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Effects of Hydro-priming Durations and Water Stress on some Morphological Characteristics of Safflower

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ABSTRACT: Seed priming is a technology that positively influence seedling establishment in many crops and may improve field performance under adverse environmental conditions. Therefore, in this research the effect of seed priming durations (0 (P0), 8 (P1) and 16 (P2) hours) on some morphological characteristics of safflower under different irrigation treatments (Irrigation after 60 (I1), 90 (I2), 120 (I3) and 150 (I4) mm evaporation from class A pan) was investigated. Results showed water stress decreased mean of plant height, stem diameter, leaves per plant, branches per plant, capitol per plant and capitol diameter. Hydro-priming increased all of these traits. The highest mean for these traits was recorded for hydro-priming at 16 hours duration period. It was, suggested that this priming duration is the best treatment for invigoration of safflower seeds.

Keywords: capitol, hydro-priming, plant height, safflower, stemdiameter.

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is one of the major oilseed crops worldwide and its genetic improvement for oil yield is very important in breeding of this crop (Balijani *et al.* 2015). In many regions of the world, including Iran, drought stress is one of the most important factors responsible for decreasing agricultural crop yield. Water stress is one of the most important abiotic stress factors affecting plant growth and photosynthesis (Flexas *et al.* 2004).Plants have evolved physiological responses as well as ecological strategies to cope with water shortages by either stress avoidance or stress tolerance. These responses allow them to survive and even to maintain some growth under very harsh circumstances. Water stress reduces plant growth by reducing cell division and enlargement and causes a decline in ion transport to the root surface, which leads to a further decrease in plant growth (Dastborhan *et al.* 2013). Plant productivity under drought stress is strongly related to the processes of dry matter partitioning and temporal biomass distribution (Willekens *et al.* 1997). Drought stress inhibits the dry matter production largely through its inhibitory effects on leaf expansion, leaf development and consequently reduced light interception (Nam *et al.* 1998). An early morphological response to drought stress is the avoidance mechanism through adjustment of plant growth rate such as a reduction in shoot height, basal diameter and total dry mass (Lei *et al.* 2006). A common adverse effect of water stress on crop plants is the reduction in fresh and dry biomass production (Zhao *et al.* 2006).

Harris *et al.* (1999) promoted a low cost, low risk technology called 'on-farm seed priming' that would be appropriate for all farmers, irrespective of their socioeconomic status. In seed priming, seeds are partially hydrated to a point where germination-related metabolic processes begin but just prior to germination where radicle emergence does not occur. After priming, seeds are air-dried back near to the original weight. According to Farooq *et al.* (2011), seeds can be primed using different media such as tap water (hydro-priming), low water potential solutions (osmo-priming) such as polyethylene glycol or salt solutions (KNO_3, KCl, $MgSO_4$, $CaCl_2$ and NaCl), solid matrix (matri-priming), and plant growth regulators (hormonal priming). Harris *et al.* (2002) indicated that hydro-priming is the best option for smallholder farmers in developing countries since it is a low cost and low risk intervention. Seed priming also promotes germination by repair of the damaged proteins, RNA and DNA (Koehler and *et al.* 1997). Priming is able to repair the age related cellular and sub-cellular damage of low vigour seeds that may accumulate during seed development (Bray, 1995). This research was undertaken to investigate the effects of hydro-priming durations on some morphological characteristics of safflower under different irrigation conditions.

MATERIALS AND METHODS

A field experiment was conducted in 2014 at the farm of the Hashtrood, East Azerbaijan, Iran (Latitude 37° 28' N, Longitude 46° 52' E, Altitude 1643 m above sea level) to evaluate the effect of hydro-priming durations and water stress on some morphological characteristics and yield of safflower (*Carthamus tinctorius* L.). The climate is characterized by mean annual precipitation of 304.05 mm per year and mean annual temperature of 10°C. A split plot experiment based on randomized complete block design with three replications was conducted. The factors were four levels of irrigation (Irrigation after 60 (I1), 90 (I2), 120 (I3) and 150 (I4) mm evaporation from class A pan) and hydro-priming durations (0 (P0), 8 (P1) and 16 (P2) hours) which were allocated to main and sub plots, respectively.

