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RESEARCH PAPER

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Changes in seed vigour of Dragon's head (*Lallemantia iberica* Fish. et Mey.) under irrigation and plant density treatments

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Key words: electrical conductivity, irrigation treatments, plant density, seed vigour.

Abstract

A field experiment was conducted in 2012 to investigate the effects of different irrigation treatments and plant density on seed vigour of Dragon's head (*Lallemantia iberica* Fish. et Mey.). The experiment was arranged as split plot based on randomized complete block design with four replications. Irrigation treatments (I1, I2, I3, I4 and I5: irrigation after 70, 100, 130, 160 and 190 mm evaporation from class A pan, respectively) were assigned to main plots and four plant density levels (D1, D2, D3 and D4: 200, 300, 400, 500 plant/m2) were allocated to the sub plots. Different planting densities were employed by changing planting distances on cultivation rows. Electrical conductivity (EC) of Dragon's head seed leachates increased, but germination percentage, germination rate and seedling dry weight decreased with enhancing drought stress levels. Electrical conductivity, seed germination percentage, germination rate and seedling dry weight was not significantly affected by plant density. Reduction in these traits was related with ion imbalances and membrane disruption under drought stress. Thus, the quality of Dragon's head seeds could be influenced by well irrigation treatments.

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Introduction

In the field, seed quality means the ability to germinate, to emerge and to produce healthy seedlings rapidly, uniformly, under a wide range of environmental conditions, and to maintain this ability for a long period (Johnson and Wax, 1987). Seed quality could be influenced by genetic constitution, environment and nutrition of mother plant, stage of maturity at harvest, seed size, seed deterioration, mechanical damage and pathogens (Ghassemi-Golezani *et al.,* 1997). Thomson (1979) commended that seed quality is a multiple concept comprising several components. Seed vigour is also an important component that can influence crop plant density and yield (Siddique and Wright, 2004). Vigour of seedlings relates with their ability upon germination to grow rapidly and well. It is suggested that speed and uniformity of emergence are important parameters of seed quality (Copeland and McDonald, 1995). Seed vigour frequently affects seedling size soon after emergence (Perry, 1980) and these relative differences may remain until harvest to influence crop yield (Finch-Savage, 2000). High vigour seed lots may improve crop yield through improving seedling emergence rate and percentage, leading to the production of vigorous plants and optimum plant population density under a wide range of environmental conditions (Ghassemi-Golezani, 1992). These are the main reasons for farmers, who are interested to buy and cultivate vigorous seeds. Reports have shown that low seed vigour causes poor stand establishment in the field and consequently yield loss of corn (Moreno-Martinez *et al.,* 1998), wheat (Ram and Wiesner, 1988), barley (Copeland and McDonald, 2001) and rapeseed (Ghassemi-Golezani *et al*., 2010a).

In dry areas, the major factor limiting agricultural production is water. Drought stress is one of the most important environmental stresses affecting agricultural productivity around the world and may result in considerable yield reductions (Ludlow and Muchow, 1990). Decreasing the growth trend of roots and shoots, leaf area, photosynthesis, transpiration, plant height and dry weight are some the drought-induced losses reported by Jiang and Huang (2000). Plant responses to drought stress are very complex and include adaptive changes or deleterious effects (Chaves *et al.,* 2002). Coincidence of water stress with reproductive stages reduces duration of flowering and seed filling and consequently lowers the number of grains per plant, mean grain weight and grain yield per unit area (Ghassemi-Golezani *et al*., 2010b). The deleterious effects of water limitation on field performance of crops may be reduced by cultivation of high vigour seeds (Sun *et al.,* 2007).

On the other hand, Plant density is one of the main factors determining seed yield (Long *et al*., 2001). In fact, the yield of plant is the result of the competition within and outside of the plant on the environmental factors and the maximum yield will be obtained when, this competition has decreased and the plant has the maximum using of these environmental factors. Najafi and Moghadam (2002) reported that with increase in the plant density seed and biological yield increased. Arabaci and Bayram (2004) reported that the highest effective substances yield in the Basil (*Ocimum basilicum* L.) was obtained in lower plant density. Ghassemi-Golezani *et al.* (1997) reported that plant density had no significant effect on seed quality of chickpea cultivars.

