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
2015 Vol. 5 (1) January-March, pp.172-178/Sarafraz and Marashi
Research Article

EFFECT OF SPLIT APPLICATION OF NITROGEN FERTILIZER ON QUANTITATIVE AND QUALITATIVE CHARACTERISTICS OF MAIZE (S.C.704) UNDER WATER DEFICIT CONDITION

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ABSTRACT
In order to investigate the effect of water deficit and split application of nitrogen fertilizer on quantitative and qualitative of grain yield of maize, a split plot experiment in the form of randomized complete block design with three replications was carried out in the educational- research farm of Islamic Azad University - Ahvaz branch in the summer of 2014. In this experiment water deficit based on the irrigation intervals as D60 (60 mm evaporation from the evaporation pan), D90 (90mm evaporation from the evaporation pan), and D120 (120 mm evaporation from the evaporation pan) and split application of nitrogen fertilizer in four levels as N1(50% at the sowing stage + 50% at the beginning of stem elongation stage), N2 (25% at the sowing stage + 50% at the beginning of stem elongation stage + 25% at the booting stage), N3 (25% at the sowing stage + 25% at the beginning of stem elongation stage + 50% at the booting stage) and N4 (50% at the beginning of stem elongation stage + 50% at the booting stage) were investigated. The results of the experiment showed that the effect of water deficit on yield components such as number of ear per square meter, number of rows per year was not significant but its effect on 1000-grain weight and number of grains per row was significant at 1% level. There was also a significant difference for grain yield at 1% probability level. The highest grain yield by 8744.50 kg/ha observed for D60 treatment. The effect of water deficit on grain protein percentage was not significant. The effect of split nitrogen fertilizer on yield components was not significant except number of grains per row. Grain yield was significant at 1% level under split nitrogen fertilizer. The highest grain yield by 8730 kg/ha was in N3 treatment and the lowest grain yield by 5643 kg/ha was in N1 treatment. The results also showed that the effect of split application of nitrogen fertilizer on the grain protein percentage was not significant.

Keywords: *Maize, Nitrogen, Protein, Water Deficit, Yield*

INTRODUCTION
Maize has spread in all over the world due to its high adaptation to climatic conditions and has allocated the third place in terms of cultivation area after wheat and rice. Studies show that about 20-25% of the world production of maize is directly used in human nutrition (corn flour, sugar, canned maize and porridge) and 60-75% is used for feeding animals as grain, paste, powder, silo, etc. (Noor-Mohammadi *et al.*, 1997).
Water and nutrients are the most important elements influencing the growth of the plants. Therefore, the management of these factors in farming systems is one of the most important components of agricultural management (Liebman and Davis, 2000).
One of the problems of arid and semiarid areas is water deficiency which affects the growth and development of plants (Ehdaei, 1993). Unfortunately, water deficit is not limited to these areas, but even in wet weather conditions irregular distribution of precipitation leads to the limitation of accessible water and consequently the reduction of plant growth (Kafi *et al*., 2005). Drought affects on different aspects of plant growth and it reduces germination, growth of shoots and dry matter production. It also decreases the total photosynthetic capacity of plants and thus the plants yield will become deficient and in case of high water deficit stress the plants growth will stop and finally the plant will die (Hassani, 2006; Singh and Patel, 1996).

Nitrogen is one of the most important nutrients found in the structure of various protein molecules, enzymes, coenzymes, nucleic acids and cytochromes (Hassegawa *et al*., 2008). Nitrogen is the first element that argued in arid and semiarid areas, because in such areas the amount of organic substances that are the main source of nitrogen supply is low for many reasons such as high temperature, low average consumption of manures and green fertilizers, little rainfall, etc,. Nitrogen deficiency is particularly more conspicuous in areas where the temperature is too high. If sufficient nitrogen is provided for the plants, it will enhance their growth. Lack of nitrogen hinders the growth of the shoots and particularly the grains (Noor-Mohammadi *et al*., 1997). Studies show that adequate consumption of nitrogen leads to more production of grain and when this element is supplied sufficiently, it enhances both the quantity and quality of the products (Shoorgashti, 1998). The aim of this research was evaluate the quantitative and qualitative of grain yield of maize under different irrigation and split application of nitrogen and to figure out their interactive effects in order to reduce the negative effects of water deficit on metabolic processes of maize.

