INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
IJPAES
VOLUME-2, ISSUE-2 APRIL-JUNE-2012 ISSN 2231-4490
Coden : IJPAES www.ijpaes.com

Received: 23rd Feb-2012 ***Revised: 26th Feb-2012*** ***Accepted: 29th Feb-2012***

Research Article

EFFECT OF SALINITY ON YIELD AND YIELD COMPONENTS OF PINTO BEAN CULTIVARS

Kazem Ghassemi-Golezani*, Neda Nikpour-Rashidabad and Saeid Zehtab-Salmasi

Department of Plant Eco-physiology, Faculty of Agriculture, University of Tabriz, Iran
* Corresponding author, e-mail: golezani@gmail.com

ABSTRACT: A Factorial experiment based on randomized complete block design (RCBD) with three replications was conducted in 2010, to evaluate yield and yield components of three pinto bean cultivars (COS_{16}, Talash and Khomain) under a non-saline (control) and three saline (4, 8 and 12 dSm^{-1} NaCl) conditions in the greenhouse. Ten seeds were sown in each pot filled with 900 g perlite, using 40 pots. After emergence, seedlings were thinned and 4 plants were kept in each pot. Mean number of pods per plant, 100 grain weight, plant biomass, grain yield per plant and harvest index decreased, due to salinity. Reduction in grain yield increased with increasing salinity. COS_{16} had more but smaller grains per plant, while Khomain produced less but larger grains, compared with other cultivars. Grain yield of Khomain was about 11.50% and 19.44% more than that of Talash and COS_{16}, respectively. However, grain yield of Khomain and Talash was statistically similar. Pods per plant, 100 grains weight and plant biomass had significant positive correlation with grains yield per plant. The highest positive correlation was observed between 100 grains weight and grain yield, suggesting that the yield differences among pinto bean cultivars mainly resulted from differences in mean 100 grain weight. It was concluded that salinity can considerably reduce grain yield of pinto bean cultivars, but the extent of this reduction depends on the severity of stress and genotype.

Keywords: grain yield, harvest index, plant biomass, salinity

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is the centerpiece of daily diet for more than 300 million of the world's people. This crop is the world's most important food legume, far more than chickpeas, faba bean, lentils and cowpea. Nutritionist characterizes the common bean as a nearly perfect food because of its high protein content and generous amount of fiber, complex carbohydrates and other dietary necessities [1]. However, this crop is sensitive to salinity and suffers yield losses under soil salinities of less than 2 dSm^{-1} [2]. Soil salinity is one of the major limiting factors to crop productivity in many arid and semi arid areas in the world [3]. Most of the salt stresses in nature are due to Na^+ salts, particularly NaCl [4]. Plant growth and development are adversely affected by salinity stress as a result of a low osmotic potential (osmotic stress), specific ion effects (salt stress), nutritional imbalances or combination of these factors [5]. Therefore, soil salinity is the largest constraint to plant productivity and global food production. Much research has been done to determine crop response to salinity by measuring crop yield at different levels of salinity. This method permits to distinguish salt tolerance and salt sensitive crops and to choose a cropping pattern corresponding with the expected soil salinity. This method is simple and practical [6]. Yield is a complex entity and associated with a number of component characters. These characters are interrelated and such interdependence of the contributory factors often affects their direct relationship with yield. Each of these components however are affected differently by salinity and hence the need to determine how the individual components are affected by salinity [7]. Salinity stress reduced number of pods and grains per plant, grain weight and grain yield in soybean [8]. Katerji et al [9] indicated that salinity stress decreased grain yield of mung-bean by about 28% and the main factor in yield reduction was difference in grain weight. Reduction in crop yield as a result of salt stress has also been reported for sunflower [10], cotton and wheat [11], canola [12]. In order to make effective utilization of salt affected soils, it is important to select plant genotypes, which may endure salt stress and produce acceptable yield under saline conditions. Thus, this research was aimed to evaluate variation in grain yield and yield components of common bean cultivars in response to different levels of NaCl salinity.

MATERIAL AND METHODS

A Factorial experiment based on randomized complete block design (RCBD) with three replications was carried out to evaluate yield and yield components of three pinto bean cultivars under a non-saline (control) and three saline (4, 8 and 12 dSm^{-1}NaCl) conditions. Ten seeds were sown 3 cm deep in each pot filled with 900 g perlite, using 40 pots in general. Pots were then placed in the Greenhouse of the Faculty of Agriculture, University of Tabriz, Iran. Tap water and saline solutions were added to the pots in accordance with the treatments to achieve 100% FC. After emergence, seedlings were thinned to keep 4 plants in each pot. During the growth period, the pots were weighed and the losses were made up with Hoagland solution (EC = 1.3 dSm^{-1}).
Perlites within the pots were washed every 20 days and non-saline and salinity treatments were reapplied in order to prevent further increase in electrical conductivity (EC) due to adding the Hoagland solution. At maturity, all plants from each pot were harvested to determinate biological yield, pods per plant, grains per plant, 100 grains weight and harvest index. Then grains were detached from the pods and grain yield per plant was determined. Analysis of variance appropriate to the experimental design was conducted, using SPSS software. Means of each trait were compared according to Duncan multiple range test at $p \leq 0.05$.