Dragon's head (*Lallemantia iberica* Fish. et Mey.) is an annual herb that belongs to Lamiaceae family and spreads in southwestern Asia and Europe (Ursu and Borcean, 2012). It grows well in arid zones and requires a light well-drained soil (Ion *et al*., 2011). Dragon's head is a valuable species, *i.e.* all plant parts (leaves or seeds) can be economically used (Hedrick, 1972). However, it is mainly cultivated for its seeds that contain about 30% oil with iodic index between 163 and 203. These seeds are used traditionally as stimulant, diuretic and expectorant as well as in food (Naghibi, 1999).

A better understanding of the effects of irrigation frequency and planting density on local and neglected crops can help to determine optimal irrigation scheduling. It is expected that good management and adoption of suitable practices will improve the water conservation and result in more efficient crop production under both rain fed and irrigated conditions (Wang and Tian, 2004). A question that also needs to be resolved is if different plant populations are relevant factors determining the final crop yield under different irrigation frequencies. Thus, this research was conducted to investigate the changes in seed quality of Dragon's head at different planting densities under water deficit.

Materials and methods

Site description and experimental design

The field experiment was conducted in 2012 at the Research Farm of the University of Tabriz, Iran (latitude 38°05_N, longitude 46°17_E, altitude 1360 m above sea level). The climate of research area is characterized by mean annual precipitation of 285 mm, mean annual temperature of 10°C, mean annual maximum temperature of 16.6°C and mean annual minimum temperature of 4.2°C. The experiment was arranged as split plot design with four replications. Irrigation treatments (I_1, I_2, I_3, I_4 and I_5: irrigation after 70, 100, 130, 160 and 190 mm evaporation from class A pan, respectively) were assigned to main plots and four plant density levels (D_1, D_2, D_3 and D_4: 200, 300, 400, 500 plant/ m^2) were allocated to the sub plots. Seeds of Dragon's head were treated with 2 g/kg benomyl and then were sown by hand in 3 cm depth of a sandy loam soil. Different planting densities were employed by changing planting distances on cultivation rows. All plots were irrigated immediately after sowing. Irrigation treatments were applied after seedling establishment. Hand weeding of the experimental area was performed as required.

At maturity, an area equal to 1 m^2 was harvested from middle part of each plot considering marginal effect. Harvested plants were dried in 25^{oC} and under shadow and air flow, and then grains were separated from their remains by threshing. Subsequently, 1000-seed weight of each sample was determined. Seed samples within separate sealed bags were then placed in a refrigerator at 3-5°C.

Seed quality tests were carried out at the Seed Technology Laboratory of Tabriz University. Four replicates of 25 seeds from each sample were treated with 2.5 g/l *thiram* for a minute, before testing. Seeds of each replicate were placed between two 30 x 30 cm wetted filter papers, which were then rolled and placed in plastic bags to prevent water loss. These bags were incubated at 20±1°C for 14 days. Germinated seeds (protrusion of radicle by 2 mm) were counted in daily intervals. At the end of each test, normal and abnormal seedlings were recorded and the germination percentage was calculated. After recording rate of seed germination, seedlings were then cut from the storage tissues and dried in an oven at 70°C for 24 h. Subsequently, mean seedling dry weight for each treatment at each replicate was determined. For electrical conductivity test, seeds of each treatment immersed in 100 ml deionized water in a container at 20°C for 24 hours. The seed-steep water was then gently decanted and electrical conductivity (EC) was measured, using an EC meter.

Statistical analysis

Statistical analysis of the data was performed with MSTAT-C software. Duncan multiple range test was applied to compare means of each trait at 5% probability.

