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Qualitative and morphologic response of forage sorghum as affected by irrigation interval and planting pattern

[1]Seyed Gholam Reza Moosavi, [2]Mohamad Javad Seghatoleslami and [3]Elham Ansari-nia

[1,2]Assistant Professor of Islamic Azad University, Birjand Branch, Birjand, Iran
[3]Member of Young Researchers Club, Islamic Azad University, Birjand Branch, Birjand, Iran

Seyed Gholam Reza Moosavi, Mohamad Javad Seghatoleslami and Elham Ansari-nia; Qualitative and morphologic response of forage sorghum as affected by irrigation interval and planting pattern

ABSTRACT

In order to study the effect of irrigation intervals and planting pattern on the morphological and qualitative traits of forage sorghum was conducted an experiment was conducted at Agricultural Research Station of Azad University, Birjand Branch, Iran in year 2006. The experimental design was split plot in form RCBD with three replications and with 4 levels of irrigation interval (5, 10, 15 and 20 days) as main plots and 2 levels of planting pattern (one row above the furrow and two rows within the furrow) as sub plots. The results showed that the effect of planting pattern and interaction irrigation interval × planting pattern on these traits was not significant but water deficit stress decreased height, diameter, number leaf of main stem and number of tiller in plant, significantly so that with increasing irrigation interval from5 to 20 days, plant height, leaf number per main stem and stem diameter in the first cut reduced 26.6, 23.2 and 28.5 percent, respectively and in the second cut, these traits and tiller number per plant declined 55.8, 40.2, 40.1 and 17.65 percent, respectively. Also, irrigation interval had a significant effect on the percentage of crude protein, crude fiber, ash and protein yield of the first and second cut. The comparison of mentioned traits average showed that with the increase of irrigation interval, the percentage of crude protein, crude fiber and ash percent decreased in both cuttings significantly. In the first cut, 5 days irrigation interval with the production of 0.90 ton/ha had the highest yield of protein and 20 days irrigation interval with 0.411 ton/ha had the lowest yield of protein. Also in the second cutting the increase of the irrigation interval from 5 to 20 days caused crude protein yield decreased from 1.2 to 0.2 ton/ha. The results showed that the 5 days irrigation interval allocated to itself the highest vegetative growth, yield and more quality of forage but with respect to water limitation and intense need to forage in the region, in order to scrounge in the amount of consumption water in the level unit and increase of under cultivation lands, we can use 10 days irrigation interval for the planting of forage sorghum in Birdjand region.

Key words: sorghum, morphological and qualitative traits, irrigation, planting pattern.

Introduction

Water is the single most limiting resource for world agriculture and food production, highly exceeding other key limitations. Large amount of water is used in field production of food crops, leading to a deficit of fresh water resources in many arid or semi-arid areas in the world. Water deficit (commonly known as drought) can be defined as the absence of adequate moisture necessary for a plant to grow normally and complete its life cycle [32].

Under dry environmental conditions plants develop different mechanisms to resist and survive. These mechanisms are commonly based on morphological and qualitative traits that delay the water deficit [10]. Therefore, understanding morphological responses of plants under stress conditions is important.

Sorghum is becoming an increasingly important forage crop in many regions of the world due to its high productivity and ability to utilize water efficiently even under drought conditions [26]. Forage sorghum which is a major summer forage crop for feed production, has greater eliability salt and drought tolerance than other summer forages. There are a number of potential forage sorghum varieties which may be appropriate at arid and semi-arid regions [22].

Rosental *et al.* [23] were reported adverse effects on stem height, LAI of sorghum as soil water deficit developed. Water deficits also affected total number of leaves of sorghum [4]. Sorghum can response to additional irrigation by stem elongation and increase of yield [24, 28].

Kazemi–Arbat *et al.* [11] were reported that highest plant height (106.9 cm) of forage sorghum

Corresponding Author

Seyed Gholam Reza Moosavi, Assistant Professor of Islamic Azad University, Birjand Branch, Birjand, Iran
E-mail: s_reza1350@yahoo.com

was obtained when 8 days irrigation interval applied in comparison 12, 16 and 20 days irrigation intervals but number tiller no affected by irrigation intervals.

