IJAIR

International Journal of Agriculture Innovations and Research
Volume 2, Issue 4, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy) :
Received : 10/02/2014 | Accepted on : 25/02/2014 | Published : 02/03/2014

Effect of Drought Stress and Plant Density on Oil Percentage, Oil and Grain Yield of Dragon's Head (*Lallemantia Iberica* Fish. et Mey.)

Parisa Aghaei-Gharachorlou
M.Sc. Student of Agronomy,
Faculty of Agriculture, Tabriz Univ., Tabriz, Iran

Safar Nasrollahzadeh
Assoc. Prof. of Eco-Physiology,
Faculty of Agriculture, Tabriz Univ., Tabriz, Iran

Abstract **– A split-plot experiment was conducted in randomized complete block design with four replication at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran in 2012 to evaluate the effect of different irrigation treatments and plant density on grain oil percentage, yield and grain yield of Dragon's head (Lallemantia iberica Fish. et Mey.). 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. Different planting densities were employed by changing planting distances on cultivation rows. Oil percentage increased with decrease in irrigation frequency, but grain yield decreased with drought severity. Oil percentage showed no response to planting density. Highest grain oil yield was achieved on I_2 treatment. Highest grain yield was achieved under I_1 treatment, but difference between I_1 and I_2 treatments was not significant. The greatest oil and 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 oil and grain production.**

Keywords **– Irrigation Interval, Oil Percentage, Oil Yield, Planting Density, Dragon's Head.**

I. INTRODUCTION

Plants are exposed to a multitude of natural biotic and abiotic stresses. Drought is a major abiotic stress that severely affects food production worldwide. About one third of the world lands are classified as arid and semi-arid region and aridity is the most common environmental stress and approximately includes 25% of the world land. Thus, irrigation plays a vital role in growth and yield of this crop in these regions [1]. In scheduling irrigation programs, methods based on pan evaporation have widespread usage due to their simple and easy application and low cost [2]. Moreover, Class-A pan is commonly used in agriculture due to the fact that it is the most suitable system for determining relationships among plant, water and climate [3]. Many researches were achieved about effects of water deficit stress and limitation of irrigation on phenologic, morphologic and physiologic traits [4, 5]. Many researchers believe that amount of crop water use determine plant growth and development. Meanwhile plants may injure under non optimal access of water at any stage [6]. Drought stress severely limits growth and development of plants by affecting different metabolic processes such as CO_2 assimilation, oil and protein synthesis [7]. Almost 90% of plant dry weight is resulted from CO_2 assimilation during photosynthesis [8]. The reduction of photosynthesis under drought stress is appeared to be associated with disturbance in biochemical reactions [9]. When stomata are closed due to drought or high temperature, the available CO_2 in intercellular space would be reduced, leading to reduced electron transport capacity and restricted assimilation potential [10]. [11] reported that irrigation not only increased the growth but also enhanced the efficiency of applied nutrients. Some evidences have indicated that stress during vegetative phase, flowering or seed filling period causes considerable decrease in yield and oil content of crops [12].[13]observed that canola yield in Montana increased with higher availability of water, but had a lower mean oil content. Under dry land conditions, [14] reported that severe drought decreased oil and increased protein content of rape seed. [15] observed water stress decreased oil yield of safflower. [16] showed that drought stress decreased oil percentage from 40 to 24% in sunflower.

Plant density is an important factor in determining the seed yield [17]. The optimization of this factor can lead to a higher yield in the crop by favorably affecting the absorption of nutrients and exposure of the plant to the light. 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. According to the results of study of [18], plantdensity no had significant effect on oil percent, but increase in density significantly increased oil yield. [19]showed that the maximum oil yield and oil percentage were obtained from the highest plant population. Increasing of oil percentage under higher plant population is related to lower husk percent.

Dragon's head (Lallemantia iberica Fish. et Mey.) is an annual herb that belongs to Lamiaceae family and spreads in southwestern Asia and Europe [20]. It grows well in arid zones and requires a light well-drained soil [21]. Dragon's head is a valuable species, i.e. all plant parts (leaves or seeds) can be economically used [22]. 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 [23].

