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RESPONSE OF MAIZE PLANT TO SOIL MOISTURE STRESS AND FOLIAR SPRAY WITH POTASSIUM

Abdel – Aziz, El – Set A.* and U. S. El – Bialy **

* Crops physiology Res. Sec., Field Crops Res. Inst., ARC.Giza, Egypt.

** Physics and Chemistry of Soil Res. Dep., Soil, Water and Env. Res. Inst., ARC. Giza, Egypt.

ABSTRACT

Foliar application of potassium and soil moisture stress were evaluated through two successive field experiments during growing seasons of 2001 and 2002 at Giza Agricultural Research Station, A. R. C. To verify this objective , maize (Zea mays) , single cross (S.C.10) cultivar was grown and treated with potassium fertilizer at concentrations of 0 , 2 and 3 % K_2O as foliar application under three conditions of soil moisture content expressed as depletion in available soil moisture namely wet (35– 40 %), medium (55 – 60 %) and dry (75 – 80 %), depletion in A.S. M. Results of the combined analysis could be summarized as follows:

1- Plant height and stem diameter of the plant were significantly increased under wet treatment followed by those under medium and dry ones. The same parameters showed gradual and significant increase with raising the concentration of K_2O from 0 to 3 % . However; the interaction between the two factors was insignificant as well.

2- All growth parameters i.e, leaf area index (LAI), net assimilation rate (NAR) and crop growth rate (CGR) at all growth stages were significantly higher under wet treatment than those under the other soil moisture stress levels.

3- LAI at all growth stages and NAR at the last period of growth (80-90 days after sowing, DAS) were significantly increased with the gradual increase of K_2O up to 3%, while vice versa was observed at 35-50 DAS. At the period of 65-80 DAS, NAR was the highest and significant with 2% K_2O. CGR at all growth stages was significantly increased with increasing K_2O level.

4- The significant effect of the interaction between moisture stress and K spray was pronounced for NAR, CGR and LAI at 50-65 and 80-90 and 35-50 DAS periods, respectively.

5- All yield attributes of maize plant were significantly and gradually increased as a result of raising the availability of soil moisture content and the level of K_2O up to 3%. The exception is shelling% which didn't affect with spraying K_2O. However, no significant effect could be noteced due to the interaction between the two factors under study on all yield parameters.

6-There was gradual and significant increase of maize productivity as a result of the reduction in soil moisture depletion. The same response was observed for raising K-level. However, the interaction caused insignificant effect on grain and stover yields. .

7- Higher protein content of maize grains was gained under condition or severe in soil moisture content. Spraying maize plants with water (0% K_2O) caused the highest protein content and the interaction between the above two treatments was the best. Total carbohydrates content of the grains showed a reverse trend for main and the interaction effects.

9-The highest mean values of water consumptive use during growing season were recorded when maize plants sprayed with the highest level of K_2O (3%) under wet treatment. Whereas, water use efficiency (kg/m^3) reached its highest value at medium soil moisture stress with potassium nutrition.

From the economic point of view and consider to the crop productivity, interaction between medium water stress (55- 60% depletion in A.S.M.) and spraying with 3 % K_2O treatment is considered the best compared to the other treatments under study.

INTRODUCTION

In Egypt, maize (Zea mays L.) is considered as one of the most adopted cereal crops to water and nutrient deficiencies. The ecological importance of water is the results of its physiological role in plant growth. Water is a biotic for life in both the biochemical and biophysical synthesis and its influences are both internal and environmental. Much attention has been focused on the effects of water deficit on primary and secondary products of the plant. Thus scheduling irrigation for maize plant may improve its production either per unit area or per unit of consumed water. El – Nomany *et al.* (1990) reported that exposed maize plants to water stress (irrigation every 18 days instead of 12 days) decreased significantly plant height, ear length , ear diameter , ear weight , number of grain/ row, number of rows / ear , 1000 grains weight , grain and straw yields as well as shelling percentage. Mahrous (1991) reported that increasing irrigation intervals up to 35 days significantly decreased plant height and grain yield / fed. of maize plants. Ibrahim *et al.* (1992) found that leaf area/plant and grain (ard / fed.) of maize plant were significantly increased with the decrease in irrigation period. Anton and Ahmed (2001) concluded that protein content of barley grain was increased, whereas total carbohydrates content decreased under dry condition or severe soil moisture stress (80 – 85%. A. S. M.)

Potassium is one of the essential elements in plant nutrition and in the case of insufficient soil supply, it could be a negative affects on plant growth. There is a great need to add such element regularly as a fertilizer for imporving crop yield. Crops that store carbohydrates like maize need an ample supplies of potassium for good production. Foliar application of potassium has attracted considerable attention in recent years because it ensures, the quick and adequate K – supply for plants at the time of yield formation to improve its productivity. Beringeer (1980) reported that grain yield of wheat increased with increasing potassium supply. Montanee (1989) and Suwanerit and Sestopukdee (1989) concluded that a single foliar K – application on any day between the 50% tasselling date and days later increased yields and sweetness of supersweet corn. Oosterhuis *et al.* (1990) reported that cotton plant receiving both soil and foliar applied – K or foliar applied – K alone gave higher seed yields than control. El – Habbasha *et al.* (1996) stated that treating pea plants by foliar application of K resulted in an increase in the yield.

It has been mentioned that potassium application plays an important role in plant grown under water deficit. Welch and Flannery (1985) reported that increasing potassium supply increased water use efficiency of corn plants. Abu-Grab and Sanna (1999) mentioned that potassium was more important of stressed corn plants than well – irrigation ones.

The present investigation is carried out to study the effect of water regime in combination with different levels of foliar of potassium on growth, yield, some yield attributes, some chemical analysis of grains and water relations i.e- water consumptive use and water use efficiency of maize plants.

