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Growth and yield responses of two forage sorghum cultivars to different nitrogen fertilizer rates

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ABSTRACT-In order to evaluate the impact of different amounts of nitrogen fertilizer on growth and yield of two forage sorghum cultivars, a 2-year field experiment was carried out at the College of Agriculture, Shiraz University, Shiraz, Iran during 2010 and 2011 growing seasons. Two factorial experiments were carried out in randomized block design with three replicates, in which the treatments included nitrogen fertilizer at three levels: 69 (N_1), 138 (N_2) and 205 (N_3) kg N ha^{-1} and two sorghum cultivars: Pegah and KFS_2. The results showed that nitrogen fertilizer enhanced plant height, leaf area index, fresh weight, total dry weight and biological yield significantly so that these traits were higher in N_3 as 5.71, 22.8, 8.13, 22.5, and 8.7% than N_1, respectively. Furthermore, increasing nitrogen rate had additive effect on crop growth rate, relative growth rate, biomass duration and leaf area duration. Comparing the cultivars, it was found that, plant height, fresh weight, total dry weight and biological yield were higher in Pegah than KFS_2 cultivar. Results also showed that most of the studied traits were superior for Pegah under N_3 treatment; so, Pegah cultivar and application of 205 kg N ha^{-1} might be offered for similar agro-climatic conditions.

INTRODUCTION

To manage the sorghum crop for achievement of maximum forage production, the farmer should be concerned about nitrogen requirement (Vanderlip, 2012). Although sorghum is a C_4 crop and uses nitrogen in a more efficient way compared to most C_3 crops, nitrogen is the most essential nutrient for sorghum growth, which is still one of the major factors limiting its yield (Young and Long, 2000). On the other hand, while nitrogen fertilization increases growth of sorghum and its yield, inappropriate amount of fertilizer during cultivation leads to lower plant performance and reduction in efficiency of the applied fertilizer compared to the actual potential of fertilizer use efficiency (Zhao et al., 2005).

The rate of nitrogen fertilization to optimize sorghum growth and yield varies with cultivars. Genetic diversity of nitrogen use has been demonstrated in sorghum with some of the most efficient types being cultivars that evolved from low-fertility environments (Gardner et al., 1994). Bebawi (1981) showed that sorghum cultivars are different in their ability to respond to different fertilization. Mansouri-Far et al. (2011) showed that increase in nitrogen fertilizer level improves maize growth and yield. They also found that the responses of different hybrids to nitrogen supply were different. Mahmud et al. (2003) reported that N fertilization increases crude protein, fodder and dry matter yield in forage sorghum. Under nitrogen deficit conditions, photosynthates are not used fully in the synthesis of organic nitrogen compounds andhence sugars are accumulated (Karic et al., 2005). There is a positive relationship between nitrogen fertilization and forage yield (Almodares et al., 2009) and as Marsalis et al. (2010) reported dry matter is decreased by N fertilization. Results of Hammad et al. (2011) revealed that maximum plant growth, number of kernels per ear and grain yield of maize was found in 250 kg N ha^{-1} treatment and the highest days to maturity and biological yield were recorded from 300 kg N ha^{-1} application.

It has been clearly shown in the literature that applying optimum rate of N at proper time is crucial in improving crop productivity (Magdoff, 1991; Hammad et al., 2011). Farmers usually apply high rates of nitrogen fertilizer to ensure the fulfillment of the crop needs, while they are using both water and nitrogen in an inefficient way by increasing leaching potential of nutrients into the ground water (Ramos et al., 2012). Depending on soil nitrogen fertility, farmers apply between 45 and 224 kg N ha^{-1} in sorghum production (Magdoff, 1991; Zhao et al., 2005). Although many researchers have examined the effect of nitrogen fertilization on sorghum growth, adequate amount of nitrogen for maximum growth and yield has been found variable for different regions, and there is not enough research being done on this forage crop in Iran. Thus, this study was carried out to investigate the effect of different levels of nitrogen fertilization on growth and yield of two widely grown forage sorghum cultivars in southern Iran.

