Available online at www.notulaebotanicae.ro

Print ISSN 0255-965X; Electronic ISSN 1842-4309

Not. Bot. Hort. Agrobot. Cluj 36 (1) 2008, 29-33

Notulae Botanicae Horti Agrobotanici Cluj-Napoca

Effects of Hydro and Osmo-Priming on Seed Germination and Field Emergence of Lentil (*Lens culinaris* Medik.)

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Abstract

Laboratory tests and two field experiments were conducted in RCB design in 2006 and 2007 at the Research Farm of the University of Tabriz, Iran, to evaluate the effects of hydro and osmo - priming (PEG: Polyethylene glycol 6000 at -0.8MPa) on seed germination and field emergence of lentil. Analysis of variance for laboratory data showed that hydropriming significantly improved germination rate and root weights, compared to other seed treatments. However germination percentage for seeds primed with water and PEG were statistically similar, but higher than those for unprimed seeds. Over all, hydropriming treatment was comparatively superior in laboratory tests. Invigoration of lentil seeds by hydropriming resulted in higher seedling emergence in the field, compared to control and seed priming with PEG. Seedling emergence rate was also enhanced by priming seed with water. Thus, hydropriming could be used as a simple method for improving seed germination and seedling emergence of lentil in the field.

Keywords: seed priming, seed germination, seedling emergence, lentil

Introduction

Lentil is an important food legume cultivated in rainfed areas in the west and northwest of Iran, where rainfall is not only low but also variable. In these areas important abiotic stresses such as extreme temperatures, soil crusting, excess or limitation of water and salinity may individually or in combination adversely affect the germination and stand establishment. Germination and seedling establishment are critical stages in the plant life cycle. In crop production, stand establishment determines plant density, uniformity and management options (Cheng and Bradford, 1999). In arid and semi-arid environments, the water needed for germination is available for only a short period, and consequently, successful crop establishment depends not only on the rapid and uniform germination of the seed, but also on the ability of the seed to germinate under low water availability (Fischer and Turner, 1978). However, if the stress effect can be alleviated at the germination stage, chances for attaining a good crop with economic yield production would be high (Ashraf and Rauf, 2001).

Strategies for improving the growth and development of crop species have been investigated for many years. Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance (Bradford, 1986; Taylor and Harman, 1990). During priming, seeds are partially hydrated so that pre-germinative metabolic activities proceed, while radicle protrusion is prevented, then are dried back to the original moisture level (McDonald, 2000).

Various prehydration or priming treatments have been employed to increase the speed and synchrony of seed germination (Bradford, 1986). Common priming techniques include osmopriming (soaking seeds in osmotic solutions such as polyethylene glycol), halopriming (soaking seeds in salt solutions) and hydropriming (soaking seeds in water). Osmopriming contributes to significant improvement in seed germination and seedling growth in different plant species. Seeds of tomato and asparagus (*Asparagus offcinalis*) osmoconditioned in -0.8 MPa PEG-8000 showed increased germination under saline media (Pill et al., 1991). Osmotic priming to improve seed germination performance may also enhance general crop performance. osmoconditioning of Italian ryegrass (*Lolium multiflorum*) and sorghum (*Sorghum bicolor*) seeds with 20% PEG-8000 for 2 d at 10°C increased germination percentage, germination rate, seedling establishment and dry matter production under water stress, water logging, cold stress and saline conditions (Hur, 1991).

Similar to other priming techniques, hydropriming generally enhances seed germination and seedling emergence, although there are exceptions. Harris et al. (1999) demonstrated that on-farm seed priming (soaking seeds overnight in water) markedly improved establishment and early vigor of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields. This simple, low-cost, low-risk intervention also had positive impacts on the wider farming system and livelihoods and the technology has proved highly popular with farmers (Harris et al., 1999, 2001). Its value has already been shown for many crops, for example wheat (Harris et al., 2001; Rajpar et al., 2006); chickpea (Musa et al., 2001; Kaur et al., 2005), maize (Ashraf and Rauf, 2001), mungbean (Rashid et al., 2004), pigeonpea (Jyotsna and Srivastava, 1998), sunflower (Kaya et al., 2006) and Barley (Abdulrahmani et al., 2007).