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 [24]. 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. In this study, we investigated the response of Dragon's head oil yield to irrigation frequency and planting density.

II. Materials

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 $10^{\circ C}$, mean annual maximum temperature of $16.6^{\circ C}$ and mean annual minimum temperature of $4.2^{\circ C}$. 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. 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 determine of grain yield an area equal to 1 m^2 was harvested from middle part of each plot considering marginal effect. Harvested plants were dried in $25^{\circ C}$ and under shadow and air flow, and then grains were separated from their remains by threshing. Seed oil content was determined according to A.O.A.C. [25] using soxhlet apparatus and diethyl ether as a solvent. Oil yield were calculated via multiply oil percentage x grain yield.

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.

III. Results

Oil percentage

Plant density had no significant effect on the grain oil percentage, whereas grain oil percentage significantly affected by irrigation treatments (Table 1). Maximum oil percentage (30.63) was obtained from I_4 treatment, and the minimum (26.19) obtained from I_1 treatment, respectively (Fig. 1). Oil percentage was increased, as the severity of water deficit increased. In contrast, the oil percentage of grains increased by increasing water limitation. Similar results were reported for (Nigella sativa L.) [26], rosemary [27]and Calendula [28]. Also, [18] in safflower and [29] in pumpkin showed that the increase in plant density had no significant effect on grain oil percentage, which confirms the results of the currentstudy. However, [30] and [31] reported the increase in grain oil percentage at lower and upper densities respectively.

Grain yield

Irrigation regime and plant density have significant effects ($P \leq 0.01$) on the grain yield of Dragon's head (Table 1). Means comparison indicated that the maximum grain yield (158.1 g/m^2) produced by I_1 followed by I_2 (irrigation at 70 and 100 mm evaporation from class A pan, respectively) (Fig. 2), but difference between I_1 and I_2 treatments was not significant. The minimum yield (50.1 g/m^2) caused by I_5 treatment (irrigation at 190 mm evaporation from class A pan) (Fig. 4). The lowest yield of seed (101.5 g/m^2) was obtained from D_1 (200 plant/m^2), increased by increasing plant density and gave a maximum value (123 g/m^2) at D_3 (400 plant/m^2). After that, dense planting (500 plant/m^2) led to decreased yield because of competition (Fig. 3).

Previous results clearly indicated that any change in the amount of irrigation water in optimum condition reduces the yield of MatricariarecutitaL. andFumariapurpurea [32]. Water deficit reduces plant photosynthesis by closing stomata, decreasing leaf area, stomata gravity, chloroplast and protoplast hydration, and protein and chlorophyll synthesis. However, reducing of photosyntate transport accumulates the products in leaves results in diminution in photosynthesis, limiting growth and crop yield [7]. Optimum planting density is a key to achieve maximum crop production especially when water is a limiting factor. Yield reduction, however, reported by any changes in plant density compared with optimal one [33]. If plant density is too high, the decrease in the availability of water per plant generates a marked fall in yield per plant that is not offset by the increase in the number of plants [34].

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			
		Grain yield	Oil percentage	Oil yield	Harvest index
Block	3	15.339	1.448	1.689	0.141
Irrigation	4	34582.660**	45.98**	2277.748**	2.936
Error	12	45.683	1.135	4.126	2.044
Plant density	3	1552.410**	0.195	120.364**	81.928**
Interaction	12	34.703	0.126	2.622	0.683
Error	45	58.313	0.733	6.161	1.332

