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SALINITY, GERMINATION PROMOTING CHEMICALS, TEMPERATURE AND LIGHT EFFECTS ON SEED GERMINATION OF *ANETHUM GRAVEOLENS* L.

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Abstract

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The aim of this study was to ascertain the effects of different osmotic solutions on water uptake of *Anethum graveolens* L. (dill) and to understand the germination behavior of the seeds in response to salinity, germination promoting chemicals, temperature, and light. For water uptake from salt solution five salinity concentrations (0.1, 0.5, 1, 2 and 3 molar NaCl) and for sucrose solution five concentrations (0.1, 0.5, 1, 2 and 3 molar) were used. Water uptake decreases when the osmotic pressure of the solution increases. A maximum water uptake was observed at 0.1 molar NaCl solutions and 0.1 molar sugar solutions in each imbibitions duration and the least at 3 molar. Temperature and time affected water uptake, and the water uptake was maximum at 20 ºC after 96 h, and the least at 30 ºC. The promotive effect of germination promoting chemicals (10 and 100 ppm IAA and GA_3) was significant. An application of IAA and GA_3 decreased the salinity stress up to 1.5% level. GA_3 proves more effective than IAA at 0.5 and 1.0% NaCl. Seed germination of dill was influenced by temperature, and 25 ºC was found to be the optimal temperature for germination, and it was also seen that light did not significantly affect seed germination percentage at 20ºC.

Key words: dill, germination, salinity, water uptake

Introduction

Anethum graveolens L. (dill) is a sparse looking plant with feathery leaves and tiny yellow flowers (Hosseinzadeh et al., 2002). It is an annual and sometimes biennial herb of the family *Apiaceae*, which is native to south-west Asia and southeast Europe, and has been cultivated since ancient times (Bailer et al., 2001). It is used as a vegetable, a carminative, an aromatic (Hornok, 1992; Sharma, 2004) and it has also some pharmacological effects (Delaquis et al., 2002).

Dill is a member of the plant family *Umbelliferae* and is mainly propagated by seed. Germination and seedling growth are the most viable criteria used for selecting salt tolerance in plants (Boubaker, 1996). Salinity is one of the major stresses and impairs seed germination, retards plant development and reduces crop yield (Sheikh, et al., 1976; Greenway and Munns, 1980; Fowler, 1991; Shannon, 1998). The inhibitory effects of salinity on germination are due to osmotic effects and in some cases to chloride toxicity or a combination of both (Welbaum, et al., 1990; Bell, 1999.).

High concentrations of salt and sugar inhibit the water uptake in the seeds resulting in lower germination ratio (Ozdemir, et al., 1994 and Ozturk et al., 2008). Many investigators evaluated the germination and growth behavior of seeds of several crop species in relation to different salinity levels (Ansari, 1972; Khan

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and Gulzar, 2003; Ahmed et al., 2006, Siddiqi et al., 2007; Ulfat et al., 2007). Tolerance to salinity during germination is critical for the establishment of plants growing in saline soil of arid regions (Schabes, 2005). Even in halophytic species, best germination is obtained under non-saline conditions and their germination decreases with increases in salinity (El-Keblawy, 2004; El-Keblawy and Al-Rawai, 2005.). Dormancy-alleviating compounds like GA_3, IAA, kinetin, nitrate and thiourea are known to alleviate the effect of salinity on seed germination of some species (Ozturk et al., 2008; Khan and Ungar, 1985; Choudhury and Gupta 1995; Khan et al., 1998; Khan et al., 2002; Pandey and Palni, 2005; Nadjafi et al., 2006).

The role of temperature, light and moisture for germination of seeds was investigated in several researches (Choudhury and Gupta 1995; Khan et al., 2002; Khan, 1980; Baskin and Baskin, 1998; Cicek and Tilki, 2006; Martínez-Sánchez et al., 2006). Salinity and temperature regimes had affected on seed viability (Khan and Ungar 1997; Khan et al., 2001; Pompell et al., 2006), and imbibition of water by the seeds was closely related with the temperature (14 Ozturk et al., 2008; Ozturk and Mert, 1983). Germination was reduced by darkness in several temperature and salinity treatments in some species (Pandey and Palni, 2005; Pompell et al., 2006; Zia and Khan, 2004). The present study was carried out to (i) ascertain the effects of different osmotic solutions on the imbibitions of water by the *A. graveolens* seeds and (ii) understand the germination behavior of *A. graveolens* seeds in response to growth regulators (IAA, GA_3), salinity, temperature, and light.

