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Investigating the effect of low irrigation and nitrogen on vegetative structure and morphological characteristics of henna ecotypes in Jiroft region

H. Sarhadhi[a]*, Z. Mokhtari [b]

[a] Department of Agronomy, Jiroft branch, Islamic Azad University, Jiroft, Iran
[b] Senior expert in Agriculture , Jiroft Sama Branch,Islamic Azad University, Jiroft ,Iran

Email: (corresponding author): hsarhadi39@gmail.com

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Abstract
In order to investigate the phenology of henna plant ecotypes with different amounts of nitrogen fertilizer and low irrigation, an experiment was carried out in the form of completely random chopped plots in 4 replications in the field and in the crop year 2018-2019. Low irrigation stress is the main factor (100%, 75% and 50% of the plant's water requirement), nitrogen is the secondary factor (including 50, 100 and 150 kg). Net nitrogen per hectare was investigated at three levels and sub-factors (including Bami, Bushehri and Rudbari) and the results of analysis of variance showed that all three factors had a significant effect on leaf weight, total, dry leaf weight and total dry weight at a statistical level of 1%. With Paying attention to the results of this research and the importance of using drought-resistant varieties and ecotypes using 150 nitrogen per hectare, 9.77 and 2.37 tons, respectively, were determined. Optimum management of fertilizer consumption in order to preserve the environment and increase the effective substance of henna plant cultivated in Bami ecotype under drought stress of 75% water requirement and consumption of 100 kg of nitrogen per hectare and without stress using henna leaf of Bari ecotype with consumption of 150 kg of nitrogen per hectare It is recommended in the same area and conditions.

***Keywords*:** henna, low irrigation, nitrogen, vegetative body, morphological characteristics

Introduction

The new approach of science towards plant breeding and drought tolerant plants and natural materials instead of using chemicals, clarifies the importance of cultivation and processing of these plants. Iran alone has four times the climatic conditions for the production of medicinal plants, among which henna (Lawsonia inermis) is an industrial and medicinal plant that is considered as one of the natural dyes and widely used in the textile and carpet industries. Weaving and cosmetics industries such as hair dye production, soap preparation, etc., as well as paper making and tanning industries, etc. (Chadhari et al., 2010). Antifungal and antibacterial effects are among the pharmacological properties of henna (Azad Bakht, 1378). Fluctuations in rainfall distribution due to global warming may increase the risk of plants being repeatedly exposed to drought. Almost all plant species show tolerance to drought stress, but the ability of different species and varieties in this field is different (Larcher, 2003). In natural environments, plants are subjected to various stresses that have negative effects on their growth. Drought is the biggest factor limiting agricultural production (Reddy et al., 2004). Drought stress is one of the multidimensional stresses. In addition to water, the availability of nitrogen is one of the important factors that affects the growth and development of agricultural plants globally (Rajala et al., 2009). The lack of water and nitrogen leads to a decrease in the yield of crops by reducing the absorption and efficiency of resource use. Petropoulos et al. (2008) concluded that with an increase in the level of water stress, the fresh weight of the whole plant, the fresh weight of the leaves, the number of leaves and the weight The root decreases, but with the increase of drought stress, the yield of essential oil increases. In this experiment, drought stress caused a decrease in biomass in leaves, root weight, and the number of leaves in the plant. Askari et al. (2012) reported the effect of compaction and nitrogen on henna plant. The highest number of leaves with the consumption of 100 kg of pure nitrogen with about 90 leaves per plant, the highest number of leaves with the consumption of 50 kg of pure nitrogen per hectare was obtained with about 85 leaves per plant. The maximum dry weight of leaves was about 20 grams with the consumption of 100 kg of pure nitrogen per hectare. Currently, efforts are being made to update information on medicinal plants, especially henna (Orva et al., 2009). In this study, an attempt has been made to investigate the growth status of vegetative body and morphological features of henna plant ecotypes under water deficit and different levels of nitrogen.

