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The effect of nitrogen management on the yield and yield components of grain sorghum (*Sorghum bicolor* L. Moench)

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Abstract

Resource constraints, environmental problems caused by intensive farming, and indiscriminate use of chemical fertilizers are considered as proper economic and ecological justification and context for conducting research on the management of nitrogen fertilizer in plants. In this regard, in order to examine the rate and the way of distribution of nitrogen fertilizer and its effect on the yield and yield components of grain sorghum (Sorghum bicolor L. Moench) a split plot experiment as randomized complete block design with three replications was carried out in Shahid Salemi research field located in Ahvaz in 2011-2012. In this experiment, nitrogen as the main plot included three levels (N_1=80, N_2=160, N_3=240 kgNha^{-1}) and the sub plot included three levels of nitrogen distribution (split) (S_1: 100% at planting stage , S_2: 50% at planting stage + 50% at stem elongation, S_3: 25% at planting stage + 50% at stem elongation+ 25% at reproductive stage). The results showed that as the use of nitrogen increased, grain yield, number of grains per plant, number of grains per ear, 1000-grain weight, and biological yield increased significantly at S_3 level. The increase of grain yield at high levels of nitrogen was due to higher number of grains per plant and more 1000-grain weight. There was a significant difference between different levels of nitrogen distribution and their effects on grain yield and number of grains per plant so that the highest grain yield and number of grains per plant belonged to S_3 level.

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Introduction

Sorghum is a crop with C_4 mechanism. Due to its deep root system, few short leaves to decrease evapotranspiration, and its stems' covered with a waxy substance, sorghum is highly resistant to drought.(Kuchaki ,1996) states that this cereal crop is used as the source of energy in poultry's diet and its nutritional value is only 3-5% lower than the corn's and needs less water and fertilizer.(Ebadi *et al* ,1997) stated that the lack of nitrogen, due to its numerous important roles in plants vital processes, constraints the crops production more than any other elements. Nitrogen increases sorghum's yield by increasing the number of plants, number of grains per plant, and the weight of 1000-grain and generally, all yield components of sorghum are directly affected by nitrogen (Bah *et al.*, 1998; Limon Ortega *et al.*, 1998 ; Howard and Lessman, 1991). Nitrogen deficiency or reduction in each growth stage impairs the synthesis of assimilates and photosynthetic capacity reduction is considered as an important principle in limiting the yield and yield components. By consuming nitrogen fertilizer, the leaves stay green for a longer time ant the loss of the leaves decreases and the photosynthetic activity of the leaves increases. Nitrogen affects photosynthesis more than other nutrients and its shortage at every stage of growth impairs assimilates photosynthesis (Noormohammadi *et al.*, 1997). By using 84 kgNha^{-1} the rate of grain nitrogen increases as much as 18% and by using 168 kgNha^{-1} the rate of grain nitrogen increases as much as 30% (Hones *et al.*, 1986).

In an experiment conducted by(.Mossedaq and Smith ,1994), the wheat grain yield increased by using nitrogen and the highest increase was observed when the remaining nitrogen was consumed before the stem elongation.

Since providing the required nitrogen by plant is very important in increasing the crop production and favorable yield this experiment was carried out to determine the levels and the ways of distribution of nitrogen fertilizer and its effect on the yield and yield components of grain sorghum in Khuzestan and also to determine the best rate and distribution of fertilizer to be recommended to the farmers in that area. (Yoshida,1987) stated that the application of nitrogen about 20 days before flowering time has a high production efficiency together with active growth of young panicles before flowering. The absorbed nitrogen at this period of time increases the number of ears and the size of plants. (Yoshida and Parao, 1976) showed in their research that the percentage of fertility of full ears in every panicle is affected by factors such as climate, soil, varietal characteristics such as the rate of consumed nitrogen fertilizer. The objective of this study The Effect of Nitrogen Management on the Yield and Yield Components of Grain Sorghum This research was carried out based on achieving the goals of sustainable agriculture and decreasing the use of chemical fertilizers and also examining the effects of Nitrogen Management as an economically and environmentally efficient and a healthy fertilizer source, on the yield and yield components of Sorghum.

