Bulgarian Journal of Agricultural Science, 19 (No 3) 2013, 479-484
Agricultural Academy

FATTY ACID, SEED PHOSPHOROUS AND GRAIN YIELD OF MAIZE AS INFLUENCED BY DIFFERENT IRRIGATION AND NITROGEN FERTILIZERS

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Abstract

TARIGHALESLAMI, M., R. ZARGHAMI, M. M. A. BOOJAR and A. A. KOLIAI, 2012. Fatty acid, seed phosphorous and grain yield of maize as influenced by different irrigation and nitrogen fertilizers. *Bulg. J. Agric. Sci.,* 18: 479-484

To evaluate the effect of drought stress and nitrogen fertilizers on grain yield, amount of fatty acid and seed phosphorus of maize (*Zea mays* L.), an experiment was carried out at field experiment of Islamic Azad University, Varamin – Pishva, Iran. Result indicated that grain yield; different irrigation and nitrogen fertilizers significantly affected a mount of fatty acid and seed phosphorous. Maximum phosphorus of seed was gained by utilization of 180 k/ha nitrogen fertilizers. Utilization of 130 kg/ha and 180 kg/ha nitrogen fertilizers increased 23.34 % and 36.54 % on phosphorus of seed in compare with application of 80 kg/ha nitrogen fertilizers. Maximum of grain yield and fatty acid was obtained by irrigation after 50 mm evaporation from A class pan) and irrigation after 200 mm evaporation from a class pan decreased 60 % on grain yield in compare with irrigation after 50 mm evaporation from A class pan interaction between different irrigation and utilization of nitrogen fertilizers treatments indicated that maximum of oil of seed was gained by irrigation after 50 mm evaporation from A class pan + application of 180 kg/ha nitrogen fertilizers.

Key words: corn, drought stress, nitrogen fertilizer, fatty acid, yield

Introduction

Corn (*Zea mays* L.) is the third most important crop worldwide following rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.). The corn kernel is composed of approximately 72% starch, 10% protein, 5% oil, 2% sugar, and 1% ash with the remainder being water (Perry, 1988). The oil in corn is an important energy source for livestock feed, and due to a high degree of unsaturation, is widely used for human consumption (Perry, 1988). Increasing nitrogen supply to corn generally resulted in increased grain and protein yields and increased grain protein concentration (Olsen et al., 1976; Pierre et al., 1977; Cromwell et al., 1983; Tsai et al., 1983; Anderson et al., 1984; Kniep and Mason, 1991; Sabata & Mason, 1992; Tsai et al., 1992; Oikeh et al., 1998). Research reported by Tsai et al. (1983) suggested that protein concentration of corn grain increases with nitrogen supply due to preferential deposition of zein over the other endosperm proteins. It is apparent that the amount of fertilizer nitrogen required to maximize grain yields is not the same as the amount that will produce maximum grain protein concentrations (Sander et al., 1987). As the protein concentration of corn grain increases, zein makes up an increasing proportion of the protein (Frey et al., 1949; Frey, 1951; Tsai et al., 1992).

Drought and high temperature (heat) stress are considered the two major environmental factors limiting crop growth and yield. These two stresses induce many biochemical, molecular, and physiological changes and responses that influence various cellular and whole plant processes that affect crop yield and quality. The impacts of environmental stress, particularly those of drought and heat, have been studied independently (Mittler, 2006). Drought (water stress) and heat stress (increases in above-optimum air temperatures) often occur simultaneously, but they can have very different effects

