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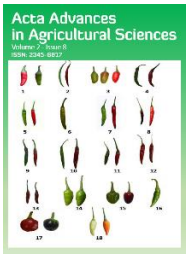

Research Article

Effect of seed priming on seed dormancy, vigor and seedling characteristics of fennel (*Foeniculum vulgare* L.)

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ABSTRACT

In order to investigate the effects of seed priming on certain important seedling characteristic and seed vigor of fennel (*Foeniculum vulgare* L.), an experiment was conducted based on randomized completely design (RCD) with three replications at the Department of Agronomy and Plant Breading, Faculty of Agriculture, Maragheh University in Maragheh state, Iran. Traits such as plumule, radicle and seedling length, seedling dry weight, mean germination rate, final germination percentage and seedling vigor index were considered. Treatment included untreated seeds (control) and those primed in water (H_2O), sodium chloride (NaCl, 100 mM) and polyethylene glycol 6000 (PEG-6000, water potential -1.6 MPa), in darkness for 18 hours. The results indicated that certain priming treatments had significant effect on above traits. Unsoaked seed (control) and hydropriming treatments had the lowest plumule, radicle and seedling length, seedling dry weight and seedling vigor index. PEG and NaCl in all of traits were better than the water priming treatments, respectively. Our results demonstrate PEG-6000 (-1.6 MPa) is the best treatment for breaking of fennel seed dormancy.

Abbreviations: Sodium chloride (NaCl), Polyethylene glycol 6000 (PEG), Mean germination rate (MGR), Final germination percentage (FGP), Seedling vigor index (SVI), International Seed Testing Association (ISTA), Superoxide dismutase (SOD) and Peroxidase (POD).

Introduction

Fennel (*Foeniculum vulgare*) is an aromatic biennial plant with soft, feathery, almost hair-like foliage. It is native to coastal areas in the Mediterranean region and widely naturalized in Europe and North America (Christman, 2004). Fennel belongs to the Umbelliferae (Apiaceae) family, a medicinal plant used as anti-spasmodic, appetite stimulant, stomachic, diuretic, anti-inflammatory, anti-diarrheic, against colic and as a lactation promoter (Piccaglia & Marotti, 1993; Cavaleiro *et al*., 1993). Several components of the essential oil of this plant show important applications, including, fenchone as counterirritant; limonene as solvent, resins, wetting and dispersing agent; trans-anethole, flavoring agent in perfumery, cosmetics, soap; metyl-chavicol or estragole is used in perfumeries and as flavor in foods and liquors; a-pinene α, used in manufacture of camphor, insecticides, solvents, perfume bases

(Marotti *et al*., 1993; Cavaleiro *et al*., 1993). Fennel seeds often fail to germinate due to presence of dormancy which results in low fennel production all over the world (Neamatollahi *et al*., 2009).

Priming can be a valuable process for improving germination and uniformity of heterogeneously matured seed lots (Olouch & Welbaum, 1996). Pre-sowing seed treatments (seed priming) include hydropriming, osmopriming, biopriming, seed soaking, hormonal-priming and magneto-priming. Osmopriming is a special type of seed priming that has been used to invigorate many horticultural (Bradford *et al*., 1990; Bray, 1995; Ghassemi-Golezani *et al*., 2008) and agronomic crops (Basra *et al*., 2002; Farooq *et al*., 2005; Neamatollahi & Souhani Darban, 2010). In osmopriming seeds are soaked in aerated low water potential solutions, which allow pregerminative activities to proceed, followed by refrying before actual germination (Cheng & Bradford, 1999). Priming of fennel seed with NaCI induces physiological and biochemical changes in plants grown under salt stress. Positive effects of priming with NaCl have been reported on growth and yield of mature tomato plants when salt treatments were applied with seed sowing (Cano *et al*., 1991). Rivas *et al*. (1984) found increased germination rates in Jalapeno and Tabasco tomato seeds primed in PEG-6000 solution. Basra *et al*. (1989) found that priming of corn seed using polyethylene glycol or potassium salts (K_2HPO_4 or KNO_3) resulted in accelerated germination at a chilling germinator (10 °C). It was concluded that hydroprimed and/or seed primed in -0.5 MPa osmotic potential solution of PEG were better in phonology and yield than all other treatments (Khan *et al*., 2008).

