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Effect of different irrigation treatments and plant density on yield and yield components of Dragon's head (*Lallemantia iberica* Fish. et Mey.)

Parisa Aghaei-Gharachorlou, Safar Nasrollahzadeh*, Jalil Shafagh-Kolvanagh

Department of Plant Eco-physiology, Faculty of Agriculture, University of Tabriz, Tabriz, Iran

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Abstract

In order to investigate the effect of different irrigation treatments and plant density on yield and yield components of Dragon's head (*Lallemantia iberica* Fish. et Mey.), an experiment was carried out as split-plot based on randomized complete block design with four replications at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran in 2012. 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. Biological and grain yield, number of lateral stem, number of grain and capsule per plant, number of capsule per lateral stem, 1000 grain weight and harvest index were recorded. Results showed that irrigation treatments had significant effects on all of the characteristics with the exception of harvest index and 1000 grain weight. Means compression showed that highest biological and grain yield, numbers of lateral stem, numbers of capsule per plant, number of capsule per lateral stem, number of grain per plant were achieved under I_1 treatments. Plant density did not have significant effects on biological yield and 1000 grain weight. Irrigation after 70 mm evaporation from class A pan produced more grain yield, but difference between I_1 and I_2 treatments was not significant. The greatest grain yield was obtained from 400 plant/m^2. According to the results obtained, irrigation after 100 mm evaporation from class a pan and density of 400 plant/m^2 is the best combination for Dragon's head grain production.

* **Corresponding Author:** Safar Nasrollahzadeh ✉ nasr.tbu@gmail.com

Introduction

Medicinal plants are valuable sources in Iranian natural resources whose understanding and scientific cultivation can play an important role in people's health and job creation. Dragon's head (*Lallemantia iberica* Fish. et Mey.) is an important annual medical plant that belongs to the Labiatae family (Naghibi, 2005). Dragon's head originates in the Caucasian region and may be locally naturalized in East and Central East Europe. *Lallemantia iberica* cultivated for its oil seeds, the seed contains up to 30% of a drying oil (Usher, 1994).

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). The effects of drought stress are observed in the form of phonological responses, morphological adaptations, physiological changes and biochemical adaptations. Plant reactions are affected by the amount of soil water directly or indirectly. All physiological processes like photosynthesis, transpiration, cell turgidity, and cell and tissue growth in plants are directly affected by water availability (Sarker *et al.,* 2005). For achieve high yield, an adequate water supply is required during the growing season. The period at the beginning of the flowering stage is most sensitive to water shortage, while maximum yield and yield components were obtained with full irrigation, almost the maximum yield generally were obtained when irrigation was made to provide adequate water during flowering and fruit formation periods (Blum, 2005).

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. Several reports indicate that yield and yield components of Chicory (Taheri *et al*., 2006), and pumpkin (Babayee *et al*., 2010), change under the effect of the different densities of planting. The better understanding effects of irrigation frequency and planting density on local and neglected crops can help to determine optimal irrigation scheduling. The question that also needs to be resolved is if different plant populations are relevant factors determining the final crop yield under different irrigation frequencies. Therefore, this investigation was undertaken to evaluate the influence of irrigation intervals and plant density on yield and yield components of Dragon's head.

Material 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 three 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. All plots were irrigated immediately after sowing. Irrigation treatments were applied after seedling establishment. Hand weeding of the experimental area was performed as required.

Measurement of traits

To specify capsule number per plant and number of capsule per lateral steam ten plants were selected from the middle of the plots and then, they were measured. Also to determine of grain yield and biological yield 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 then grains were separated from their remains by threshing.

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

The biological yield of dragon's head was significantly affected by irrigation ($P<0.01$), but plant density and interaction between irrigation and plant density was not significant (Table 1). Highest biological yield (504.7gr/m^2) was obtained in I_1 treatment, but different between I_1 and I_2 was not significant (Table 2). Effect of drought stress on decreasing of biological yield was reported by Pezeshkpour *et al.,* (2008) and Fallah *et al.*, (2005). Effects of irrigation and plant density treatments on grain yield and lateral stem number were significant ($P<0.01$) (Table 1), but their interaction was not significant for this traits. Highest grain yield (158.1 gr/m^2) were achieved under I_1 treatment (Table 3). Lowest lateral stem number (1.237) obtained in I_5 treatment and between other treatments had not significantly different (Table 2). Highest grain yield (123.0 gr/m^2) and lateral stem number (2.442 stem/plant) were achieved under planting density of 400 and 200 plant/m^2 respectively. But different between D_1 and D_2 treatments was not significant for the lateral stem number (Table 2). Decreasing of grain yield by drought stress, also were reported by Yang and Wang (2001) and Jaleel *et al.*, (2008). The effect of low or high plant density on decreasing grain yield was also reported by Binaco., *et al* (1994) and El-Gengai and Abdollah (1987). Also plant density had a significant effect on harvest index (Table 1). Highest harvest index was achieved under planting density of 400 plant/m^2 (Table 4). Interaction of irrigation and planting density treatments had significantly affected grain per plant, number of capsule per plant and number of capsule per lateral steam (Table 1). Highest grain per plant (294.5), number of capsule per plant (63.30) and number of capsule per lateral steam was achieved under I_1 irrigation treatment and planting density of 200 plant/m^2 (Table 4). I_1D_1 and I_2D_1 treatments had similar results for these traits.