Materials and Methods

In order to investigate and evaluate the effect of different amounts of nitrogen fertilizer and lack of irrigation on the growth characteristics and performance of experimental henna ecotypes in the form of a split plot in the form of a completely randomized block design in 4 replications in the educational and research farm of Azad University of Jiroft in the crop year of 2013-2014 Done. In this research, stress of lack of irrigation in three levels (100% water requirement, 75% water requirement, 50% plant water requirement), nitrogen in three levels (50, 100, 150 kg of pure nitrogen from urea fertilizer source) and ecotype factor in three The surface (Bami, Boushehri and Roudbari) were placed in the main, sub and sub plots, respectively. To break the dormancy of the seeds, 1000 ppm concentration of Jibber Lake acid was used. Cultivation was done in the treasury in March and after the height of seedlings reached about 15 cm, they were transferred to the main land. Each plot has 6 planting lines at a distance of 50 centimeters and 6 meters long, and the distance between the main plots is 3 meters, the sub plots are 1 meter, and the sub plots are 1 meter. Sub-75 cm distance between repetitions was considered 2 meters. An evaporation pan was used to apply the low irrigation factor. And to calculate the amount of water consumed, it was calculated based on the amount of daily evaporation from the surface of the evaporation pan and different levels of low irrigation treatments using the following formula:

KP Epan = ET0

In this formula: ET0 is the rate of evaporation and transpiration of the base plant, KP is the rate of evaporation from the surface of the pan and Epan is the coefficient of the pan, which was considered equal to 0.7, then the water consumption of the desired plant was calculated from the formula: ETC = ET0 KC. In this formula, ETC, the water consumption of the plant in question, KC is the plant factor, and considering that the henna plant is a shrub, its coefficient was considered to be 1.1. Then according to the provisions of the plan, different levels of water consumption were calculated and according to the area of the plot, it was used with the volume contour of water consumption. Also, nitrogen fertilizer was given to the plant in 3 stages (the first stage about 2 weeks after transplanting, the second stage about one month after the first stage and the third stage before flowering). The studied ecotypes were obtained from the agricultural research centers of Rudbar Zaban, Bushehr and Bam cities. The studied traits are plant height, number of leaves per plant, number of secondary stems, leaf fresh weight, total fresh weight, leaf dry weight, and total dry weight. SAS v.7 and MSTAT-C software were used to perform analysis of variance and comparison of averages.

Table1. Variance analysis of the effect of low irrigation, nitrogen and ecotype on vegetative traits

average of squares						
total dry weight	**weight of dry Leaf**	**Number of secondary stems**	**Number Of leaves**	**plant height**	**Degrees of freedom**	**Sources of changes**
ns0/01	**ns0/01**	**ns920/9**	**ns17377 /56**	**Ns19/53**	**3**	repetition
13/45	**3/94**	**ns2772 /7**	**2365755 /90**	**21508 /86**	**2**	Dehydration (A)
0/007	**0/002**	**ns833/3**	**15921 /083**	**14/50**	**6**	Error A
1/32	**0/55**	**ns2194 /8**	**79058 /04**	**1218 /53**	**2**	Nitrogen (B)
1/15	**0/70**	**ns690/45**	**ns20411 /88**	**1176 /72**	**4**	**B × A**
0/003	**0/001**	**783/7**	**21358 /90**	**9/225**	**18**	Error B
0/06	**0/10**	**ns760/4**	**ns1029 /79**	**56/33**	**2**	Ecotype (C**)**
0/50	**0/16**	**ns611/83**	**79911 /43**	**229/65**	**4**	**C× A**
0/02	**ns0/10**	**ns596/5**	**ns24854 /36**	**47/28**	**4**	**C × B**
0/05	**0/02**	**ns712/74**	**ns26260 /10**	**ns23/01**	**8**	**A × B × C**
0/200	**0/001**	**799/929**	**18590 /985**	**11/608**	**54**	**Error C**
15/16	**14/09**	**10/69**	**6/13**	**16/28**	**-**	Coefficient of Variation (**cv%)**

Bush Height

Based on the results from the analysis of variance table (Table 2), plant height was statistically affected at the level of 1% by the stress of water deficit, nitrogen and the interaction effect of low water nitrogen and low water ecotype and at the level of 5% it was affected by different levels of ecotype it placed. But the interaction effect of drought stress nitrogen Eco type on the height was not significant. The comparison of the average interaction effects showed that the highest plant height from the bilateral treatment of dehydration nitrogen and application of 100% water requirement and consumption of 150 kg of pure nitrogen with a height of 25 97 cm, and the lowest one was obtained from the water stress of 50% of the plant's water requirement and the consumption of 100 kg of pure nitrogen with a height of 30.75 cm (Chart 1).