Materials and Methods

Seeds of *A. graveolens* were collected in 2008 from north-west of Turkey, Bursa. The seeds were sterilized using sodium hypochlorite for 1 min, followed by thorough rinsing with distilled water and air-drying.

For water uptake from salt solution five salinity concentrations (0.1, 0.5, 1, 2 and 3 molar NaCl) were prepared and four replicates of 50 seeds for each salt treatment, or for the control, non-treated seeds, were placed on two layers of filter paper in Petri dishes at 20ºC for 24, 48 and 96 h. Distilled water was used as a control and water or salt solutions were added periodically maintaining the filter paper wet during the course of the experiment. Water uptake in four replicates of 50 seeds each was also recorded in 50 ml of distilled water in petri dishes at 20, 25 and 30ºC for 24, 48 and 96 h. For sucrose solution five concentrations (0.1, 0.5, 1, 2 and 3 molar) were prepared and placed in Petri dishes containing 50 seeds per replicate at 20ºC for 12 h light.

The growth regulators (10 and 100 ppm IAA and GA_3) were applied for two hours and then seeds were left in 0.5, 1, 1.5 % NaCl solutions placed at 20ºC. Germination was carried out in a germination chamber with a regime of 12 h photoperiod at 20ºC. To determine the effect of temperature on germination and water uptake, four replicates with 50 seeds were germinated at the constant temperatures of 20, 25 and 30ºC with a 12 h photoperiod with 1000 lux. To determine the effect of light on germination, seeds were germinated at constant temperature of 20ºC under dark or light.

Seeds were germinated in Petri dishes, 12 cm in diameter, (4 replicates of 50 seeds each) containing two layers of filter paper moistened with distilled water. Germination was carried out in a germination chamber. Seeds were counted at 2-d intervals until the 14th day and were considered to have germinated when the radicle emerged. Any germinated seeds were then removed from the Petri dishes at each counting. The data for germination was recorded daily up to the termination of the experiment. Germination percentage was calculated using the following formula:

Germination % = (number of germinated seeds / total number of seeds) x 100

For each trial, germination percentage data were arcsine transformed prior to analysis of variance to stabilize any heterogeneous variance. Mean values were subjected to analysis of variance, and the means were separated according to Duncan's Multiple Range Test ($p<0.05$).

Results and Discussion

Imbibition in relation to the osmotic solutions

The seeds in general absorbed water from all five osmotic solutions, however, imbibition increased with time in all osmotic solutions (Figure 1). However, water uptake decreased when the osmotic pressure of the solution increased. A maximum water uptake was observed at 0.1 molar NaCl solution in each imbibition duration and the least at 3 molar. The same results were found in *Brassica* species (Ozturk et al., 2008) and *Myrtus communis* (Ozturk et al., 1993).

Higher concentrations of salt solutions inhibit the water uptake in the seeds due to toxicity of high Cl ions or osmotic pressure because of high salt concentrations (1993). These results coincide with the findings of Ozturk et al. (2008) and Ozdemir et al. (1994). A maximum water uptake was observed at 0.1% molar NaCl solutions and the least at 3 molar in *Brassica nigra*, *B. juncea* and *B. oleracea* var. *botrytis* whereas in the seeds of *B. oleracea* var. *botrytis* the uptake decreases abruptly from 0.5 molar onwards, even at 0.1% level water uptake is low after 48 hours (Ozturk et al., 2008).

The seeds left in different sugar solutions showed the highest water uptake in 0.1 molar sugar solution followed by 0.5 molar solution, the least at 3 molar sugar solutions. In general, water uptake increases with time. Higher concentrations of sugar solutions inhibit the water uptake in the seeds due to osmotic pressure because of high sugar concentrations as said by Ozturk et al. (1993). The *Brassica nigra* and *B. juncea* seeds left in different sugar solutions showed maximum water uptake in 0.1 followed by 0.5 molar solution, minimum in 3 molar solution. In *Brassica oleracea* var. *botrytis* water uptake occurs in all salt and sugar solutions but was maximum at 0.1% NaCl and sugar concentrations (Ozturk et al., 2008).

Imbibition in relation to the temperature

Temperature and time affected water uptake in the present study (Figure 2). The water uptake was maximum at 20ºC after 96 h, and the least at 30ºC. At 20ºC minimum water uptake took place after 24 and 48 h. An increase has been observed in the water uptake of seeds at 20 and 25ºC when time increases. A continuous increase was also observed in the water uptake of seeds at different temperatures by Ozturk et al. (2008) and Ozturk and Mert (1983).

