Journal of Plant Process and Function, Vol. 9, No. 40, Year 2021

Research Article

The effect of different irrigation intervals and fertilizers on Common purslane (*Portulaca oleracea* L.)

Ali Esmaeilzadeh, Ahmad Koochekzadeh*, Seyed Ataollah Siadat, Amin Lotfi Jalal Abadi, Abdolreza Siyahpoosh

Department of Plant Production and Genetics, Faculty of Agriculture, Khuzestan Agricultural Sciences and Natural Resources University of Khuzestan

(Received: 11/03/2020 Accepted: 21/12/2020)

Abstract

Common purslane is a warm season plant which has a lot of medicinal properties. An experiment was conducted as a split plot design arranged in completely randomized block design with three replications in the research field of Agricultural Sciences and Natural Resources University of Khuzestan during 2015-2016. In this experiment, the main plots consisted of four levels of irrigation intervals (5, 10, 15 and 20 days), and the sub-plots included four different types of fertilizers (no fertilizer, chemical fertilizer, chicken manure, and cow manure). The results indicated that five-day irrigation interval exhibited the best results for the most of the traits. Among different types of fertilizers, chemical fertilizer and chicken manure had relatively the highest dry weight of plant, stem, leaf, stem length, number of sub-stems and leaf protein content. The results of this study revealed that in semi arid region such as Khuzestan with low rainfall, the 10-day irrigation interval could be an appropriate alternative for 5-day irrigation interval. Chicken manure not only provided the highest yield, but also it reduced the amount of chemical fertilizer inputs to the purslane farms. In addition to an acceptable yield, it can be a great step towards environmental health and, finally sustainable agriculture through reducing application of chemical fertilizers.

Keywords: Chemical fertilizer, Chicken manure, Cow manure, Irrigation, Leaf protein, Sustainable agriculture

Introduction

Common purslane (*Portulaca oleracea* L.) is a warm season plant which has a lot of medicinal properties. (Samy *et al*., 2009). This plant is a great source of antioxidants such as vitamins A, C and E and beta-carotene, and has the ability to neutralize free radicals and can prevent cardiovascular disease, cancer and infectious diseases. The stems of this plant are rich in omega-3 fatty acids, ascorbic acid, beta-carotene, and glutathione (Liu *et al*., 2000).

Khuzestan is considered as one of the most important agricultural production regions in Iran, which, with its special climatic conditions always has desirable conditions for occurrence of destructive environmental and water stress. The distribution pattern of rainfall in Khuzestan Province shows that water stress and drought stress are most often observed after the hot seasons. Fallah and Soltaninejhad (2014) reported that elevated levels of water stress reduced Common purslane stem and shoot dry weight. Mirtaheri *et al*. (2010) reported that wheat yield will be reduced due to water stress caused by diminished number of tillers, number of grains, and grain weight. Kabiri *et al*. (2014) in a study on *Nigella sativa* concluded that drought stress significantly reduced shoot dry weight, leaf relative water content, and photosynthetic pigments, but increased the activity of antioxidant enzymes and membrane electrolyte leakage. In order to reduce the effects of drought stress, maintaining soil moisture at optimal level, applying proper management and advanced techniques are among effective measures to increase irrigation efficiency and, as a result, improve the utilization of limited water resources. Deficit-irrigation is a desired method for production under drought conditions. In this method, the plant yield is deliberately reduced. However, reducing water usage in the production of crops has a negative impact on the plant yield (English and James, 1990). Oktem *et al*. (2003) also applied different irrigation intervals (2, 4, 6 and 8 days) and adjusted the amount of water consumed based on 70, 80, 90 and 100% evaporation of class A pan. They observed the maximum water use efficiency at 4-day irrigation interval, where the amount of water consumed was 90% evaporation from the pan. Therefore, the need to pay more attention to deficit-irrigation as an appropriate solution to reduce the effect of water shortage in this province seems to be crucial. In this regard, with proper usage, the area under cultivation can be developed and irrigation water can be saved.

*Corresponding Author, Email: koochekzadeh@asnrukh.ac.ir

In addition to optimizing irrigation intervals, the adoption of proper management method that balance the condition of water shortage to some extent in favor of the plant yield and neutralize the damaging impact of drought can be effective for producing an acceptable product under water shortage conditions. In this regard, organic fertilizers can be used not only to meet the nutritional requirements of the plant, but also to improve the physical structures of the soil in terms of moisture preservation during drought and lack of rainfall. Organic materials can store water several times as much as mineral particles (Parvizi and Nabati, 2004).