MATERIALS AND METHODS

A 2-year field study was conducted at the College of Agriculture, Shiraz University, Shiraz, Iran (52° 46'E, 29° 50'N, altitude 1810 m ASL) during 2010 and 2011 growing seasons. Field soil properties are shown in Table 1.

Each experimental unit was a plot of 3 × 3.6 m, in both years. Uniform sorghum seeds were hand sown at a depth of 3-4 cm with the rate of 20 seeds m^{-2} in June 3th. Plots were irrigated by using a tap system, where each nozzle was located across each plant. For each plot, the timing and amount of irrigation was determined by soil field capacity percentage (F.C. %) at depth of 0-30 cm.

Irrigation volume was estimated based on Michael and Ojha (1987) equation:

$$dn = \frac{(FC - \theta m) \times \rho b \times D}{100}$$

where*dn*, *FC*, *θm*, *ρb* and *D* were the estimatedirrigation depth, field capacity of the soil (based onweight percentage), soil moisture (based on weight), bulk density and soil depth, respectively. Weeds were controlled manually as well as by applying 2, 4-D herbicide at 2 g L^{-1}.

Table 1. Soil properties of the experimental field

Clay	Silt	Sand	OM	N	K	Cu	Mn	Zn	Fe	P	pH
		%						mg kg^{-1}			
18	60.70	21.30	1.20	0.11	540	2.48	6.75	2.31	6.40	28	7.8

In each year, factorial experiment (2×3) was carried out as a randomized block design with three replicates. Nitrogen fertilization levels at: 69 (N_1), 138 (N_2) and 205 (N_3) kg N ha^{-1} and the sorghum cultivars of: Pegah and KFS_2 were the two factors. Different amounts of N fertilization were applied as urea (N_1, 150 kg ha^{-1}; N_2, 300 kg ha^{-1} and N_3, 450 kg ha^{-1}). At planting time, ⅓ of N fertilizer was added to the field and the remained (⅔) was added at growing point differentiation (stage 3; Vanderlip, 2012).During growth period, frequent sampling (2-3 plants each) was employed to estimate physiological indices including crop growth rate (CGR), relative growth rate (RGR), biomass duration (BMD), and leaf area duration (LAD). Also, at the end of the experiment, final plant height (HT), fresh weight (FW), total dry weight (TDW), leaf to stem dry weight (L/S) and biological yield (BY) were measured.The collected data for the two years were subjected to analysis of combined variance and significant differences between treatment means were determined by using least significant difference (LSD) test at $p \leq 0.05$ level using a computer software SAS *v*. 9.1. Since interactions of the treatments with year were not significant, averages of the two years were presented in mean comparisons.