Each plot had 6 rows of 3 m length, spaced 25 cm apart. Before sowing, seeds were divided into three sub-samples, one of which was kept as control (non-primed, P0) and two other samples were soaked in distilled water at 20°C for 8 (P1) and 16 (P2) hours and then dried back to initial moisture content at room temperature of 22 ± 2°C. Seeds were treated with Benomyl at a rate of 2 g/kg before sowing. The seeds were then sown by hand on 1 May 2014 in 4 cm depth of a sandy loam soil. All plots were irrigated immediately after sowing, but subsequent irrigations were carried out according to the treatments. Weeds were controlled by hand during crop growth and development as required.

At maturity, five plants randomly were harvested from each plot and plant height, stemdiameter, leaves per plant, branches per plant, capitol per plant and capitol diameter were recorded. Analysis of variance appropriate to the experimental design was conducted, using GenStat 12software. Means of each trait were compared according to Duncan multiple range test at $p \leq 0.05$. Excel software was used to draw figures.

RESULTS AND DISCUSSION

Analyses of variance of the data showed that plant height, stem diameter, leaves per plant, branches per plant, capitol per plant and capitol diameter were significantly affected by irrigation. As the table shows, hydro-priming on all this traits had a significant effect, but had no significant effect on plant height. Interaction of irrigation × hydro-priming was only significant for capitol diameter (Table 1).

Table 1: Analyses of variance of the effects of irrigation and hydro-priming durations on morphological traits of safflower.

Source of Variation	Df	Mean Square					
		Plant height	Stem diameter	Leaves per plant	Branches per plant	Capitol per plant	Capitol diameter
Replication	2	90.53	0.000475	8.36	2.528	2.1736	0.00017
Irrigation (I)	3	807.44**	0.64277**	802.89**	51.370**	367.6111**	2.09563**
Error	6	19.60	0.00627	19.47	7.343	0.4051	0.02362
Hydro-priming (P)	2	67.86^{ns}	0.15257**	400.11**	86.694**	53.8403**	0.95751**
I × P	6	7.71^{ns}	0.01553^{ns}	15.22^{ns}	0.954^{ns}	0.2662^{ns}	0.10376**
Error	16	37.25	0.00956	22.69	4.847	0.8785	0.02626
CV (%)	-	10.7	7.1	6.7	24.3	8.0	5.4

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

Plant height decreased with increasing levels of water stress conditions (Table 2). Plant height may be reduced due to dehydration of protoplasm; decrease in relative turgidity associated with turgor loss and decreased cell expansion and cell division (Hussain *et al.* 2008). The adverse effect of water stress may also be decreased by increasing the availability of water to the plant due to reduction in transpiration by partial closure of stomata (Hoad *et al.* 2001). In this research hydro-priming had no significant effect on plant height, but in maize (Al-soquer, 2004) and sorghum (Chivasa *et al.* 2000) plant height was increased by hydro-priming.

Table 2: Means of morphological traits of safflower affected by irrigation treatments and hydro-priming durations.

Treatments	Plant height (cm)	Stem diameter (cm)	Leaves per plant	Branches per plant	Capitol per plant
Irrigation					
I_1	67.44^{a}	1.566^{a}	81.56^{a}	11.667^{a}	15.22^{a}
I_2	61.44^{b}	1.520^{a}	76.00^{b}	10.111^{ab}	13.83^{b}
I_3	53.56^{c}	1.408^{b}	69.00^{c}	8.333^{bc}	11.22^{c}
I_4	45.67^{d}	0.980^{c}	59.67^{d}	6.111^{c}	6.83^{d}
Hydro-priming					
P_0	45.6^{a}	1.255^{c}	65.50^{c}	6.583^{c}	9.38^{b}
P_1	57.3^{a}	1.367^{b}	72.17^{b}	8.667^{b}	12.58^{a}
P_2	59.2^{a}	1.482^{a}	77.00^{a}	11.917^{a}	13.38^{a}

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

I_1, I_2, I_3, I_4: irrigation after 60, 90, 120 and 150 mm evaporation from class A pan, respectively

P_0, P_1 and P_2: non-primed and hydro-primed seeds for 8 and 16 h, respectively.