Since the effect of seed priming on field emergence of lentil is poorly documented, this research was conducted to investigate the effects of osmo-priming and hydro-priming on seed germination and seedling emergence of this grain legume.

Materials and methods

In this research, seeds of lentil (*Lens culinaris* Medik. cv Ziba) which is commonly grown in Iran, was used. Seed moisture content was determined by the high-temperature oven method at 130±2 °C for 4 hours (ISTA, 2003). Mean moisture content of the seed sample was about 9.5%. Seeds were pre-treated with a mixture of benomyl and thiram fungicides at a rate of 3.3 g/kg, in order to control possible fungal contamination during priming. Seed sample was divided into three sub-samples. One of the sub-samples was considered as control (unprimed) and the other two sub-samples were prepared for priming treatments.

Seed priming

Seeds of a sub-sample were soaked in distilled water and seeds of another sub-sample were pretreated with Polyethylene glycol 6000 (PEG) at a concentration of 253 g/kg water giving an osmotic potential of -0.8MPa (Michel and Kaufmann, 1973) for 12 hours. Priming treatments were performed in an incubator adjusted on 20±1°C under dark conditions. After priming, samples of seeds were removed and rinsed three times in distilled water and then dried to the original moisture level.

Laboratory germination

Four replicates of 50 seeds were germinated between double layered rolled germination papers. The rolled paper with seeds was put into plastic bags to avoid moisture loss. Seeds were allowed to germinate at 10±1°C in the dark for 21 days. Germination was considered to have occurred when the radicles were 2mm long. Germinated seeds were recorded every 24 h for 21 days. Rate of seed germination ($\overline{R}$) was calculated according to Ellis and Roberts, (1980).

$$\overline{R} = \frac{\sum n}{\sum D.n}$$

Where n is the number of seeds germinated on day D, D is the number of days counted from the beginning of the test and $\overline{R}$ is mean germination rate.

The seedlings with short, thick and spiral formed hypocotyls and stunted primary root were considered as abnormally germinated (ISTA, 2003). At the end of germination test (21 days), radicles and shoots were cut from the cotyledons and then dried in an oven at 75±2°C for 24 hours. The dried radicles and shoots were weighted to the nearest milligram and the mean radicle and shoot dry weight and consequently mean seedling dry weight were determined.

Field emergence

Field experiments were conducted in 2006 and 2007 at the Research Farm of the Faculty of Agriculture, Tabriz University, Iran (38°5' N, 46°17' E). The area is located at an altitude of 1360 m with the annual rainfall of 285 mm. The plots were 10 m^2 with six sowing rows of 5 m long. Seeds were treated with benomyl at a rate of 3 g/kg before sowing. The seeds were then sown in a sandy-loam soil at a depth of about 3 cm with a density of 80 seeds/m^2 (25cm × 5cm) during the last week of April in both years. Number of emerged seedlings in an area of 1 m^2 within each plot was counted in daily intervals until seedling establishment became stable. Seedling emergence rate was calculated in accordance with the equation introduced by Ellis and Roberts (1980).

Experimental design

Laboratory tests were carried out at the Seed Technology Laboratory of Tabriz University, Iran, using randomized complete block (RCB) design with 4 replicates. Field experiments were conducted with 9 replicates on the basis of RCB design in 2006 and 2007. Analysis of variance (ANOVA) of the laboratory data and combined analysis of variance of field emergence data were carried out, us-

Table 1 Analysis of variance for seed priming effects on lentil seed germination and vigor in laboratory

Seedling dry weight	Shoot dry weight	Root dry weight	Germination percentage	Rate of germination	Degree of freedom	Source of variation
36	14.2	4.9*	12	0.274**	2	Treatment
10	5.6	1.1	61.77	0.009	9	Error
21.6	25.19	18.44	8.8	18.06		CV(%)

*Statistically significant at p% 0.05, **significant at p% 0.01, CV= Coefficient of variation