The water plays a constructive role for starting the biochemical and physiological processes in seeds and its uptake is regarded as the most important factor in the chain of events triggering the germination. The structural features of the seeds, seed coat permeability, temperature and salinity mainly control it. An increase in the volume, respiration, and enzyme activity, transportation of food, cell growth and division fol-

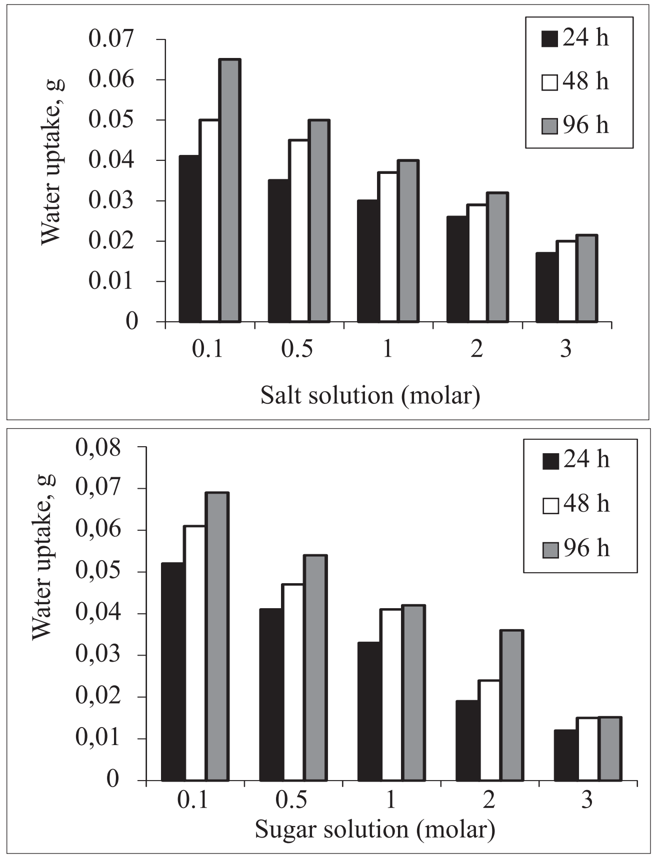

Fig. 1. Water uptake from different salt and sugar solutions

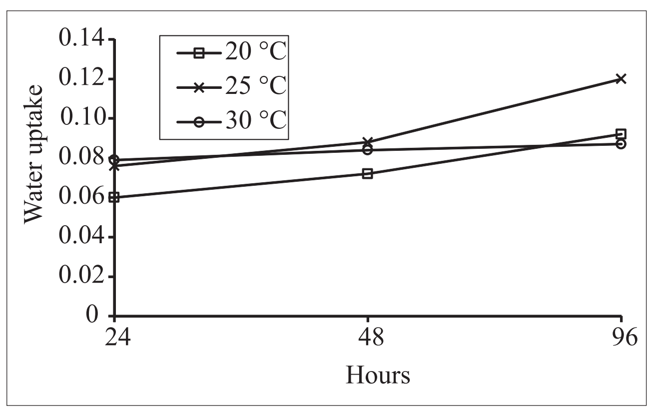

Fig. 2. Water uptake under different temperatures

lowed by differentiation of tissues and organs due to water uptake during seed germination is controlled by the critical hydration level varying from species to species (Ozturk et al., 2008). The role of moisture and temperature in soil for the germination of seeds has been well stressed by several investigators because a probe combination of critical temperature and humidity for the seeds to germinate in the soil is of great importance (Khan, 1980; Baskin and Baskin, 1998; Kramer and Kozlowski, 1979; Mayer and Mayber, 1982). During seed germination as soon as water uptake starts, membrane systems are reorganized and this process is mainly related to the temperature and the plant species (Uygunlar et al., 1985). An assessment of the water uptake of *Brassica* species at different temperatures and time revealed that water imbibition by the seeds from the soil was closely related with the temperature, and maximum and minimum water uptake was affected by the species (Ozturk et al., 2008).

Germination in relation to different osmotic solutions

Germination percentage was 83% in control and when seeds were treated with IAA and GA_3 growth regulators for two hours, germination percentage was not significantly different from the control (Figures 3 and 4). An increase in salinity decreased germination, and germination percentage was 35% in 0.5% NaCl. However, germination was inhibited at 1% and 1.5% NaCl. However, when seeds were treated with 10 and 100 ppm IAA and GA_3 growth regulators for two hours and then left in 0.5, 1.0 and 1.5% NaCl solutions, germination was increased significantly in each salt solution. Germination was the lowest in the highest salt solution (1.5% NaCl) (12% germination percentage) but germination increased to 40% in 1.5% NaCl followed by IAA or GA_3.

