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Full Length Research Paper

The role of hull in germination and salinity tolerance in some sunflower (*Helianthus annuus* L.) cultivars

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Six different NaCl levels (0, 5, 10, 20, 30 and 40 dS m^{-1}) and two seed types (hulled and dehulled) of sunflower seeds of Opal, Shelly (Confectionary) and Pactol (Oily) were tested to determine the effects of the hull on salinity tolerance during germination. Germination percentage (%), mean germination time (day), root and shoot length (cm) were investigated. Kernel type seeds exhibited higher germination percentage, longer root and shoot length and lower mean germination time compared to the achene type seeds at all NaCl levels. Both achene and kernel type seeds of cv. Pactol gave the highest germination percentage, root and shoot length. Hull was responsible for delaying germination and water uptake by seeds while it had no role in lowering the toxic effects of NaCl during germination. Therefore, it was concluded that inhibition in germination at all levels of NaCl was mainly due to osmotic barriers created by the presence of hulls rather than salt toxicity.

Key words: Sunflower, *Helianthus annuus* L., hull, NaCl, cultivar, germination.

INTRODUCTION

Salinity is the most common problem adversely affecting germination and stand establishment (Almansouri et al., 2001). Germination failure under saline conditions results from either reduction in imbibition of water by seed due to osmotic potential created by NaCl, or toxic effects due to uptake of excessive Na^+ and Cl^- ions by germinating seeds. In many research, the inhibitory effect of the salinity on germination is mainly due to restriction of water uptake by NaCl (Murrillo-Amador et al., 2002; Khajeh-Hosseini et al., 2003; Okçu et al., 2005; Atak et al., 2006; Kaya et al., 2006).

Sunflower is classified as salt tolerant crop (Katerji et al., 2000), but salt tolerance of plants depends on their growth period. Depending on the genotype sunflower cultivars show different response to salinity (Ashraf and Tufail, 1995; Muralidharudu et al., 1998). Saha and Gupta (1997) found that seedling growth of sunflower was inhibited at 15 mmhos cm^{-1} and above. However, Kaya et al. (2006) reported that germination percentage was not influenced by NaCl level of 23.5 dS m^{-1}. Mohammed et al. (2002) reported that by NaCl levels germination percentage decreased and mean germination time increased proportionately. In many plant species, germination and seedling growth is inhibited b mechanical restriction exerted by the seed coat (Sung and Chiu, 1995). Sunflower seeds may take longer time to germinate and emerge than grain crops because of slow moisture movement through the seed coat; as the seed coat may inhibit germination and seedling growth by preventing or slowing down water uptake. However, seed coat constitutes a barrier against the toxic ions in the exogenous water, do not permit their passage to the embryo and protect the seeds from diseases and insects. But, it is still not clear if salinity tolerance of sunflower during germination is due to a barrier constituted by hull. Therefore, the study aimed to ascertain the role of hull in seed germination and find out its importance under saline conditions.

MATERIALS AND METHODS

This study was carried out at the Department of Field Crops, Faculty of Agriculture, University of Ankara, Turkey using the seeds oil type cvs. Pactol and two confectionary type cv. Shelly and Opal of sunflower. These were obtained from Variety Registration and Seed Certification Institute, Ankara-Turkey, were used as seed material. All three cultivars were tested against 5, 10, 20, 30 and 40 dS m^{-1} (electrical conductivities of the solutions) of NaCl using a conductivity meter (Model WTW Cond. 314i, Germany) both as hulled and dehulled seeds. Distilled water served as a control (0 dS m^{-1}). Dehulling was done manually. Three replicates of 20 seeds of each cultivar were germinated between 3 rolled filter papers with 15 ml of respective test solutions. Seed materials were treated with fungicide before planting. The papers were replaced every 2 days to prevent accumulation of salts. In order to prevent evaporation, each rolled paper was put into a sealed plastic bag. Seeds were allowed to germinate at 25 ± 1°C in the dark for 8 days. A seed was considered germinated when the emerging radicle elongated to 2 mm. Germination percentage was recorded every 24 h for 8 days. Mean germination time (MGT) was calculated following Ellis and Roberts (1980) to assess the rate of germination. MGT= $\sum fx/\sum f$, where x is the number of the seeds newly germinated on day f, and f is the number of days from the beginning. Root and shoot length were measured on 10th day.

