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Effect of irrigation period on some morphological traits of Guar (*Cyamopsis Tetragonoloba*) in karaj region

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Abstract

In order to evaluate irrigation period on some morphological traits of guar plant, a randomized complete block design experiment with three replications was conducted in 2015 and 2016. Irrigation treatments included three steps, the first step was irrigation with the volume of 210 liters per day, once every three days, the next step consisted of total two irrigations that considered as control and Finally, which was dryland farming. The evaluated traits was including the emergence index, emergence percentage, leaf area index, stem diameter in two steps and plant height in three steps. Analysis of variance showed that drought stress (dryland farming) had a significant effect on some traits. The results showed that Drought stress decreased the amount of emergence index, emergence percentage, leaf area index, stem diameter at the harvest time and plant height in three steps , But on stem diameter in podding step had no significant effect. The results showed that increasing the amount of irrigation increased emergence index, emergence percentage, leaf area index and plant height in three steps, But on stem diameter in two steps had been ineffective.

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Introduction

In recent decades, extensive research has been done on medicinal plants and drugs with natural active ingredients, has opened new horizons for researchers. So that now about a third of the drugs used in human societies and herbal medicines are made of natural origin. Many researchers have turned their attention to the cultivation, production and study of medicinal plants. Guar (*Cyamopsis tetragonoloba*) is an annual plant of beans family (*Leguminous*) and is the source of guar gum (Whistler and Hymowitz, 1979). Many parts of it are used to humans and animals, but its seed which contains gel is the most important part (Mudgil *et al*., 2011). Guar is one of the unique beans which its large spherical endosperm contains a significant amount of galactomonas that is used in a wide range of food and industrial applications (Marina *et al*., 2007; Mudgil *et al*., 2011).

This plant can be used in various textile, paper, explosive and pharmaceutical industries as adhesives or as a decomposition agent in pills and the main ingredient in some of the laxatives, In the cosmetics industry as a concentrator, in toothpaste, shampoos, oil industry and gas industry (Alexander *et al*., 1988; Narayan, 2012). Much of guar production is in arid and semi-arid India, Pakistan, United States of America, Australia and Africa and rain is the most important environmental factor which determines growth and yield. Guar is generally known as a stress tolerant crops. Studies have shown that water crisis during the main stages of growth can lead to significant reductions in some vegetative and reproductive traits (Reddy *et al*., 2001).

The importance of water is such that it is the main driving force of agricultural activities (Ministry of Agriculture-Jahad, Iran, 2008). Due to the reaction of the plants to the deficiency or excessivation of water at different stages of development and familiarity with the structure of the plant, it is possible to change the irrigation time as much as possible to prevent any tension and negative reaction in the plant (Hossain, 2008). This plant needs regular irrigation and moisture during planting and especially during the maturity of the seeds (Anderson, 1949).

A frequent drought period can lead to maturation delays (Undersander *et al*., 1991). In a research on Moldavian dragonhead (*Dracocephalum moldavica* L.) reported that one of the reasons for lowering the height, leaf length and width was drought stress (Safikhani, 2006). In a research on basil (*Ocimum basilicum*) reported that Reducing the moisture content of the pots has a direct effect on reducing the diameter of the stem (Hassani *et al*., 2003). During growth and development of plant cell, leaf sensitivity to moisture deficiency causes a significant reduction in leaf growth and leaf area (Miri, 2005). Water scarcity is one of the most important environmental factors which affecting on germination (Falleri, 1994).

Previously, researchers worked on weeds, salt stress, drought stress and etc on guar plant and they reported that removing weeds at 20 or 30 DAS increased the number of pods per plant, water use efficiency and seed yield of clusterbean. Water consumption was higher in unweeded plots. Water use efficiency decreased with the increase in time of weed removal beyond 20 days after crop sowing (R. S. Yadav, 1998).

Several workers reported that water stress caused more shedding of flowers, immature pods and smaller seeds, e.g. (Boutraa and Sanders, 2001). However, in this ex-periment, stressed plants at 65 DAS did not show this esponse. Increased amounts of irrigation water or sam-pling errors are possible reasons for this clear discrep-ancy. Moreover, (Pandey *et al*., 1984) reported that pod density was most affected by water stress, among yield components with pod reduction averaging more than 50%, mainly due to the reduced flower production and the greater abortion of flowers.

