Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231-6345 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jls.htm
2014 Vol. 4 (3) July-September, pp. 223-227/Amiri et al.

Research Article

THE EFFECT OF DIFFERENT LEVELS AND TIME OF NITROGEN APPLICATION ON GRAIN YIELD, SOME PHYSIOLOGICAL TRAITS AND NITROGEN USE EFFICIENCY IN GRAIN SORGHUM

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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 (N1=80, N2=160, N3=240 kgNha-1) and the sub plot included three levels of nitrogen distribution (split) (S1: 100% at planting stage, S2: 50% at planting stage + 50% at stem elongation, S3: 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 year, 1000-grain weight, and biological yield increased significantly at S3 level. The results show that the increase of nitrogen level and its split application has affected nitrogen use efficiency, so that as the nitrogen level increases, nitrogen use efficiency (NUE) has decreased significantly and the highest one is related to N1. Split application of nitrogen has also had significant effects on nitrogen use efficiency so that the highest rate for all above cases has been related to the treatment of S2 kg nitrogen.

Keywords: *Grain Sorghum, Nitrogen, Yield, Nitrogen Use Efficiency*

INTRODUCTION
Sorghum is a crop which is resistant to drought conditions. Its optimum yield in arid areas has opened new horizons in production of grain sorghum. Although a large area of Iran is arid and grain sorghum adapts to drought conditions, a few studies have been done on optimal farming aspects of this crop. The surveys done by FAO in recent 40 years indicate that 33% to 60% of increase of crops' yield in various countries has resulted from the consumption of chemical fertilizers and FAO has called manure as the key to food security (Huggins and Pan, 1993). Nitrogen is one of the major elements limiting crops production. The average rate of this element in dry matter produced by crops is 1-2% which sometimes reaches 4-6%. Considering the total amount of nitrogen required for crop production, nitrogen is the fourth among 16 basic elements required by crops. More than 2.4 million tons out of 4 million tons of fertilizers consumed in Iran in 2006 were nitrogen fertilizers (Laegreid *et al.*, 1996). The efficiency of nitrogen consumption for grain products, maize, and rice in developed countries is 15 kg grains per 1 kg of nitrogen consumption. Global efficiency of nitrogen fertilizers recycling in grains has been reported to be 33% which reaches to 29 and 42% respectively in developing and developed countries (Raun and Johnson, 1999). As the level of nitrogen increased to 140-230 kg/ha, grain yield in sorghum increased, too. The increase of nitrogen fertilizer consumption up to 200 kg/ha has increased the yield of millet (Mirlohi *et al.*, 2010). In studying the effect of 0-250 kg/ha nitrogen on sorghum, the maximum yield and nitrogen consumption efficiency belonged to the treatment with consumption of 100 kg/ha nitrogen. In an experiment on two maize genotypes, Beyaert and Roy (2008) found a strong relationship between harvest index and changes of carbohydrates and stored nitrogen. Changes in harvest index of plants also depend on difference and rate of assimilates production and synthesis during grain filling stage and assimilates remobilization before each genotype pollination and sink strength (Buah *et al.*, 2005). The highest

efficiency of nitrogen consumption belonged to the cultivar with minimum absorption during grain filling stage (Nameless, 2010). Increase of nitrogen consumption increased relative content of nitrogen and reduced the efficiency of this element in oat. Collins *et al.*, (1990) reported that nitrogen efficiency decreased as its consumption increased from 90 to 180 kg/ha in millet. Staley *et al.*, (1991) stated that determining the rate of chlorophyll at silk producing stage was one of the ways to recognize.

MATERIALS AND METHODS

Experimental Location

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 (N1=80, N2=160, N3=240 kgNha-1) and the sub factor included three levels of nitrogen distribution (split) (S1: 100% at planting stage, S2: 50% at planting stage + 50% at stem elongation, S3: 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. Harvest index was calculated by equation:

HI= Harvest Index

Ye= Economical yield HI=Ye / Yb

Yb= Biological yield

Statistical Analysis

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.

RESULTS AND DISCUSSION

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. 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/m2 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 (Scheinev *et al.*, 2004; Akbarlo, 1994). On the other hand, since the light absorption by the leaves and changing it to assimilate 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 S3 distribution by 371.02 g/m2 and the lowest belonged to S1 by 214.33 g/m2. It seems like that the increase

of grain yield in S3 distribution is due to high nitrogen uptake and the increase of leaf area and leaf longevity at early flowering stage until the grain maturity.

