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# EFFECT OF SOWING DATE AND NITROGEN FERTILIZER ON SORGHUM (*SORGHUM BICOLOR* L. VAR. SPEED FEED) FORAGE PRODUCTION IN A SUMMER INTERCROPPING SYSTEM

**S. JOORABI[1]*, N. AKBARI[2], M. R. CHAICHI[3], Kh. AZIZI[2]**

*E-mail: sima_joorabi@yahoo.com

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**ABSTRACT.** To evaluate the interaction effects of planting date and different levels of nitrogen fertilizer on sorghum (*Sorghum bicolor* var. Speed feed) forage production, an experiment was conducted in split plots based on a complete randomized block design in Agricultural Research Station of Khorramabad, Lorestan province, Iran. The experimental treatments comprised of three nitrogen fertilizer levels of control (N0), 100 (N1), and 150 kg per hectare (N2), assigned to main plots and three sowing dates of T1 (June, 10$^{th}$), T2 (June 26$^{th}$) and T3 (July 11$^{th}$) assigned to subplots. Results showed that in sum of two harvests, the yield of hay, forage, leaf and shoot hay weigh in second planting date and N2 and N3 level of fertility was higher than all treatments. In the case of quality treatments the percent of crude protein in first harvest had the most amounts in first and second planting date and N1, N2 and N3 fertility levels. Crude fiber percentage in first harvest of second planting date was highest in N1, N2 and N3 levels of fertility. Treatment interactions had not any significant effect for crude fiber. The most ash percent was observed in first harvest and N1, N2 and N3 fertility level. In second harvest time N2 and N3 fertility levels were superior to the rest. Also, fat percentage in first and second planting date and N1, N2 and N3 increased than the control fertility treatment.

**Key words:** Crop management; Forage sorghum; Summer intercropping.

## INTRODUCTION

Population growth and inability of rangelands to support livestock needs enhance agronomists to pay more attention to develop cultivation of forage plants. Sorghum with good characteristics like high yield y and

[1]Agriculture Organization of Lorestan, Khoramabad, Iran
[2]College of Agriculture, Lorestan University, Khoramabad, Iran
[3]College of Agriculture, California State Polytechnic University, Pomona, USA

tillering potential, rapid growth and high nutrient contents is most considered in arid and semiarid regions of the world (Ayub *et al.,* 2007).

Nitrogen is an important nutrient because of its many functions in the vital processes of plant growth and development. Nitrogen deficiency imposes most limits on crop production compared to other nutrients. With large areas of the arable land in Iran being located in arid and semiarid regions, most of them face low organic matter content as well as nitrogen deficiency. To achieve an economically sound production, nitrogen plays a significant role in these regions.

Sorghum yield and its attributed physiological properties is significantly affected by nitrogen fertility. Nitrogen fertilizer application increases plant yield, forage quality and quantity (Ashiono *et al.,* 2005; Gardner *et al.,* 1994; Jarvis, 1996). Several reports showed that sorghum had severed reaction to nitrogen fertility. Beyart *et al.* (2005) studied nitrogen fertility on sorghum sudangrass and reported that highest yield was produced by application 125 kg nitrogen per hectare.

Study of sorghum in intercropping system requires identification and development of appropriate genotypes that have low competition with each other. Results of the previous studies recommended more revenue cultivation system such as: sorghum- chickpea, sorghum-bean and sorghum- peanut. Also, results showed that sorghum single planting had lower yield than intercropping (Doughton and Mackenzie, 1984).

To increase the efficacy of crop production, improve soil fertility and environmental protection, an alternative cropping system could be needed (Kiminami *et al.,* 2010). One of the best ways to increase forage production for animal feed is to develop cropping systems that cause balance between crop production and other critical factor of ecosystem (Fales *et al.,* 2007). Development of double cropping system is a suitable way to increase plant hay matter production during the growing season which provides several advantages (Wrather *et al.,* 2008; Arshad *et al.,* 2007). In these systems two crops are harvested in one growing season that include a psychrophilic crop (usually cover crop), harvested in spring, and a thermophilic crop that is planted after cover crop in summer (Snap *et al.,* 2005). Double cropping lead to soil conservation by reducing the soil erosion, because crop plants prolonged more that sole crop in the field. Because of double cropping the life cycle of pests and plant disease is disrupted (Kinoshita *et al.,* 2008). This cultivation system would allow farmers to benefit better economic opportunities, face lower risk of damages and more adaptation to circumstances (Seddiqi *et al.,* 2013). Double planting have high potential in increase land efficiency, labor, irrigation water, equipment and capital and in conclusion increase agricultural profitability (Kiminami *et al.,* 2010).