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on various physiological, growth, developmental, and yield processes. Although drought and heat stresses have been extensively studied independently, relatively little is known about how their combination affects crop productivity. The few studies that examined the impact of the combined effects of drought and heat stress suggested that the combination of drought and heat stress had a significantly higher detrimental effect on growth and productivity of crops than when each stress was applied individually (Craufurd and Peacock, 1993; Savin and Nicolas, 1996). In addition, the combination of drought and heat stress was found to alter physiological processes such as photosynthesis, accumulation of lipids, and transcript expression (Jagtap et al., 1998; Jian and Huang, 2001; Rizhsky et al., 2004). The impact of drought and heat stress in combination or isolation on important physiological, growth, developmental, and yield processes are described in the following sections. We acknowledge that responses of crop or plant species to drought and/or heat stress are highly variable. Therefore, the effects are discussed in a more generalized fashion, and sufficient care should be taken while making specific conclusions regarding a particular crop or variety within a crop species, which can differ in its responses. In addition, it should also be considered that drought and heat stress impacts on these various processes and traits depend on the intensity, rate of increase, duration of stress, and stage of crop development. thesis either through pathway regulation by stomatal closure and decreasing flow of CO_2 into mesophyll tissue (Chaves, 1991; Chaves et al., 2003; Ort et al., 1994; Flexas et al., 2004) or by directly impairing metabolic activities (Farquhar et al., 1989).

Materials and Methodology

Geographical location, climate and soil conditions of the experimental field

This study carried out during the 2008-2009 growing season at the educational farm of varamin Islamic Azad University in Iran. This region has a semi-arid climate, with mean annual maximum and minimum daily air temperatures of 30.8°C and 4.6°C, respectively. The precipitation during the growing season of corn was 6 mm, as show the long-term (1978–2008) meteorological data in Varamin, Iran (Table 1). The soil was a clay loam, low in total nitrogen (5–6 g/kg), very low in organic matter (7–8 g/kg) with a pH of 7.6 and Ec = 0.88 dS/m (Table 2).

Statistical design

The field experiment was laid out in a randomized complete block-design with split plot arrangement with four replications. Water regimes were allotted to main plots and nitrogen levels to sub-plots.

Irrigation treatments

The water deficit treatments were applied by changing in irrigation intervals. Irrigations were carried out when an amount of evaporated water from the class "A pan" evaporation reached 50 mm (S1; optimum conditions of irrigation), 100 mm (S2; moderate water deficit), 150 mm (S3; extreme water deficit) and 200 mm (S4; very extreme water deficit), respectively. Amount of irrigation was identical for all water deficit treatments from the beginning of planting time until complete establishment of plants. In order to make sure the identical amount of water discharge to every plot, the water

Table 1
Long-term (1978–2008) meteorological data in Varamin, Iran

	Average of temperature, °C		Monthly total of precipitation, mm	Average of relative humidity, %	
	minimum	maximum		minimum	maximum
May	12.8	32.5	22.5	38	59
June	17.4	38.7	1	33	51
July	20.2	48.7	0.2	31	51
August	20.3	44.3	0.9	29	56
September	14.6	35.7	0.2	35	56
Annual	9.1	26.6	126.3	42	64

Table 2
Field soil test results

Test Type	EC, DS/m	PH	TNT, %	OC, %	TotalN, %	P (ava) p.p.m	K (ava) p.p.m	Clay, %	Silt, %	Sand, %	Texture
About desirable	<5	7-7.5	15	2-2.5	0.2	15	400	25	25	50	LOM
Results	2.53	7.68	13.79	1.03	0.1	24	350	25	30	45	LOM

contour instruments were used. Total irrigation water applied in S1, S2, S3 and S4 were 465, 234.5 and 146.56 m^3, respectively. After this stage, the plots were irrigated according to their prescribed treatment.

Nitrogen application

Nitrogen fertilizer (urea) at Three Level: 80, 130, 180 kg per hectare was applied.

Agricultural practices and sampling

A subplot size of 3.75 m × 7 m, having 5 rows 7 m long was used and sowing was done on 26 May 2008 at the rate of 7 plants per square meter. Uniformity of sowing depth was achieved by using a hand dibbler to make holes 5 cm deep. The spaces between rows were 75 cm wide. Within each plot, an area of 3.5 m2 was hand harvested on 30 September to estimate the grain and biomass yield. Dry weights were recorded after the plant material was oven-dried at 70°C for 48 h. At harvest, a random sample of 15 plants was chosen from two middle rows for recording the number of grains per ear and 1000-grain weight. Harvest index was calculated as the ratio of grain yield to biomass. Source strength was defined as contribution of current photosynthesis for grain filling (%), which is used by Madani et al. (2010).