Simultaneously, studying the effect of drought stress and biological fertilizers on Common purslane, Inanloofar *et al*. (2013) stated that water stress reduced the quantitative yield and content of seed oil of common purslane, but combined application of biological fertilizer and nitrogen treatment increased common purslane quantitative and qualitative yield under water stress conditions. During his study, Ahmadian *et al*. (2009) investigated the effects of four irrigation intervals and two treatments involving use and non-use of manure on *Cuminum cyminum*. They reported that low irrigation reduced the number of umbels per plant, number of seeds per plant, 1000 seed weight and biological functions of straw and seed significantly. However, if the animal manure is used, irrigation intervals can be reduced and a proper yield can be obtained. On the other hand, study of *Salvia officinal* is affected by water stress reduced the plant height and leaf area, with dry weight loss also being observed in the plant shoot (Bettaieb *et al*., 2009).

Given that the effect of animal fertilizers on reducing the amount of water consumed by Common purslane has not been studied yet, this study examined the effects of animal and chemical fertilizers on the medicinal plant Common purslane at different irrigation intervals. Also, for environmental preservation and sustainable agriculture, the use of animal fertilizers instead of chemical fertilizers is evaluated.

Materials and methods: In order to study the effects of irrigation intervals and different types of fertilizers on qualitative and quantitative traits of Common purslane, this experiment was conducted in the research field of Agricultural Sciences and Natural Resources University of Khuzestan, located 36 kilometers north of Ahwaz in Iran, during 2015-2016. This study was conducted as a split plot in a completely randomized block design with three replications. According to the long-term meteorological data, Ahwaz has an average annual rainfall of 269 mm, average temperature of 23°C and average maximum and minimum temperatures of 36 and 9.5 °C, respectively. According to Advanced Meteorological Classification System, it is an arid and semi-arid region. In order to study the physical and chemical properties of the studied field soil, combined soil samples were prepared before planting, and the samples' physical and chemical properties were evaluated, with their results presented in Table 1. According to the soil triangle, the soil texture was silty clay. In addition, the studied field was fallowed in the previous cropping year.

In this experiment, the main plots consisted of four levels of irrigation intervals: 1) 5-day irrigation interval (control), 2) 10-day irrigation interval, 3) 15-day irrigation interval, and 4) 20-day irrigation interval. There were also different fertilizer types at four levels: 1) no fertilizer; 2) chemical fertilizer (Triple super phosphate 150 kg / ha mixed with soil before cultivation and urea, 200 kg / ha as 1/2 base and the second part, 20 days after emergence); 3) chicken manure system (8 tons / ha) mixed with soil before cultivation; and 4) cow manure system (20 tons per hectare) mixed with soil before cultivation in sub-plots. Irrigation interval treatment was applied three weeks after planting. In this experiment, the local population of Khuzestan was used as the studied seed at a depth of 0.5 cm and density of 300 plants / m². Each sub-plot included 8 planting lines of 2 meters in length, with lines spaced 30 cm, where the spacing between sub-plots was 1 m and 1.5 m between the main plots. Table 2 shows some chemical properties of organic fertilizers used in this experiment. The planting was done on May 1. For weed control, one month before planting, the land was irrigated, and once the weeds emerged they were taken with a disk under the soil. In addition, weeds were controlled manually in the plots, but the weeds between the plots were chemically controlled.

At the time of 25% flowering, above ground biomass was harvested at the height of 7 cm manually. Biological yield (biomass) in each plot was weighed and packaged in the field. During sampling and harvesting, we also considered 0.2 m from each side of the length of the yield lines (the fourth and fifth lines) as lateral margins. Then, the plant dry weight, stem dry weight, leaf dry weight, stem length, number of sub-stems and leaf protein content were measured. In order to measure the water use efficiency, water pump and meter were used and the volume of water input in each plot was calculated. Water use efficiency was also calculated for biomass production in kilograms per cubic meter via dividing the biological yield by water consumed. In order to measure the shoot protein content, Kjeldahl method (Bremner, 1996) was used.

The results were analyzed using SAS 9.1 and MSTATC softwares. In order to compare the means, LSD test was used at a probability level of 5% error.

