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Evaluation of the Sensitive Components in Seedling Growth of Common Bean (*Phaseolus vulgaris* L.) Affected by Salinity

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ABSTRACT

Salinity is one of the most important abiotic stresses in many parts of the world. Salinity reduces growth by disturbing the physiological processes. Growth of the common bean (*Phaseolus vulgaris* L.) is sensitive to salinity. Only seedlings that have sufficient weight and hence sufficient strength for growth can withstand the effects of salinity. Sufficient strength is affected by transmitted materials from seed and the efficiency of this transmission. In order to identify which component of the bean's seedlings is sensitive to the salinity, an experiment was conducted. The experiment tested for the effect of five levels of salinity on six genotypes of common beans. The experimental design was a randomized complete block design with four replications per treatment. Results showed that decreasing the seedling dry weight and seed reserve utilization efficiency, with increasing NaCl amount. Low levels of salinity up to 33 mM produced an increasing in seedling dry weight. The route of the changes in the weight of mobilized seed reserve and the seed reserve depletion percentage were in reverse with the seedling dry weight. These results clarity showed that seed reserve utilization efficiency is the main component (trait) for toleration of salinity. Therefore, breeding programs should be focused on the sensitive component, i.e., SRUE and the breeding of this component results in the breeding of SLDW in common bean.

Key words: Salinity, common bean, seedling dry weight, seed reserve utilization efficiency, weight of mobilized seed reserve, seed reserve depletion percentage

INTRODUCTION

Drought and salinity are major and widespread problems throughout the world (Soltani *et al*., 2006; Tavili and Biniaz, 2009). Soil salinity in areas with dry climate is one of the barriers to sustainable agriculture. High levels of salinity delay growth of the most plant species and may limit growth to salt tolerant plants (halophytes) only (Guan *et al*., 2010). It has been reported, however, that low salinity may stimulate germination or may no effect on it (Gonzalez-Murua *et al*., 1985).

Plant growth is stressed by salinity in three ways: 1) Reducing hydration potential in the root area which produces drought stress, 2) Ionic toxic affection related to ions such as Na^+ and Cl^- and 3) Nutrient disequilibrium caused by reducing matter transfer in stalk (Munns and Termaat, 1986; Iqbal, 2005; Saboora *et al*., 2006). In Saline soils, Poor germination and decreased seedling growth result in poor establishment and occasionally crop failure (Soltani *et al*., 2006; Al-Ahmadi and Kafi, 2006; Zadeh and Naeini, 2007; Aishah *et al*., 2010; Almodares *et al*., 2007). During the growth cycle in Leguminous, great amounts of protein are synthesized and stored in seeds. During germination and seedling development, stored proteins are hydrolyzed and contributed to the other organelles for their cell metabolism. It showed that the greater amount of compositions (stored proteins and carbohydrates) in bean seeds, the better the conditions for rapid and optimal germination which will result in increased seed establishment. Increasing the transfer rate of the stored materials from the seed to the seedling and subsequently better growth, coupled with weight of the seedling, will increase the establishment of the growing seedling. If the stored materials and other compositions in the seed affecting germination are not sufficient, the germination will be poor and, if the germination is poor, the seedling's growth will be reduced, there by leading to weak establishment of the plant (Jamil *et al*., 2007). poor establishment results in reducing the plant ability to compete with weeds (Rebetzke and Richards, 1999), less shadowing on the ground which increases evaporation from the soil surface, decreasing the absorption of the light energy, thus inhibiting growth and weakening the seedling, leading to susceptibility to pests and diseases. During the early phases of germination which occurs in the absence of light, stored compositions are transfer to the seedling. During germination, because of respiration, seed dry weight related to the growing seedling is less than weight of mobilized seed reserve (Bewley and Black, 1982). This means that during transferring to the seedling, some of WMSR is consumed for respiration. The more intensive respiration, the less material are transfer to the seedling which reduces SLDW and thus reduces seed reserve utilization efficiency of the seed. Based on mentioned, the strength of establishing seedling depends on its SLDW and SLDW depends on WMSR and SRUE. WMSR is affected by primary dry weight of seed (mg $seed^{-1}$) and seed reserve depletion percentage in which is transferred for developing the seedling (WMSR = dry weight of seed×SRDP). SRUE (SLDW/WMSR) is the efficacy of transferring of WMSR to seedling which in fact is some of WMSR transformed to SLDW. There are different reports regarding which component of WMSR or SRUE is responsible in seedlings growth. Further research should focus on the two above mentioned components to determine the sensitivity of each and their roles in developing seedlings with high rate of establishment. In this way, breeding programs can focus on this sensitive component and only with the breed of this component responsible in increasing SLDW; establishment of seedling will be promoted.

