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ORIGINAL ARTICLE

Effects of Plant Density and Sowing date on some Quantitative and Qualitative Characteristics of forage Sorghum as Second Cropping

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ABSTRACT
In order to evaluate the effect of plant density and sowing date on forage sorghum growth, a field experiment was arranged as factorial, based on randomized complete block design with three replications at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran during growing season of 2013. Factors were plant density at levels of 15, 20, 25 and 30 plants m^{-2} (as the first factor) and sowing date at levels of 23 July, 28 July and 2 August (as the second factor). Results showed that yield and yield components of forage sorghum were affected by plant density and sowing date. The highest and the lowest forage dry weight were achieved from sowing date of 23 July and 2 August, respectively. The effect of plant density was significant on the number of tiller per plant and main stem diameter. Increasing plant density decreased the number of tiller per plant and stem diameter. Maximum (4.7) and minimum (2.2) the number of tiller per plant, were observed at 15 and 30 plants density, respectively. The highest (1065.07 gr m^{-2}) and the lowest (633.98 gr m^{-2}) forage dry weight were obtained from the 30 and 15 plant m^{-2} density, respectively. Leaf to stem dry weight ratio was enhanced as plant density increased. Among different treatments, treatment combination of 30 plant m^{-2} with sowing date of 23 July had maximum values for the evaluative traits. Generally, based on our results, speed-fed variety of forage sorghum is recommended to cultivate in Azerbaijan and other similar regions as a second cropping according to some important agronomic traits.
Keywords: *forage sorghum, plant density, sowing date, yield and morphological traits.*

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INTRODUCTION

Sorghum (*Sorghum bicolor* Moench) is considered as one of the most important forage crops of arid and semi-arid regions with a satisfactory yield under drought conditions according to its adaptation to these situatios and high water use efficiency. It has the fifth highest cultivation area in the world [18]. Sorghum is able to re-grow with minimum yield loss after short drought periods and can produce more biomass than maize [6]. This crop is becoming an increasingly important forage crop in many regions of the world [30]. It is a thermophilic plant needing hot weather. The minimum temperature for the germination of its seeds is 10- 12°C [16]. Sorghum needs 2500-3500°C aggregative heat during its growth and development [17] and can grow in adverse climates, on different soils and at any density [5]. (Conely et al., 2005). The results of previous studies showed that plant density and planting pattern differently affected yield and morphological traits [4, 9, 11, 13, 15]. Plant density can affect forage yield [7]. Besides, appropriate plant density should be used in order to optimally use solar radiation, soil moisture and other inputs in sustaining their competitiveness against weeds. Many of studies indicated that tiller number and main stem diameter were decreased as plant density increase. Caraveta et al. [3] declared that the reduction of sorghum tillering with the increase in plant density was caused by the reduction of light penetrance into the canopy. Duncan [8] showed that forage dry weight increased with the increasing of plant density.

Plant density can affect plant morphology [20] and dry matter content [23]. Moaveni and Heidari [21] studied the effect of plant density and irrigation interval on yield and some physiological traits of forage sorghum in Karaj, Iran and stated that the most suitable plant density was determined to be the density with on row spacing of 12 cm and inter-row spacing of 50 cm to realize its maximum forage. It was shown that dry forage yield was the maximum (37.13 t ha^{-1}) at the on-row spacing of 12 cm and inter-row spacing of 50 cm. Turget et al. [27] studied the effect of plant density and urea fertilization levels on dry matter and some yield components of sweet sorghum. They reported that forage yield of sorghum was decreased as inter-row spacing was increased. Mean grain yield was increased from 3.45 to 4.53 t ha^{-1} during two experimental years. Staggenborg et al. [26] stated that increased crop yield in narrow row spacings may be related to decreased soil water depletion or increased evapotranspiration efficiency. Sowing date is one of the important aspects for production system of different crops. Bevacqua and Vanleeuwen [2] reported that Chile pepper (*Capsicum annuum* L.) yields were highly variable and were strongly influenced by disease and weather. They stated that the planting date had a significant effect on crop performance. Planting date is critical in cold climates due to the potential for frost damage in late of season [17]. Rastegar [22] reported that delay in sowing from April 25 to June 9 decreased total yield of corn by 38%. Also, Kresovic et al. [19] in sweet corn reported that delay in sowing from June 21 to July 11 decreased total yield of corn as second crop. Yarnia [29] reported that interaction between delay sowing and increasing plant density decreased leaf area of amaranth at least 19.63 up to 97.15%. Safari et al. [24] in a study to determine the best planting date and plant density on forage yield of foxtail millet stated that forage yield increased with increasing plant density. The best stand establishment and the highest yield were associated with the earliest planting date, 13 March. Optimum sowing or planting time ensures proper growth and development of plant resulting maximum yield of crop and economic use of land. The present study was carried out to clarify the optimum density and planting time for forage sorghum in Tabriz.

