1]

In the present experiment dry weights of plant roots at high salt concentrations were too small for requisite analyses (Na and Cl concentrations), hence

only plants in the 0.3 and 0.5% NaCl treatments were analysed. At these concentrations, however, the dry weights of plant roots in No. 3329 were higher than the weights of roots in Nos. 11941 and 11940. It could thus be expected that as a result of higher root weights, plants in No. 3329 could have absorbed Na and Cl more rapidly, thus increasing Na and Cl contents of plant tops. However, since both the ion contents and the weights of plant tops in No. 3329, in these treatments were similar to those in Nos. 11941 and 11940, the possibilty of a'dilution effect' may be ruled out. It could then follow that either both Na and Cl ions were excluded by the plant roots, a mechanism observed in many plant species,[6] or if absorbed the bulk of the ions might have been retained by the roots. Although examples of such absorption characteristics are not uncommon[7] an evidence suggesting the presence of either mechanism in barley has not been seen.[2] Since comparable data on root contents of Na and Cl in plants under discussion are not at hand, no conclusions could be drawn in terms of absorption of these ions or their subsequent translocation.

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