An application of IAA and GA_3 decreased the salinity stress up to 1.5% level. GA_3 proves more effective than IAA at 0.5 and 1.0% NaCl. However, at 1.5 % NaCl germination percentages of seeds treated with GA_3 or IAA were not significantly different (Figures 3 and 4).

Seed germination was affected by salinity and an increase in salinity stress causes a reduction in percentage of seeds (Ungar, 1982; Phillipupillai and Ungar, 1984; Khan and Ungar, 1998; Pujol et al., 2001; Rubio-Casal et al., 2003). Seed germination behavior of several crop species in relation to salinity levels were investigated by several authors (Fowler, 1991; Ozturk et al., 2008; Ansari, 1972; Khan and Gulzar, 2003; Zehtab-Salmasi, 2008). *Brassica nigra* and *B. juncea* are found to sensitive to salinity at the stage of seedling emergence and an application of IAA and GA_3 alleviates the salinity stress up to 1.5% level and to some extent at 2% level in *B. juncea*, but was not effective at 3% level (Ozturk et al., 2008). GA proves more effective than IAA at that study. In *Brassica oleracea* var. *botrytis* at 1% NaCl germination was 84% and at 2 and 3% NaCl gemination was completely inhibited (Ozturk

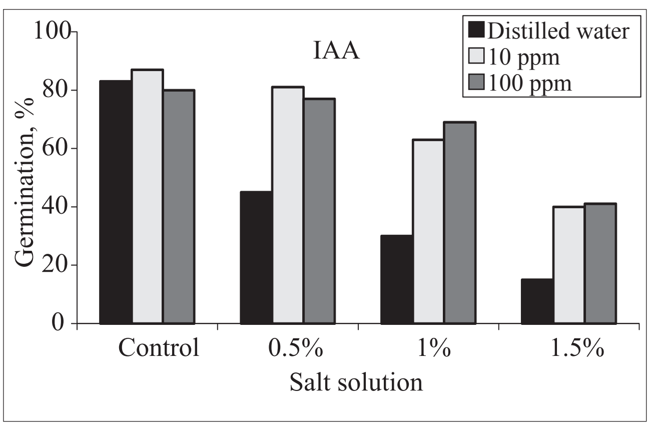

Fig. 3. Effects of IAA on seed germination of *A. graveolens* under different levels of salt solution

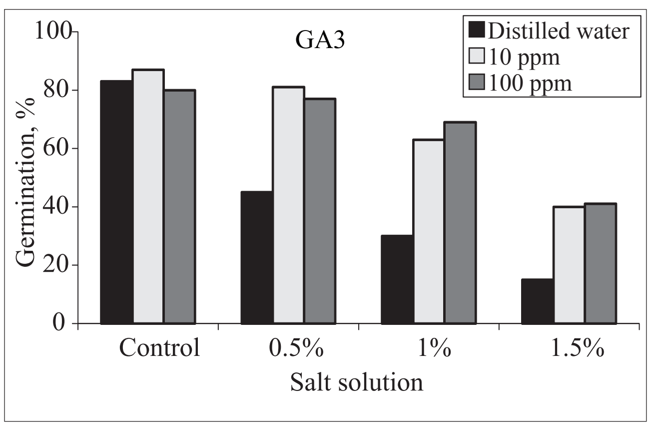

Fig. 4. Effects of GA3 on seed germination of *A. graveolens* under different levels of salt solution

et al., 2008). An improvement was observed in 0.5 and 1% NaCl solutions when *Brassica oleracea* var *botrytis* seeds were treated with 10 or 100 ppm GA_3 and IAA.

Higher concentrations of salt solutions inhibit the water uptake in the seeds resulting in lower germination percentage. Plant regulators like IAA and GA_3 applied externally can improve physical and metabolic conditions of seed germination (Khan et al., 2002; Ozturk et al., 1994; Khan and Ungar, 1998). It was found that 20-30ºC is the optimal temperature for germination of *Dyckia encholirioides* and any increase or decrease in temperature-inhibited germination (Pompell, 2006). This inhibition was progressively increased by salinity. 300 or more mmol L^{-1} NaCl decreased *Dyckia encholirioides* germination. The *Solanum central* seeds showed considerably salinity tolerance, germinating in solutions of up to 200 mM NaCl (Ahmed et al., 2006).

