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Yield and Yield Components of Two Maize Hybrids as affected by Water Deficit and Arginine

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ABSTRACT

Two field experiments were carried out at private farm Wadi El-Rayyan, El-Fayoum governorate, Egypt, during the two successive summer seasons of 2017 and 2018 to study the effect of skipping one irrigation with or without arginine on yield and yield components of two maize hybrids (Fine Seeds-101 and T.W. 329). Omitting 5th irrigation + 200 cm^3/ fed., arginine gave the highest values followed by control in plant height, ear length (cm), ear diameter (cm), number of row / ear, grain index, grain yield / plant, grain yield / fed., straw yield / fed., and biological yield / fed., while control gave the highest values for straw yield / plant , harvest index, protein and carbohydrate percentage. Fine Seeds-101 cultivar significantly surpassed T.W. 329 cultivar in plant height (cm), ear length (cm), ear diameter (cm), number of row / ear, grain index, grain yield / plant, straw yield / plant, protein and carbohydrate percentage in both seasons, while the differences between the two maize cultivars in grain, straw, biological yields per feddan and harvest index were not significant in both seasons. The interaction between maize cultivars and water shortage with or without arginine were not significant in all characters under study except plant height (cm), number of row / ear, grain index, grain yield / plant, biological yield / fed., and carbohydrate percentage in both seasons, where the best treatment was omitting 5th irrigation + 200 cm^3 / fed., arginine with Fine Seeds- 101 cultivar.

Keywords: Maize, cultivars, arginine, skipping, irrigation, yield and yield components.

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops in Egypt as a food crop for humans and animals, maize also is one major crop in summer season in Egypt. The actual water use by crop varies greatly due to the variation of seasons and locations, depending on the evaporative conditions of the atmosphere and the crop characteristics. Therefore the knowledge of the optimum amounts of water required for obtaining maximum yield and high quality is essential. It has been reported that soil moisture limits the growth of the plants before it reaches the permanent wilting point. Water stress affects every process in the plant, where it reduces cell turgor, the size of assimilation leaf area and number of potential sites for produced dry matter (Simpson, 1981). It is well established that water supply affects the growth and production of grown crops, limited soil moisture critically influenced the performance of maize plants by reducing plant height, weight and size of assimilating leaf area and dry matter accumulation (Hefni *et al*, 1993). Yield and yield components of maize were also affected by limited water supply, Ibrahim *et al* (1992). El-Sheikh (1994) and Zaki, *et al* (2014) reported that the plant exposed to skipping one irrigation reduced grain yield. However, Egyptian maize cultivars may differ in their assimilation capacity and distribution of photosynthates between the various plant organs which could be referred to as "source and sink relation".

Water is generally considered the most limiting factor in higher plants. Exposing higher plants to water stress adversely affected plant growth and productivity (Ahmed *et al*, 2010).Therefore, it seems imperative to work for improving water use efficiency for major through increase inorganic ions or organic solutes (Simpson, 1981). The productivity of maize plants depends on the available amount of water, to evaluate the yield of maize cultivars it is useful to estimate the ability of maize plants to accumulate dry matter. Arginine is considered, as essential amino acids that founds in the structural proteins, but in small quantities do not meet the needs of plant (Yang and Gao, 2007). It is one of the

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most common amino acids in natural proteins in plants. It uses a source of nitrogen and transporter for it, so arginine represents 50% to 90% of the nitrogen in the seeds and vegetative tissue, respectively. In addition, it considered precursor for amines that have a role in many physiological processes as growth, cell division and plant protection from aging. Arginine constructed in green plastids with the contribution of some plant enzymes. Arginine, has a role in many vital processes, therefore, its importance lies in its effectiveness at all stage of plant growth as well as being an essential component of proteins as constructing material for important compounds such as nucleotide, porphyries and many co-enzymes (Tarraf and Zaki, 1999, El-Bassiouny *et al*, 2008, Winter *et al*, 2015 and Al- Hayani, 2018).

The aim of this investigation is to study the effect of water regime and arginine on two maize hybrids.