The experimental design was 3 factors factorial, arranged in a completely randomized design with 3 replications and 20 seeds per replicate. The first factor was cultivar (Shelly, Opal and Pactol), the second was seed type (hulled or dehulled) and the third was NaCl level (0, 5, 10, 20, 30 and 40 dS m^{-1}). Data given in percentages were subjected to arcsine transformation before statistical analysis. For all investigated parameters, Analysis of Variance was performed using the MSTAT-C software package program (Michigan State University). Significant differences among the mean values were compared by LSD test (P < 0.05).

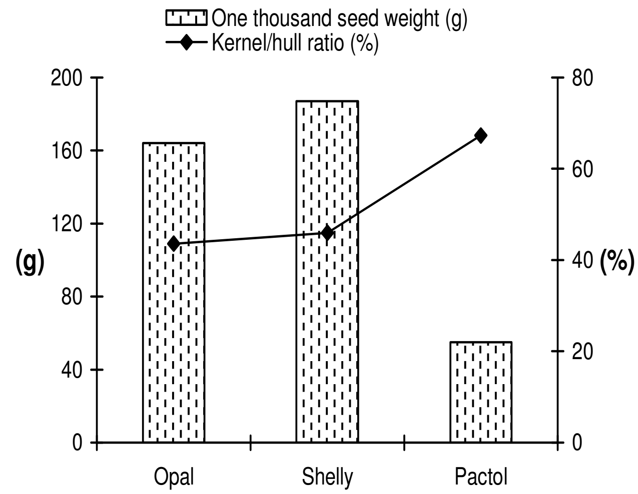

Figure 1. One thousand seed weight and kernel/hull ratio of the investigated sunflower cultivars.

RESULTS

One thousand seed weight and kernel/hull ratio of the cultivars are shown in Figure 1. Confectionary types of sunflower had higher one thousand seed weight while lower kernel/hull ratio. Cv. Pactol had the lowest one thousand seed weight, while the highest kernel/hull ratio (67.3%). A significant 3 way interaction (cultivar, seed type and NaCl level) was found (P < 0.05, 60 df) for all investigated characters. It is evident that as NaCl level increased, germination decreased for hulled seeds (Figure 2a and b). Especially, it declined considerably at 40 dS m^{-1}. At 40 dS m^{-1}, the highest germination percentage was obtained from cv. Pactol. MGT was delayed by increasing NaCl level (Figure 2c and d). Dehulled seeds of all cultivars were superior to hulled seeds at all NaCl levels for MGT. Among all cultivars, cv. Pactol germinated faster compared to others.

Increasing NaCl resulted in decrease in root length except for 5 dS m^{-1} (Figure 2e and f). Kernel gave the highest values at all levels of NaCl, while hulled seeds of cv. Shelly and Opal had the highest values in control. None of the cultivars were able to grow roots at 30 dS m^{-1} of NaCl and above. Dehulled seeds of cv. Shelly were superior to the others at 20 dS m^{-1} and had a root length of 7.27 cm. Increasing salinity by NaCl caused a remarkable decrease in shoot length but inhibition was greater at 10 dS m^{-1} for the hulled and 20 dS m^{-1} for dehulled seeds (Figure 2g and h). No shoot length was recorded for the cultivars at 30 and 40 dS m^{-1}. However, higher shoot length was determined from the dehulled seeds.

