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Effects of Hydropriming Duration and Limited Irrigation on Field Performance of Chickpea

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Abstract: Chickpea seeds (cv. ILC_{482}) were soaked in distilled water at 17.3°C for 8(P_2), 16(P_3) and 24(P_4) hours and subsequently dried back to about 30% moisture content. Germination percentage, germination rate and seedling dry weight for different treatments were determined in laboratory. The field experiment was conducted under different irrigation regimes (I_1, I_2 and I_3-irrigation after 80, 120 and 160 mm evaporation from class A pan) in 2006. In laboratory, seed germination rate was increased with increasing hydropriming duration. Maximum germination rate was obtained for P_4 treatment, which was not significantly different from P_3 treatment. Seedling dry weight of hydroprimed seeds was significantly higher than that of control (P_1). In the field, ground cover, biological yield and grains per unit area were decreased, as water deficit severed. The lowest number of grains per unit area, 1000 grain weight and grain yield per unit area were obtained under I_3. However, these traits were not significantly different between I_1 and I_2. Mean seedling emergence rate and percentage improved, as a result of hydropriming. Consequently, ground cover of plants from primed seeds was higher than that from unprimed seeds, but this difference was not statistically significant. Mean biological yield, grains per unit area and grain yield of plants from primed seeds were significantly higher than those from non-primed seeds, but the effect of hydropriming duration on these traits was not significant. Mean 1000 grain weight of plants from P_1 and P_4 treatments decreased, with increasing water limitation. However, plants from P_2 and P_3 treatments produced the largest grains under I_2. Yield improvement was 25-40%, depending on hydropriming duration. The highest yield increase was achieved with 16 h hydropriming. It was, therefore, suggested that this priming duration is the best treatment for invigoration of chickpea seeds.

Key words: Chickpea, hydropriming, seedling emergence, ground cover, grain yield

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is cultivated across a wide range of environments, from the subtropics to arid and semiarid Mediterranean regions and has considerable importance as food, feed and fodder (Singh, 1997; Saxena *et al*., 1996). Although, chickpea is one of the major drought tolerant food legumes, but water deficit can limit growth and productivity of this crop (Ludlow and Muchow, 1990; Singh and Rao, 1993). Different techniques could be used to enhance chickpea yield, particularly under drought conditions. One of the simple techniques which can improve seedling vigor and establishment and consequently crop performance in the field is seed priming (Eira and Marcos Filho, 1990; Khan, 1992; McDonald, 2000).

Priming allows seed hydration to initiate the early events of germination but not to permit radicle emergence, followed by drying (McDonald, 2000; Ashraf and Foolad, 2005). Methods of seed priming include soaking seeds in water or osmotic solution and intermixture with matrix materials

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(Khan, 1992; McDonald, 2000). There are reports that seed priming permits early DNA replication, increase RNA and Protein synthesis, enhances embryo growth, repairs deteriorated seed parts and reduces leakage of metabolites (McDouald, 2000). The early improvements may increase the rate and uniformity of seed germination and seedling emergence (Rowse *et al*., 2001; Basra *et al*., 2003, 2005; Farooq *et al*., 2005; Abdurrahmani *et al*., 2007). In this way, some of the deleterious effects of water limitation on crop performance may also be overcome by seed priming (Singh and Rao, 1993; Demir and Van de Venter, 1999; Bittencourt *et al*., 2004; Demir *et al*., 2006).

Hydropriming is a very simple, economical and environmental friendly type of seed priming in which seeds are soaked in water for a certain time and dried before sowing (Thornton and Powell, 1992). Since the beneficial effects of hydropriming on field performance of chickpea under water stress are poorly documented, this research was aimed to investigate the effects of hydropriming duration on seed invigoration, seedling emergence and grain yield of chickpea under different irrigation regimes.

MATERIALS AND METHODS

Seeds of chickpea (cv. ILC_{482}) were obtained from Dryland Agricultural Research Institute, Maragheh, Iran. These seeds 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 17.3°C for 8 (P_2), 16 (P_3) and 24 (P_4) hours and then dried back to about 30% moisture content at room temperature of 20-22°C. All the seeds were treated with Mancozebe at a rate of 2 g kg^{-1}. Laboratory tests were carried out with CR design at Seed Technology Laboratory of Tabriz University, Tabriz, Iran. Four replicates of 25 seeds were placed between moist filter papers and germinated in an incubator adjusted on 10°C for 6 days. Germination (protrusion of radicle by 2 mm) was recorded in daily intervals. Seed germination rate for each treatment was calculated according to Ellis and Roberts (1980). At the end, percentage of normal seedlings and seedling dry weight were also determined.