MATERIALS AND METHODS

This study was carried out in the agronomy laboratory of the University of Guilan. Experimental treatments were the composition of 6 genotypes of common beans (*Phaseolus vulgaris* L.) and 5 levels of Salinity. Genotypes were including KBC31170, KS21467, KS21487, KS31167, KS41134 and KS41231 which were obtained from the Research Center of Agriculture and Natural Resources of Khomein. The levels of Salinity were 0, 33, 65, 98 and 130 mM which were prepared using pure NaCl and distilled water. Factorial design on the basis of complete random block with four repeats for each treatment was used as pilot. Twenty five seeds were used for each experimental unit. Before caring out the main experiment, 25 seeds from each genotype were

Table 1: Summary of analysis of variance for weight of mobilized seed reserve (WMSR), seed reserve depletion percentage (SRDP), seed reserve utilization efficiency (SRUE) and seedling dry weight (SLDW) attributes in salinity experiment

	df	WMSR	SRDP	SRUE	SLDW
C	5	7479.84**	6179.23**	3763.05*	660.42**
S	4	4880.28**	775.22**	6867.18**	177.76**
S×C	20	1049.86^{NS}	307.15^{NS}	1462.19^{NS}	190.63**

**p<0.01, *, ** Significant at p<0.05 and 0.01, respectively, NS: Not significant

chosen with 4 repeats to calculate the water content of the seed. Seeds were weighted (w_1) and then seeds were dried in an oven at 104°C for 24 h and weighed again (w_2). Seed Water Content (SWC) was calculated from w_1-w_2/w_2 correlation. Primary dry weight of seeds for each genotype (w_2) was calculated using w_1 and SWC. Results are indicates in Table 1. Seeds were put in a 16 cm petri dish and related salinity solution was added to each Petri according to the experiment plan. Seeds were kept for seven days at 25°C in the germinator. After seven days seedlings were brought out of petri dishes and stem and root of each seed were cut and together with the rest of the seeds were kept in oven at 75°C for 48 h and were dried. Then dry weight of stem, root and rest of seeds were recorded separately. The sum of dried weight of stem and root shows SLDW (mg seed^{-1}). WMSR was calculated by subtraction of dried weight of residuals of seeds (R) from primary dried weight of seeds (W_2) (W_2-R = WMSR mg seed^{-1}). SRDP was obtained by using the calculated WMSR and dividing it to primary dried weight of seeds (WMSR/W2 = SRDP%). SRUE was calculated by dividing SLDW to WMSR (SLDW/WMSR = SRUE mg mg^{-1}). Obtained data were analyzed by using SAS software (SAS Institute, 1985).

RESULTS AND DISCUSSION

Results showed that there was significant difference in salinity levels (Table 1). Genotypes showed significant difference in the SLDW, tolerance of genotypes to salinity is therefore different. On the other hand, there was a reduction in SLDW of all genotypes in different levels of salinity (Fig. 1). Some of genotypes, such as KBC31170 and KS21487, are showed high tolerance to salinity. Salinity levels, however, showed significant difference for studied traits (Table 1). SLDW did not decrease under influence of levels of salinity 0 and 33 mM and even increasing was observed for it. This increasing is corresponding with the results obtained by Mozafar and Goodin (1986) for wheat. This report and the results of this study both show an increasing for SLDW in low levels of salinity. Levels 33 and 130 mM had the minimum and maximum SLDW average respectively (Fig. 1). Thus it seems that level of salinity of 33 mM might have a positive effect in germination, seedling growth and eventually successful establishment of common beans. Although there was a significant difference among genotypes and levels of salinity for both traits of WMSR and SRDP (Table 1) but there was not a constant reduction in both of these traits with the increasing levels of Salinity and even in both of these traits, especially in WMSR, an constant increasing was observed (Fig. 2 and 3). As for SLDW, the difference of genotypes in SRUE was significant (Table 1) and they showed a constant reduction with increasing the level of salinity (Fig. 3). The course of changes in traits of SRUE and SLDW was quite similar in all genotypes in different levels of salinity (Fig. 1, 4 and 5). Correlation analysis was calculated SRUE and SLDW also indicated this subject (Fig. 5). In both of these traits an increasing is observed in the level of salinity of 33 mM compared with the 0 mM level. Salinity at a level of 65 mM tolerated less reduction compared with the level of 33 mM and the reduction trend was continued in the next

