American Journal of Plant Sciences, 2011, 2, 790-807
doi:10.4236/ajps.2011.26094 Published Online December 2011 (http://www.SciRP.org/journal/ajps)

Interactive Effects of Drought Stress and Phytohormones or Polyamines on Growth and Yield of Two M (*Zea maize* L.) Genotypes

M. A. K. Shaddad[1], M. Hamdia Abd El-Samad[2], H. T. Mohammed[1]

[1]Botany Department, Faculty of Science, Assiut University, Assiut, Egypt, [2]Department of Botany and Microbiology, Faculty of Science, Minia University, Minia, Egypt.
Email: hamdia10@yahoo.com

Received November 19th, 2010; revised June 25th, 2011; accepted July 8th, 2011.

ABSTRACT

Two maize genotypes (Nefertiti and Bashaier) were picked up from nine maize genotypes during the early vegetative growth (25 days) to be cultivated in open field upon the crop yield under the different drought stress levels (90,70,50,30) or under the interaction effect of drought stress and phytohormones or polyamines. According to the data of growth criteria, the maize genotype Nefertiti was found to be the most drought sensitive genotype, while the genotype Bashaier was found to be the most drought resistant genotype. Additionally while the photosynthetic pigments remained more or less unchanged in genotype Bashaier, their biosynthesis destroyed earlier in the drought sensitive genotype (Nefertiti). Also while the genotype Bashaier absorbed and accumulated a sufficient amount of mono and divalent cations (K^+, Ca^{++} and Mg^{++}), the genotype Nefertiti did not. Accordingly while the genotype Bashaier gave a crop yield up to 50% field capacity, the genotype Nefertiti gave a crop yield only up to 70% field capacity and failed to give a crop yield beyond this level. The interaction effect of drought stress and phytohormones and polyamines improved the all above characteristics. Interestingly each of these activators considerably improved the production of crop yield only in genotype Bashaier specially polyamines they produced more than 60% field capacity and at the level of 30% field capacity (the level which did not give crop yield in this genotype). However, phytohormones in generally did not make an important effect on the crop yield in genotype Nefertiti although they improved the dry matter production during the vegetative stages. Such situation seemed to be complicated and borne many questions to be studied in the future.

Keywords*: *Drought, Maize (Zea maize L.), Phytohormones, Polyamines, Leaf Area, Dry Weight, Yield

1. Introduction

Drought is the most important limiting factor for crop production and it is becoming an increasingly severe problem in many regions of the world [1,2]. Drought is still a serious agronomic problem and one of the most important factors contributing to crop yield loss. According to statistics, the percentage of drought affected land areas more than doubled from the 1970s to the early 2000s in the world [3]. Maize is one of the major summer crops in the irrigated areas of Egypt. However, maize is very sensitive to water stress [4-6]. The effects of water stress on maize include the visible symptoms of reduced growth, delayed maturity and reduced biomass and crop grain yield. For example, water stress on maize has been shown to reduce plant height [6], leaf area index [7] and root growth [8]. Grain yield can be reduced by decreasing yield components like grain number and grain weight [5,9]. Many researchers have evaluated the effect of timing of water stress on maize yield [6,10-12]. Flowering has been found to be the most sensitive stage to water deficit, with reductions in biomass, yield and harvest index [4,5,9,13, 14]. The high sensitivity of maize to water stress means that under water limiting conditions it is difficult to implement irrigation management strategies without incurring significant yield losses [4,15]. Much of the past research on water stress on maize has consisted of full withholding of irrigation and conditions of severe water stress [11,12]. It is clear from the literature that cessation of irrigation in maize causes significant yield losses. Therefore, it is important to know the crop response to moderate water deficit at different growth stages and under cropping and irrigation conditions similar to the one experienced by farmers in the area.

Phytohormones such as IAA, gibberellic acid (GA_3), and kinetin are known to be involved in the regulation of plant response to the adverse effect of stress conditions [16-18] show that plant hormones can be defined as organic substances that are produced in one part of plant and trans located to another parts, where at very low concentration, they stimulate physiological response. Plants are usually subjected to environmental factors such as drought or water salinity.

Also, exogenously applied phytohormones or polyamines have multiple roles in improving drought tolerance of maize. These functions are improved cell water status and alleviation of oxidative damage on the biological membranes. This suggests that maintenance of water economy through stabilized cellular structure is an important mechanism of drought tolerance in maize. Establishment of similar roles of polyamines are likely to be a great step in improving drought tolerance in high water requiring plant species.

Polyamines are now being regarded as plant growth regulators and secondary messenger in signaling pathways [19-21], and play an array of physiological roles in plant growth and development [22]. Although, they induce tolerance against several abiotic stresses in plants [23-25], mechanisms of their action during exogenous application in modulating physiological phenomena and improving drought stress tolerance are not fully understood.). Thus the aim of the present work was to test the effect of exogenous treatments with some phytohormones and polyamines in counteracting the adverse effects of drought on growth, photosynthetic pigments, some mineral contents and yield production, of the two maize genotypes, which has been recorded to be differed in their drought stress tolerance according to the data of short duration experiment [26].

2. Materials and Methods

A field experiment was conducted using two maize genotypes Bashaier and Nefartiti selected for drought tolerance in the growth chamber experiments. Grains were obtained from the breeding program of seeds station, Beni-suef, Egypt to be used in the field Work of Minia governorate. In view of the nature of the field experiment, Minia represented an ideal location since it is virtually rainless in the summer. A randomized split plot design was used [27]. Soil plots (50 m^2) were prepared by adding manure 25 m^3 Feddan-1 (60 $m^3 \cdot ha^{-1}$), plowing twice (once perpendicular to the other), leveling, and lining (7 m-long lines, 60 cm apart). Sowing (early June) on lines in small holes (Goras, 25 - 30 cm apart, two seeds per hole). Only one seedling per Gora was left after seedling establishment. Fertilizers included 200 kg. $Feddan^{-1}$ Superphosphate (15% P_2O_5), and 120 units nitrogen $Feddan^{-1}$ (200 kg Feddan-1 46% urea, in three installments once after sowing, once after second irrigation, and once after third irrigation). Plots were flood-irrigated after sowing, and seeds were sown in each plot and soil was brought to field capacity, then plots are classified into four groups according to the amount of moisture content in each plot. Plants were grown with further irrigation at 90%, 70%, 50%, and 30% field capacity, plants was irrigated every 12 day with these field capacities. Irrigation water was thoroughly measured by introducing a water meter on the irrigation line. Irrigation was stopped three weeks before harvest to allow drying. Plants were harvested 120 days after sowing.

Plants in each soil plots are classified into eight groups the first group was the control, the rest groups were treated with 10 ml 200 µ. mol of one of the polyamines (putrescine, spermine or mixture of putrescine and spermine polyamines) or 20 µ. mol of one of the phytohormones (IAA, GA_3, Kinetin and mixture of these phytohormones). Plants are treated with these phytohormones or polyamines two time during the age of maize the first at 30 old-days and the second at 45 old-day. At the end of the experimental period plant height, dry matter yield of the different organs (stem and leaves) were determined. Plant height was determined by direct measurement from soil surface to the tip of the flag leaf. Determination of the dry matter involved harvesting and careful separation of fresh organs. Fresh organs were then dried in an oven at 80˚C. Successive weighing was carried out until a constant dry weight was recorded. Leaf area was determined by measuring leaf length and maximum width and applying the formula;

Leaf area = k (leaf length * leaf maximum width) $cm^2 \cdot plant^{-1}$

This formula provided a simple way for determination of leaf area particularly in the field where large leaves had to be measured. The coefficient k was calculated and assigned different values for different grasses [28,29], and was recently reviewed and given a value of 0.75 for maize [30]. The photosynthetic pigments, chlorophyll a, chlorophyll b and carotenoids, were determined using the spectrophotometric method recommended by [31]. The flame emission technique was chosen for determination of potassium due to its simplicity, precision, and sensitivity. A flame photometer (Corning 410, Corning Science Products, Halstead, Essex, England) was used for this purpose.

The EDTA titration method was employed for calcium and magnesium of different plant organs [32]. Harvest was carried out 120 days after sowing and cobs were left to dry (air dry for 2 weeks). Yield was determined as

Ardab $Feddan^{-1}$ (Ardab = 120 kg) of air-dry grains. Yield attributes determined included the 1000 grain weight, and number of grains in each row.

3. Statistical Analysis

The experimental data were subjected to the one way analysis of variances (ANOVA test) using the SPSS version 11.0 to quantify and evaluate the source of variation and the means were separated by the least significant differences, L.S.D. at P level of 0.05% and 0.01% [33].