RESULTS

Analysis of variance of the data for yield and yield components (Table 1) showed that pods per plant, grains per plant, 100 grain weight, plant biomass, grain yield per plant and harvest index were significantly affected by salinity and cultivar, but grains per pod and grain yield plant only affected by salinity. The interaction of salinity × cultivar for pods per plant, grains per plant, 100 grain weight, plant biomass and grain yield per plant was also significant.

Table 1. Analysis of variance of the effects of salinity and cultivars on various traits of pinto bean

Source of variation	Mean of squares							
	df	Plant Biomass	Pods per plants	Grains per pod	Grains per plant	grains 100 weight	Grain yield per plant	Harvest index
Block	2	7.71n.s	2.25n.s	0.36n.s	37.02n.s	38.13n.s	0.36n.s	0.004n.s
(Cultivar (C	3	140.07**	20.08*	0.18n.s	227.86**	848.22**	0.70n.s	0.14**
(Salinity (S	2	51.96**	31.63**	2.51*	290.55**	700.92**	6.2**	0.028**
C×S	6	23.09**	17.71*	1.46n.s	122.86**	85.74*	1.19**	0.012n.s
Error	22	3.92	5.37	0.6	32.42	24.86	0.22	0.005
(%) CV		19.05	21.72	30.61	21.18	16.23	18.39	26.18

ns, *, **: No significant and significant at $p \leq 0.05$ and $p \leq 0.01$, respectively.

Mean number of pods per plant, 100 grain weight, plant biomass, grain yield per plant and harvest index under non-saline condition (S_0) and low salinity (S_1) were statistically similar, but were considerably higher than those under moderate (S_2) and severe (S_3) salinities. The number of pods and grains per plant was comparatively higher for COS_{16}, but the largest grains produced by khomain. Talash had the lowest plant biomass, but the highest harvest index. The highest and the lowest grain yield per plant were obtained from Khomain and COS_{16}, respectively. However, differences in grain yield between Khomain and Talash, Talash and COS_{16} were not statistically significant (Table 2).

Table 2. Comparison of means of grain yield and yield components of three pinto bean cultivars under salinity stress

Treatment		Plant Biomass (g)	Pods per plant	Grains per pod	Grains per plant	grain 100 weight (g)	Grain yield per plant (g)	Harvest index (%)
Salinity (dSm^{-1})	0	12.42^{a}	11.66^{ab}	2.18^{b}	24.44^{b}	39.27^{a}	3.06^{a}	0.29^{a}
	4	11.95^{ab}	12.66^{a}	2.40^{b}	29.55^{ab}	37.00^{a}	3.29^{a}	0.32^{a}
	8	10.06^{b}	9.88^{bc}	3.31^{a}	31.44^{a}	25.67^{b}	2.40^{b}	0.25^{ab}
	12	7.12^{c}	8.44^{c}	2.23^{b}	18.77^{c}	20.94^{b}	1.44^{c}	0.19^{b}
cultivar	Cos_{16}	13.31^{a}	12^{a}	2.56^{a}	29.75^{a}	23.68^{c}	2.32^{b}	0.16^{c}
	Talash	6.63^{c}	10.58^{ab}	2.63^{a}	27.16^{a}	28.45^{b}	2.52^{ab}	0.38^{a}
	Khomain	11.22^{b}	9.41^{b}	2.39^{a}	21.25^{b}	40.03^{a}	2.81^{a}	0.26^{b}

Different letters in each column for each treatment indicate significant difference at $p \leq 0.05$

Plant biomass of Talash under non-saline and all saline conditions was statically similar, but it was lower than that of other cultivars under all treatments. Plant biomass of COS_{16} and Khomain significantly reduced under severe salinity. The extent of reductions in number of pods and grains per plant and also grain yield per plant under severe salinity were higher for COS_{16} than for other cultivars. The superiority of Khomain in grain weight and grain yield per plant was more evident under moderate and severe salinities, compared with other treatments (Table 3).