DISCUSSION

Germination and seedling growth of sunflower cultivars was adversely influenced by increased NaCl levels. Up to 30 dS m^{-1} germination percentage of dehulled seeds did not significantly affect germination while it declined at 40 dS m^{-1}. Inhibitory effects of NaCl on seed germination were a greater on hulled seeds compared to dehulled seeds. Superiority of dehulled seeds was due to fast imbibition compared to hulled seeds where hull slowed or prevented the uptake of water. Similarly, Kaya et al. (2006), found that germination percentage did not decrease at NaCl level of 23.5 dS m^{-1}. Contrarily, Delgado and Sanchez-Raya (2007) observed that seed germination declined by increasing NaCl. Mohammed et al. (2002) reported that germination percentage of sunflower considerably declined with increasing NaCl concentrations after 1 and 2 days incubation while the decline in germination reduced when incubation period was extended to 10 days. Considering hulled seeds, differentces among cultivars are very obvious and dramatic. Ashraf and Tufail (1995), Mohammed et al. (2002), Delgado and Sanchez-Raya (2007) argued that differentces for salinity tolerance during germination of sunflower depended on genotypes.

However, the results of this finding clearly indicate that differences for salt tolerance of sunflower genotypes during germination was due to changing kernel/hull ratio rather than genotypes because viability of hulled seeds decreased with increasing NaCl while it remained unchanged in dehulled in increasing the MGT in agreement with Kaya et al. (2006), Turhan and Ayaz (2004) in sunflower, Okçu et al. (2005) in pea, Atak et al. (2006) in triticale and Khajeh-Hosseini et al. (2003) in soybean. They determined that an increase in salt level delayed germination time. Dehulled seeds needed less time to germinate while hulled seeds needed more. At the same NaCl level, the lower germination time and higher final germination in dehulled seeds compared to hulled seeds could be explained by more rapid water uptake in

