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Research Article

THE EFFECT OF DROUGHT STRESS AND TIME OF DISTRIBUTION OF NITROGEN FERTILIZER (SPLIT APPLICATION) ON THE YIELD AND YIELD COMPONENTS OF GRAIN SORGHUM

Tollou Nadimpour and *Mani Mojaddam
Department of Agronomy, College of Agriculture, Ahvaz branch, Islamic Azad University, Ahvaz, Iran
**Author for Correspondence*

ABSTRACT
In order to investigate the effect of drought stress and the time of distribution of nitrogen fertilizer (Split application) on the yield and yield components of grain sorghum, a split plot experiment was carried out in the form of randomized complete block design with three replications in the research field of Ahvaz Islamic Azad University (summer 2013) in Veis weather conditions. The treatments include drought stress in three levels (75, 110,145) mm evaporation from class A evaporation pan as the main factor and the distribution of nitrogen fertilizer (split application) in three levels (N1: 100% along with planting, N2: 50% during the planting time + 50% during the stem elongation, and N3: 25% during the planting time, 50% during the stem elongation + 25% during the spiking) as the sub factor. The results showed that the increase of drought stress levels significantly decreased the grain yield and the yield components (number of grains per spike, number of spikelet per spike, number of grains per spikelet, 1000-grain weight) so that the highest rate of grain yield was obtained at 75 mm evaporation level (optimal irrigation) while appropriate and timely distribution of nitrogen fertilizer significantly increased the yield components of grain at 1% probability level, so that the highest rate of grain yield and yield components belonged to N3 treatment.

Keywords: *Grain Sorghum, Yield, Split Application of Nitrogen, Growth Components, Drought Stress*

INTRODUCTION
Sorghums belong to Poaceae (Gramineae) family and are tropical products with African origin. The crop cultivars of sorghum belong to annual grains. Sorghum is a spring annual that grows in warm and dry climate with little water and has good agronomic properties and grows quickly . It yields in a short time for 50 days and the temperature of about 27℃ is good for its growth and development. Drought and shortage of water are tangible realities in our country. Due to its special geographical position, Iran is always facing flood, shortage of water, and drought. Therefore, in order to save water and to achieve satisfactory yield of crops, it is recommended to plant crops that require less water. Grains such sorghum require less water than other common grains and forage like maize. Hajar (1997) reported that plants under stress would get shorter and the weight of their roots and stems would decrease. Lewis *et al.*, (1974) reported that the most sensitive growth stage of sorghum to drought stress is during the flag leaf swelling until the end of pollination stage. Drought stress in this stage dropped the yield by 44% (while the potential of soil water was _13 bars). The high sensitivity of this stage to drought stress can be attributed to disorder in the formation of flower and the order of pollination which on the whole will affect the number of grains per spike because sorghum pollination in a spike and in a plant population occurs in a short period of time. Bad environmental conditions such as drought and high temperature, have severs impact on pollination and consequently on grain yield and lack of moisture at the time of pollination reduces the grain potential through the abortion of flower and death of pollen seeds (Fisher and Wilson, 1975). Since the main grain yield components that is the number of spike per area unit, number of grains per spike, and 1000-grain weight are determined during the relatively different stages of plant growth the existing environmental conditions at the beginning and during the development of each yield component will affect the relative share of that yield component. The reduction in each yield component due to improper environmental condition is remarkably compensated for after removing the stress conditions by the components that are formed and developed later. However, the yield components

compensation is not often perfect and depends on the plant genotype and the severity of the stress (Keisling, 1982). The yield components in sorghum compensate for each other quite well and thus the severe reduction of yield due to the reduction of a yield component is prevented (Blum *et al.*, 1997). In an experiment, did Santamaria *et al.,* (1990) study the effect of drought stress on 6 cultivars of grain sorghum during the stages before pollination. The grain yield in all 6 cultivars reduced compared with the control treatment, but the reduction in cultivars with high osmotic adjustment capability was less than the cultivars with low osmotic adjustment capability. Mousavi *et al.,* (1984) investigated the effect of different levels of nitrogen (0 to 200 kgNha) on the grain yield and concluded that as the level of nitrogen increased, the number of grains, grain weight, and grain yield increased significantly.

The most important objectives of the research are the following:

1. Investigating the effect of proper time of nitrogen fertilizer consumption on growth indices
2. Investigating the effect of proper time of nitrogen fertilizer consumption on yield and yield components of grain sorghum
3. Investigating the interactive effects of split application of nitrogen fertilizer and water deficit stress on quantitative and qualitative properties of grain sorghum

MATERIALS AND METHODS

Experimental Location

The experiment was carried out in the summer of 2013-2014 in the bank of the Karun River , at the research field of Islamic Azad University in Veis Region . The experimental filed is located in the northeast part of Ahvaz at latitude 31°29' N and longitude 48°54' E and 23 m above the sea level. It was a split plot experiment in the form of randomized complete block design with 3 replications. The irrigation treatment (I) in the main plots included water deficit stress in three levels (6-day, 10-day, and 14-day irrigation intervals) and the split application of nitrogen (N) in sub plots included three levels (N1: 100% along with planting, N2: 50% during the planting time + 50% during the stem elongation, and N3: 25% during the planting time, 50% during the stem elongation + 25% during the spiking. Therefore, the plan included 27 experimental units. The space between the main plots was 2.25 in order to avoid water penetration into the adjacent plots. The distance between each sub plot from another sub plot was as 1non-planting line and 2 non-planting lines for the next plot and the same trend was repeated again. The plant density was considered as 120000 plants per hectare. The final harvest area was equal to 2 m^2.