MATERIALS AND METHODS

This experiment was carried out in the summer 2014 in educational-research farm of Islamic Azad University- Ahvaz branch. The studied treatments included irrigation intervals as 60 (D60), 90 (D90) and 120 (D120) mm evaporation from the evaporation pan as the main plot and split application of nitrogen fertilizer at four levels as N1(50% at the sowing stage + 50% at the beginning of stem elongation stage), N2 (25% at the sowing stage + 50% at the beginning of stem elongation stage + 25% at the booting stage), N3 (25% at the sowing stage + 25% at the beginning of stem elongation stage + 50% at the booting stage) and N4 (50% at the beginning of stem elongation stage + 50% at the booting stage) as the sub plot. The experimental design was a split plot in the form of randomized complete block design with three replications. The hybrid cultivar in this experiment was S.C. 704. Nitrogen fertilizer was applied in from the urea source according to the norm of 250 kg/ha. The first irrigation was done simultaneous with the sowing date. The next irrigations were done on the basis of plant water requirement and it continued till before the emergence of the male flower. Then the irrigation interval was regulated according to the type of the studied treatment and class A evaporation pan. In this experiment the space between planting lines was 75 cm and the space between the seeds on each planting line was 20 cm. In order to measure the yield, all plants in 3 middle lines as long as 5 m were manually harvested in each experimental plot after eliminating 0.5 m from the two ends of the harvest lines and after counting the number of ear per plot the total grain yield, biological yield were determined. Yield components were measured according to their mean in 10 ears per each plot. The grain protein was measured via the Kjeldahl method. The data were analyzed using Mstatc software and the means were compared using Duncan's method.

RESULTS AND DISCUSSION

Number of Ears per Square Meter

The results showed that the effect of water deficit, split application of nitrogen and their interactive effect on the number of ear per square meter were not significant (Table 1). The present research shows that the number of ear in each plant is one of the stable components of the yield and a genetic feature that is less influenced by the environmental factors particularly at the end of growth period. Similar results have been also reported by Uhart and Anderade (1995).

Number of Grains per Row

The results showed that the effect of water deficit, split application of nitrogen and their interactive effect on number of grains per row were significant (Table 1). Mean values comparison results (Table 2, 3) showed that the increase of water deficit leads to reduction in number of grains per row. The highest number of grains per row by 42.50 belongs to D60 and the lowest by 35.64 was belongs to D120 (Table 2). Alizadeh *et al*., (2006) found the same results. Nesmith and Ritchie (1992), Ritchie and Hanway (1997) reported that the decrease of the number of grains per row was affected by the drought stress at 12-leaf stage due to the disorder in the formation of potential number of grains per row at this growth stage.

Studies show that water deficit delays the silking; thus, the tassels appear when the pollination is done and there is no living pollen to inoculate female flowers or they have sharply fallen and consequently no grain is formed and fewer numbers of grains are formed in the ear (Havall *et al*., 1981; Mcpherson and Boyer, 1977). Setter *et al*., (2001) reported that water stress at pollination stage influences graining process in ear through the reduction of leaves photosynthesis and reduces the number of grains per row due to the increase of production of sterile pollen resulting from the lack of assimilates. The results also showed that the effect of split application of nitrogen on the number of grains per year was significant at 1% level. The highest number of grains per row by 40.86 was observed in treatment of N3 (Table 2). Aktinoye *et al*., (1997) concluded that at high levels of nitrogen due to proper nutrition and decrease of competition and abortion of flowers at the stages of determining the number of ovule per row, the number of grains per row increased.

Number of Rows per Ear

The results of analysis of variance showed that the effect of water deficit was not significant on number of grains per year (Table 1). This result suggested to the genetically of this component and it is high stable against the environmental changes. No influence of this trait has been confirmed by several researchers (Parastar *et al*., 2000; Sayede *et al*., 1996; Siadat, 1994). As it is observed in table (1) none of the nitrogen fertilizer treatments has a significant effect on the number of grains per year. The results show that the changes of this component towards the applied treatments are very few; in other words, this component is seriously affected by genetic factors in the plant. Meanwhile, since the final number of the rows per year is determined on the development area (shoot apex) before other yield components, thus there has possibly been no serious competition between physiologic destinations of assimilates (Ritchie and Hanway, 1997).