Nakhoda *et al.* [19] were reported that water deficit stress reduced protein yield and qualitative traits such as leaf/stem ratio, crud protein, crude fiber and ash percentage of forage millet.

Yılmaz *et al*. [31] reported that morphological traits and dry matter yields were significantly affected by planting patterns in corn hybrids. Bullock *et al.* [6] found that the dry weight of plant and morphological traits in the arrangement of square cultivation was superior in comparison with the arrangement of rectangle cultivation.

This research was conducted to determine effect of different irrigation intervals and planting patterns on morphological and qualitative traits of forage sorghum.

Materials and Methods

The experiment was conducted in the Agricultural Research Station of Islamic Azad University, Birjand branch (latitude: 32^0 52'; longitude: 59^0 13' and 1400 m above sea level), Iran during 2006 spring and summer seasons. The soil texture was sandy loam with 8.25 pH, 0.67% organic matter and 7.6 ms/cm EC.

The experiment was a split plot in the form of randomized complete block design (RCBD) with three replications. Irrigation interval with four levels (5, 10, 15 and 20 day) was as main plot and planting pattern with two levels (one row above the furrow and two rows within the furrow) was as sub plot. The distance between plots and blocks (replications) were 0.5 and 2.5 meter, respectively. The used sorghum hybrid was speed feed. Also the distance between row in one row and tow rows were 50 and 25 cm, respectively. The plant density was 200000 plants per hectare. The size of each plot was 3m × 7m and consisted of 6 rows.

The fertilizer was applied according to the region tradition. The weeds were three times controlled by hand during growth stages. The seeds of forage sorghum sowing in middle spring 2006 year and after 4 weeks (in four leaf stage) young plants were thinning for plant density of consist (200000 plants/ha) .

To measure morphological traits, 10 plants randomly selected from two middle rows and their plant height, stem diameter, leaf and tiller number per plant were measured. At time of 10 percent flowering of forage sorghum, in each plot, two middle rows with 4 meters length were harvested. The Crude protein yield was estimated by multiplying protein parentage by dry yield of forage and quality parameters like crude protein, crude fiber and ash percent were determined using the methods given by AOAC [1].

Finally, the data were analyzed by software MSTAT-C for each trait and the means were compared by Duncan Multiple Range Test at 5% level.

Results and Discussion

1- Morphological traits:

The analysis of variance showed that irrigation interval had significant effect on of morphological traits in both two cut but the effect of planting pattern and interaction irrigation interval × planting pattern on this traits was not significant (Table 1).

Table 1: Mean square for effects of irrigation intervals and planting patterns on morphological traits of forage sorghum.

		Cut 1			Cut 2			
S.O.V	df	Stem height	Leaf number per main stem	Stem diameter	Stem height	Leaf number per main stem	Stem diameter	Tiller number per plant
Replication	2	128.8 ^{ns}	0.623 *	1.667^{ns}	496.9 ^{ns}	0.543 ^{ns}	1.145 ^{ns}	1.41 ^{ns}
Irrigation Interval (II)	3	1522.6*	6.113**	14.112*	7606.7**	24.47**	25.99**	2.56*
Error (a)	6	296.66	0.094	1.531	112.75	0.436	0.93	0.318
Planting Pattern (PP)	1	0.189 ^{ns}	0.589 ^{ns}	0.049 ^{ns}	321.06 ^{ns}	0.23 ^{ns}	0.84 ^{ns}	16.25 ^{ns}
II×PP	3	8.172 ^{ns}	0.118 ^{ns}	0.801 ^{ns}	42.42 ^{ns}	0.281 ^{ns}	2.01 ^{ns}	5.53 ^{ns}
Error (b)	8	91.22	0.634	2.657	115.3	0.395	0.71	3.34

*, ** and ^{ns} that is significant at $p < 0.05$, $p < 0.01$ levels and non-significant, respectively

