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Effect of plant density and nitrogen fertilizer on some attribute ofgrain sorghum (*sorghum bicolor* (l.) moench)

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ABSTRACT

A field experiment was conducted in 2010, to evaluate the effects of plant density (D_1, D_2 and D_3: 8, 14 and 20 plant/m^2) on field performance of Sorghum under different nitrogen application rates (N_1, N_2 and N_3: application of 40, 80 and 120 kg/ha Nitrogen, respectively). The experiment was arranged as factorial based on randomized complete block design in three replicates. Results indicated that as plant density increased tillers per plant, Steam diameter and days to 50% flowering decreased, the effects of N application rate on these traits were not significant. While tillers per unit of area increased as more plant density. Plant height not affected by both treatments. As plant density and N application rates raised grain yield increased. Thus, N application and plant density increases can raise yield of grain sorghum.

Key words: Plant density; nitrogen; grain yield; Sorghum.

INTRODUCTION

Plant density is one of the important factor determines growth, development and yield (McMurray, 2004; McRae *et al.*, 2008; Hassan and Khaliq, 2008). Plant density selection to allow for expression of maximum grain yield is a management practice that would make sorghum production more economical. Results indicate that yields of grain sorghum can be improved by increasing the plant densities (Schatz *et al.*, 1990). Cultivation of plants with desirable density has positive effect on crop yield components, so that the suitable will be achieved by optimum plant density (Cox, 1996; Widdicombe and Thelen, 2002). However, maintenance of optimum planting density is always a big problem to the farmers. Substandard plant density result in high weeds infestation, poor radiation use efficiency and low yield, while dense plant population on the other hand cause lodging, poor light penetration in the canopy, reduce photosynthesis production due to shading of lower leaves and drastically reduce the yield (Vassilev, 1998; Jettner *et al.*, 1998a&b; Lemerle *et al.*, 2004;Lemerle *et al.*, 2006). Tillering is an important morphological component of grain sorghum (Sorghum bicolor L. Moench) development because it affects light capture, water use, grain yield, plant competition and other physical and biological processes(Krishnareddy *et al.*, 2006). Researchers reported as increased plant populations number of tillers (Pawlowski *et al.*, 1993; Ibrahim and Hala, 2007; Caliskan *et al.*, 2007),Plant height (Garrison and Briggs, 1972; Shepel and Aristarkhova, 1982; Ayub*et al.*, 2003) and steam diameter decreased (Caravetta *et al.*, 1990),but grain yield per unit of area increased(Caliskan *et al.*, 2007).

Nitrogen demand may also increase as plant density increases. Nitrogen is the most expensive fertilizer used to raise crop plants yield (Spiertz, 2010). A reliable portion of the applied N is lost through leaching and denitrification (Jamieson and Semenov, 2000). Increased demand for N fertilizers also raises farm input costs. It is necessary to apply sufficient amount of nitrogen to achieve optimum yield and high quality product. However, over-fertilization and insufficient fertilization lead to economic losses and discharge an excessive amount of nitrogen in the nitrate form through washing (Henke *et al*., 2007).Therefore suggestions for fertilizers with nitrogen should be made so as to ensure a high quality product, optimum yield, high profit and less environmental pollution risks (Strasil and Vorlicek, 2002). Studies have shown grain yield significantly differ at different nitrogen levels and grain yield increased as more nitrogen application rates (El-Hattab *et al*., 1980; Mkhabela *et al*., 2001; Ma *et al*., 2006; Khaliq*et al*., 2009).The aim of this research is to study the effect of nitrogen levels, plant density and their reaction on some attribute of grain Sorghum.

MATERIALA AND METHODS

An experiment was conducted at the Research Farm of Tabriz University, Tabriz, Iran (latitude 38.05°N, longitude 46.17°E, Altitude 1360 m above sea level) in 2010. The experiment was arranged as three N levels (40, 80 and 120 kg/ha) and plant densities (8, 14 and 20 plants/m^2).Nitrogen fertilizer was applied in three stages at planting, stem elongation and flowering stages, respectively compared with 40%, 40% and 20% N application. Each plot consisted of 8 rows, with plants spaced of 25, 14, and 10 cm to achieve 8, 14, and 20 plants in m^2, respectively. Before sowing, grains were disinfected by spraying Benomyl (2/1000 gr). Plants were irrigated every week. In this experiment, the use of any chemicals (chemical herbicides and pesticides) was denied during field preparation and during the growing season. At maturity, three middle rows were used for sampling and measurements. When grain moisture content was about 14%, plants of per unit area were harvested to determine grain yield. Also plant height and Tillers per plant and per square meter measured at this stage and average of data from 5 plants was recorded for each experimental unit. Analysis of variance was carried out factorial based on complete randomized block design. Statistical analysis was performed using SPSS software and MSTATC and graph drawing was done by Excel.

RESULTS AND DISCUSSION

Analysis of variance of the data for grain yield and some characters (table 1) showed that days to 50% flowering and grain yield per unit of area were significantly affected by N application rate and plant density. Tillers per plant and per unit of area and Steam diameter only affected by plant density, but the effects of N application rate on these traits were not significant. Plant height not affected by both treatments. The interaction of N application rate × plant density was significant for grain yield per unit of area.

