International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 4, No. 12, p. 12-18, 2014

RESEARCH PAPER OPEN ACCESS

Seed hydro-priming, a simple way for improving mung-bean performance under water stress

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Key words: Grain yield, ground cover, seedling emergence, mung-bean, water stress.

http://dx.doi.org/10.12692/ijb/4.12.12-18 Article published on June 22, 2014

Abstract

Seedling establishment and ground cover can strongly influence grain yield of crops. Thus, a split-plot experiment based on RCB design with three replications was conducted in 2013, in order to evaluate the effects of water supply (I_1, I_2, I_3 and I_4: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively) and hydro-priming duration (P_1, P_2 and P_3: 0, 8 and 16 h, respectively) on field performance of mung-bean (*Vigna radiata* L.). Hydro-priming of seeds for 16 h resulted in the highest seedling emergence in the field, compared with control and priming duration of 8 h. Seedlings from hydro-primed seeds also emerged earlier than those from unprimed seeds, with no significant difference between priming durations. Increasing water limitation reduced ground cover and plant biomass, leading to yield loss of mung-bean. However, these traits were improved as a result of hydro-priming, particularly hydro-priming for 16 h. Biological yield and percentage ground cover had the highest positive correlations with grain yield per unit area, indicating the importance of ground cover and plant biomass in determining final grain yield of mung-bean.

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Introduction

Seed germination, seedling emergence and crop establishment are important aspects of agricultural and horticultural production, and are important components of seed and seedling vigor. These factors are related to early growth of the crop, and may be related to resistance to early-season stresses and final yield (Tavakoli Kakhki *et al.,* 2008). A method to improve the rate and uniformity of germination is the priming or physiological advancement of the seed lot (Finch-Savage, 2004; Halmer, 2004).

Seed priming is a pre-germination treatment in which seeds are held at a water potential that allows imbibition, but prevents radicle extension (Bradford, 1986), and then seeds are dried back to the original moisture level (McDonald, 2000). Various seed priming techniques have been developed, including hydro-priming (soaking in water), halo-priming (soaking in inorganic salt solutions), osmo-priming (soaking in solutions of different organic osmotica), thermo-priming (treatment of seeds with low or high temperatures), solid matrix priming (treatment of seed with solid matrices) and bio-priming (hydration using biological compounds) (Ashraf and Foolad, 2005).

Seed priming 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. These effects of priming are associated with the repairing and building up of nucleic acids, increased synthesis of proteins as well as the repairing of membranes (McDonald, 2000). Priming also enhances the activities of anti-oxidative enzymes in treated seeds (McDonald, 1999; Wang *et al.*, 2003; Hsu *et al.*, 2003). Due to readily available food during germination (Farooq *et al.*, 2006), primed seeds are better able to complete the process of germination in a short time and cope with environmental stresses (Farooq *et al*, 2007; Kant *et al*, 2006).

One of the most notable environmental stresses is drought, which drastically limits crop production around the world (Bohnert *et al.*, 1995) Some of the deleterious effects of environmental stresses such as water limitation on crop performance may be also overcome by seed priming (Demir Kaya *et al*, 2006; Ghassemi-Golezni *et al*, 2008c), via improving stand establishment (Finch-Savange, 1995). Thus, this research was undertaken to evaluate the effects of hydro-priming duration on field performance of mung-bean under different irrigation treatments.

Materials and methods

Experimental design

An experiment was conducted in 2013 at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran. The experiment was arranged as split-plot, based on RCB design with three replications. Irrigations after 70 (I_1), 100 (I_2), 130 (I_3) and 160 (I_4) mm evaporation from class A pan and hydro-priming durations of 0 (P_1), 8 (P_2) and 16 (P_3) hours were allocated to main and sub plots, respectively.

Seed preparation and sowing

Seeds of mung-bean (*vigna radiata* L.) were divided into three sub-samples, one of which was kept as control (non-primed, P_1) and two other samples were soaked in distilled water at 20°C for 8 (P_2) and 16 (P_3) hours and then dried back to initial moisture content at room temperature of 20-22°C. All the seeds were treated with Benomyl at a rate of 2 g kg^{-1} before sowing. Seeds were hand sown in about 4 cm depth with a density of 80 seeds per m^2 on 7 May 2013. Each plot consisted of 6 rows with 3.5 m length, spaced 25 cm apart. All plots were irrigated immediately after sowing and subsequent irrigations were carried out according to irrigation treatments. Weeds were frequently controlled by hand during crop growth and development.