Statistical analysis. Data were statistically analyzed using analysis of variance, technique appropriate for randomized complete block-design with nitrogen factor split on water regime. Duncan's multiple range test ($P < 0.05$) was applied for mean separation when F values were significant.

Results and Discussion

Grain yield

Results showed that grain yield was significantly affected by different irrigation and utilization of nitrogen fertilizer treatments; however, interaction between treatments did not have significant effect on grain yield (Table 3). Effect of different irrigation on grain yield indicated that maximum of grain yield was obtained by irrigation after 50 mm evaporation from A class pan however means comparison showed that there wasn't significant difference between irrigation after 50 mm and 100 mm evaporation from A class pan on grain yield (Table 4). The lowest grain yield was gained by ir-

Table 3
ANOVA of the effects of different irrigation and nitrogen fertilizers on grain yield, fatty acid and seed phosphorous of corn

S.O.V	Df	Grian Yied	Fatty acid	Phosphorus of seed
Replication	3	1813758.74^{ns}	0.031^{ns}	458.028^{ns}
Factor A (irrigation)	3	99813641.655**	4.504**	18394.750**
Error	9	1296593,507	0,007	148,62
Factor B (nitrogen fertilizers)	2	15210054.732**	7.183**	21118.938**
AB	6	704512.480^{ns}	0.271**	2070.771**
Error	24	383222,188	0,042	194,701
CV%	-	9,87	5,11	5,93

ns,*,**: Non- significant and significant at in 0.05 and 0.01 level of probability respectively

Table 4
Means comparison of effects of different irrigation and nitrogen fertilizers on grain yield, fatty acid and seed phosphorus of corn

S.O.V	Grain yield, kg/h	Fatty acid, mg/100g	Phosphorus of seed, mg/100g
Different irrigation	-	-	-
S1	8919 a	4.439 a	266.7 a
S2	8603 a	4.531 b	268.2 a
S3	4015 b	3.895 c	219.0 b
S4	3548 b	3.199 c	187.7 c
Nitrogen fertilizers	-	-	-
N1	5188 c	3.364 c	196.2 c
N2	6549 b	3.982 b	242.0 b
N3	7078 a	4.702 a	267.9 a

Means with the same letter in each column have not statistically significant difference rigation after 200 mm evaporation from A class pan however irrigation after 150 mm evaporation from A class pan had similar effect on grain yield in compare with irrigation after 200 mm evaporation from A class pan (Table 4). Irrigation after 200 mm evaporation from a class pan decreased 60 % on grain yield in compare with irrigation after 50 mm evaporation from A class pan. The utilization of nitrogen fertilizers had significant effect on grain yield. Maximum grain yield was obtained by utilization of 180 kg/ha nitrogen fertilizers that it was 36.4 % more than utilization of 80 kg/ha nitrogen fertilizers (Table 4).

Oil of seed (fatty acid)

Table 3 indicated that oil of seed was significantly affected by different irrigation and application of nitrogen fertilizers treatments. Interaction between treatments had significant effect on oil of seed. Effect of different irrigations on oil of seed represented that maximum oil of seed was obtained by irrigation after 50 mm evaporation from A class pan and there wasn't significant difference between irrigation after 150 mm and 200 mm evaporation from A class pan on oil of seed however the lowest of oil of seed was gained by irrigation after 200 mm evaporation from A class pan (Table 4). Means comparison indicated that irrigation after 200 mm evaporation from A class pan decreased 27.93 % on oil of seed in compare with irrigation after 50 mm evaporation from A class pan (Table 4). Effect of nitrogen fertilizers treatments had significant effect on oil of seed. Means comparison showed that maximum oil of seed was gained by application of 180 kg/ha nitrogen fertilizers and this treatment increased 39.77 % on oil of seed in compare with utilization of 80 kg/ha nitrogen fertilizers (Table 4). Means comparison of interaction between different irrigation and utilization of nitrogen fertilizers treatments (Figure 1) indicated that maximum of oil of seed was gained by irrigation after 50 mm evaporation from A class pan + application of 180 kg/ha nitrogen fertilizers however there wasn't significant difference between this treatment and irrigation after 100 mm evaporation from A class pan + application of 180 kg /ha nitrogen fertilizers. However utilization of 180 kg /ha nitrogen fertilizers increased oil of seed in different irrigation treatments but there wasn't significant difference between utilization of 80 kg/ha and 130 kg/ha nitrogen fertilizer treatments on oil of seed in irrigation after 200 mm evaporation from a class pan And the lowest oil of seed was gained by irrigation after 200 mm evaporation of a class pan+ application of 80 kg/ha nitrogen fertilizers (Figure 1).