In the current age, considering the high application of guar and gum obtained from it, as well as the availability of adequate water and the limitation of cultivated land in some countries, it will be questioned that can increasing the yield of this plant and some other vegetative and reproductive factors by increasing the amount of irrigation? So, the aim of this study was to investigate the effect of irrigation intervals (increasing irrigation and drought stress) on valuable Guar herb.

Materials and methods

Study areas

The study was conducted in March of 2015 and 2016 in Karaj (longitude 50 degrees 54 minutes latitude 35 degrees 55 minutes and 1312.5m above sea level). Karaj with hot-dry summers and cool-wet winters, with the average of 239.5 mm annual rainfall, is arid and the annual average of minimum and maximum temperatures of Karaj is respectively 8.7 and 21.1 degrees Celsius. The soil type of experimental farm was silty-sandy.

Design type and analysis

This experiment was conducted in a randomized complete block design with three replications. Data analysis was performed using SAS software and Duncan's multi-domain test was used to compare averages.

Evaluated traits

After the stages of growth, some morphological characteristics such as the emergence index, emergence percentage, leaf area index, stem diameter in two steps and plant height in three steps were measured.

Farm preparation

In the autumn of the 2014 and 2015 tillage including plowing, make the bed and Kurt were carried and the type of soil cultivation before planting tested and evaluated. planting operations was done in March of 2015 and 2016 in Karaj region on the personal farm. As well as pre- and post-emergence weed control was carried out. Each plot consists of 5 rows of 2×3m, plant spacing on rows 25cm and between rows 50 cm was considered. In this experiment, planting was done by clumped seeds and immediately after planting, watering was done.

Treatments

In this study, three levels of irrigation was considered. First level was irrigation once every three days (on days 3, 6, 9, 12,.). The amount of required water for irrigation in different treatments was determined to reach the root zone to field capacity.

To enter the required amount of water, water meter was used in each plot. Second level was irrigated in two steps, the first step was after germination and the next step coincides with flowering. Finally, the last level was dryland farming.

Methods

The different stages of sampling and data collection were as follows:

To measure the emergence index and emergence percentage, the number of emergenced seeds per day in each experimental unit was counted and after confirming the number of seedlings per plot, the emergence percentage and then the emergence index were calculated (Shekari, 2001). The emergence index as a criterion for the rate of emergence was obtained according to the following formula (Shekari *et al*., 2010):

$EI= (E1 \times 14) + (E2\times 13) + ...+ (E14\times 1)$.

E: Respectively, the number of greenery seedlings from the first count to the last count. In this regard, any treatment that can produce more seedlings in the earliest days, will produce a larger number, comparing with the treatment that produces the same number of seedlings in the last days and therefore, it is considered as a criterion for seedling emergence rate.

Also, to calculate plant height at certain times, 5 plants from each plot were randomly selected and measured their height from cotyledon to plant ends by the ruler and their mean was considered as plant height.

Coles were used to measure stem diameter at specified times.

Leaf Area Meter was used to measure leaf area. The leaf area in each experimental unit was measured after the project, and for this purpose, at an area of 1 square meter, 3 plants per plot were randomly taken out and immediately inside the nylon bags were transferred to the lab and then in the laboratory after separating the leaves from the plants, the leaf area of the plants was measured with the above apparatus.

Results and discussion

Emergence index and Emergence percentage

The results showed that irrigation had a significant effect on the emergence index and emergence percentage that dry land treatment with control and irrigation every three days treatment compared in different groups of Duncan grouping. For emergence index, rainfed treatment with an average of 53.000 was the minimum value, irrigation every three days treatment with average of 573.833 was the maximum value, and control treatment with average of 118.000 was the intermediate (Fig. 1). Also in emergence percentage, rainfed treatment with an average of 19.568 was the minimum value, irrigation every three days treatment with average of 89.5 was the maximum value, and control treatment with average of 42.713 was the intermediate and all three treatments were significantly different (Fig. 2).

