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Full Length Research Paper

Influence of hydro-priming duration on field performance of pinto bean (*Phaseolus vulgaris* L.) cultivars

Kazem Ghassemi-Golezani*, Afsaneh Chadordooz-Jeddi, Safar Nasrullahzadeh and Mohammad Moghaddam

Department of Agronomy and Plant Breeding, Faculty of Agriculture, University of Tabriz, Tabriz, Iran.

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A factorial experiment (using RCB design) with 3 replications was conducted in 2008, in order to evaluate the effects of hydro-priming duration (P_1, P_2, P_3 and P_4: 0, 7, 14 and 21 h, respectively) on field performance of three pinto bean (*Phaseolus vulgaris* L.) cultivars (Talash, COS_{16} and Khomain). The highest seedling establishment, ground cover, plant biomass and grain yield per unit area were recorded for P_2 followed by P_3. Mean chlorophyll content index of Talash was significantly higher than that of COS_{16} and Khomain. Ground cover, plant biomass, pods per plant, grains per plant and grain yield per unit area of COS_{16} and Talash were significantly higher than those of Khomain, but 1000 grain weight of Khomain was higher than that of other cultivars. Ground cover positively correlated with plant biomass, pods per plant, grains per pod, grains per plant, harvest index and grain yield per unit area. Thus, it can be used as a reliable index to estimate the yield potential of pinto bean cultivars. No significant interaction of priming duration × cultivar indicated that optimal time of hydro-priming for all pinto bean cultivars is 7 h.

Key words: Chlorophyll content, ground cover, hydro-priming, pinto bean, seedling establishment.

INTRODUCTION

Rapid and uniform field emergences of seedlings are two essential pre-requisites to increase yield and quality in annual crops (Finch-Savage, 1993). Uniform performance of seeds of cultivated plants is seldom achieved, where a seed lot represents an amalgam of individuals, each with different germination vigor (McDonald, 2000). Various prehydration or priming treatments have been employed to increase the speed and synchrony of seed germination (Ashraf and Foolad, 2005). Common priming techniques include osmo-priming (soaking seeds in osmotic solutions), halo-priming (soaking seeds in salt solutions) and hydro-priming (soaking seeds in water) (Ghassemi-Golezani et al., 2008a).

Hydrating seeds with water and redrying them before they complete germination is a technique which minimizes the use of chemicals and avoids discarding materials that may be undesirable to the environment (McDonald, 2000). This simple, low cost and 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, 2001b; Ghassemi-Golezani et al., 2008a). The beneficial effects of priming have been associated with various biochemical, cellular and molecular events including synthesis of RNA and proteins (Bray et al., 1989; Dell'Aquila and Bewley, 1989; Davison and Bray, 1991; Bray, 1995). Priming also restores activities of enzymes involved in the cell detoxifying mechanisms such as super oxide dismutase, catalase and glutathione reductase in aged seeds (Bailly et al., 1997). These effects can lead to better stand establishment, more vigorous plants, better drought tolerance, earlier flowering, earlier harvest and higher grain yield (Harris et al., 1999; 2001a; 2002). Since the effects of priming on field performance of beans are not well known, this research was conducted to prevail the

*Corresponding author. E-mail: golezani@gmail.com. Tel: +98411-3392028.

Table 1. Means of pinto bean field traits influenced by hydro-priming duration and cultivar.

Treatments	Seedling establishment (%)	Ground cover (%)	Chlorophyll content index (CCI)	Plant biomass (g m^{-2})
Hydro-priming				
P1	55.11b	55.28b	24.76a	364.3b
P2	68.22a	63.83a	25.19a	429.1a
P3	64.22a	60.67ab	24.91a	407.7ab
P4	54.00b	53.89b	24.83a	359.0b
Cultivar				
Talash	60.16a	59.58a	30.58a	426.2a
Cos16	60.83a	62.00a	22.90b	430.1a
Khomain	60.16a	53.67b	21.29b	313.8b

Different letters at each column for each treatment indicating significant difference at $p \leq 0.05$.
P_1, P_2, P_3 and P_4: non-primed and hydro-primed seeds for 7, 14 and 21 h, respectively.

influence of hydro-priming duration on ground cover, grain yield and yield components of pinto bean cultivars.

MATERIALS AND METHODS

Seeds of pinto bean (*Phaseolus vulgaris* L.) cultivars (Talash, COS_{16} and Khomain) were divided into four sub-samples, one of which was kept as control (non-primed, P_1) and three other samples were soaked in distilled water at 20°C for 7 (P_2), 14 (P_3) and 21 (P_4) hours and then dried back to initial moisture content at room temperature of 20-22°C. The field experiment was conducted in 2008 at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran (38°5′N, 46°17′E). The area is located at an altitude of 1360 m with the annual rainfall of 285 mm. All the seeds were treated with benomyl at a rate of 2 g kg^{-1} before sowing. Seeds were hand sown in about 5 cm depth with a density of 50 seeds m^{-2} on 19 April 2008. Each plot consisted of 6 rows with 4 m length, spaced 25 cm apart. The experiment was arranged as factorial, based on RCB design with three replications. All plots were irrigated immediately after sowing and then fertilized with 30 kg ha^{-1} urea (46% N). Subsequent irrigations were carried out after 70 mm evaporation from class A pan. Weeds were frequently controlled by hand during crop growth and development. Plants were protected from heliothis caterpillar attack by spraying Diazinon at a rate of 2 ml l^{-1} before 50% flowering.