RESULTS AND DISCUSSION

The effect of nitrogen ($p \leq 0.01$), cultivars ($p \leq 0.01$) and their interaction on sorghum plant height were significant ($p \leq 0.05$), (Table 2). In all nitrogen treatments, height of Pegah cultivar was higher than KFS_2 (Fig. 1A). On average, maximum plant height was obtained from N_3 treatment (Table 3). Although sorghum height increased by nitrogen fertilization in both cultivars, the responses of cultivars were not similar. Pegah cultivar did not respond to nitrogen rate except in N_3 (205 kg N ha^{-1}); while KFS_2 height responded to first nitrogen level and then increasing nitrogen level had no effect on plant height (Fig. 1A). These results are in agreement with those of Amanullah et al. (2009) who showed that the maize plant height responded positively to higher nitrogen rate. Turgut (2000), also, indicated that plant height in maize could be increased up to 280 kg N ha^{-1}; however, further increase in nitrogen rate had no significant effect on plant height. Leaf area index was significantly affected by nitrogen and cultivar (Table 2). On average, there were significant differences between three nitrogen levels on leaf area index. Maximum and minimum leaf area indices were obtained in N_3 and N_1 treatments, respectively (Table 3). KFS_2 cultivar responded to nitrogen increasing earlier than Pegah cultivar; such higher response to nitrogen level was also observed for plant height (Fig. 1A & 1B). In contrast to most other traits (for example, fresh and dry weights), LAI was greater in KFS_2 than Pegah cultivar (Fig. 1B). Under lower nitrogen fertilization conditions, crop growth slows down causing reproductive structures to decline, as a result, lower leaf area is achieved (O'Neill et al., 2004; Ding et al., 2005; Monneveux et al., 2005). Leaf area index was the most sensitive trait to nitrogen rate (Fig. 3).The effect of nitrogen ($p \leq 0.01$), cultivars ($p \leq 0.01$) and their interaction ($p \leq 0.05$) on sorghum fresh weight was significant (Table 2). In all nitrogen treatments, as shown in Figure 1C, Pegah had higher fresh weight than KFS_2 cultivar. Quick response of KFS_2 to nitrogen rate, compared to Pegah cultivar, was also observed in fresh weight. Nevertheless, even in higher nitrogen rate (i.e. N_3), KFS_2 fresh weight was lower than Pegah cultivar. On average, nitrogen at 205 kg N ha^{-1} rate increased sorghum fresh weight by 8.13% compared to 69 kg N ha^{-1} level. Nitrogen deficiency has been reported to suppress sorghum growth and dry matter accumulation (Zhao et al., 2005). Increased fresh weight due to nitrogen application enhancement might be associated with an increase in both leaf area and leaf photosynthetic capacity (Sinclair, 1990) and could be attributed to a higher sorghum canopy (greater leaf area and plant height) in the present study (Fig. 1A&B and

Table 3). Although the effect of increasing nitrogen supply on crops growth and yield has been well studied,cultivars with different nitrogen efficiency were included in only a few studies.

Table 2. Combined variance analysis of the effect of nitrogen, cultivar and their interaction on yield and its components of two sorghum cultivars

Source of variation	Degrees of Freedom	Ht†	LAI	FW	TDW	L/S DW	BY
		Mean squares					
Year (Y)	1	593.022*‡	0.396ns	7214.236*	201.724*	0.791**	15.987ns
Replication (Y)	2	58.841	0.247	28.426	46.455	0.015	6.935
Nitrogen (N)	2	373.855**	3.335**	1254.934**	10336.797**	1.597**	51.046**
Cultivar (C)	1	9723.136**	8.341**	16263.351**	1257.947**	4.370**	266.275**
N×C	2	106.945*	2.739*	519.351*	1137.888**	0.002ns	24.524**
Y×N	2	0.155ns	0.001ns	8.852ns	4.305ns	0.001ns	1.212ns
Y×C	1	4.049ns	0.003ns	48.422ns	0.523ns	0.001ns	5.109ns
Y×N×C	2	0.044ns	0.001ns	2.132ns	0.473ns	0.001ns	2.102ns
Error	20	22.197ns	0.090	27.810	16.618	0.163	0.065
CV (%)		17.369	15.841	13.492	14.440	11.759	14.521

‡. ns, non-significant; * and ** significant effect at 5 and 1% probability level.
†. Ht, Plant height; LAI, Leaf area index; FW, Fresh weight; TDW, Total dry weight; L/S DW, Leaf to stem dry weight ratio; BY, Biological yield.