Results and discussion

Stem height: The results of the analysis of variance (Table 3) indicated that the effect of fertilizer and irrigation on the plant height was significant, but the interaction between these two factors on this trait was not significant. The mean comparison (Table 4) revealed that with prolongation of irrigation intervals, the plant height shrank significantly, such that the maximum plant height (16.56 cm) was related to 5-day irrigation, while the lowest plant height was related to

Table 1. Physical and chemical properties of farm soil

properties of soil	Soil depth (centimeters)
	0-30
Salinity (dS.m-1)	7.46
pH	7.73
Total N (%)	0.07
Phosphorus (mg.kg-1)	7.1
Potassium (mg.kg-1)	242
Organic carbon (%)	0.89
Soil mineral parts	
Clay (%)	40.2
Silt (%)	36
Sand (%)	23.8

Table 2. some chemical properties of organic fertilizers used

Zn	Cu	Fe	OC	K	P	N	PH	Fertilizer
mgr/kgr			(%)					
54	4	1611	61	0.91	1.03	2.5	7.72	Cow manure
298	36	955	36	0.88	1.5	3.2	5.12	Chicken manure

Table 3. Analysis of variance of some phenological and yield traits of common purslane

	Df	mean of squares					
		Stem height	Stem diameter	The number of sub-stems	Dry weight of leaf	Dry weight of stem	Dry weight of shoot
Replication (r)	2	2.88 ^{ns}	0.03^{ns}	0.0002^{ns}	1870.02^{ns}	199143.83**	365607.63**
Irrigation interval(i)	3	58.10**	0.50^{ns}	1.09**	175436.92**	990843.25**	1467033.64**
Error a	6	2.49	0.49	0.002	14901.39	8028.75	21983.14
Fertilizer (s)	3	174.72**	2.19**	2.38**	1025594.82**	6700079.17**	12359508.50**
Interaction (s×i)	9	3.82 ^{ns}	0.11^{ns}	0.15**	29995.46^{ns}	106061.69^{ns}	138265.81^{ns}
Error b	24	4.54	0.39	0.012	13860.50	49011.57	91965.75
C.V. (%)	-	15.38	16.70	22.14	8.52	16.49	11.24

*** and ** are significant at a probability level of 5% and 1%, ns: non significan**

Table 4. Mean comparison of forage yield components of common purslane

treatment	Stem height (cm)	Stem diameter (mm)	The number of sub-stems per plant	Dry weight of leaf	Dry weight of stem	Dry weight of shoot
				(kg/ha)		
Irrigation interval(i)						
i1	16.56^{a}	3.90^{a}	0.79^{a}	1536.40^{a}	1673.85^{a}	3017.35^{a}
i2	14.21^{b}	3.62^{a}	0.69^{b}	1385.17^{b}	1475.24^{b}	2949.39^{a}
i3	13.46^{b}	3.88^{a}	0.38^{c}	1366.06^{b}	1192.43^{c}	2558.50^{b}
i4	11.22^{c}	3.48^{a}	0.13^{d}	1241.45^{c}	1029.80^{d}	2271.25^{c}
Fertilizer(s)						
s1	10.18^{b}	3.29^{b}	0.25^{d}	1174.72^{b}	709.40^{b}	1888.5^{b}
s2	17.62^{a}	4.17^{a}	1.06^{a}	1637.55^{a}	2040.66^{a}	3603.2^{a}
s3	16.66^{a}	3.10^{c}	0.63^{b}	1629.52^{a}	1937.03^{a}	3549.9^{d}
s4	10.99^{b}	3.43^{b}	0.15^{d}	1087.28^{b}	684.23^{b}	1754.8^{b}

The same letters in a column indicate no significant difference at the 5% probability level (Duncan test)
i1, i2, i3 and i4: 5, 10, 15 and 20 day irrigation interval, respectively
s1, s2, s3 and s4: no fertilizer (control), chemical fertilizer, chicken manure and cow manure, respectively

20-day irrigation interval. Various researchers have reported that reduction of plant height with reducing water consumption and water shortage severity is due to high sensitivity of processes associated with the division and growth of cells to water stress (Inanloofar *et al.*, 2013). Due to water deficit, the water potential of tissues is reduced and Turgor pressure falls to a level lower than the amount required for cell growth and development, thereby affecting the growth and division of cells. It has been reported that decline in available water to plant leads to higher concentration of Abscisic acid and decrease the Cytokinins movement from root to shoot. This may reduce cell growth and cell wall flexibility (Rahbarian and Afsharmanesh, 2011).