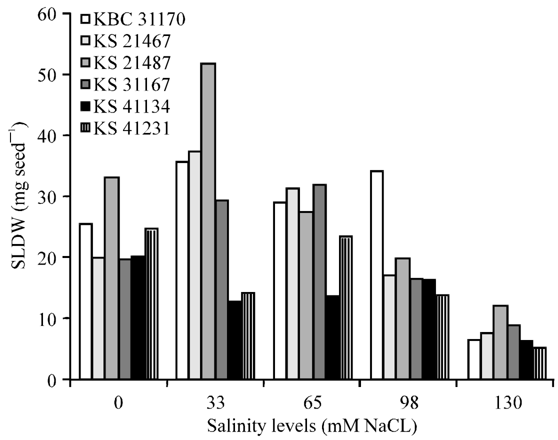

Fig. 1: The course of changes in SLDW in genotypes in the levels of salinity

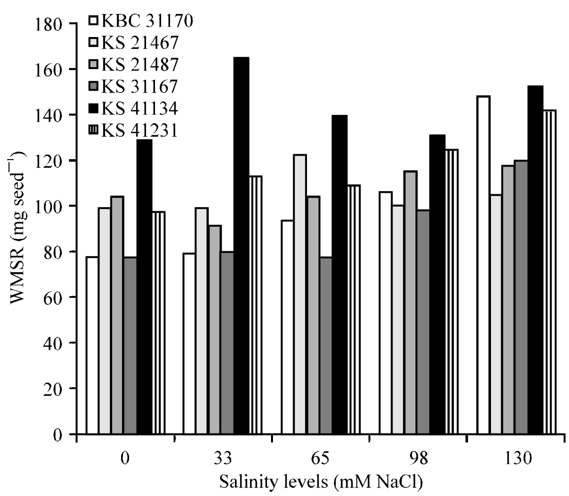

Fig. 2: The course of changes in WMSR in genotypes in the levels of salinity

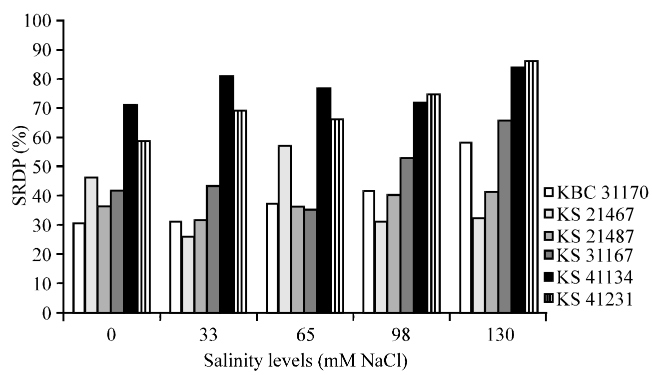

Fig. 3: The course of changes in SRDP in genotypes in the levels of salinity

levels. Here, the primary weight of the seed had a significant correlation with the tolerance of the genotypes related to salinity, in the same way that the bigger the size of seeds of each genotype,

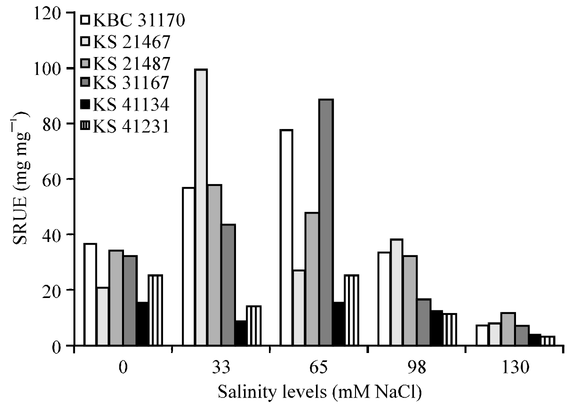

Fig. 4: The course of changes in SRUE in genotypes in the levels of salinity

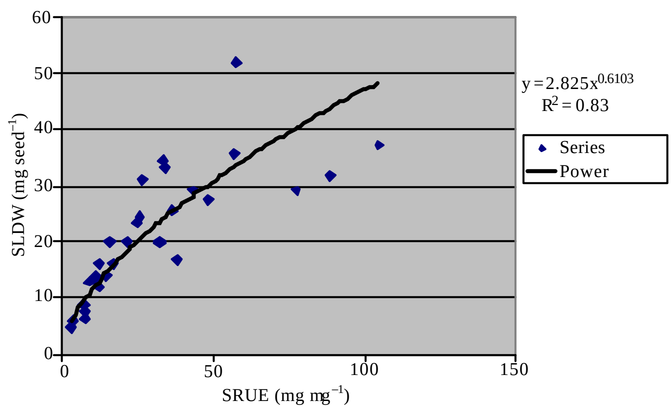

Fig. 5: Correlation for SRUE and SLDW

the greater the amount of SLDW of that genotype. Both of these genotypes, KBC31170 and KS21487, had the greatest size of the seeds while they had also the greatest amount of SLDW (Fig. 1). In the same manner, genotypes KS41134 and KS41231 had the lowest SLDW (Fig. 1) and smallest size of the seeds. It should be noted that there are controversial reports regarding the correlation of the size of the seeds to the amount of SLDW. Lafond and Backer (1986) have shown that smaller seeds germinate growth and develop faster than bigger ones. On the other hand, there other reports indicate a positive and significant correlation between the size of seeds and strength of germination (Singh, 1970).

Overall, our results clearly indicate that decline in SLDW in response to salinity is a consequence of decline in SRUE, not WMSR. This is not in agreement with observation of Soltani *et al.* (2002) in chickpea. They found that SLDW reduction was a result of reduction in WMSR, not conversion SRUE to seedling tissue. Therefore, evaluation of genetic variation for seed vigor traits will be found significant genetic differences for SRUE. This genetic variation can be used in breeding programs that aimed at the improvement in SRUE rate. Therefore, breeding programs should be focused on the sensitive component, i.e., SRUE and the breeding of this component results in the breeding of SLDW in common bean.

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