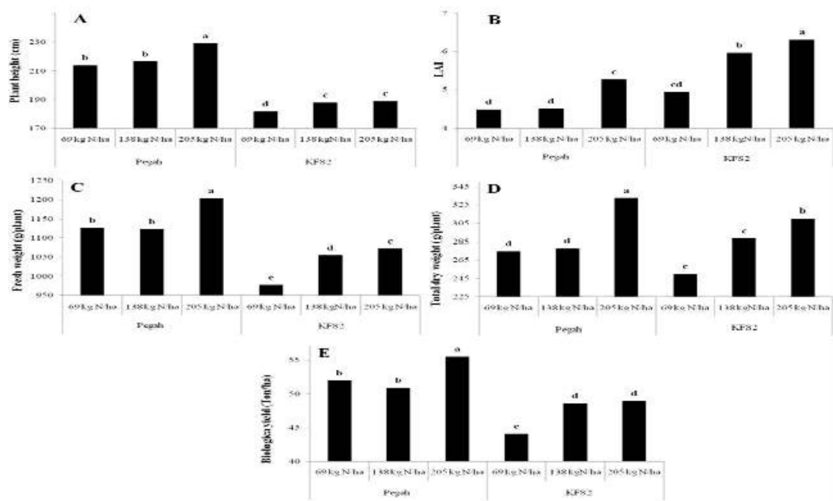

Fig. 1. Effect of different nitrogen levels on A) Plant height, B) LAI, C) Fresh weight, D) Total dry weight, E) Biological yield of two forage sorghum cultivars (LSD ≤ 0.01)

Table 3. The main effect of nitrogen levels on traits of two sorghum cultivars

Treatment	Ht† (cm)		LAI		FW (g/plant)		TDW (g/plant)		L/S DW		BY (ton/ha)	
Nitrogen												
69 N/ha	197.69	b‡	4.71	c	1052.5	c	262.29	c	0.246	a	48.031	c
138 N/ha	202.12	b	5.23	b	1089.4	b	283.04	b	0.234	b	49.728	b
205 N/ha	208.99	a	5.79	a	1138.1	a	321.32	a	0.223	c	52.215	a
Cultivar												
KFS_2	186.16	b	5.73	a	1035.4	b	282.85	b	0.245	a	47.216	b
Pegah	219.7	a	4.75	b	1151.3	a	294.91	a	0.223	b	52.767	a

†. Ht, Plant height; LAI, Leaf area index; FW, Fresh weight; TDW, Total dry weight; L/S DW, Leaf to stem dry weight ratio; BY, Biological yield.
‡. The mean in each column and for each treatment with similar letter are not significantly different(LSD≤0.05).

The effect of nitrogen fertilization, cultivars and their interactions was significant on total dry weight (Table 2). Nitrogen fertilizer application increased total dry weight so that N_3 treatments resulted in the higher total dry weight in both cultivars. Similar to previously reported traits, KFS_2 cultivar showed a faster response to nitrogen application in terms of total dry weight (Fig. 1D). Kamoshita et al. (1998) also observed a considerable genotypic variation in total biomass production among sorghum hybrids. Indeed, total dry weight was the second most sensitive trait to nitrogen application (Fig. 3), which showed a 22.5% increase as a result of 205 kg N ha^{-1} nitrogen application (N_3 *vs.* N_1). Higher nitrogen can cause delay in leaf senescence leading to a larger biomass accumulation. According to Borrell and Hammer (2000), at higher nitrogen levels, root growth might be prolonged resulting in a more extensive root system and hence larger aboveground biomass. Leaf to stem dry weight ratio (L/S) was also significantly affected by nitrogen and cultivar at 1% probability level (Table 2). Nitrogen fertilizer reduced L/S so that the highest and the lowest L/S were obtained from N_1 and N_3 treatments, respectively. KFS_2 had greater L/S than Pegah cultivar (Table 3). This indicated that additive effect of nitrogen on leaf weight was remarkably lower than on stem weight. It has been documented that leaf to stem ratio is remarkably different among species as well as cultivars (Borrelland Hammer, 2000). The higher leaf to stem ratio is, the more desirable quality trait in forage crops since proteins are more concentrated in leaves than stems (Grewaland Williams, 2003).