Results and discussion

Electrical conductivity (EC), significantly affected by irrigation treatments but plant density and their interaction had no effect on this trait (Table 1). Electrical conductivity of seed leachates increased as irrigation intervals increased. Minimum electrical conductivity for Dragon's head seeds (12.09 μS/m) was obtained under without drought stress treatment (I_1) (Fig. 1). Highest electrical conductivity (27.45 μS/m) was achieved at I_5 (irrigation after 190 mm evaporation from class A pan) (Fig. 1). Water stress reduces photosynthate production because of stomatal closure and early senescence which ultimately affect seed development processes (Singh and Wilkens, 1999). It is well known that drought stress during seed development reduces seed yield. The stress shortens the seed filling period, which reduced the final seed size. The major influence of water stress by applying at seed production period was to minimize the seed yield. Reproductive growth is very sensitive to water stress. Heatherly (1993) also observed that drought stress during seed production of soybean usually reduced the yield and quality of seeds. However, there is disagreement in the literature on the effects of drought stress on seed vigour, Vieira *et al.* (1992) reported that water stress has no significant effect on seed quality and electrical conductivity of soybean, but it can considerably reduce seed yield.

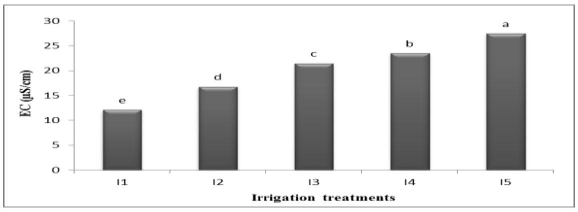

Fig. 1. Effect of different irrigation treatments (I1, I2, I3, I4 and I5: irrigation after 70, 100, 130, 160 and 190 mm evaporation from class A pan, respectively) on electrical conductivity (EC) of Dragon's head seed (Different letters indicate significant difference at p≤ 0.05).

Table 1. *Analysis of variance of selected parameters of Dragon's head affected by irrigation and plant density treatments.*

S.O.V	**df**	**Mean Square**				
		1000 grain weight	EC	Germination percentage	Germination rate	Seedling dry weight
Block	3	0.166	0.4	3.799 *	0.001	0.001
Irrigation	4	0.2	570.57 **	1241.7693 **	0.082 **	0.088 **
Error	12	0.107	1.128	1.07	0.001	0.001
Plant density	3	0.034	0.109	0.581	0.001	0.001
Interaction	12	0.157	0.213	0.531	0.001	0.001
Error	45	0.095	0.916	3.466	0.001	0.001

Ns=Non significant; * and ** = Significant at 5% and 1% probability level, respectively.

Plant density had no significant effect on the seed germination percentage, whereas seed germination percentage significantly affected by irrigation treatments (Table 1). Maximum germination percentage (93.51) was obtained from I_1 treatment, and the minimum (71.17) obtained from I_5 treatment, respectively (Fig. 2). Germination percentage test showed that seeds from severe drought stress treatment (I_5) were low in vigour. These results are in contrast with some previous experiments that showed effect of moisture stress on germination (Yaklich, 1984 and Vieira *et al.*, 1991). However, they are consistent with other reports which showed reduction in germination (Dornbos *et al.*, 1989 and Simiciklas *et al.*, 1989) and vigour (Yaklich, 1984 and Dornbos *et al.*, 1989). Drought stress occurring during seed formation or seed filling resulted in reduced seedling vigour and germination (Simiciklas *et al.*, 1989 and Yaklich, 1984). In the present studies drought stress reduced germination of the harvested seeds. Rapid germination of high vigour seeds led to production of vigorous seedlings. These seedlings emerged earlier and more than those from low vigour seeds. Optimum stand establishment can potentially improve crop yield under different environmental conditions. Even when plants from high vigour seed lots were compared with similar populations obtained from high sowing rates of low vigour seed lots, the plants from the former seeds yielded more than those from the latter (Perry, 1980).

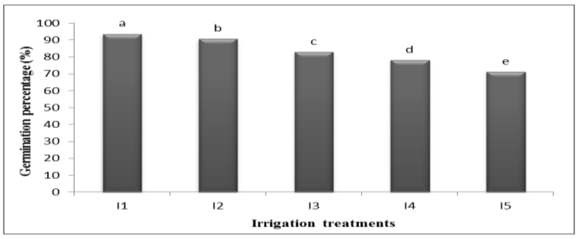

Fig. 2. Effect of different irrigation treatments (I1, I2, I3, I4 and I5: irrigation after 70, 100, 130, 160 and 190 mm evaporation from class A pan, respectively) on germination percentage of Dragon's head seed

(Different letters indicate significant difference at p≤ 0.05).