The highest plant height was related to chemical fertilizer (s_2) and chicken manure (s_3), while the lowest was associated with no fertilizer (s_1) and cow manure (s_4) treatments. These two types of fertilizers (chemical fertilizer and chicken manure) had the highest plant height with a mean of 17.61 and 16.65 cm, respectively, where no significant difference was observed. The chemical fertilizer demonstrated that this effect was due to the rapid absorption. Also, chicken manure showed this impact was related to higher temperatures and severe microbial decomposition as well as rapid material release. The mean comparison showed that no-fertilizer and cow manure treatments had the lowest plant height. These results were expectable due to the lack of nutrients in the no-fertilizer treatment and slow process of matter release by cow manure (Abbasi *et al*., 2013).

Stem diameter: Analysis of variance (Table 3) revealed that only the effect of fertilizer on the stem diameter was significant, while irrigation and interaction did not have any significant effect on the stem diameter. Due to fast release of nutrients and fast acting, the chemical fertilizer was able to produce the greatest effect on the diameter of the stem. Also, with a mean diameter of 4.17 mm, the thickest stems were formed in the fertilizer treatments. In this regard, chicken manure did not show any significant difference, but the lowest stem diameter was related to two other fertilizer treatments i.e. cow manure and no fertilizer (Table 4). Abbasi *et al*. (2013) also reported similar results.

The number of sub-stems: The effect of fertilizer, irrigation and interaction between these two factors on the number of sub-stems was significant (Table 3). The mean comparison of the main effect of fertilizer treatment on this trait showed that chemical fertilizer had the highest sub-stems while the non-fertilized treatment presented the lowest sub-stems with no significant difference with cow manure (Table 4). Increasing the photosynthetic green surface in response to the consumption of chemical fertilizers and nutrients at a balanced level would increase the production and transfer of photosynthetic matter and stimulation of growth hormones to terminal and lateral meristems. Hence, the set of these factors augmented the stimulation of the terminal and lateral meristems and production of sub-stems (Hassani Malayeri *et al*., 2004).

The mean comparison of interactions (Table 5) revealed that 5-day irrigation interval and chemical fertilizer produced the highest number of sub-stems which decreased with prolonging the irrigation intervals. We had the lowest number of sub-stems in 20-day irrigation interval with no fertilizer and cow manure. Also, the mean comparison of interactions (Table 5) suggests that with prolongation of irrigation intervals, the positive effect of the chemical fertilizer was attenuated. In this regard, 20-day irrigation interval compared to 5-day irrigation interval showed a reduction in the number of sub-stem by 81%. Increased irrigation intervals and reduced water consumption would reduce the production of photosynthetic matter and thus reduce the number of sub-stems in the plant. Ghobadi *et al*. (2006) also indicated that with intensification of water stress and reduction of the amount of water consumed, the number of sub-stems dropped in *Brassica napus* significantly. It should be noted that high stems under water stress conditions is an undesired trait for the plant, as it causes excessive use and loss of soil moisture.

Dry weight of leaf, stem, and shoot: The effect of fertilizer type and irrigation interval on the leaf dry weight was significant, whereas the interaction between the two factors on the above trait was not significant (Table 3). The leaf dry weight declined with prolonging the irrigation intervals (Table 4). In this regard, one of the main effects of water on plants is the regulation of the pressure of the cell's inflammation. Accordingly, during high irrigation intervals due to reduced water available to the plant, the amount of the cell's inflammation diminished, thereby reducing the growth and development of the plant cells as well as fresh and dry weight of the leaf (Moeini Alishah *et al*., 2006). It can be concluded that reducing the leaf dry weight under the conditions of this experiment was the result of lowering the number of sub-stems per plant, which was followed by a reduction in the leaf dry weight (Table 4).

Chicken manure and chemical fertilizer treatments produced the highest fresh and dry weight of leaf (Table 4). Because of the suitability of air temperature and activity of bacteria as well as the rapid release of the nutrients by these two fertilizer treatments, the plant dry weight grew (Channabasanagowda *et al*., 2008). However, cow manure due to slow release of nutrients (Manna *et al*., 2007) and no-fertilizer treatment was not able to provide plant nutritional requirements well, with the lowest leaf dry weight obtained from these two treatments.

