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In the name of Allah

بنام خدا

NOTE

INTERACTIVE EFFECTS OF N, SALINITY, AND SALINITY DURATION ON THE GROWTH AND CHEMICAL COMPOSITION OF BROAD BEANS[1]

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اثرات متقابل ازت، میزان شوری و طول مدت شوری برروی رشدوترکیب شیمیائی باقلا

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ABSTRACT

A greenhouse experiment was conducted to find out the interactive effects of N (0, 25, 50, and 100 ppm), salinity (EC_w of 1.5 and 3.5 mmhos/cm), and salinity duration (3, 6, and 9 weeks) on the growth and chemical composition of broad beans (*Vicia faba* L.). Nitrogen addition increased growth but decreased the concentrations of P, K, and Cu in tops and roots, Na in tops, and Mg in roots. Increasing irrigation water salinity decreased the growth and increased the concentrations of Cl, Na, and P in tops and roots and Ca, Mg, Mn, and Zn in tops. Nitrogen fertilization alleviated the harmful effects of salinity to some extent, particularly at short salinity duration (3 weeks) and after the plants were well-established (9 weeks after sowing).

خلاصه

دریک آزمایش گلخانه ای اثرات متقابل ازت (صفر، ۲۵، ۵۰و ۱۰۰ قسمت در میلیون)، میزان شوری (قابلیت هدایت الکتریکی ۱/۵ و ۳/۵ میلی‌موز درسانتیمتر)، وطول مدت شوری(۳، ۶ و ۹ هفته) برروی رشدوترکیب شیمیائی گیاه باقلامورد بررسی قرارگرفت.
افزایش ازت باعث افزایش رشد نبات گردیدلیکن غلظت فسفر، پتاسیم ومس رادرقسمتهای هوائی وریشه، سدیم رادرقسمتهای هوائی ومنیزیوم رادر ریشه کاهش داد. افزایش شوری درآب آبیاری رشدرا تقلیل، وغلظت کلرو سدیم وفسفررا درقسمتهای هوائی وریشه وکلسیم، منیزیوم، منگنزوروی رادرقسمتهای هوائی افزایش داد. کود ازته تا اندازه ای اثرات زیان آورآب شوررا، بخصوص درگیاهانی که خوب استقرار یافته (۹ هفته بعدازکاشت) و مدت آبیاری آنها کوتاه (۳ هفته) بود، تقلیل داد.

INTRODUCTION

Broad beans (*Vicia faba* L.) are used as forage as well as food in Asia, Middle East, Europe, and other countries (1).

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In recent years, due to the shortage of good-quality water for irrigation, increased attention has been given to the potential use of saline water for crop production in Iran. Moreover, there is widespread concern over the benefits resulting from N fertilization in broad beans because seed inoculation is not presently practiced and thus broad beans are poorly nodulated. The relative salt tolerance of broad beans and the effect of N on the growth of this crop plant have received some attention (8, 10). Meager and sporadic information regarding the effect of N on the growth and mineral composition of this crop irrigated with saline water for different durations led to conducting the present study.

MATERIALS AND METHODS

The experiment was conducted in a greenhouse using an alluvial calcareous loam soil, classified as Calcixerollic Xerochrept. The soil had a pH of 7.95 (saturated paste), EC_e of 0.46 mmhos/cm, 0.03% total N, 11 ppm $NaHCO_3$-soluble P, and 410 ppm exchangeable K. Two-kg portions of the soil were weighed into plastic pots. The treatment combinations consisting of four rates of N, two levels of salinity, and three salinity durations were arranged in a completely randomized design with three replications.

Five seeds of the 'Khalili' local broad bean cultivar were planted in each pot and the pots were irrigated with water of electrical conductivity (EC_w) of 0.5 mmhos/cm. Two weeks later, seedlings were thinned to three per pot and N treatments were applied. Nitrogen as urea reagent grade was applied in aqueous solution at the rates of 0, 25, 50, and 100 ppm. The two salinity treatments consisted of NaCl added to tap water to increase the EC_w to 1.5 and 3.5 mmhos/cm. The pots were divided into three groups. One group received the salinity treatment 3 weeks after planting (for a duration of 9 weeks) and the next two groups, 6 and 9 weeks after planting (for durations of 6 and 3 weeks), respectively.

The seedlings were daily irrigated with appropriate saline water to near field capacity by weight.