The field experiment was conducted at the Research Farm of Tabriz University (Latitude 38° 05' N, Longitude 46° 17' E, Altitude 1360 m above sea level) in 2006. The climate is characterized by mean annual precipitation of 246 mm, mean annual temperature of 10°C, annual maximum temperature of 16.6°C and mean annual minimum temperature of 4.2°C. Soil type was sandy loam with EC of 0.68 dS m^{-1} and pH of 8.1.

Seeds were hand sown in about 4 cm depth with a density of 68 seeds m^{-2} on 11 April 2006. Each plot consisted of 6 rows with 5 cm length, spaced 25 cm apart. Experimental design was factorial, based on RCB design with four replications. All plots were irrigated immediately after sowing and then fertilized with 30 kg ha^{-1} urea. Subsequent irrigations were carried out after 80 (I_1), 120 (I_2) and 160 (I_3) mm evaporation from class A pan. Weeds were controlled by hand weeding during crop growth and development. Plants were protected from heliothis caterpillar attack by spraying Diazinon (2 ml L^{-1}) at pod formation stage.

Seedling emergence was recorded in daily intervals up to the day, when maximum seedling establishment in each plot was achieved. Subsequently, rate and percentage of seedling emergence were 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. At maturity, 10 plants were harvested from each plot and grains per unit area, 1000 grain weight and above ground biomass were determined. Finally, plants of 3 m^2 in the middle part of each plot were harvested and grain yield per unit area was 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. EXCEL software was used to draw figures.

RESULTS

Analysis of variance of the laboratory data showed significant effects of hydropriming duration on germination rate and seedling dry weight ($p \leq 0.05$). The highest germination rate was achieved with P_4 (hydropriming for 24 h), which was not significantly different from P_3 (hydropriming for 16 h). Rate of germination for P_2 (hydropriming for 8 h) was significantly lower than that for P_3 and P_4, but it was significantly higher than that for P_1 (non-primed seeds). Primed seeds (P_2, P_3 and P_4) were also produced larger seedlings, compared to non-primed seeds (P_1). However, no significant effect of hydropriming duration on seedling dry weight was observed (Table 1).

Seedling emergence rate and percentage in the field were significantly affected by hydropriming duration, but the effects of irrigation regimes and irrigation × hydropriming interaction on these traits were not significant (Table 2). Rate and percentage of seedling emergence for primed seeds were significantly higher than those for non-primed seeds. However, seedling emergence did not differ significantly among P_2, P_3 and P_4 (Table 4).

Effect of irrigation on ground cover in the field was significant (Table 2). Mean ground cover percentage decreased, as water limitation increased. However, differences between I_1 and I_2 and between I_2 and I_3 were not significant (Table 3). Although mean ground cover of plants from primed seeds was higher than that from unprimed seeds, but this difference was not statistically significant (Table 2, 4). Ground green cover of chickpea cultivars under different irrigation regimes increased with increasing growth period up to about 66-68 days after sowing and then started to decrease (Fig. 1). In general, ground cover of plants from P_2 and P_3 treatments was higher than that from P_1 and P_4 treatments (Fig. 1, Table 4).

Table 1: Effects of hydropriming on mean germination rate, germination percentage and seedling dry weight in laboratory

Treatments	Germination rate (per day)	Germination (%)	Seedling dry weight (mg)
P_1	0.340^c	96^a	21.2^b
P_2	0.453^b	97^a	27.0^a
P_3	0.502^a	94^a	27.5^a
P_4	0.515^a	95^a	28.2^a

Different letters indicating significant difference at $p \leq 0.05$. P_1, P_2, P_3 and P_4: non-primed and hydroprimed seeds for 8, 16 and 24 h, respectively

Table 2: Analysis of variance of the effects of hydropriming on field performance of chickpea

		MS							
Source	df	Emergence rate	Emergence percentage	Ground cover	Grains per unit area	1000 grain weight	Biological yield	Harvest index	Grain yield
Replication	3	2.461×10^{-5}ns	304.267*	26.919ns	30608.892ns	220.971ns	4455.110ns	108.273ns	1508.422ns
Irrigation	2	1.631×10^{-5}ns	8.644ns	73.847*	125484.357*	2665.514*	13001.372*	84.906ns	2139.225*
Hydropriming	3	1.573×10^{-5}**	331.230*	40.914ns	79243.317*	696.528ns	12660.088**	226.236ns	3653.365*
Irrigation× Hydropriming	6	2.164×10^{-5}ns	59.376ns	16.748ns	4634.603ns	1967.886*	1363.194ns	75.605ns	832.126ns
Error	33	3.03×10^{-5}	87.705	21.041	26146.316	785.250	2801.560	75.588	730.680