According to various reports, low soil water potential reduces the percentage of emergence and growth of the plant (Harris *et al*., 2001). It has been reported that the reduction of soil water potential (effect of water stress) had a significant effect on delaying and reducing germination and also the establishment of plants (Schneider and Gupta, 1985). Rapid seed germination and uniform germination are essential for the successful establishment of plants under stress conditions. Suitable germination and root formation, with strong root formation, will lead to the development of the superficial and deep root of the young plant that an strong root system helps to grow the plant by appropriately absorbing water and nutrients. Also, the plant with a broad roots will be deployed and strengthened (Bradford, 1986).

The researchers placed soybeans (*Glycine max*) under different levels of drought stress and observed that during the treatment of most days under drought stress, the plant had the least germination percentage (Dornbos *et al*., 1989). In the study of soybean seeds, it was reported that drought stress was associated with decreasing germination percentage and germination rate (Vieira *et al*., 1992). Researchers also reported on canola (*Brassica napus*) in a test that the germination index has decreased due to drought stress (Khaksar *et al*., 2013). Based on the results obtained from this study, it can be stated that different irrigation rates have affected seed germination and given that whatever the germination rate of seeds is higher, the emergence rate will be higher, so they have a direct relationship with each other.

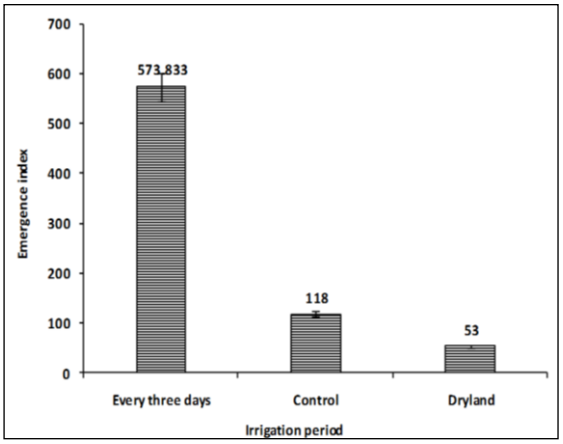

Fig. 1. effect of irrigation period on emergence index in guar plant.

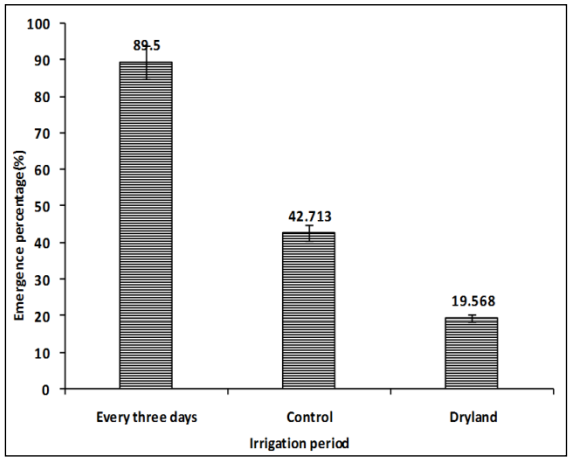

Fig. 2. effect of irrigation period on emergence percentage in guar plant.

Leaf area index

The results showed that rainfed, control and irrigation every three days treatments, respectively with averages of 279.83, 551.00 and 771.83 were in different statistic groups (Fig. 3). The leaf area index is defined as the ratio of leaf to area and is considered as the main factor determining the physiological function of the product. Previous studies have shown that the decreasing plant photosynthesis activity,

growth stops and the increasing leaf loss rates may be due to a decrease in leaf area that occurs under the influence of water stress. Although water deficit in vegetative growth stage has less effect on final yield in comparison with water deficit in flowering stage (plant sensitivity stage) and grain filling stage, but it is important because it effects on leaf expansion (photosynthetic agent) and stem development, which greatly reduces the accumulation of material in these organs (Nesmithe and J. T. Ritchie, 1992). Leaf as the main organ of photosynthesis in the plant produces enough physiological source to use light as much as possible and provide the necessary material to fill the grain and increase the yield, therefore, as the number and area of leaves increase, it will have a positive effect on the growth of the plant (Gardner *et al*., 1989). Lack of moisture through reducing leaf production and growth and increasing leaf aging reduces leaf area index (Cakir, 2004). In a study on mung bean (*Vigna radiate*), the leaf area had reduced when the plant exposed to water shortages and by doing this, it prevented the moisture of plant and soil before the plant was fully ripened (Shokouhfar and Abofatilehnezhad, 2013). The researchers reported that leaf area index in 10 days irrigation interval was more than 12 days, and in 12 days irrigation interval was more than 14 days and had a significant difference. So we conclude that with increasing irrigation, the leaf area index was increased (Ghatavi *et al*., 2012).