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

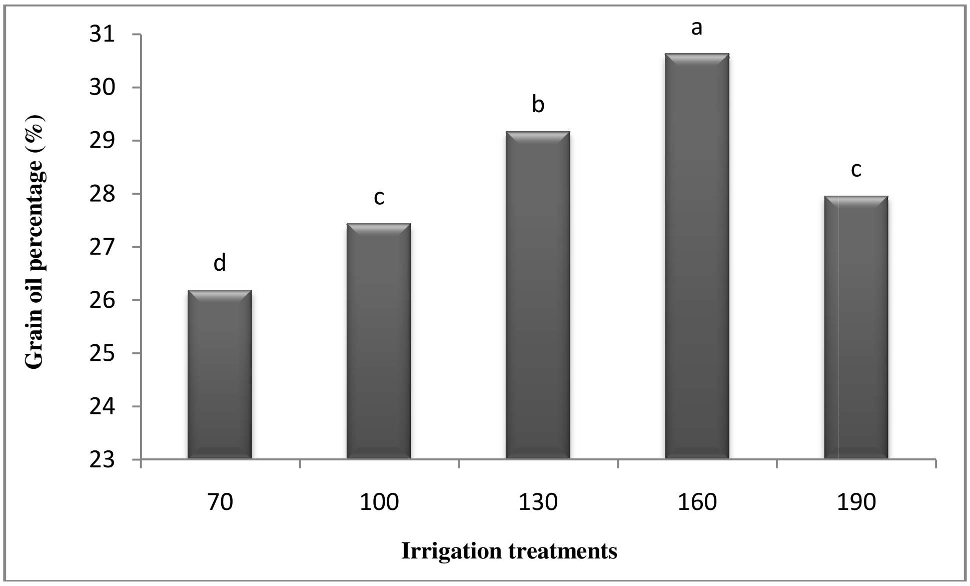

Fig.1. sEffect of different irrigation treatments (I_1, I_2, I_3, I_4 and I_5: irrigation after 70, 100, 130, 160 and 190 mm evaporation from class A pan, respectively) on grain oil percentage of Dragon's head (Different letters indicate significant difference at p≤ 0.05).

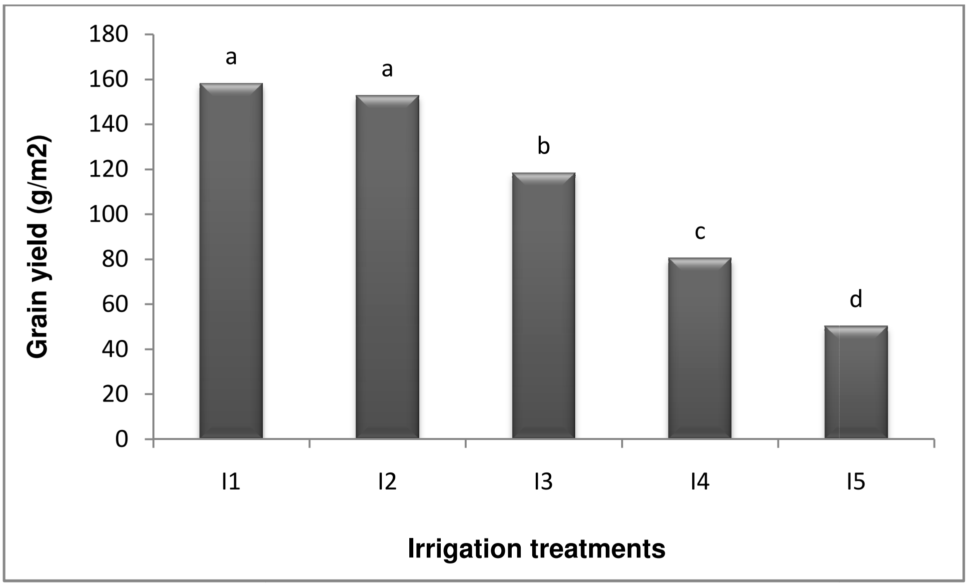

Fig.2. Effect of different irrigation treatments (I_1, I_2, I_3, I_4 and I_5: irrigation after 70, 100, 130, 160 and 190 mm evaporation from class A pan, respectively) on grain yield of Dragon's head (Different letters indicate significant difference at p≤ 0.05).

