Effect of Irrigation Intervals and Planting Patterns on Yield and Qualitative Traits of Forage Sorghum

Seyed Gholam Reza Moosavi, Mohamad Javad Seghatoleslami, Hamed Javadi and Elham Ansari-nia

ABSTRACT

In order to study the effect of irrigation intervals and planting pattern on the yield, yield components and qualitative traits of forage sorghum (Speedfeed variety) was conducted an experiment in Research Field of Islamic Azad University, Birjand, Iran in 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 into the furrow) as sub plots. The irrigation intervals had a significant effect on the yield and yield components of forage sorghum but the planting pattern and the interaction of the irrigation intervals x planting pattern had no significant effect on these traits. The increase in irrigation interval from 5 to 20 days decreased the weight of the dry leaf, stem, ear and total fresh weight (sum of two cuttings) by 57.2, 72.1, 69 and 66.9 percent, respectively. The total dry forage in 5 days irrigation interval was 16.9 ton/ha which in comparison to 10, 15 and 20 days irrigation intervals advanced by 19.4, 44.3 and 66 percent, respectively. The irrigation intervals had a significant effect on the leaf to stem ratio and protein yield (sum of two cuttings). The comparison of mentioned traits averages in this experiment showed that with the increase of irrigation intervals, the leaf to stem ratio increased but protein yield decreased, significantly. The yield of crude protein with the increase of irrigation interval from 5 to 20 days decreased by 66.5 percent. The result 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.

Key word: forage sorghum, irrigation intervals, planting pattern, yield, qualitative traits.

Introduction

Drought is a worldwide problem, constraining global crop production seriously and recent global climate change has made this situation more serious [8,10,34,35,36,37,38,39,40,41,42,43,44,45]. Under dry environmental conditions plants develop different mechanisms to resist and survive. These mechanisms are commonly based on morphological and physiological responses such as LAI reduction, that delay the water deficit [13].

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]. Water scarcity and drought are the main features of the dry areas. 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. In regions where water scarcity is the principal limiting factor for cultivation, farmers are interested in growing crops that are able to adapt to drought conditions [4,21].

Sorghum is becoming an increasingly important forage crop in many regions of the world [32]. Its high resistance to drought makes it a suitable crop for semi-arid areas [31]. Sorghum can respond to additional irrigation by stem elongation and increase of yield [27,29].

[23] were reported that water deficit stress reduced quantitative and qualitative yield included total fresh weight, total dry weight, leaf dry weight, stem dry weight, protein yield and leaf/stem ratio of forage millet " nutrifeed " [14] were reported that significant difference between irrigation intervals of 8, 12, 16 and 20 days for fresh-feed yield and dry-feed yield were obtained in forage sorghum. In this study, highest fresh and dry-feed yield (52.4 and 15.5 ton/ha, respectively) obtained when 8 days irrigation interval was applied. [25] were reported adverse

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effects on LAI of sorghum as soil water deficit developed.

The objective of this research was to study the effects of irrigation intervals and planting patterns on yield and qualitative traits of forage sorghum.

Materials and Methods

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

The experimental design used was a split plot in the base RCBD with three replications, in which the main plots were the irrigation intervals, and the sub-plots were planting pattern treatments. The irrigation intervals were four levels (5, 10, 15 and 20 days) and planting patterns were two levels (one row above the furrow and two rows into the furrow). The used sorghum hybrid was Speedfeed. The distance between sub and main plots and blocks (replications) were 0.5, 1.5 and 2.5 meter, respectively. Also the distance between row in one row and tow rows were 50 and 25cm, respectively. The plant density was 200000 plants per hectar. The size of each plot was 3m × 7m and consisted of 6 rows. The fertilizer was applied according to the regions 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 of (in four leaf stage) young plants were thining for reach to plant density of consist (200000 plants/ha).

After thining, in order to study of effect irrigation intervals on physiological traits, with 10 plant density of consist (200000 plants/ha).

Variance analysis for effects of irrigation intervals and planting patterns on yield and yield components of forage sorghum.

Table 1: Variance analysis for effects of irrigation intervals and planting patterns on yield and yield components of forage sorghum.