The effects of nitrogen fertilization, cultivars and their interactions on biological yield were significant at 1% probability level (Table 2). Biological yield was increased upon nitrogen fertilizer application in both cultivars so that N3 caused 6.7 and 11.7% increase in Pegah and KFS_2, respectively. On average, the highest (52.2 ton ha^{-1}) and the lowest biological yields (48.0 ton ha^{-1}) were found under N_3 and N_1, respectively (Table 3). The highest biological yield was achieved in N_3 for Pegah and in N_2 for KFS_2 (Fig. 1E). Marsalis et al. (2010) also noted that responses of biological yield to nitrogen in sorghum cultivars were different and showed a positive reaction to nitrogen fertilization rate. However, Cox and Cherney (2001) reported no benefit on yield or silage quality when nitrogen was applied at levels higher than 150 kg N ha^{-1}, with the exception of increased crude protein. Higher response in KFS_2 compared to Pegah also was observed for biological yield; however, on average, biological yield of Pegah was greater than that of KFS_2. Positive effect of nitrogen rate on sorghum biological yield has also been reported by other researchers (Borrell and Hammer, 2000; Cox and Cherney, 2001; Zhao et al., 2005; Marsalis et al., 2010).

Relative growth rate (RGR) showed a decreasing trend throughout the experiment (Fig. 2A). Until 10 days after planting (DAP), there were no significant differences in RGR among nitrogen levels in both cultivars. However, in KFS_2 cultivar, from 10 DAP onwards, reduction in RGR significantly differed between nitrogen treatments so that until 109 DAP, the N_3 treatment had the highest RGR compared to N1 and N_2. The highest differences between nitrogen treatments were found from 45 to 77 DAP (Fig. 2A). Although relative growth rate (RGR) showed the decreasing trend during the experimental period, this reduction was not similar in both sorghum cultivars and nitrogen rates. Difference between treatments was increased at 45 DAP and then it was decreased at 109 DAP towards the end of the experiment. RGR was higher in KFS_2 compared to Pegah cultivar almost in all samplings and in all three nitrogen rates; also, the highest RGR was found in higher nitrogen rate. Indeed, our results showing enhancement of RGR when nitrogen fertilization level was increased in both cultivars are consistent with previous findings such as those reported by Valiela et al., (1976), Levine et al., (1998), Tyler et al., (2003), and Qing et al. (2011). Pegah and KFS_2 cultivars showed almost similar responses to nitrogen treatments in terms of crop growth rate (CGR) throughout the experiment (Fig. 2B). Indeed, CGR was increased from the beginning to mid-experiment and then, it was decreased for all treatments (i.e. two cultivars and three nitrogen levels). Although there were no significant differences in CGR among three nitrogen levels at 10 and 45 DAP, at other samplings, nitrogen application could increase CGR in both cultivars. CGR was increased from the beginning of the experiment to 67 DAP and then, it was decreased at the end of the experiment. This trend was similar in both cultivars under all nitrogen treatments (Fig. 2B).

Also, Jensen (1987) reported that Pea plants reached maximum CGR 10 weeks after seedling emergence, and it was slightly decreased when plants began to flower. KFS_2 reached maximum CGR earlier than Pegah cultivar; nevertheless, maximum CGR of Pegah was more than that of KFS_2. Our growth analysis confirmed the results of previous studies (Milbourn and Hardwick, 1968; Jensen, 1987) that maximum CGR are reached some times after flower initiation. The peak crop growth rate has been reported to be associated with high photosynthetic rates in legumes leaflets at flowering (Bethlenfalvayand Phillips, 1977; Jensen, 1987). The present investigation found that differences between treatments were lower at the earlier and later stages compared to when maximum of CGR was achieved i.e. where the difference was highest (Fig. 2B).

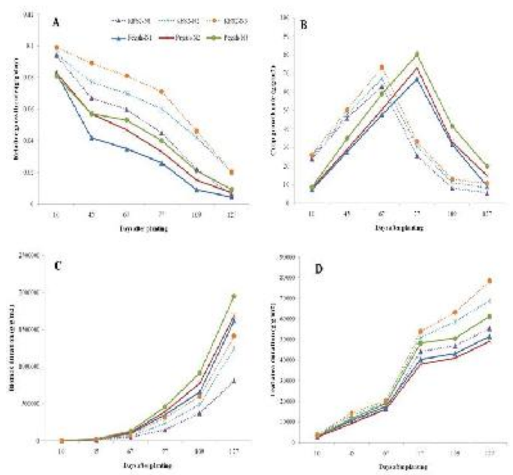

Fig. 2. Effect of different nitrogen levels onhysiological indices of two forage sorghum cultivars.