Oil yield

Analysis of variance of the data indicated that, the grain oil yield of Dragon's head was significantly affected by irrigation treatments and plant density (P<0.01), but interaction of irrigation and plant density was not significant for this trait (Table 1). Maximum oil yield (41.94 g/m^2) was obtained from I_2; Irrigation at 100 mm evaporation from class A pan, and the minimum oil yield (14.02 g/m^2) obtained from irrigation at 190 mm (I_5) evaporation from class A pan, respectively (Fig. 4). The maximum oil yield (34.32 g/m^2) obtained from D_3 (400 plant/m^2), decreased with any changes in density, so that the minimum one (28.39 g/m^2) was obtained from D_1 (200 plant/m^2) (Fig. 5).

An increase in oil yield was observed underI_2 treatment, but a decrease occurred with drought severity. Our results showed that grain yieldgradually decreased as irrigation limited more from I_1 to I_5, however grain oil percentage significantlyincreased in this condition.Given results can be said that decrease of oil yield in I_3 and I_4 treatments were due to decreasing of grain yield. Therefore irrigation after 100 mm evaporation from class A pan, is suitable irrigation treatment for having balance between oil percentage and grain yield that lead to the highest grain oil yield. There are various studies on the effects of irrigation intervals on production of grain oil in different crops. Severe drought stress reduced oil yield of safflower [15] compared to optimum irrigation condition. The reason for reduction of oil yield with increasing severe drought stress was reducing grain yield and oil percentage due to water deficit [35]. Similar results were reported for soybean [36] and sunflower [37].

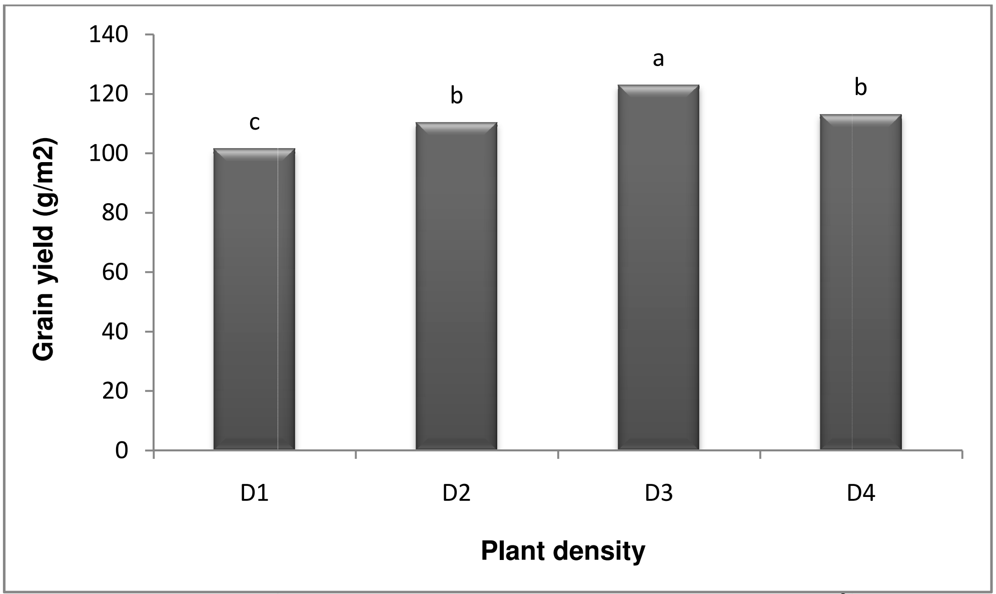

Fig.3. Effect of different plant density levels (D_1, D_2, D_3 and D_4: 200, 300, 400, 500 plant/ m^2) on grain yield of Dragon's head (Different letters indicate significant difference at $p\leq 0.05$).