MATERIALS AND METHODS

The present work was carried out during the two successive seasons namely 2001 and 2002 at Giza Agriculture Research Station, A. R. C. to study the effect of soil moisture stress in combination with different levels of foliar spray of potassium fertilizer on some characters of maize cultivar single cross (S. C. 10). The experiment was laid out in a split plot design with four replicates. The main plots were occupied by soil moisture levels, while sub – plots contained foliar spray with potassium fertilizer. Each sub – plot was 1/200 feddan (6 x 3.5 m2) and included 5 rows, each 6 m long and 70 cm apart. To avoid the interference between irrigation treatments, 1.5 meter beds were left among the experimental plots. The average values for the physical and chemical analysis for experimental soil site during the two growing seasons are presented in Tables (1).

Table (1): Some physical and chemical properties of the experimental site of Giza Res. Farm

Seasons	Particle size distribution				Texture class	O.M. %	pH (1:2.5)	EC soil paste extract ds/m	Available nutrients (ppm)		
	Coarse sand %	Fine sand %	Silt %	Clay %					N	P	K
2001	3.41	28.40	30.39	37.8	Clay loam	1.5	7.6	0.62	50	24	441
2002	3.22	27.13	31.30	36 72	Clay loam	1.4	7.4	0.68	52	21	430

The treatments are as follows:

I - Main plots (soil moisture level):

A– Irrigation when 35 – 40 % of available soil moisture (A. S. M.) was depleted (designated as wet).

B– Irrigation when 55 – 60 % of available soil moisture (A. S. M.) was depleted (designated as medium).

C- Irrigation when 75 – 80 % of available soil moisture (A.S.M.) was depleted (designated as dry).

II – Sub – plots (K- fertilizer levels).

1 – Spraying with water (control)

2- Spraying with 2 % K_2O – solution.

3 - Spraying with 3 % K_2O – solution.

Maize grains were planted on 15 / 5 and 20 / 5 in the first and second seasons, respectively in hills spaced 25 cm – Phosphatic fertilizer in the form of calcium superphosphate (15.5% P_2O_5) at the rate of 200 Kg / fed. was added before planting – Nitrogen fertilizer in the form of ammonium nitrate (33.5 % N) was applied to each sub – plot at the rate of 120 Kg N /

fed. in two equal doses, the first was given before life watering (21 days after sowing) and the second was added before the second irrigation. Potassium fertilizer was sprayed two times at 21 and 35 days after sowing, the volume of water was 400 L / fed. Tween 20 was used as wetting agent at the concentration of 50%. Cultural practices were completed according to usual methods being adopted for maize plant. Irrigation treatments started after maize plants received the life watering (21 days after sowing).

Growth Analysis: -

For growth analysis random samples, each of five plants were taken from the rows of the four replications. The sampling dates were 35 , 50 , 65 , 80 and 95 days after sowing. In each sampling date, plants were separated into their components i.e root, leaves, stems,, tassels and ears plus husks. Plant parts were dried in a ventilated oven to the constant weight for 24 hours at 90 C ° to determine the following characters :-

1- Leaf area index (L. A. I.)
2- Net Assimilation Rate (N. A. R.) (gm /dm^2 / week)
3- Crop Growth Rate (C. G. R.) (gm / week)

The following formulae were used to computerize such characters according to (Watson 1952).

LAI = Unit leaf area /unit ground area .

NAR = $(W_2 - W_1)$ (loge A_2 – loge A_1) / ($A_2 - A_1$) ($t_2 - t_1$).

CGR = $W_2 - W_1$ / ($t_2 - t_1$).

Where W_1 ,A_1 and W_2 , A_2 refer to dry weight of the whole plant and leaf area at time t_1 and t_2 in weeks, respectively.

Harvesting took place on 9 / 9 and 12 / 9 in the frist and secand seasons, respectively.

At harvest time, five individual guarded plants were randomly taken from the other sub – plots of the four replecation to determine the following characters:-

1 – plant height (cm)
2 – stem diameter (cm)
3 – Ear length (cm)
4 – Ear diameter (cm)
5 – Number of ear / rows)
7 – Ear grain weight (gm)
8 – shelling percentage
9 – 100 – grain weigh (gm)

Yield data i.e. grain yield and stover yield (ton/fed.) were obtained and calculated from a central area of each sub – plot to avoid any border effect.

Mature grains of the second season were subjected to chemical analysis for the determination of :-

a – Grain protein percentage according to A. O. A. A. C. (1975).
b – Total carbohydrates percentage as glucose%according to Dubois *et al.* (1956).

Water Relations:-

A – Water consumptive use (W.C.U.)

Soil samples were taken with a regular auger at planting time, just before and after 48 hours of each irrigation and at harvest time for soil moisture determination. Irrigation water was applied when the moisture content reached the desired available soil moisture in each treatment At each sampling date, duplicate soil samples were taken from 0 – 15 , 15 – 30 , 30 – 45 and 45 – 60 cm depths and their moisture contents were determined gravimetrically. Field capacity, bulk density were determined for the experimental site and recorded in Table (2).

Table (2) Soil moisture constants of the experimental site.

Soil depth Cm	Bulk density g/cm^3	Field Capacity %	Wilting point %	Available Moisture %
0 –15	1.15	35 . 80	17 . 74	18.06
15 – 30	1.22	31 . 12	16 . 66	14.46
30 – 45	1.20	29 . 92	16 . 31	13.61
45 - 60	1.28	27 . 94	15 . 97	11.97

The depleted soil moisture was detected after each irrigation and the following equation was used in calculating water consumptive use as follows according to (Israelsen and Hansen, 1962):

$cu = D \times Bd \times (e_2 - e_1) / 100$

Where:-

Cu = water consumptive use (ET) in mm.

D = soil depth (cm).

Bd = Bulk density in g / cm^3 .

e_1 , e_2 = soil moisture content before and after each irrigation.

B – Water Use Efficiency (W. U. E): -

Water use efficiency was calculated for each treatment according to the following equation: -

W.U.E.= grain yield kg/ fed./seasonal water consumption m^3/fed.