The results of this study showed that with increase of irrigation interval in both cut height of main stem, leaf number per main stem and diameter of main stem decreased, significantly. Also in second cut, tiller number per plant with increase of irrigation interval from 5 to 20 days decreased from 9.1 to 7.5 (Table 2). With increasing irrigation interval from5 to 20 days, plant height, leaf number per main stem and stem diameter in the first cut reduced 26.6, 23.2 and 28.5 percent, respectively. In the second cut, these traits and tiller number per plant declined 55.8, 40.2, 40.1 and 17.65 percent, respectively (Table 2). It can be said that the effect of water stress on root growth and mineral and water absorption was more in the second cut than the first one.

Table 2: Effect of irrigation intervals on morphological traits of forage sorghum.

	Cut 1			Cut 2			
Irrigation intervals (day)	Stem height	Leaf number per main stem	Stem diameter	Stem height	Leaf number per main stem	Stem diameter	Tiller number per plant
5	113.1 a	9.5 a	13.0 a	143.8 a	9.4 a	10.2 a	9.1 a
10	108.9 a	7.9 b	10.8 b	108.3 b	6.7 b	9.7 a	8.1 b
15	84.2 b	7.5 bc	10.9 b	77.5 c	5.1 c	6.6 b	8.0 b
20	83.0 b	7.3 c	9.3 b	63.6 c	4.7 c	6.1 b	7.5 b

Means followed by the same letter symbols in each column-according to Duncan's multiple range test are not significantly (P<0.05) different from each other.

In general water deficit stress (increase of irrigation interval) caused reduction of growth ability of plant, so that reduced stem elongation and tillering of forage sorghum. The cause of this response can be reduction cell division and photosynthesis under water deficit stress conditions. In other words, water increases cellular turgidity, and it increases cells size and capacity, therefore, diameter of plant organs increases. When the plant encounters with inadequacy of water, the turgidity will be decreased or never increases, therefore, the stem diameter is reduced. The result of this research is according with reports of many experiments [9, 17, 28]. Also, Haji-Hassaniasl *et al.* [8] stated that water deficit stress had negative significant effect on plant height and stem diameter and Saberi *et al.* [25] reported that water deficit stress reduced the number of tillers pre plant in forage sorghum.

The results showed that irrigation interval had significant effect on all of qualitative traits, except leaf: stem ratio but planting pattern and interaction irrigation interval × planting pattern had not significant effect on these traits (Table 3).

Table 3: Mean square for effects of irrigation intervals and planting patterns on qualitative traits of forage sorghum.

		Cut 1				Cut 2			
S.O.V	df	% protein	% fiber	% ash	L/s	% protein	% fiber	% ash	L/s
Replication	2	0.016 ^{ns}	0.296 ^{ns}	0.053 ^{ns}	0.047 ^{ns}	0.096 ^{ns}	2.007 *	0.283 ^{ns}	0.065 ^{ns}
Irrigation Interval (II)	3	3.269**	16.67**	6.78 **	1.152 ^{ns}	25.74**	20.874**	5.328**	0.322
Error (a)	6	0.023	0.157	0.058	0.097	0.091	0.064	0.092	0.082
Planting Pattern (PP)	1	0.001 ^{ns}	0.202 ^{ns}	0.001 ^{ns}	0.04 ^{ns}	0.04 ^{ns}	0.202 ^{ns}	0.001 ^{ns}	0.024 ^{ns}
II×PP	3	0.004 ^{ns}	0.076 ^{ns}	0.025 ^{ns}	0.01 ^{ns}	0.019 ^{ns}	0.007 ^{ns}	0.016 ^{ns}	0.07 ^{ns}
Error (b)	8	0.014	0.077	0.136	0.021	0.08	0.261	0.047	0.05

*, ** and ^{ns} that is significant at $p < 0.05$, $p < 0.01$ levels and non-significant, respectively

The means comparison of these traits indicated that with increase of irrigation interval from 5 to 20 days decreased protein percent from 13.3 to 11.9 % (Fig. 1) and ash percent from 12.1 to 9.7 % (Table 4) in the first cut. Also with increase of water deficit stress protein percent decreased from 14.9 to 12.4 % (Fig. 2) and ash percent from 12.1 to 9.7 % (Table 4) in the second cut, significantly. The reason for increasing protein percent in the second cut may be due to the younger plant tissue as result of short growth period as compared with the first.