Table 3. Comparison of means of different traits for pinto bean cultivars

Cultivar	Salinity	Biomass	Pods per plant	Grains per plant	grain 100 (weight(g	Grain yield per (plant(g
Cos_{16}	0	18.20^{a}	16.66^{a}	31.66^{ab}	35.59^{bc}	3.49^{ab}
	4	16.78^{a}	14.33^{ab}	37.66^{a}	32.28^{bc}	3.48^{ab}
	8	11.38^{bc}	9^{c}	38^{a}	16.29^{de}	1.84^{e}
	12	6.87^{d}	8^{c}	11.66^{d}	10.54^{e}	0.48^{f}
Talash	0	6.8^{d}	9.33^{c}	22.66^{bc}	41.10^{ab}	3.09^{abc}
	4	5.8^{d}	11.66^{bc}	28.33^{abc}	30.35^{c}	2.87^{abcd}
	8	7.43^{d}	11.66^{bc}	33.00^{ab}	20.69^{d}	2.28^{cde}
	12	6.5^{d}	9.66^{c}	24.66^{bc}	21.68^{d}	1.82^{e}
Khomain	0	12.25^{b}	9^{c}	19^{cd}	41.11^{ab}	2.60^{bcde}
	4	13.26^{b}	12^{bc}	22.66^{bc}	48.36^{a}	3.53^{a}
	8	11.37^{bc}	9^{c}	23.33^{bc}	40.04^{ab}	3.08^{abc}
	12	8^{cd}	7.66^{c}	20^{cd}	30.59^{c}	2.02^{de}

Different letters in each column for each treatment indicate significant difference at $p \leq 0.05$

Correlations of pods per plant with grains per plant and plant biomass and also correlation of grains per pod with grains per plant were positive and significant. Pods per plant, 100 grains weight and plant biomass had significant positive correlation with grains yield per plant. The highest positive correlation was observed between 100 grains weight and grain yield (Table 4).

Table 4. Correlation coefficients among yield and yield components

Traits	1	2	3	4	5	6	7
1-Pods per plant	1						
2-Grains per pod	-0.172	1					
3-Grains per plant	0.594^{*}	0.667^{*}	1				
4-100 grains weight	0.261	-0.231	-0.088	1			
5-Plant biomass	0.688^{*}	-0.049	0.430	0.407	1		
6-Harvest index	0.042	0.137	0.116	0.424	-0.412	1	
7-Grains yield per plant	0.658^{*}	0.003	0.426	0.837^{**}	0.595^{*}	0.464	1

**, *: significant at $p\leq0.01$ and $p\leq0.05$, respectively.

DISCUSSION

Large reductions in plants biomass, number of pods and grains per plant, grain weight and harvest index under severe salinity resulted in considerable decrease in grain yield per plant (Table 2). Reduction in crop yield as a result of salt stress has also been reported for maize [13], broad bean [9] and chickpea [14], rice [15], soybean [8]. According to Munns [16], Salt stress decreases growth in most plants and these plants not to be able to produce their maximum biomass. This stress at pod filling stage can cause a decrease in the photosynthate mobilization to grains and thereby decreasing grain weight [17]. Ghassemi-Golezani et al [8] reported that grain filling duration decreased with increasing salinity which resulted in decreasing final grain weight. The negative effect of salinity on plants may provoke osmotic potential by salt in the culture medium, so root cells do not obtain required water from the medium. Consequently, the uptake of some mineral nutrients dissolved in water is also restricted. [18] reported that salinity can severely limit crop production, because high salinity lowers water potential and induces ionic stress and results in a secondary oxidative stress. This can potentially reduce photosynthesis and consequently grain yield of pinto bean cultivars.

Decreasing harvest index with increasing salinity could be mainly attributed to large reduction in grain yield per plant under saline conditions (Table 2). The highest harvest index and the lowest plant biomass of Talash resulted in statistically similar grain yield with Khomain. Severe salinity reduced plant biomass, pods per plant, grains per plant, 100 grains weight and grain yield of all pinto bean cultivars, particularly COS_{16} (Table 3). Therefore, COS_{16} is more sensitive to salinity, compared with Talash and Khomain.

Less number of grains per plant was compensated by more photosynthate mobilization to grains, leading to the production of larger grains by Khomain (Table 2). Consequently, grain yield of khomain was about 11.50% and 19.44% more than that of Talash and COS_{16}, respectively. Yield differences among pinto bean cultivars mainly resulted from differences in mean 100 grain weight (Table 2), which was also reflected in highly significant and positive correlation of 100 grain weight with grain yield per plant (Table 4). Thus, grain weight was the most important yield component in determining yield potential of pinto bean cultivars under saline and non-saline conditions. Significant and positive correlations of pods per plant and plant biomass with grain yield (Table 4) suggest that these traits are also important for improving pinto bean yield. In general, both environmental stress and genotype could be responsible for variations in yield and yield components of pinto bean.

CONCLUSIONS

Grain yield of pinto bean considerably reduced under moderate and severe salinities, but the extent of this reduction varied among cultivars. Therefore, pinto bean is a sensitive crop to salinity and acceptable yield of this crop can be obtained under non-saline conditions. Mean grains weight was determined as the most important yield component influencing grain yield of pinto bean cultivars under non-saline and saline conditions.

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