Materials and methods

The experiment was carried out in the research center of Shahid Salemi in Ahvaz at longitude 48°40´E and altitude 31°20´N and altitude of 22.5 m above the sea level in the summer of 2012. The experiment site had clay loam soil with ph=7.8 and ec=5 and the rate of nitrogen=5.7 ppm. It was a split plot experiment in the form of randomized complete block design with three replications. In this experiment, nitrogen as the main factor included three levels (N_1=80, N_2=160, N_3=240 kgNha^{-1}) and the sub factor included three levels of nitrogen distribution (split) (S_1: 100% at planting stage , S_2: 50% at planting stage + 50% at stem elongation, S_3: 25% at planting stage + 50% at stem elongation+ 25% at reproductive stage).after plowing and driving operations and applying triple superphosphate fertilizer between first and second driving to supply the phosphorus required by plant, some furrows were made by plowing machine. The planting was done in July as ridge and furrow. The project included 27 experimental units. Each sub plot included 6 planting lines as long as 5 meter and 7cm spacing from each other. Plant density was 11 plants per square meter. The required nitrogen was provided by the urea source. In order to prevent horizontal movement of urea fertilizer during the fertilization, some furrows were made in irrigation streams and the fertilizer was evenly placed in the furrows. Then they were covered by soil and immediately irrigated. While planting at the first stage, urea fertilizer was distributed to the experiment land as the basic fertilizer. The final harvest was done during the physiological maturity of the grains and in order to measure the grain yield, the products of two square meters were harvested while considering the marginal effects of both sides. In order to determine the yield and yield components (1000-grain weight, number of grains per plant, number of ears per plant, number of grains per ear) 10 plants were randomly selected and measured.

Data variance analysis was done by means of SAS software the means were compared by Duncan's multi range tests at 5% and 1% probability levels and EXCEL software was used to draw diagrams and curves.

Results and discussion

1000-grain Weight

The ANOVA results showed that the weight of sorghum 1000-grain was significantly affected by the rate and distribution of nitrogen at 1% probability level. The interactive effect of nitrogen rate and distribution was not significant. The mean comparison via Duncan's test (table 2) at 5% level showed that the highest weight of 1000-grain by 25.81 g was related to the treatment with 240 $kgNha^{-1}$ and the lowest weight of 1000-grain by 23.83 g was related to the treatment with the use of 80 $kgNha^{-1}$. The results showed that nitrogen increased the weight of 1000-grain by increasing the mobilization of assimilates produced by plant into grains. The results were consistent with the findings of(Ulger *et al*, 1997; and Toshih and Shariati, 2000).

Table 1. The results of ANOVA, grain yield, and yield components (1000-grain weight, number of ears per plant, number of grains per plant, number of grains per ear) of grain sorghum based on the mean of squares.

Variation sources	Degree of freedom	1000-grain weight	Number of ears per plant	Number of grains per plant	Number of grains per ear	Grain yield
Replication (R)	2	1.010	52.2*	40090	6.49	2660
Nitrogen rate (N)	2	71/412*	61/87*	18/85*	128/48*	15168**
R*N	4	8/42	7/45	3/771	12.01	960
Nitrogen split (s)	2	57/979*	48/01*	476185**	152.37**	56323**
Nitrogen rate x nitrogen split (N×S)	4	10/135ns	9/11n.s	18/66n.s	9/29n.s	437n.s
Error Coefficient of variations (CV%)	12	6/27 11//55	6/7 5/82	22246 1382	22246 13/82	1659 13/62

NS,*,** respectively mean non-significant, significant difference at 5% and 1% level.

The highest weight of 1000-grain by 26.50 g belonged to S_3 split and the lowest weight by 23.69 belonged to S_1 split. It seems like that the higher weight of 1000-grain in S_3 in comparison to S_1 and S_2 could be related to the increase of nitrogen uptake available for plant, the increase of leaf area index and consequently the increase of flowering period and assimilates mobilization to the grain. The result is consistent with the findings of (Banzigar *et al* , 2002 ; and Tavakol ,1998) who reported that the delayed application of nitrogen fertilizer increased the weight of corn grain because of its positive effect on the leaf area continuity and thus the increase of grain filling period.

(Khalife, 1973) stated that if the nitrogen distribution were done in such a way that it could increase the grain filling period by affecting the increase of leaf life and current photosynthesis, the weight of wheat grain would increase.

Number of ears per Plant

The ANOVA results showed that the number of ears in sorghum was significantly affected by the rate and distribution of nitrogen at 5% level. The interactive effect of nitrogen rate and distribution was not significant. The mean comparisons via Duncan's test (table 2) at 5% level showed that the highest number of ears by 45.67 belonged to the treatment with 240 $kgNha^{-1}$ and the lowest number by 42.63 belonged to the treatment with80 $kgNha^{-1}$. Among the yield components, the number of ears per plant was affected by the rate of nitrogen consumption. According to(Kim and Paulsen , 1986), the increase of the number of ears per plant as one of the yield components is very important and leads to the increase of the number of grains per plant and finally the increase of grain yield. The highest number of ears by 46.44 belonged to S_3 distribution and the lowest number by 20.42 belonged to S_1 distribution.

Table 2. The mean comparison of the simple effects of different levels of nitrogen and its distribution (split) on traits, grain yield, and yield components (1000-grain weight, number of ears per plant, number of grains per plant, number of grains per ear) of grain sorghum.

