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Effects of Salinity and Drought Levels in Seed Germination of Five Crop Species

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***Abstract*—The heterotrophic seedling growth can be defined as a product of two components: (1) the weight of mobilized seed reserve, and (2) conversion efficiency of utilized seed reserve to seedling tissue. The first component can be further divided into (1) initial seed weight, and (2) the fraction of seed reserve, which is mobilized. The objective of this study was the identification of the sensitive seedling growth component(s) in response to drought and salinity stresses. Two experiments were separately conducted using various salinity levels (osmotic pressure) of 0, 0.25, 0.50, 0.75, 1, 1.25 and 1.5 MPa created using NaCl as first experiment and by polyethylene glycol (drought stress) of 0, 0.2, 0.4, 0.6, 0.8, 1, 1.2 and 1.4 MPa in second experiment. Seeds of five crops species (*Hordeum vulgare, Brassica napus, Zea mays, Medicago sativa and Medicago scutellata*) were used in each experiment. In both experiments, seedling growth, fraction of seed reserve utilization and weight of mobilized seed reserve decreased with increasing drought and salt intensity. However, drought and salinity stresses had no effect on the conversion efficiency. It was concluded that the sensitive component of seedling growth is the weight of mobilized seed reserve.

***Keywords*—Salinity, Drought, Seed reserve, Seedling, Crops species

I. INTRODUCTION

SALINITY and drought are major environmental limiting plant growth and productivity. Salinity and drought stress biology and plant or seed responses to high levels have been discussed over two decades [13, 17, 18].

Germination and seedling growth were negatively affected by drought and salinity stresses [6, 16]. Poor germination and decreased seedling growth resulted in poor establishment and occasionally crop failure [1, 9]. Poor establishing in turn causes :(a) decreased crops competitiveness with weed (b) lowers shading of the soil surface and subsequently higher loss of soil water through evaporation and hence, lower availability of water for crop; (c) lower light interception and yield potential; (4) lower growth in early season when vapor pressure deficit is low and as a result diminished CO_2 exation per unit transpiration loss [5].

The detrimental effects of high salinity and drought on plants can be observed at the whole-plant as the death and/or decreases in productivity. During the onset and development of salt and drought stress, all major processes such as protein synthesis, energy and lipid metabolism are affected. Carbohydrates, which among other substrates are needed for cell growth are supplied mainly through the process of photosynthesis, and photosynthesis rates are usually lower in plants exposed to salinity and especially to NaCl. Salinity of soil and water is caused by the presence of excessive amounts of salts. Most commonly, high Na^+ and Cl^- cause the salt stress. Salt stress, reduces water potential and causes ion imbalance or disturbances in ion homeostasis and toxicity. This altered water status leads to initial growth reduction and limitation of plant productivity. Since salt stress involves both osmotic and ionic stress, growth suppression is directly related to total concentration of soluble salts or osmotic potential of soil water. High salt (NaCl) uptake competes with the uptake of other nutrient ions, especially K^+, leading to K^+ deficiency. Increased treatment of NaCl induces increase in Na^+ and Cl^- and decrease in Ca^{2+}, K^+, and Mg^{2+} levels in seeds. Unfortunately, there is little difference among commercial seeds within a species for drought tolerance [4, 20]. Although the ability to tolerate drought and have acceptable yields is limited among seeds within a species [4, 20, 22], there are considerable differences among seeds that allow them to avoid drought.

The objective of this study was the identification of the sensitive seedling growth component(s) in response to drought and salinity stresses.

II. MATERIAL AND METHODS

Two experiments were separately conducted at Seed Research Laboratory of Shahrood University of Technology Shahrood, Iran.

-Salinity experiment:

Factorial combinations of 5 crop specie (*Hordeum vulgare, Brassica napus, Zea mays, Medicago sativa and Medicago scutellata*) and 7 salinity levels were the treatments of the first experiment. The experimental design was a randomized complete block design with three replications per treatment. Salinity levels (osmotic pressure) of 0, 0.25, 0.50, 0.75, 1, 1.25 and 1.5 MPa were created using NaCl. Seeds were germinated in 10 cm Petri dishes with one whatman No. 1 filter papers moistened with the appropriate solutions or distilled water for 0 MPa. Twenty seeds per dish were used for each treatment. Seeds were incubated in the dark at 25±1 ^{0}C in a controlled temperature room. Three replicates of 20

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seeds were weighed (W_1), dried at 104^0C for 24 h and then reweighed (W_2). Seed water content was calculated as $[(W_1-W_2)/W_2]$.