Materials and Methods

Two field experiments were carried out at private farm Wadi El-Rayyan, El-Fayoum governorate, Egypt, during the two successive summer seasons of 2017 and 2018 to study the response of two maize hybrids to arginine grown under water shortage. Soil sample was taken at depth of 30 cm for mechanical and chemical analysis as described by Chapman and Pratt (1961). The mechanical and chemical analysis of the soil of the experimental site were illustrated in Table (1).

Table 1: Mechanical and chemical analysis of soil at experimental sites.

Sand (%)	Silt (%)	Clay (%)	Texture	pH	Organic matter O.M.%	Available N ppm	Available K ppm	Available P ppm
73.59	22.47	3.45	Sandy	8.00	0.49	84.00	134.00	12.5

The experimental design was split plot design with six replications, where, the skipping irrigation and arginine [i.e. skipping the third irrigation with or without arginine (200 cm^3/ fed.), skipping the fourth irrigation with or without arginine and skipping the fifth irrigation with or without arginine beside the control (without skipping and arginine)] occupied the main plot, two white maize hybrids (i.e. single cross – Fine Seeds-101 and three way cross- T.W. 329) were allocated in sub-plot. The experimental unit consisted of six ridges 4.5 meter in length and 80 cm between the ridges, the size of each plot was 21.6 m^2.

Grains of maize hybrids were sown on 20 and 28 May in both seasons, respectively, in hills spaced 25 cm along, three kernels per hill. After three weeks, plants were thinned to one plant / hill. Phosphorus fertilizer were added to soil before sowing at rate of 200 kg / fed., of calcium superphosphate (15.5% P_2O_5). Nitrogen fertilizer as ammonium nitrate (33.5% N) was applied at the rate of 120 kg N/feddan.

At harvest ten guarded plants were taken out at random from the middle two ridges of each plot to determine : plant height(cm), ear length (cm), ear diameter (cm), number of row / ear, grain index (1000 grain weight "g"), grain yield / plant (g), straw yield/plant (g). All plants of each plot were harvested to estimate: grain yield (ton/fed.), straw yield (ton/fed.), biological yield (ton/fed.) and harvest index %.

Nitrogen was determined using Micro-Kjeldahl according to A.O.A.C (1988) and the grain protein content was calculated by multiplying total nitrogen concentration by 5.75. Carbohydrate % was determined according to Dubois *et al* (1956).

Statistical analysis was performed according to procedure outlined by Gomez and Gomez (1984). Treatment means were compared by L.S.D. test at 5% level. Combined analysis was made for the two growing seasons as results followed similar trend.

Results and Discussion

Yield and yield components:-

A-Effect of water regime and foliar application of arginine:

It is clear from Table (2) that skipping one irrigation significantly decreased yield and yield components (i.e. plant height(cm), ear length(cm), ear diameter(cm) , number of row / ear, grain index, grain yield / plant, straw yield/ plant, grain yield / fed., straw yield / fed., biological yield / fed., harvest index, protein percentage and carbohydrate percentage in both seasons). Higher reduction of the previous characters was registered when maize plants were exposed skipping the 3rd irrigation compared with the normal irrigation (control), followed by skipping the 4th and 5th irrigation. On the other hand, normal irrigation (control) and skipping the 5th irrigation + 200 cm^3/ fed., arginine promoted growth and resulted in higher plant height, yield components, increase leaves area per plant and thereby increased rate of photosynthesis and better translocation of photosynthates from leaves and stems to the sink, this is turn favorably influenced grain yield /plant and consequently per feddan. These results are in agreement with those obtained by El-Hattab *et al* (2000), Singh *et al* (2002), Ahmed and Salem (2005), Ahmed *et al* (2009) and Zaki *et al* (2014). Data in Table (2) illustrated that spraying plant with arginine 200 cm^3 /fed., significant increased yield and its components. Arginine is a catalyst for plant growth and it produces proteins and enzymes important for physiological processes, particularly growth and division, and the expansion of plant cells faster and better because of direct entry through the stomata into the guard cells and this has encouraged the longitudinal growth and the occasional expansion of stem cells (Ahmed *et al* (2010) and Ibrahim (2013). Or may be due to work of amino acids to improve growth and stimulate the work of plant enzymes and increase its activity, as well as the organization of biological processes that take place within the tissues of the plant, including stimulation of flowering and contract (Idris, 2009). In addition, amino acids, such as Arginine, considered a source of nitrogen and act to crease the plant content from element such as potassium and phosphor. This in turn increases the weight of the seed if the nutrition is balanced by the important elements during its full time (Abbas and Makkah, 2016 and Mostafa *et al*, 2010). The increase of yield when arginine spray may be due to the role of arginine in increased of vegetative growth parameters and it is the perimeter of polyamine. In addition, amines have role in many of the physiological processes including cell division, growth and development of plant. Arginine is a source of nitrogen which play an important role in increasing growth plant and composition of the strong roots part helps in the absorption of elements needed by plants (Al-Hayani 2018).