Measurements

Seedling emergence was recorded in daily intervals up to final establishment in each plot. Subsequently, percentage and mean time to seedling emergence was calculated. Ground cover was measured at flowering by viewing the canopy through wooden frame (50 × 50 cm dimensions) divided into 100 equal sections. The sections were counted when more than half filled with crop green area. At maturity, plants in 1 m^2 of the middle part of each plot were harvested and grain yield per unit area was determined. Then above ground biomass was oven-dried at 80°C for 48 hours and biological yield per unit area was calculated. Analysis of variance of the data appropriate to the experimental design and comparison of means at $p \leq 0.05$ were carried out, using MSTATC and SPSS soft-wares. Excel software was used to draw figures.

Results and discussion

Seedling emergence

Analysis of variance of the data showed that seedling emergence percentage and mean emergence time were significantly affected by hydro-priming duration (Table 1). Seedling emergence percentage in the field was increased with increasing hydro-priming duration. Seedlings of P_3 emerged about 2 days earlier than those of P_1. However, mean emergence time for P_2 (hydro-priming for 8 h) and P_3 was statistically similar (Table 2).

Optimum stand establishment and early achievement of maximum ground cover are essential for the efficient use of resources like water and light (Nasrullahzadeh *et al.*, 2007; Ghassemi-Golezani *et al*, 2008b, c). Kibite and Harker, (1991) reported that pre-hydration of wheat, barley and oat seeds improved the uniformity of seedling emergence. Rapid emergence of seedlings could lead to the production of vigorous plants (Ghassemi-Golezani *et al.*, 2008c). Improvement in seedling establishment due to hydro-priming was also reported for lentil (Ghassemi-Golezani *et al.*, 2008a), chickpea (Ghassemi-Golezani *et al.*, 2008c) and pinto bean (Ghassemi-Golezani *et al*, 2010a).

Table 1. Analysis of variance of the effects of hydro-priming duration on seedling emergence of mung-bean.

Source of Variation	df	MS	
		Emergence percentage	Emergence time
Replication	11	2.108^{ns}	1.116^{ns}
Hydro-priming	2	326.797^{**}	37.311^{**}
Error	22	1.391	4.621
CV		2.47%	8.06%

ns and **: Not significant and significant at $p \leq 0.01$, respectively.

Table 1. Means of mung-bean seedling emergence traits influenced by hydro-priming duration.

Treatments	Emergence (%)	Emergence time (day)
P_1	42.30c	28.6a
P_2	48.27b	26.22b
P_3	52.70a	25.15b

Different letters at each column for each treatment indicate significant difference at $p \leq 0.05$.

P_1, P_2 and P_3: non-primed and hydro-primed seeds for 8 and 16 h, respectively.

Ground cover

Percentage ground cover was significantly affected by both hydro-priming duration and water limitation. Interaction of hydro-priming duration × water limitation was also significant for ground cover (Table 3). Percentage ground cover significantly decreased with decreasing water supply. Reductions of percentage ground green cover due to water stress can strongly reduce the absorption of incident PAR, either by drought-induced limitation of leaf area expansion, or by early leaf senescence (Hugh and Richard, 2003), which can potentially reduce photosynthesis and consequently grain yield. Ground green cover of chickpea (Ghassemi-Golezani *et al*., 2012) and pinto bean (Ghassemi-Golezani *et al*, 2013a) was also reduced as a consequence of water limitation.

Table 3. Analysis of variance of the effects of irrigation and hydro-priming duration on field performance of mung-bean

Source of Variation	df	MS		
		Ground cover	Biological yield	Grain yield
Replication	2	0.444^{ns}	1309.416^{ns}	198.307^{ns}
Irrigation (I)	3	13.202^{**}	24026.783^{*}	8072.613^{**}
Error a	6	0.672	4225.547	134.234
Hydro-priming (HP)	2	39.502^{**}	39761.490^{**}	3153.878^{*}
I × HP	6	1.246^{*}	181.909^{ns}	72.862^{ns}
Error b	16	0.346	5917.797	516.095
CV		1.24%	16.88%	15.80%

ns,* and * *: No significant and significant at $p \leq 0.05$ and $p \leq 0.01$, respectively.

Table 4. Means of mung-bean field traits influenced by irrigation and hydro-priming duration.

Treatments	Ground cover (%)	Biological yield (g m^{-2})	Grain yield (g m^{-2})
Irrigation			
I_1	48.75a	505.7a	174.7 a
I_2	48.18a	494.9a	162.3a
I_3	47.06b	415.9b	128.2b
I_4	46.02c	406.7b	109.9 c
Hydro-priming			
P_1	45.60c	392.2b	126.9b
P_2	47.70b	470.8a	145.2ab
P_3	49.21a	504.4a	159.2a

Different letters at each column for each treatment indicate significant difference at $p \leq 0.05$.