The length, diameter, and weight of the stem as an active and strong reservoir for the storage and accumulation of carbohydrates vary depending on environmental and climatic conditions. In this experiment, it was found that the effect of all experimental factors except the interaction between the two factors was significant on the stem dry weight (Table 3). According to the mean comparison table of irrigation effect on the stem dry weight (Table 4), it can be concluded that with prolongation of irrigation intervals and curtailing the amount of water consumed, the stem dry weight diminished. It seems that with increasing irrigation intervals and reducing the amount of water available to the plant, the extent of absorption of nutrients and production diminished. This phenomenon has the potential to decrease photosynthesis and production of assimilates, stem length and diameter (Table 4) and consequently stem weight (Shokhmgar *et al*., 2013). Also, the mean comparison (Table 4) revealed that the chemical fertilizer produced the highest dry weight of the stem, while the two treatments of no-fertilizer and cow manure were at the lowest level. Nevertheless, the study of this table suggests that chicken manure was to some extent similar to chemical fertilizer in terms of this trait. In the production of stems, we should consider the plant diameter and height. In this regard, it should be

Table 5. Comparison of the effects of irrigation intervals and different fertilizer on number of stems per plant, leaf to stem ratio and water use efficiency

characteristics / treatment	The number of sub-stems per plant	Leaf to stem ratio	water use efficiency (kg/m3)
i1s1	0.50^{e}	1.44^{d}	0.44^{f}
i1s2	1.60^{a}	0.60^{f}	0.88^{d}
i1s3	1.00^{c}	0.72^{ef}	0.81^{de}
i1s4	0.07^{gh}	1.32^{d}	0.37^{f}
i2s1	0.50^{e}	1.45^{d}	0.69^{e}
i2s2	1.33^{b}	0.87^{ef}	1.29^{c}
i2s3	0.80^{d}	0.93^{e}	1.38^{bc}
i2s4	0.13^{fgh}	1.42^{d}	0.71^{e}
i3s1	0.01^{h}	1.92^{bc}	0.92^{d}
i3s2	1.00^{c}	0.97^{e}	1.76^{a}
i3s3	0.503	0.84^{ef}	1.75^{a}
i3s4	0.01^{h}	2.19^{ab}	0.77^{de}
i4s1	0.01^{h}	2.31^{a}	0.83^{de}
i4s2	0.30^{f}	0.91^{e}	1.50^{b}
i4s3	0.23^{f}	0.97^{e}	1.52^{b}
i4s4	0.01^{h}	1.89^{c}	0.79^{de}

The same letters in a column indicate no significant difference at the 5% probability level (Duncan test)
i1, i2, i3 and i4: 5, 10, 15 and 20 day irrigation interval, respectively
s1, s2, s3 and s4: no fertilizer (control), chemical fertilizer, chicken manure and cow manure, respectively

noted that any factor that can reduce these two traits leads to a reduction in the stem dry weight. The results of this study suggest that changes in the plant diameter and height are in line with the changes in the stem dry weight to some extent. Furthermore, the stress conditions affect the metabolic processes of the plant, including the absorption of nutrients, photosynthetic activity rate, and accumulation of assimilates, possibly decreasing the growth of the stem in terms of length, diameter and weight. However, application of appropriate nutritional methods such as chemical fertilizer or chicken manure can optimally reduce the negative impact of water stress and prevent the severe drop in the product (Shokhmgar *et al*., 2013).

In this study, it was also found that the effect of irrigation treatment and fertilizer type on shoot dry weight was significant at the probability level of 1% error (Table 3). However, the interaction between the two factors on this trait was not significant. The shoot dry weight is obtained from the total dry weight of the leaf and stem. Accordingly, this trait has a process similar to the stem and leaf dry weight. As mentioned for the leaf and stem dry weight, typically in most cases reduced water consumption caused diminished leaf and stem dry weight and, consequently, shoot weight, as well as 5- and 10-day irrigation treatments were able to yield the highest weight, but 20-day irrigation treatment presented the lowest degree of these traits (Table 4). Meanwhile, various studies have indicated that diminished water consumption increased the stress conditions. Also, the occurrence of drought with reduced plant metabolic and photosynthesis activities resulted in curtailed plant growth and production (Shokhmgar *et al*., 2013; Inanloofar *et al*., 2013).

As suggested by the results, chemical fertilizer and chicken manure treatments were also able to augment plant production and yield with regard to the rapid release of nutrients, providing the plant with required nutrients, and the increase in soil micro-organic activity through enhancing the leaf and stem weight as well as increasing the number of sub-stems along with development of stems and leaves and photosynthetic levels of the plant. Parvizi and Nabati (2004) reported similar results in their studies.