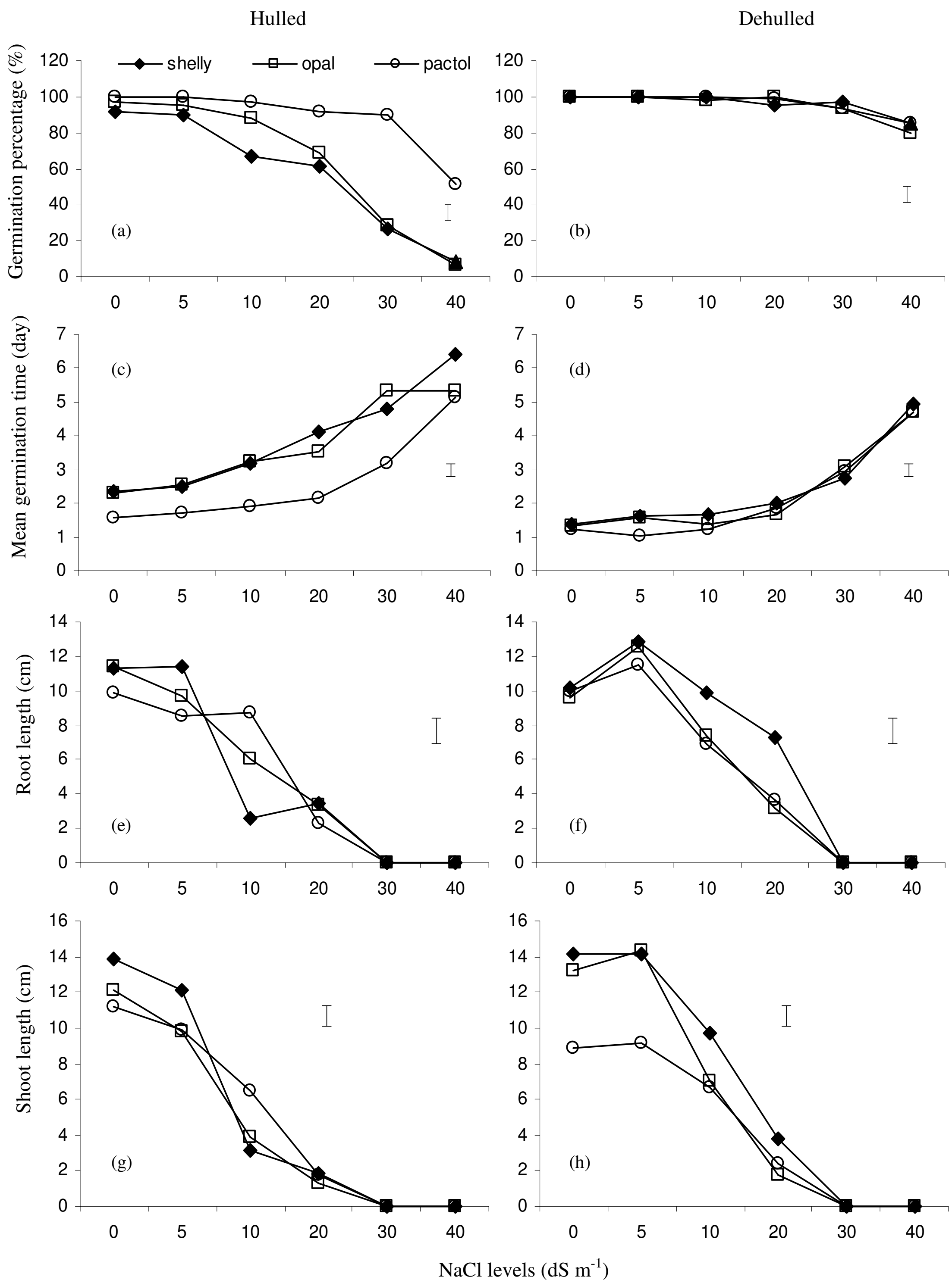

Figure 2. Effects of different salt concentration on 3 sunflower cultivars Shelly, Opal and Pactol. (a, b) Germination percentage, (c, d) MGT, (e, f) root length and (g, h) shoot length. Bars represent LSD values. *: LSD values belong to three way interaction within the same trait.

dehulled seeds by early achievement of necessary moisture content required for germination. The results are in line with the findings of Kaya et al. (2006) in sunflower; Murillo-Amador et al. (2002) in cowpea, Khajeh-Hosseini et al. (2003) found that in soybean salinity influenced germination by decreasing water uptake. Dehulled seeds absorbed water faster compared to hulled seeds and resulted in early germination. As dehulling of seeds gave the highest germination percentage at 40 dS m^{-1}, it was concluded that NaCl had no toxic effect of NaCl on germination.

Root and shoot length decreased with increase in NaCl concentration. Consequently, seedling growth was inhibited in sunflower. NaCl level of 5 dS m^{-1} had a stimulating effect on the root growth of the dehulled seeds. Saha and Gupta (1997) indicated NaCl level of 5 mmhos cm^{-1} promoted root and shoot growth of sunflower because low NaCl levels supplied nutrient effect rather than deleterious effect. Similar conclusions were drawn by Rehman et al. (1996) in Acacia, Khan et al. (2000) in *Atriplex griffithii* and Esechie et al. (2002) in chickpea.

Deleterious effects of NaCl were found less important for dehulled seeds compared to hulled seeds. Our findings showed that NaCl had greater detrimental effects on seedling growth than on germination because no root and shoot growth at 30 and 40 dS m^{-1} was observed in agreement with Turhan and Ayaz, (2004), Muralidharudu et al. (1998) in sunflower and Kaya et al. (2003) in safflower. It is assumed that reducing cell division and plant metabolism induced by accumulation of Na ion caused changes in ion balances such as Na:Ca and K:Na in plant cell in agreement with Khan et al. (2000) in *Atriplex griffithii*, Sivritepe et al. (2003) in melon, Ashraf and O'leary (1997), Delgado and Sanchez-Raya (1999), Ashraf et al. (2003) in sunflower, therefore, the rate of seedling growth was not determined.

Conclusion

The results suggested that the achene type seeds of the sunflower cultivars needed a considerably longer time to germinate under saline condition and the hull was responsible for delaying germination and water uptake by seeds but has no role in reducing or discarding toxic effects of NaCl during germination. It was also concluded that root and shoot growth was inhibited after germination due to absorption of Na^+ and Cl^- ion rich water in the growth medium.

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