After 12 weeks, the tops were cut from the roots at the soil surface, and the roots were washed thoroughly free of soil. Each portion was then dried to constant moisture content at 70°C and weighed. The samples were ground in a Wiley mill to pass a 40-mesh screen. Total N was determined by the micro-kjeldahl method (3). The concentration of Cl was obtained by the method outlined by Chapman and Pratt (4). For determination of Na, P, K, Ca, Mg, Cu, Mn, Zn, and Fe concentrations, 500-mg samples were wet-ashed with HNO_3-$HClO_4$ (3:1). Phosphorus was determined by the ammonium molybdate-stannous chloride method (4) and other elements by a Carl Zeiss Atomic Absorption Spectrophotometer. Data were subjected to the analyses of variance and Duncan's new multiple range test was used for mean comparisons at the 1% probability level.

RESULTS AND DISCUSSION

The analyses of variance showed the main effects of salinity level (S), salinity duration (D), and nitrogen level (N) to be highly significant for top and root dry weights and top Na concentration, while no significant differences were found among the different levels of these factors for top and root N concentrations. Except for the interaction of S x D which was highly significant for most of the characters, other interactions were in most cases not significant. None of the factors or their interactions produced significant changes in the top N concentration, while the concentration of N in roots was significantly affected by the S x D, S x N, and D x N interactions.

Nitrogen addition had no significant effect on mean top growth at the salinity of 1.5 mmhos/cm (Table 1). However, at 3.5 mmhos/cm, 100 ppm N produced more dry weight than those of untreated check. An increase in plant growth in

Table 1. Effects of salinity level and duration and N level on dry weights (g) of tops and roots of broad beans.

Salinity level, mmhos/cm	Salinity duration, weeks	N level, ppm 0	25	50	100	Mean
				Tops		
1.5	3	7.07b*	8.43a	9.10a	8.87a	8.37ab
	6	10.03a	9.13a	8.97a	9.33a	9.36a
	9	6.30b	7.57a	8.17a	9.03a	7.77b
	Mean	7.80A	8.38A	8.75A	9.08A	8.50
3.5	3	8.73a	8.73a	9.20a	10.07a	9.18a
	6	6.43ab	7.43ab	7.67ab	8.77ab	7.58b
	9	5.90b	6.23b	6.83b	6.73b	6.42c
	Mean	7.02B	7.46AB	7.90AB	8.52A	7.73
Mean		7.41B	7.92AB	8.32AB	8.80A	
				Roots		
1.5	3	5.03a	6.37a	7.27a	8.33a	6.75b
	6	6.70a	7.57a	8.33a	9.53a	8.03a
	9	6.20a	6.60a	7.40a	7.93a	7.03b
	Mean	5.98C	6.85BC	7.67AB	8.60A	7.27
3.5	3	6.00a	7.00a	7.10ab	8.00a	7.02a
	6	6.63a	5.97ab	7.87a	7.23a	6.92a
	9	5.37a	5.03b	5.57b	4.23b	5.05b
	Mean	6.00A	6.00A	6.85A	6.49A	6.33
Mean		5.99B	6.42B	7.26A	7.54A	

*Means for each group within columns (lower case letters) or rows (capital letters) followed by the same letter are not significantly different at the 1% probability level.

saline media with N fertilization has also been reported by Bernstein *et al.* (2) for wheat and barley, by Sameni *et al.* (14) for dry beans, and by Ravikovich and Porath (13) for corn and tomato.

Increasing N fertilization increased root growth of plants irrigated with water of 1.5 mmhos/cm salinity but had no significant effect at the higher salinity level (Table 1). However, the stimulatory effect of N application at the 1.5 mmhos/cm level was less pronounced when salinity treatment was applied at an early period.

Plants irrigated with saline water of 1.5 mmhos/cm for 3 and 9 weeks produced statistically similar top and root dry weights, whereas at 3.5 mmhos/cm, increasing salinity duration significantly reduced top and root growth. Similar results have been reported by others (9, 12) and explained on the basis of the variability in the sensitivity of the plant to different salinity levels at various stages of growth. In general, dry weights of tops and roots were reduced with salinity. This result is consistent with that of others (7, 11).

Although the concentration of Cl in tops and roots was considerably greater than that of Na, changes in Cl and Na accumulations were primarily due to salinity treatment. (Tables 2 and 3). Nitrogen addition had no significant effect on top and root Cl concentrations. However, plants supplied with saline water of 3.5 mmhos/cm for 9 weeks accumulated significantly more Cl ions than those irrigated for shorter periods. Hajrasuliha (6) concluded that Cl accumulation in the bean leaves was dependent on Cl concentration in the medium as well as the duration of salinity. Similarly in the present experiment, increasing salinity from 1.5 to 3.5 mmhos/cm significantly increased top and root Cl concentrations and this trend became more apparent when salinity duration was prolonged.