Chemical properties of the soil of tested land:

Soil tissue	**Soil constitutive particles (%)**			**Absorbable potassium K(A.V) (ppm)**	**Absorbable phosphorus P(A.V) (ppm)**	**Organic Carbon %o.c**	**Total saturation reaction pH of paste**	**Electric conductivity E*10^3**	**Saturation percentage**	**Sampling depth Cm**
Silty clay loam	sludge 32	Clay 49	sand 19	152	5.4	0.63	7.01	6.6	46.7	Soil depth 30 cm

The sorghum seed cultivated in this experiment is Kimia cultivar which is a post-mature cultivar with the growth period of 100-120 days which is typical in the region and in the province.

Fertilizer: in order to supply the phosphorus that the plant needs triple super phosphate fertilizer has been used between the first and the second disk interval as 80 kg phosphorus per hectare. The required nitrogen has been supplied from the urea source (150 kg/ha).In order to apply fertilizer treatments in the desired times, at first some grooves were made in the irrigation furrows in each plot then the consumed fertilizer was placed evenly inside the grooves. Then they were covered by soil and were immediately irrigated. In this way, the horizontal (surface) displacement of fertilizer was prevented due to its solubility in water.

Irrigation was fully donefor all treatments immediately after planting until 4-leaf stage. Each plot included 7 rows of planting line as long as 5 m.

Measuring the Studied Traits:The measured traits include the number of grains per spike, number of spikelet per spike, 1000-grain weight, and grain yield which were measured separately after the final harvest of plants from each plot. The data obtained through the measurement of traits were analyzed using Mstatc software and the diagrams were drawn using Excel software. The means were compared through the Duncan's Multi range test (DMRT) at 5% and 1% probability levels.

RESULTS AND DISCUSSION

Number of Spikelet per Spike

The ANOVA results in Table (1) shows that the number of sorghum spikelet was significantly affected by drought stress and split application of nitrogen at 1% probability level. The highest number of spikelet by 45.07 belonged to moderate drought stress and the lowest number by 41.89 belonged to sever drought stress. As Tabatabaei and Dehghan (2012), Jana *et al.,* (2012), Vojoodi *et al.,* (2013) stated the yield components of sorghum decrease significantly as the drought stress increases which indicates the lack of relative stability of this component of grain yield. The highest number of spikelet per spike belongs to N3 treatment by 46.2 and the lowest number belongs to N1treatment by 41.76. Richie and Hanoi (1997) reported that since the ultimate number of grain rows in ear seems to be more than the other components of grain there is no serious competition between the other components to use photosynthesis materials when determining the number of grain rows per ear and consequently the number of rows per ear has a relative stability. The interactive effect of drought stress and split application of nitrogen fertilizer was not significant.

Number of Grains per Spike

The ANOVA results in Table (1) shows that the number of grains per spike was significantly affected by three levels of drought stress at 5% level and split application of nitrogen at 1% level. The interactive effect of drought stress and split application of nitrogen was not significant. Among different levels of drought stress the highest and the lowest number of grains per spike by 1176.5 and 971.5 respectively belonged to optimal irrigation and severe drought stress. The results of the research seem to be consistent with the findings of Alizadeh *et al.,* (2007) and Actium (2003) who stated that drought stress decreased the number of grains per spike due to impairment of fertilization and the increase of sterility and abortion. The highest number of grains per spike by 1243.3 was related to N3 treatment and the lowest number of grains per spike by 881 was related to N1 treatment. The increase of the number of grains per spike in N3 treatment indicates more efficiency of nitrogen absorption and availability of sufficient nitrogen concurrent with the linear growth of plant. In this regard, Boyer and Mc Pierson (1975) stated that any reduction of nutrients particularly nitrogen since the linear growth stage of plant is critical with regard to determining the grain production potential. It seems like that the availability of nitrogen in the critical period of grain formation affected the number of grains through the increase of plant growth rate in three-stage application of nitrogen (N3) including 25% during the planting stage, 50% during stem elongation, and 25% during the reproductive stage.

1000-Grain Weight

The ANOVA results in Table (1) shows that weight of 1000-grain in sorghum was significantly affected by drought stress and split application of nitrogen at 1% probability level. Among different levels of drought stress, the highest and the lowest weight of 1000-grain by 29.64 g and 21.8 g respectively belonged to optimal irrigation (I1) and severe drought stress (I3).