The objective of this research was to determine optimum planting date and its interaction with nitrogen fertilizer on forage quantity and quality of sorghum in a double cropping system after winter wheat in Khorramabad, Iran.

## MATERIALS AND METHODS

This experiment was conducted in Agricultural Research Station of Khorram abad, Iran. This city is located in 21°, 48'E and 29°, 33' N, with 1621 m altitude from sea level and mean precipitation of 524 mm per year. The climate of the area is classified as temperate.

The experimental treatments were arranged as split plots based on a completely randomized block design with three replications. Main plots were assigned to nitrogen fertilizer levels of control (N0), 100 (N1), and 150 (N2) kg per hectare while the planting dates of T1 (June, $10^{th}$), T2 (June $26^{th}$) and T3 (July $11^{th}$) were allocated to subplots. The nitrogen fertilizer was provided from urea source (Jafari *et al.,* 2012). Seeds were sown by hand on the rows with 10 cm intervals. The sowing density was considered 170,000 plants per ha. Sowing depth was 2-3 cm with 2-3 seed in each hole to guarantee the expected plant population. After plant establishment, the extra seedling was removed to achieve 170,000 designed populations. First irrigation was done immediately after planting. From planting to harvest time, irrigation was applied on weekly basis according to plant needs.

Nitrogen fertilizer was split and applied at proper phonological periods according to previous researches. In N1 and N2 treatments, 50 kg/ha of the nitrogen fertilizer was applied at planting time and before irrigation. Then the second portion of 50 kg/ha of nitrogen fertilizer was applied at eight-leaf stage. Before the first harvest no fertilizer treatment was added.

In each treatment, a two square meter forage sample was harvested at beginning of heading stage. Plants were harvested at 10 cm above the field surface. Samples was transferred to laboratory for forage fresh and dry weight measurements as well as other traits such as leaf dry weight, plant height. Seed yield was measured after plants reached physiological maturity. Analysis of variance for all traits was done with MSTAT-C statistical program. Means comparisons were done with Duncan test at 5 and 1% of probability levels.

## RESULTS AND DISCUSSION

### Vegetative traits

#### *Fresh and dry forage yields*

Fresh and dry forage yields followed an increasing trend as the level of N fertilizer application increased (*Table 3*). The highest fresh and dry forge yields were achieved at N2 (100 kg/ha) nitrogen treatment with 120.8 and 23.2 t $ha^{-1}$, respectively. Across all n fertilizer treatments, for both fresh (138.2 t $ha^{-1}$) and dry forge (26.13 t $ha^{-1}$), the highest values obtained when sorghum was planted on T2 (June $26^{th}$) treatment (*Table 3*).

The interaction effect of N fertilizer and planting date was significant and led to the highest fresh and dry forage yields of 148.8 t $ha^{-1}$ and 29.01 t $ha^{-1}$ at $N_2T_2$ (150 kg/ha and June 26th sowing date) treatment. Changing planting date could effluence on growth process with changing environment temperature (Dehghan, 2007). Because of good response of sorghum to fertilizer yield will increase with nitrogen consumption. Greef believed that increased nitrogen application, could increase nitrogen absorbance by plant (Greef, 1994).

***Tiller number***

Nitrogen fertilizer levels and planting date had a significant effect on tiller number at 1% and 5% of probability levels, respectively. The maximum tiller number was observed in third planting date (3.65) because of more favorable environmental conditions. There were not any significant effects between first and second planting date. The number of tillers in all N treatments (3.7 per plant) were higher than control (no N fertilizer). In response to interaction effects of the treatments, the highest number of tellers were observed in N2 and N3 in interaction of the first and third planting dates (*Tabs. 1-3*). Carvatta *et al.* (1990) concluded that tiller number in sorghum was affected by genotype and environmental conditions.

***Seed yield***

Seed yield followed an increasing trend as the N fertilizer application increased Across all planting dates the maximum seed yield of 9.84 t $ha^{-1}$ was produced in N2 (100 kg/ha) which was 31.7% higher than control (no N fertilizer application) (*Table 3*). In response to planting date, the seed yield also followed the trend as forage yield and the highest seed yield of 9.71 t $ha^{-1}$ was obtained in second planting date T2 (June 26th). More favorable climatic conditions created at grain filling stage of sorghum in T2 treatment caused a better sink-source relationship and higher seed yield. It seems that in T2 planting date there was enough time for seed filling before winter cold arrival.