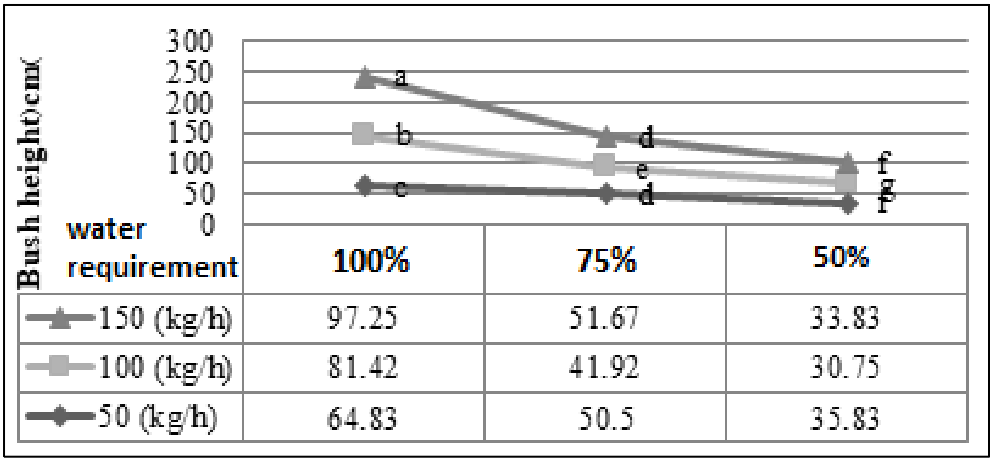


Chart 1. Comparison of the average interaction effect of low irrigation nitrogen on henna plant height

The interaction effect of low irrigation ecotype showed that the maximum height of the plant from river ecotype and 100% plant water requirement treatment was obtained with 86.92 cm, which was not significantly different from other ecotypes at this level of irrigation. The lowest height was obtained from the Roudbari ecotype with 50% water requirement treatment and 30.83 cm, which was not significantly different from the Boushehri ecotype (Chart 2).

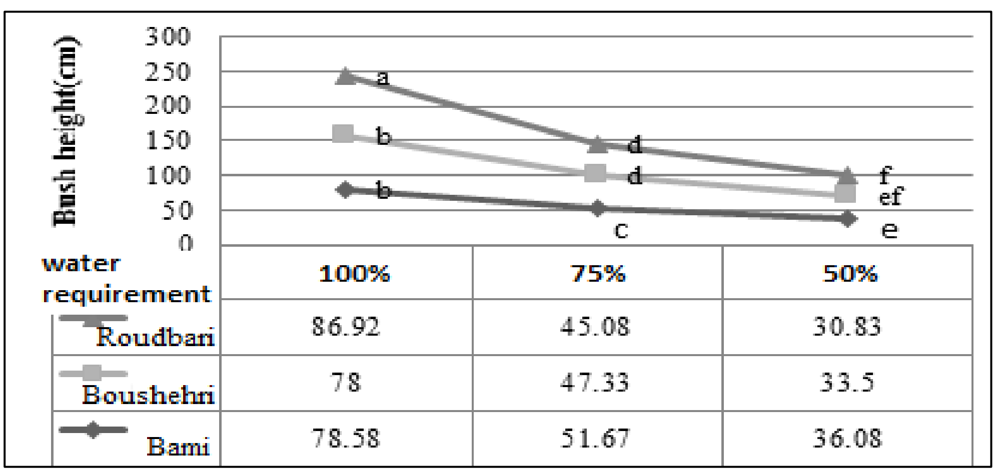
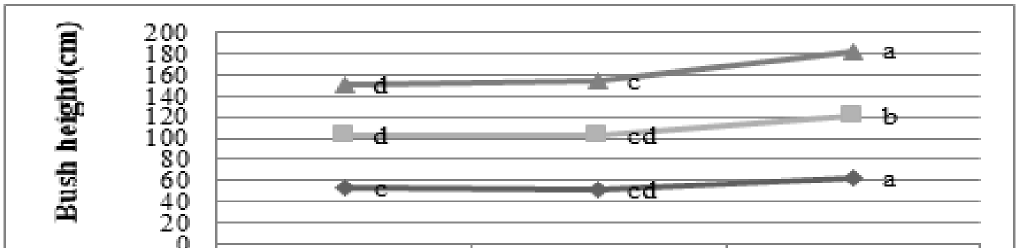


Chart 2. Comparison of the average effect of low irrigation ecotype on henna plant height

From the interaction effect of nitrogen ecotype, the highest height was obtained from Bami (62.33 cm) and Roudbari (58.42 cm) ecotypes with the consumption of 150 kg of nitrogen per hectare. Consumption of 50 kg of nitrogen per hectare showed the lowest plant height on Boushehri (48.83 cm) and Bami (53.5 cm) ecotypes (Chart 3).