Phosphorus of seed

Results indicated that phosphorus of seed was significantly affected by different irrigation and application of nitrogen fertilizers treatments (Table 3) and interaction between treatments had significant effect on phosphorus of seed. Effect of Different irrigation treatments on phosphorus of seed indicated that irrigation after 50 mm and 100 mm evaporation from A class pan treatments had similar effects on phosphorus of seed and maximum of phosphorus of seed was obtained by irrigation after 50 and 100 mm evaporation from A class pan (Table 4). Means comparison of different irrigation treatments on phosphorus of seed represented that irrigation after 200 mm evaporation from A class pan decreased 29.62 % on phosphorus of seed in compare with irrigation after 50 mm evaporation from A class pan and the lowest phosphorus of seed was obtained by irrigation after 200 mm evaporation from A class pan (Table 4). Different level of nitrogen fertilizers treatments had significant effect on phosphorous of seed and maximum phosphorus of seed was gained by utilization of 180 k/ha nitrogen fertilizers. Utilization of 130 kg/ha and 180 kg/ha nitrogen fertilizers increased 23.34 % and 36.54 %

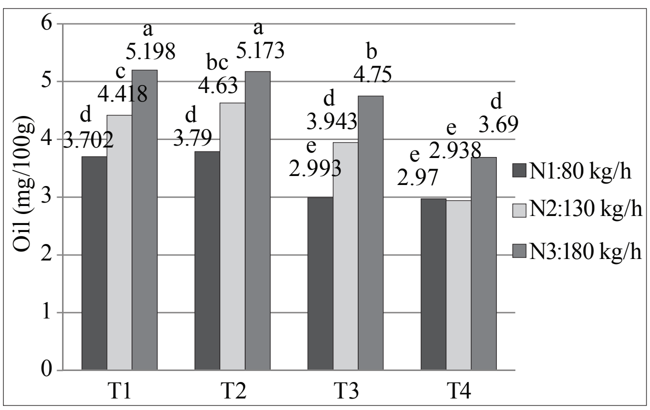

Fig. 1. Interaction between different irrigation and nitrogen fertilizers on fatty acid (oil of seed)

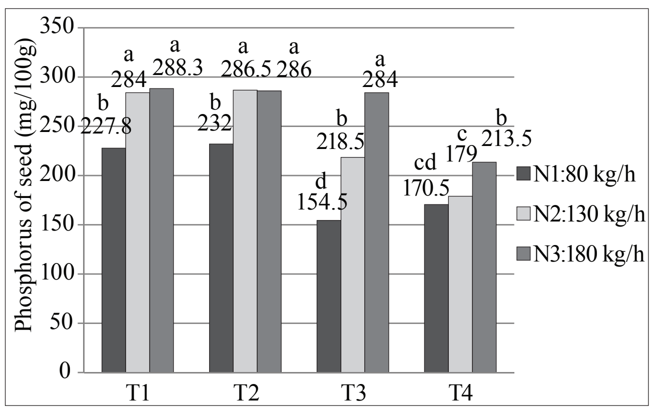

Fig. 2. Interaction between different irrigation and nitrogen fertilizers on seed phosphorous of corn

on phosphorus of seed in compare with application of 80 kg/ha nitrogen fertilizers (Table 4). Interaction between different irrigations and utilization of nitrogen fertilizers treatments indicated that utilization of 180 kg/ha nitrogen fertilizers increased phosphorus of seed in different irrigation (Figure 2). Application of 130 kg/ha and 180 kg/ha nitrogen fertilizers had similar effects on phosphorus of seed in the irrigation after 50 mm and 100 mm evaporation from A class pan treatments. The lowest phosphorus of seed was gained by irrigation after 150 mm and 200 mm evaporation from A class pan + application of 80 kg/ha nitrogen fertilizers treatments (Figure 2).

