Differential Lineal Response of Barley Germination and Growth to Controlled Salinity Conditions

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ABSTRACT

Experiments were conducted to evaluate germination and growth response of different introduced barley lines to salinity and to correlate their germination ability under saline conditions with their production ability under the same conditions. The effect of salinity on germination was assessed on 12 introduced lines and a local variety of barley. Germination test was conducted in petri dishes, using solutions of NaCl ranging from 0-25000 ppm. It was found that lines differ significantly in their ability to germinate under saline conditions. Moreover, germination percentage was decreased as the salinity of the media increased. However, some lines showed a lower reduction percentage in germination at 10,000 and 15.000 ppm NaCl Concentration than others. This indicated the possibility of selecting barley lines with salinity resistance at germination.

Field experiments indicated that these lines differed in their growth response to salinity. Lines were divided into salinity susceptible and salinity resistant groups on the basis of their salinity susceptible index. Data also showed that yield under saline conditions was positively correlated to yield under normal growing conditions. Yield under normal and saline growing conditions was negatively correlated with salinity susceptible index. However, salinity susceptible index, and yield under saline growing conditions, were found to be not related to the germination percentage under saline conditions. It is suggested that the germination test is of a little direct use in breeding program for salinity resistance. It is also suggested that selection for yield under saline conditions, naturally or artificially would be a more productive method for improving salinity resistance unless other more efficient and rapid selection criteria are developed.

INTRODUCTION

The salinity of soils and irrigation water is a problem that restricts yield and cultivation of many large areas in the world. Moreover, salinity is the major threat to the

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permanence of irrigation agriculture, particularly in arid and semi-arid regions of the world (9). The process of gradual soil salinization and preponderance of saline water sources point to a future reliance on salt resistant crops (3, 4). Therefore, development of salt resistant crop cultivars not only would complement salt management programs to help maximize yield in these areas, but it might even allow the use of sea water to irrigate crops on sandy coastal soils (3, 4).

A crop improvement program must be based on adequate genetic variability for the desired traits, and indeed evidence is accumulating that considerable intraspecific and interspecific diversity in salt tolerance exists (3, 4, 6, 14). In addition, various screening procedures have been accumulating for identifying salt tolerant lines or even individual plants within a species (2, 9, 16, 18). Salt resistant genotypes which are identified through selection can be incorporated into a breeding program to improve agronomic traits. They also afford a means for comparative studies on the physiological basis for salt tolerance in agronomic plants.

Several reviews (11, 12, 14, 16) indicate that one of the critical stages for selecting salt resistant varieties is germination. However, the effect of salinity on the growth of rice *(Oryza sativa)* is related to the stage of plant development at which salinity is imposed (8, 12). Under field conditions, Kapp *et. al* (8) observed that soil salinity at the time of planting resulted in greater decrease in grain yield than a comparable level of salinity induced when the plants were six weeks old. Pearson et al. (13) studying the effect of salinity at three stages of development on the growth of rice reported that salinity inhibited growth more severely at earlier stages of growth than at later stages. Thus, it appears that the ability of seed to germinate under salt stress indicates that it has the genetic potential for salt resistance at least at this stage of the plant life cycle.

Barley *(Hordeum vulgare L.)* is a crop well adapted to semi-arid regions of the world, however, the excessive accumulation of salt in these areas may reduce the germination, growth, and eventually the yield of this crop. Studies have not yet been initiated to show the response of different lines or varieties of barley to salinity. Therefore, the objectives of these experiments were: (1) to determine the response of different barley lines to different NaCl concentrations, at germination, and (2) to evaluate their performance, and to correlate their ability to germinate in saline solutions with their yield performance under this stress condition. The use of NaCl in these experiments was dictated by the fact that Na is the most dominant cation in Libyan saline soil (Dr. Gilani Abdelgawad., personal communication).

METHODS AND MATERIALS

Experiment I:

Solutions of NaCl were mixed in increments of 5000 ppm from 5000 to 25000 ppm. The control consisted of distilled water representing 0 ppm. The seeds of 12 introduced lines received from CIMMYT and a check variety (California Mariot) were germinated in sterilized petri dishes. One filter paper was placed in each petri dish in which 10 seeds of a line were placed. Seeds of each line were tested in all the above solutions. Ten ml of the appropriate solution were added to each petri dish. They were then placed in a germinator at a temperature of 20 C°. After 3 and 7 days, the dishes were removed from the germinator and the number of germinated seeds in each petri dish was recorded. Percent germination was calculated based on the number of germinated seeds after 7 days, and the speed of germination was also calculated according to the following formula:

$$\text{Speed of germination} = \frac{G_2 - G_1}{4 \text{ days}}$$

where G_1 and G_2 represent the number of germinated seeds after 3 and 7 days, respectively.