Data of the two seasons were combined and statistically analyzed according to Steel and Torrie (1980).

The discussion of the results were carried out on the basis of combined analysis for the two seasons.

RESULTES AND DISCCSSTION

I – Maize Growth :-

a – Growth measurements :-

Results of Table (3) show the effect of soil moisture stress and foliar application of potassium fertilizer on growth of maize expressed as plant height and stem diameter. Statistical analysis indicates that both factors had a significant effect on the measured growth characters of maize. The highest values of plant height and stem diameter were obtained from the wet treatment which was watered at 35 – 40 % depletion in available soil moisture (A.S.M.) followed by the medium soil one i.e. irrigation at 55 – 60 % depletion in A.S.M.. However, the lowest values were gained from severe water deficit or those plots irrigated at 75-80 % depletion in A.S.M.These results reveal that increasing soil moisture stress did decrease plant height and stem diameter. Also, these findings indicate that increasing available moisture level enhanced the growth of maize plants and increased the plant height and stem diameter. in other words soil moisture content accompanied by such irrigation intervals might control the elongation of the above ground part of the plant. In this respect, Slatyer (1973) concluded that the growth and development of plants depend upon continuous cell division, in differentiation and enlargement of cells. Noureldein *et al.* (1986) reported that the reduction in plant height of maize plants exposed to stress conditions might be due to the reduction in internode lenght.

As for the foliar application effect of potassium on growth of maize, results of combined analysis in Table (3) indicate that applying foliar spray of K on maize generally resulted in a significant increase in plant height and stem diameter. Such characters increased gradually with raising potassium levels from 0 up to 3 % K_2O.These results are in line with those reported by Anton and Ahmed (2001) who found that spraying barley plants with 2 % K_2O increased significantly plant height .

Data of Table (3) show that the interaction between soil moisture stress and potassium levels was found to be insignificant for plant height and stem diameter. However, the maximum values of plant height and stem diameter were gained from irrigation treatment at 35 – 40 % depletion in available soil moisture and sprayed with 3 % K_2O.

b- Growth analysis:-

1 – leaf area index (L.A.I.):

Data of Table (3) show that leaf area index (L.A.I.) increased by advancing age up to 80 days after sowing. This is mainly due to the production of new leaves as well as leaves expansion through the growth of maize plant. Whereas (L.A.I.) decreased slightly at 95 days after sowing. Such decrease may be due to the drying or/ and failing of some maize leaves. Leaf area index was significantly affected by soil moisture stress and foliar spray with potassium at different stages of maize growth i.e. 35, 50, 65, 80 and 95 days after sowing. The wet treatment had the highest values of L.A.I. followed by medium one at different stages of growth under study .However , the dry soil moisture level gave the lowest values of leaf area index at different growth stages. The differences between results gained from the wet treatment and the two other soil moisture stress levels i.e. medium and dry ones were found to be significant at all tested growth stages. This reduction may be due to the reduction in leaf area and number of leaves/plant. These results are in harmony with those obtained by Osman *et al.* (1989) and Hefni and El-Shabbagh (1993).

Regarding the effect of foliar spray with potassium fertilizer, results of combined analysis in Table (3) indicate that spraying K on maize plants resulted in a significant increase on L.A.I. at all growth stages Such character was increased gradually with raising potassium levels from 0 up to 3 % K_2O which recorded the maximum value. These results are in line with those reported by Kandil *et al.* (1984) who found that increasing K_2O to the higher rate i.e. 20 Kg K_2O / fed. increased leaf area of maize plant.

Data of Table (3) show that the interaction between soil moisture stress and potassium levels on L.A.I. was found to be significant on the first stage i. e. 35 days A.S. . Whereas the other stages i e 50 ,65, 80 and 95 days A S. recorded insignificant effect .The maximum values of L.A.I. at different stages of growth were obtained from treatment irrigated at 35 – 40 % depletion in available soil water and sprayed with 3 % K_2O .

2 – Net Assimilation Rate (N.A.R.).

From Table (4), it was observed that there were significant difference in NAR distinguished among the three ASMD levels at all growth periods. The dry treatment provided significantly higher NAR at (35 – 50 D.A.S.) than wet treatment, with insignificant effect compared with medium one. Such results could be attributed to that the accumulation of dry matter or photosynthesiate compounds seemed to be more in proportion to leaf area. In other words, when plants exposed to dry treatment , leaf area of maize plants decreased less than the increase in dry matter accumulation at (35 – 50 D.A.S.) . However, at (50 – 65 days A.S.) NAR was significantly lower in case of water stress (75 – 80 % ASMD) compared to (35 – 40 % and (55 – 60 %) i.e. wet and medium treatments, respectively. Later on , at 65 – 80 and 80 – 95 D.A.S. the value of NAR at dry treatment also decreased significantly compared with wet treatment with insignificant effect with medium one. In this connection, Hefni and El-Shabbagh (1993) found that NAR of maize plant decreased by increasing available soil moisture depletion up to 80%.

Concerning the effect of potassium fertilizer on NAR of maize plants, data in Table (4) indicate that NAR decreased significantly and gradually at 35 – 50 and 50 – 65 DAS with increasing K_2O levels from 0 up to 3% K_2O. Such results could be due to the role of potassium in plant growth which reflected on increasing leaf area in proportion to dry matter accumulation Whereas, at 65-80 DAS, NAR increased significantly when maize plant sprayed with 2% K_2O compared with 0 or 3 % K2o treatments. At last period of growth i.e 80-95 DAS, NAR increased significantly with raising potassium levels up to 3 % K_2O.

Data of Table (4) show that the interaction between soil moisture stress and potassium levels on NAR was found to be significant at 50-65 and 80-95 DAS. Whereas, there was insignificant effect at 35 – 50 and 65 – 80 DAS. The maximum value of NAR was varied according to the period of growth i.e 35 – 50 or 50 – 65 or 65 – 80 or 80 – 95 D.A.S.