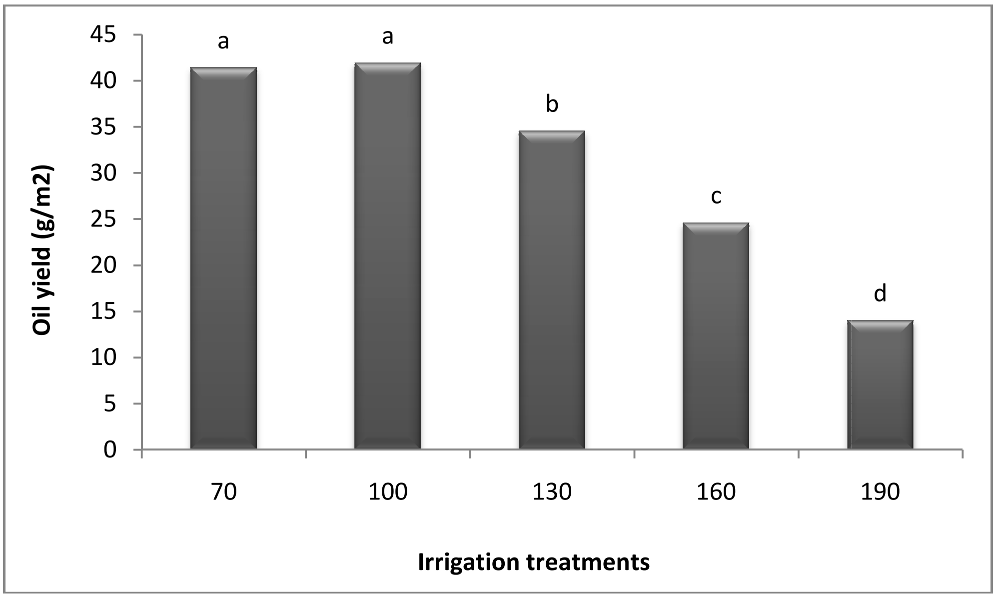

Fig.4. Effect of different irrigation treatments (I_1, I_2, I_3, I_4 and I_5: irrigation after 70, 100, 130, 160 and 190 mm evaporation from class A pan, respectively) on oil yield of Dragon's head (Different letters indicate significant difference at $p\leq 0.05$).

Optimum planting density is a key to achieve maximum crop production especially when water is a limiting factor. Our results showed that difference for grain yield was obtained at the planting density of D_3 (400 plants/m^2) compared to the three other planting densities (200, 300 and 500 plants/m^2), also different planting density did not show any effect on oil percentage, therefore the highest oil yield (34.32 g/m^2) was obtained at planting density of 400 plant/m2, while the lowest oil yield (28.39 g/m^2) was obtained at the planting density of 200 plant/m^2. [19] reported that increasing of oil yield at high densities due to the increase grain yield at optimum irrigation. Also [18] showed that the highest density with optimum irrigation condition is considerably better than other cases with respect to the oil yield production. Present result is in agreement with the investigation of [38] on Sunflowerand [29] on pumpkin.

Harvest index

Analysis of variance showed significant effects of plant density on the grain harvest index, but interaction of irrigation and plant density was not significant for this trait (Table 1). The maximum amount of harvest index (33.63 %) was obtained from D_3 treatment and increasing or decreasing the plant density, caused the reducing in the amount of harvest index (Fig. 6). Harvest index reduction, however, reported by any changes in plant density compared with optimal one [33, 39]. The highest harvest index in German chamomile was reported for optimal plant densities in different condition [40].