Seedling emergence was recorded in daily intervals up to final establishment in each plot. Subsequently, percentage of seedling establishment was calculated. Ground cover was measured every week 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. Chlorophyll content index (CCI) was also measured in weekly intervals, using a portable chlorophyll-meter (CCM-200). At the end, maximum CCI and ground cover was recorded for all treatments at each replicate. At maturity, 10 plants were harvested from each plot and pods per plant, grains per pod, grains per plant and 1000 grain weight were determined. Finally, plants of 1 m^{-2} in the middle part of each plot were harvested and plant biomass, grain yield/m^2 and harvest index were recorded. 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 software.

RESULTS

The effects of hydro-priming on percentage of seedling establishment ($p \leq 0.01$), ground cover (GC) and plant biomass ($p \leq 0.05$) were significant, but hydro-priming had no significant effect on chlorophyll content index (CCI) ($p > 0.05$). In contrast, percentage of seedling establishment was not affected by cultivar, but it had significant effects on ground cover ($p \leq 0.05$), chlorophyll content index and plant biomass ($p \leq 0.01$). No significant interaction of hydro-priming × cultivar on these traits were found ($p > 0.05$). Percentage of seedling establishment for P_2 (hydro-priming for 7 h) and P_3 (hydro-priming for 14 h) was significantly higher than that for P_1 (non-primed seeds) and P_4 (hydro-priming for 21 h) (Table 1). The highest ground cover percentage and plant biomass were also for plants from P_2 followed by those from P_3. However, ground cover and biomass of plants from P_1 and P_4 were almost similar (Table 1). Talash had the highest chlorophyll content index, compared with similar CCI of COS_{16} and Khomain. While, ground cover and plant biomass of COS_{16} and Talash were significantly higher than those of Khomain (Table 1).

Pods per plant, grains per plant and 1000 grain weight were only affected by cultivar ($p \leq 0.01$), but grain yield per unit area was affected by both hydro-priming ($p \leq 0.05$) and cultivar ($p \leq 0.01$). Neither hydro-priming nor cultivar had significant effect on grains per pod and harvest index. Interaction of hydro-priming × cultivar for these traits were not significant ($p > 0.05$). Grain yield per unit area for P_2 treatment was considerably higher than that for P_1 and P_4 treatments, but P_2 had no significant difference with P_3 (Figure 1). Mean number of pods per plant and grains per plant of COS_{16} and Talash were significantly higher than those of Khomain. In contrast, Khomain produced the largest grains among the cultivars (Table 2). COS_{16} and Talash produced significantly higher grain yield per unit area, compared with khomain

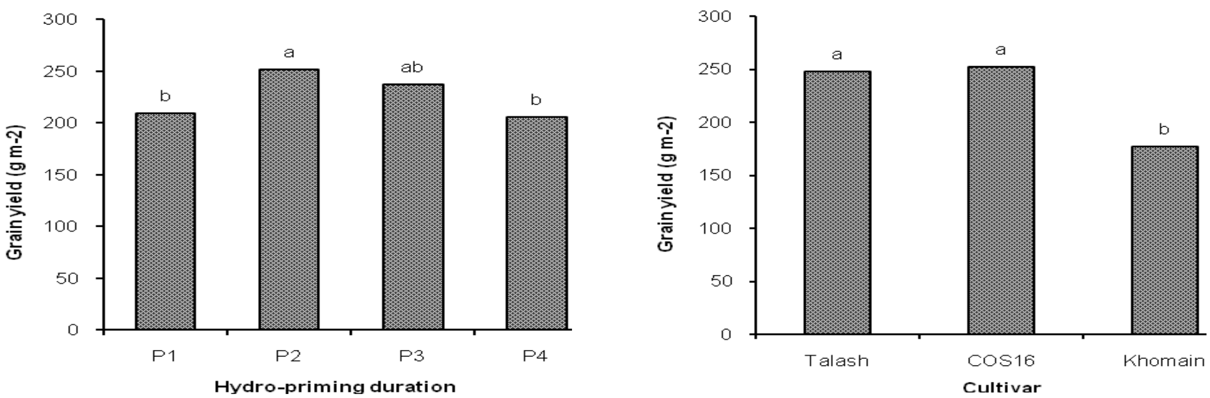

Figure 1. Mean grain yield per unit area for different hydro-priming durations and pinto bean cultivars. P_1, P_2, P_3 and P_4: Non-primed and hydro-primed seeds for 7, 14 and 21 h, respectively.

Table 2. Means of field traits for hydro-priming durations and pinto bean cultivars.