B-Effect of hybrid differences:

Data in Table (2) show that the yield and its components of the two studied maize cross were significant different for plant height (cm), ear length (cm), ear diameter (cm), number of row / ear, grain index (g), grain yield / plant, straw yield/ plant, protein percentage and carbohydrate percentage in both seasons. Fine seeds-101 was superior in yield and yield components compared to other maize cross (T.W 329).The superiority of grain yield /plant in Fine seeds- 101 was mainly attributed to the increase in some yield components such as ear length, ear diameter, number of row / ear and grain index. The hybrid differences herein may be due to the differences in genetic structure between the two maize hybrids and to the differences in growth characters and to the differences in photosynthetic partitioning that previously indicated by Zaki *et al* (1999), Ahmed and Hassanein (2000), Mirdad (2010) and Abo El- Seoud and Wafaa (2010). This results are in harmony with those obtained by Ahmed *et al* (2011), Refay (2011) and Zaki *et al* (2014).

C- Effect of interaction:

It is clear from Table (3) that the interaction between skipping one irrigation with or without arginine and maize hybrid was significant at plant height (cm), number of row / ear, grain index, grain yield / plant, biological yield/fed., and carbohydrate percentage. The best treatment for biological yield ton / fed., was omitting 5th irrigation + 200 cm^3 arginine + T.W. 329, while, the best treatment for plant height, grain index and grain yield/ plant were omitting 5th irrigation + 200 cm^3 arginine + Fine seeds- 101 +. The best treatment for number of row/ear and carbohydrate percentage was normal irrigation with Fine seeds- 101.

Table 2: Effect of water regime, arginine and cultivars on yield and its components of maize hybrids. (Average of 2017 and 2018 seasons).

Characters / Treatments	Plant height (cm)	Ear length (cm)	Ear diameter (cm)	Number of row/ ear	Grain index (g)	Grain yield (g)/plant	Straw yield (g)/plant	Grain yield (ton/fed.)	Straw yield (ton/fed.)	Biological yield (ton/fed.)	Harvest index (%)	Protein (%)	Carbohydrate (%)
Water regime													
1	245.8	21.3	5.69	19.8	27.34	147.0	331.7	4.544	4.348	8.892	51.10	11.18	80.70
2	229.5	19.5	4.71	17.3	24.55	133.7	318.3	3.980	4.067	8.046	49.44	9.86	80.08
3	240.2	20.7	5.18	18.3	25.84	137.3	320.6	4.232	4.178	8.410	50.20	10.29	80.30
4	245.5	20.7	5.44	18.8	27.11	142.8	324.8	4.556	4.325	8.881	51.27	10.61	80.59
5	238.7	19.5	4.92	18.0	25.08	138.6	318.3	4.270	4.137	8.405	50.81	10.62	80.30
6	246.9	20.7	5.24	18.6	27.23	144.2	324.2	4.376	4.372	8.748	50.01	10.75	80.49
7	253.0	21.1	5.52	19.6	28.27	148.9	326.4	4.668	4.778	9.446	49.42	10.82	80.64
L.S.D. at 5%	3.1	0.7	0.24	0.8	0.86	2.3	1.9	0.197	0.115	0.255	1.17	0.27	0.02
Cultivars													
Fine Seeds-101	247.4	21.9	5.71	19.2	26.90	143.7	325.8	4.420	4.310	8.730	50.60	10.68	80.53
T.W. 329	238.2	19.1	4.77	18.0	26.08	139.9	321.7	4.330	4.320	8.650	50.04	10.50	80.36
L.S.D. at 5%	0.8	0.3	0.08	0.3	0.33	0.6	1.0	n.s	n.s	n.s	n.s	0.14	0.01