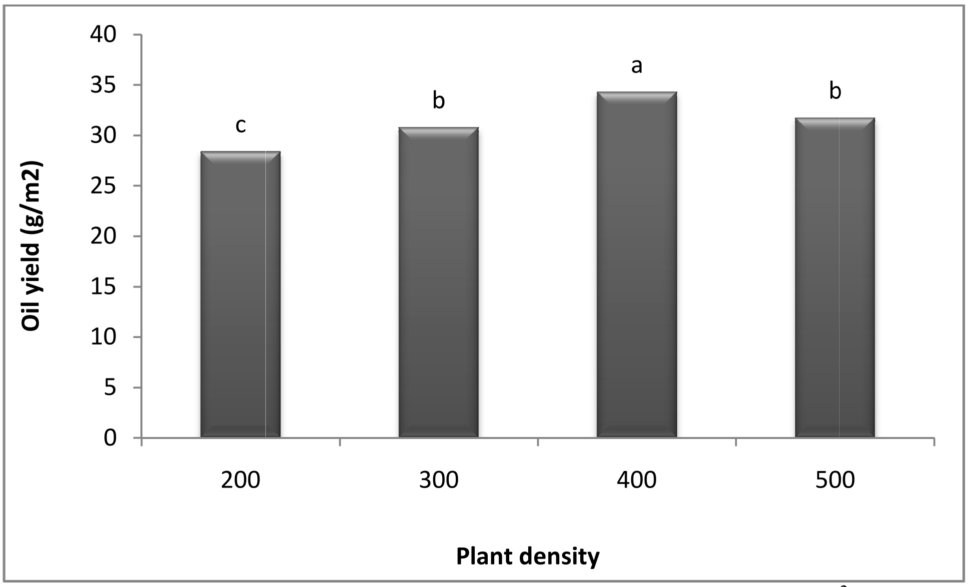

Fig.5. Effect of different plant density levels (D_1, D_2, D_3 and D_4: 200, 300, 400, 500 plant/ m^2) on oil yield of Dragon's head (Different letters indicate significant difference at $p \leq 0.05$).

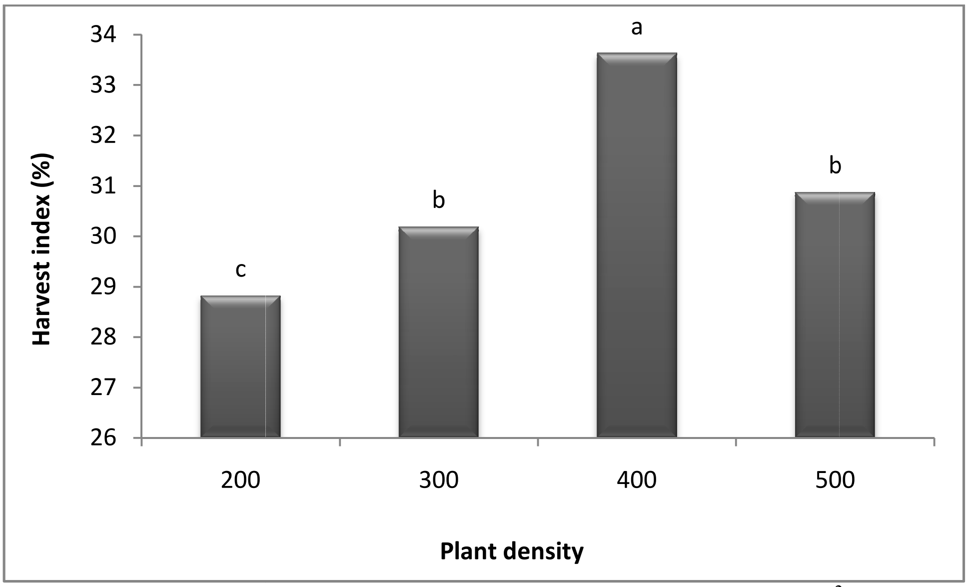

Fig.6. Effect of different plant density levels (D_1, D_2, D_3 and D_4: 200, 300, 400, 500 plant/ m^2) on grain harvest index of Dragon's head (Different letters indicate significant difference at $p \leq 0.05$).

IV. Conclusion

In the present investigation, there was not found statistically difference between irrigation after 70 mm evaporation and 100 mm evaporation in oil and grain yield, whereas highest oil yield was achieved on I_2 (irrigation after 100 mm evaporation from class A pan) treatment. 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/m^2 is most suitable for oil and grain yield of Dragon's head.

References

[1] D. Martin, J. Brocklin, and V. Wilmes, "Operating rules for deficit irrigation management", American Journal of Society of Agriculture, 1989, 22:1207-1215.

[2] G. S. Stanhill, "Is the Class-An evaporation pan still the most practical and accurate meteorological method for determining irrigation Water requirement", Journal of Agriculture and Meteorology 2002, 112:233- 236.