3 – Crop Growth Rate (C.G.R.)

Table (5) shows C.G.R. of maize plants as affected by water stress and foliar spray with K.It is clear that the differences in C.G.R. among the levels of available soil moisture depletion were significant at all growth periods.

Table (3): Effect of soil moisture stress and foliar spray with potassium on some growth characters of maize during two growing seasons and combined analysis .

Irrigation levels	K-foliar spray	Plant height (cm)			Stem diameter (cm)			Leaf area index (L.A.I)														
								35 days A.S.			50 days A.S.			65 days A.S.			80 days A.S.			95 days A.S.		
		2001	2002	Comb.	2001	2002	Comb	2001	2002	Comb	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.
(35-40) % depletion in A.S.M (wet)	0	189.51	202.15	195.83	3.32	3.54	3.43	1.20	0.98	1.09	1.78	1.98	1.88	2.88	2.82	2.85	3.58	3.69	3.64	3.31	3.05	3.18
	2	205.70	220.30	213.00	3.95	4.10	4.03	1.31	1.25	1.28	2.26	2.32	2.29	3.16	3.12	3.14	3.92	3.93	3.93	3.76	3.41	3.59
	3	219.33	231.92	225.63	4.15	4.38	4.27	1.41	1.63	1.52	2.55	2.73	2.64	3.33	3.59	3.46	4.07	4.15	4.11	4.08	3.76	3.92
Mean		204.85	218.12	211.49	3.81	4.01	3.91	1.31	1.29	1.30	2.20	2.34	2.27	3.12	3.17	3.15	3.86	3.92	3.89	3.71	3.41	3.56
(55-60) % depletion in A.S.M (medium)	0	173.60	190.12	181.86	3.08	3.16	3.12	0.71	0.71	0.71	1.69	1.72	1.71	2.36	2.30	2.33	2.90	2.86	2.88	2.72	2.61	2.67
	2	190.73	203.85	197.29	3.34	3.53	3.44	0.95	1.05	1.00	2.01	2.08	2.05	2.60	2.77	2.69	3.34	3.13	3.24	3.00	2.83	2.92
	3	210.35	216.51	213.43	3.82	4.02	3.92	1.16	1.41	1.29	2.21	2.39	2.30	2.85	3.05	2.95	3.35	3.55	3.45	3.35	3.37	3.36
Mean		191.56	203.49	197.53	3.41	3.57	3.49	0.94	1.05	1.00	1.97	2.06	2.02	2.60	2.70	2.66	3.20	3.18	3.19	3.02	2.94	2.98
(75-80) % depletion in A.S.M (dry)	0	160.21	175.88	168.05	2.07	2.11	2.09	0.65	0.60	0.63	1.30	1.36	1.33	1.98	1.85	1.92	2.50	2.55	2.53	2.22	2.18	2.20
	2	179.13	185.33	182.23	2.40	2.59	2.50	0.81	0.87	0.84	1.62	1.71	1.67	2.18	2.28	2.23	2.84	2.78	2.81	2.59	2.60	2.60
	3	189.25	196.12	192.64	2.73	2.88	2.81	1.05	1.17	1.11	1.95	2.09	2.02	2.38	2.60	2.49	3.28	3.04	3.16	2.95	2.96	2.96
Mean		176.20	185.78	180.99	2.40	2.53	2.47	0.84	0.88	0.86	1.63	1.72	1.67	2.18	2.24	2.21	2.87	2.79	2.83	2.59	2.58	2.59
General mean of potassium levels	0	174.44	189.38	181.91	2.82	2.94	2.88	0.85	0.76	0.81	1.59	1.69	1.64	2.41	2.32	2.37	2.99	3.03	3.01	2.75	2.61	2.68
	2	191.85	203.16	197.51	3.23	3.41	3.32	1.02	1.06	1.04	1.96	2.04	2.00	2.65	2.72	2.68	3.37	3.28	3.33	3.12	2.95	3.04
	3	206.31	214.85	210.58	3.57	3.76	3.76	1.21	1.40	1.31	2.24	2.40	2.32	2.85	3.08	2.97	3.57	3.58	3.58	3.46	3.36	3.41
LSD 5%	Irrig.	23.47	22.69	14.26	0.30	0.32	0.20	0.08	0.10	0.06	0.09	0.10	0.06	0.11	0.13	0.07	0.23	0.25	0.15	0.17	0.15	0.10
	K	16.63	15.79	10.14	0.21	0.22	0.15	0.05	0.06	0.03	0.07	0.08	0.04	0.08	0.09	0.05	0.17	0.18	0.10	0.12	0.11	0.07
	Irrig.x K	N.S	N.S	N.S	N.S	N.S	N.S	0.11	0.13	0.08	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

A.S.M. = available soil moisture

Table (4): Effect of soil moisture stress and foliar spray with potassium on net assimilation rate at different growth stages during the two growing seasons .