4. Results

The data in **Table 1** reveal that, the dry weight of stem and leaves of *maize genotype Nefertiti* decreased highly significantly by increasing the drought stress level in the soil. This reduction in the dry weight of stem and leaves was highly significant even at the highest soil moisture content level used when compared with the relative control values (90% F.C.). At the level of 30% F.C the percent of reduction in the dry weight in stem and leaves was 75%, and 62% respectively, which indicate more deleterious effect of sever drought stress was recorded in dry weight of *maize genotype Nefertiti*. The stimulatory effect of the growth promoters varied considerably from one to another. Polyamines alone or in combination increase the dry matter yield at 50% F.C over those of the relative control values, (the level which reduce dry matter yield to about 50% in only drought stresses plants). Also IAA promoted the dry matter production in plants irrigated with 50% F.C by about 56% over those of related control value. Kinetine and mixture phytohormones induce a slight increase in these values at 50% F.C (about 27%). GA_3 alleviated the inhibitory effect of drought at 50% F.C. In general polyamines seemed to be the superior up to 50% F.C, while phytohormones were the superior at 30% F.C (most of them nearly alleviated the inhibitory effect of drought stress.

Drought stress up to 70% F.C induced a slight effect in the stem dry weight of *maize genotype Bashaier*, then it reduced gradually by the further increase in the level of drought stress. On the other hand the dry matter yield of leaves remained more or less unchanged up to the level of 50% F.C, and then a minute reduction was obtained. At the level of 30% F.C the percent of reduction in the dry weight of stem and leaves was 51% and 20% respectively in compared with the relative control (90% F.C). Phytohormones or polyamines treatments considerably increased the values of dry weight of stem and leaves of *maize genotype Bashaier* as compared with those of plants subjected only to the various level of drought stress. According to the data of dry matter of stem and leaves the *maize genotype Bashaier* considered the drought tolerant genotype, while the *maize genotype Ne- fertiti* was the drought sensitive genotype. At the level of 30% F.C, the percent of reduction in the stem dry weight in *maize genotype*. *Bashaier* was 51% while in *maize genotype Nefertiti* the percent of reduction in the stem dry weight was 75%. Thus the data of field experiment recommended the data of growth chamber experiment where *maize genotype Bashaier* still the most drought tolerant genotype and the *maize genotype Nefertiti* was the most drought sensitive genotype.

The leaf area of the *maize genotype Nefertiti* decreased highly significant by decreasing the soil moisture content, this reduction was more pronounced at the lowest field capacity used (30% F.C). At this level the percent of reduction was about 45% as compared with the relative control. The inhibitory effect of drought stress on the values of leaf area was completely alleviated as a result of phytohormones and polyamines treatments.

Spermine was the most effective in the production of leaf area especially at the level of 90% F.C when compared with putrescine. The mixture of putrescine & spermine was much more obvious in production of leaf area at all soil moisture content used. It is worthy to mention that, the highest values of leaf area obtained at the level of 30% F.C were recorded in plants treated with IAA or the mixture of polyamines (**Table 2**).

The leaf area of *maize genotype Bashaier* decreased smoothly by increasing the drought stress level in the soil. It reduced by only 24% at the level of 30% F.C. Phytohormones treatment considerably increased the values of leaf area, whatever the level of the soil moisture content used as compared with the corresponding drought stressed plants. Interestingly kinetin seemed to be the most effective phytohormones in the two maize cultivars at the sever drought than the other phytohormones and or the mixture of them. Also, while IAA was the least effective phytohormones at mild drought it on the other hand the most effective at sever drought stress. Polyamines treatment resulted in a considerable increase in these values over those of the relative control up to the level of 70%, which was much more obvious in plants sprayed with mixture of polyamines. Thereafter these polyamines considerably elevated the values of leaf area, when compared with those of plants subjected to the 50% and 30% F.C without polyamines treatment (**Table 2**).

One of the especial interest in this work is that the number of leaves remained constant in the two maize genotypes *Nefertiti*, and *Bashaier* whatever the treatment used which means that, the differences might located in the growth of leaves (area), rather than in the number of leaves which means that at least in maize external environmental conditions is not a limiting factor in the num-

Table 1. Interactive effect of drought stress and phytohormones or polyamines on dry matter of stem and leaves (gm·plant^{-1}) of two the maize genotypes.

Bashaier (drought tolerant)				Nefertiti (drought sensitive)				F.C	Treatments
%	Leaves D·wt	%	stem D·wt	%	Leaves D·wt	%	Stem D·wt		
100	30	100	87	100	29	100	59	90%	Control
97	29	98	85*	76	22**	86	51**	70%	
93	28*	89	77**	62	18**	56	33**	50%	
80	24**	49	43**	38	11**	25	15**	30%	
153	46**	178	155**	86	25**	151	89**	90%	IAA
130	39**	155	135**	131	38**	215	127**	70%	
107	32*	131	114**	103	30	156	92**	50%	
107	32*	85	74**	90	26**	83	49**	30%	
127	38**	159	138**	96	28	153	90**	90%	GA_3
133	40**	134	117**	134	39**	186	110**	70%	
113	34**	99	86	110	32**	105	62	50%	
96	29	89	78*	82	24**	76	45**	30%	
143	43**	144	125**	134	39**	192	113**	90%	Kinetin
133	40**	132	115**	134	39**	181	107**	70%	
130	39**	108	94*	120	35**	127	75**	50%	
93	28*	86	75**	103	30	80	47**	30%	
140	42**	160	139**	138	40**	220	130**	90%	Mixture hormone
130	39**	142	124**	134	39**	203	120**	70%	
127	38**	113	98**	110	32**	129	76**	50%	
86	26**	84	73**	75	22**	81	48**	30%	
160	48**	159	138**	120	35**	231	136**	90%	Putrescine
133	40**	149	130**	117	34**	180	106**	70%	
113	34**	114	99**	113	33**	144	85**	50%	
100	30	80	70**	75	22**	63	37**	30%	
156	47**	160	139**	137	40**	217	128**	90%	Spermine
153	46**	131	114**	96	28	147	87**	70%	
113	34**	115	100**	86	25**	117	69**	50%	
90	27**	86	75**	79	23**	59	35**	30%	
160	48**	163	142**	155	45**	225	133**	90%	Mixture poly amines
126	38**	149	130**	131	38**	190	112**	70%	
133	40**	121	105**	113	33**	153	90**	50%	
96	29	83	72**	89	26**	66	39**	30%	
2.38		2.55		2.24		7.16		0.01	LSD
1.79		1.92		1.68		5.39		0.05	

* Significant difference and ** highly significant difference as compared with relative control.

Table 2. Interactive effect of drought stress and phytohormones or polyamines on number of leaves per plant, and leaves area ($cm^2 \cdot plant^{-1}$) of two maize genotypes.

Bashaier (drought tolerant genotype)				Nefertiti (drought sensitive genotype)				F.C	Treatments
%	Leaf area	%	No, of leaves	%	Leaf area	%	No, of leaves		
100	6150	100	15	100	4637	100	15	90%	Control
90	5546^{**}	100	15	82	3802^{**}	100	15	70%	
84	5151^{**}	93	14	58	2700^{**}	100	15	50%	
76	4700^{**}	87	13^{*}	55	2570^{**}	87	13^{*}	30%	
104	6425^{**}	107	16	91	2400^{**}	93	14	90%	IAA
102	6306^{**}	107	16	130	6036^{**}	93	14	70%	
91	5605^{**}	100	15	101	4685	93	14	50%	
89	5473^{**}	100	15	80	3700^{**}	93	14	30%	
113	6937^{**}	100	15	103	4776^{**}	93	14	90%	GA_3
107	6583^{**}	100	15	136	6300^{**}	93	14	70%	
83	5103^{**}	100	15	108	5000^{**}	80	12^{**}	50%	
75	4628^{**}	93	14	65	3000^{**}	73	11^{**}	30%	
114	7000^{**}	107	16	104	4800^{**}	107	16	90%	Kinetin
113	6975^{**}	107	16	83	3829^{**}	100	15	70%	
98	6003^{**}	100	15	80	3700^{**}	100	15	50%	
82	5020^{**}	93	14	71	3280^{**}	87	13^{*}	30%	
111	6859^{**}	100	15	132	6100^{**}	107	16	90%	Mixture hormone
110	6762^{**}	100	15	129	6000^{**}	100	15	70%	
88	5430^{**}	100	15	111	5140^{**}	87	13^{*}	50%	
67	4140^{**}	93	14	75	3475^{**}	73	11^{**}	30%	
108	6660^{**}	107	16	107	4961^{**}	100	15	90%	Putrescine
101	6236^{**}	107	16	93	4300^{**}	100	15	70%	
84	5165^{**}	107	16	88	4100^{**}	93	14	50%	
83	5082^{**}	100	15	57	2630^{**}	60	9^{**}	30%	
109	6730^{**}	107	16	137	6373^{**}	107	16	90%	Spermine
106	6519^{**}	107	16	91	4200^{**}	107	16	70%	
96	5918^{**}	106	16	86	4000^{**}	87	14	50%	
86	5292^{**}	100	15	66	3068^{**}	73	11^{**}	30%	
117	7214^{**}	100	15	135	6304^{**}	100	15	90%	Mixture poly amines
111	6827^{**}	100	15	136	6300^{**}	100	15	70%	
97	6000^{**}	100	15	104	4813^{**}	100	15	50%	
81	4960^{**}	100	15	80	3700^{**}	67	10^{**}	30%	
	68.55		2.17		57.96		2.43	0.01	LSD
	46.43		1.63		35.98		1.83	0.05	

* Significant difference and ** highly significant difference as compared with relative control.

ber of leaves.