Many resent researches suggested that priming of seeds might be a useful way for better germination, seedling growth, establishment and yield (Leubner-Metzger, 2001; Ramaih *et al*., 2003; Naba'ee *et al*., 2013). The present study was, therefore, carried out with objective to evaluate the effects of different priming treatments on seed germination behavior of fennel (*Foeniculum vulgare*) under laboratory conditions to find out the most promising procedure.

Materials and Methods

In order to investigate the effect of seed priming on germination and some seedling characteristic of fennel (*Foeniculum vulgare*), an experiment was conducted based on randomized completely design (RCD) with three replications at the Department of Agronomy and Plant Breading, Faculty of Agriculture, Maragheh University in Maragheh state, Iran.

Seed priming

Seeds were disinfected with 96% ethanol for 30 seconds and 10% sodium hypochlorite solution for 50 seconds (Abdoli and Saeidi, 2012). Treatments included unsoaked seed (control) and seed priming treatments in water (H_2O), sodium chloride (NaCl, 100 mM) and polyethylene glycol 6000 (PEG-6000, water potential -1.6 MPa), for 18 hours at 20±2°C under dark conditions.

Germination tests

Lots of 25 seeds were germinated on one layers of filter paper in 9 cm Petri dishes. The Petri dishes were covered to prevent the loss of moisture by evaporation under laboratory condition (25±2 ^oC and 45-55% RH) for 14 days. Seeds were considered germinated when they exhibited radicle extension of > 2 mm. Every 24 hours after soaking, germinated seeds were examined daily during the course of the experiment to determine following germination parameters. Where the number of germinated seeds was recorded 14 days after planting as final germination percentage (FGP) according to ISTA (1999):

Table 1. *Some of the germination and growth parameters of fennel as affected by priming treatments.*

Priming treatments	Plumule length (cm)	Radicle length (cm)	Seedling length (cm)	Seedling fresh mass (mg plant^{-1})	Seedling dry mass (mg plant^{-1})
Control	1.27±0.45 c	2.90±0.58 a	4.17±0.98 b	14.0±2.5 a	0.95±0.29 a
Water	2.83±0.21 b	4.11±0.97 a	6.94±1.16 ab	21.4±2.9 a	1.29±0.34 a
NaCl	2.92±0.33 b	3.93±0.36 a	6.85±0.65 ab	14.2±3.0 a	0.65±0.21 a
PEG	4.49±0.14 a	3.88±0.34 a	8.37±0.35 a	20.9±2.2 a	1.22±0.03 a
	**	ns	*	ns	ns
CV (%)	8.4	18.8	12.1	12.7	11.1

ns, * and **: Non significant, significant at 5% and 1% levels of probability, respectively.
Means in the same column followed by the same letter are not significantly different at $p<0.05$ according to Duncan's test.
Mean ± standard error.

$FGP = (N_g/N_t)\times 100$

N_g=Total number of germinated seeds

N_t=Total number of seeds evaluated

The mean germination rate was calculated according to the following equation (Ellis *et al*., 1987):

$MGR = \Sigma n/\Sigma D_n$

n=Number of seeds which were germinated on day D

D_n=Number of days counted from the beginning of germination

The seedling vigor index (SVI) was calculated according to following formula (Abdul-Baki & Anderson, 1970):

SVI = (seedling length (cm) × germination percent)/100

The experiment was terminated by harvesting seedlings on 14th day plumule and radicle lengths were measured. Dry mass was determined after drying samples in oven at 70 ^{o}C for 24 hours.

Statistical analysis

Statistical analyses were performed using EXCEL and SAS statistical software (version 8.0). The significant differences between treatments were compared with the critical difference at 5% probability level by the Duncan's test.