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

Table 3: Comparison of mean ground cover, grain yield and yield components of chickpea under different irrigation regimes

Treatments	Ground cover (%)	Biological yield (g m^{-2})	Grains m^{-2}	1000 Grain weight (g)	Grain yield (g m^{-2})
I_1	37.854^a	242.0^a	529.1^a	307.244^{ab}	78.85^a
I_2	35.970^{ab}	206.7^{ab}	434.1^{ab}	324.837^a	101.20^a
I_3	33.567^b	185.6^b	352.2^b	299.681^b	80.60^b

Different letters indicating significant difference at $p \leq 0.05$. I_1, I_2 and I_3: Irrigation after 80, 120 and 160 mm evaporation from class A pan, respectively

Table 4: Means of field traits for chickpea affected by hydropriming

Treatments	Emergence rate (per day)	Emergence (%)	Ground cover (%)	Biological yield (g m^{-2})	Grains m^{-2}	Grain yield (g m^{-2})	Yield improvement (%)
P_1	0.061^b	78.92^b	33.685a	168.9^b	324.5^b	78.805^b	0
P_2	0.068^a	89.46^a	36.942^a	223.8^a	460.3^{ab}	101.00^{ab}	28
P_3	0.068^a	89.95^a	37.692^a	237.3^a	517.0^a	110.70^a	40
P_4	0.068^a	88.73^a	34.868^a	220.7^a	452.1^{ab}	98.67^{ab}	25

Different letters indicating significant difference at $p \leq 0.05$. P_1, P_2, P_3 and P_4: non-primed and hydroprimed seeds for 8, 16 and 24 h, respectively

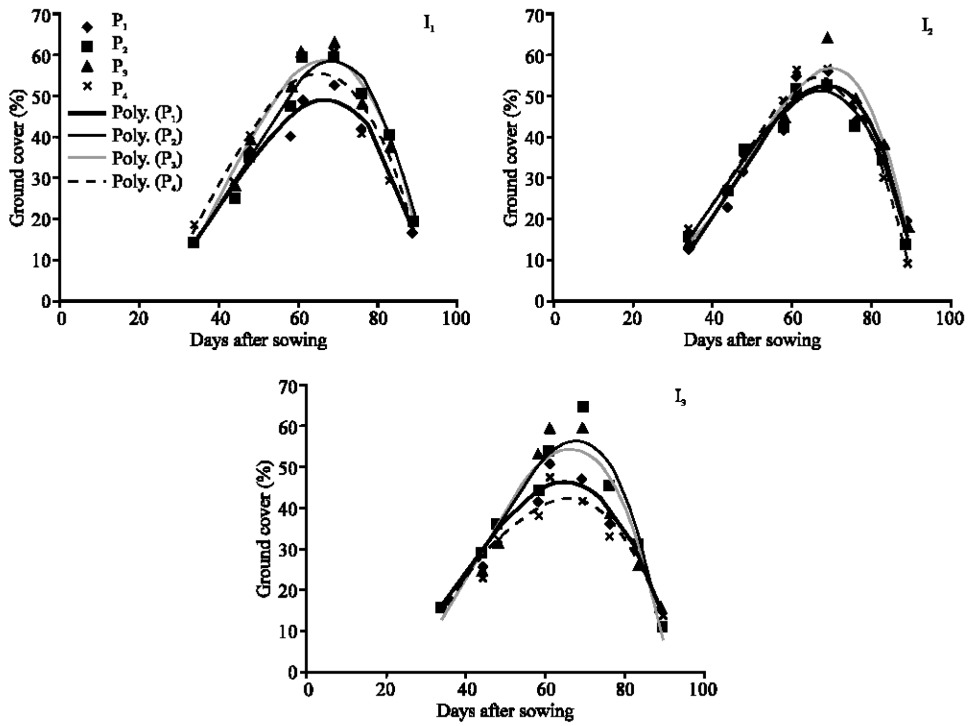

Fig. 1: Changes in ground cover of chickpea affected by seed priming and water limitation during growth and development
P_1, P_2, P_3 and P_4: non-primed and hydroprimed seeds for 8, 16 and 24 h, respectively
I_1, I_2 and I_3: Irrigation after 80, 120 and 160 mm evaporation from class A pan, respectively

Table 5: Mean 1000 grain weight of chickpea for hydropriming × irrigation interaction

Treatments	P_1	P_2	P_3	P_4
I_1	323.15^{abc}	289.13^{bc}	300.50^{bc}	316.20^{abc}
I_2	316.98^{abc}	332.05^{ab}	352.78^{a}	297.55^{bc}
I_3	309.83^{abc}	321.95^{abc}	282.03^{c}	284.93^{bc}