Correlation of grain yield with oil and phosphorus of seed

Table 5 indicated that grain yield had significant correlation with oil and phosphorus of seed.

Table 5
Correlation

	Grain yield	Fatty acid	Phosphorus of seed
Grain yield	1		
Oil of seed (fatty acid)	763	1	
Phosphorus of seed	793	905	1

Conclusion

The application of N fertilizer to drought-stressed plants seems to have a positive effect on maize yield (Boyer, 1996; Eck, 1984). Durieux et al. (1994) reported that the root weight of mature field-grown maize declined as the rate of N application declined. Pandey et al. (2000) conducted experiments in Niger with five levels of N fertilization and five irrigation regimes. They found that the effect of drought on kernel number m-2 depended strongly on the irrigation regime. Kniep and Mason (1989) reported significant effects of water regime x N fertilization on grain yield, grain protein concentration, and lysine concentration in the grain of maize in Nebraska. In developing countries, stimated is due to drought and N deficiency, with both stresses often occurring simultaneously. While the single effects of irrigation and N application on the grain yield, grain yield omponents, and N-related parameters of maize have been reported in numerous publications, relatively little has been published about the interactive effects of these factors, especially for tropical maize.

References

Anderson, E. L., E. J. Kamprath and R. H. Moll, 1984. Nitrogen fertility effects on accumulation, remobilization, and partitioning of N and dry matter in corn genotypes differing in prolificacy. *Agron. J.*, **76:** 397–404.

Boyer, J. S., 1996. Advances in drought tolerance in plants. In: "Advances in agronomy", Vol. 56.*Academic Press*, Inc.

Chaves, M. M., 1991. Effects of water deficits on carbon assimilation. *J. Exp. Bot.,* **42:** 1–6.

Chaves, M. M., J. P. Maroco and J. Pereira, 2003. Understanding plant responses to drought– from genes to the whole plant. *Funct. Plant Biol.*, **30**: 239–264.

Craufurd, P. Q. and J. M. Peacock, 1993. Effect of heat and drought stress on sorghum. *Exp. Agric.*, **29**: 77–86.

Cromwell, G. L., M. J. Bitzer, T. S. Stahly and T. H. Johnson, 1983. Effects of soil nitrogen fertility on the protein and lysine content and nutritional value of normal and opaque-2 corn. *J. Anim. Sci.*, **57:** 1345–1351.

Durieux, R. P., E. J. Kamprath, W. A. Jackson and R. H. Moll, 1994. Root distribution of corn: The effect Of nitrogen fertilization. *Agronomy Journal,* **86:** 958-962.

Eck, H. E., 1984. Irrigated corn yield response to nitrogen and water. *Agronomy Journal,* **76:** 421-428.

Farquhar, G. D., K. T. Hubick, A. G. Codon and R. A. Richards, 1989. Carbon isotope fractionation and plant water use efficiency. pp. 220–240. In: P.W. Rundell et al. (ed.) Stable isotopes in ecological research. *Springer-Verlag*, New York.

Flexas, J., J. Bota, F. Loreta, G. Cornic and T. D. Sharkey, 2004. Diffusive and metabolic limitation to photosynthesis under drought and salinity in C3 plants. *Plant Biol.,* **6:** 269–279.

Frey, K. J. 1951. The inter-relationships of protein and amino acids in corn. *Cereal Chem.*, **28:** 123–132.

Frey, K. J., B. Brimhall and G. F. Sprague, 1949. The effects of selection upon protein quality in the corn kernel. *Agron. J.*, **41:** 399.

Jagtap, V., S. Bhargava, P. Streb, and J. Feierabend, 1998. Comparative effect of water, heat and light stresses on photosynthetic reactions in *Sorghum bicolor* (L.). Moench. *J. Exp. Bot.,* **49**: 1715–1721.