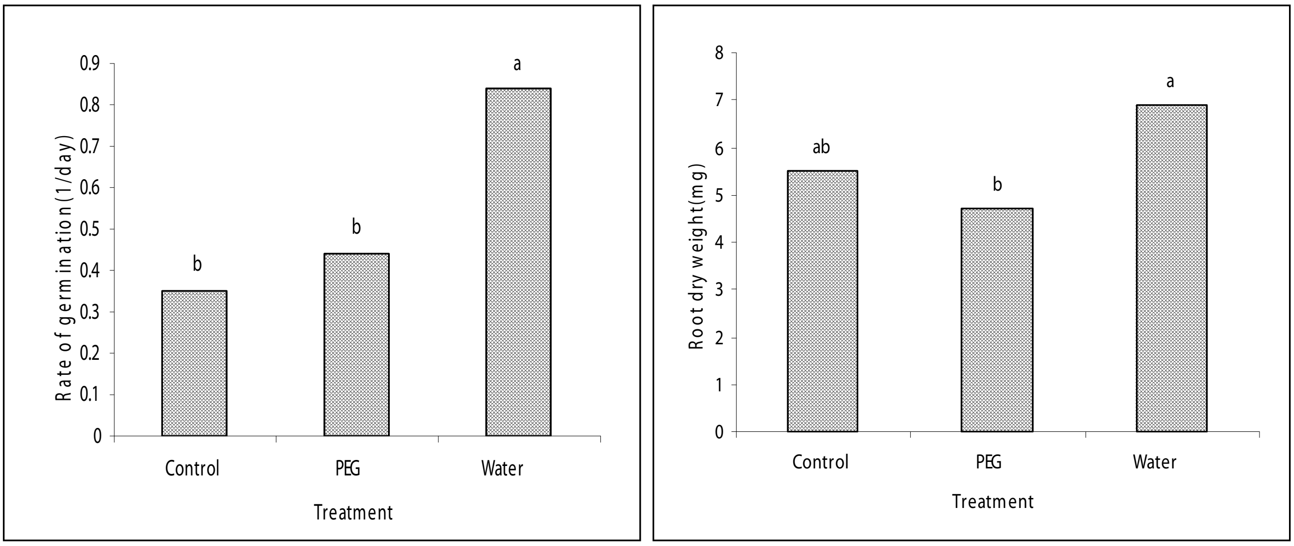

Figure 1 Mean germination rate and mean root dry weight for primed and unprimed seeds of lentil. Different letters indicating significant difference at p≤0.05.

ing SAS software (SAS, 2001). Excel software was used to draw figures. Means were compared by applying Duncan test at 5% probability.

Results and discussion

Seed germination and seedling growth

The effect of seed priming on germination percentage of lentil seeds was not significant. However, Seed germination rate was significantly affected by seed priming (Table 1). The highest germination rate was obtained for seeds primed with water, but this trait did not significantly differ between other seed treatments (Figure 1).

Although seed priming had significant effect on root dry weight, but shoot and seedling dry weights were statistically similar for primed and unprimed seeds (Table 1). Seeds primed with water were significantly superior in root dry weight, compared to other seed treatments (Figure 1).

Field emergence

There were significant differences in seedling emergence percentage and rate among seed treatments (Table 2). Seedling emergence percentage for seeds primed with water was higher than that for other primed and unprimed seeds. Seed priming with water enhanced seedling emergence rate in the field. However, both rate and percentage of seedling emergence did not differ significantly between seeds of control and those primed with PEG (Figure 2).

The fastest rate of germination was obtained by soaking seeds in water, probably due to faster water uptake and earlier initiation of metabolism processes, which determine radicle protrusion. Soaking seeds in limited water imposed by osmopriming, was slower and resulted in less advanced metabolic processes and slower germination (Figure 1).

Hydroprimed seeds produced the largest roots, compared to other seed treatments (Figure 1). These results are in line with the findings of Kathiresan and Gnanarethinam (1985) in sunflower. This means that during priming, seeds would be simultaneously subjected to processes of repair and deterioration and force between the two determined the success or failure of the treatment (McDonald, 2000). Also, important to consider is the toxic effect reported for PEG (Grzesik and Nowek, 1998) and the decrease in oxygen solubility (Welbaum, 1998; Toselli and

Table 2 Combine analysis of variance for seed priming effects on lentil for field emergence and establishment in 2006-2007