	50 (kg/h)	100 (kg/h)	150 (kg/h)
Roudbari	48.83	52	62
Boushehri	48.83	51.58	58.42
Bami	53.5	50.5	62.33

Chart 3. Comparison of the average effect of ecotype interaction in nitrogen on henna plant height

According to the obtained results, the consumption of 150 kg of nitrogen and conditions without water stress resulted in the highest plant height, which seems that nitrogen accelerates the phenological development in the vegetative stage. In this condition, the speed of development and durability of the leaf surface increases, and the efficiency of light use increases in the same proportion. On the other hand, as much as the concentration of nitrogen in the leaves increases, it seems that the intensity of carbonation and the amount of chlorophyll synthesis increases. When there is no moisture stress, the plant will have optimal conditions for growth. However, with the increase in water stress and decrease in nitrogen consumption, Bami ecotype had a significant difference in height compared to other ecotypes and gave the highest amount. Askari et al. (2012) in a research on henna, obtained the highest height of henna plant by consuming 100 kg of nitrogen per hectare. In the survey of quantitative and qualitative characteristics of chamomile plant, (Rangbari 2019), the results showed that the height of the plant and the diameter of the stem were affected by fungus and zinc. Number of leaves per plant According to the results obtained from the analysis of variance table (Table 2), the effect of low irrigation and nitrogen on the number of leaves per plant was statistically significant at the level of 1% and 5%, but the effect of ecotype and the interaction of treatments on the number of leaves were significant. No. In terms of comparing the average effect of low irrigation levels on the number of leaves per plant, the highest value was obtained by applying 100% of the water requirement of the plant (2496 leaves per plant) (Chart 4).

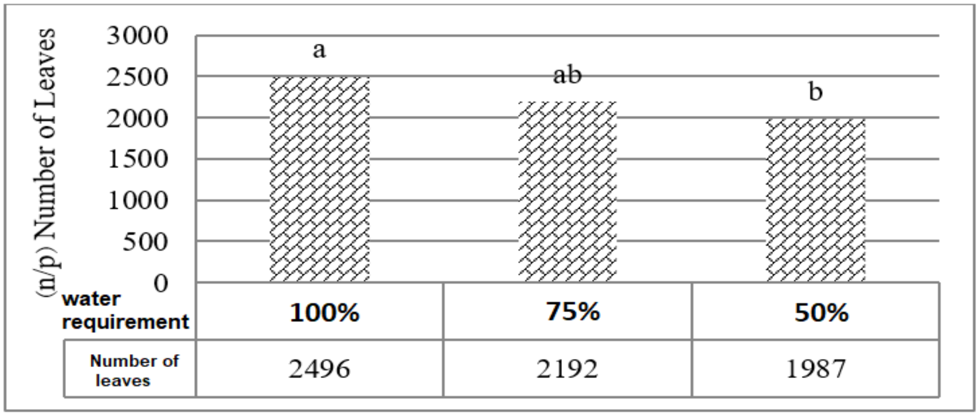


Chart 4. Comparison of the average effect of low irrigation levels on the number of henna leaves

Comparison of the average effect of different levels of nitrogen on the number of leaves showed that the highest number of leaves with 2278 belonged to the treatment of 150 kg of nitrogen per hectare, which was at a statistical level with the consumption of 100 kg of nitrogen per hectare (Chart 5).