Analysis of variance was performed as a split plot with three replications. The solution concentrations were as the main plots and the barley lines as the sub plots.

Experiment II:

Laboratory measurements of the ability of a line to germinate in saline solutions are quick, but their relevance to field performance must be evaluated. A trial was conducted during 1985-86 growing season at the Faculty of Agriculture, Exp. Station, Univ. of Al Fateh, to evaluate the performance under this stress condition. The experiment was carried out with the same materials used in Exp. I. Seeds of each line and the check variety were planted on Nov. 20, 1985 into pots 25 cm in diameter. Each pot had been filled to within 5 cm from the top with field soil.The pots were arranged in the field under natural lighting into a split plot design with three replications. Main plots were the barley lines. After gremination, seedings were thinned to leave three seedlings/ pot. At the time of seeding, soil was fertilized with 0:46:18 as N: P_2O_5: K_2O at the rate of 150 Kg/ha.

The treatments applied were (1). Irrigation with farm water (576 ppm) as a control, and (2) irrigation with saline solutions (treated). [For the later treatment, six week old plants of this treatment were watered with 300 ml/pot of the corresponding solution concentration].

Some signs of leaf necrosis were noticed on some plants that were irrigated with the saline solutions on Jan. 20, 1986. However, on Feb. 5, 1986 severe damage occurred to most of the plants of this treatment. At this time, the lines were classified as tolerant, intermediate or sensitive based on a rating score of leaf necrosis and wilting. The ratings were on a scale of 0-4, where 0 being the tolerant line and 4 sensitive. After this, plants of this treatment were watered every 3 days as before with a solution containing 4500 ppm NaCl till the end of the experiment. Because of the unavailability of seeds for these lines, this procedure was taken as a precautionary measure against possible plant loss through salinity damage. Protective measures were also taken when the rain was expected at high probability.

At maturity, soil was separated from the roots of plants. Number of tillers was counted, and plant material was separated into roots, straw and spikes. Spikes were threshed and the weights of the different plant parts were taken following drying for 24 hours at 70 degree C in a forced air oven. Harvest index (grain yield divided by (straw weight + root weight) was calculated. Moreover, a susceptibilty index (S) was calculated for grain yield data using the formula presented by Fisher and Mauser (5).

$$S = (1 - Y/YP)/ D$$

where Y = yield under stress, YP = yield potential without stress, and D = Stress intensity = 1 − (mean Y of all lines)/ (mean YP of all lines). The susceptibility index was used to characterize the relative resistance of lines studied to salinity. At the end of the experiment soil samples were taken from the pots for the determination of soil electric conductivity as well as at the beginning of the experiment.

RESULTS AND DISCUSSION

Experiment I:

The mean germination percentage of all entries in the control solutions was 86.5% ± 5.2% indicating a satisfactory perfomance of the seed stock available. The effect of salinity on the percent germination expressed as a percent of the same entry from the control treatment for the 12 introduced lines and the local variety is presented in Table 1. As shown in the table, the germination reduction due to increase in salt concentration tended to be the same for all entries up to 5000 ppm NaCl concentration. However, beyond this concentration, most of the introduced lines showed a different reduction trend, but the germination of the line LO-7 remained significantly higher compared with the other entries at 15,000 ppm NaCl concentration. The higher germination percentage of the line LO-7 at 15,000 ppm NaCl concentration, indicates that it is better adapted to germinate at higher salt concentration than the other entries used in this study. From graphs (not presented) of percent germination Vs. salt concentration, the effect of salinity on germination could be further evaluated. The average salt concentration for all entries associated with 50% reduction in germination was 11478.8 (± 146.1) ppm NaCl (Table 1). However, this concentration tended to be higher for the line L0-7 and L0-15 compared with the other introduced lines and the local variety (Table 1). Pearson *et. al.* (12) reported an average of 26 mmhos/cm (16640 ppm) associated with 50% reduction in percent germination of rice varieties. Furthemore, increasing salt concentration slowed germination (Table 2). The differences among entries and salt concentrations were significant (Table 2). These data collectively demonstrate variability for salt tolerance in this group of introduced barley lines. This suggests that progeny of intergeneric crosses may represent further sources of germplasm with the germination potential under saline conditions. However, the results of this experiment did not indicate whether the reduction in germination associated with increasing salt concentration of any of the entries was due to osmotic potential, to ionic concentration of NaCl solution, or due to a combination of the two effects. Moreover, the data of this experiment dealt only with salt resistance at the critical first stage of the life cycle which may or may not be associated with the ability to resist salinity at later stages of plant growth (11). Norlyn and Epstein (11) also suggested that a more ambitious program should include screening all available material not only at emergence, but also at the other stages of the life cycle. This would be most useful in a breeding program for the development of higher levels of salt resistance in corps at all stages of development.