<table>
<thead>
<tr>
<th>SOV</th>
<th>df</th>
<th>Total Fresh weight</th>
<th>Leaf dry weight</th>
<th>Stem dry weight</th>
<th>Ear dry weight</th>
<th>Total dry weight</th>
<th>Ratio of Leaf to stem</th>
<th>Total protein yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>175.67**</td>
<td>1.48**</td>
<td>3.37**</td>
<td>0.075**</td>
<td>10.44**</td>
<td>0.039**</td>
<td>0.032**</td>
</tr>
<tr>
<td>Irrigation intervals (A)</td>
<td>3</td>
<td>2697.50**</td>
<td>19.39**</td>
<td>50.16**</td>
<td>0.17**</td>
<td>142.40**</td>
<td>0.236**</td>
<td>0.638**</td>
</tr>
<tr>
<td>Error a</td>
<td>6</td>
<td>81.30</td>
<td>0.62</td>
<td>2.15</td>
<td>0.023</td>
<td>5.21</td>
<td>0.047</td>
<td>0.013</td>
</tr>
<tr>
<td>Planting patterns (B)</td>
<td>1</td>
<td>236.60**</td>
<td>2.68**</td>
<td>2.03**</td>
<td>0.006**</td>
<td>9.79**</td>
<td>0.05**</td>
<td>0.052**</td>
</tr>
<tr>
<td>A × B</td>
<td>3</td>
<td>30.27**</td>
<td>0.114**</td>
<td>0.522**</td>
<td>0.001**</td>
<td>0.999**</td>
<td>0.004**</td>
<td>0.004**</td>
</tr>
<tr>
<td>Error b</td>
<td>8</td>
<td>71.53</td>
<td>0.336</td>
<td>1.98</td>
<td>0.008</td>
<td>3.352</td>
<td>0.017</td>
<td>0.007</td>
</tr>
<tr>
<td>CV (%)</td>
<td>-</td>
<td>17.44</td>
<td>11.47</td>
<td>23.88</td>
<td>26.01</td>
<td>16.03</td>
<td>13.41</td>
<td>11.43</td>
</tr>
</tbody>
</table>

ns Non Significant at 0.05 probability level and *, ** Significant at 0.05 and 0.01 probability levels, respectively

The means comparison of this traits indicated that with increase of water deficit stress decreased yield and yield components, significantly (Table 2). In summary with increase of irrigation interval from 5 to 20 days, total fresh, total dry, leaf dry, stem dry and ear dry weight of forage sorghum decreased 66.9, 66, 57.3, 72.1 and 69 percent, significantly. The results showed that maximum of total fresh yield (72.58 ton/ha) was obtained with the 5 days irrigation interval and treatment of 20 days irrigation interval with production of 24.03 ton per hectar had lowest total fresh yield. Irrigation intervals 5, 10, 15 and 20 days produced 16.9, 13.63, 9.42 and 5.74 ton/ha dry matter, respectively (Table 2). The moisture stress decreases assimilate supply by decreasing leaf area and duration and disrupting nutrient intake and
transfer and hence, it decreases yield components and yield.

Although stomata closure generally occurs when plants are exposed to drought but water stress is a multi-dimensional stress, which causes different physiological and biochemical effects on plants. Such effects may contain reduction in cell division and thus retardation of cellular growth, decrease in photosynthesis, closure of stomata and changes in the amount of chlorophyll [5,12,30]. Total this occurs caused decline in photosynthesis and growth of plant and yield decreased.

### Table 2: Effect of irrigation intervals on yield and yield components of forage sorghum

<table>
<thead>
<tr>
<th>Irrigation intervals (day)</th>
<th>Total fresh weight (ton/ha)</th>
<th>Leaf dry weight (ton/ha)</th>
<th>Stem dry weight (ton/ha)</th>
<th>Total dry weight (ton/ha)</th>
<th>Ratio of leaf to stem</th>
<th>Total protein yield (ton/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>72.56 a</td>
<td>7.16 a</td>
<td>9.23 a</td>
<td>0.536 a</td>
<td>16.90 a</td>
<td>0.78b</td>
</tr>
<tr>
<td>10</td>
<td>57.91 b</td>
<td>6.99 a</td>
<td>7.12 b</td>
<td>0.491 a</td>
<td>13.63 b</td>
<td>0.86b</td>
</tr>
<tr>
<td>15</td>
<td>39.48 c</td>
<td>4.49 b</td>
<td>4.68 c</td>
<td>0.227 b</td>
<td>9.42 c</td>
<td>0.92b</td>
</tr>
<tr>
<td>20</td>
<td>24.03 d</td>
<td>3.06 c</td>
<td>2.57 d</td>
<td>0.166 b</td>
<td>5.74 d</td>
<td>1.19a</td>
</tr>
</tbody>
</table>

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.

**Ratio of leaf to stem:**

The results showed that irrigation intervals had significant effect on ratio of leaf to stem of forage sorghum but the planting pattern and interaction between irrigation interval × planting pattern had not significiation effect on this trait (Table 1). The means comparison of this trait indicated that with increase of water deficit stress increased ratio of leaf to stem of forage sorghum, significantly. So that, with increase of irrigation interval from 5 to 20 days ratio of leaf to stem weight in forage sorghum increased 52.6 percent (Table 2).