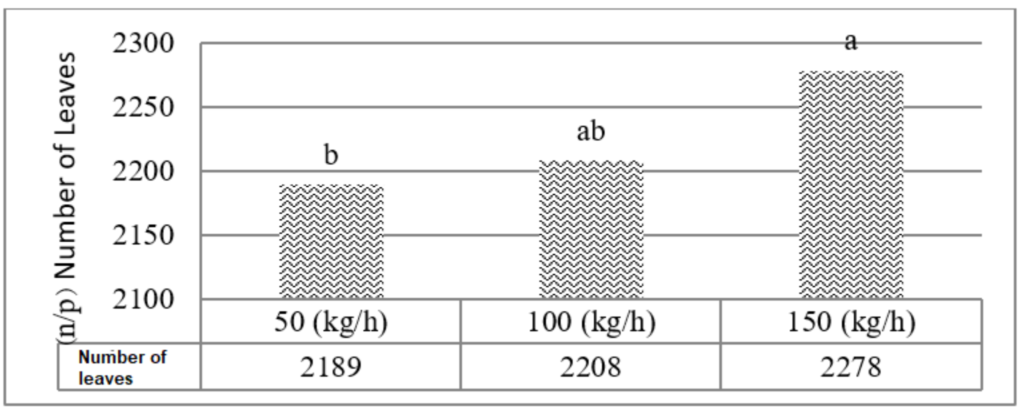


Chart 5. Comparison of the average effect of nitrogen values on the number of henna leaves

In the comparison of the average of the mutual effects of low irrigation and ecotype on the number of leaves per plant, the highest number of leaves with 100% water requirement of the plant was obtained from the riverine ecotype with the number of 2585 leaves, which was not significantly different from the Boushehri ecotype. The lowest one was obtained by applying 50% of the water requirement of the plant and with the amount of 1940 leaves, and statistically there was no difference between the studied ecotypes (Chart 6).

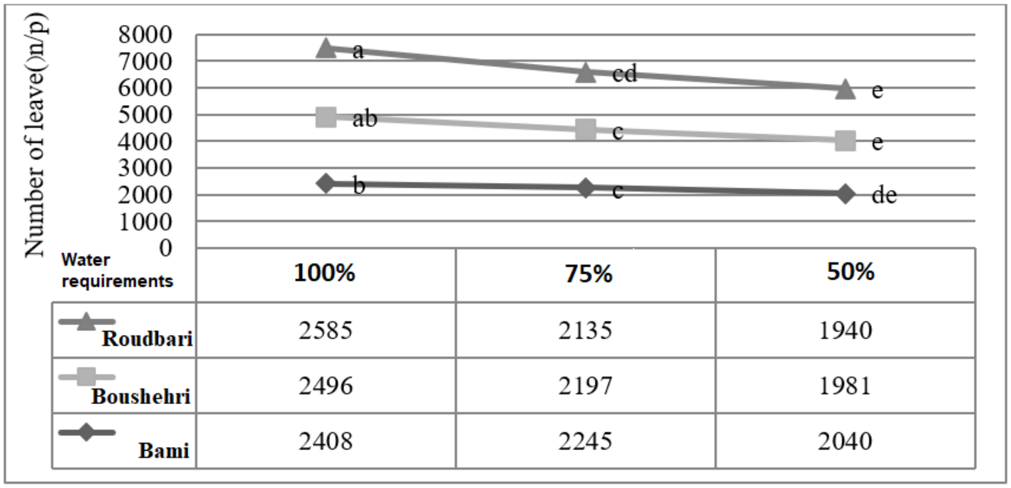


Chart 6. Comparison of the average effect of low irrigation in ecotype

According to the results, although the Roudbari ecotype had the highest number of leaves in the condition of 100% water requirement and 100 kg nitrogen consumption, but with the application of moisture stress, the Bami ecotype produced more leaves than other ecotypes. Of course, the number of leaves depends on the amount and duration of stress in addition to the ecotype. Applying stress of 50 and 25% of the crop capacity caused a fifty percent reduction in the number of leaves in the henna plant (Enneb et al., 2015). Some researchers also stated that the reduction in the number of leaves led to the reduction of dry matter accumulation (Guttieri et al., 2001) and the acceleration of plant aging (Sankar et al., 2008). Consumption of 100 kg of nitrogen led to an increase in phenological growth, development and durability. The leaf surface was (the measured traits including the number of leaves, in addition to the ecotype, were dependent on the amount and duration of stress Ding et al., 2005; Heidari et al., 2012). Number of secondary stems per plant The results of analysis of variance (Table 1) showed that none of the investigated factors and their mutual effects on the number of secondary stems in the plant were significant. Fresh weight of leaves The leaf weight was influenced by all the investigated factors at a statistical level of 1%. Their two-way and three-way interactions also had a significant effect on the leaf weight at the 5% level (Table 2). The comparison of the average interaction effect of low irrigation nitrogen ecotype on the leaf weight showed that the maximum leaf weight with the application of 100% requirement water and the consumption of 150 kg of pure nitrogen per hectare was obtained from the river ecotype at the rate of 9.77 tons per hectare. The lowest was obtained from the same ecotype with water application of 50% of the plant's water requirement and consumption of 150 kg of pure nitrogen per hectare, which was not statistically significantly different from the Boushehri ecotype and consumption of 50 and 100 kg of nitrogen (Table 3). By using 100 kg of nitrogen per hectare in the period of planting growth and the beginning of leafing, Delfard (1400) came to the conclusion that mycorrhiza and nitrogen inoculation had a positive and significant effect on aloe Vera plant. Fallah (2017) concluded in a research that the effect of inoculation on the number and weight of fresh leaves per plant was significant at the level of 5%.

