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Field Screening of Barley Genotypes Under Different Levels of Soil Salinity and Potassium

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ABSTRACT

A field experiment was conducted in the Soil Salinity Lab, Alexandria, ARC in two consecutive seasons; 1995/96 and 1996/97 to study the effects of natural soil salinity and potassium application under salinity stress on the performance of some Egyptian barley cultivars. The treatments included three levels of soil salinity (5, 9.6, and 20.1 ECe, dsm^{-1}), in the first season and two levels; 7.5 and 15.5 dsm^{-1} in the second season, three levels of potassium (0, 57, and 114 kg K_2O/ha), and four barley cultivars (Giza 123, Giza 124, Giza 125, and Giza 126) with three replications. Split-split plot design was used where soil salinity was assigned to the main plots, potassium fertilizer to the sub-plots, and barley cultivars to the sub-sub-plots. Results of the 1995/96 season showed significant differences in plant height, number of spikes/m^2, and biological and grain yields among the three salinity levels. Significant reduction resulting from the high level of salinity (20.1 dsm^{-1}) reached about 55.2, 64.3, 79.5, and 76.4%, respectively, for the four characters. On the average, overall salinity levels, the application of 57 kg K_2O/ha increased biological and grain yields by about 20 and 14%, respectively, over the check treatment. It seems that the higher level of K (114 kg K_2O/ha) caused some counter effects on the plants, where it caused some reduction, compared to the check, in both biological and grain yields reached 5.5 and 3.7%, respectively. No significant differences were observed among cultivars over all treatments, except for plant height, where Giza 125, the newly released drought-tolerant cultivar was, significantly ($P < 0.05$), shorter than the other three cultivars. Results of the 1996/97 season showed significant differences in number of spikes/m2, biological, straw, and grain yields between the two salinity levels. The reduction of these characters for the higher salinity level reached 41.3, 61.6, 69.1, and 57.3%, respectively. Potassium treatments were insignificant for all characters but were significant for the first order interaction with variety and salinity. On the average over salinity levels, Giza 126 at 114 kg K_2O/ha was the highest, while Giza 125 without potassium fertilizer was the lowest. The reduction was about 30.4 and 43.1% for biological and grain yields, respectively. The cultivar Giza 125 with 114 kg K_2O/ha at the lower salinity level showed the highest biological yield, while at the higher salinity level it showed the lowest biological yield with a reduction of about 78.7%.

Key words: *Hordeum vulgare*, Potassium, Salinity, Sodium Chloride.

INTRODUCTION

The inhibitory effect of salinity on plants as a consequence of high sodium chloride level has been attributed to water deficit, salt toxicity, or nutritional imbalance (Bernstein and Hayward, 1958). Under such conditions, sodium adversely affects potassium supply to the plants (Pearson and Bernstein, 1958; Mustafa et al., 1966). Potassium has a significant role in plant physiology as a cofactor or activator for many enzymes of carbohydrate and protein metabolism and as a stomatal osmotic regulator.

On the other hand, sodium was found to replace potassium partially in sugar beet (El-Sheikh et al., 1967). Results of Storey and Wyn Jones (1978) on barley showed a decrease in potassium of the shoot and root tissues when plants were subjected to sodium chloride stress. The response of plants to potassium differs according to plant species and salinity levels and the ratio of K/Na. High level of K was more harmful to sorghum and mung bean than high levels of Na (Weimberg et al., 1984; Salim and Pitman, 1983). Dvorak and Noaman (1994) studied the effect of Kna1 locus transferred from the *Triticum aestivum* to durum wheat found that under salt stress, the

Kna1^{+} families had higher K^{+}/Na^{+} ratios in the flag leaves and higher yields of grain and biomass than the Kna1^{-} families. They concluded that K^{+}/Na^{+} ratio is one of the factors responsible for the higher salt tolerance in wheat.

The addition of K to the root medium of barley and rye grass was found to reduce the harmful effects of high Na (Helal et al., 1975; Hylton et al., 1967). Fresh and dry weights as well as leaf water potential of sorghum decreased with increased salinity regardless of K/Na ratio. The increase of proline content was noticed at higher salinity levels and was significantly higher at the higher ratio of K/Na (El-Haddad and O'Leary, 1994).