The data of *maize genotype Nefertiti* in **Table 3** reveal that chlorophyll "a, b, and carotenoids" contents decreased by decreasing the soil moisture content, which was much more obvious at the sever drought A marked and progressive increase in the photosynthetic pigments concentration was exhibited when the drought stressed plants sprayed with phytohormones or polyamines, which was much more obvious in IAA treated plants.

The data of *maize genotype Bashaier* in **Table 4** observed that, the photosynthetic pigments (chlorophyll "a, b, and carotenoids) concentration remained almost more or less unchanged at most drought stress level and a slight reduction was recorded in these values only at the level of 30% F.C. Using of the growth regulators (phytohormones or polyamines) considerably activated the biosynthesis of the photosynthetic pigments. This stimulatory effect was much more obvious in polyamines treated plants than in phytohormones treated plants. Also, the mixture of polyamines was the superior especially at the sever drought when compared with the other activators.

The data of *maize genotype Nefertiti* in **Table 5** reveals that, The contents of potassium in shoots and roots slightly increased up to the level of 50% F.C, then it remained more or less unchanged even at the lowest field capacity used (30% F.C). A marked and progressive activation in absorption of K^+ in shoots and roots has been observed as a result of phytohormones or polyamines treatment. There is no, observable differences among the different growth promoting substances used (**Table 5**)

The data of *maize genotype Nefertiti* in **Table 5** reveals that, there is a highly significant reduction in the absorption and accumulation of Ca^{++} and Mg^{++} in shoots and roots, as the drought stress level increased in the soil the highest reduction was obtained at the highest drought stress level used. On the other hand the absorption and accumulation of Ca^{++} and Mg^{++} improved as a result of the interaction effect of phytohormones or polyamines in shoots and roots of the *maize genotype Nefertiti*. This stimulatory effect was more pronounced in shoots than in roots and in polyamines treated plants than in phytohormones treated plants.

The data of the *maize genotype Bashaier* in **Table 6** reveals that, the contents of potassium in shoots and roots increased progressively by increasing drought stress level in the soil, therefore the highest increase in K^+ content was found to be at 30% F.C. At this level the percent of increase in K^+ content in shoots and roots was 124% and 128% respectively in relation to the relative control values. The amount of K^+ in shoot was much higher than in roots whatever the drought stress level used. Additional activation in K^+ content in shoots and roots of drought stressed *maize genotype Bashaier* was observed as results of the phytohormones or polyamines treatments. This seemed to be more observable in shoots than in roots. The data of *maize genotype Bashaier* in **Table 6** reveal that, there is a general promotion in the absorption and accumulation of calcium and magnesium in stems and roots of *maize genotype Bashaier* by drought stress. This was more pronounced in roots than in stems. Treatment with growth regulators resulted in most cases in a general activation in calcium and magnesium in the two tested plant organs.

The data of *maize genotype Nefertiti* in **Table 7** reveals that, the number of grains per ear and the 1000 grain weight reduced slightly in up to the level of 70% F.C. On the other hand the number of grains and the 1000 grain weight increased progressively at the level of 90% F.C, and to some extent at the level of 70% F.C as a result of phytohormones or polyamines treatment

The data of *maize genotype Nefertiti* in **Table 7** reveals that, it is worthy to mention that, the drought sensitive cultivar produce crop yield only up to the level of 70% F.C, while treatment with polyamines produce crop yield up to 50% F.C. The crop yield at the level of 50% in plants treated with putrescine, spermine or mixture polyamines was 13, 15, and 12.8 Ardab/feddan in relation to 21.14 Ardab/feddan produced in normally treated plants (90% F.C). Also IAA is the only phytohormone which produce crop yield at the level of 50% F.C (5.23 Ardab/feddan). Additionally all of the used polyamines increased the crop yield at the normal condition (90% F.C) as compared with untreated plants. The crop yield of plants treated with putrescine, spermine or mixture polyamines was 26.5, 24, and 26 Ardab/feddan compared to 21.14 (at the normal level). Moreover plants treated with mixture of polyamines produced 25 Ardab/ feddan; at the level of 70% F.C. GA_3, Kinetin and mixture of hormones retarded the crop yield even at the level of 90% F.C, although they considerably enhance the plant growth during the vegetative stage. This unexpected phenomenon seemed to be complicated and needs a numerous and further studies, Why those phytohormones stimulated the vegetative growth and inhibit crop yield? Is there a negative correlation between the exogenous application of these phytohormones and the group of phytohormones responsible for the flowering and fruiting or associated with the exogenous dose of the applied phytohormones???,, Is a concentration affect,, or what????

The data of *maize genotype Bashaier* in **Table 8** reveals that, imposing drought stress induce a very minute reduction in a number of grains per ear (12% only at 50% F.C) and the 1000 grain weight. On the other hand

Table 3. Interactive effect of drought stress and phytohormones or polyamines on chlorophyll a, chlorophyll b, and carotenoids (mg·gm^{-1} dwt) of maize cv. Nefertiti.

%	Carotenes	%	Chlorophyll "b"	%	Chlorophyll "a"	F.C	Treatments
100	2.67	100	5.49	100	12.44	90%	Control
68	1.82**	90	4.96**	98	12.2*	70%	
63	1.67**	80	4.33**	55	6.87**	50%	
55	1.46**	78	4.31**	60	7.43**	30%	
86	2.3**	230	12.64	198	24.63**	90%	IAA
107	2.88**	229	12.62*	186	23.10**	70%	
102	2.72	229	12.62*	197	24.54**	50%	
130	3.49**	147	8.10**	191	23.76**	30%	
51	1.36**	216	11.88**	124	15.38	90%	GA_3
40	1.08**	222	12.17*	116	14.43**	70%	
103	2.76**	172	9.44**	143	17.84**	50%	
230	6.16**	87	4.76**	157	19.52**	30%	
104	2.77**	233	12.78**	130	16.19**	90%	Kinetin
95	2.54**	181	9.91**	160	19.91**	70%	
89	2.37**	133	7.28**	97	12.12**	50%	
137	3.66**	131	7.2**	108	13.52**	30%	
83	2.22**	224	12.28**	143	17.79**	90%	Mixture hormone
78	2.08**	209	11.51**	121	15.00**	70%	
79	2.12**	163	8.96**	116	14.48**	50%	
89	2.38**	143	7.88**	114	14.14**	30%	
52	1.39**	316	17.34**	147	18.32**	90%	Putrescine
76	2.04**	276	15.15**	131	16.27**	70%	
128	3.43**	190	10.43**	166	20.64**	50%	
69	1.85**	185	10.17**	153	19.01**	30%	
149	3.99**	191	10.49**	121	15.03**	90%	Spermine
120	3.21**	183	10.03**	111	13.75**	70%	
105	2.81**	160	8.8**	148	18.45**	50%	
62	1.65**	150	8.26**	147	18.29**	30%	
80	2.14**	244	13.38**	107	13.28**	90%	Mixture poly amines
82	2.2**	268	14.75**	118	14.65**	70%	
168	4.5**	159	8.73**	102	12.69**	50%	
100	2.69	152	8.35**	148	18.43**	30%	
	0.07		0.28		0.168	0.01	LSD
	0.053		0.21		0.127	0.05	

* Significant difference and ** highly significant difference as compared with relative control.

Table 4. Interactive effect of drought stress and phytohormones or polyamines on chlorophyll a, chlorophyll b, and carotenoids (mg·gm^{-1} dwt) of maize genotype Bashaier.

%	Carotenes	%	Chlorophyll b	%	Chlorophyll a	F.C	Treatments
100	3.86	100	9.37	100	15.62	90%	Control
72	2.78**	87	7.24**	100	15.6	70%	
71	2.74**	88	8.25**	80	12.49**	50%	
70	2.69**	96	8.98*	73	11.48**	30%	
100	3.86	104	9.74*	150	23.49**	90%	IAA
42	1.64**	118	11.05**	136	21.24**	70%	
107	4.14	136	12.78**	191	29.79**	50%	
97	3.73	126	11.86**	142	22.64**	30%	
36	1.38**	132	12.04**	149	23.27**	90%	GA_3
138	5.32**	126	11.79**	136	21.26**	70%	
82	3.18*	141	13.2**	117	18.20**	50%	
88	3.39	108	10.12**	131	20.48**	30%	
47	1.82**	148	13.86**	146	22.78**	90%	Kinetin
89	3.44	146	13.71*	142	22.17**	70%	
87	3.37	138	12.92**	186	28.98**	50%	
60	2.32**	136	12.90**	107	16.69**	30%	
81	3.12**	89	8.36**	107	16.69**	90%	Mixture hormone
97	3.76	112	10.51**	142	22.19**	70%	
111	4.32	139	13.07**	178	27.74**	50%	
102	3.97	158	14.85**	181	28.25**	30%	
87	3.37	121	11.38**	105	16.43**	90%	Putrescine
88	3.38	141	13.23**	184	28.71**	70%	
130	5.3**	144	13.47**	175	27.37**	50%	
74	2.86**	174	16.3**	208	32.51**	30%	
58	2.23**	120	11.23**	120	18.75**	90%	Spermine
128	4.96**	172	16.08**	235	36.68**	70%	
120	4.64**	130	12.18**	138	21.75**	50%	
143	5.55**	146	13.68**	196	30.69**	30%	
138	5.35**	212	19.85**	124	19.36**	90%	Mixture poly amines
197	7.64**	166	15.56**	213	33.33**	70%	
131	5.06**	156	14.59**	167	26.06**	50%	
169	6.53**	175	16.44**	218	34.07**	30%	
	0.69		0.50		0.078	0.01	LSD
	0.52		0.37		0.059	0.05	

* Significant difference and ** highly significant difference as compared with relative control.