As a response to interaction effect of planting date and N fertilizer levels, the highest seed yield of 10.22 $tha^{-1}$ was also obtained at N2T2 (150 kg $ha^{-1}$ and June 26th sowing date) treatment. Higher assimilate transfer during seed filling determines higher seed weights. Higher nitrogen fertilizer could increase foliage production which lead to higher seed weight due better sink and source relationship.

***Biological biomass***

Biological biomass followed an increasing trends as the level of N fertilizer application increased (*Table 3*). The highest biological biomass was achieved at N2 (100 kg $ha^{-1}$) nitrogen treatment with 33.05 t $ha^{-1}$. Across all N fertilizer treatments, the highest biological biomass values (35.88 t $ha^{-1}$) was obtained when sorghum was planted on T2 (June 26th) treatment (*Table 3*).

The interaction effect of N fertilizer and planting date was significant and led to the highest biological biomass of 39.23 t $ha^{-1}$ at

N2T2 (150 kg ha[1] and June 26th sowing date) treatment. Silvakumar and Salaam (1999) in their study on pear millet observed that forage dry matter yield in fertilizer application increased twofold compared to control treatment.

## Qualitative traits

### *Crude protein*

Across all planting dates, in all N fertilizer levels the crude protein content was higher ($p<0.05$) than control (*Table 5*). These results supports results of Ayub *et al.* (2002) that maximum crude protein percent was observed in 150 kg $ha^{-1}$ nitrogen and minimum was in control treatment (without fertilizer). According to Ashiono *et al.* (2005), 40 kg $ha^{-1}$ nitrogen with 20 kg $ha^{-1}$ phosphorus fertilizer, increased crude protein percent in sorghum.

### *Crude fiber*

The maximum crude fiber percentage belonged to all N treatments (N1, N2 and N3 treatments with 29.13, 29.13 and 29.24, respectively), compared to control (27.73%). Forage digestibility has a direct relationship with cell wall properties. Cell wall generally is composed of structural carbohydrate that changes digestibility according to lignin content. As shown in *Table 1*, NDF (that states total amount of lignin and cellulose), and ash percent gradually increased with higher nitrogen application. Since any increase in the percent of insoluble fiber in acid and ash percent has adverse effect on digestibility, the forage digestibility has the lowest values in N3 treatment.

### *Ash*

Maximum ash content was observed in all N fertilizer treatments (N1, N2 and N3 treatments with 8.590, 8.553 and 8.578, respectively), compared to control (7.76) (*Tab. 4*). Ash content in forage showed available minerals for livestock (Alan Rotz and Sanderson, 2001). This trait was enhanced in all N fertilizer applications. According to Ayub *et al.* (2002), application 150 kg $ha^{-1}$ nitrogen produced maximum percent of ash. Increasing in ash content by nitrogen application was also reported by Ahmad (1999).

### *Fat*

The effect of planting date and nitrogen fertilizer was significant on fat percent ($p<0.01$). Fat content in all N levels (N1, N2 and N3) were significantly higher than control (1.732). Ayub *et al.* (2002) found that, maximum fat percent was produced in 150 kg N $ha^{-1}$ and lowest one was produced in control treatment. The results of variance analysis for qualitative traits in first and second harvest was presented in *Tabs. 4 and 5*.

**Table 1 - Means comparison of nitrogen fertility levels and planting date on some of qualitative properties of forage sorghum in double cropping with wheat by first harvest evaluated by Duncan test**