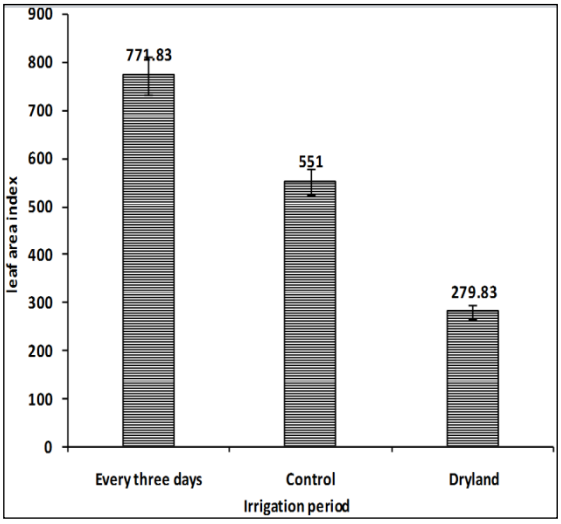

Fig. 3. effect of irrigation period on leaf area index in guar plant.

stem diameter

The results showed that irrigation had a significant effect on the stem diameter in podding step, that dry land treatment and irrigation every three days treatment compared in different groups of Duncan grouping, but no significant differences were observed between them and the control treatment. Also at the time of harvest, the stem diameter of control and irrigation every three days treatment had no significant differences, but both of them were significantly different with rainfed treatment. So at the podding step, rainfed treatment with an average of 3.8333 was the minimum value and irrigation every three days treatment with average of 5.6667 was the maximum value.

Also at the harvesting time, rainfed treatment with an average of 6.5000 was the minimum value and irrigation every three days treatment with average of 8.6667 was the maximum value and both of them were significantly different, but Comparison of stem diameter in the two stages showed that the stem diameter of control treatment in harvesting time (8.1667) had a significant increase compared to the podding time (4.6667) and made a significant difference with rainfed treatment (Fig. 4).

Stem diameter is influenced by some factors such as density, genotype and also environmental factors such as drought stress and heat that the disruption of each of them can have a negative effect on the stem diameter. It seems that plants that have more mature stalks will be able to supply more reproductive units and will result in more dry matter (Hashim and Schinter, 1988; Khajehpoor, 2004).

Researchers in safflower plant said that under the influence of irrigation regimes, stem diameter in plant was significantly reduced (Nabipour *et al*., 2007). Drought stress reduces stem diameter by decreasing vegetative growth and decreasing cell division (Sadras *et al*., 1998). It was reported that in Oregano herb, the diameter of the stem decreases with increasing irrigation intervals (Gerami *et al*., 2016).

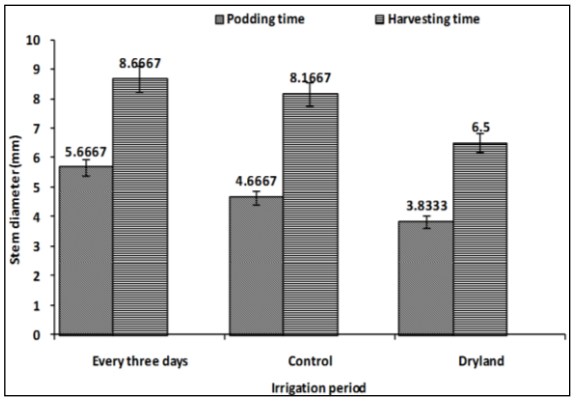

Fig. 4. effect of irrigation period on stem diameter in guar plant.

plant height

Irrigation at different phonological stages (flowering time, podding time and harvesting time) had a significant effect on the treatments. At flowering time, the lowest plant height was related to rainfed treatment (13.167) and highest plant height was related to irrigation every three days treatment (25.333) and all three treatments were significantly different.