Table 5. Interactive effect of drought stress and phytohormones or polyamines on potassium, calcium and sodium (mg·gm^{-1} plant dwt) of maize genotype Nefertiti.

Treatment	F.C	K^+				Ca^{++}				Mg^{++}			
		Shoot	%	Root	%	Shoot	%	Root	%	Shoot	%	Root	%
Control	90%	11.1	100	10.4	100	22	100	18	100	6.9	100	6.1	100
	70%	11.9**	107	12.1**	116	21**	95	14**	78	6.1**	88	5.2**	85
	50%	11.9**	107	13.6**	131	20**	91	13**	72	5.2**	75	4.2**	68
	30%	10.6**	95	9.9**	95	16**	73	10**	56	4.4**	64	4.1**	67
IAA	90%	14.8**	133	11.9**	114	28**	127	21**	117	10**	145	7**	115
	70%	12.6**	113	14.8**	142	32**	145	22**	122	11**	159	8.4**	137
	50%	10.6**	95	17.2**	165	26**	118	26**	144	8**	116	6	98
	30%	10.6**	95	13.8**	133	24**	109	24**	133	8**	116	9.6**	157
GA_3	90%	12**	108	16**	154	21**	95	26**	144	14.4**	209	8.2**	134
	70%	17.5**	157	13.4**	129	23**	105	26**	144	14**	203	7.1**	116
	50%	13.3**	119	15.2**	146	22	100	24**	133	13**	188	7.1**	116
	30%	16.5**	148	15.5**	149	22	100	23**	128	11**	159	6.2	101
Kinetin	90%	13.3**	119	14**	135	26**	118	23**	128	11.6**	168	10.8**	177
	70%	13.3**	119	16.8**	162	26**	118	23**	128	10.8**	156	7**	115
	50%	10.2**	92	17.2**	165	25**	114	24**	133	13**	188	7.1**	116
	30%	9.9**	89	12.4**	119	24**	109	16**	89	13**	188	7.2**	118
Mixture hormones	90%	8.9**	80	14.4**	138	22	100	24**	133	14**	203	8.1**	133
	70%	15.3**	138	15.1**	145	28**	127	20**	111	12**	174	7**	115
	50%	9.2**	83	15.5**	149	36**	164	21**	117	10**	145	6	98.
	30%	9.2**	83	16.1**	155	26**	118	18	100	9**	130	5**	82
Putrescine	90%	12**	108	15.2**	146	32**	145	32**	178	13**	188	9**	147
	70%	11.6**	104	21.5**	206	31**	141	28**	156	13**	188	9**	147
	50%	11.9**	107	15.5**	149	21**	95	22**	122	13**	188	12**	197
	30%	12**	108	17.5**	168	21**	95	23**	128	13**	188	11**	180
Spermine	90%	10.8**	97	11.9**	114	26**	118	20**	111	18**	261	14**	229
	70%	12.4**	112	14.6**	140	20**	91	20**	111	16**	232	14**	229
	50%	19.9**	179	12.4**	119	23**	104	24**	133	12**	174	12**	197
	30%	14.7**	132	14.1**	135	21**	95	24**	133	12**	174	8**	131
Mixture poly amines	90%	12.9**	116	12.6**	121	22	100	20**	111	12**	174	7**	115
	70%	15.8**	142	19.6**	188	22	100	18	100	10**	145	10**	164
	50%	12.3**	111	17.2**	165	20**	91	18	100	10**	145	8**	131
	30%	11.5**	104	17.5**	168	19**	86	18	100	8**	116	8**	131
LSD	0.01	0.22		0.35		0.37		0.34		0.23		0.2	
	0.05	0.16		0.30		0.31		0.27		0.17		0.15	

* Significant difference and ** highly significant difference as compared with relative control.

Table 6. Interactive effect of drought stress and phytohormones or polyamines on potassium, calcium and sodium (mg·gm^{-1} plant dwt) of maize genotype Bashaier.

Treatment	F.C	K^+				Ca^{++}				Mg^{++}			
		shoot	%	Root	%	Shoot	%	Root	%	shoot	%	Root	%
Control	90%	12.9	100	10.2	100	30	100	36	100	24	100	14	100
	70%	14.5**	112	8.9**	87	40**	133	44**	122	28**	117	16**	114
	50%	15.3**	118	11.3**	111	33**	110	44**	122	25**	104	18**	128
	30%	16**	124	13.1**	128	28**	93	40**	111	26**	108	12**	85
IAA	90%	13.3**	103	12.8**	125	35**	116	41**	114	36**	150	14	100
	70%	24.6**	190	11.2**	109	34**	113	38**	106	23**	96	16**	114
	50%	26.5**	205	11.4**	112	34**	113	42**	117	30**	125	18**	128
	30%	26.8**	208	14.3**	140	30**	100	44**	122	30**	125	28**	200
GA_3	90%	14**	108	18.2**	178	50**	166	39**	108	48**	200	17**	121
	70%	20.5**	159	13.4**	131	30**	100	42**	117	33**	137	18**	128
	50%	22**	170	15.5**	152	62**	206	41**	114	29**	121	19**	135
	30%	18**	139	20.5**	201	50**	166	36	100	30**	125	20**	142
Kinetin	90%	13.3**	103	11**	108	46**	153	36	100	40**	166	14	100
	70%	15.7**	122	14.4**	141	45**	150	36	100	33**	137	18**	128
	50%	17**	132	10.2	100	36**	120	40**	111	29**	121	18**	128
	30%	15**	116	19.9**	195	36**	120	41**	114	32**	133	18.5**	132
Mixture hormones	90%	13	101	10.6**	104	38**	126	39**	108	25**	104	25**	178
	70%	14**	108	21.8**	214	38**	126	36	100	36**	150	14	100
	50%	21**	163	16**	157	36**	120	54**	150	30**	125	21**	150
	30%	39**	302	16**	157	36**	120	40**	111	26**	108	17**	121
Putrescine	90%	14**	108	10.9**	106	54**	180	44**	122	28**	116	21**	150
	70%	18**	139	14**	137	39**	130	43**	119	21**	87	18**	128
	50%	20**	155	19.5**	191	40**	133	40**	111	24	100	18**	128
	30%	20.8**	161	18.9**	185	42**	140	46**	128	23**	96	16**	114
Spermine	90%	11**	85	17.8**	174	40**	133	47**	131	54**	225	22**	157
	70%	20.8**	161	10.2	100	48**	160	41**	114	25**	104	25**	178
	50%	15**	116	11.6**	114	32**	106	46**	128	26**	108	22**	157
	30%	18.7**	145	17.8**	174	36**	120	40**	111	26**	108	18**	128
Mixture poly amines	90%	23**	178	24.6**	241	3**6	120	40**	111	32**	133	18**	128
	70%	16**	124	19**	186	46**	153	35**	97	26**	108	20**	143
	50%	16**	124	15.5**	152	62**	206	36	100	44**	183	18**	128
	30%	17**	132	14.3**	140	36**	120	36	100	26**	108	27**	193
LSD	0.01	0.30		0.25		0.4		0.42		0.38		0.35	
	0.05	0.25		0.21		0.36		0.35		0.33		0.30	

* Significant difference and ** highly significant difference as compared with relative control.

Table 7. Interactive effect of drought stress and phytohormones or polyamines on number of grains per ear, 1000 grain weight (gm), and net yield (Ardab. Faddan-1) of maize genotype Nefertiti.

%	yield	%	1000 grain weight	%	No, of grains	F.C	Treatments
100	21.1	100	324	100	580	90%	Control
88	18.6**	95	308**	92	536**	70%	
-	-	-	-	-	-	50%	
-	-	-	-	-	-	30%	
107	22.7**	104	336*	104	601**	90%	IAA
107	22.6**	105	340**	102	591	70%	
25	5.23**	102	330	24	141**	50%	
-	-	-	-	-	-	30%	
95	20.2**	93	300**	103	597**	90%	GA_3
88	18.6**	98	316	95	550**	70%	
-	-	-	-	-	-	50%	
-	-	-	-	-	-	30%	
95	20.1**	106	344**	101	590	90%	Kinetin
72	15.2**	73	236**	97	560**	70%	
-	-	-	-	-	-	50%	
-	-	-	-	-	-	30%	
99	21	97	314	107	623**	90%	Mixture hormone
55	11.6**	58	189**	102	590	70%	
-	-	-	-	-	-	50%	
-	-	-	-	-	-	30%	
125	26.5**	116	377**	116	674**	90%	Putrescine
95	20.2**	102	329	99	572	70%	
62	13**	93	300**	85	492**	50%	
-	-	-	-	-	-	30%	
114	24**	122	396**	122	708**	90%	Spermine
106	22.5**	112	364v	96	559**	70%	
71	15**	97	313	88	513**	50%	
-	-	-	-	-	-	30%	
123	26**	105	340**	117	680**	90%	Mixture poly amines
118	25**	115	374**	112	650**	70%	
61	12.8**	93	301**	76	440**	50%	
-	-	-	-	-	-	30%	
0.49		15.51		15.89		0.01	LSD
0.37		11.66		11.94		0.05	

* Significant difference and ** highly significant difference as compared with relative control.