Irrigation treatments significantly affected seed germination rate but plant density and their interaction had no effect on this trait (Table 1). Mean germination rate significantly decreased with increasing drought severity. Reduction in seed quality under moderate and severe drought was comparatively high (Fig. 3). Highest germination rate (0.38 per day) was achieved under without drought stress treatment (Fig. 3). The effect of water stress on seed quality has been investigated in soybean (Simiciklas *et al.*, 1989) and in peas (Fougereux *et al.*, 1997). They observed that water stress induced a reduction in seed quality assessed by germination rate results. Nichols *et al.* (1978), working with potted plants of peas observed no effect of drought stress on germination rate.

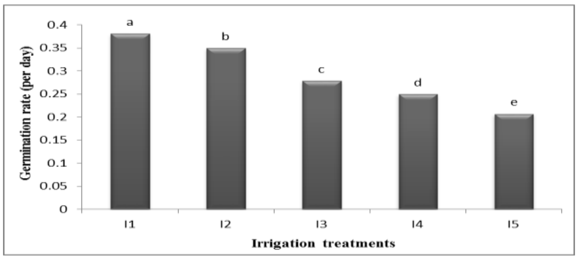

Fig. 3. Effect of different irrigation treatments (I1, I2, I3, I4 and I5: irrigation after 70, 100, 130, 160 and 190 mm evaporation from class A pan, respectively) on germination rate of Dragon's head seed (Different letters indicate significant difference at p≤ 0.05).

The effect of irrigation treatments on seedling dry weight was significant (Table 1). The highest seedling dry weight (0.45 gr) was obtained for seeds of irrigated with I_1 treatment (irrigation after 70 mm evaporation from class A pan) (Fig. 4). This could be attributed to early formation and longer duration of seed filling of Dragon's head which resulted in the production of large and vigorous seeds. Rapid germination of high vigour seeds led to production of vigorous seedlings. These seedlings emerged earlier and more than those from low vigour seeds. These results are in agreement with Fougereux *et al.* (1997) for peas and Vieira *et al.* (1992) for soybean, who reported that it seems unlikely that drought stress would have a direct effect on metabolic activity of the seed that would subsequently affect quality but, water stress can considerably reduce yield.

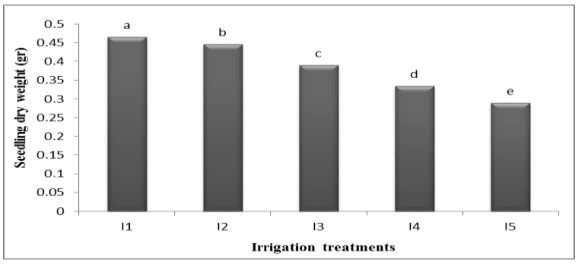

Fig. 4. Effect of different irrigation treatments (I1, I2, I3, I4 and I5: irrigation after 70, 100, 130, 160 and 190 mm evaporation from class A pan, respectively) on seedling dry weight of Dragon's head (Different letters indicate significant difference at p≤ 0.05).

In this research effect of plant density on seed quality was not significant. Interaction of irrigation × plant density was not also significant for these traits. Ghassemi-Golezani *et al.* (1997) reported that plant density had no significant effect on seed vigour of chickpea cultivars. No effect of plant density on seed vigour had a practical value for commercial seed producers, but was not of relevance to the elucidation of those factors responsible for seed quality.

Also, effect of plant density on mean 100-seed weight was not significant (Table 1). But this suggests that the heavier seeds can produce larger seedlings. The advantage of large seeds in enhancing the seedling size lies in their higher reserve content and the ability to provide energy to the growing seedling at a faster rate (Ghassemi- Golezani, 1992).

Conclusion

In the present investigation, plant density had no significant effect on seed vigour, whereas drought stress reduced seed quality. It is necessary to cultivate high vigour seeds, in order to improve crop yield under favorable and adverse environmental conditions. Thus, irrigation after 70 mm evaporation from class A pan recommended as the best irrigation interval for production the vigorous seeds in Dragon's head.

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