1-Normal irrigation 2-Omitting 3rd irrigation3-Omitting 4th irrigation 4-Omitting 5th irrigation 5-Omitting 3rd irrigation + 200cm^3 arginine 6-Omitting 4th irrigation+200cm^3 arginine
7- Omitting 5th irrigation+200cm^3 arginine

Table 3: Effect of interaction between water regime, Arginine x Cultivars on yield and its components of maize hybrids. (Average of 2017 and 2018 seasons).

Treatments	Characters	Plant height (cm)	Ear length (cm)	Ear diameter (cm)	Number of row / ear	Grain index (g)	Grain yield(g)/plant	Straw yield(g)/plant	Grain yield (ton/fed.)	Straw yield (ton/fed.)	Biological yield (ton/fed.)	Harvest index (%)	Protein (%)	Carbohydrate (%)
Water regime x Cultivars														
1	**Fine Seeds-101**	250.9	23.0	6.16	20.9	27.63	150.2	333.2	4.478	4.263	8.741	51.23	11.23	80.87
	T.W. 329	240.7	19.7	5.22	18.7	27.04	143.8	330.3	4.610	4.433	9.044	50.97	11.12	80.53
2	**Fine Seeds-101**	230.7	20.8	5.09	17.6	24.51	134.4	320.8	3.920	4.027	7.947	49.31	10.02	80.03
	T.W. 329	228.4	18.2	4.33	16.9	24.59	133.0	315.8	4.039	4.107	8.146	49.58	9.70	80.13
3	**Fine Seeds-101**	245.8	22.1	5.60	18.6	26.04	138.6	322.7	4.557	4.240	8.797	51.77	10.35	80.35
	T.W. 329	234.5	19.3	4.75	17.9	25.64	136.0	318.5	3.906	4.117	8.023	48.63	10.24	80.25
4	**Fine Seeds-101**	250.9	22.0	5.96	19.8	27.59	144.0	327.1	4.732	4.397	9.129	51.82	10.65	80.75
	T.W. 329	240.1	19.4	4.91	17.9	26.63	141.6	322.5	4.380	4.253	8.633	50.73	10.56	80.44
5	**Fine Seeds-101**	243.7	20.6	5.40	17.9	25.23	140.7	320.4	4.291	4.087	8.378	51.22	10.87	80.34
	T.W. 329	233.6	18.3	4.43	18.0	24.93	136.4	316.3	4.249	4.187	8.433	50.39	10.38	80.27
6	**Fine Seeds-101**	252.2	22.3	5.84	19.0	28.10	146.7	326.2	4.295	4.443	8.738	49.13	10.92	80.57
	T.W. 329	241.6	19.0	4.64	18.1	26.35	141.6	322.3	4.457	4.300	8.757	50.89	10.58	80.41
7	**Fine Seeds-101**	257.9	22.4	5.96	20.3	29.16	151.2	330.2	4.664	4.713	9.378	49.75	10.71	80.79
	T.W. 329	248.2	19.8	5.09	18.8	27.38	146.6	326.4	4.671	4.843	9.515	49.08	10.93	80.50
L.S.D. at 5%		2.2	n.s	n.s	0.9	0.88	1.6	n.s	n.s	n.s	0.489	n.s	n.s	0.02

1-Normal irrigation 2-Omitting 3rd irrigation 3-Omitting 4th irrigation 4-Omitting 5th irrigation 5-Omitting 3rd irrigation+200cm^3 arginine 6-Omitting 4th irrigation + 200cm^3 arginine
7- Omitting 5th irrigation+200cm^3 arginine

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