MATERIALS AND METHODS

The field study was conducted at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran (38°5N, 46°E) in 2013. The forage sorghum cultivar was speed- feed. A factorial experiment was arranged as factorial, based on RCBD with three replications. Treatments were plant density (15, 20, 25 and 30 plants m^2) and sowing date levels (23 July, 28 July and 2 August). The fertilizers were applied according to result of soil analyses and sorghum requirement. At the time of 10 percent flowering, two middle rows of each plot with 2 meters length were harvested. Then, the main shoot and tillers were separated into leaves, stems and ears. Samples were dried at 60°C via an oven to reach constant weight. Also diameter of main stem and the number of tiller per plant were measured. Then, forage dry weight was recorded after drying of the samples. At the end, the variance of data was analyzed via MSTAT-C and SPSS software, and the means were compared.

RESULTS AND DISCUSSION

Analysis of variance showed that the agronomic traits of diameter of main stem, the number of tiller per plant, leaf to stem dry weight ratio, leaf to stem dry weight ratio and forage dry weight were significantly influenced by the studied treatments (Table1).

Diameter of main stem and the number of tiller per plant

Diameter of main stem and the number of tiller were influenced by the studied treatments at 1% probability level (Table1). The means comparison showed that with increasing of plant density, stem diameter and the number of tiller per plant were significantly decreased (Table 2). Plant density was enhanced from 20 to 30 plant m^{-2}, stem diameter and the number of tiller per plant decreased from 4.9 to 4.6 and from 3.8 to 2.2, respectively. High tillering at low densities can be resulted from more space and low intera specific competition. The maximum and minimum stem diameters were obtained at the lowest and the low plant densities, respectively. It also, can be attributed to competition among of sorghum plants. Result showed that stem diameter and the number of tiller per plant were significantly redacted as sowing date was delayed (Table 2). Ferraris and Charles [13] noted that high density of sorghum reduced tiller number, tiller number was decreased due to reduction in the allocated photosynthetic materials per plant under this condition. Results of Sarikhani and Razmjoo [25], confirmed our results. They also reported diameter of main stem was decreased with increasing of density due to competition for moisture, nutrients and the quantity and quality of light to penetrate into the plant. Caraveta et al [3] have also been reported similar results.

Leaf and stem dry weight

Analysis of variance of data showed that leaf and stem dry weight was significantly affected by plant density and sowing date at 1% probability level (Table1). Increasing of plant density, resulted in the redaction of leaf and stem dry weight. The highest leaf dry weight (21.67 gr) was observed in the first sowing date (23 July) and the highest density, respectively (Table 2). Previous researches heave demonstrated that leaf and stem weight were decreased as plant density increased [28]. Firozeh et al. [12] reported that plant density significantly affected stem diameter, so that higher plant density resulted in lower stem diameter which is in agreement with our findings.

Leaf to stem dry weight ratio

Analysis of variance of data showed that leaf to stem dry weight ratio was significantly influenced by the studied treatments at 1% probability level (Table 1). With increasing of plant density and early planting, leaf to stem dry weight ratio was significantly increased (Table 2). However, stem and leaf dry weight per plant were decreased with increasing of density, but this reduction was greater in stem than that of leaf dry weight and therefore, leaf to stem dry weight ratio was increased with increasing of density.

Forage dry weight

Result showed that forage dry weight was significantly influenced by sowing date, plant density and interaction of sowing with plant density (Table 1).

The lowest forage dry weight (787.91 gr m^{-2}) was produced at the sowing date of 2 Aug and density of 15 plants m^{-2} (633.98 gr m^{-2}). Interaction results of the effect of two factors (sowing date× plant density) showed that density of 30 plant m^{-2} and sowing date of June 23 produced maximum forage dry weight (Figure 1). Fanaei et al. [10] asserted that plant density brought about significant differences in individual plant yield of sorghum. Azari Nasrabad and Bazari [1] obtained 14.7 t ha^{-1} sorghum forage dry weight from the first harvest, 7.81 t ha^{-1} from the second harvest and in total, 22.52 t ha^{-1} forage dry weight. In addition, they stated that sorghum cv. Speed feed produced the highest forage dry weight of 8.58 t ha^{-1} at the second harvest under the density of 40 plants m^{-2}. In terms of total forage dry weights too. Speed feed had the highest one (22.3 t ha^{-1}) at the density of 40 plant m^{-2} following line KFSI. Fouman [14] reported that forage dry weight was significantly affected by plant density at 1% probability.