Table 1- Analysis of variance of the data for some characters of Sorghum under different N application rate and plant density

Source	df	Tillers per plant	Tillers per unit of area	Plants height	Steam diameter	Days to 50% flowering	Grain yield per unit of area
R	2	$0.52^{n.s}$	$198^{n.s}$	$27.4^{n.s}$	$0.94^{n.s}$	$0.04^{n.s}$	$3577^{n.s}$
N	2	$0.503^{n.s}$	$138.8^{n.s}$	$54.3^{n.s}$	$0.98^{n.s}$	46.7^{**}	1566989^{**}
D	2	3.18^{**}	812.4^{**}	$205.4^{n.s}$	15.87^{**}	4.9^{**}	12747364^{**}
N*D	4	$0.01^{n.s}$	$33.8^{n.s}$	$20.9^{n.s}$	$0.32^{n.s}$	$0.2^{n.s}$	221264^{**}
E	16	0.14	41.8	81.2	0.62	0.7	1324
CV%	-	12.98	16.71	10.85	3.12	0.54	6.2

*, ** Significant at p≤0.05 and p≤0.01, respectively.

As plant density increased tillers per plant, Steam diameter and days to 50% flowering decreased (Table 2), while tillers per unit of area increased as more plant density. The highest tiller per plant was obtained at the lowest plant density. More plant density increased tillers per unit of area, although tillers per unit of area were not significantly by 14 and 20 plants in m^2(Table 2). In this study, more plant per unit of area results tillers per plant decreased. Lafarge et al (2002) recorded that tillering and yield responses to density could be related to general concepts associated with interplant competition and resource capture. High tillering in low densities can be resulted from more space and low interplant competition. Ferraris and Charles (1986) found that the reduced tiller number at high density due to decreases of dialed down canopy photosynthesis in dense cultures and Stated that the plant uses photosynthetic to grow shoots up with this action. The highest steam diameter mean (26.76.mm) obtained at 8 plants in m^2 but 14 and 20 plants/m^2caused no significant deference at steam diameter (Table 1). Reason of stem diameter reduction at high densities can be linked to a reduction of assimilate allocation and more intra-plant competition.The lowest and the highest days to 50% flower in obtained at 40 and 120 kg N application rates respectively. Although, 80 and 120 (kg N ha) treatment caused no significant deference at this parameter. This might link to nitrogen increased vegetative period and it delays reproductive period. More plant density reduced days to 50% flowering. This could be related to the supportive effects of more available fertilizers to lower number of plants per unit area which permitted building of more vigorous growth that resulted in higher number of days for flowering. More plant density resulted inter competition increased and early flowering.

Table 2-Means of some characters and grain yield of Sorghum under different N application rate and plant density

Treatment	Tillers per plant	Tillers per square meter	Steam diameter	Days to 50% flowering	Grain yield ($kg.ha^{-1}$)
density					
D1	3.5^a	28.2^b	26.7^a	74^a	5364^c
D2	2.9^b	41.2^a	24.3^b	73^b	7400^b
D3	2.3^c	46.6^a	24.7^b	73^b	7503^a
nitrogen					
N1	2.7	35.1	24.9	71^b	5234^c
N2	2.9	38.1	25.3	74^a	7287^b
N3	3.2	42.8	25.5	75^a	7942^a

Different letters at each column indicate significant difference at $p \leq 0.01$
D1, D2 and D3: 8, 14 and 20 plant density
N1, N2 and N3 application of nitrogen 40, 80 and 120 respectively

As increasing plant density and N application rates grain yield increased. The Highest grain yield (8563 $kgNha^{-1}$) obtained at 120 $kgNha^{-1}$and 20plants in m^2 (Table 3). Studies have shown a direct relationship between the numbers of tillers and plant yield, produces a much higher number of tillers which ultimately leads to increased panicle and grain yield per plant (Taser, 1984).

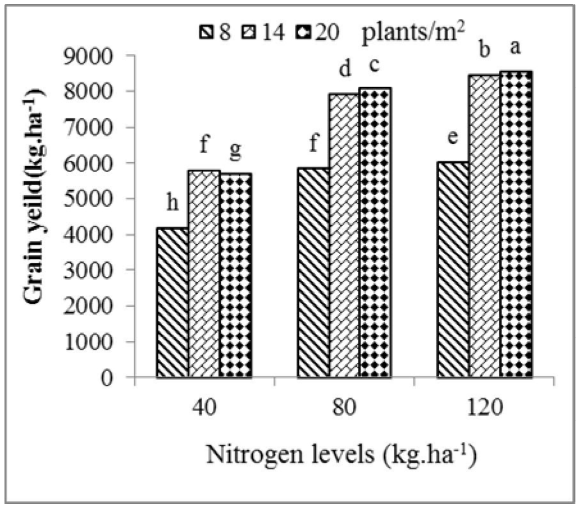

Figure 1-Grain yield of sorghum as affected by interaction of plant density and N application rate

CONCLUSION

Results indicated that as plant density increased tillers per plant, Steam diameter and days to 50% flowering decreased, the effects of N application rate on these traits were not significant. While tillers per unit of area increased as more plant density. So increase of tillers per unit of area lead to steam diameter decreased. It probably occurred because of reduction of assimilate allocation and more intra-plant competition. Plant height not affected by both treatments. As plant density and N application rates raised grain yield increased. Grain yield increase can link to produces a much higher number of tillers which ultimately leads to increased panicle and grain yield. Thus, N application and plant density increases can raise yield of sorghum.

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