Treatments	Traits mean				
Nitrogen	1000-gratin weight (g)	Number of ears per plant	Number of grains per plant	Number of grains per ear	Grain yield (g/m²)
N1=80	23/83b	42/63b	955/42b	22.20b	251/60b
N2=160	25/74a	4439a	1137/34a	25/55a	323/37
N3=240	25/81ª	45/67a	1144/06a	24/90a	322//02
Nitrogen split					
S1	23/69b	42/02c	829/96b	19/65b	214/33c
S2	25/149a	44/22	1123/34a	25/36a	311/65b
S3	26/50a	46/44a	1283/53a	27/46a	371/02a

The Means of treatments which have the same letters based on Duncan's multi range tests at 5% level are not significantly different from each other in terms of statistics.

Number of Grains per Ear

The ANOVA results showed that the number of grains in sorghum ear was significantly affected by the rate and distribution of nitrogen at 1% level. The interactive effect of nitrogen rate and distribution was not significant. The mean comparisons via Duncan's test (table 2) at 5% level showed that the highest number of grains per ear by 25.55belonged to the treatment with 160 $kgNha^{-1}$ and the lowest number of grains per ear by 22.2 belonged to the treatment with80 $kgNha^{-1}$. The highest number of grains per ear by 25.55 belonged to S_2 distribution and the lowest number by 22.2 belonged to S_1 distribution.

Number of Grains per Plant

The ANOVA results showed that the number of grains in sorghum plant was significantly affected by the rate of nitrogen at 5% probability level and by nitrogen distribution at 1% level. The interactive effect of nitrogen rate and distribution was not significant. The mean comparisons via Duncan's test (table 2) at 5% level showed that the highest number of grains per plant by1144.06 belonged to the treatment with 240 $kgNha^{-1}$ and the lowest number of grains per plant by 955.42 belonged to the treatment with80 $kgNha^{-1}$. The obtained results showed that the presence of adequate nitrogen during pollination could partly prevent the destruction of grains during the competition of fertile flowers for assimilates. The positive effect of nitrogen on the number of grains per plant was reported by (Motiei ,1991; and Sepehri ,2001). The highest number of grains per plant by 1283.53 belonged to S_3 distribution and the lowest number of grains per plant by 829.96 belonged to S_1 distribution.

Grain Yield

Area unit is a proper criterion for evaluating applied treatments in an experiment because grain production in a crop depends on environmental and genetic factors so that during the experiment by fixing all factors it is possible to measure the effect of applied treatment on the grain yield. On the other hand, in planting crops the ultimate goal is to produce grains; therefore, it is the grain yield which mostly determines the acceptance or rejection of a genotype with a certain management (Imam, 1994).

The ANOVA results showed that the sorghum grain yield was significantly affected by the rate and distribution of nitrogen at 1% probability level. The interactive effect of nitrogen rate and distribution was not significant. The mean comparisons via Duncan's test (table 2) at 5% level showed that the highest grain yield by323.37 g/m2 belonged to the treatment with160 $kgNha^{-1}$ and the lowest grain yield by 251.6 g/m^2 belonged to the treatment with80 $kgNha^{-1}$.

It seems like that the better grain yield is due to the positive effect of nitrogen and better absorption of light and increase of photosynthesis, plant growth rate, leaf area index and leaf area continuity. The results were consistent with the findings of(Navaz *et al* , 2005 ; Shinro *et al* , 2004 ; and Akbarloo ,1994).

In another study by (Ulger *et al* ,1997), as the level of nitrogen increased, number of grains per corn, 1000-grain weight, corn diameter and length increased and the increase of yield components in turn led to the increase of grain yield. On the other hand, since the light absorption by the leaves and changing it to assimilates are the other factors affecting the plant growth and production, the increase of leaf area in the farm increases the absorption of light which ultimately increases the yield.

The highest grain yield belonged to S_3 distribution by 371.02 g/m^2 and the lowest belonged to S_1 by 214.33 g/m^2. It seems like that the increase of grain yield in S_3 distribution is due to high nitrogen uptake and the increase of leaf area and leaf longevity at early flowering stage until the grain maturity. The increase of grain yield was reported by(Motiei ,1991) by consuming ½ nitrogen at planting stage and ½ nitrogen at 6-8-leaf stage.

In this research, the effect of different levels of nitrogen and its distribution on the yield and yield components of grain sorghum (Peyam cultivar) was studied in Shahid Salemi research field located in Khuzestan. The effect of different levels of nitrogen and its distribution on the yield and yield components of grain sorghum was significant so that the highest rate of yield and yield components belonged to N_2 and N_3 and S_3.

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