Table 8. Interactive effect of drought stress and phytohormones or polyamines on number of grains per ear, 1000 grain weight (gm), and net yield (Ardab. Faddan-1) of maize genotype Bashaier.

%	yield	%	1000 grain weight	%	No, of grains	F.C	Treatments
100	27	100	380	100	680	90%	Control
95	25.7**	99	376	96	654*	70%	
78	21**	97	369*	88	600**	50%	
-	-	-	-	-	-	30%	
114	30.8**	105	398**	108	733**	90%	IAA
110	29.9**	102	388	104	709**	70%	
100	27	97	370*	102	695	50%	
32	8.6**	58	220**	63	425**	30%	
115	31**	111	424**	111	758**	90%	GA3
99	26.8	105	398**	97	663	70%	
76	20.4**	100	380	77	525**	50%	
37	9.9**	70	265**	59	400**	30%	
106	28.6**	102	390*	103	698	90%	Kinetin
87	23.5**	98	374	82	558**	70%	
79	21.4**	95	362**	77	526**	50%	
32	8.6**	57	216**	52	354**	30%	
114	30.8**	102	388	110	751**	90%	Mixture hor-mone
103	28**	101	384	102	694	70%	
86	23.2**	97	370*	89	606**	50%	
44	12**	74	280**	70	474**	30%	
126	34**	111	240**	114	772**	90%	Putrescine
112	30.3**	100	380	111	756**	70%	
101	27.2	98	374	102	695	50%	
68	18.3**	81	306**	87	590**	30%	
125	33.7**	114	434**	105	715**	90%	Spermine
111	30**	106	404**	103	700	70%	
93	25**	101	384	93	631**	50%	
56	15**	81	308**	74	505**	30%	
124	33.4**	113	430**	107	731**	90%	Mixture poly amines
114	30.9**	107	406**	108	732**	70%	
99.9	26.9	101	384	98	665	50%	
62	16.8**	80	305**	81	550**	30%	
	0.59		13.18		27.69	0.01	LSD
	0.44		9.91		20.81	0.05	

* Significant difference and ** highly significant difference as compared with relative control.

phytohormones or polyamines treatment considerably increased the number of grains per ear and the 1000 grain weight up to 70% F.C. Additionally putrescine and IAA increase this number at the level of 50% F.C.

The data of the crop yield of *maize genotype Bashaier* in **Table 8** was interesting:

1) It produced a suitable amount of crop yield up to 50% F.C (It produce 21 Ardab/feddan compared to 27 Ardab/feddan at 90% F.C) note that the sensitive genotype did not produce any crop yield at 50% F.C.

2) Phytohormones or polyamines give a crop yield more or less similar to that recorded in the relative control up to 50% F.C. This was more pronounced in polyamines than in phytohormones. Moreover most of these activators enhanced the crop yield to 70% F.C in relation to the relative control. This was also more pronounced in polyamines & IAA treated plants.

3) Phytohormones or polyamines give a suitable amount of crop yield at the level of 30% F.C (The level which did not give a crop yield in this genotype)

5. Discussion

The phenological characteristics (dry matter yield and leaf area) of the field experiment recommended the drought tolerance of *maize genotype Bashaier* and the susceptibility of *maize genotype Nefertiti.* Accordingly the growth of *maize genotype Bashaier* remained mostly unchanged at mild drought stress whereas the growth of *maize genotype Nefertiti* dropped even at the lower level of drought stress, also the percent of reduction of the studied growth parameter at sever drought was much more higher in *maize genotype Nefertiti* than *maize genotype Bashaier*. Accordingly, at the level of 30% F.C. The percent of reduction in the dry matter of leaves and stems of *maize genotype Nefertiti* was 62% & 75% respectively, while in *maize genotype Bashaier* it was 20% & 51% respectively. The differences in the growth criteria among species and cultivars might be used as a suitable selection criterion for the drought tolerance of these species and *genotype*s. The inhibitory effect of drought on growth parameters could be attributed to the osmotic effect of water stress [26,34,35]. Also, the reduction of yield may be ascribed to the harmful effect of soil moisture stress and nutrient balance disorder in root media [36], or reduced rate of new cell production may be make additional contribution to the inhibition of growth [37-39]. The reduction in growth criteria due to drought stress might be related to disturbance of water flow from root to shoot [40], decrease in water potential of cell sap [41], or inhibition of cell division [42].

The values of leaf area are varied among the two drought stressed maize genotypes. They were much higher in *maize genotype Bashaier* than in *maize genotype Nefertiti*. Also the reduction in the leaf area was much more pronounced in *maize genotype Nefertiti* than in *maize genotype Bashaier*. Along with this the photosynthetic pigments remained more or less unchanged in *maize genotype Bashaier* and decreased highly significantly in *maize genotype Nefertiti*, which might improved the photosynthetic apparatus in *maize genotype Bashaier* than in *maize genotype Nefertiti.* The ability of the plants to increase its green area could be increased its drought tolerance [26]. This was found to be linked with the efficiency of photosynthesis apparatus and consequently the production of photoassimilates in the two maize genotypes. [43,44] reported that, the reduction in leaves area by drought stress may be due to a reduction in leaf expansion, probably due to the effect of drought stress on cell division or cell expansion or both. [45] reported that, the reduction observed in the leaf area and dry weight of the drought stressed plants can be attributed to the changes in plant water relations under drought stress which cause a reduction in meristem activity as well as cell elongation [46], thereby inhibiting leaf expansion [47]. The observed decrease in dry weight of the drought-stressed plants can be traced to the scanty recovery of leaves following limited photosynthesis production [45]. [48] proposed that, the death of old leaves due to the drought stress in the tissue would prevent the supply of nutrients or hormones to emerging leaves, and reducing leaf area. [49] concluded that a part from decreased growth might be attributed to the reduction in the leaf area and leaf number. The death of expanded leaves leading to decrease in photosynthetic leaf area [50]. Leaf area reduced significantly under water stress [51]. Reduction in the leaf area by water stress is an important cause of reduced crop yield through reduction in photosynthesis [51,52].

In recommendation when this plants sprayed with polyamines or phytohormones, the dry matter yield, leaf area, and photosynthetic pigments enhanced markedly, which indicated the complete correlation among the three parameters. [53] study the effect of drought stressed maize, cowpea and broad bean plants and found that while the photosynthetic pigments decreased significantly in maize they remained more or less unchanged in cowpea and broad bean plants, consequently the dry matter production in maize was much more affected by drought stress than in cowpea and broad bean plants. They also reported that when these plants sprayed with phytohormones or polyamines there is a marked stimulatory effect in green area and consequently the photosynthetic pigments which consequently accumulated the dry mass of the three tested species [54] working with drought stressed wheat cultivars and found that, the reduction in photosynthetic pigments was more pronounced in drought susceptible than in drought resistant cultivars. Other investigators reported a reduction in chlorophyll contents under drought conditions [55,56]. The reduction in total photosynthetic pigments has been reported to be related to the activation of chlorophyllase, which catalyses the catabolism of chlorophyll [57]. [58,59] reported that the degradation of thylakoid can occur in response to water stress. The enhancement of chlorophyll degradation in leaves of stressed plants can probably be due to the disturbance in hormonal balance. Such disturbance may be manifested by dimensioned kinetin biosynthesis and increased abscisic acid. The former is known to inhibit chlorophyllase activity whereas the letter is known to accelerate it [60].

The differences in the responses to drought stress between the two selected maize genotypes were mirrored by the differences in the absorption, accumulation and compartmentation of K^+, Ca^{++} and Mg^{++} in the different organs of the two genotypes. Our data reveal that while drought stress had a marked stimulatory effect in the absorption and accumulation of K^+, Ca^{++} and Mg^{++} in different organs of *maize genotype Bashaier* it on other hand, significantly inhibited the accumulation of these cations in the different organs of *maize genotype Nefertiti.* It has been well known that osmotic regulators include many important small molecules such as potassium, soluble sugars, proline and petaine [61-63]. These small molecules are also important physiological indicators for evaluating osmotic adjustment ability [64].