		Mean of Squares	
Source of variation	Degree of freedom	Rate of seedling emergence	Seedling emergence
Year	1	0.00018**	28.74
R(year)	16	0.00004*	148.8
Treatment	4	0.00009*	525.2**
Year*T	4	0.00001	237.7
Error	32	0.00001	93.5
CV(%)		4.9	17.4

*Statistically significant at p% 0.05, **significant at p% 0.01, CV= Coefficient of variation

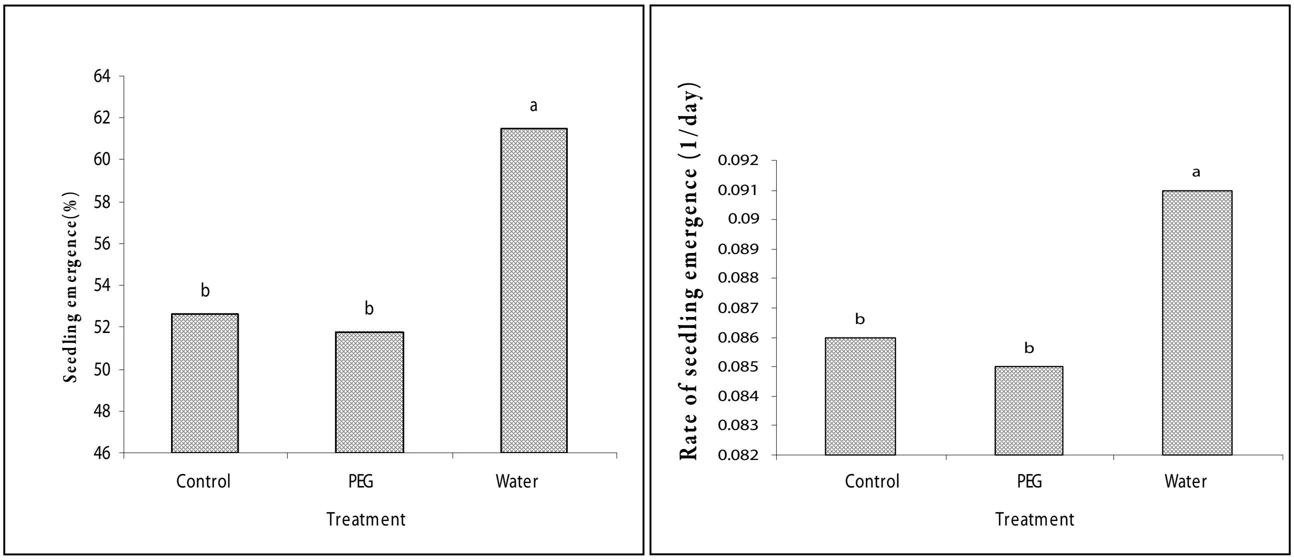

Figure 2 Mean rate and percentage of seedling emergence in the field for primed and unprimed seeds of lentil. Different letters indicating significant difference at p≤0.05.

Casenave, 2002, 2003) that could be responsible for the anoxia damages suggested by Sung and Chang, (1993). This could be especially important for seeds with higher oxygen requirements.

Hydropriming improved seedling emergence rate and percentage and consequently seedling establishment in the field (Figure 2). Good seedling emergence is the key to controlling stand establishment. Kibite and Harker, (1991) reported seed hydration of wheat, barley and oat seeds improved the uniformity of seedling emergence. Harris et al.,(1999) found that hydropriming enhanced seedling establishment and early vigor of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields. Similarly, vigorous early growth is often associated with better yields (Okonwo and Vanderlip, 1985; Austin, 1989; Carter et al., 1992). The resulting improved stand establishment can reportedly increase drought tolerance, reduce pest damage and increase crop yield (Harris et al., 1999). These results suggest that hydropriming is a useful technique for improving seed germination and seedling emergence of lentil in the field.

Conclusions

In many rainfed areas, germination and subsequent seedling growth can be inhibited by adverse conditions in the field. Priming is helpful in reducing the risk of poor stand establishment under a wide range of environmental conditions. Our findings revealed that hydropriming is a simple and useful technique for enhancing seedling emergence rate and percentage of lentil. These effects can improve seedling establishment and field performance of this important food legume.

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