Harvest Index

The ANOVA results (Table 1) showed that harvest index was significantly affected by the rate and split application of nitrogen at 5% probability level. The interactive effect of rate and split application of nitrogen on harvest index was not significant. Comparison of the means via Duncan's multi range test at 5% level (Table 2) showed that the highest rate of harvest index by 25.45% belonged to the treatment with consumption of 160 kg/ha nitrogen and the lowest rate of harvest index by 23.44% belonged to the treatment with application of 80 kg/ha nitrogen because as the consumption of nitrogen increased, more assimilated were produced and assimilates remobilization into grains during grain filling stage and leaf area index increased. The results were consistent with the findings of Roya and Blanco (1999). The highest rate of harvest index by 28.19% belonged to split application S3 and the lowest rate belonged by 20.30% belonged to split application S1. Since there is a strong relationship between harvest index and nitrogen stock, the increase of harvest index in plants is due to increase of production and synthesis of assimilates during grain filling stage and assimilates remobilization before pollination. The results of this research were consistent with the findings of Buah *et al.,* (2005).

Chlorophyll Index

The ANOVA results (Table 1) showed that the effect of nitrogen level and split application on chlorophyll index was significant at 1% level. The interactive effect of nitrogen level and split application on chlorophyll index was not significant. Comparison of the means via Duncan's multi range test at 5% level (Table 2) showed that the highest rate of chlorophyll index by 58.04% belonged to the treatment with consumption of 240 kg/ha nitrogen and the lowest rate of chlorophyll index by 46.88% belonged to the treatment with application of 80 kg/ha nitrogen. Since nitrogen is used in molecular structure of chlorophyll it seems that under nitrogen deficiency conditions. There is a close relationship between nitrogen and chlorophyll in plants and that is why the rate of chlorophyll is used to determine nitrogen position in plants. The highest rate of chlorophyll by 56.47% belonged to split application S3 and the lowest rate by 48.39% belonged to S1. Due to direct relationship between chlorophyll index and nitrogen and more absorption of nitrogen by plant, this stage of plant application S3 is followed by increase of chlorophyll index. The results were consistent with the findings of Subedi (2005).

Nitrogen Use Efficiency (NUE)

The ANOVA results (Table 1) showed that showed that the effect of nitrogen level and split application on nitrogen use efficiency was significant at 1% level. The interactive effect of nitrogen level and split application on nitrogen use efficiency was not significant. Comparison of the means via Duncan's multi range test at 5% level (Table 2) showed that the highest rate of nitrogen use efficiency by 31.45 kg belonged to the treatment with consumption of 80 kg/ha nitrogen and the lowest rate of nitrogen use efficiency by 13.42 kg belonged to the treatment with application of 240 kg/ha nitrogen. It seems that as Doyle and Helford expressed, one of the reasons of decrease of crop yield and nitrogen use efficiency is the increasing speed of loss of nitrogen through leaching and sublimation or lack of efficient use of it. Collins *et al.,* (1990) found that the increase of nitrogen consumption enhanced nitrogen relative content but reduced nitrogen use efficiency in oats. Stally *et al.,* (1991) stated that as the consumption of nitrogen increased from 90 to 180 kg/ha, nitrogen use efficiency decreased in millet. The highest rate of nitrogen use efficiency by 27.22 kg belonged to split application of S3 and the lowest rate by 15.48 kg belonged to split application of S1. Malakooti and Nafisi (2003) stated that when a large percentage of nitrogen is used during cultivation, the loss of nitrate due to leaching in early irrigations increases and nitrogen use efficiency decreases. Therefore, several application of nitrogen fertilizer at different growth stages is highly important for increasing nitrogen use efficiency. Bowadr *et al.,* (2003) reported that due to further loss of nitrogen in first irrigation, the application of a high percentage of total nitrogen at planting stage should be avoided.

Table 1: The results of ANOVA based on the mean of squares

NUE	Chlorophyll Index	Harvest index	Grain Yield	df	S.O.V
13.24	4.855	17.456	2660	2	R
746.48**	291.938*	89.132*	15168*	2	(N)
3.60	14.306	14.751	960	4	Ea
313.26**	159.667 **	140.429*	56323*	2	(S)
26.32 n.s	4.702	1.795	437 n.s	4	(N×S)
10.29	2.423	8.489	1659	12	Eb
14.78	2.93	41.34	13.62	—	(CV%)

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

Table 2: The mean comparison of the simple effects of different levels of nitrogen and its distribution (split) on traits