The decrease of 1000-grain weight after the drought stress is due to reduction of water and mineral absorption by plant and consequently reduction of synthesizing assimilates and mobilization of assimilate juice into grains (Pazoki, 2000). The decrease of irrigation interval will increase the weight of 1000-grain. Moreover, as the amount of water increases up to 80% evaporation from class A evaporation pan, the weight of 1000-grain gets maximized. The highest weight of 1000-grain by 27.47 g belonged to N3 treatment and the lowest weight by 24.83 g belonged to N1 treatment. The high weight of 1000-grain in

N3 treatment compared with N1 and N2 is the increasing absorption of available nitrogen, the increase of leaf area index and mobilization of assimilates into grain. The result was consistent with the findings of Benziger *et al.,* (2002) who reported that application of nitrogen fertilizer in several phases during the growth increased the weight of 1000-grain due to the positive effect on the leaf area continuity and consequently the increase of grain filling period.

Grain Yield

The ANOVA results showed a significant difference for three levels of drought stress at 5% level and split application of nitrogen at 1% level. The highest rate of grain yield of sorghum by 367.67 g/m^2 belonged to optimal irrigation (I1) and the lowest rate by 245.46 g/m^2 belonged to severe drought stress (I3). Ferere (1986) found that due to drought stress, the leaf area in sunflower decreased quickly and had a negative effect on grain yield. The main reason of decrease of grain yield in drought stress was the significant decrease of the number of grains per spike and the weight of grain. The highest rate of grain yield in sorghum belonged to N3 treatment by 377.9 $g/m^2$and the lowest rate belonged to N1 by 253.71 g/m^2. More nitrogen absorption in N3 treatment is followed by more production of leaf area index and leaf area continuity as well as the increases availability of assimilates for production and survival of yield components. Therefore, the significant increase of the number of grains per spike and the increase of 1000-grain weight in N3 treatment were the main reasons of better grain yield in this treatment than the N1 treatment. The results were consistent with the findings of Khalifeh (1973) who concluded that the changes of wheat yield due to split application of nitrogen fertilizer resulted from the increase of leaf area index and leaf lifetime at the emergence of spike until the grain maturity. Siadat and Fathi (2001) stated that the effect of nitrogen fertilizer on grain yield depends on the rate of soil moisture so that the higher the soil moisture is the greater the yield will be. However, when the nitrogen fertilizer is distributed at different growth stages the effect of soil moisture reduces.

Table 1: The ANOVA results of yield components (number of grains per spike, number of spikelet per spike, 1000-grain weight) and grain yield of grain sorghum according to the mean of squares

Grian yield	1000-grain weight	Number of spikelet per spike	Number of grains per spike	Df	Sources of variations
667	1.417	0.388	35835	2	**Replication**
36757*	139.265**	28.4**	94638*	2	**Irrigation(I)**
2336	3.025	0.523	15851	4	**Ea**
34766**	15.526**	44.389**	299426**	2	**Split application of nitrogen (N)**
18564*	0.693n.s	0.58n.s	1582n.s	4	**Drought stress × Split application of Nitrogen (N* S)**
966	0.888	0.37	11731	12	**Eb**

*ns, **, and *: mean squares of the treatments are respectively non-significant and significant at 1% and 5% probability level.*

Grain Yield

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Table 2: Mean comparison of simple effects of different levels of drought stress and split application of nitrogen on grain yield components (number of spikelet per spike, number of grains per spike, 1000-grain weight) and grain yield in grain sorghum

Grain yield (g/m^2)		1000-grain weight (g)		Number of spikelet per spike		Number of grains per spike		Treatment
								Drought stress
367.67	a	29.46	a	1176.5	a	45.07	a	75 mm evaporation (I1)
338.97	b	27.19	b	1079.7	b	44.85	a	110 mm evaporation (I2)
245.46	c	21.8	c	971.5	c	41.89	b	145 mm evaporation (I3)
								Nitrogen (kg/ha)
253.71	c	24.83	c	881	c	41.76	c	N1: 100% during planting
320.49	b	26.17	ab	1102.9	b	43.82	b	N2: 50% during planting + 50% during stem elongation
377.9	a	27.46	a	1243.3	a	46.2	a	N3: 25% during planting + 50% during stem elongation + 25% during spiking

According to Duncan's test, the means with similar letters in each column are not significantly different at5% probability level

Conclusion

The highest rate of yield belongs to drought stress treatment with 75 mm evaporation (optimal irrigaton).

The effect of different methods of split application of nitrogen on the number of grains per spike, number of spikelet per spike, 1000-grain weight, and grain yield was significant, so that the highest yield belonged to split application of nitrogen at N3 (25% during planting + 50% during stem elongation + 25% during spiking).

If sufficient water is not available and plant faces moderate drought stress during the growth, the proper distribution and spilt application of nitrogen fertilizer at the right time when the plant greatly needs this element such as the optimal irrigation treatment, can compensate for the decrease of grain yield to some extent in such conditions. Under the severe drought stess conditions, if the distribution of nitrogen like optimal irrigation conditions and moderate drought stess is such that a low percentage of nitrogen is used during planting to prevent the waste of nitrogen, it can improve the positive effect of nitrogen on yield.

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