Experiment II:

The conductivity of the soil solution at 5 cm depth at the beginning and the end of Experiment II is shown in Table 3. The conductivity of the soil solution responded greater to irrigation with the saline solution compared to the control (Table 3). Because of the added fertilizer, the conductivity of the control soil at the end of the experiment was greater than that at the beginning of this experiment (Table 3).

Results of experiment II showed that the interaction between entries and treat-

Table 1 — Percent germination expressed as % of the same entry from the control treatment and NaCl concentration associated with 50% reduction in germination.

Entry	NaCl Conc. (ppm × 10) 5	10	15	20	25	means	NaCl conc. associated with 50% reduction in germination (ppm)
Misc-37	3.2	6.8	74.9	100	100	57.0	11602.1
Misc-38	3.5	17.3	72.4	100	100	58.6	11548.6
Misc-39	6.7	16.7	66.7	100	100	58.0	11696.6
L0-7	7.1	25.0	39.2	100	100	54.3	12295.8
L0-8	10.7	35.7	64.3	100	100	62.1	11483.4
L0-10	15.5	30.8	65.4	100	100	62.3	11585.0
L0-11	3.5	13.9	86.3	100	100	60.7	11275.1
L0-12	4.4	56.6	95.7	100	100	71.3	10592.5
L0-13	11.8	29.9	64.7	94.2	100	60.0	11838.6
L0-14	8.3	33.3	100.	100	100	68.3	10729.9
L0-15	11.2	44.5	100	100	100	71.1	12359.3
L0-16	9.0	45.4	81.9	100	100	67.3	11000.6
California Mariot	11.9	40.0	80.0	100	100	66.4	11217.2
Means	8.2	30.5	76.3	99.6	100		

L.S.D. (0.05) or comparing entry means = 11.9
L.S.D. (0.05) for comparing concentration means = 9.3
L.S.D. (0.05) for comparing entry means at the same time concentration = 25.9
L.S.D. (0.05) for comparing concentration means at the same entry or different entries = 33.9

Table 2 — Speed of germination (seeds/ day) of different barley entries at different salt concentrations.

Entry	Salt Concentration (ppm) 0	5000	10000	15000	20000	25000	Means
Misc-37	2.19	2.00	1.25	0.58	0.00	0.00	1.00
Misc-38	2.19	1.58	1.42	1.36	0.00	0.00	1.09
Misc-39	2.00	1.25	0.75	0.08	0.00	0.00	0.68
L0-7	1.80	1.75	1.25	0.42	0.00	0.00	0.87
L0-8	3.11	1.42	0.75	0.08	0.00	0.00	0.89
L0-10	1.50	1.22	1.00	0.75	0.00	0.00	0.75
L0-11	3.22	3.11	1.50	0.33	0.00	0.00	1.36
L0-12	1.86	0.75	0.52	0.08	0.00	0.00	0.54
L0-13	1.04	0.89	0.42	0.25	0.08	0.00	0.45
L0-14	0.75	0.72	0.42	0.00	0.00	0.00	0.32
L0-15	0.83	0.61	0.44	0.00	0.00	0.00	0.31
L0-16	1.05	0.72	0.67	0.33	0.00	0.00	0.46
California Mariot	1.39	0.72	0.67	0.50	0.00	0.00	0.58
Means	1.76	1.30	0.85	0.37	0.00	0.00	

L.S.D. (0.05) for comparing entry means = 0.42
L.S.D. (0.05) for comparing concentration means = 0.40
L.S.D. (0.05) for comparing entry means at the same time concentration = 0.66
L.S.D. (0.05) for comparing concentration means at the same entry or different entries = 1.03.

Table 3 — Soil electric conductivity and salt concentration at different times during Exp. II.