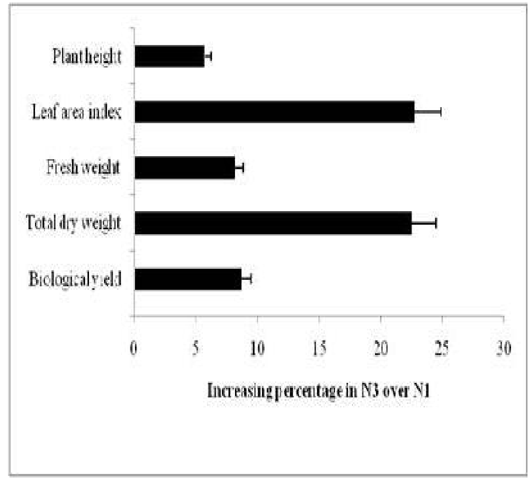

Fig.3. Increasing percentage (±SE) in some traits for N3 (205 kg N/ha) compared to N1 (69 kg N/ha)

As expected, biomass duration (BMD) showed an increase throughout the experiment with maximum at 127 DAP (Fig. 2C). No significant difference was observed among nitrogen treatments until 67 DAP for KFS_2 and 77 DAP for Pegah; from then, nitrogen application had additive effect on BMD. From 67 DAP to the end of the experiment, BMD of Pegah was found to be greater than that of KFS_2 cultivar (Fig. 2C). Nitrogen application also had incremental effect on leaf area duration (LAD) in both cultivars (Fig 2D). Positive effect of nitrogen fertilizer on BMD was also reflected in its positive effect on growth and yield. LAD showed an increasing trend throughout the experiment. Indeed, BMD and LAD were higher in Pegah compared to KFS_2 cultivar (Fig. 1C & D). Nitrogen fertilizer increased both BMD and LAD, and a significant increase was observed from 67 DAP onwards. According to Mansouri-Far et al. (2010), the level of nitrogen supply can affect leaf area duration in maize. At lower nitrogen levels, CGR slows down causing reproductive structures to decline which results in lower yield as well as lower LAD and BMD (O’Neill et al., 2004; Hammad et al., 2011).

CONCLUSIONS

In the present 2-year study, it was shown that nitrogen could affect most sorghum measured growth and forage parameters. The highest plant height, leaf area index, total fresh weight, total dry weight as well as biological yield were achieved from application of 205 kg N ha^{-1} treatment. Pegah cultivar showed larger crop canopy with more fresh or dry weight whereas KFS_2 appeared to be a shorter cultivar with higher leaf area and leaf to stem ratio. Leaf area and biological yield had the highest and the lowest sensitivity to nitrogen rate, respectively. Furthermore, nitrogen could increase physiological indices such as CGR, RGR, BMD and LAD. Overall, the results of this 2-year experiment demonstrated that nitrogen could have a positive effect on sorghum growth and yield up to 205 kg ha^{-1} emphasizing that Pegah was found to be a more responsive cultivar to nitrogen application, and this cultivar could be recommended to growers under fertilized conditions.

REFERENCES

Amanullah, H., Marwat, K.B., Shan, P., Maula, N., &Arifullah, S. (2009). Nitrogen levels and its time of application influence leaf area, height and biomass of maize planted at low and high density. *Pakistan Journal of Botany*, 41, 761-768.

Bebawi, F.F. (1981). Response of sorghum cultivars and striga population to nitrogen fertilization. *Plant Soil*, 59, 261-267.

Bethlenfalvay, G.J., & Phillips, D.A. (1977).Ontogenetic interactions between photosynthesis and symbiotic N 2 fixation in legumes.*Plant Physiology*, 60, 419-421.