After seven days, oven-dried weight of seedlings was determined. The weight of utilized (mobilized) seed reserve was calculated as the dry weight of the original seed minus the dry weight of the seed remnant. Conversion efficiency of mobilized seed reserve into plant tissue was estimated by dividing seedling dry weight (SLDW) by the utilized seed reserve. The ratio of utilized seed reserve to initial seed dry weight was considered as seed reserve depletion percentage (SRDP).

-Drought experiment

The second experiment was carried out as the first experiment, but Drought levels of 0, 0.2, 0.4, 0.6, 0.8, 1, 1.2 and 1.4 MPa were created using polyethylene glycol (PEG). All measurements were similar to salinity experiment.

Data from both experiments were separately analyzed, using the Statistical Analysis System.

III. Results And Discussion

In salinity treatments, the difference between crop species were significant for weight of mobilized seed reserve and seed reserve depletion percentage (Table 1). Corn had a greater weight of mobilized seed reserve and seed reserve depletion percentage (Fig. 1a and b). Part of the difference between crop species in salinity experiment can be ascribed to their seed size. Corn had a greater seed size than other seeds. Salinity×cultivar interaction was not significant for weight of mobilized seed reserve but, significant for seed reserve depletion percentage (Table 1).

The effect of all sources of variations including crop species, and their interactions were not significant for seed reserve utilization efficiency except for salinity levels, indicating that seed reserve utilization efficiency was a conservative trait.

Effect of crop species, salinity and their interaction was significant for seedling dry weight (Table 1). Similar findings have been reported by Ashraf and Mc-Neily [1], Francois et al. [8] and Hampson and Simpson [12] for negative effect of salinity on seedling dry weight. As shown in Fig. 1d, crop species difference for this trait was greater at lower OP and decreased with increasing OP. There are generally conflicting reports on the advantage of large seeds in producing more vigorous seedling. For example, Shroyer and Cox [21] speculated that seedling dry weight of some cultivars of each crop species may not be affected by seed size differences. Lafond and Backer [16] pointed out small seeds germinate and emerge more rapidly than large seeds. With purple-flower alfalfa (*Medicago sativa*), sainfoin (*Onobrychis viciafolia* Scop), soybean (*Glycine max*) [2, 14, 15], a significant positive relation between seed size and seedling dry weight has not been detected. On the other hand, there is more experimental evidence for positive correlation between seed size and seedling vigor [3, 7, 10, 11, 19, 21].

The results indicated that across drought levels, the difference between crop species (*Hordeum vulgare, Brassica napus, Zea mays, Medicago sativa and Medicago scutellata*) was significant for weight of mobilized seed reserve and seed reserve depletion percentage (Table 1; Fig. 2a and b). There was also a significant drought× crop species interaction for seed reserve depletion percentage (Table 1). The difference between crop species was not great in drought levels less than 1 MPa, but at drought stress greater than 1MPa, Corn and Barley retained a higher weight of utilized seed reserve and seed reserve depletion percentage (Fig. 2a and b).

The effect of, drought, crop species and their interactions was not significant for seed reserve utilization efficiency (SRUE) (Table 1; Fig. 2c). Effect of crop species and drought and their interaction was significant for seedling dry weight (Table 1). Across drought OPs, Corn and Barley had a greater seedling dry weight than other crop species (Fig. 2d). While seedling dry weight was declined with increasing drought stress in all of crop species, but this reduction was greater for Canola, Alfalfa and Annual medic at levels more than 0.4MPa.

Overall, our results clearly indicate that decline in seedling dry weight in response to salinity and drought is a consequence of decline in weight of mobilized seed reserve (seed reserve depletion percentage), and seed reserve utilization efficiency.