	Beginning of Exp. II	End of Exp. II	
		Control	Irrigated with Saline water
Elect. Conductivity (m mhos/ cm)	2.75	4.38	2753
Salt Conc. (ppm)	1716	2803	17617

ments was not significant for the measured parameters. Therefore, data for each entry are presented as the average over the two treatments. Likewise, data for each treatment are given as the average over entries.

The effect of salinity on some morphological characteristics and yield components is presented in Table 4. Irrigation with saline water resulted in significant reduction in total number of tillers/ plant compared with the control. However, the number of vegetative tillers/ plant, stem length, spike length and number of seeds/ spike were not affected significantly with saline water. Moreover, irrigation with saline water caused a 22.8%, 28.4% and 31.9% reduction in number of spikes/ plant, weight of grains/ spike and weight of 100 grains, respectively. These results were in agreement with previous work (20). It was noted in this experiment that a large number of spikes produced by these lines were infertile when irrigated with saline water which lead to lower seed weight/ spike and lower number of seeds/ spike. This observation is in agreement with the results of Chuprinina (1) who reported that increasing salts in the soil resulted in an increase of percentage of sterile, unviable pollen which may lead to a reduction in yield. On the other hand, there were highly significant differences between entries regarding their total number of tillers/ plant, number of vegetative tiller/ plant, stem length and the yield components (Table 4). However, the differences between entries in spike length was not significant, but Misc-37 and L0-15 tended to produce the shortest spikes compared with the other tested entries (Table 4).

Results in Table 5 showed that irrigation with saline water brought a significant reduction in straw weight, biological yield as well as the harvest index. However, plants of this treatment gave about 142.4% more root weight compared with the control treatment (Table 5). In addition, there was a significant difference in straw weight, root weight, biological yield and harvest index among entries (Table 5). The results showed a difference in the harvest index of more than 2.6 times between the best line, Misc-39, and the poorest line, L0-15 (Table 5). This differential growth response was probably a strategy of adaptation to this salinity stress. This demonstrates a wide variability for partitioning of assimilates between the different plant parts in this group of barley lines which was reflected on their grain yield (Table 6). Irrigation with saline water resulted in 48.8% reduction in grain yield compared with the control. This was attributed to the significant reduction in spike number/ plant, weight of grains/ spike and weight of 100 grains. Similar results were reported on the effect of salinity on yield of different wheat cultivars (20). Superior adaptation to saline conditions is indicated in Misc-39 and L0-7 which had significantly higher yield compared with the other introduced lines when irrigated with the saline water (Table 6). Some of the other lines

Table 4 — Means of some morphological and agronomic traits of different barley entries.

	Total tillers	Vegetative tillers	Spikes	Stem length	Spike length	No. of seeds/ spikes	wt. of 100 seeds	wt. of seeds spike
		No./Plant		cm		no.		mg
Treatment								
Control	21.7	9.4	12.3	28.8	3.5	13.9	1672.8	232.8
Treated	17.7	7.8	9.5	25.6	3.3	8.5	1139.3	166.8
L.S.D. (0.05)	3.4	n.s	1.0	n.s	n.s	n.s	389.4	61.6
Entry								
Misc-37	21.2	13.5	7.7	26.9	1.7	3.7	2070.9	77.0
Misc-38	17.3	6.5	10.8	29.3	4.2	10.2	1715.7	174.8
Misc-39	19.8	6.3	13.5	29.3	4.1	11.8	2372.9	279.6
L0-7	24.0	11.7	12.3	26.8	4.9	13.8	2044.3	282.3
L0-8	18.3	9.6	8.7	33.0	2.5	11.0	2685.5	295.7
L0-10	11.5	5.5	6.0	31.0	4.3	17.3	1300.6	225.0
L0-11	20.8	10.8	10.0	28.3	2.7	10.8	1555.6	167.6
L0-12	19.5	8.7	10.8	28.4	4.4	19.8	1491.8	161.3
L0-13	21.7	11.4	10.3	30.0	4.2	7.8	2302.7	180.0
L0-14	19.2	13.5	5.7	24.2	3.8	18.7	1275.9	238.7
L0-15	14.0	10.8	3.2	24.6	1.2	4.8	1237.0	58.3
L0-16	22.7	14.1	8.6	24.6	2.3	7.2	1566.5	113.1
California Mariot	23.8	12.1	11.7	22.0	3.6	11.8	2274.4	268.1
L.S.D (0.05)	5.6	2.0	4.1	5.3	n.s	6.0	562.7	112.3

Table 5 — Means of straw and root weight, biological yield, and harvest index of different barley entries.