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

S.O.V	df	Biological yield	Grain yield	Lateral stem	number of Capsule per plant	number of Capsule per lateral steam	Grain per plant	1000 grain weight	Harvest index
Block	3	232.942	15.339	0.057	14.177	0.684	36.658	0.166	0.141
Irrigation	4	364255.501**	34582.660**	1.834**	2382.358**	521.121**	59406.778**	0.2	2.936
Error	12	966.385	45.683	0.163	14.906	6.385	53.506	0.107	2.044
Plant density	3	900.277	1552.410**	10.389**	387.617**	1140.246**	30968.801**	0.034	81.928**
Interaction	12	535.150	34.703	0.164	20.150*	63.488**	1400.901**	0.157	0.683
Error	45	771.454	58.313	0.103	8.427	4.051	33.602	0.095	1.332

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

As it was shown in the results of this study, water deficit stress had a negative effect on all of the Dragon's head characteristics under study, which was in agreement with the results of Albright *et al.*, (1989) and Taheri *et al.*, (2006). Silvius *et al.*, (1977) stated that the effects of water stress on soybean yield appeared to be related to limited availability of photosynthate and nitrogen for translocation to developing seed. Also, increase of planting density causes increase in grain yield. The effect of high density on increasing grain yield of green cumin was also reported, by Mashayekhi *et al*., (2011). In the present investigation, there was not found statistically difference between irrigation after 70 mm evaporation and 100 mm evaporation in grain yield. Thus, irrigation after 100 mm evaporation recommended as the best irrigation interval for the semi-arid regions. On the other hand, it seems that plant density of 400 plant/m² is most suitable for grain yield of dragon's head in Tabriz climate conditio

Table 2. Mean comparisons for different traits of Dragon's head under different irrigation treatments.

Irrigation	Biological yield (gr/m²)	Grain yield (gr/m²)	Lateral stem (stem/plant)
I_1	504.7[a]	158.1[a]	2.05[a]
I_2	499.3[a]	152.8[a]	1.696[a]
I_3	391.5[b]	118.3[b]	1.65[a]
I_4	259.2[c]	80.53[c]	2.056[a]
I_5	161[d]	50.18[d]	1.237[b]

The means with same letters in each column are not significantly different at $p \leq 0.05$. (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).

Table 3. Mean comparisons for different traits of Dragon's head under plant density.

Plant density	Grain yield (gr/m²)	Lateral stem (stem/plant)	Harvest index (%)
D_1	101.5[c]	2.442[a]	28.82[c]
D_2	110.4[b]	2.215[a]	30.18[b]
D_3	123.0[a]	1.41[b]	33.63[a]
D_4	113.1[b]	0.885[c]	30.87[b]

The means with same letters in each column are not significantly different at $p \leq 0.05$. (D_1, D_2, D_3 and D_4: 200, 300, 400, 500 plant/m²).

Table 4. Mean comparisons traits of Dragon's head at different levels of irrigation and plant density.

Treatment	Grain per plant	Capsule per plant	Capsule per lateral steam
I_1D_1	294.5 [a]	63.30 [a]	31.92 [a]
I_1D_2	248.9 [b]	58.47 [b]	22.40 [b]
I_1D_3	210.3 [d]	52.65 [c]	17.23 [c]
I_1D_4	171.0 [f]	51.25 [c]	6.650 [de]
I_2D_1	287.0 [a]	63.42 [a]	31.50 [a]
I_2D_2	253.1 [b]	58.65 [b]	22.90 [b]
I_2D_3	213.9 [d]	58.15 [b]	15.38 [c]
I_2D_4	153.3 [g]	53.28 [c]	7.250 [de]
I_3D_1	225.1 [c]	50.74 [c]	25.92 [b]
I_3D_2	184.3 [e]	45.00 [d]	14.80 [c]
I_3D_3	151.7 [g]	42.43 [de]	5.600 [de]
I_3D_4	121.6 [h]	34.08 [fgh]	4.375 [ef]
I_4D_1	173.3 [f]	40.58 [e]	15.80 [c]
I_4D_2	144.1 [g]	33.80 [fgh]	14.40 [c]
I_4D_3	128.9 [h]	35.80 [f]	9.875 [d]
I_4D_4	104.3 [i]	31.10 [gh]	6.025 [de]
I_5D_1	107.3 [i]	34.33 [fg]	8.550 [de]
I_5D_2	92.18 [j]	31.58 [fgh]	7.950 [de]
I_5D_3	72.00 [k]	29.48 [h]	6.075 [de]
I_5D_4	77.75 [k]	29.65 [h]	1.383 [f]

The means with same letters in each column are not significantly different at $p \leq 0.05$. (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 and D_1, D_2, D_3 and D_4: 200, 300, 400, 500 plant/ m²).

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