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Seed treatments to overcome salt and drought stress during germination in sunflower (*Helianthus annuus* L.)

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Abstract

The treated seeds (control, KNO_3 and hydropriming) of sunflower (*Helianthus annuus* L.) cultivar Sanbro were evaluated at germination and seedling growth for tolerance to salt (NaCl) and drought conditions induced by PEG-6000 at the same water potentials of 0.0, −0.3, −0.6, −0.9 and −1.2 MPa. Electrical conductivity (EC) values of the NaCl solutions were 0.0, 6.5, 12.7, 18.4 and 23.5 dS m^{-1}, respectively. The objective of the study was to determine factors responsible for germination and early seedling growth due to salt toxicity or osmotic effect and to optimize the best priming treatment for these stress conditions.

Results revealed that germination delayed in both solutions, having variable germination with different priming treatments. Germination, root and shoot length were higher but mean germination time and abnormal germination percentage were lower in NaCl than PEG at the same water potential. Seeds were able to germinate at all concentrations of NaCl but no seed germination was observed at −1.2 MPa of PEG treatments. NaCl had less inhibitor effect on seedling growth than the germination. It was concluded that inhibition of germination at the same water potential of NaCl and PEG resulted from osmotic effect rather than salt toxicity. Hydropriming increased germination and seedling growth under salt and drought stresses.

Keywords: Sunflower (*Helianthus annuus* L.); Salt and drought stress; Seed treatment; Germination

1. Introduction

Sunflower (*Helianthus annuus* L.) is one of the most important oil seed crops in Turkey. One of the major obstacles to high yield and production is the lack of synchronized crop establishment in sunflower due to poor weather and soil conditions (Mwale et al., 2003). The seeds are occasionally sown in seedbeds having unfavorable moisture because of the lack of rainfall at sowing time (Angadi and Entz, 2002), which results in poor and unsynchronized seedling emergence (Mwale et al., 2003). Under the conditions of central Anatolia in Turkey, moisture content of soil at sowing time (Mid-April–Mid-May) is most often not adequate with significant variation in micro pockets of the same field; a condition that results in irregular seed germination and stand establishment.

Another major constraint to seed germination is soil salinity, a common problem in irrigated areas of Anatolia, with low rainfall (Kaya et al., 2003). Soil salinity may affect the germination of seeds either by creating an osmotic potential external to the seed preventing water uptake, or through the toxic effects of Na^+ and Cl^- ions on the germinating seed (Khajeh-Hosseini et al., 2003). Salt and osmotic stresses are responsible for both inhibition or delayed seed germination and seedling establishment (Almansouri et al., 2001). Under these stresses there is a decrease in water uptake during imbibitions and furthermore salt stress may cause excessive uptake of ions (Murillo-Amador et al., 2002).

Seed priming has been successfully demonstrated to improve germination and emergence in seeds of many crops, particularly seeds of vegetables and small seeded grasses (Heydecker and Coolbaer, 1977; Bradford, 1986). The beneficial effects of priming have also been demonstrated for many field crops such as wheat, sugar beet, maize, soybean and sunflower (Parera and Cantliffe, 1994; Singh, 1995; Khajeh-Hosseini et al., 2003; Sadeghian and Yavari, 2004). Dharmalingam and Basu (1990)

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reported beneficial effect of a hydration-dehydration seed treatment on germination of sunflower. Rao et al. (1987) reports that primed Brassica seeds may reduce the risk of poor stand establishment in cold and moist soils. However, Singh and Rao (1993) stress that KNO_3 effectively improved germination, seedling growth and seedling vigour index of the seeds of sunflower varieties with low germination.

The aims of the present study were to determine factors responsible for failure of germination of sunflower seeds under saline conditions due to an osmotic barrier or due to the toxic effects of NaCl by comparing seed germination under a range of osmotic potentials due to NaCl and PEG. Furthermore, the study examined the possibilities to overcome salt and drought stresses by seed treatments with hydropriming or treatment with KNO_3.