	wt. of straw	wt. of roots	Biological Yield*	Harvest Index
		gm/plant		%
Treatment				
Control	6.78	0.59	7.37	38.8
Treated	4.83	1.43	6.26	14.7
L.S.D (0.05)	1.70	0.53	0.84	9.1
Entry				
Misc-37	6.77	1.36	8.13	7.3
Misc-38	5.59	1.12	6.71	28.2
Misc-39	3.97	0.76	4.73	79.9
L0-7	5.72	1.16	6.88	50.4
L0-8	5.49	0.93	6.42	40.0
L0-10	7.50	1.35	8.85	15.3
L0-11	5.93	0.79	6.72	25.0
L0-12	5.76	0.92	6.68	26.1
L0-13	4.06	0.52	4.58	40.4
L0-14	7.56	1.07	8.63	15.8
L0-15	5.15	0.99	6.14	3.1
L0-16	5.62	1.34	6.96	13.9
California Mariot	4.56	0.81	5.37	58.5
L.S.D. (0.05)	1.50	0.44	1.13	10.9

* Biological yield includes straw and root weight.

showed improved yield under the control treatment. This differential yield response could be due to difference among these lines with respect to physiological mechanisms of salinity resistance. Differences among wheat genotypes with respect to osmoregulation and salt accumulation has been reported and appear to be correlated with relative resistance to drought and salinity (10, 15).

Values of salinity susceptibility index are presented in Table 6. This was used to characterize the relative salinity resistance of the lines tested. It must be emphasized that this index provides a measure of salinity resistance based on minimizing yield level under saline conditions per se. The results showed that of the 12 introduced lines used in this experiment, two were relatively resistant to salinity and three were relatively susceptible to salinity (Table 6). The salinity susceptible indices indicated that Misc-39 and L0-7 are relatively resistant to salinity, while Misc-37, L0-12 and L0-15 are relatively susceptible (Table 6). Other lines exhibited moderate yield under both treatments, with moderate salinity susceptible indices. The rating of California Mariot as salinity resistant is consistent with what is known about this variety. This variety has long been recognized as salinity resistant variety. The tolerance class of these lines based on rating scores of leaf necrosis induced by salinity is consistent with the susceptibility-indices (Table 6).

Correlatrions were determined for yield under both treatments, salinity susceptibility index and same germination parameters (Table 7). Perhaps of greater significance was the strong positive correlation between yield under the control treatment and that

Table 6 — Grain yields, resistance classes and salinity susceptibility indices of different barley entries.

Entry	Grain Yield			Resistance class	susceptibility Index
	Control	Treated	Means		
		gm/plant			
Misc-37	0.94	0.24	0.59	Sensitive	1.82
Misc-38	2.38	1.40	1.89	Intermediate	1.00
Misc-39	4.32	3.24	3.78	Resistant	0.32
L0-7	3.71	3.23	3.47	Resistant	0.32
L0-8	3.26	1.88	2.57	Intermediate	1.03
L0-10	1.93	0.77	1.35	Intermediate	1.47
L0-11	2.38	0.98	1.68	Intermediate	1.45
L0-12	2.73	0.75	1.74	Sensitive	1.77
L0-13	2.24	1.46	1.85	Intermediate	0.85
L0-14	1.93	0.79	1.36	Intermediate	1.44
L0-15	0.28	0.10	0.19	Sensitive	1.57
L0-16	1.34	0.60	0.97	Intermediate	1.35
California Mariot	3.44	2.84	3.14	Resistant	0.43
Means	2.38**	1.41			

** Mean grain yield of the control and treated treatment are significantly different at 0.01 probability level.

L.S.D. (0.05) for comparing grain yield means of entries = 1.18

L.S.D. (0.05) for comparing grain yield means of entries at the same treatment = 1.66

L.S.D. (0.05) for comparing treatment means at the same entry or different entries = 2.22.

Table 7 — Correlations between yield, salinity susceptibility index and some germination parameters.