The highest forage dry weight was achieved at plant density of 30 plant m^{-2} and sowing date of 230July with values of 1065.07 and 890.2 gr m^{-2} (i.e. at the highest density and the earliest sowing date of this research) (Table 2).

Table 1. Analysis of variance for morphological traits, yield and yield components of forage sorghum.

SOV	df	Stem diameter	The number of tiller per plant	leaf dry weight	Stem dry weight	Leaf to stem dry weight ratio	Forage dry weight
Replication	2	1.451**	0.194 ns	8367 **	9560 **	0.053 **	1231016.5 **
Plant density(D)	3	0.559**	11.33**	11832**	2116**	0.029**	3200319.6 **
Sowing date (T)	2	0.226**	1`.36**	5172**	13348**	0.027*	30205369.6**
D×T	6	0.05 ns	0.25 ns	668 ns	988 ns	0.002 ns	542339.5*
Error	22	0.028	6.27	372	416	0.004	178

*, ** and ns indicate significance at $p < 0.05$, $p < 0.01$ levels and non-significance, respectively.

Table 2. Means comparison of traits at sowing date× plant density interaction for forage sorghum.

	Stem diameter	The number of tiller per plant	Leaf dry weight (gr m^{-2})	Stem dry weight (gr m^{-2})	Leaf to stem dry weight ratio	Forage dry weight (gr m^{-2})
Sowing data						
23 july	5.1 a	3.75 a	433.4 a	373.2 a	1.17 a	890.21 a
28 july	4.8 ab	3.5 ab	413.2 b	352.6 b	1.17 a	851.41 b
2 August	4.7 b	3.08 b	371.6 c	344.8 b	1.08 b	787.91 c
Density						
15 plant m^{-2}	5.1 a	4.77 a	439 a	406 a	1.08 b	633.98 d
20 plant m^{-2}	4.9 a	3.88 b	408.6 b	366.6 b	1.17 b	775.16 c
25 plant m^{-2}	4.8 b	2.88 b	388.6 cb	328.8 c	1.85 a	898.5 b
30 plant m^{-2}	4.65 b	2.22 d	387 c	322.8 c	1.98 a	1065.07 a

Means in each column with similar letters are not significantly different at the 1% probability level.

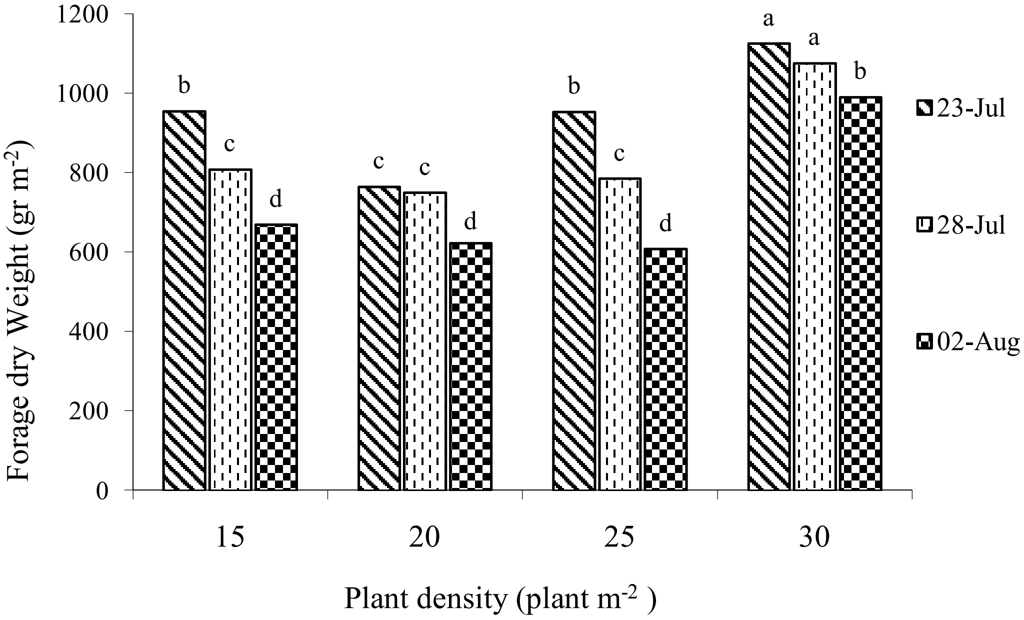

Fig 1: comparison of the effects of sowing date and plant density on forage dry weight. Means in each column with similar letters are not significantly different at the 1% probability level.

CONCLUSION

In the present study, the results showed that with the delay in sowing, forage dry weight was significantly decreased. Also plant density of 30 plants m^{-2} on June 23 produced maximum forage dry weight. Therefore, it was concluded that forage sorghum can be considered as a suitable second cropping in Azerbaijan after some crop such as cereals according to produce of high forage yield.

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