Irrigation Levels	Foliar spray with K_2O % solution	Net assimilation rate (mg/dm²/week)											
		(35 – 50) days			(50 – 65) days			(65 – 80) days			(80 – 95) days		
		2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.
(35-40) % depletion in A.S.M (wet)	0	1263.10	1269.57	1226.49	1145.48	1399.79	1272.64	708.65	801.78	755.22	838.64	622 16	730.40
	2	1264.19	1193.23	1228.71	1087.00	1212.37	1149.69	812.39	812.08	812.24	898.02	924.78	911.40
	3	1211.55	1071.35	1141.45	945.85	1038.38	992.12	753.13	810.57	781.85	160.90	1180.66	1070.78
Mean		1246.28	1178.15	1212.22	1059.44	1216.85	1138.15	758.06	808.14	783.10	899.19	909.29	904.19
(55-60) % depletion in A.S.M (medium)	0	1373.12	1487.10	1430.11	1312.98	1153.85	1233.42	783.86	589.62	686.74	759.65	749.45	754.55
	2	1292.79	1286.42	128.61	1237.63	1098.38	1168.01	874.62	696.50	785.56	737.07	717.65	727.36
	3	1196.10	1135.21	1165.66	1290.97	1053.24	1172.11	855.64	596.78	726.21	759.70	813.79	786.75
Mean		1287.34	1302.91	1295.13	1280.53	1101.82	1191.18	838.04	627.63	732.84	752.14	760.30	756.22
(75-80) % depletion in A.S.M (dry)	0	1316.72	1391.41	1354.07	903.16	1036.01	969.59	673.15	635.17	654.16	799.03	626.61	712.82
	2	1351.57	1284.78	1318.18	1015.99	1020.17	1018.08	810.47	705.08	757.78	740.12	676 49	708.31
	3	1387.33	1111.44	1249.39	866.65	907.31	886.98	758.97	684.43	721.7	802.12	763 61	782.64
Mean		1351.87	1262.54	1307.21	928.60	987.83	958.22	747.53	674.89	711.21	780.42	688.75	734.59
General mean of K-levels	0	1317.65	1382.79	1350.22	1120.54	1196.55	1158 55	721.89	675.52	698.71	799.11	666 07	732.59
	2	1302.85	1254.81	1278.83	1113.54	1110.31	1111.93	832.49	737.89	785.19	791.74	772.97	783.36
	3	1264.99	1106.00	1185.50	1034.49	999.64	1017.07	789.25	697.26	743.26	840.91	919.20	880.06
LSD 5%	Irrig.	N.S	N.S	81.46	164.43	160.74	92.54	77.73	74.15	46.87	86.68	87.63	52.07
	K	N.S	111.11	66.37	115.10	116.67	68.69	50.71	47.86	32.09	N.S	57.81	35.66
	Irrig.x K	N.S	N.S	N.S	185.60	188.04	114.34	N.S	N.S	N.S	96.19	98.16	56.56

A.S.M. = available soil moisture

Table (5): Effect of soil moisture stress and foliar spray with potassium on crop growth rate at different growth stages in the two growing seasons.

Irrigation Levels	Foliar spray with K_2o % solution	Crop growth rate (gm / week) (C.G.R)											
		(35 – 50) days			(50 – 65) days			(65 – 80) days			(80 – 95) days		
		2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.
(35-40) % depletion in A.S.M (wet)	0	36.41	33.25	34.83	40.05	43.04	41.55	39.87	45.32	42.60	48.10	36.82	42.46
	2	41.11	39.59	40.35	47.62	48.20	47.91	50.04	49.79	49.92	49.65	43.31	46.48
	3	46.72	41.67	44.20	48.61	49.81	49.21	48.62	54.67	51.56	57.22	52.94	55.08
Mean		41.41	38.17	39.79	45.43	47.02	46.22	46.18	49.93	48.06	51.66	44.36	48.01
(55-60) % depletion in A.S.M (medium)	0	24.72	27.22	25.97	48.08	43.46	45.77	30.84	28.54	29.69	34.41	25.92	30.17
	2	31.25	31.36	31.31	49.26	46.25	47.76	41.86	38.52	40.19	42.54	43.49	43.02
	3	34.54	35.66	35.10	54.84	49.82	52.33	42.71	39.15	40.93	52.39	26.26	57.33
Mean		30.17	31.41	30.79	50.73	46.50	48.62	38.47	35.40	36.94	43.11	43.89	43.51
(75-80) % depletion in A.S.M (dry)	0	22.58	23.91	23.25	32.41	38.96	35.69	30.99	22.51	26.75	37.31	36.31	36.81
	2	26.79	26.99	26.89	35.92	41.99	38.96	38.20	30.68	34.44	40.81	37.36	39.09
	3	30.41	31.43	30.92	35.70	42.45	39.08	41.91	29.40	35.66	46.48	49.18	47.83
Mean		26.59	27.44	27.02	34.68	41.13	37.91	37.03	27.53	32.28	41.53	40.95	41.24
General mean of K-levels	0	27.90	28.13	28.02	40.18	41.82	41.00	33.90	32.12	33.01	39.94	33.02	36.48
	2	33.05	32.65	32.85	44.27	45.48	44.88	43.37	39.66	41.52	44.33	41.39	42.86
	3	37.22	36.25	36.74	64.38	47.36	46.87	44.42	41.07	42.75	52.03	54.79	53.41
LSD 5%	Irrig.	1.84	1.88	1.13	3.02	3.18	1.84	4.83	4.61	2.77	4.98	4.88	2.26
	K	1.22	1.25	0.81	2.18	2.22	1.28	3.66	3.76	1.21	3.47	3.43	2.02
	Irrig.x K	N.S	N.S	N.S	3.91	1.03	2.37	N.S	N.S	N.S	6.31	6.21	3.80

A.S.M. = available soil moisture

The values of C.G.R. were increased mostly with advance maize plant in age. This trend is mainly due to the increase of dry matter accumulation with advance age.

Regarding the effect of water stress on C.G.R. of maize plant, results indicate that, increasing soil moisture depletion level from 35-40 % to 75-80 % decreased significantly CGR at all growth periods. Such trend may be due to the important of water to the accumulation of dry matter or photosynthesiate compounds . these results are in harmony with those obtained by Hefni and El-Shabbagh (1993),who found on maize plant that CGR was significantly decreased by increasing available soil moisture depletion up to 80%.

Concerning the effect of potassium fertilizer on CGR of maize plant, data in Table (5) indicate that, raising K_2O level from 0 up to 3 % increased significantly the values of CGR. Such finding may be explained on the important role of potassium in carbohydrates synthesis, which in turn increase CGR. In this respect, Mahender-Singh *et al.* (1992) found that spraying potassium at rates of 0, 50, 100 or 200 ppm K on maize plant grown in pots increased dry matter of maize plants with increasing potassium levels.