The cellular growth on plant is the activity that is very sensitive to water deficiency. The decreasing of water potential in meristem is a cause for lessening of the turgor (potential) pressure, that isn't sufficient for the cell growth. In other words, stomata closure, the sensitivity of cell division and cell elongation under water deficit conditions are some reasons for the decrease in photosynthesis, growth and dry matter production and protein content as affected by water deficit stress. Decreasing of protein percentage reported by many researchers such as Misra [14], Nakhoda *et al.* [19], sasani *et al.* [27] and Haji-Hassaniasl *et al.* [8] in dry stress conditions and lack of repeated synthesis in these conditions.

This fact that ash percent demonstrates amount of mineral articles in plant texture [Modeer Shanechi], and noting that absorption of these materials are decreased in low water environments by the plant [6], therefore water deficit stress is possible to decrease the ash percent. Decrease in provender ash in low water environments is reported by Wilson [30] and Paygozar *et al.* [21]. Also, results of Haji-Hassaniasl *et al.* [8] showed that protein and ash percent of forage sorghumr declined with reduction of available water, significantly which is in agreement with the results of the current study.

Means comparison for leaf: stem dry matter ratio in first cut showed that the treatments of irrigation could not make a considerable change in this trait, so that it only slightly increased from 1 to 1.2 (Table 4).

The reason for the slight change of leaf: stem ratio between different irrigation intervals could be related to the rather uniform effect of applied stress on dry matter accumulation and dry weight loss of all aerial organs of the plants. The results of Nakoda [19] study on Nutrifeed millet showed non-

significant effect of water deficit stress on leaf: stem ratio which is in agreement with the results of the current study in first cut. Also, Buxton [7] and Afsharmanesh [2] in alfalfa and Nabati and Resvanimoghadam [18] on millet, sorghum and corn of forage stated that with the increase in the intensity of drought stress, leaf: stem ratio increased which is in agreement with the results of the current study in second cut. While the studies of Akaalikhani [3] on forage sorghum and Tabatabaei [29] on millet showed the decrease in leaf: stem ratio under water deficit stress.

The results of analysis of variance showed that crude protein yield in both cuts was significantly affected by irrigation interval but planting pattern and interaction irrigation interval × planting pattern had not significant effect on this trait (Table 5).

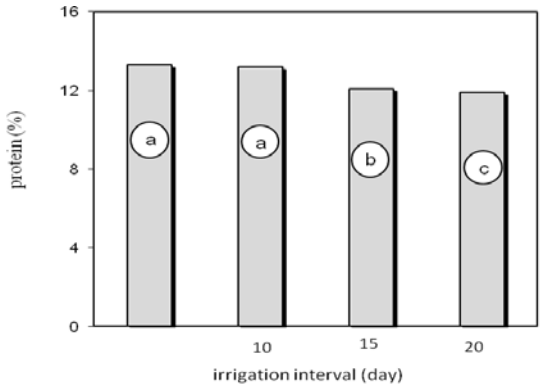

Fig. 1: Effect of irrigation intervals on protein percent of forage sorghum in first cut.

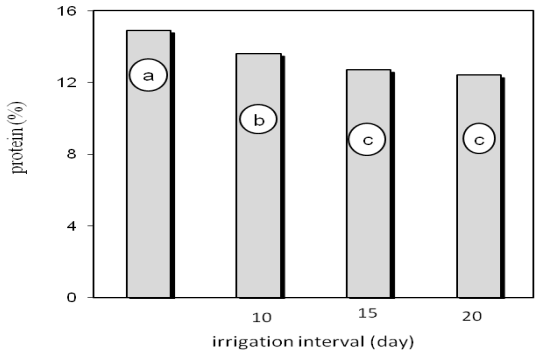

Fig. 2: Effect of irrigation intervals on protein percent of forage sorghum in second cut.