Table 2. Effects of salinity level and duration and N level on Cl concentration (% dry wt.) of tops and roots in broad beans.

Salinity level, mmhos/cm	Salinity duration, weeks	N level, ppm 0	25	50	100	Mean
				Tops		
1.5	3	2.31a*	2.61a	2.42a	1.82b	2.29ab
	6	2.64a	2.07a	1.83a	1.68b	2.06b
	9	2.84a	2.91a	2.43a	2.79a	2.74a
	Mean	2.60A	2.53A	2.23A	2.10A	2.36
3.5	3	3.46b	3.55b	2.34c	3.50b	3.21b
	6	3.46b	3.88b	3.36b	3.46b	3.54b
	9	6.49a	6.35a	6.82a	7.27a	6.73a
	Mean	4.47A	4.59A	4.17A	4.74A	4.49
Mean		3.53A	3.56A	3.20A	3.42A	
				Roots		
1.5	3	2.90a	2.40a	1.83a	2.66a	2.45a
	6	3.89a	3.20a	2.44a	3.40a	3.23a
	9	2.26a	2.79a	2.59a	3.31a	2.74a
	Mean	3.02A	2.80A	2.29A	3.12A	2.81
3.5	3	3.58a	4.21a	3.26a	4.06ab	3.78b
	6	2.97a	3.66a	4.16a	3.75b	3.64b
	9	3.87a	4.37a	4.86a	5.81a	4.73a
	Mean	3.47A	4.08A	4.09A	4.54A	4.05
Mean		3.25A	3.44A	3.19A	3.83A	

*Means for each group within columns (lower case letters) or rows (capital letters) followed by the same letter are not significantly different at the 1% probability level.

Table 3. Effects of salinity level and duration and N level on Na concentration (% dry wt.) of tops and roots in broad beans.

Salinity level, mmhos/cm	Salinity duration, weeks	N level, ppm 0	25	50	100	Mean
		Tops				
1.5	3	0.40a*	0.27a	0.22a	0.10a	0.25b
	6	0.65a	0.49a	0.22a	0.13a	0.37ab
	9	0.67a	0.67a	0.33a	0.32a	0.50a
	Mean	0.57A	0.48AB	0.26BC	0.18C	0.37
3.5	3	0.65b	0.57b	0.14b	0.16b	0.38b
	6	0.75b	0.83b	0.24b	0.38b	0.55b
	9	2.05a	2.60a	1.88a	1.42a	1.99a
	Mean	1.15A	1.33A	0.75B	0.65B	0.97
Mean		0.86A	0.91A	0.51B	0.42B	
		Roots				
1.5	3	1.58b	0.94b	0.88b	0.95a	1.09b
	6	2.37a	1.71a	1.51ab	1.87a	1.87a
	9	1.81ab	1.88a	2.15a	1.52a	1.84a
	Mean	1.92A	1.51AB	1.51AB	1.45B	1.60
3.5	3	2.02b	2.10a	1.66b	1.84b	1.91b
	6	2.59ab	2.59a	2.65a	2.81a	2.66a
	9	3.11a	2.77a	3.22a	2.81a	2.98a
	Mean	2.57A	2.49A	2.51A	2.49A	2.52
Mean		2.25A	2.00A	2.01A	1.97A	

*Mean for each group within columns (lower case letters) or rows (capital letters) followed by the same letter are not significantly different at the 1% probability level.

At both salinity levels, the mean concentration of Na in tops was reduced with increasing N supply (Table 3), probably due to increased growth and the dilution of Na ions in the tissues. However, at 1.5 mmhos/cm, plants provided with 100 ppm N contained a significantly lower Na percent in roots than that of untreated check. At higher salinity, N addition did not significantly affect the mean root Na concentration.

Plants irrigated with water of 1.5 and 3.5 mmhos/cm for 9 weeks accumulated more Na in tops than those irrigated for 3 and 6 weeks. This result is consistent with that of Hajrasuliha (6). Moreover, salinity durations of 6 and 9 weeks produced a significantly higher mean Na percent in roots as compared with the shorter period. As expected, top and root Na concentrations were increased with a rise in salinity level of the irrigation water; the trend being more pronounced as salinity period was prolonged.

Broad bean plants accumulated similar amounts of Cl ions in tops and roots, whereas the accumulation of Na ions was much greater in roots than in tops, suggesting an Na ion retention mechanism operating in the roots. Gates *et al.* (5) reported that although both Cl and Na ions entered plant roots from the medium quite readily, most of Na ions tended to be retained in the roots, while a greater proportion of Cl ions was translocated to the tops. Furthermore, Hajrasuliha (6) postulated that such a translocation for Na was prevented due to an appreciable loss of Na-binding sites in the leaves.