Borrell, A., & Hammer, G.L. (2000).Nitrogen dynamics and the physiological basis of stay-green in sorghum.*Crop Science*, 40, 1295–1307.

Borrell, A., Van Osterom, E., Hammer, G., Jordanand, D., & Douglas, A.(2003).The physiology of “stay-green” in sorghum. Proceedings of the 11th Australian Agronomy Conference, 2-6 Feb 2003.

Cox, W.J.,&Cherney, D.J.R. (2001). Row spacing, plant density, and nitrogen effects on corn silage. *Agronomy Journal*, 93, 597–602.

Ding, L., Wang, K.J., Iang, G.M., Biswas, D.K., Xu, H., Li, L.F., & Li, Y.H. (2005). Effects of nitrogen deficiency on photosynthetic traits of maize hybrids released in different years. *Annals of Botany*, 96, 925-930.

Gardner, J.C., Maranville, J.W., &Paparozzi, E.T. (1994).Nitrogen use efficiency among diverse sorghum cultivars.*Crop Science*, 34, 728-733.

Grewal, H.S., & Williams, R. (2003). Liming and cultivars affect root growth, nodulation, leaf to stem ratio, herbage yield, and elemental composition of alfalfa on an acid soil. *Journal of Plant Nutrition*, 26, 1683-1696.

Hammad, H.M., Ahmad, A., Wajid, A.,&Akhter, J. (2011).Maize response to time and rate of nitrogen application.*Pakistan Journal of Botany*, 43, 1935-1942.

Jensen, E.S. (1987).Seasonal patterns of growth and nitrogen fixation in field-grown pea.*Plant Soil*, 101, 29-37.

Kamoshita, A., Fukai, S., Muchow, R.C., & Cooper, M. (1998). Genotypic variation for grain yield and grain nitrogen concentration among sorghum hybrids under different levels of nitrogen fertilizer and water supply. *Australian Journal of Agricultural Research*, 49, 737–747.

Karic, L., Vukasinovic, S., &Znidarcic, D. (2005).Response of leek (*Allium porrum*L.) to different levels of nitrogen dose under agro-climate conditions of Bosnia and Herzegovina.*ActaAgriculturaeSlovenica*, 85, 219-226.

Levine, J.M., Brewer, J.S., &Bertness, M.D. (1998).Nutrients, competition and plant zonation in a New England salt marsh. *Journal of Ecology*, 86, 285-292.

Magdoff, F.R. (1991). Managing nitrogen for sustainable corn systems: problems and possibilities. *American Journal of Alternative Agriculture*, 6, 3-8.

Mahmud, K., Ahmad, I., &Ayub, M. (2003).Effect of nitrogen and phosphorus on the fodder yield and quality of two sorghum cultivars (*Sorghum bicolor* L.).*Journal of Agricultural & Biological Science*, 5, 61-63.

MansouriFar, C., ModarresSanavy, S.A.M., &Saberali, S.F. (2010).Maize yield response to deficit irrigation during low-sensitive growth stages and nitrogen rate under semi-arid climatic conditions.*Agricultural Water Management*, 97, 12-22.

Marsalis, M.A., Angadi, S.V.,& Contreras-Govea, F.E. (2010). Dry matter yield and nutritive value of corn, forage sorghum, and BMR forage sorghum at different plant populations and nitrogen rates. *Field Crops Research*, 116, 52-57

Micheal, A.M., &Ojha, T.P. (1987).Principles of agricultural engineering. Vol. II. New Delhi Jain Brothers Publisher.320 p.

Milbourn, G.M., &Harwick, R.C. (1968).The growth of vining peas. I. The effect of time of sowing. *Journal of Agricultural ScienceCambridge*, 70, 393-402.

Monneveux, P., Zaidi, P.H. and Sanchez, C. (2005). Population density and low nitrogen affects yield-associated traits in tropical maize. *Crop Science*, 45, 535-545.