Results and Discussion

Priming treatments increased plumule length in primed seeds over unprimed ones (Table 1); being maximum in PEG-6000 (4.49 cm) treated seeds and minimum in control (1.27 cm). These observations are in accordance with the findings of Demir & Van-Deventer (1999) who observed improved shoots length in watermelon seeds due to seed priming.

The osmopriming effect on radicle length was not significant. Priming improved the seedling length and results showed the same pattern for seedling length as in the case of plumule length is maximum in seeds primed in PEG-6000 (8.37 cm) followed by those primed with NaCl (6.85 cm), statistically at par with each other (Table 1). In seed priming treatments, a negative correlation was found between plumule length and seedling length (Figure 2).

The osmopriming (PEG-6000 and NaCl) effect on seedling fresh weight and seedling dry weight was not signification (Table 1). It is evident from the results that NaCl salinity caused growth

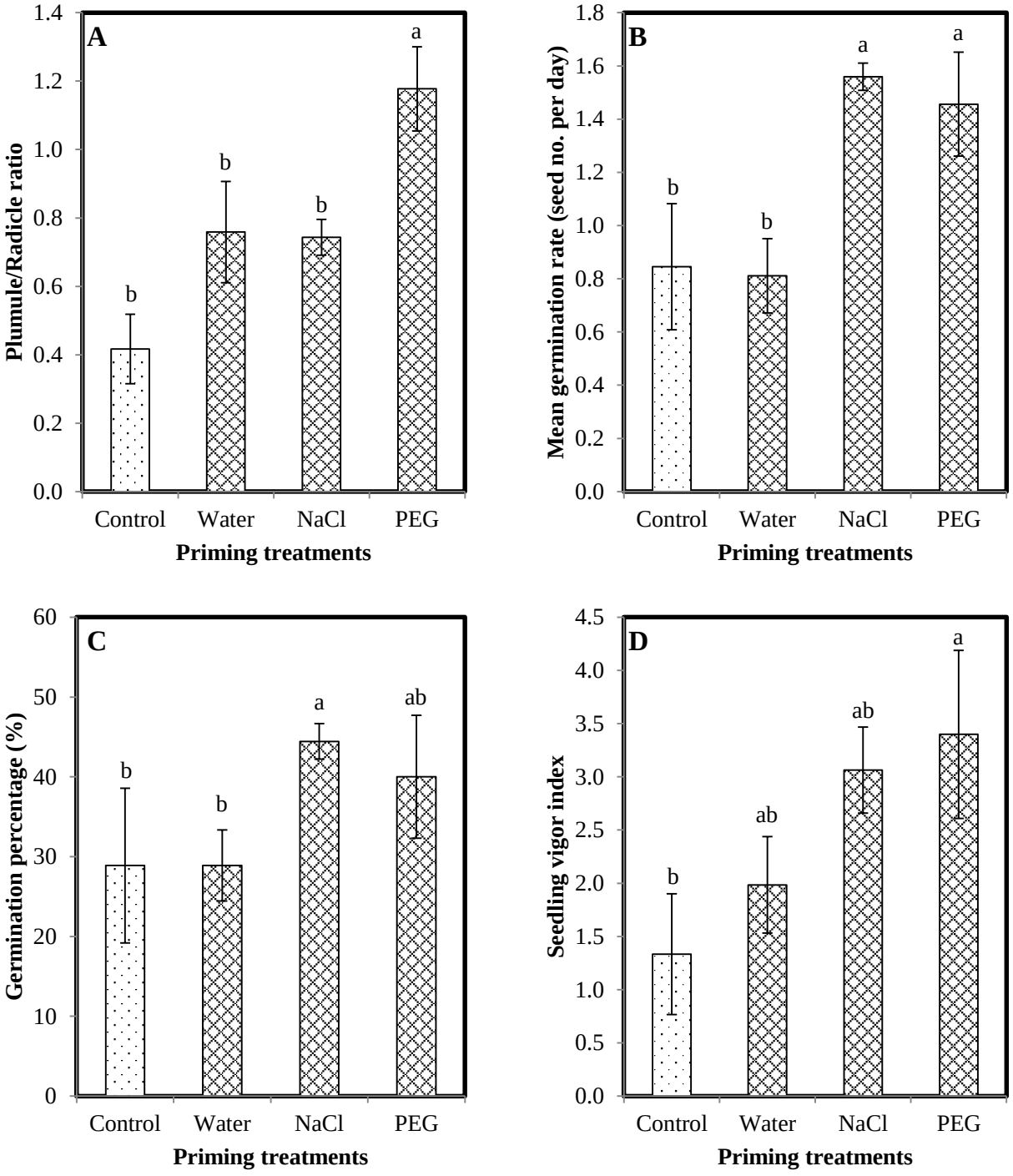

Fig 1. Plumule to radicle ratio (A), mean germination rate (B), final germination percentage (C) and seedling vigor index (D) of fennel seedling primed by water, NaCl and PEG. Vertical bars represent ± standard error.