[3] U. Kennan, F. Killi, C. Gencoglan, and H. Merdun, "Effect of irrigation frequency and amount on water use efficiency and yield of sesame (Sesamumindicum) under field condition", Field Crops Research, 2007, 101:249-258.

[4] A. T. Goksoy, A. Demir, Z. Turan, and N. Dagustu, "Responses

of sunflower to full and limited irrigation at different growth stages", Filed Crops Research, 2004, 87: 167-178.

[5] P. S. Kiani, P. Hewezi, L. Gentzbittle, and A. Sarrafi, "Genetic variability for physiological traits under drouth conditions and differential expression of water stress –associated genes in sunflower (Helianthus annuus L.)", Theoretical and Applied Genetics, 2007, 114: 193-207.

[6] J. Daneshian, D. Zare, "Diversity for resistance drought on soybean", J. Agric. Sci. 2005, 1: 23-50.

[7] M. Nasirkhan, H. Siddiqui, M. Masroor, A. Khan, and M. Naeem, "Salinity induced changes in growth, enzyme activities, photosynthesis, proline accumulation and yield in linseed genotypes", World J. Agric. Sci. 2007, 3:685-695.

[8] M. Makhdum, M. Malik, S. Din, F. Ahmad, and F. Chaudhry, "Physiological response of cotton to methanol foliar application", J. Res. Sci. 2002, 13:37-43.

[9] T. Graan, T and J. Boyer, "Very high CO2 partially restores photosynthesis in sunflower at low water potentials", Plant, 1990, 181:378-384.

[10] J. Liang, J. Zhang, and M. Woog, "Can stomata closure caused by xylem ABA explain the inhibition of leaf photosynthesis under soil drying", Photosynthesis Res. 1997, 51:149-159.

[11] O. Sharma, A. Kumar, Fertilizer News, 1992, 37: 37-41.

[12] H. Razi, and M. Asad, Agricultural and Natural Resources Sciences, 1998, 2: 31-43.

[13] J. Smis, D. J. Solum, D. M. Wichman, G. D. Kushnk, and L. E. Welty, Montana Agro. Res., 1993, 10: 15- 20.

[14] J. Henry, and K. B. MacDonald, Can. J. Soil Sci.,1978, 58:303-310.

[15] M. Naderi, G. Nour-mohammadi, I. F. Majidi, Darvish, A.H. Shirani-rad and H. Madani, Evolution of summer safflower reaction to different intensities of drought stress at Isfahan region. J. Agronomy Sciences of Iran. 2005, 7(3):212-225.

[16] L. R. Stone, D. E, Goodrum, M. N. Jaffar, and A. H. Khan, "Rooting front and water depletion Depths in grain sorghum and sunflower", Agron. J., 2001, pp: 1105-1110.

[17] M. Long, B. Field, W. Diepenbrock, "Effects of plant density, row spacing and row orientation on yield and achene quality in rain fed sunflower",ActaAgronomicaHungarica 2001, 494:397-407.

[18] S. Ghasemi, M. Bohrani, M. Kheradnam, S. Motalebipour, "Effect of row and plant spacing on yield and yield components of two spring cultivars of safflower", Iran J of Agri Sci., Agri, P Bree and Biotech. 2006, 1-37(3): 585-591.

[19] S. Rahbar, S. Mohammadi, L. Hoshmand, and T. Shams, "Evaluation of effect of plant density on yield and yield components of three var. sunflower", The 10 Congress Agronomy and Breeding of Iran. Karaj. 19-20 Jul. 2008, pp: 246.

[20] B. Ursu, and I. Borcean, "Researches concerning the sowing technology at Lallemantia iberica F. ET M", Research Journal of Agricultural Science, 2012, 44(1):168-171.

[21] V. Ion, A. Basa, D. Sandoiu, and M. Obrisca, "Results regarding biological characteristics of the species Lallemantia iberica in the specific conditions from south Romania", UASVM Bucharest, Series A, Vol. LIV, 2011, 275-280.