Increased salinity level of the irrigation water did not affect top K, Cu, and Fe and root K, Ca, Cu, Mn, and Zn concentrations significantly (Tables 4 and 5). However, this factor caused increased concentrations of top P, Ca, Mg, Mn, and Zn and root P and decreased concentrations of root Mg and Fe. In general, salinity duration did not seem to have a significant effect on the micronutrient

Table 4. Effects of salinity level and duration and N level on P, K, Ca and Mg concentrations (% dry wt.) of tops and roots in broad beans.

Main effects	level	P		K		Ca		Mg	
		Tops	Roots	Tops	Roots	Tops	Roots	Tops	Roots
Salinity level (S), mmhos/cm	1.5	.21b†	.23b	2.43a	1.60a	2.22b	1.53a	.35b	.87a
	3.5	.22a	.26a	2.64a	1.73a	2.38a	1.50a	.39a	.78b
Salinity duration (D), weeks	3	.22a	.26a	2.72a	2.01a	2.20b	1.50a	.37a	.85a
	6	.20b	.24ab	2.56ab	1.57b	2.23b	1.56a	.36a	.87a
	9	.22a	.23b	2.33b	1.40b	2.47a	1.48a	.39a	.76b
Nitrogen level (N), ppm	0	.24a	.29a	2.72a	1.80a	2.54a	1.46a	.35a	.91a
	25	.21b	.26b	2.58ab	1.66ab	2.06b	1.49a	.37a	.80b
	50	.21b	.24b	2.52ab	1.71ab	2.10b	1.50a	.37a	.83ab
	100	.19c	.20c	2.33b	1.47b	2.51a	1.60a	.39a	.77b
S x D		ns	*	ns	ns	**	ns	**	ns
S x N		**	ns	ns	ns	*	ns	**	**
D x N		ns	ns	ns	ns	ns	ns	ns	*
S x D x N		ns	ns	ns	ns	ns	ns	ns	*

*, **, ns Significant at the 5 and 1% probability levels and not significant, respectively.

† Means for each group within columns followed by the same letter are not significantly different at the 1% probability level.

Table 5. Effects of salinity level and duration and N level on Cu, Mn, Zn and Fe concentrations (ppm dry wt.) of tops and roots in broad beans.

Main effects	level	Cu		Mn		Zn		Fe	
		Tops	Roots	Tops	Roots	Tops	Roots	Tops	Roots
Salinity level (S),	1.5	41a†	31a	134b	153a	35b	54a	288a	2992a
mmhos/cm	3.5	36a	27a	167a	129a	49a	56a	161a	1203b
Salinity duration (D),	3	39a	29ab	144a	138a	40a	56a	263a	1883a
weeks	6	38a	26b	157a	154a	48a	56a	328a	2200a
	9	38a	33a	150a	131a	37a	53a	83a	2208a
Nitrogen level (N),	0	58a	39a	143a	132b	46ab	51b	469a	2456a
ppm	25	33b	27b	147a	131b	34b	48b	166a	2578a
	50	29b	26b	147a	130b	40ab	54ab	148a	1400a
	100	33b	26b	164a	172a	48a	68a	115a	1956a
S x D		ns	ns	*	ns	ns	ns	ns	ns
S x N		**	**	**	ns	ns	ns	ns	**
D x N		ns	ns	ns	ns	**	ns	ns	ns
S x D x N		ns	ns	ns	ns	**	ns	ns	ns

*, **, ns Significant at the 5 and 1% probability levels and not significant, respectively.

†Means for each group within columns followed by the same letter are not significantly different at the 1% probability level.

concentrations of tops and roots of broad beans; the major effect of this factor being pronounced only for top K and Ca and root P, K, and Mg concentrations.

Nitrogen fertilization had no significant effect on top Mg, Mn, and Fe and root Ca and Fe concentrations. However, with increased levels of N, top P, K, and Cu and root P, K, Mg, and Cu concentrations decreased significantly. The elements which showed significant increases were the root Mn and Zn at 100 ppm N.

The interaction effects of salinity level and duration and N levels were, in most cases, nonsignificant for the elemental composition of tops and roots. Among the interactions, however, the S x N seemed to be more effective.

The results of this study indicated that N fertilization of broad beans irrigated with saline water alleviated the harmful effects of salinity to some extent, especially at short salinity durations and after the plants were well-established. Probably the relatively high concentrations of Cl and Na and water stress caused by excess soluble salts were responsible for growth suppression at high salinity.

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