Table 4: Effect of irrigation intervals on qualitative traits of forage sorghum.

Irrigation	Cut1			Cut2		
intervals (day)	% fiber	% ash	L/s	% fiber	% ash	L/s
5	18.2 a	12.1 a	1.1 a	21.8 a	11.6 a	0.73 b
10	17.5 b	11.0 b	1.0 a	21.0 b	10.7 b	0.86 ab
15	15.9 c	10.1 c	1.1 a	19.1 c	9.8 c	0.95 a
20	14.4 d	9.7 d	1.2 a	17.7 d	9.5 c	1.14 a

Means followed by the same letter symbols in each column-according to Duncan's multiple range test are not significantly (P<0.05) different from each other

Table 5: Mean square for effects of irrigation intervals and planting patterns on protein yield trait of forage sorghum.

S.O.V	df	Cut 1	Cut 2
		Protein yield	Protein yield
Replication	2	0.006 ^{ns}	0.019 ^{ns}
Irrigation Interval (II)	3	0.047*	0.345**
Error (a)	6	0.005	0.007
Planting Pattern (PP)	1	0.006 ^{ns}	0.023 ^{ns}
II×PP	3	0.001 ^{ns}	0.005 ^{ns}
Error (b)	8	0.002	0.007

*, ** and ^{ns} that is significant at $p < 0.05$, $p < 0.01$ levels and non-significant, respectively

According to means comparison, in the first cutting of the 5 days irrigation interval with the production of 0.90 ton/ha had the highest protein yield and the 20 days irrigation interval with 0.411 ton/ha had the lowest yield of protein (Fig. 3). Also, in the second cutting the increase of the irrigation interval from 5 to 20 days caused crude protein yield decrease from 1.2 to 0.2 ton/ha ton/ha (Fig. 4). The result of this research is according with reports of some experiments [12,13,16,20,28]. The reason for crude protein yield loss under water deficit stress could have been the decrease in crude protein percentage and also the decrease in dry matter production because crude protein yield is the product of dry matter yield and crude protein percentage of forage.

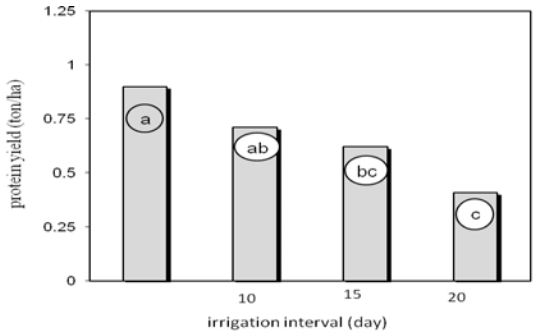

Fig. 3: Effect of irrigation intervals on protein yield of forage sorghum in first cut.

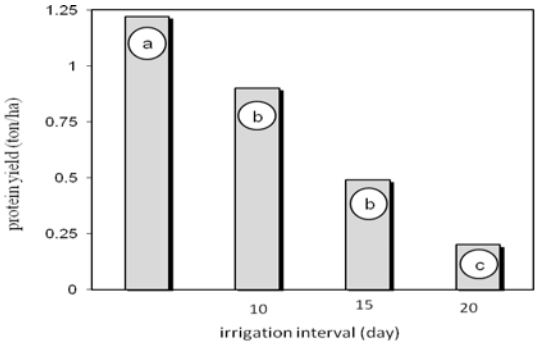

Fig. 4: Effect of irrigation intervals on protein yield of forage sorghum in second cut.

Conclusions:

The results of this research showed that water stress had negative effect on forage production and qualitative traits but planting pattern had not significant effect on these traits. Also with respect to water limitation and intense need to forage in the region, in order to scrounge in the amount of consumption water in the level unit and increase of under cultivation lands, we can use 10 days irrigation interval for the planting of forage sorghum in Birdjand region.

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