Germination in relation to different temperature and light

Temperature affected seed germination under 24-h light and germination percentage was the highest at 25ºC (97%), and the least at 30ºC (57%) in non-saline control (Figure 5). When seeds were germinated at 20 ºC under dark or light condition, it was seen that 24 h light did not significantly affect seed germination percentage (Figure 6).

Zehtab-Salmasi (2008) found that seed germination of dill was influenced by temperature, and 20/30 ºC was found to be the optimal temperature for germination and any increase or decrease in temperature inhibited germination. In addition, dill seeds germinated rapidly in control and in up to 5 dS m-1 NaCl at 20/30ºC temperature regime at that study. Seeds of different species show different germination behavior in response to different light and temperature conditions (Ozturk et al., 2008; Pandey and Palni, 2005; McDermott, 1973; Phartyal et al., 2003; Khan and Ungar, 1986). An assessment of the water uptake of *B. nigra*, *B. juncea* and *B. oleracea* at different temperatures and time interval revealed that imbibitions of water by the seeds from the soil were closely related with the temperature (Ozturk et al., 2008). Although temperature did not affect germination in the present study, temperature (10:20, 15:25, 20:30, 25:30ºC) affected germination rate of dill in another research done by Zehtab-Salmasi (2008). Germination percentage was not affected by temperature (15, 20, 25 or 15/25ºC) in *Halimum* species (Perez-Garcia and Gonzalez-Benito, 2005). Seed germination was influenced by temperature in *Dyckia encholirioides* and it was found that 20-30ºC is the optimal temperature for germination and any increase or decrease in temperature inhibited germination (Pompell et al., 2006).

Conclusions

Water uptake decreases when the osmotic pressure of the solution increases. A maximum water uptake was observed at 0.1 molar NaCl solutions in each imbi-

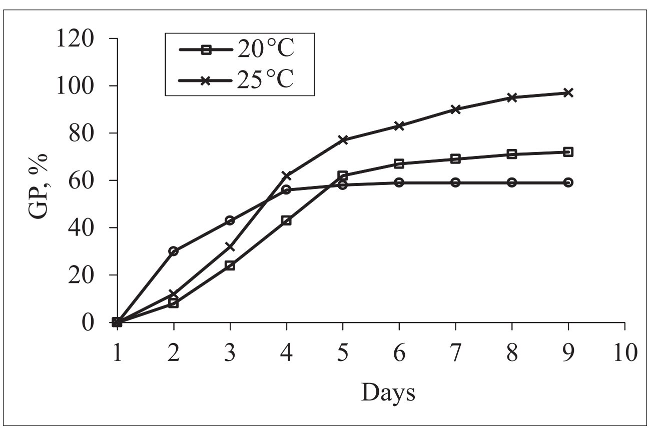

Fig. 5. Effects of temperature on seed germination of *A. graveolens*

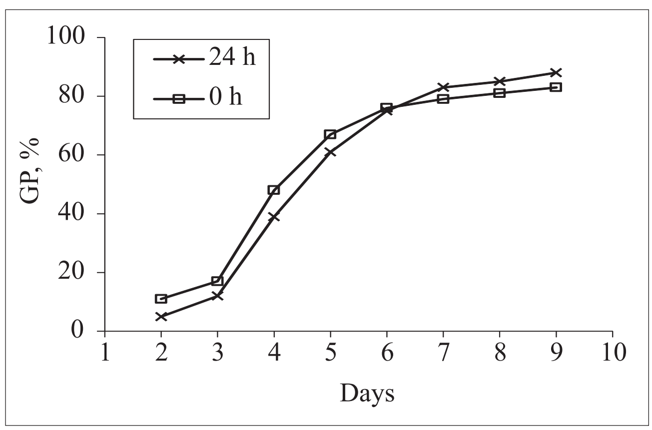

Fig. 6. Effects of light on seed germination of *A. graveolens*

bitions duration and the least at three molar. The seeds left in different sugar solutions showed the highest water uptake in 0.1 molar sugar solution followed by 0.5 molar solutions, the least in three molar sugar solutions. In general, temperature and time affected water uptake, and the water uptake was maximum at 25ºC after 96 h, and the least at 30ºC. The promotive effect of germination promoting chemicals (IAA and GA_3) was found to be significant. Germination of dill was influenced by temperature, and 25ºC was found to be the optimal temperature for germination. When seeds were germinated at 20ºC under dark and light condition, it was observed that light did not significantly affect seed germination percentage.

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