The interaction between the two factors i.e. water stress and potassium fertilizer on CGR was found to be significant at the periods of 50 – 65 and 80 – 95 days after planting. Whereas it recorded insignificant effect at the periods of 35-50 and 65-80 days after planting. The maximum value of C.G.R. was obtained when maize plants received wet treatment and sprayed with 3 % K_2O at the periods of 35-50 and 65-80 days after sowing. Whereas when maize plants received medium treatment and sprayed with 3% K_2O, C.G.R. recorded its maximum values at periods of 50 – 65 and 80 – 95 days after sowing.

II – Maize Yield and its attributes: -

a – yield attributes .

Results of Table (6) show that soil moisture stress had a significant effect on the ear length, ear diameter, number of rows/ear, ear weight, ear grain weight, shelling percentage and 100 grain weight. The highest values of such characters were obtained from the wet treatment which was watered at 35 – 40% depletion in available soil moisture (A.S.M.), followed by the medium treatment which was irrigated at 55 – 60 % depletion in A.S.M. The lowest values were gained from severe water deficit (dry treatment, which irrigated at 75 – 80 % depletion in A.S.M.).

These results reveal that increasing soil moisture stress resulted in a significant decrease in maize growth which was reflected on yield attributes of maize plants. These findings indicate that high moisture level enhanced the growth of maize therby its yield attributes. In this connection, Kramer (1980) showed that plants subjected to water stress not only show a general reduction in size but exhibit modification in structure, leaf area, cell size and intercellular volume. Also, simialr results were obtained by Noureldin *et al.* (1986) and Hifni and El-Shabbagh (1993)

Table (6): Effect of soil moisture stress and foliar spray with potassium on yield attributes of maize during two growing seasons and combined analysis .

Irrigation Levels	K-foliar spray	Ear length (cm)			Ear diameter (cm)			Number of Rows/ ear			Ear weight (gm)			Ear grain weight (gm)			Shelling %			100 – grain weight (gm)		
		2001	2002	Comb.	2001	2002	Comb	2001	2002	Comb	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.
(35-40) % depletion in A.S.M (wet)	0	19.00	18.81	18.91	4.37	4.60	4.49	12.51	13.67	13.59	265.15	270.51	263.33	211.66	224.14	217.90	82.60	82.73	82.76	32.62	33.26	32.94
	2	19.77	20.75	20.26	4.92	5.16	5.04	13.95	14.13	14.04	299.30	302.10	300.70	249.11	252.97	251.04	83.23	83.88	83.56	33.84	35.75	34.80
	3	20.51	21.20	20.86	5.56	5.44	5.50	14.53	14.78	14.66	318.51	325.16	321.84	269.27	276.41	272.84	84.85	85.41	85.13	35.91	36.91	36.41
Mean		19.76	20.25	20.01	4.95	5.07	5.01	14.00	14.19	14.10	291.32	299.26	295.29	243.35	251.17	247.26	38.56	84.01	83.79	34.12	35.31	34.72
(55-60) % depletion in A.S.M (medium)	0	16.36	17.85	17.11	3.98	4.23	4.11	12.85	13.20	13.03	211.83	200.18	206.01	168.40	173.02	170.71	79.73	80.11	79.92	28.79	31.15	29.97
	2	17.20	18.74	17.79	4.77	4.75	4.76	13.68	13.92	13.80	275.73	291.53	283.63	225.05	238.70	231.88	82.06	81.74	81.90	31.81	33.28	32.55
	3	18.16	19.81	18.99	5.20	5.51	5.36	14.54	14.31	14.43	298.10	310.34	304.22	246.14	257.46	251.80	82.40	83.17	82.79	33.56	34.51	34.04
Mean		17.24	18.80	18.02	4.65	4.83	4.74	13.69	13.81	13.75	261.89	267.35	264.62	213.20	223.06	218.13	81.40	81.67	81.54	31.39	32.98	32.19
(75-80) % depletion in A.S.M (dry)	0	14.22	15.25	14.74	3.63	3.86	3.75	12.10	12.26	12.18	182.34	195.17	188.76	141.94	152.72	147.33	77.78	77.91	77.85	26.12	28.19	27.16
	2	15.69	15.98	15.84	4.22	4.45	4.34	12.83	13.16	13.00	213.56	226.33	519.95	167.86	180.75	174.31	78.82	79.90	79.36	27.93	30.55	29.24
	3	16.73	16.48	16.61	4.57	4.66	4.62	13.22	13.53	13.38	243.19	259.16	251.33	194.48	208.53	201.51	80.21	80.43	80.32	30.74	32.63	31.69
Mean		15.55	15.90	15.73	4.14	4.32	4.24	12.72	12.98	12.85	213.03	226.99	220.01	168.09	180.67	174.38	78.94	79.41	79.18	28.26	30.46	29.36
General mean of potassium levels	0	16.53	17.30	16.92	3.99	4.23	4.11	12.82	13.04	12.93	216.77	221.95	219.36	174.00	183.29	178.65	80.04	80.25	80.15	29.18	30.87	30.03
	2	17.55	18.49	18.02	4.64	4.79	4.71	13.49	13.74	13.61	262.86	273.32	268.09	214.01	224.14	219.07	81.37	81.84	81.61	31.19	33.19	32.19
	3	18.47	19.16	18.82	5.11	5.20	5.16	14.10	14.21	14.16	286.60	298.32	292.46	236.63	247.47	242.05	82.49	83.00	82.75	33.40	34.68	34.04
LSD 5%	Irrig.	0.97	1.01	0.58	0.65	0.56	0.38	0.87	0.88	0.50	28.62	29.43	17.16	21.04	22.01	13.17	4.02	4.29	2.24	1.74	1.90	1.09
	K	0.68	0.70	0.43	0.46	0.39	0.26	0.63	0.57	0.41	20.16	20.51	12.89	14.42	15.38	8.78	N.S	N.S	N.S	1.14	1.21	0.70
	Irrig x K	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

A.S.M. = available soil moisture

Regarding the effect of foliar spray with potassium fertilizer, results of combined analysis in Table (6) indicate that applying foliar spray of K on maize resulted in a significant increase in ear length, ear diameter, number of rows/ ear, ear weight, ear grain weight and 100- grain weight, except the character of shelling % which recorded insignificant effect. Such characters were increased gradually with raising potassium levels from 0 up to 3 % K2o. These results are in line with those reported by Abou El-Defan *et al.* (1999) who found that spraying wheat plants with 1.5 % K_2O increased significantly 100-grain weight compared with control. Also, Anton and Ahmed (2001) reported that applying foliar spray of K on barley resulted in a significant increase in spike length, grain weight / spike and 1000 - grain weight.