1000-Grain Weight

The result showed that the effect of water deficit and interaction between water deficit and split application of nitrogen on 1000-grain weight were significant at 1% level (Table 1). Mean comparison results show that 1000-grain weight significantly decreases under increasing of water deficit so that among the water deficit treatments (Table 2, 3), the highest 1000-grain weight by 257.5 g was belonged to D60 treatment and the lowest by 226.5 g was in D120 treatment. Cakir (2004) has also reported the significant decrease of 1000-grain weight due to the water deficit stress. Sarmadnia and Kouchaki (1989) stated that improper moisture regime not only reduces the leaves area but also accelerates their aging and thus reduces the production rate much more than the reduction that occurs due to the decline of photosynthesis rate. The decrease of 1000-grain weight at water deficit after the pollination is mainly due to the decrease of grain filling stage (Westgate, 1994). According to Table (2) there was no significant difference between different levels of split application of nitrogen fertilizer. However, the highest 1000-grain weight by 241.78 g belonged to N3 treatment which was better than the other levels of split application of nitrogen. In another research similar results were achieved and it was found that the late application of nitrogen fertilizer would increase the weight of 1000-grain but not significantly which could be due to the increase of leaf area durability (Bohrani and Tahmasebi, 2006). Such a result might be achieved due to the fact that since nitrogen causes the formation of more chlorophyll and more leaf area and in this situation, more assimilate have been made. Therefore, the grains that are formed are filled with more assimilates (Majidian *et al*., 2008).

Grain Yield

Effect of water deficit on grain yield was significant at 1% probability level (Table 1). Mean comparison results showed that increasing of water deficit decreased grain yield, so that the highest grain yield by 8744.5 kg/ha was observed for D60 treatment and the lowest grain yield by 6652.50 kg/ha was belongs to D120 treatment (Table 2). It is reported that water scarcity at flowering stage and pollination leads to severe decrease of grain yield via abnormal development of embryo sac, pollen sterility and ultimately reduction of the number of fertile grains (152). Eck *et al*., (1998), Nissanka *et al*., (1997) and Schussler and Westgate (1991) concluded that water deficit at vegetative and reproductive stages reduced the number of grains and at the grain filling stage reduced the weight of grain and led to the decrease of grain yield. Sarmadnia and Kouchaki (1089) stated that improper moisture regime not only reduces the leaves area but also accelerates their aging and thus reduces the production rate much more than the reduction that occurs due to the decline of photosynthesis rate. Researchers found that drought stress during the flowering stage led to asynchronous emergence of male and female organs and increased the period between the emergence of the tassel and the silks and consequently the grain yield of maize decreased. Meanwhile, the occurrence of drought stress coincided with meiosis in tassel led to the pollen sterility, prevented the silk elongation and reduced the grain yield severely (Rashidi, 2005). The results of table 1 showed that the effect of split application of nitrogen fertilizer on the grain yield was significant. Mean comparison results showed that the highest grain yield by 8730 kg/ha belonged to N3 treatment and the lowest grain yield by 5643 kg/ha was in N1 treatment (Table 2). The increase of grain yield could be associated with the increase of grain yield components and leaf area index as the main source of supplying assimilates. It is observed that during the sowing, the plant is not very capable of absorbing nitrogen. Thus, application of less nitrogen during the sowing date in N3 treatment and consumption of most it at the maximal vegetative growth stage can increase the grain yield. Adding fertilizer after the flowering stage causes good distribution of nutrients and the competition will decrease. In an experiment in Brazil the split application of nitrogen fertilizer as $\frac{1}{3}$ fertilizer during the planting, $\frac{2}{3}$ fertilizer 30 days after planting, as compared to full consumption of fertilizer during the planting, had positive effects on the maize grain yield. In another research, the increase of nitrogen consumption due to creating a strong reservoir, i.e. greater number of grains and more durability was expressed as the main reason of the increase of grain yield (Rafiei, 2002).

Grain Protein Percentage

Result showed that the effect of water deficit, split application of nitrogen and their interactive effect on the protein percentage were not significant (Table 1).