Treatments	Pods per plant	Grains per pod	Grains per plant	1000 Grain weight (g)	Grain yield/m^2 (g m^{-2})	Harvest index (%)
Hydro-priming						
P1	9.43a	3.44a	33.52a	326.8a	209.1b	57.06a
P2	10.92a	3.64a	34.94a	324.7a	251.7a	58.62a
P3	10.30a	3.57a	34.06a	324.7a	236.8ab	57.96a
P4	9.41a	3.43a	33.48a	327.0a	205.7b	57.02a
Cultivar						
Talash	11.16a	3.43a	38.63a	317.0b	248.1a	58.12a
Cos16	11.83a	3.68a	39.52a	305.4b	252.5a	58.63a
Khomain	7.06b	3.46a	23.86b	355.1a	176.9b	56.25a

Different letters at each column for each treatment indicating significant difference at $p \leq 0.05$.
P_1, P_2, P_3 and P_4: non-primed and hydro-primed seeds for 7, 14 and 21 h, respectively.

Table 3. Correlation coefficients of different field traits.

Traits	1	2	3	4	5	6	7	8	9	10
1- Establishment	1									
2- Ground cover	0.73**	1								
3- Chlorophyll index	0.01	0.27	1							
4- Plant biomass	0.51	0.87**	0.55	1						
5- Pods per plant	0.31	0.78**	0.51	0.97**	1					
6- Grains per pod	0.61*	0.76**	-0.34	0.56	0.54	1				
7- Grains per plant	0.11	0.66*	0.59*	0.91**	0.97**	0.39	1			
8- 1000 grain weight	-0.09	-0.66*	-0.44	-0.88**	-0.96**	-0.49	-0.98**	1		
9- Harvest index	0.56	0.88**	0.40	0.97**	0.95**	0.67*	0.86**	-0.85**	1	
10- Grain yield/m^2	0.51	0.88**	0.53	0.99**	0.97**	0.58*	0.91**	-0.88**	0.98**	1

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

(Figure 1). Simple correlation studies (Table 3) showed that percentage of seedling establishment positively correlated with ground cover and grains per pod. Correlation of ground cover with plant biomass, pods per plant, grains per pod, grains per plant, harvest index and grain yield per unit area was positive and significant, but with 1000 grain weight was negative and significant. Chlorophyll content index had only significantly positive relation with grains per plant. Plant biomass, pods per plant, grains per pod, grains per plant and harvest index negatively correlated with 1000 grain weight, but positively correlated with grain yield per unit area. Correlations among plant biomass, pods per plant and grains per plant were also positive and significant (Table 3).

DISCUSSION

Hydro-priming of seeds in water for 7 and 14 h before sowing improved field performance of pinto bean cultivars, as reflected in higher percentage of seedling establishment, ground cover, plant biomass (Tables 1 and 2) and grain yield per unit area (Figure 1). The efficiency of seed hydro-priming for better seedling establishment is also reported in barley (Abdulrahmani et al., 2007), lentil (Ghassemi-Golezani et al., 2008a) and chickpea (Ghassemi-Golezani et al., 2008c). However, the resultant effect of priming depends on duration of seed soaking (Ashraf and Foolad, 2005; Ghassemi-Golezani et al., 2008c). Kumar et al. (2002) found safe maximum lengths of time for which seed should be primed, beyond which it could be damaging to the seed or seedling. Recommended safe limits were 24 h for maize and rice, 10 h for chickpeas and 8 h for pearl millet. In our research, optimal time of hydro-priming for pinto bean seeds was 7 h, statistically similar with 14 h. A longer time of hydro-priming seems to have a negative effect on seed quality of pinto bean (Tables 1). 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). There is a linear relationship between ground cover and light interception (Burstall and Harris, 1983). Consequently, ground cover is strongly related with plant biomass, pods per plant, grains per pod, grains per plant, harvest index and grain yield per unit area (Table 3). Ground cover also has the practical advantage as a simple, quick and non-destructive measurement, allowing frequent sampling (Ghassemi-Golezani et al, 2008b, c). Therefore, it can be used as a reliable index to predict the yield potential of pinto bean cultivars.

The superiority of Talash and COS_{16} in ground cover led to the production of comparatively more plant biomass, pods and grains per plant (Tables 1 and 2) and grain yield per unit area (Figure 1). Although mean grain weight of Khomain was higher than that of other cultivars, but it produced the lowest number of pods and grains per plant (Table 2), leading to lower grain yield per unit area (Figure 1). This is also reflected in significantly positive correlation of grains per plant and negative correlation of 1000 grain weight with grain yield per unit area (Table 3). Therefore, photo-assimilates directed to less number of grains in khomain and resulted in production of comparatively larger grains. However, this superiority was not sufficient to compensate the reduction in number of grains per plant, compared with other cultivars. Similar results were reported for black bean (Nielsen and Nelson, 1998) and common bean (Ghassemi-Golezani and Mardfar, 2008). No significant interaction of seed priming × cultivar on measured traits suggest that hydro-priming for 7 h is the best pretreatment to improve field performance of all pinto bean cultivars. However, hydro-priming duration may differ by plant species (Bradford, 1986; Taylor and Harman, 1990; Harris et al., 1999; Ghassemi-Golezani et al., 2008c).

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