[22] U. Hedrick, "Sturtevant's Edible Plants of the World", Dover Publications, 1972, New York.

[23] A. Naghibi, "Seed oil rich in linolenic acid as renewable feed stock for environment friendly cross linkers in powder coating", Industrial Crops and Products, 1999, 11: 157- 165.

[24] C. R. Wang, X. H. Tian, "Effects of plastic sheet-mulching on ridge for rainwater harvesting cultivation on WUE and yield of winter wheat", Sci. Agric. Sin. 2004, 37, 208–214.

[25] A.O.A.C. Assoc. Office. "Agri. Chemists, Official methods of analysis", Editor Hormitz, W. 10th edition, Washington DC, USA, 1990, pp: 129.

[26] F. Mozzafari, S. Ghorbanli, M. Babaie, and A. Farzami, The effect of water stress on the seed oil of (Nigella sativa L.). Journal of Essential oil research, 2000, 12: 36-38.

[27] M. Singh, and S. Ramesh, "Effect of irrigation and nitrogen on herbage oil yield and water use efficiency in rosemary grown under semi-arid tropical conditions", Journal of Mediterranean Aromatic Plant, 2000, 22: 659-662.

[28] K. Shubhra, J. Dayal, C. Goswami, and R. Munjal, "Effects of water deficit on oil of Calendula aerial Parts", Biologiaplantrum, 2004, 48(3):445-448.

[29] S. Babayee, J. Daneshian, and S. Valadabadi, "Effect of plant density and irrigation interval on some grain characteristics of pumpkin (Cucurbitapepo L.)" International Journal of Agriculture and Crop Sciences, 2012, 4 (8), 439-442.

[30] H. Aliyari, F. Shekari, and F. Shekari, "Oily Seeds, Agronomy and Physiology", Tabriz. Publications of Abdi Tabriz, 2000, pp: 182

[31] E. H. Roberts, "Quantifying seed deterioration ln: M. B. Mcdonald, J. r. and C. J. Nelcon (eds), Physiology of seed deterioration", Cssa special publication, Madison, Wl, U. S. A, 1998, pp: 101-123.

[32] R. Omidbaigi, "Effect of environmental factors on growth, yield and active substances of some medicinal plants, Doctoral thesis", Hungarian Academy of Sciences, Budapest.

[33] J. Lioveras, J. Manent, J. Vioudas, A. Lopez and P. Santiveri, "Seeding rate influence on yield and yield components of irrigated winter wheat in a Mediterranean climate", Agron J 2004, 96:1258-1265.

[34] C. Vega, F. Andrade, V. Sadras, S. Uhart, O. R. Valentinuz, "Seed number as a function of growth", A comparative study in soybean, sunflower and maize. Crop Sci. 2001, 41:748–754.

[35] M. Roshdi, H. Heydari, M. Sharifabad, G. H. Karimi, G. Nourmohammadi, and F. Darvish, A "Survey on the impact of water deficiency over the yield of sunflower seed cultivar and its components", J. Agri. Sci., 2006, 12(1): 109-121.

[36] E. Cober, and H. D. Voldeng, "Developing high-protein, high-yield soybean population and lines", Crop Sci. 2000, 40:39-42.

[37] M. Rinaldi, "Application of EPIC model for irrigation scheduling of sunflower in Southern Italy", Agric. Water Manage. 2001, 49:185–196.

[38] E. Gholinezhad, A. Aynaband, A. Hassanzade, G. Noormohamadi, and I. Bernousi, "Effect of Drought Stress on Grain Yield, Quality Traits, Phyllochron and Leaf Appearance Rate of Sunflower Hybrid Iroflor at Different Levels of Nitrogen and Plant Population", American-Eurasian J. Agric. & Environ. Sci., 2012, 12 (3): 306-314.

[39] J. Douglas, J. M. Follett, M. Douglas, and A. Heaney, "The effect of plant density on the production of valerian root", ActaHort, 1996, 426:375-379.

[40] T. Wagner, "Chamomile production in Slovenia", ActaHort 1993, 344: 476-478.