The objective of this study was, therefore, to study the effects of natural soil salinity and potassium application on the performance of four Egyptian barley cultivars.

MATERIALS AND METHODS

A field experiment was conducted in the Soil Salinity Lab, Alexandria, ARC in two consecutive seasons; 1995/96 and 1996/97 to study the effects of natural soil salinity and potassium application under salinity stress on the performance of some Egyptian barley cultivars. The soil represents the newly reclaimed area of Abees, which is characterized by a high water table at a depth of about 80-90 cm and subjected to secondary salinization source from the uprising stream from saline groundwater. The upper layer of the soil is sandy clay or clay loam texture with good permeability. The average soil salinity in the 1995/96 as expressed by electrical conductivity (ECe) of the soil paste extract was distinguished into three levels (high, medium, and medium-low). The experiment started on 25 November with the first shower. No irrigation was applied. The amount of precipitation did not exceed 130 mm, but its distribution was suitable to obtain quite good stand. Potassium was broadcasted prior to sowing on the soil surface. The recommended doses of nitrogen (140 kg N/ha) as ammonium nitrate and phosphorus (35 kg P_2O_5/ha) as super-phosphate were used. Split-split plot design was used where soil salinity was assigned to the main plots, potassium fertilizer to the sub-plots, and barley cultivars to the sub-sub-plots. The treatments included three levels of soil salinity (5.0, 9.6, and 20.1 ECe dsm^{-1}) in the first season, and two levels; 7.5 and 15.5 dsm^{-1} in the second season, three levels of potassium (0, 57, and 114 kg K_2O/ha), and four barley cultivars (Giza 123, Giza 124, Giza 125, and Giza 126) with three replications. Soil salinity showed no change throughout the growing season because of the low rainfall without any irrigation.

In the 1996/97 season, the experiment was repeated in the same field at two sites; one with relatively medium soil salinity of ECe 7.4 dsm^{-1} and the other with higher soil salinity of ECe 15.5 dsm^{-1}.The first shower on December 5th was not sufficient for germination, thus, the two field sites were supplemented by one irrigation and the rest of the plant life depended completely on the rainfall.The treatment of potassium fertilizer and barley cultivars were the same as the first season.

RESULTS AND DISCUSSION

In the 1995/96 season, significant differences (ranging from $P < 0.05$ to 0.01) in plant height, number of spikes/m^2, and biological and grain yields were detected among the three salinity levels (Table 1).However, no significant differences were found between S1 (5.0 dsm^{-1}) and S2 (9.6 dsm^{-1}), except in the case of number of spikes/m^2. Significant reduction resulting from the high level of salinity (20.1 dsm^{-1}) reached about 55.2, 65.3, 79.6, and 76.4%, respectively, for the four characters. These results were in agreement with those obtained by Bernstein and Hayward (1958) who found that the inhibitory effect of salinity on plants as a consequence of high sodium chloride level was attributed to water deficit, salt toxicity, or nutritional imbalance, which caused reduction in yield. Under such conditions, sodium adversely affects potassium supply to the plants as was reported by Pearson and Bernstein (1958) and Mustafa et al. (1966).

Potassium application resulted in significant differences in biological and grain yields, where K2 level (57 kg K_2O/ha) gave the highest values for both characters, significantly ($P < 0.05$) than both the check treatment and the higher level of K3 (114 kg K_2O/ha). On the average, over all salinity and cultivars, K2 treatment increased biological and grain yields by about 20 and 14%, respectively, over the check treatment. It seems that the higher level of K (114 kg K_2O/ha) had some counter effects on the plants, where it caused some reduction, compared to the check, in both biological and grain yields reached 5.5 and 3.7%, respectively (Table 1). In this respect, El-Sayed et al. (1996) reported that biological yield of barley increased with applying 57 kg K_2O/ha, while 114 kg K_2O caused reduction at Ismailia sandy soils. This result was also in agreement with that obtained by (Weimberg et al., 1984; Salim and Pitman, 1983) who found that high level of K was more harmful to sorghum and mung bean than high levels of Na.

No significant differences were observed among cultivars over all treatments, except for plant height, where Giza 125, the newly released drought-tolerant cultivar was, significantly ($P < 0.05$), shorter than the other three cultivars.