Table 1: Mean squares of quantitative and qualitative traits of maize

Sources of variations	df	Number of ears per m^2	Number of grains per row	Number of rows per ear	1000-grain weight (g)	Grain yield (Kg/h)	Protein percentage
Water deficit (D)	2	3971.25 ns	37.64 **	4.82 ns	130.76**	3971.25 **	9.82 ns
Error A	4	576.82	10.61	3.26	41.82	576.22	3.26
Split application of nitrogen fertilizer (N)	3	3846.87 ns	35.77 **	7.47 ns	133.22 ns	3846.88 **	9.2 ns
D*N	6	3793.18 ns	36.77 **	5.24 ns	147.3 **	3793.18 **	5.67 ns
Error B	18	617.62	11.14	3.58	37.62	617.62	3.58
(CV%)		11.47	10.36	8.37	8.25	11.47	9.53

*ns ,** Respectively indicate that the mean squares of the treatments are non-significant and significant at 1% probability level.*

Mean comparison results (Table 2) showed that although there were no significant differences, but the highest grain protein percentage by 10.88% was observed for D120 treatment and the lowest protein percentage by 10.04 % was in D60 treatment. The results are consistent with the findings of Noor-Mohammadi *et al*., (1997). Valad *et al*., (2000) stated that protein percentage increased in maize and sorghum under water stress conditions, but the percentage of grain starch decreased (Table 1). In our experiment different methods of split application of nitrogen had no significant effect on rate of grain protein, but the highest percentage of grain protein was observed in N3 treatment and the lowest percentage of grain protein belongs to N1 treatment. Oikeh *et al*., (1998) stated that as the nitrogen fertilizer increased from 0 to 120 kg/ha, the rate of grain protein increased in all the experimented hybrids. Siadat (1994) stated that the way of nitrogen fertilizer distribution particularly at the heading stage in wheat would increase the rate of protein in grain even though the increase varies in different cultivars and different years. Also it is stated that when the leaves aging and nitrogen transition occur slowly, the high grain yield might be followed by the low percentage of nitrogen in grain. When the leaves aging occur quickly the starch storage might be affected faster than the protein storage followed by the low yield and high percentage of nitrogen.

Table 2: Mean comparison for quantitative and qualitative traits of maize

Sources of variations		Number of ears per m^2		Number of grains per row		Number of rows per ear		1000-grain weight (g)		Grain yield (Kg/h)		Protein (%)	
Water deficit	D60	8.50	a	42.55	a	15.01	a	257.50	a	8744.50	a	10.04	a
	D90	8	a	40.08	a	15	a	230.17	b	7061	b	10.50	a
	D120	7.50	a	35.64	b	14.64	a	226.50	c	6652.50	c	10.88	a
Split application of nitrogen fertilizer	N1	7.65	a	29.22	c	14.67	a	240	a	5643	d	9.90	a
	N2	8.50	a	38.56	b	15.11	a	240.78	a	7648	b	10.80	a
	N3	8.75	a	40.86	a	15.33	a	241.78	a	8730	a	11.07	a
	N4	8.25	a	36.11	b	14.67	a	240.08	a	6900	c	10.12	a

Means with different letters are significantly different at P=0.05 , using Duncan's Multiple Range Test

Table 3: Mean comparison of interactive effect between water deficit and split application of nitrogen on quantitative and qualitative traits of maize

Sources of variations		Number of ears per m^2		Number of grains per row		Number of rows per ear		1000-grain weight (g)		Grain yield (Kg/h)		Protein (%)	
D60	**N1**	8.25	a	35.55	b	15.33	a	236	bc	6800	de	9.08	a
	N2	8	a	40	a	16	a	256	a	7800	d	10.03	a
	N3	8.75	a	42.55	a	16	a	259	a	9300	a	10.5	a
	N4	8	a	39.20	b	15.33	a	242	ab	9570	a	9.2	a
D90	**N1**	8	a	29	c	14.67	a	222	d	6740	de	9.70	a
	N2	8.5	a	38.60	b	14.67	a	235	bc	7570	d	10.5	a
	N3	8.5	a	40	a	15.31	a	241	ab	8910	bc	10.9	a
	N4	7.80	a	36.40	b	14.67	a	228	d	6840	de	10.08	a
D120	**N1**	7.50	a	25.10	c	14	a	200	d	4250	g	10.9	a
	N2	8	a	35	b	14.67	a	220	d	6460	e	11.5	a
	N3	8	a	35.80	b	14.67	a	220	d	7910	dc	11.4	a
	N4	7.65	a	29	c	14	a	204	d	5590	f	11.2	a

Means with different letters are significantly different at P=0.05 , using Duncan's Multiple Range Test

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