I_1, I_2, I_3, I_4: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively

P_1, P_2 and P_3: non-primed and hydro-primed seeds for 8 and 16 h, respectively.

Hydro-priming enhanced ground cover, with P_3 as the most effective treatment (Table 4). The superiority of P_3 plants in ground cover was more pronounced under well watering than under limited irrigations (Figure 1). Anyway, priming proved to be a useful remedy for deleterious effects of water stress on ground cover of mung-bean. Similar outcome has been also reported for barley (Ghassemi-Golezani and Abdurrahmani, 2012) borage (Ghassemi-Golezani *et al*, 2013a) and rapeseed (Ghassemi-Golezani *et al*, 2013c).

Table 5. Correlation coefficients of different field traits

Trait	Emergence percentage	emergence time	Ground cover	Biological yield	Grain yield
Emergence percentage	1				
Emergence time	-0.850^{**}	1			
Ground cover	0.775^{**}	-0.757^{**}	1		
Biological yield	0.720^{**}	-0.694^{*}	0.931^{**}	1	
Grain yield	0.453	-0.471	0.845^{**}	0.922^{**}	1

*, **: Statistically significant at $p \leq 0.05$ and $p \leq 0.01$, respectively.

Biological and grain yields

Water supply and hydro-priming had significant effects on biological and grain yields of mung-bean (Table 3). Increasing water limitation led to 2.1-19.5 % reduction in biological yield, compared with well watering (I_1). However, there was no significant difference between I_1 and I_2 treatments. Grain yield per unit area was also significantly reduced by decreasing water availability, although no significant difference between I_1 and I_2 treatments was observed. Mean grain yield per unit area under I_2, I_3 and I_4 were 7.1, 26.6 and 37.1 % lower than that under well irrigation (Table 4). Reductions in plant biomass and grain yield per unit area were directly related with poor ground cover under water stress (Figure 1). Water deficit through the reduction in the leaf area index and photosynthetic capacity reduces grain yield, because the earliest response to the leaf water deficit is stomata closure, which limits CO_2 diffusion to chloroplasts (Berkowitz *et al.*, 1983; Cornic and Masaccio, 1996; Muller and Whitsitt, 1996).

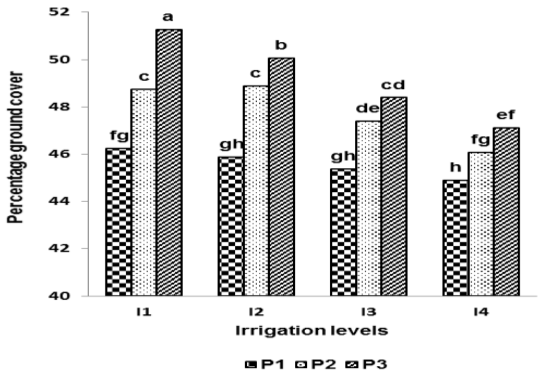

Fig. 1. Ground cover for plants from primed and unprimed seeds of mung-bean under different irrigation treatments. Different letters at each column for each treatment indicate significant difference at p≤0.05. I_1, I_2, I_3, I_4: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively
P_1, P_2 and P_3: non-primed and hydro-primed seeds for 8 and 16 h, respectively.

Biological yield and grain yield per unit area for P_3 treatment was higher than that for P_1 and P_2 treatments, but P_3 had no significant difference with P_2 (Table 4). Harris *et al.* (1999) found that hydro-priming enhanced seedling establishment of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields. The resulting improved stand establishment can increase stress tolerance and crop yield. Kumar *et al.* (2002) found the maximum length of time for which seed should be soaked and exceeding it could be harmful to the seed or seedling. Recommended safe limits for maize and rice, chickpea and pearl millet were 24 h, 10 h and 8 h, respectively. Optimal times of hydro-priming were 7 h for pinto bean (Ghassemi-Golezani *et al*, 2010a), 12 h for chickpea (Ghassemi-golezani *et al*, 2013b), and 18 h for maize (Mir Mahmoodi *et al*, 2011). In our research, the best duration for hydro-priming of mung-bean seeds was 16 h.

Correlations

Correlations of emergence percentage with ground cover and plant biomass and correlations of ground green cover and biological yield with grain yield were positive and significant. However, mean emergence time negatively correlated with ground cover and plant biomass. Biological yield and percentage ground cover had the highest positive correlations with grain yield per unit area (Table 5). This suggests that percentage ground cover and plant biomass have the major roles in determining final grain yield of mung-bean, similar to that reported for rapeseed (Jabbarpour *et al*, 2012) and borage (Ghassemi-Golezani *et al*, 2013a).

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