Character	1	2	3	4	5
1) Grain yield under the control treatment	—	0.91*	0.47	−0.05	−0.78
2) Grain yield under irrigation with saline water		–	0.46	0.25	−0.95*
3) Average germination % under different conc. of NaCl solutions			–	0.33	−0.43
4) NaCl Conc. associated with 50% reduction in germination.				–	−0.37
5) Salinity susceptibility index					–

significant at $p < 0.05$.

obtained under irrigation with saline water ($r = 0.91$, $p < 0.05$). This is in agreement with the results of Sojka *et al.* (19) who reported that cultivars of wheat with high yield under adequate moisture conditions generally yielded well under limited conditions as well. Roy and Murty (17) reported that selection for yield and its components was more efficient under optimal than under suboptimal growing conditions. The statistical evidence suggests that high yielding cultivars under optimal soil growing conditions are advantageous to salinity stress, and can also produce high base-lines yield under saline conditions. However, caution must be taken that these high yields should not be interpreted as an indicaton of superior salinity resistance.Rather, salinity resistance is better characterized as the ability to minimize yield loss in the absence of optimal soil growing conditions. This implies that salinity resistance lines would be perhaps only of interest as a source of particular salinity resistance characteristics for incorporation into cultivars with higher yielding potential under normal and saline soil conditions. Moreover, the results in Table 7 showed that the salinity susceptibility index is negatively correlated with both yield under irrigation with saline water and with control yield. However, there was no significant relationship between either yield under irrigation with saline water, salinity susceptibility index and any of the average germination parameters measured under saline solutions in the first experiment. Similar results have also been reported for wheat grass (7) and wheat (8). Apparently, the most sensitive stage of the life cycle for barley is not germination, but rather a later development stage. Thus, it appears that the ability of seeds to germinate under saline conditions, is not indicative of subsequent resistance. This suggests that germination studies under saline conditions cannot be used as a method to isolate saline resistant lines.

In conclusion, these results indicated that this group of barley lines differed in their germination and yield ability under saline conditions. Although the germination test is a rapid procedure, but because of the lack of relationship between germination parameters and salinity resistance appears to be of a little direct use in salinity resistance program. However, in the absence of simpler character (s) related to salinity resistance, it could serve as a preliminary procedure to select lines with vigorous germination under saline conditions, and identify a manageable number of promising lines.

Finally, these studies illustrate that selection for yield under saline conditions, naturally or artificially, should be a more productive method for improving salinity resistance, unless other more efficient and rapid selection procedures are developed. However, given the variation in type and intensity in our cultivated land and environment we suggest that selection for high yielding widely adapted lines would be preferable to selection for a particular stress resistance per se.

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الاستجابة التفاضلية لإنبات ونمو سلالات من الشعير لظروف الملوحة المحكمة

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المستخلص

أجريت تجارب لغرض تقييم استجابة إنبات ونمو سلالات مختلفة من الشعير للملوحة ولربط قدرتها على الإنبات تحت ظروف الملوحة مع قدرتها على الانتاج تحت الظروف نفسها. لقد درس تأثير الملوحة على 12 سلالة مدخلة وصنف محلي من الشعير. أجريت إختبارات الإنبات في أطباق بتري باستخدام تراكيز من محلول ص كل تراوحت ما بين 25000 جزيء في المليون. لقد اختلفت هذه السلالات اختلافاً معنوياً في قدرتها على الانبات تحت ظروف الملوحة، وإلى جانب هذا فقد انخفضت نسبة الانبات كلما ارتفعت الملوحة، ولكن بعض السلالات أوضحت انخفاضاً أقل في نسبة الإنبات عند 10,000، 15,000 جزيء في المليون ص كل مقارنة ببعض السلالات الأخرى. إن هذا يدل على إمكانية انتخاب سلالات من الشعير قادرة على مقاومة الملوحة عند الإنبات.

لقد أشارت الدراسة الحقلية إلى اختلاف هذه السلالات في استجابتها للملوحة، فقد قسمت هذه السلالات بناءً على دليل تأثرها بالملوحة إلى سلالات مقاومة للملوحة وأخرى متأثرة بالملوحة. إلى جانب هذا، أوضحت النتائج أن الانتاج تحت الظروف المالحة يرتبط ارتباطاً موجباً مع الإنتاج تحت الظروف العادية. كما إن الإنتاج تحت الظروف المالحة والعادية يرتبط ارتباطاً سالباً مع دليل التأثر بالملوحة، ولكنه وجد أن دليل التأثر بالملوحة والانتاج تحت الظروف المالحة لا يرتبطان بنسبة الإنبات تحت الظروف المالحة. لقد اقترح أن لاختبار نسبة الإنبات أهمية قليلة في برامج التربية من أجل المقاومة للملوحة. بينما اقترح أن الانتخاب الطبيعي أو الصناعي لأجل الإنتاج يكون وسيلة أكثر جدوى لتحسين المقاومة للجفاف، ما لم يتم إيجاد وسائل أخرى أسرع وأكثر فعالية.