The *maize genotype Nefertiti produced a* crop yield (number of grains per ear, 1000 grain weight and the total yield per feddan) up to only 70% F.C, and failed completely to give crop yield at the levels of 50% & 30% F.C. while treatment with polyamines produce crop yield up to 50% F.C. Additionally all of used polyamines increased the crop yield at the normal condition (90% F.C) as compared with untreated plants. The crop yield of plants treated with putrescine, spermine or mixture polyamines was 26.5, 24, or 26 Ardab/feddan compared to 21.14 (at the normal level). It is worthy to mention that IAA is the only phytohormone which produced a crop yield up to 50% F.C (5.23 Ardab/feddan), although the other phytohormones considerably enhanced the plant growth during the vegetative stage. This unexpected phenomenon seemed to be complicated and need a numerous and further studies.

On the other hand the production of crop yield in *maize genotype Bashaier* under different treatments was interesting. This genotype produce 21 Ardab/feddan of maize grain at the level of 50% F.C, which considered an excellent results (note that the sensitive cultivar produce the same amount at the normal condition), on the opposite to the sensitive cultivar, phytohormones treatment increased the crop yield over the control value of the this drought tolerant cultivar up to 70% F.C, also the produced crop yield of IAA treated plants at 50% F.C was similar to that of control plants. Also a pronounced increased the crop yield was obtained up to the level of 70% F.C as a results of polyamines treatment in comparison with the relative control values. Moreover Putrescine increase the crop yield by 1.24 Ardab/feddan over the control at the level of 50% F.C. Interestingly at the level of 30% F.C. while the only drought stressed plants did not give a crop yield, the phytohormones or polyamines yielded a suitable amount of maize grain at the level of 30% F.C. The data also reveal that the improvement of crop yield was much more pronounced in polyamines treated plants than phytohormone ones. Putrescine was also superior in produce 18.3 Ardab/feddan at 30% F.C in relation to 27 Ardab/feddan in relative control plants (*A very interesting results)*. Stress during different growth stages might decrease translocation of assimilates to the grains, which lowered grain weight and increased the empty grains. There are some reports indicated that lower soil moisture might inhibit photosynthesis and decrease translocation of assimilates to the grain which lowered grain weight [65,66]. Moreover, water stress might lead to a considerable increase in secondary rachis branch abortion and resulted in a reduction in spikelets number per panicle [67]. In addition, drought stress could curtail the kernel sink potential by reducing the number of endosperm cells and amyloplasts formed [68,69]. Therefore, the rate of reducing in grain weight is correlated to the reduction in the capacity of the endosperm to accumulate starch, in terms of both rate and duration [69].

On the other hand, some studies show that there would be significantly higher gain in biomass (dry Ministry weight) after stress imposed. This dry weight would be associated to the cell division and new material synthesis [67,70]. Increasing the number of filled grains might be due to the contribution of carbohydrates from current photosynthesis which have been more and efficiently would translocated into the grain and thus increased the grain yield [71]. Usually, water stress at grain filling induces early senescence and shortens the grain filling period but increases remobilization of assimilates from the straw to the grains [72,73]. The early senescence induced by a moderate water-deficit during grain filling can enhance the remobilization of stored assimilates and accelerate grain filling of rice [69,71].

Other experiences show that plants could cope with stress condition exhibiting morphological alteration such as root characteristic in which affect grain formation [74]. The slow grain-filling rate and low grain weight of inferior spikelets have often been attributed to a limitation in carbohydrate supply [69].

It's important to stress on the differential effects of the using of phytohormones or polyamines from the vegetative stage to the fruiting stage among the two selected maize genotypes. Exogenous application of any of the growth promoters "phytohormones and polyamines". Improved the drought tolerance of the two maize genotypes during vegetative stage through the improvement of phonological characteristics and the physiological behavior which consequently and interestingly induce a surprising improvement in the crop yield especially in *maize genotype Bashaier* (the drought tolerant cultivar), They produce a suitable amount of crop at the level of 30% F.C (the level which did not give any crop yield in plants subjected only to 30% F.C), also IAA is the only phytohormone which give a crop yield in *maize genotype Nefertiti* up to 50% F.C. Why the phytohormone did not give a crop yield in *maize genotype Nefertiti* beyond 70% F.C Although they improved Interactive Effects of Drought Stress and Phytohormones or Polyamines on Growth and Yield of Two M(Zea maize L) Genotypes.

The growth and the physiology of this cultivar during the vegetative stage and also why these phytohormones make this considerable improvement in crop yield only in *maize cv. Bashaier*? The answer seemed to be complicated which might associated with the genotypic variation rather than the growth activators it self which might indicated the great variation in the interaction between the response of the two maize genotypes with the different growth activators. The situation was very complicated and might include many physiological processes and also may be associated with induction of phlorogen and phytochrome (phytohormones responsible for flowering and fruiting stage). So, and according to our data in *maize genotype Nefertiti* the role played by these activators was differed from vegetative to flowering stage and the use of these activators only up to vegetative growth is not a sign for improving of crop yield. The diversity and complexity between the stress factors and gene action among the different species and genotypes as well as the different growth stages, still open question.

In conclusion maize genotype Nefertiti in addition to its sensitivity to drought stress, is also not responded enough to exogenous application of the used growth promoters especially phytohormones except for IAA to some extent. On the other hand the drought stressed maize genotype Bashaier was also strongly responded to phytohormones or polyamines treatments. Exogenous application of polyamines seemed to be more effective than phytohormones. Putrescine might be the superior polyamine. Finally and according to these results, this study opened many fields of studies in the future, this fields might linked with the breading programs (the con- trasting behaviors of the produced cultivars and lines), from one hand and the differential responses of the added plant promoters. Also it's difficult to recommend the role of any of these plant promoters before the flowering and fruiting stages.

REFERENCES

[1] J. B. Passioura, "Drought and Drought Tolerance," *Plant Growth Regulation*, Vol. 20, No. 2, 1996, pp. 79-83. doi:10.1007/BF00024003

[2] J. B. Passioura, "The Drought Environment: Physical, Biological and Agricultural Perspectives," *Journal of Experimental Botany*, Vol. 58, No. 2, 2007, pp. 113-117. doi:10.1093/jxb/erl212

[3] N. Isendahl and G. Schmidt, "Drought in the Mediterranean-WWF Policy Proposals," *A. WWF Report*, Madrid, 2006.

[4] F. M. Rhoads and J. M. Bennet, "Irrigation of Agricultural Crops," In: B. A. Stewart and D. R. Nielsen, Eds., *American Society of Agronomy*, *Agronomy Madison*30, *Crop Science Society of America and Soil Science Society of America*, 1991, pp. 569-596.

[5] R. K. Pandey, J. W. Maranville and A. Admou, "Deficit Irrigation and Nitrogen Effects on Maize in a Sahelian Environment," *Agriculture Water Management*, Vol. 46, No. 1, 2000, pp. 1-13. doi:10.1016/S0378-3774(00)00073-1

[6] R. Çakir, "Effect of Water Stress at Different Development Stages on Vegetative and Reproductive Growth of Corn," *Field Crops Research*, Vol. 89, No. 1, 2004, pp 1-6. doi:10.1016/j.fcr.2004.01.005

[7] S. B. Traore, R. E. Carlson, C. D. Pilcher and M. E. Rice, "Bt and Non-Bt Maize Growth and Development as Affected by Temperature and Drought Stress," *Agronomy Journal*, Vol. 92, No. 5, 2000, pp. 1027-1035. doi:10.2134/agronj2000.9251027x

[8] A. O. Jama and M. J. Ottman, "Timing of the First Irrigation in Corn and Water Stress Conditioning," *Agronomy Journal*, Vol. 85, No. 6, 1993, pp. 1159-1164. doi:10.2134/agronj1993.00021962008500060013x

[9] M. E. Otegui, F. H. Andrade and E. E. Suero, "Growth, Water Use and Kernel Abortion of Maize Subjected to Drought at Silking," *Field Crops Research*, Vol. 40, No, 2, 1995, pp. 87-94. doi:10.1016/0378-4290(94)00093-R

[10] O. T. Denmead and R. H. Shaw, "The Effects of Soil Moisture Stress at Different Stages of Growth on the Development and Yield of Corn," *Agronomy Journal*, Vol. 52, No. 5, 1960, pp. 272-274. doi:10.2134/agronj1960.00021962005200050010x

[11] E. C. Stegman, "Corn Grain Yield as Influenced by Timing of Evapotranspiration Deficits," *Irrigation Science*,

Vol. 3, No. 1, 1982, pp. 75-87. doi:10.1007/BF00264851

[12] S. M. Scheierling, G. E. Cardon and R. A. Young, "Impact of Irrigation Timing on Simulated Water-Crop Production Functions," *Irrigation Science*, Vol. 18, No. 1, 1997, pp. 23-31. doi:10.1007/s002710050041

[13] D. S. NeSmith and J. T. Ritchie, "Effects of Soil Water-Deficits during Tassel Emergence on Development and Yield Component of Maize (*Zea mays*)," *Field Crops Research*, Vol. 28, No. 3, 1992, pp. 251-256. doi:10.1016/0378-4290(92)90044-A

[14] D. S. NeSmith and J. T. Ritchie, "Maize (*Zea mays* L.) Response to a Severe Soil Water-Deficit during Grain Filling," *Field Crops Research*, Vol. 29, No. 1, 1992, pp. 23-35. doi:10.1016/0378-4290(92)90073-I

[15] F. R. Lamm, D. H. Rogers and H. L. Manges, "Irrigation Scheduling with Planned Soil Water Depletion," *T. ASAE*, Vol. 37, No. 5, 1994, pp. 1491-1497.