Different letters indicating significant difference at $p \leq 0.05$. P_1, P_2, P_3 and P_4: non-primed and hydroprimed seeds for 8, 16 and 24 h, respectively. I_1, I_2 and I_3: Irrigation after 80, 120 and 160 mm evaporation from class A pan, respectively

Thousand grain weight was only affected by irrigation, but grains per unit area and grain yield were affected by both irrigation and hydropriming. Irrigation × hydropriming interaction for 1000 grain weight was also significant. Neither priming nor irrigation had significant effect on harvest index (Table 2). Mean number of grains per unit area, 1000 grain weight and grain yield were significantly decreased under sever water deficit (I_3), compared to other irrigation treatments (Table 3). Grains per unit area and grain yield for P_1 were lower than those for P_2, P_3 and P_4, but these traits were statistically similar for primed seeds (Table 4). Mean 1000 grain weight of plants from P_1 and P_4 treatments decreased, with increasing water limitation. However, plants from P_2 and P_3 treatments produced the largest grains under I_2 (Table 5).

DISCUSSION

Hydropriming improved seedling vigor of chickpea as indicated by seed germination rate and seedling dry weight in laboratory tests (Table 1). The earlier germination might be attributed to increased metabolic activities in the hydroprimed seeds (Soon *et al*., 2000; Basra *et al*., 2002). It is obvious that higher rate of seed germination can lead to the production of large and uniform seedlings. According to McDonald (2000), primed seeds can rapidly imbibe and revive the seed metabolism, enhancing germination rate and uniformity. In many crops, seed germination and early seedling growth are the most sensitive stages to water limitation. Water deficit may delay the onset and reduce the rate and uniformity of germination, leading to poor crop performance and yield (Demir *et al*., 2006). Therefore, the beneficial effects of priming may be more evident under unfavorable rather than favorable conditions (Parera and Cantliffe, 1994; Bradford, 1995).

Since plots irrigated immediately after sowing, seeds did not experience drought stress during germination and seedling emergence in the field. So, rate and percentage of seedling emergence for irrigation treatments were not statistically different (Table 2). Therefore, reductions in ground cover and biological yield of chickpea under limited irrigation (Table 3) were not influenced by rate and percentage of seedling emergence. These reductions were then the consequence of growth retardation, due to water deficit (Sing, 1993; Kamara *et al*., 2003). Poor ground cover and biological yield under sever water deficit (I_3) resulted in production of less and smaller grains and finally lower grain yield per unit area (Table 3), compared to well-watering (I_1) and mild water stress (I_2). These traits did not differ significantly between I_1 and I_2, suggesting that when water resources are limited, irrigation after 120 mm evaporation from class A pan could be a favorite irrigation regime for chickpea crop.

Enhanced emergence rate and percentage of chickpea seedlings as a result of hydropriming, without any effect of priming duration (Table 4), suggest that hydration of chickpea seeds is an effective method to improve seedling vigor and establishment in the field. The rate and percentage of seedling emergence are very important in determining yield potential of annual crops (Kahlon *et al*., 1992; Musa *et al*., 1999; Hussain *et al*., 2006). Rapid emergence of seedlings could lead to the production of vigorous plants. In addition, improvement of seedling emergence percentage could help to establish optimum plant population density under a wide range of enviroumental conditions (Harris *et al*., 1999; Podlaski *et al*., 2003; Hussain *et al*., 2006).

Some improvement in ground cover of plants from primed seeds (Fig. 1) was clearly related with the early emergence and superior establishment of their seedlings (Table 4). Since, there is a linear relationship between ground cover and light interception (Burstall and Harris, 1983), it is, therefore a reliable index to estimate crop performance and yield, particularly under adverse conditions. Also, it has the practical advantage of quick, simple and non-destructive measurement, allowing frequent sampling.

The beneficial effects of hydropriming on grain yield were previously reported in sunflower (Hussain *et al*., 2006), rice (Farooq *et al*., 2006) and wheat (Kahlon *et al*., 1992). In this research, superiorities of hydroprimed seeds in stimulation of seedling emergence and establishment continued to improve biological yield, grains m^{-2} and grain yield per unit area. Plants from P_2 and P_3 also produced the largest grains under I_2 (Table 5).

CONCLUSION

Hydropriming improved field performance and grain yield of chickpea. Yield improvement was 25-40%, depending on hydropriming duration. The highest yield increase was obtained with 16 h hydropriming (Table 4). Thus, it is conceivable to suggest that this priming duration is the best treatment for invigoration of chickpea seeds.

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