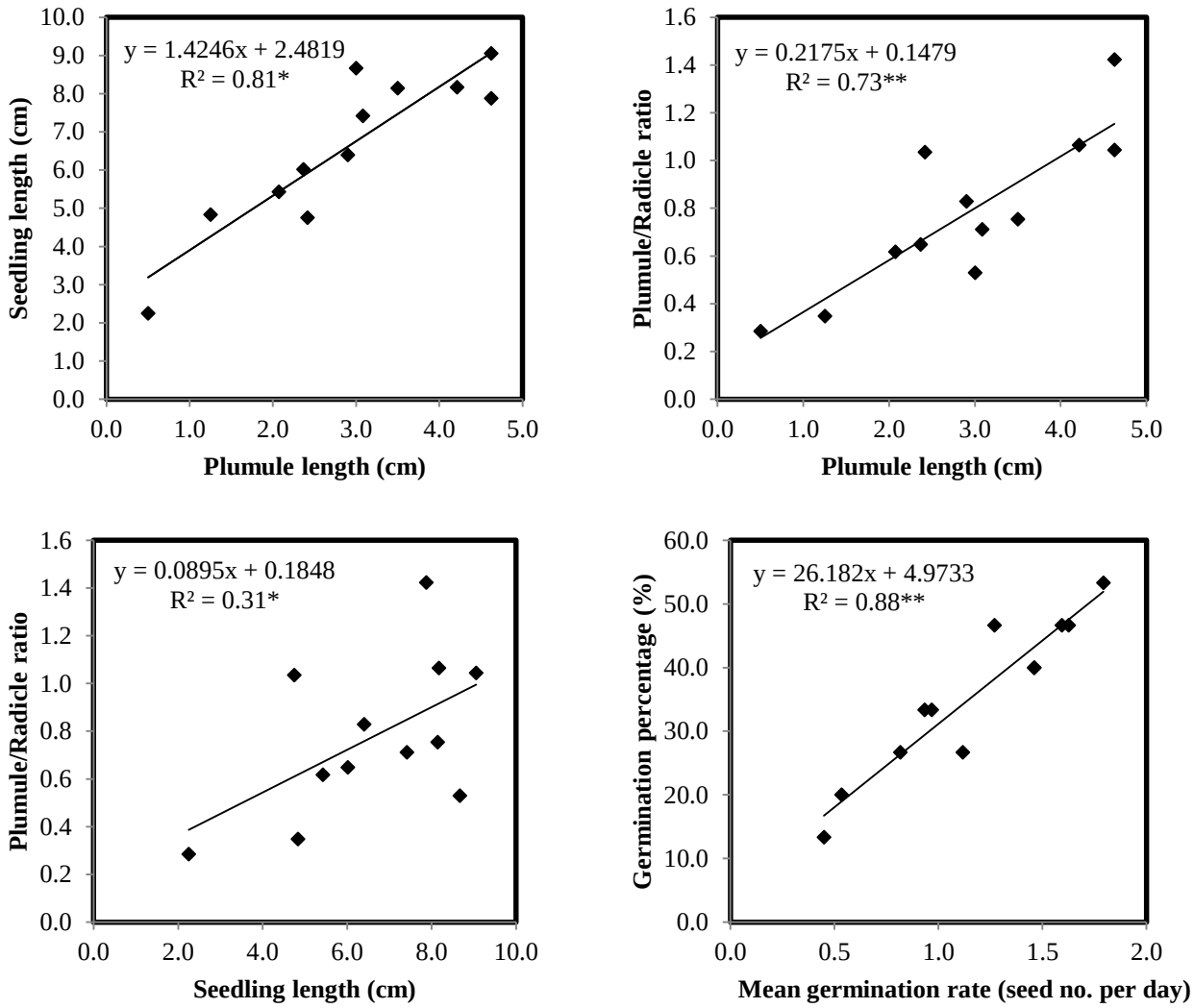

Fig 2. Relationship between the plumule length, seedling length, plumule to radicle ratio, final germination percentage and mean germination rate of fennel seedling primed by water, NaCl and PEG (n=12). * and **: significant at 5% and 1% levels of probability, respectively.

inhibition in fennel seeds due to a decrease in seedling dry weight. Accumulation of Na ion changes ion balances such as Na:Ca and K:Na in plant cells under saline conditions (Levitt, 1980). While the change in Na:Ca balance results in increased cell permeability, the change in K:Na balance cause decreasing use of metabolic energy (Levitt, 1980).

The present results are in accordance with observation of Bennett & Waters (1987) who reported that seedling dry weight, seed germination and vigor in sweet corn decreased with osmo-conditioning, although germination significantly enhanced by water soaking. However, osmopriming has been shown to activate processes related to germination, for instance, by affecting the oxidative metabolic such as increasing superoxide dismutase (SOD) and peroxidase (POD) (Jie *et al*., 2002) or by the activation of ATP_{ase} as well as acid phosphatase and RNA syntheses (Fu *et al*., 1988).

Priming treatments significantly improved final germination percentage, mean germination rate, plumule to radicle ratio and vigor in fennel seeds (Figure 1). The ratios plumule to radicle in primed seeds in water and NaCl generally did not decrease, but in PEG -1.6 MPa increased (Figure 1 A). However, several authors described positive