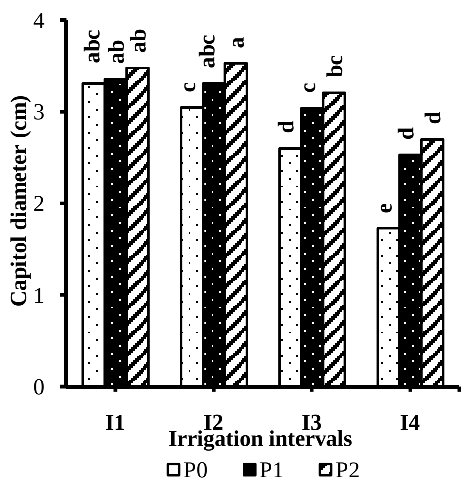
Stem diameter significantly decreased as a result of water stress. However, there was no significant difference between I1 and I2 treatments. Hydro-priming especially for 16 hours had increasing effect on this trait (Table 2). When plants experience drought stress, stem diameter shrinks in response to changes in internal water status (Simonneau *et al.* 1993). Changes in stem diameter were well correlated with predawn leaf water potential under prolonged drought (Katerji *et al.* 1994). Hydro-priming affects DNA and RNA synthesis, ATP availability, alpha-amylase activity and embryo's better growth. Hence, germination better rate, growth consistency, seeding vigor and deployment leads to better plant growth and high stem diameter. (Ruan *et al.* 2002; Basra *et al.* 2005).

Water stress significantly reduced leaf number of safflower, but hydro-priming increased number of this trait. Reduction in leaf number can be related with plant height (Table 2). Cakir and Cebi (2006) reported that water stress of various severity occurring during rapid vegetative growth and yield formation periods reduced plant height and it influenced leaf number and leaf area development. Also, a significant effect of water stress on leaf number was confirmed in tobacco (Maw *et al.* 1977; Wilkinson *et al.* 2002) and cowpea (Hayatu *et al.* 2014). As the crop near to maturity more leaves were produced although 16 hours primed seeds had the highest compared to the 8 hours and control. Similar results were reported in sorghum (Chivasa *et al.* 2000) and *Brassica napus* L. (Hassanpouraghdam *et al.* 2009), which hydro-primed seeds had produced more number of leaves.

Number of branches per plant reduced with increasing water deficit and the highest reduction in this trait was obtained from I4 irrigation treatment. However there was no significant difference between I3 and I4 (Table 2). Similar result was reported by Zakirullah *et al.* (2000). Hydro-priming for 16 hours and the control of plants had the highest (11.91) and lowest (6.58) number of branches, respectively (Table 2). Increasing the number of branches by hydro-priming could probably be due to better performance of primed seeds in using environmental resources. It is possible that in plants that are established lately, reduction of soil moisture in the vegetative stage caused reduction in the number of branches. Also, it seems that in the treatments which have longer time of emergence, increasing temperature during vegetative growth caused the acceleration of the development and reduction of vegetative growth, which finally decreased the numbers of branches per plant (Zarei *et al.* 2011).

Capitol per plant of safflower decreased with decreasing water availability. This trait increased with hydro-priming techniques. However, differences between 8 and 16 hours were not significant. Changes in this trait can be related with number of branches per plant (Table 2). Mardanand Kazemi (2011) reported that there is a positive correlation between number of branches per plant and number of the capitol.

The interaction of irrigation × hydro-priming durations showed that in all irrigation treatments capitol diameter enhanced as a result of hydro-priming. In I1 treatment there was no significant difference between hydro-priming treatments and control. However, with increasing water deficit capitol diameter decreased in all treatments (Fig. 1). Reduction in capitol diameter due to water stress was also reported by Goksoy *et al.* (2004).



Different letters indicate significant difference at p ≤0.05 (Duncan test).
I1, I2, I3, I4: irrigation after 60, 90, 120 and 150 mm evaporation from class A pan, respectively
P0, P1 and P2: non-primed and hydro-primed seeds for 8 and 16 h, respectively.

Fig. 1. Mean capitol diameter of safflower for interaction of irrigation × hydro-priming durations.

CONCLUSIONS

Hydro-priming, especially for 16 hours duration period increased the plant height, stem diameter, leaves per plant, branches per plant, capitol per plant and capitol diameter. That lead to ability of safflower to grow successfully in the field. Therefore, hydro-priming is a simple, low cost and environmentally friendly technique for improving safflower morphological characteristics.

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