[16] M. A. Walker and B. Dumbroff, "Effect of Salt Stress on Abscisic and Cytokinin Levels," *Zeitschrift für Pflanzen Physiologie*, Vol. 101, 1981, p. 661.

[17] M. A. Hamdia, "The Counteraction Effect of GA3 or IAA with Endogenous Ethylene of Wheat Plants under Salt Stress Conditions," *Sixth Egyptian Botanical Conference Cairo University*, No. 1, 1998, pp. 97-110.

[18] C. Kaya, A. L. Tuna and I. Yokas, "The Role of Plant Hormones in Plants under Salinity Stress," *Book Salinity and Water Stress*, Vol. 44, No. 1, 2009, pp. 45-50. doi:10.1007/978-1-4020-9065-3_5

[19] P. J. Davies, "The Plant Hormones: Their Nature, Occurrence and Function," In: P. J. Davies, Eds., *Plant Hormones*, *Biosynthesis*, *Signal Transduction*, *Action*, Kluwer, Dordrecht, 2004.

[20] J. H. Liu, H. Kitashiba, J. Wang, Y. Ban and T. Moriguchi, "Polyamines and Their Ability to Provide Environmental Stress Tolerance to Plants," *Plant Biotechnology*, Vol. 24, No. 12, 2007, pp. 117-126.

[21] T. Kusano, T. Berberich, C. Tateda and Y. Takahashi, "Polyamines: Essential Factors for Growth and Survival," *Planta*, Vol. 228, No. 3, 2008, pp. 367-381. doi:10.1007/s00425-008-0772-7

[22] R. M. Ali, "Role of Putrescine in Salt Tolerance of Atropa Belladonna Plant," *Plant Science*, Vol. 52, No. 2, 2000, pp. 173-179. doi:10.1016/S0168-9452(99)00227-7

[23] H. Nayyar, S. Kaur, S. S. Kumar, K. J. Singh and K. K. Dhir, "Involvement of Polyamines in the Contrasting Sensitivity of Chickpea (*Cicer arietinum* L.) and Soybean (*Glycine max* (L.)," *Botanical Bulletin Academia Sinica*, Vol. 46, No. 4, 2005, pp. 333-338.

[24] J. Yang, J. Zhang, K. Liu, Z. Wang and L. Liu, "Involvement of Polyamines in the Drought Resistance of Rice," *Journal of Experimental Botany*, Vol. 58, No. 6, 2007, pp. 1545-1555. doi:10.1093/jxb/erm032

[25] M. Farooq, S. M. A. Basra, M. H. Rehman and B. A. Saleem, "Incorporation of Polyamines in the Priming Media Enhances the Germination and Early Seedling Growth in Hybrid Sunflower (*Helianthus annuus* L.)," *International Journal of Agricultural Biology*, Vol. 9, No. 6, 2007, pp. 868-872.

[26] M. A. K. Shaddad, M. A. Hamdia and H. T. Mohammed, "Drought Tolerance of Some *Zea mays* L. Genotypes at the Early Growth Stage," *Assiut University Journal of Botany*, Vol. 38, No. 2, 2009, pp. 135-147.

[27] M. J. Roberts, S. P. Long, L. L. Tieszen and C. L. Beadle, "Measurement of Plant Biomass and Net Production of Herbaceous Vegetation," In: D. O. Hall, J. M. Scurlock, H. R. Bolhar-Nordenkampf, R. C. Leegoood and S. P. Long, Eds., *Photosynthesis and Production in a Changing Environment*, Chapman & Hall, London, 1993, pp. 1-21. doi:10.1007/978-94-011-1566-7_1

[28] G. W. McKee, "A Coefficient for Computing Leaf Area in Hybrid Corn," *Agronomy Journal*, Vol. 56, 1964, pp. 240-241.

[29] R. Bonhomme, M. Varlet, C. Grancher and P. Chartier, "The Use of Hemispherical Photographs for Determining Leaf Area Index of Young Crops," *Photosynthetica*, Vol. 8, No. 3, 1974, pp. 299-301.

[30] J. M. Norman and G. S. Campbell, "Canopy Structure," In: R. W. Pearcy, J. Ehleringer, H. A. Moony and P. W. Rundel, Eds., *Plant Physiological Ecology*, Chapman & Hall, London, 1994, pp. 301-326,.

[31] H. Metzner, H. Rauand and H. Senger, "Untersuchungen Zur Synchronsiserbakeit Einzelner Pigment-Mangel Mutanten von Chlorella," *Planta*, Vol. 65, No. 2, 1996, pp. 86-194.

[32] D. Schwarzenbach and H. Biederman, "Komplexone X-Erdoliukomplex von 0, 0-Diazofarbstoffen," *Helvetia Chemica Acta*, Vol. 31, No. 3, 1948, pp. 678-687. doi:10.1002/hlca.19480310303

[33] R. G. Steel and J. H. Torrie, "Principles and Procedures of Statistics," McGraw-Hill Book Co., New York, 1960.

[34] R. Munns, D. P. Szhachtmanand and A. G. Condon, "The Significance of Two-Phase Growth Response to Salinity in Wheat and Barley," *Austrian Journal Plant Physiology*, Vol. 22, No. 4, 1995, pp. 561-569. doi:10.1071/PP9950561

[35] J. Salter, K. Morris, P. C. E. Bailey and P. I. Boon, "Interactive Effects of Salinity and Water Depth on the Growth of Melaleuca Ericifolia Sm. (*Swamp Paper Bark*) Seedlings," *Aquetic Botany*, Vol. 86, No. 3, 2007, pp. 213-222. doi:10.1016/j.aquabot.2006.10.002

[36] A. L. Saleh, M. M. Hussien, S. Y. El-Faham, M. S. Abo-El-Kier and A. A. Abd-El-Kader, "Mineral Status in Barley Grains as Affected by Benzyladenine and Salinity," *Thailand 17th WCSS*, Bangkok, 14-21 August 2002, pp. 14-21.

[37] M. E. Younis, O. A. Shahaby, S. A. Abo-Hamed and A. H. Ibrahim, "Effects of Water on Growth, Pigments and 14 CO_2: Assimilation in Three Sorghum Cultivars," *Journal of Agronomy and Crop Science*, Vol. 10, No. 2, 2000, pp. 918-924.

[38] Z. Zhu, G. Wei, J. Li, Q. Qian and J. Yu, "Silicon Alleviates Salt Stress and Increases Antioxidant Enzymes Activity in Leaves of Salt—Stressed Cucumber (*Cucumis sativus* L.)," *Plant Science*, Vol. 167, No. 3, 2004, pp. 527-533. doi:10.1016/j.plantsci.2004.04.020

[39] M. H. Baek, J. H. Kim, B. Y. Chung, J. S. Kim and I. S. Lee, "Alleviation of Salt Stress by Low Dose-Irradiation in Rice," *Biologia Planarum*, Vol. 49, No. 2, 2005, pp. 273-276. doi:10.1007/s10535-005-3276-3

[40] F. C. Meinzer, J. H. Fownes and R. A. Harrington, "Growth Indices and Stomatal Control of Transpiration in Acacia Koa Stands Planted at Different Densities," *Tree Physiology*, Vol. 16, No. 7, 1996, pp. 607-615.

[41] J. M. Ribaut and P. E. Pilet, "Effect of Water Stress on the Growth, the Osmotic Potential and Abscisic Acid Content of Maize Roots," *Physiologia Plantarum*, Vol. 81, No. 2, 1991, pp. 156-162. doi:10.1111/j.1399-3054.1991.tb02123.x

[42] M. Bracale, M. L. Christian-Sauini, W. Dicordo and M. Grazia-Galli, "Water Deficit in Pea Root Tips: Effect on the Cell Cycle and on the Production of Dehydrin-Like Protein," *Annual Botany*, Vol. 6, No. 2, 1997, pp. 593-600. doi:10.1006/anbo.1996.0356

[43] R. Munns, H. Greenway, R. Delane and J. Gibbs, "Ion Concentration and Carbohydrate Status of the Elongation Leaf Tissue of Hordeum Vulgaris Growing at High External NaCl. II-Cause of the Growth Reduction," *Journal of Experimental Botany*, Vol. 33, No. 4, 1982, pp. 574-583. doi:10.1093/jxb/33.4.574

[44] M. Drew, C. Guenther and T. Läuchi, "The Combined Effect of Salinity and Root Anoxia on Growth and Net Na^+ and K^+ Accumulation in Zea Mays Grown in Solution Culture," *Annal of Botany*, Vol. 61, No. 1, 1988, pp. 41-53.

[45] S. H. Shah, "Effects of Salt Stress on Mustard as Affected by Gibberellic Acid Application," *General Appied Plant Physiology*, Vol. 33, No. 1-2, 2007, pp. 97-106.