Data of Table (6) show the interaction between soil moisture stress and potassium levels which was found to be insignificant for ear length, ear diameter, number of rows / ear, ear weight, ear grain weight, shelling % and 100 – grain weight. The highest values of all yield attributes were relatively scored from irrigated plants at 35 – 40 % depletion in available water and received foliar spray of 3 % K_2O.

b – Yield

The effect of soil moisture stress and foliar spray of potassium on the productivity of maize expressed as grain yield ard. /fed. and stover yield ton/fed. is presented in Table (7). Results indicate that the two factors significantly affected the productivity of maize. The highest values of grain and stover yield were scored from the wet treatment (irrigation at 35 – 40 % depletion in A.S.M.) followed by the medium level of soil water (irrigated at 55-60 % depletion in A.S.M.). the lowest productivity of maize was recorded from severe water deficit (plots irrigated when 75-80 % of A.S.M. is depleted). Such findings were found to be clear in both seasons under study and combined analysis. This trend could be due to the effect of water deficit on maize growth and yield attributes which was in turn reflected on maize productivity.

These results are in line with those reported by Sinclair *et al.* (1990) who found that maize grain yield was decreased under severe water stress.

Concerning the effect of potassium fertilizer on maize yield, data in Table (7) indicate that the foliar application of K levels had a significant influence on maize yield i.e. grain and stover yields. This trend was observed in two seasons under study as well as from the combined analysis. Spraing maize plant with 2 or 3 % K_2O significantly increased grain and stover yields compared with control one, with insignificant effect between the levels 2 and 3 % K_2O. These results could be ascribed to the enhanced effect of potassium to growth which in turn resulted in higher yield of maize. These results were explained by Beringeer (1980) who stated that increasing wheat grain yield as a result of increasing K application rates due to the greater area of flag-leaf,was being as a major source of assimilates for grain development. The same auther added that the potassium nutrition increased the grain weight and number of grain/ear.In this conection, he concluded that the multiple bio- physical and bio- chemical function of K in the plant are best integrated by data on yield and by measurement of some morphological parameters.

Table (7): Effect of soil moisture stress and foliar spray with potassium on maize yield as well as protein and total carbohydrates contents of groin.

Irrigation Levels	Foliar spray with K_2o % solution	Grain yield (ard. / fed.)			Stover yield ton / fed.			Protein %	Total carbohydrate
		2001	2002	Comb.	2001	2002	Comb.	2002	2002
(35-40) % depletion in A.S.M (wet)	0	25.54	26.60	26.07	8.31	8.82	8.57	8.14	64.25
	2	27.68	28.83	28.26	9.85	9.90	9.88	7.59	68.62
	3	28.76	29.51	29.14	10.77	10.7	10.74	6.73	71.50
Mean		27.33	28.31	27.82	9.64	9.81	9.73	7.49	68.12
(55-60) % depletion in A.S.M (medium)	0	23.83	25.18	24.51	7.70	8.02	7.86	8.93	60.52
	2	25.55	26.56	26.06	8.75	8.51	8.63	8.36	65.81
	3	26.73	27.62	27.18	9.86	9.72	9.79	8.93	68.22
Mean		25.37	26.45	25.92	8.77	8.75	8.76	8.23	64.85
(75-80) % depletion in A.S.M (dry)	0	19.08	20.66	19.87	7.10	6.57	6.84	9.61	55.13
	2	20.84	21.31	21.08	7.82	8.13	7.98	8.98	58.30
	3	21.91	22.55	22.23	8.28	8.45	8.37	7.95	63.64
Mean		20.61	21.51	21.06	7.73	7.72	7.73	8.85	59.02
General mean of K- levels	0	22.82	24.15	23.49	7.70	7.80	7.75	8.89	59.97
	2	24.69	25.57	25.13	8.81	8.85	8.83	8.31	64.24
	3	25.80	26.56	26.18	9.64	9.63	9.64	7.36	67.79
LSD 5%	Irrig.	2.66	2.73	1.68	0.90	0.98	0.55		
	K	1.88	1.75	1.13	0.59	0.62	0.35		
	Irrig.x K	N.S	N.S	N.S	N.S	N.S	N.S		

A.S.M. = available soil moisture

The interaction effect between water deficit and foliar spray with K recorded insignificant effect on grain and stover yields of maize. The highest values of grain and stover yields were relatively scored when maize plants irrigated at 35 -- 40 % depletion in A.S.M. and received foliar spray with 3 % K_2O.

III – chemical composition of maize grains.

a – Protein content :-

Variations in protein content of maize grain as affected by water deficit and K fertilizer is presented in Table (7) . Results clearly show that the level of soil moisture is an important factor controlling protein content of maize grain . As soil moisture stress increased protein content of maize grains increased. Higher protein content was gained under dry condition or severe soil moisture stress (75 – 80 % depletion in A.S.M.), while it decreased by frequent irrigation's (35-40 % A.S.M.).In this respect, El-kalla *et al.* (1985) concluded that crude protein percentage of maize grain increased by increasing the amount of available soil moisture deficit as adpoted in 80 % S.M.D.