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TABLE I 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 AND DROUGHT EXPERIMENTS.

Anova	WMSR	SRDP	SRUE	SLDW
Salinity exp				
crop species(C)	*	*	n.s	*
Salinity(S)	**	*	*	**
C×S	n.s	**	n.s	*
Drought exp				
crop species(C)	*	**	n.s	**
Drought (D)	n.s	*	n.s	**
C×D	**	n.s	n.s	**

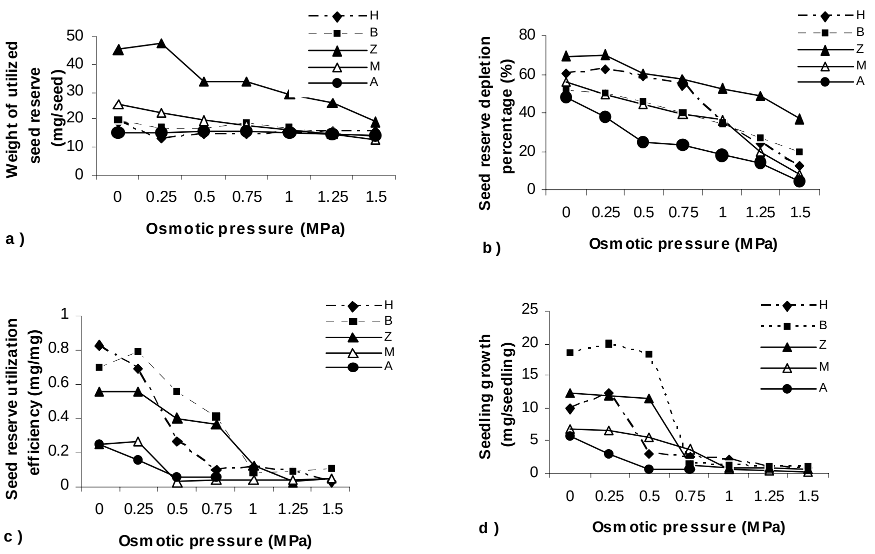

Fig 1. Effect of NaCl-induced salinity (MPa) on weight of utilized (mobilized) (a), seed reserve depletion percentage (b), seed reserve utilization efficiency (c) and seedling growth in seeds of *H.vulgae* (H), *B.napus* (B), *Z.mays*(Z), *M.sativa* (M) *and M. scutellata* (A).

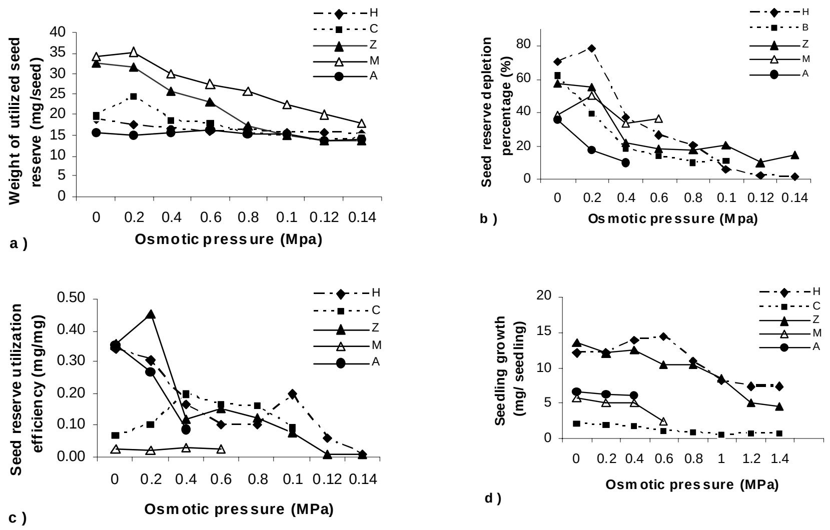

Fig 2. Effect of PEG-induced drought (MPa) on weight of utilized (mobilized) (a), seed reserve depletion percentage (b), seed reserve utilization efficiency (c) and seedling growth in seeds of *H.vulgare* (H), *B.napus* (B), *Z.mays*(Z), *M.sativa* (M) *and M. scutellata* (A).