effects of seed priming with water alone (Rashid *et al*., 2002; Harris *et al*., 2004). In seed priming treatments, a negative correlation between plumule length and plumule to radicle ratio was found (Figure 2).

Final germination percentage (FGP) of fennel seeds was significantly improved by different priming treatments over the control (Figure 1 C). Seeds primed in NaCl and PEG-6000 showed the maximum value of FGP i.e. 44 and 40% in each. Sivritepe *et al*. (2003) demonstrated that primed melon seeds with NaCl solution for 3 days at 20°C, significantly increased seedling emergence percentage, emergence rate, and root dry weight under salinity conditions when compared to non-primed seeds. But, Neamatollahi *et al*. (2009) result that NaCl salinity caused growth inhibition in fennel seeds due to a decrease in total germination. In seed priming treatments, a negative correlation was found between final germination percentage and mean germination rate (Figure 2).

Priming with PEG and NaCl, significantly improved MGR and SVI in fennel (*Foeniculum vulgare*) (Figure 1 B, D) over other treatments. Comparison of seedling vigor index means of seeds exposed to priming in the PEG and NaCl solutions were 3.40 and 3.06 respectively. Liu *et al*. (1996) have found that osmopriming improves both germination rate and speed in tomato seeds, especially when they utilized freshly harvested seeds. Our data confirmed that the primed seed with PEG-6000 or NaCl solution is a simple and effective way to improve all seed characteristics investigated, compared to those of the control treatment.

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