[46] E. A. Dorgham, "Effect of Water Stress, Irradiation and Nitrogen Fertilization on Grain Filling, Yield and Quality of Certain Wheat Cultivars," Ph. D. Thesis, Ain Shams University of Cairo, Cairo, 1991.

[47] L. Bernstein, A. Laüchli and W. K. Silk, "Kinematics and Dynamics of Sorghum (*Sorghum bicolor* L.) Leaf Development at Various Na^+/Ca^{++} Salinities," *Plant Physiology*, Vol. 103, No. 2, 1993, pp. 1107-1114.

[48] R. Munns, "Physiological Process Limiting Plant Growth in Saline Soils: Some Damage and Hypotheses," *Plant Cell Environmental*, Vol. 16, No. 1, 1993, pp. 15-24. doi:10.1111/j.1365-3040.1993.tb00840.x

[49] M. Nabil and A. Coudret, "Effects of Sodium Chloride on Growth, Tissue Elasticity and Solute Adjustment in Two *Acacia Nilotica* Subspecies," *Physiologia Plantarum*, Vol. 93, No. 2, 1995, pp. 217-224. doi:10.1111/j.1399-3054.1995.tb02220.x

[50] R. Munns and S. Termaut, "Whole-Plant Response to Salinity," *Austrian Journal Plant Physiology*, Vol. 13, No. 1, 1986, pp.143-160. doi:10.1071/PP9860143

[51] S. K. Yadav, N. J. Lakshmi, M. Maheswari, M. Vanaja and B. Venkateswarlu, "Influence of Water Deficit at Vegetative, Anthesis and Grain Filling Stages on Water Relation and Grain Yield in Sorghum," *Indian Journal of Plant Physiology*, Vol. 10, No. 1, 2005, pp. 20-24.

[52] A. R. Reddy, K. V. Chaitanya and M. Vivekanandan, "Drought Induced Responses of Photosynthesis and Antioxidant Metabolism in Higher Plants," *Journal Plant Physiology*, Vol. 161, No. 11, 2004, pp. 1189-1202. doi:10.1016/j.jplph.2004.01.013

[53] M. A. Shaddad and M. A. El-Tayeb, "Interactive Effects of Soil Moisture Content and Hormonal Treatment on Dry Matter and Pigment Contents of Some Crop Plants," *Acta. Agronomica*, Vol. 39, No. 1-2, 1989, pp. 49-57.

[54] M. A. K. Shaddad, H. M. Abd-ElSamad and M. M. Ragaey, "Drought Tolerance of Wheat Genotypes at the Early Vegetative Stage," *Assiut University Journal of Botany*, Vol. 37, No. 2, 2008, pp. 15-32

[55] A. H. Ibrahim and H. S. Aldesuquy, "Glycine Betaine and Shikimic Acid-Induced Modification in Growth Criteria, Water Relation and Productivity of Droughted Sorghum Bicolor Plants," *Phyton* (*Horn*, *Austria*), Vol. 43, No. 2, 2003, pp. 351-363.

[56] U. A. A. Radwan, "Plant Water Relations, Stomatal Behavior, Photosynthetic Pigments and Anatomical Characteristics of *Solenostemma arghel* (Del.) Hayne under Hyperarid Environmental Conditions," *American-Eurasian Journal of Scientific Research*, Vol. 2, No. 2, 2000, pp. 80-92.

[57] S. Majumdar, S. Ghosh, B. R. Glick and E. B. Dumbroff, "Activities of Chlorophyllase, Phosphoenolpyruvate Carboxylase and Ribulose 1,5-biphosphate Carboxylase in Primary Leaves of Soybean during Senescence and Drought," *Physiologia Plantarum*, Vol. 81, No. 4, 1991, pp. 473-480. doi:10.1111/j.1399-3054.1991.tb05087.x

[58] S. Kulshreshtha, D. P. Mishra and R. K. Gupta, "Changes in Contents of Chlorophyll, Proteins and Lipids in Whole Chloroplast Membrane Fractions at Different Leaf Water Potentials in Drought Resistant and Sensitive Genotypes of Wheat," *Photothenthetica*, Vol. 21, 1987, pp. 65-70.

[59] M. M. Chaves, "Effects of Water Deficits on Carbon Assimilation," *Journal of Experimentsl Botany*, Vol. 42, No. 1, 1991, pp. 1-16.

[60] M. Drazkiewicz, "Chlorophyllase: Occurrence, Functions, Mechanism of Action, Effects of External and Internal Factors," *Photosynthetica*, Vol. 30, No. 3, 1994, pp. 321-331. doi:10.1093/jxb/42.1.1

[61] G. R. Sun, Y. Z. Peng, H. B. Shao and L. Y. Chu, "Does *Puccinelia tenuiflora* Have the Ability of Salt Exudation?" *Colloids and Surfaces B*: *Biointerfaces*, Vol. 46, No. 4, 2005, pp. 197-203. doi:10.1016/j.colsurfb.2005.11.003

[62] H. B. Shao, M. A. Shao and Z. S. Liang, "Osmotic Adjustment Comparison of 10 Wheat (*Triticum aestivum* L.) Genotypes at Soil Water Deficits," *Colloids and Surfaces*

B: *Biointerfaces*, Vol. 47, No. 2, 2006, pp. 132-139. doi:10.1016/j.colsurfb.2005.11.028

[63] Y. Tan, Z. S. Liang and H. B. Shao, "Effect of Water Deficits on the Activity of Anti-Oxidative Enzymes and Osmoregulation among 3 Different Genotypes of Radix Astragali at Seeding Stage," *Colloids and Surfaces B*: *Biointerfaces*, Vol. 49, No. 1, 2006, pp. 60-65. doi:10.1016/j.colsurfb.2006.02.014

[64] X. A. Liu and D. R. Bush, "Expression and Transcriptional Regulation of Amino Acid Transporters in Plants," *Amino Acids*, Vol. 30, No. 2, 2006, pp. 113-120. doi:10.1007/s00726-005-0248-z

[65] P. D. R. Van Heerden and R. Laurie, "Effects of Prolonged Restriction in Water Supply on Photosynthesis, Shoot Development and Storage Root Yield in Sweet Potato," *Physiologia Plantarum*, Vol. 134, No. 1, 2008, pp. 99-109. doi:10.1111/j.1399-3054.2008.01111.x

[66] K. Liu, Y. Ye, C. Tang, Z. Wang and J. Yang, "Responses of Ethylene and ACC in Rice Grains to Soil Moisture and Their Relations to Grain Filling," *Frontiers of Agriculture in China*, Vol. 2, No. 2, 2008, pp. 172-180. doi:10.1007/s11703-008-0008-4

[67] Y. Katoa, A. Kamoshitab and J. Yamagishia, "Preflowering Abortion Reduces Spikelet Number in Upland Rice (*Oryza sativa* L.) under Water Stress," *Crop Science Society of America*, Vol. 48, No. 6, 2008, pp. 2389-2395.

[68] E. S. Ober, J. T. Setter and J. F. Madison and P. S. Shapiro, "Influence of Water Deficit on Maize Endosperm Development. Enzyme Activities and RNA Transcripts of Starch and Zein Synthesis, Abscisic Acid and Cell Division," *Plant Physiology*, Vol. 95, No. 1, 1991, pp. 154-164. doi:10.1104/pp.97.1.154

[69] J. Yang, J. Zhang, Z. Wang, K. Liu and P. Wang, "Post-anthesis Development of Inferior and Superior Spikelets in Rice in Relation to Abscisic Acid and Ethylene," *Journal of Experimental Botany*, Vol. 57, No. 1, 2006, pp. 149-160. doi:10.1093/jxb/erj018

[70] N. Sunderland, "Cell Division and Expansion in Growth of the Leaf," *Journal of Experiment Botany*, Vol. 11, No. 1, 1960, pp. 68-80. doi:10.1093/jxb/11.1.68

[71] Z. Z. Xu and G. S. Zhou, "Photosynthetic Recovery of a Perennial Grass *Leymus chinesis* After Different Periods of Soil Drought," *Plant Production Science*, Vol. 10, No. 3, 2007, pp. 277-285. doi:10.1626/pps.10.277

[72] S. Asseng and A. F. van Herwaarden, "Analysis of the Benefits to Wheat Yield from Assimilates Stored Prior to Grain Filling in a Range of Environments," *Plant and Soil*, Vol. 256, No. 1, 2000, pp. 3217-3219.

[73] Z. Plaut, B. J. Butow and C. S. Blumenthal, "Transport of Dry Matter into Developing Wheat Kernels and Its Contribution to Grain Yield under Post-Anthesis Water Deficit and Elevated Temperature," *Field Crops Research*, Vol. 86, No. 2-3, 2004, pp. 185-198. doi:10.1016/j.fcr.2003.08.005

[74] A. Mostajeran and V. Rahimi-Eichi, "Drought Stress Effects on Root Anatomical Characteristics of Rice Cultivars (*Oryza sativa* L.)," *Pakistan Journal of Biological Science*, Vol. 11, No. 18, 2008, pp. 2173-2183. doi:10.3923/pjbs.2008.2173.2183