Table2. Effect of inoculation on the number and weight of fresh leaves per plant

Total weight of Dried) t/h(	weight of Dried stems (t/h)	weight of Dried leaves t/h)(	Total weight of Fresh leaves) (t/h	weight of Fresh leaves t/h)(			
4/47E	G2/72	1/75i	F20/74	E8/62	Bami	50Kg	%100Water requirements
4/66 d	F2/81	1/85fg	D21/33	D8/78	Boushehri		
4/73 d	Ef2/84	1/89ef	Cd21/48	Ed8/91	Roudbari		
4/72 d	De2/88	1/84gh	E21/02	E8/82	Bami	100Kg	
4/81 c	Cd2/89	1/92de	Cd21/42	Cd8/86	Boushehri		
4/87c	Bc2/92	1/95cd	C21/61	C8/94	Roudbari		
4/81 c	Def2/84	1/97c	C21/62	Cd8/87	Bami	150Kg	
5/18 b	B2/95	2/23b	B22/33	B9/54	Boushehri		
5/52 a	A3/16	2/37a	A22/76	A77/9	Roudbari		
3/99 h	I2/48	1/51kl	Gh19/99	Gh8/23	Bami	50Kg	%75Water requirements
3/84 j	Jk2/42	1/41mn	Ij19/71	H8/16	Boushehri		
3/69 lmn	Klm2/38	1/30qrs	K19/26	I8/00	Roudbari		
4/16 g	H2/61	1/54k	G20/12	Fg8/33	Bami	100Kg	
3/88 ij	Ij2/45	1/43m	Ij19/77	Gh8/23	Boushehri		
3/72 kl	Mn2/35	1/37no	J19/61	Gh8/27	Roudbari		
4/45 e	H2/65	1/80h	F20/60	F8/21	Bami	150Kg	
4/35 f	H2/61	1/69j	Hi19/83	Fg8/32	Boushehri		
3/99 h	Ij2/45	1/54k	Ij19/65	Gh8/22	Roudbari		
3/71 klm	Lm2/37	1/35opg	N18/13	K7/59	Bami	50Kg	%50Water requirements
3/62 n	N2/32	1/31qrs	O17/85	Lm7/35	Boushehri		
3/53 o	O2/26	1/26s	P17/40	N7/12	Roudbari		
3/76 k	Jkl2/41	1/36op	M18/39	K7/55	Bami	100Kg	
3/70 klm	Klm2/38	1/32pqr	O17/91	Lm7/41	Boushehri		
3/54 o	O1/26	1/28rs	Q17/16	O6/86	Roudbari		
3/91 i	Jk2/42	1/49l	L19/01	J7/77	Bami	150Kg	
3/71 klm	Klm2/37	1/34opq	M18/34	Kl7/50	Boushehri		
3/65mn	mn2/35	1/30qrs	o17/84	m7/29	Roudbari		

Drought stress resulted in significant weight loss. It seems that this was caused by the decrease in relative water content and the different ability of ecotypes to retain water and freshness of plant tissues, which is consistent with the findings of other researchers on garden thyme (Sarajoughi et al., 2014) and aromatic parsley (Tyler, 2009).

Total Fresh Weight

The results of analysis of variance showed (Table2) that the effect of low irrigation, nitrogen and ecotype, as well as the interaction effect of low irrigation nitrogen, low irrigation ecotype and low irrigation nitrogen ecotype, on the total fresh weight was statistically significant at the 1% level. The interaction effect of nitrogen ecotype on the mentioned trait was statistically significant at the level of 5%. The average comparison of the three-way interaction effect of low irrigation nitrogen ecotype on the total weight showed that the maximum amount was applied with 100% of the plant's water requirement and consumption of 150 kg. Pure nitrogen per hectare was obtained from the river ecotype with 22.76 tons per hectare, and the lowest was obtained with 50% water stress of the plant's water requirement and consumption of 100 kg of pure nitrogen from the river ecotype with 17.16 tons per hectare (Table 3). According to the results of this research, the Bami ecotype had more weight with the application of moisture stress and the adverse effect of drought on this ecotype was much less.