In the 1996/97 season, significant differences were observed in number of spikes/m^2, biological, and grain yields between the two salinity levels. The reduction in these three characters at the higher salinity level reached 41.3, 61.6, and 57.3%, respectively.

Potassium levels were insignificant for all characters. On the average over salinity levels, Giza 126 at the rate of 114 kg K_2O/ha was the highest while Giza 125 without potassium was the lowest. The reduction was about 30.4 and 43.1% for biological and grain yields, respectively. The cultivar Giza 125 with 114 kg K_2O/ha at the lower salinity level showed the highest biological yield, while at the higher salinity level it showed the lowest biological yield with a reduction of about 78.7%. No significant differences were observed among cultivars over all treatments for all traits.

It seems that the change in watering regime was responsible for the change in response to potassium application for the two seasons, but it could be concluded that potassium had some positive effect on barley grain and biological yields under moderate rate of K_2O, after which the higher rate of potassium causes harmful effects on the plants. The experiment will be repeated for at least two more seasons for confirmation and practical application.

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Table 1. Mean plant height, number of spikes, and biological and grain yields of four barley cultivars under salinity and potassium application, 1995/96.

Salinity (dsm^{-1})	Potassium (kg K_2O/ha)	Cultivar	Plant height (cm)	No. of spikes/m^2	Biological yield (kg/ha)	Grain yield (kg/ha)
5.0			62.9 a †	319 b	13,957 a	3,970 a
9.6			57.4 a	354 a	14,177 a	4,338 a
20.1			28.2 b	114 c	2,854 b	936 b
Sign.			*	**	**	**
	0		50.7	271	9,838 b	2,979 b
	57		50.6	262	11,852 a	3,395 a
	114		47.2	253	9,298 b	2,870 b
Sign.			NS	NS	*	*
		Giza 123	49.5 a	261	10,538	3,066
		Giza 124	49.9 a	244	10,068	3,023
		Giza 125	47.9 b	271	10,210	3,211
		Giza 126	50.7 a	272	10,501	3,025
Sign.			*	NS	NS	NS
S1	K1		61.6 a	320 ab	12,705 b	3,501 b
S1	K2		64.8 a	304 b	15,987 a	4,444 a
S1	K3		62.5 a	335 ab	13,180 ab	3,964 ab
S2	K1		60.7 b	365 a	14,070 a	4,487 a
S2	K2		59.2 b	376 a	16,377 a	4,632 a
S2	K3		52.3 c	319 ab	12,084 b	3,896 ab
S3	K1		30.1 d	127 c	2,741 c	949 cd
S3	K2		27.8 d	107 c	3,191 c	1,110 c
S3	K3		26.7 d	106 c	2,629 c	750 d
Sig.			*	*	*	*
CV%			8.14	20.48	14.16	13.47

*, ** = Significant at 0.05 and 0.01 levels, respectively.

NS = Not significant.

† Values in a column followed by the same letter are not significantly different at the 0.05 level.

Table 2. Mean number of spikes, and biological and grain yields of four barley cultivars under salinity and potassium application, 1996/97.

Salinity ECe (dsm^{-1})	Potassium (kg K_2O/ha)	Cultivar	No. of spikes/m^2	Biological yield (kg/ha)	Grain yield (kg/ha)
7.4			574 a †	22,496 a	8145 a
15.5			337 b	8649 b	2520 b
Sign.			*	*	**
	0		424	15,125	5212
	57		468	15,163	4981
	114		473	16,429	5803
Sign.			NS	NS	NS
		Giza 123	497	16,003	5,474
		Giza 124	440	14,807	5,088
		Giza 125	457	15,451	5,223
		Giza 126	425	16,028	5,542
Sign.			NS	NS	NS
S1	K1		553 b	22,036 b	8,210 a
S1	K2		563 b	21,481 b	7,407 b
S1	K3		605 a	23,971 a	8,815 a
S2	K1		295 d	8,214 d	2,213 c
S2	K2		373 c	8,844 c	2,555 c
S2	K3		342 c	8,888 c	2,789 c
Sig.			*	*	*
CV%			20.6	17.2	21.5

*, ** = Significant at 0.05 and 0.01 levels, respectively.
NS = Not significant.
† Values in a column followed by the same letter are not significantly different at the 0.05 level.