Leaf-to-stem ratio: The leaf-to-stem ratio is considered as one of the most important qualitative traits of forage plants and plants whose green part is consumed. The results of analysis of variance revealed that the effects of irrigation, fertilizer treatments and two factors' interaction were significant on leaf to stem ratio (Table 6). Further, 20-day irrigation produced the highest ratio, while it decreased with increasing water usage and approaching irrigation intervals. According to the results of this study, it can be concluded that with more water consumption, the number of leaves and stems increases due to the increase in the length and diameter of the stem and sub-stems. However, this increase occurs at a higher rate in the stem, i.e. under 5-day irrigation conditions, the plant tends to produce more stems (Table 7). The mean comparison table indicated that with improving the nutritional conditions of the plant using chemical fertilizer and chicken manure, the stem size of the plant also increased further while the leaf-to-stem ratio shrank, where this increase in the stem and leaf is due to improved plant growth conditions. Akbari *et al*. (2011) also reported similar results.

Table 4 presents the mean comparison of interactions between treatments, where the highest leaf-to-stem ratio was observed in 20 and 15-day irrigation, no fertilizer, and cow manure treatments. According to these results, the reason can be attributed to enlarged size of the stem due to use of water and nutrients.

Water use efficiency: The results of analysis of

Table 6. Analysis of variance for leaf to stem ratio, water use efficiency and stem and leaf protein percentage of common purslane

Source of variation	Df	mean of squares			
		Leaf to stem ratio	Water use efficiency	Stem protein content	Leaf protein content
Replication (r)	2	0.04*	0.048**	4.16*	0.81*
Irrigation interval(i)	3	0.71**	1.02**	3.72*	2.23**
Error a	6	0.02	0.003	1.30	0.874
Fertilizer (s)	3	3.19**	1.79**	0.21ns	8.38*
Interaction (s×i)	9	0.15**	0.041**	0.32	2.80ns
Error b	24	0.03	0.01	0.38	2.69
C.V. (%)	-	13.81	10.38	11.53	16.11

*** and ** are significant at a probability level of 5% and 1%, ns: non significant**

Table 7. Mean comparison of irrigation intervals and fertilizer types on some traits of common purslane

treatment	Leaf to stem ratio	Water use efficiency	stem protein content	Leaf protein content
Irrigation interval (i)				
i1	1.018b	0.63d	4.76b	9.75b
i2	1.168b	1.02c	5.07ab	10.28ab
i3	1.480a	1.30a	5.68ab	10.74a
i4	1.520a	1.16b	5.98a	9.96ab
Fertilizer (s)				
s1	1.780a	0.72b	5.32a	9.48b
s2	0.840b	1.36a	5.22a	10.84ab
s3	0.860b	1.63a	5.43a	10.97a
s4	1.71a	0.66b	5.52a	9.44b

The same letters in a column indicate no significant difference at the 5% probability level (Duncan test)
i1, i2, i3 and i4: 5, 10, 15 and 20 day irrigation interval, respectively
s1, s2, s3 and s4: no fertilizer (control), chemical fertilizer, chicken manure and cow manure, respectively

variance of experimental factors on water use efficiency showed that the effects of all factors on this trait were significant (Table 6). Table 6 reveals that the 15-day irrigation treatment had the highest water use efficiency with a mean of 1.30 kg/m³. Among fertilizer treatments, chemical fertilizer offered the highest water use efficiency (Table 7). In an experiment, Parvizi and Nabati (2004) stated that improved nutritional conditions, especially with increasing fertilizers, improved the plant growth conditions and enhanced production per unit water consumption, which in turn augmented the water use efficiency. Meanwhile, no significant difference was observed between chemical fertilizer and chicken manure, which may be attributed to the desired nutritional and biological conditions of chicken manure compared to the chemical fertilizer. Study of the mean comparison table of interactions (Table 5) indicates that chemical fertilizer and chicken manure treatments generated the highest water use efficiency in 15-day irrigation interval with a mean of 1.76 and 1.74 kg/m³, respectively. However, 5-day irrigation interval in no-fertilizer and cow manure treatments presented the lowest mean of water use efficiency.

Probably, chemical fertilizer and chicken manure with providing the plant with better nutrition conditions may have been able to increase the production of assimilates and the plant production per unit of water consumption. Among irrigation treatments, it was also found that 5-day treatment yielded the minimum water use efficiency per unit of water consumption due to the higher consumption than the plant requirement and less dry matter production. Parvizi and Nabati (2004) reported similar results. They also stated that with improving the plant growth conditions thanks to proper nutrition and reducing the amount of water consumed due to increased irrigation intervals, water use efficiency can be greatly improved.

Leaf and stem protein content: Table of analysis of variances revealed that the effects of irrigation on stem and leaf protein content were significant, while the effect of fertilizer was significant only on leaf protein content. However, in both traits the interaction between experimental factors was not statistically significant (Table 6). These results suggest that only irrigation as a factor could change the stem protein content, and fertilizers did not have a considerable effect on the stem protein. Study of the leaf protein content showed that changes in the leaf protein were more sensitive to the environmental conditions than variations of the stem protein content, where irrigation and fertilizers could both change the leaf protein content. Abbasdokht *et al*. (2015) also reported similar results.