| | Forage yield (t ha$^{-1}$) | Hay yield (t ha$^{-1}$) | Tiller number | Seed yield (t ha$^{-1}$) |
|---|---|---|---|---|
| Fertility treatments | | | | |
| N0 | 41.750b | 8.291b | 2.817b | 7.47c |
| N1 | 73.420a | 13.710a | 3.533a | 8.94b |
| N2 | 72.830a | 13.970a | 3.775a | 9.84a |
| Planning data | | | | |
| T1 | 60.000c | 11.280b | 3.388b | 8.936b |
| T2 | 64.630b | 11.280b | 3.381b | 9.751a |
| T3 | 71.560a | 14.860a | 3.365a | 8.509c |
| Interaction | | | | |
| N0T1 | 40.000d | 7.485d | 2.600c | 8.585d |
| N0T2 | 42.250d | 8.097d | 2.800c | 8.073d |
| N0T3 | 43.000d | 9.290c | 3.050bc | 5.763e |
| N1T1 | 66.250c | 12.440b | 3.450ab | 8.020d |
| N1T2 | 72.500b | 11.990b | 3.600ab | 9.968ab |
| N1T3 | 81.500a | 16.700a | 3.550ab | 8.840cd |
| N2T1 | 65.500c | 12.710b | 3.800a | 9.460bc |
| N2T2 | 71.750b | 12.470b | 3.525ab | 10.220ab |
| N2T3 | 81.250a | 16.740a | 4.000a | 9.837b |
| significantly different man plot | ** | ** | ** | ** |
| significantly different sub plot | ** | ** | * | ** |
| significantly different interaction | ** | ** | ns | ** |

In each column means with same letters have not any significant differences.
*and **: significant at the 5% and 1% probability levels, repectively; ns: not significant; N0: Control (without fertility), N1: 100 kg nitrogen/ha and N2: 150 kg nitrogen/ha; T1 (June, 10th), T2 (June 26th) and T3 (July 11th)

**Table 2 - Means comparison of nitrogen fertility levels and planting date on some of qualitative properties of forage sorghum in intercropping by second harvest evaluated by Duncan test**

| Fertility treatments | Forage yield (t ha$^{-1}$) | Hay yield (t ha$^{-1}$) |
|---|---|---|
| N0 | 54.750c | 9.906c |
| N1 | 64.750b | 11.940b |
| N2 | 71.880a | 13.490a |
| Interaction | | |
| N0T1 | 45.250d | 7.180f |
| N0T2 | 64.250b | 12.630c |
| N0T3 | 53.750c | 9.205e |
| N1T1 | 75.750a | 14.670b |

| Fertility treatments | Forage yield (t ha$^{-1}$) | Hay yield (t ha$^{-1}$) |
|---|---|---|
| N1T2 | 66.750b | 11.180d |
| N1T3 | 77.000a | 15.790a |
| N2T1 | 67.000b | 10.900d |
| N2T2 | 77.250a | 15.580a |
| significantly different man plot | ** | ** |
| significantly different sub plot | ** | ** |
| significantly different interaction | ** | * |

*and **: significant at the 5% and 1% probability levels, repectively; ns: not significant; N0: Control (without fertility), N1: 100 kg nitrogen/ha and N2: 150 kg nitrogen/ha; T1 (June, 10th), T2 (June 26th) and T3 (July 11th)

**Table 3 - Means comparison of nitrogen fertility levels and planting date on some of qualitative properties of forage sorghum in intercropping by total harvest evaluated by Duncan test**

| Fertility treatments | Fresh forage yield (t ha$^{-1}$) | Dry forage yield (t ha$^{-1}$) | Biological biomass (t ha$^{-1}$) | Seed yield (t ha$^{-1}$) |
|---|---|---|---|---|
| N0 | 78.25c | 14.90c | 22.37c | 7.473c |
| N1 | 116.60b | 21.67b | 30.61b | 8.943b |
| N2 | 120.80a | 23.21a | 33.05a | 9.838a |
| Planning data | | | | |
| T1 | 118.20b | 20.90b | 29.83b | 8.94b |
| T2 | 138.20a | 26.13a | 35.88a | 9.75a |
| T3 | 71.56c | 14.86c | 23.37c | 8.51b |
| Interaction | | | | |
| N0T1 | 85.25e | 14.66g | 23.25f | 8.585d |
| N0T2 | 106.50d | 20.73e | 28.80d | 8.073d |
| N0T3 | 43.00f | 9.29h | 15.05g | 5.763e |
| N1T1 | 120.00c | 21.65de | 29.67d | 8.020d |
| N1T2 | 148.30a | 26.66b | 36.63b | 9.968ab |
| N1T3 | 81.50e | 16.70f | 25.54e | 8.840cd |
| N2T1 | 132.30b | 23.89c | 33.35c | 9.460bc |
| N2T2 | 148.80a | 29.01a | 39.23a | 10.220ab |
| significantly different man plot | ** | ** | ** | ** |
| significantly different sub plot | ** | ** | ** | ** |
| significantly different interaction | ** | ns | * | ** |