مجلة الامارات للعلوم الزراعية (١٩٩٧) ٩: ٢٣-٣٣

الانتخاب الحقلي لبعض سلالات الشعير تحت معدلات مختلفة من الملوحة والبوتاسيوم

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ملخص:

أقيمت تجربة حقلية بمحطة البحوث الزراعية بالصبحية بالإسكندرية في سنتين متتاليتين، ١٩٩٦/٩٥ و ١٩٩٧/٩٦ لدراسة تأثير ملوحة التربة وكذلك ودراسة إضافة عنصر البوتاسيوم كسماد على المقاومة للملوحة في بعض أصناف الشعير المصرية. اشتملت التجربة على ثلاثة معدلات للملوحة في السنة الأولى (٥، ٩,٦ ، ٢٠,١ ديسي سيمون) ومعدلين للملوحة (٧,٤ ، ١٠,٥ ديسي سيمون) في السنة الثانية، وثلاثة معدلات من البوتاسيوم (صفر، ٥٧، ١١٤ كجم بو٢أ/هكتار)، وأربعة أصناف من الشعير ذو الستة صفوف (جيزة ١٢٣، ١٢٤، ١٢٥، ١٢٦) في ثلاثة مكررات في تصميم القطع المنشقة مرتين حيث وضعت الملوحة في القطع الرئيسية بينما وضع البوتاسيوم في القطع المنشقة الأولى والأصناف وضعت في القطع المنشقة الثانية. وقد أظهرت النتائج للسنة الأولى فروقا معنوية في صفات طول النبات وعدد السنابل في المتر المربع والمحصول البيولوجي وأيضا محصول الحبوب بين معاملات الملوحة الأرضية حيث

حدث نقص شديد تحت ظروف المعدل العالي من الملوحة وصل إلى حوالي ٥٥,٢، ٦٤,٣، ٧٩,٥، ٧٦,٤%، لهذه الصفات على التوالي. ومن ناحية أخرى، فقد أظهرت معاملة البوتاسيوم ٥٧ كجم بو٢أ/هكتار زيادة في المحصول البيولوجي ومحصول الحبوب وصل إلى حوالي ٢٠، ١٤%، على التوالي. ويبدو أن المعاملة العالية من البوتاسيوم وهي ١١٤ كجم بو٢أ/هكتار قد تسببت في بعض النقص في كلا الصفتين وصل إلى ٥,٥ ، ٣,٧ %، على التوالي. ولم تشاهد اختلافات معنوية بين أصناف الشعير ماعدا طول النبات حيث تأثر الصنف جيزة ١٢٥ أكثر من باقي الأصناف. وأظهرت نتائج الموسم الثاني اتجاه مشابه إلى حد ما، حيث وصلت نسبة النقص في صفات عدد السنابل في المتر المربع، والمحصول البيولوجي، ومحصول الحبوب إلى حوالي ٤١,٣، ٦١,٦، ٥٧,٣%، على التوالي. أما معاملات البوتاسيوم فلم تكن الفروق بينها معموية ولكنها كانت معنوية للتفاعل بين الأصناف ومعاملات الملوحة حيث أظهر الصنف جيزة ١٢٦ تفوقا واضحا تحت معدل ١١٤ كجم بو٢أ/هكتار بالمقارنة بباقي الأصناف، بينما كان الصنف جيزة ١٢٥ أقلهم في قيم هذه الصفات، وكانت نسبة النقص حوالي ٣٠,٤، ٤٣,١%، للمحصول البيولوجي ومحصول الحبوب، على التوالي. وقد أظهر الصنف جيزة ١٢٥ تحت معدلات البوتاسيوم العالية (١١٤ كجم بو٢أ/هكتار) وتحت معدلات الملوحة المنخفضة أعلى محصول بيولوجي، بينما أظهر أعلى نسبة نقص تحت معدلات الملوحة العالية وصلت إلى حوالي ٧٨,٧% مما يدل على حساسية هذا الصنف للملوحة العالية بالمقارنة بباقي الأصناف بالتجربة.

كلمات مفتاحية: البوتاسيوم، الملوحة، كلوريد الصوديوم، الشعير.