At the podding time, the lowest plant height was related to rainfed treatment (14.333) and highest plant height was related to irrigation every three days treatment (27.667) and all three treatments were significantly different. Although the second irrigation of the control treatment compensated for the difference in height, but the differences remained significant.

Also, at the harvesting time, the lowest plant height was related to rainfed treatment (39.167) and highest plant height was related to irrigation every three days treatment (83.333) and all three treatments were significantly different (Fig. 5).

In soybean, reduced water availability, especially in the early flowering period, reduced the growth rate and reduced reproductive growth and had a negative effect on plant height and reduced crop Yield (Korte *et al*., 1993) and it was clearly seen in this study. It was observed that Guar's height decreased in the experimental conditions of this study due to water shortage. The higher plant height in irrigation interval of 10 days than 20 days can be attributed to the unlimited growth of chickpea (*Cicer arietinum* L.) and vegetative growth stimulation due to increased irrigation frequencies and also the increase in the duration of chickpea growth period (Rezaeyan zadeh, 2008; Yousefi *et al*., 1997).

Table 1. Analysis of variance of evaluated traits of Guar in three diferent levels of irrigation**.**

(S.O.V)	(DF)	(MS)			
		Emergence index	Emergence percentage	Stem diameter in podding time	Stem diameter in harvesting time
(Y)	1	364.5000^{ns}	0.00000168^{ns}	1.38888889^{ns}	0.88888889^{ns}
REP(Y)	4	275.7778	0.00112921	0.55555556	1.55555556
(Treat)	2	483276.3889**	0.76153157**	5.05555556*	7.72222222*
(Treat*Y)	2	60.1667^{ns}	0.00000230^{ns}	0.38888889^{ns}	1.72222222^{ns}
ERROR	8	166.8611	0.00060767	0.63888889	1.38888889
(CV)	-	5.202831	4.872365	16.61111111	15.15229

ns=non significant

* and ** = respectively significant in level of 5% and 1%

Continue of table1. Analysis of variance of evaluated traits of Guar in three diferent levels of irrigation.

(S.O.V)	(DF)	(MS)			
		Leaf area index	Plant height in flowering time	Plant height in podding time	Plant height in harvesting time
(Y)	1	490.8889^{ns}	0.0555556^{ns}	8.0000000^{ns}	29.388889^{ns}
REP(Y)	4	2694.0556	2.2222222	3.1666667	60.055556
(Treat)	2	364362.7222**	247.7222222**	298.6666667**	2926.388889**
(Treat*Y)	2	235.3889^{ns}	1.7222222^{ns}	0.0000000^{ns}	13.722222^{ns}
ERROR	8	1894.2222	3.1388889	3.2500000	27.305556
(CV)	-	8.146921	9.812442	8.072130	8.512081

ns=non significant, * and ** = respectively significant in level of 5% and 1%

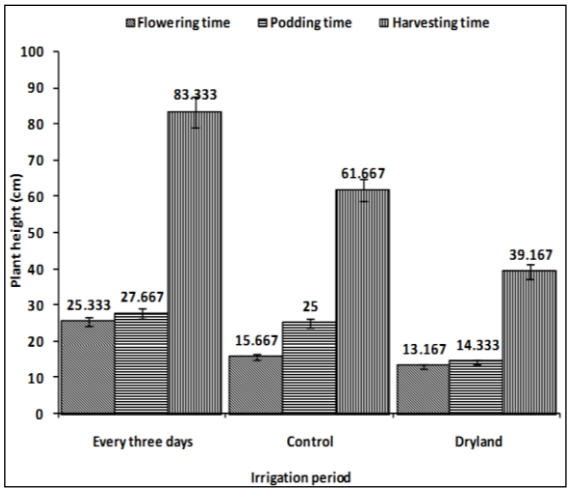

Fig. 5. effect of irrigation period on plant height in guar plant.

Conclusion

The results of the experiment indicated that irrigation every three days had a significant positive effect on all studied traits except stem diameter and due to the fact that the important part of this plant is seed and gum obtained from it, the grain yield is more considered and therefore, due to the direct relationship between plant height, emergence index and emergence percentage with grain yield, irrigation every three days is introduced as the most suitable treatment for reducing costs and harvesting the highest yield in the shortest possible time.

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