*and **: significant at the 5% and 1% probability levels, repectively; ns: not significant; N0: Control (without fertility), N1: 100 kg nitrogen/ha and N2: 150 kg nitrogen/ha; T1 (June, 10th), T2 (June 26th) and T3 (July 11th)

**Table 4 - Means comparison of nitrogen fertility levels and planting date on some of qualities properties of forage sorghum in intercropping in first harvest evaluated by Duncan test**

| Fertility treatments | Crude protein (%) | Crude fiber (%) | Ash (%) | Fat (%) |
|---|---|---|---|---|
| N0 | 8.547b | 27.73b | 7.762b | 1.732b |
| N1 | 9.418a | 29.13a | 8.590a | 2.005a |
| N2 | 9.354a | 29.13a | 8.553a | 2.047a |
| Planning data | | | | |
| T1 | 9.473a | 28.67b | 8.396a | 2.071a |
| T2 | 9.323a | 28.67b | 8.343a | 2.025a |
| T3 | 8.684a | 29.08a | 8.374a | 1.760b |
| Interaction | | | | |
| N0T1 | 8.930bcd | 27.66c | 7.782b | 1.770bc |
| N0T2 | 8.705d | 27.41c | 7.738b | 1.732bc |
| N0T3 | 8.007e | 28.11bc | 7.767b | 1.692c |
| N1T1 | 9.648ab | 28.78ab | 8.585a | 2.168a |
| N1T2 | 9.613ab | 29.12a | 8.615a | 2.043ab |
| N1T3 | 8.993abcd | 29.49a | 8.570a | 1.805bc |
| N2T1 | 9.648ab | 29.15a | 8.632a | 2.210a |
| N2T2 | 9.490abc | 28.94a | 8.445a | 2.148a |
| N2T3 | 8.925bcd | 29.31a | 8.583a | 1.783bc |
| significantly different man plot | ** | ** | ** | ** |
| significantly different sub plot | ** | ** | ns | ** |
| significantly different interaction | ns | ns | ns | ns |

*and **: significant at the 5% and 1% probability levels, repectively; ns: not significant; N0: Control (without fertility), N1: 100 kg nitrogen/ha and N2: 150 kg nitrogen/ha; T1 (June, 10$^{th}$), T2 (June 26$^{th}$) and T3 (July 11$^{th}$)

**Table 5 - Means comparison of nitrogen fertility levels and planting date on some of qualities properties of forage sorghum in intercropping in second harvest evaluated by Duncan test.**

| Fertility treatments | Crude protein (%) | Crude fiber (%) | Ash (%) | Fat (%) |
|---|---|---|---|---|
| N0 | 9.235c | 26.49c | 7.436c | 1.761b |
| N1 | 9.985b | 27.34b | 8.260b | 1.859ab |
| N2 | 10.50a | 28.15a | 8.688a | 2.029a |
| Interaction | | | | |
| N0T1 | 9.503cd | 25.59e | 7.445b | 1.695a |
| N0T2 | 8.968d | 27.39c | 7.427b | 1.827a |
| N0T3 | 10.40b | 26.42d | 8.243a | 1.837a |
| N1T1 | 9.750cd | 28.26b | 8.278a | 1.880a |

| Fertility treatments | Crude protein (%) | Crude fiber (%) | Ash (%) | Fat (%) |
|---|---|---|---|---|
| N1T2 | 11.19a | 26.99cd | 8.720a | 1.947a |
| N1T3 | 9.807c | 29.32a | 8.655a | 2.110a |
| N2T1 | 11.32a | 27.06cd | 8.667a | 1.923a |
| N2T2 | 9.688c | 29.07a | 8.715a | 2.178a |
| significantly different man plot | ** | ** | ** | ** |
| significantly different sub plot | ** | ** | ns | ns |
| significantly different interaction | ** | ns | ns | ns |

*and **: significant at the 5% and 1% probability levels, repectively; ns: not significant; N0: Control (without fertility), N1: 100 kg nitrogen/ha and N2: 150 kg nitrogen/ha; T1 (June, 10$^{th}$), T2 (June 26$^{th}$) and T3 (July 11$^{th}$)

## CONCLUSION

Results of this study showed that nitrogen fertilizer could increase qualitative and quantitative traits of sorghum forage in Speed feed variety. Across all harvests (total yield), the best results obtained from second planting date (June 26$^{th}$) and N2 (150 kg ha$^{-1}$) nitrogen treatment. Further experiments to confirm the best planting date and nitrogen application level is recommended.

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