2. Materials and methods

This study was carried out at the Department of Agronomy, Faculty of Agriculture, University of Ankara, Turkey. Sunflower cultivar Sanbro from Syngenta Seeds Inc., which is commonly grown in Turkey, was used as seed material. Germination and early seedling growth (7 days) of the cultivar were studied using distilled water (control) and under osmotic potentials of −0.3, −0.6, −0.9 and −1.2 MPa, for NaCl (Coons et al., 1990) or polyethylene glycol (PEG 6000) (Michel and Kaufmann, 1973). NaCl concentrations had the electrical conductivity (EC) values of 6.5, 12.7, 18.4 and 23.5 dS m^{-1}, respectively.

2.1. Seed treatments

For hydropriming, sunflower seeds (4.4% seed moisture) were immersed in distilled water at 25 °C for 18 h under dark conditions. The hydropriming duration was determined by controlling seed imbibition during germination. For KNO_3 treatment, the seeds were immersed in 500 ppm KNO_3 solution at 25 °C for 2 h in the dark (Singh and Rao, 1993). Thereafter, the seeds were rinsed with tap water three times. The treated seeds were surface-dried and dried back to their original moisture content at room temperature (about 22 °C, 45% relative humidity) determined by changes in seed weight.

Moisture content of untreated seeds (control, 4.4% moisture content), hydroprimed and KNO_3 treated seeds was equilibrated at room temperature for 2 days.

2.2. Germination tests

Three replicates of 25 seeds were germinated between double layered rolled Anchor germination paper with 10 ml of respective test solutions. The papers were replaced every 2 days to prevent accumulation of salts (Rehman et al., 1996). The rolled paper with seeds was put into sealed plastic bags to avoid moisture loss. Seeds were allowed to germinate at 25 ± 1 °C in the dark for 7 days. Germination was considered to have occurred when the radicles were 2 mm long. Germination percentage was recorded every 24 h for 7 days. To determine the toxic effects of the solutions on germination, non-germinated seeds in each treatment were transferred to distilled water and counted 3 days later. Mean germination time (MGT) was calculated to assess the rate of germination (Ellis and Roberts, 1980). The seedlings with short, thick and spiral formed hypocotyls and stunted primary root were considered as abnormally germinated (ISTA, 2003). Root length, shoot length and seedling fresh weights were measured after the 7th day.

Three grams of the seeds from each seed treatment were placed in Petri dishes containing distilled water to determine water uptake of seeds necessary for germination. The water uptake was expressed as the percentage increase in moisture content on fresh weight basis.

2.3. Experimental design

The experimental design was three factors factorial (3 × 2 × 5) arranged in a completely randomized design; with three replications and 25 seeds per replicate. The first factor was seed treatments (control, KNO_3 and hydropriming), the second, solutions (NaCl and PEG) and the third was osmotic potential levels (0, −0.3, −0.6, −0.9 and −1.2 MPa). Data for germination and abnormal germination percentage were subjected to arcsine transformation before analysis of variance was made using MSTAT-C program (Michigan State University). The differences between the means were compared using LSD values ($P < 0.05$).

3. Results

A significant three-way interaction (seed treatment, solution and stress) was found ($P < 0.05$, 60 d.f.) for all investigated characters. The mean germination time (MGT) increased with decrease in osmotic potential in both NaCl and PEG solution; however, PEG delayed it more compared to NaCl (Table 1). Both priming treatments shortened the time to seed germination. Hydropriming resulted in the accelerated germination for both NaCl and PEG, especially under low osmotic potential. Water uptake of primed seeds did not change significantly ($P < 0.05$) (Fig. 1), while the time to seed germination for hydropriming, KNO_3 and control was delayed by 12, 18 and 38 h, respectively (data not shown).

Germination percentage was influenced by salt and osmotic stresses, but inhibition was greater in PEG (Table 2). None of the

Table 1
Mean germination time (days) of sunflower seeds treated with KNO_3, hydropriming and control (untreated) at water stress of NaCl and PEG

MPa	Seed treatments					
	Control		KNO_3		Hydropriming	
	NaCl	PEG	NaCl	PEG	NaCl	PEG
0	1.87	1.87	1.23	1.23	1.13	1.13
−0.3	2.00	2.13	1.63	2.07	1.30	2.23
−0.6	2.00	3.13	1.93	2.73	1.33	2.60
−0.9	2.30	3.80	2.03	3.93	2.10	3.60
−1.2	2.67	–	2.37	–	2.17	–

LSD (Int) = 0.21 (60 d.f.).