Jian, Y. and B. Huang, 2001. Drought and heat stress injury to two cool-season turf grass in relation to antioxidant and lipid peroxidation. *Crop Sci.*, **41**: 436–442.

Kniep, K. R. and S. C. Mason, 1989. Kernel breakage and density of normal and *opaque-2* maize grain as Influenced by irrigation and nitrogen. *Crop Science,* **29:** 158-163.

Kniep, K. R. and S. C. Mason, 1991. Lysine and protein content of normal and opaque- 2 maize grain as influenced by irrigation and nitrogen. *Crop Sci.,* **31**: 177–181.

Madani, A., A. H. Shirani-Rad, A. Pazoki, Gh. Nourmohammadi and R. Zarghami, 2010a. Grain filling and dry matter partitioning responses to source: sink modifications under post-anthesis water and nitrogen deficiencies in winter wheat (*Triticum aestivum* L.). *Acta Scientarum Agronomy*, **32:** 145–151.

Mittler, R., 2006. Abiotic stress, the field environment and stress combination. *Trend Plant Sci.,* **11**: 15–19.

Oikeh, S .O., J. G. Kling and A. E. Okoruwa, 1998. Nitrogen management effects on maize grain quality in the West Africa moist savanna. *Crop Sci.*, **38**: 1056–1061.

Olsen, R. A., K. D. Frank, E. J. Deibert, A. F. Dreier, D. H. Sander and V. A. Johnson, 1976. Impact of residual mineral N in soil on grain protein yields of winter wheat and corn. *Agron. J.,* **68**: 769–772.

Ort, D. R., K. Oxborough and R. R. Wise, 1994. Depressions of photosynthesis in crops with water deficits. pp. 315–329. In: N. R. Baker and J. R. Bowyer (ed.) Photoinhibition of photosynthesis: From molecular mechanisms to the field. *Bio Scientific Publisher*, Oxford, UK.

Pandey, R. K., J. W. Maranville and A. Admou, 2000. Deficit irrigation and nitrogen effects on maize in A Sahelian environment: I. Grain yield and yield components. *Agricultural Water Management,* **46:** 1-13.

Perry, W. P., 1988. Corn as a Livestock Feed. pp. 941–963. In C.E Sprague and J. W. Dudley (eds) Corn and corn improvement, 3rd edition, American Society of Agronomy, Madison, WI.

Pierre, W. H., L. Dumenil, V. D. Jolley, J. R. Webb and W. D. Shrader, 1977. Relationship of corn yield, expressed as a percentage of maximum and the N percentage in grain: I. Various N-rate experiments. *Agron. J.,* **69:** 215–220.

Rizhysky, L., H. Liang, J. Shuman, V. Shulaev, S. Davletova and R. Mittler, 2004. When defense pathways collide: The response of Arabidopsis to a combination of drought and heat stress. *Plant Physiol.*, **134**: 1683–1696.

Sabata, R. J. and S. C. Mason, 1992. Corn hybrid interactions with soil nitrogen level and water regime. *J. Prod. Agric.*, **5**: 137–142.

Sander, D. H., W. H. Allaway and R. A. Olson, 1987. Modification of nutritional quality by environment and production practices, pp. 45–82. In R.A. Olson and K.I. Frey (eds) Nutritional quality of cereal grains: Genetics and agronomic management, American Society of Agronomy, Madison, WI.

Savin, R. and M. E. Nicolas, 1996. Effect of short episodes of drought and high temperature on grain growth and starch accumulation of two malting barley cultivars. *Aust. J. Plant Physiol.*, **23**: 201–210.

Tsai, C. Y, I. Dweikat, D. M. Huber and H. L. Warren, 1992. Interrelationship of nitrogen nutrition with maize (*Zea mays*) grain yield, nitrogen use efficiency and grain quality. *J. Sci. Food Agric.*, **58**: 1–8.

Tsai, C. Y., H. L. Warren, D. M. Huber and R. A. Bressan, 1983. Interactions between the kernels N sink grain yield and protein nutritional quality of maize. *J. Sci. Food Agric.,* **34**: 255–263.

Received May, 2, 2012; accepted for printing February, 2, 2013.