Afsharmanesh [1] stated that the effect of water deficit stress on leaf/stem ratio of alfalfa was significant and with the increase in the intensity of drought stress, leaf/stem ratio increased. Also, Buxton [7] reported that alfalfa leaf/stem ratio increased by 19% under drought stress conditions which supports the results of the current study.

**Total protein yield:**

The analysis of variance showed that irrigation intervals had significant effect on total protein yield of forage sorghum but the planting pattern and interaction between irrigation interval × planting pattern had not significiation effect on this trait (Table 1). The total protein yield (sum two cutting) with the the increase of irrigation interval from 5 to 20 days decreased from 2.12 to 0.61 ton/ha. In the other hand, total protein yield decreased by 66.5% (Table 2). The results of this research which is accord with reports of many experiment [6,17,18,20,24,28].

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. The cellular growth on plant is the activity that is very sensitive to water efficiency. The decreasing of water potential in meristem is a cause for reduction of the turgor (potential) pressure, that isn’t enough for the cell growth; this subject is one of the causes of decreasing protein synthesis and declining the cells growth. Also, the other cellular alterations such as decreased protein content, increased ribonuclease activity, protein hydrolysis, hydrogen peroxide concentration and dissociation of polyribosomes are also known to occur in plants exposed to water stress [15,22]. Decreasing of protein percentage and yield reported by many researchers such as Misra [19], Nakhooda et al., [23], sasani et al., [28] and Haji Hassani Asl et al., [11] in dry stress conditions.

**Dry weight one plant:**

The study of physiological traits showed that dry weight each plant of sorghum in 52 days after emergence and receives of 743 GDD in irrigation intervals of 5, 10, 15 and 20 days was 9.1, 6.6, 5.3 and 4 gram, respectively (Figure 1). In the order hand, increase of irrigation interval form 5 to 20 days caused 56 percent reduction of dry matter accumulation of each plant at first harvest.

Also 5 days irrigation interval had the heighest biomass yield of one plant (25.2 g) at the first cut time. This quantity was 14, 50 and 49.9 percent more than 10, 15 and 20 days irrigation intervals treatments, respectively. It seems that the reduction of photosynthesis as a result of stomata closing and
leaf area reduction caused the plant growth reduction. Thus with increasing irrigation interval unit 15 days, plant biomass declined but more irrigation interval had not any significant effect on dry matter accumulation at the first cutting time (Figure 1). 20 days declined biomass yield of one plant (78.6%). This caused significant reduction of forage yield and yield components.

At harvest second cut time, dry weight each plant in irrigation intervals of 5, 10, 15 and 20 days was 54.3, 44.3, 27.8 and 11.6 gram, respectively. In other words, increasing irrigation interval from 5 to

![Fig. 1](image1.png)

**Fig. 1:** The effect irrigation intervals of dry weight of one plant of forage sorghum during first cut.

**Leaf area index (LAI):**

In away that observe in Figure 2, with time leaf area index (LAI) increased in all of irrigation intervals but in irrigation intervals of 5 and 10 days increase of LAI was faster in comparison with irrigation interval 15 and 20 days. At harvest of first cut time LAI of irrigation intervals 5, 10, 15 and 20 days was 4.95, 4, 3.5 and 3.1, respectively.

Maximum LAI was 13.3 that belonged to irrigation interval of 5 days at harvest of second cut time, that was 1.3, 2.6 and 3.9 times more than 10, 15 and 20 days irrigation interval treatments, respectively. LAI increasing in the second cutting was related to tillering enhancement and more developing of roots in the soil (more absorption of water and nutrients).

![Fig. 2](image2.png)

**Fig. 2:** The effect of irrigation intervals on leaf area index of forage sorghum during the first cut.

The increase or reduce in LAI has a direct effect on plant growth rate. This index is the main tool for enhancing photosynthesis power and assimilates production. Also, Lizaso et al., [16] stated that the average absorbed photosynthetic active radiation (PAR) by leaf area at silking stage was the determining factor of corn grain number and the decrease in grain yield had a high correlation with the decrease in corn leaf area. LAI reduction under water deficit condition is a main reason for forage yield reduction. Probably, the decrease in leaf area is a response to stress for adapting water deficit conditions and survival through decreasing cell turgor pressure and the resulting decrease in leaf growth and development as well as shedding of older leaves for decreasing transpiring area of the plant.
Conclusion:

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 the 5 days irrigation interval allocated to itself the highest yield of fresh and dry 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, Iran.

References

7. Buxton, D.R., 2004. Growing quality forages but with respect to water irrigation interval allocated to itself the highest yield of fresh and dry forage but with respect to water