NUE g/g	Chlorophyll Index	Harvest index(%)	Grain Yield g/m2	Treatments
31.45[a]	46.88[b]	23.44[b]	251.60[b]	N1= 80
20.21[b]	46.54[a]	25.45[a]	323.37[a]	N2= 160
13.42[c]	58.04[a]	24.36[ab]	322.02[a]	N3= 240
				S
15.48[c]	48.39[b]	20.30[c]	214.33[c]	S1
22.38b	54.52[a]	24.77[b]	311.65[b]	S2
27.22[a]	56.47[a]	28.19[a]	317.02[a]	S3

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

The consumption of one-third of nitrogen fertilizer during planting and consumption of residual at later stages of plant growth, increased nitrogen use efficiency. Huggins *et al.*, (1993) found that at high levels of nitrogen fertilizer consumption the absorption of available nitrogen increased gradually which led to decrease of nitrogen use efficiency.

Conclusion

In this research the effect of different levels of nitrogen fertilizer and its split application on yield and some physiological properties of grain sorghum (Payam cultivar) was investigated in Shahid Salemi Field in Khuzestan. The effect of different levels of nitrogen and its split application on grain yield, harvest index, chlorophyll index was significant, so that the highest rate of grain yield, harvest index, chlorophyll index was related to N2 and N3 levels and S3 split application. The results show that the increase of nitrogen level and its split application has affected nitrogen use efficiency, so that as the nitrogen level increases, nitrogen use efficiency (NUE) has decreased significantly and the highest one is related to N1. Split application of nitrogen has also had significant effects on nitrogen use efficiency so that the highest rate for all above cases has been related to the treatment of S2 kg nitrogen.

ACKNOWLEDGEMENT

The Islamic Azad University of Ahvaz is highly appreciated for providing all necessary facilities and equipment for carrying out the research.

REFERENCES

Akbrlou H (1994). Reviews Asrkvdazth plant density on yield and agronomic characteristics of sunflower. Master's thesis, Agriculture Branch.

Bawder TA and Waskom RM (2003). Best management practices for Colorado Corn. Colorado State univ. Coop. Ext. Serv – Agriculture XCM 574 A – no. 514.

Beyaert RP (2008). In fertilization on multi - cut foages sudangrass yield and nitrogen use. Agro n.g. **97** 1493 -1501.

Buah S and Maranville G (2005). Response of nitrogen use efficient sorghum to nitrogen fertilizer. *Journal of Plant Nutrition*, Zill 2303-2318.

Collins M, Brinkman MA and Salman A (1990). Forage yield and quality of oat cultivars with increasing rate of nitrogen fertilization. *Agronomy Journal* **82** 724-728.

Huggins DR and Pan WL (1993). Nitrogen efficiency component analysis: an evaluation of cropping system differences in productivity. *Agronomy Journal* **85** 895-905.

Laegreid M, Bockman OC and Kaarstad O (1996). *Agriculture, Fertilizers and the Enviroment* (Norsk Hydro ASA.CABI pub).

Malakuoti MJ and Nafisi M (1992). *Fertilization of Dry Matter and Irrigation Soils* (A Publication of Tarbiat Modarres) 342 (In Persian).

Mirlohi **A, Honorable N and Bassiri CE (2010).** Nitrogen fertilizer effects on growth, yield and quality The hybrid forage sorghum silage Tuesday. *Science and Technology of Agriculture and Natural Resources*, Chapter 4, **2** 105-115.

Nameless (**2010)**. Effect of water stress and nitrogen on leaf SPAD during reproductive growth of corn Paponov, I.A., Sambo, P., Schulte, G., Presterl, T., Geiger, H.H., and Engels, C. 2005. Grain yield and kernel weight of two maize genotypes differing in nitrogen use efficiency at various levels of nitrogen and carbohydrate vailability during flowering and grain filling. Plant and Soil **272:** 111–123.

Royo C and Blanco R (1999). Use of potassium iodide to mimic drought stress in triticale. *Field Crops Research* **59** 212-201.

Scheinev JD and Flavio H (2004). Sunflower nitrogen pampas, and 15N fertilizer recovery in vester pampas, argentina. *European Journal of Agronomy* **17** 73-79.

Staley TE, Stout WL and Jung GA (1991). Nitrogen use by tall fescue and swichgrass on acidic soils of varying water holding capacity. *Agronomy Journal* **83** 732-738.

Subedi KD and Ma BL (2005). Nitrogen uptake and partitioning in stay -green and leafly maize hybrids. *Crop Science* **45** 740 - 747.