The stem protein content might have been affected by irrigation due to the young age of plant and rapid growth in early stages. Further, with the growth of water stress intensity, the stem protein content rose such that the highest stem protein content was obtained by 20-day irrigation interval with a mean of 5.97% at the same statistical level with 10-and 15-day treatments, which had less water than the five-day treatment. Also the leaf protein content showed a similar process to the stem protein content process (Table 7). Probably, changes in the intensity of protein synthesis or decomposition are one of the metabolic processes that can affect drought tolerance and low irrigation. Accordingly, under stress conditions through increasing the leaf and stem protein content the plant can probably change the low-irrigation conditions in favor of its growth (Roustaie *et al*., 2012).

Results showed that, leaf protein content was significantly increased by the application of chemical fertilizer and chicken manure treatments (Table 7). It is suggested that slow release of nutrients from cow manure and nutrient deficit in no fertilizer treatment lead to lower leaf protein content. It has been reported that fertilizer treatment provides required nutrients for plant growth and enhances protein production in plant leaves (Roustaie *et al*., 2012).

Conclusion

It is concluded that by reducing the amount of water consumption due to strong dependence of the growth of the plant organs on the amount and potential of water in cells, a significant reduction was observed in the stem height and diameter as well as the number of sub-stems. However, in the stem diameter, due to less sensitivity to environmental conditions and a greater dependence on genetics, these changes were far milder. On the other hand, through curtailing sub-stems, high irrigation intervals reduced the physiological sources of the plant, leading to diminished plant height, stem and leaf dry weight, and biological yield. Study of the effect of different levels of fertilizer treatments on some morphological traits and yield of the plant suggested that changes in nutritional systems can lead to severe morphological and quantitative changes in the plant. In this regard, the results revealed that in these traits, chemical fertilizers and chicken manure typically produced the highest amount. However, cow manure due to slow decomposition and non-fast release of nutrients and no-fertilizer treatment due to defect of nutrients caused a sharp decline in these traits. In general, the results of this study suggested that the use of a fertilizer system that could meet the plant's requirements in a timely manner and adequately could partly neutralize the negative impact of water shortage. Accordingly, by applying the correct method for the plant nutrition and soil fertility, while preserving the environment, increasing water quality, reducing erosion and maintaining biodiversity, the efficiency of inputs can also be enhanced. Further, by avoiding unnecessary and excessive use of nutrients, production costs can be minimized, and economical and sustainable agriculture can be achieved.

References

Abbasdokht, H., Gholami, A. and Esfandiari, S. (2015) Effects of different mulch and optimal management of fertilizer sysmtems on agronomic characteristics, chlorophyll, carotenoids and yield of Common purslane (*Portulaca oleracea* L.). Iranian Journal of Field Crop Sciences 46: 529-545.

Abbasi, M., Najafi, N., Aliasgharzad, N. and Oustan, S. (2013) Effects of soil water conditions, sewage sludge, poultry manure and chemical fertilizers on the growth characteristics and water use efficiency of rice plant in a calcareous soil. Water and Soil Science 23: 189-208.

Ahmadian, A., Ghanbari, A. and Golvi, M. (2009) The interaction effect of water stress and animal manure on yield components, essential oil and chemical composition of *Cuminum cyminum*. Iranian Journal of Field Crop Sciences 40: 173-180.

Akbari, P., Ghalavand, A., Modarres Sanavy, A. M. and Agha Alikhani, M. (2011) The effect of fertilizers, nitrogen fertilizer and farmyard manure on grain yield and seed quality of sunflower (*Helianthus annus* L.). Journal of Agricultural Technology 7: 173-184.

Bettaieb, I., Zakhama, N., Aidi Wannes, W., Kchouk, M. E. and Marzouk, B. (2009) Water deficit effects *Salvia officinal* is fatty acids and essential oils composition. Science Horticulture 120: 271-275.

Bremner, J. M. (1996) Nitrogen- Total. In: Methods of Soil Analysis: Part 3- Chemical Methods.(eds. Sparks, D. L., Page, A. L., Helmke, P. A., Loeppert, R. H., Soltanpour, P. N., Tabatabai, M. A., Johnston, C. T. and Sumner, M. E.) Pp. 1085-1121. Soil Science Society American Inc. American Society Agronomy Inc. Book Series, No. 5, Madison, WI, USA.