O'Neill, P.M., Shanahan, J.F., Schepers, J.S., & Caldwell, B. (2004).Agronomic responses of corn hybrids from different eras to deficit and adequate levels of water and nitrogen.*Agronomy Journal*, 96, 1660-1667.

Qing, H., Yao, Y., Xiao, Y., Hu, F., Sun, Y., Zhou, C., &An, S. (2011). Invasive and native tall forms of *Spartinaalterniflora* respond differently to nitrogen availability. *ActaOecologica*, 37, 23-30.

Turgut, I. (2000). Effects of plant populations and nitrogen doses on fresh ear yield and yield components of sweet corn grown under Bursa conditions.*Turkish Journal of Agriculture and Forestry*, 24, 341-347.

Tyler, A.C., Mastronicola, T.A., &McGlathery, K.J. (2003).Nitrogen fixation and nitrogen limitation of primary production along a natural marsh chronosequence.*Oecologia*, 136, 431-438.

Valiela, I., Teal, J.M., &Persson, N.Y. (1976). Production and dynamics of experimentally enriched salt marsh vegetation: belowground biomass. *Limnology and Oceanography*, 21, 245-252.

Vanderlip, R.L. (2012).*How a sorghum plant develops*. Kansas State University Press.20 p.

Young, K.J., & Long, S.P. (2000). Crop ecosystem responses to climatic change: maize and sorghum. In: Reddy K.R, Hodges H.F (ed) Climate change and global crop productivity. CABI Publishing, Wallingford.

Zhao, D., Reddy, K.R., Kakani,V.G., & Reddy, V.R. (2005). Nitrogen deficiency effects on plant growth, leaf photosynthesis and hyperspectral reflectance properties of sorghum. *European Journal of Agronomy*, 22, 391-403.

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واکنش رشد و عملکرد دو رقم سورگوم علوفه‌ای به مقادیر مختلف کود نیتروژن

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دوام سطح برگ
سرعت رشد نسبی

چکیده- به منظور ارزیابی تأثیر مقادیر مختلف کود نیتروژن بر رشد و عملکرد دو رقم سورگوم علوفه‌ای ازمایشی مزرعه‌ای در دانشکده کشاورزی دانشگاه شیراز در دو سال زراعی ۹۰-۱۳۸۹ انجام شد. دو ازمایش فاکتوریل در قالب طرح بلوک‌های کامل تصادفی با سه تکرار انجام شد که در آن تیمارها شامل سه سطح کود نیتروژن (۶۹، ۱۳۸ و ۲۰۵ کیلوگرم نیتروژن در هکتار) و دو رقم سورگوم (پگاه و KFS_2) بودند. نتایج نشان داد که کود نیتروژن به طور معنی‌داری ارتفاع بوته، شاخص سطح برگ، وزن تر، وزن خشک کل و عملکرد بیولوژیک را افزایش داد، به نحوی‌که این صفات در تیمار ۲۰۵ کیلوگرم نیتروژن در هکتار به ترتیب ۵/۷۱، ۲۲/۸، ۸/۱۳، ۲۲/۵ و ۸/۷ درصد نسبت به تیمار ۶۹ کیلوگرم نیتروژن در هکتار افزایش داشت.علاوه بر این، افزایش میزان نیتروژن اثر افزایشی بر سرعت رشد گیاه، سرعت رشد نسبی، دوام زی‌توده و دوام سطح برگ داشت. در مقایسه ارقام مشاهده شد که ارتفاع بوته، وزن تر، وزن خشک کل و عملکرد بیولوژیک در رقم پگاه بیشتر از KFS_2بود. نتایج نشان داد که رقم پگاه در بیشتر صفات مطالعه شده و در تیمار ۲۰۵ کیلوگرم نیتروژن در هکتار برتری داشت. بنابراین، رقم پگاه و کاربرد تیمار ۲۰۵ کیلوگرم نیتروژن در هکتار می‌تواند برای شرایط زراعی و آب و هوایی مشابه پیشنهاد گردد.