Dry Weight Of Leaves

Based on the variance analysis summary table (Table 1), leaf dry weight was influenced by the investigated factors and the effect of water stress, nitrogen and ecotype on this trait was statistically significant at 1% level. The interaction effect of low irrigation nitrogen, low irrigation ecotype and low irrigation nitrogen ecotype was also significant at the 1% level on leaf dry weight, but the interaction effect of nitrogen ecotype was not significant on this trait. Ecotype on leaf dry weight shows that the highest dry weight was obtained from the Roudbari ecotype at the rate of 2.37 tons per hectare and the consumption of 150 kilograms of nitrogen and the application of 100% of the water requirement of the plant. The lowest dry weight was also obtained from the same ecotype at the rate of 1.26 tons per hectare and 50 kg of nitrogen consumption and with 50% moisture stress of water requirement, which was achieved with Boushehri ecotype under conditions of 50 kg of nitrogen consumption and 100 kg of nitrogen consumption in the Roudbari ecotype. They were placed on the same level (Table2). In his research (1390), Nikbakht obtained the highest dry weight of leaves 5775 kg/ha and the lowest dry weight 756 kg/ha on Vesme plant. In a research on henna, the maximum dry weight of leaves (692.5 kg per hectare) was obtained with the consumption of 60 kg of pure nitrogen, and with the consumption of 80 kg of nitrogen and 40 kg of P2O5, the dry weight of leaves increased by 19.3 percent and reached 6.6 It reached 1302 kg per hectare (Roal et al., 2003). The research showed (Moalemi 2016) that the use of 150 kg of nitrogen per hectare and mycorrhizal fungus has a significant effect on fresh and dry weight of leaves.

Total Dry Weight

The results of analysis of variance (Table 2) showed that the effects of low irrigation, nitrogen and ecotype as well as their mutual effects were statistically significant at the 1% level on the total dry weight. The average comparison of the interaction effect of low irrigation nitrogen ecotype on the traits indicated It is that the highest total dry weight of 5.52 tons was obtained by applying 100 plant water requirements and 150 kg of pure nitrogen per hectare in riverine ecotype, and the lowest was 3.54 tons per hectare by applying 50% water requirement stress. The plant and the use of 50 and 100 kg of pure nitrogen per hectare were also obtained from the river ecotype (Table2). The results indicate that although the river ecotype with full irrigation and consumption of 150 kg of nitrogen produced the highest total dry weight, but with Increasing low irrigation to 75% and 50% of water requirement, Bami ecotype was more successful and other ecotypes showed statistically significant superiority. So, in the moisture stress of 75%, the water requirement with the consumption of 150 kg of nitrogen obtained the highest amount of dry weight with 4.45 tons per hectare. Applying the stress of 50% of the agricultural capacity caused a 50% decrease in the number of henna leaves (Enneb et al., 2015), a decrease in dry matter accumulation (Gutterie et al., 2001) and an acceleration of plant aging (Sankar et al., 2008). Nitrogen up to 100 kg/ha could reduce the oxidative stress caused by moisture stress up to 75% of the water requirement, and this issue led to an increase in growth (Ozturk, 2010; Kazemeini et al., 2010; Ebrahimi et al., 2011; Goldust - Khirshidi et al., 2013).

Conclusions

The results of this experiment showed that drought had a negative effect on the measured vegetative traits of the henna plant. Although the stress of low irrigation caused a decrease in vegetative growth, there was no significant difference with full irrigation in most of the traits measured with the application of low irrigation stress of 75% of the plant's water requirement. Therefore, it can be applied to reduce water consumption, especially in arid and semi-arid areas such as Jeiroft and similar areas. Considering that in the absence of stress, the Roudbari ecotype has the highest leaf yield, in order to use the Roudbari ecotype henna leaves with The consumption of 150 kg of nitrogen per hectare of the Bami vacotype has been able to show good adaptability in stressful conditions and has the highest performance in these conditions and has been more successful, which is very important, especially since resistance to stress was one of the main goals of this experiment. Among other ecotypes, it is recommended in stressful conditions, and the irrigation regime of 75% of the water requirement and consumption of 100 kg of nitrogen per hectare in stressful conditions is introduced to achieve the best results.

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