Channabasanagowda, N. K., Patil, B., Patil, B. N., Awaknavar, J. S., Ninganurn, B. T. and Hunje, R. (2008) Effect of organic manures on growth, seed yield and quality of wheat. Karnataka Journal. Agriculture Science 21: 366-368.

English, M. J. and James, L. (1990) Deficit irrigation. II: Observation on Colombia basin. Journal of Irrigation and Drainage Engineering 116: 413-426.

Fallah, S. and Soltaninejhad, F. (2014) Interactions of drought stress and different levels of fertilizer sources on production of purslane (*Portulaca oleracea*). Research in Field Crops 2: 44-58.

Ghobadi, M., Bakhshandeh, A., Fathi, Gh., Gharineh, M. H., Alami-Saeed, Kh. and Naderi, A. (2006) Effects of sowing date and heat stress during flowering on yield and yield components in canola (*Brassica napus* L.) cultivars. Iranian Journal of Crop Sciences 8: 46-57.

Hassani Malayeri, S., Omidbaigi, R. and Sefidkon, F. (2004) Effect of N-fertilizer and plant density on growth, development, herb yield and active substance of feverfew (*Tanacetum parthenium* ct. Zardband) medicinal plant. In: 2nd International Congress on Traditional Medicine and Materia Medica. Tehran, Iran.

Inanloofar, M., Omidi, H. and Pazoki, A. R. (2013) Morphological, agronomical changes and oil content in Purslane (*Portulaca oleracea* L.) under drought stress and biological / chemical fertilizer of nitrogen. Journal of Medicinal Plants 4: 170-184.

Kabiri, R., Farahbakhsh, H. and Nasibi, F. (2014) Effect of drought stress on physiological and biochemical characteristics of *Nigella sativa* L. Iranian Journal of Medicinal and Aromatic Plants 30: 600-609.

Liu, L., Howe, P., Zhou, Y. F., Xu, Z. Q., Hocart, C. and Zhang, R. (2000) Fatty acids and B-carotene in Australian purslane (*Portulaca oleracea* L.) varieties. Journal of Chromatography A 893: 207-213.

Manna, M. C., Swarup, A., Wanjari, R. H., Mishra, B. and Shahi, D. K. (2007) Long-term fertilization, manure and liming effects on soil organic matter and crop yields. Soil and Tillage Research 94: 397-409.

Mirtaheri, S. M., Syadat, S. A., Najafi, M. S., Fathi, Gh. and Alami Saeed, Kh. (2010) Effect of drought stress in remobilization of dry matter in five varieties of bread wheat. Iranian Journal of Field Crops Research 8: 308-314.

Moeini Alishah, H., Heidari, R., Hassani, A. and Asadi Dizaji, A. (2006) Effect of water stress on some morphological and biochemical characteristics of purple Basil (*Ocimum basilicum* L.). Journal of Biological Sciences 6: 763-767.

Oktem, A., Siesek, M. and Oktem, G. (2003) Deficit irrigation effects on sweet corn (*Zea mays sooch arata sturt*) with drip irrigation system in a semi-arid region. I: Water- yield relationship. Agricultural Water Management 61: 63-74.

Parvizi, Y. and Nabati, E. A. (2004) Effect of irrigation intervals and livestock fertilizers on water use efficiency and quantitative and qualitative yield of corn. Research and Construction 63: 21-29.

Rahbarian, P. and Afsharmanesh, Gh. (2011) Effects of water deficit and manure on yield and morphological characters some of dragonhead (*Dracocephalum moldavica*) in Jiroft Area. Journal of Crop Eco physiology 5: 41-52.

Roustaie, Kh., Movahhedi Dehnavi, M., Khadem, S. A. and Owliaie, H. R. (2012) Effect of different super absorbent polymer and animal manure ratios on the quantitative and qualitative characteristics of soybean under drought stress. Journal of Crops Improvement 14: 33-42.

Samy, J., Sugumaran, M., Lee, K. L. W. and Wong, K. M. (2009) Herbs of Malaysia: An Introduction to the Medicinal, Culinary, Aromatic and Cosmetic Use of Herbs. Selangor: federal publications.

Shokhmgar, M., Baradaran, R., Mosavi, Gh., Poyan, M. and Arazmjoo, E. (2013) Effects of irrigation interval and nitrogen on seed yield and physiological characteristics of Fenugreek (*Trigonella foenum-gracum* L.). Iranian Journal of Medicinal and Aromatic Plants 29: 527-538.