Regarding the effect of foliar spray of K on protein content of maize grains, result of Table (7) show that protein content of grains decreased with increasing K level up to 3 % K_2O. These results are in line with those reported by Abou- El-Defan *et al.* (1999),who stated that increasing potassium dose decrease nitrogen percentage in wheat grains.

The interaction between soil moisture content and K foliar application treatments, Table (7) indicate that the highest value of protein could be obtained from plants irrigated at 75-80 %.depletion in A.S.M. and sprayed with water (control).

b – Total carbohydrates content

Carbohydrates content of maize grain (Table, 7) showed a reverse trend to that obtained with protein. Under wet conditions or low water deficit, total carbohydrates of maize grains was increased while increasing water deficit by prolonged irrigation intervals did result in decreasing the percentage of carbohydrates in maize grain. In other words, the increase in carbohydrates were on account of decrease in protein content of grains. The same results on maize plants was obtained by El-Kalla *et al.* (1985), who also explained such result as a water shortage causes stomatal closure and this in turn prevents CO_2 diffusion into the air inside the tissue of plants and consequently the photosynthetic efficiency becomes low.

As for the effect of foliar spray of K, data in table (7) indicate that total carbohydrates of maize grains increased with increasing K level up to 3 % K_2O. Such findings may be explained on the important role of potassium in carbohydrates synthesis and translocation. The same trend was observed by Anton and Ahmed (2001) on barley plants. Also , Abd El-lateef (1996) mentioned that soil application of P and foliar sparing with K showed significant increase in carbohydrates percentage of mung bean seeds. El – Bialy *et al.* (2001) concluded that grain, biological and straw yield of wheat plant as well as seed index were all significantly increased over the control as a result of either soil application or foliar one of potassium fertilizer. Foliar application of 7.2 Kg K_2O/fed. recorded the best grain yield among the other foliar spraying rates having 75 % relative increase compared to control. Total carbohydrates responded significantly due to K treatments.

The highest carbohydrates content of maize grains could be achieved by irrigation maize plants when 35 – 40 % depletion in available water and sprayed with K at the rate of 3 % K_2O.

IV- Water Relations :-

a - Seasonal water consumption:-

Seasonal rates of water consumptive use by maize under the various treatments are presented in Table (8) . Results indicate that the values of seasonal water consumptive use by maize ranged from 54.66 to 74.64 cm during the period of study. These results revealed that water consumption increased with increasing soil moisture by frequent irrigations. The highest water use was achieved under wet treatment (irrigated at 35 – 40 % depletion in ,A.S.M.), whereas the lowest values were gained from dry soil moisture level, which watered at depletion of 75 – 80 % A.S.M. The medium treatment had inter medium values. In other words, the rate of evapotranspiration increased with increasing soil moisture level in the order:

Dry < medium < wet soil moisture level.

Such results could be explained on the basis that frequent irrigation provides chance for more luxuriant use of water. These finding could be ascribed to the availability of soil water to maize plants in addition to higher evaporation rate from wet soil surface, than a dry one. In this connection Ibrahim (1981) showed that the increase in evapotranspiration rate by maintaining soil moisture at high level can be attributed to excess available water in the root zone to be consumed by the plants.

Regarding the rate of foliar spray by potassium on seasonal water use by maize plants, results indicate that there was a slight increase in seasonal water use by maize. The values increased gradually with increasing K_2O concentration. Such increase in evapotranspiration role with increasing potassium fertilizer levels may be due to the enhancing effect of K fertilizer on maize growth which resulted in an increase in plant canopy thereby increasing the transpiring surface and that reflected on seasonal water consumption. The above results are in the line with those reported by El–Naggar *et al.*. (1996) who found an increase in water consumptive use of barley and soybean by increasing K_2O from 0 to 72 Kg/fed.

As for the interaction effect between water stress treatments and potassium fertilizer levels, the maximum value was obtained when maize plants watered at 35 – 40 % depletion in A.S.M. and sprayed with 3 % K_2O.

b – Water use efficiency

Water use efficiency by maize expressed as Kg. grains produced per m^3 of water consumed in complete evapotranspiration in the period of study is presented in Table (8). It indicates that water use efficiency was higher under medium soil moisture stress (irrigated at 55 -60 % A.S.M.), while it was lower under wet condition or severe soil moisture stress. These results may be due to the higher grain yield of maize gained from medium treatment and less water consumed by such treatment.

Table (8): Effect of soil moisture stress and foliar spray with potassium on seasonal water consumptive use (cm) and water use efficiency (Kg / m^3/fed.) during the two growing seasons.

Irrigation treatments	Foliar spray with K_2o % solution	seasonal water consumptive use (cm)			Water use efficiency Kg / m^3 fed.		
		2001	2002	mean	2001	2002	mean
(35-40) % depletion in A.S.M (wet)	0	71.80	72.43	72.12	1.19	1.22	1.21
	2	72.63	73.78	73.21	1.27	1.30	1.30
	3	73.99	74.64	74.32	1.30	1.32	1.32
Mean		72.81	73.62	73.22	1.25	1.28	1.27
(55-60) % depletion in A.S.M (medium)	0	63.45	64.32	63.89	1.25	1.30	1.28
	2	64.98	65.77	65.38	1.31	1.35	1.33
	3	65.83	66.48	66.16	1.35	1.38	1.37
Mean		64.75	65.52	65.14	1.30	1.34	1.33
(75-80) % depletion in A.S.M (dry)	0	54.68	54.66	54.67	1.16	1.26	1.21
	2	55.49	56.12	55.81	1.25	1.27	1.26
	3	56.68	57.87	57.27	1.29	1.30	1.30
Mean		55.52	56.15	55.92	1.23	1.28	1.26
General mean of potassium levels	0	63.31	63.80	63.56	1.20	1.26	1.23
	2	64.37	65.22	64.80	1.28	1.31	1.29
	3	65.50	66.33	65.92	1.31	1.33	1.33

A.S.M. = available soil moisture

It can be concluded that medium soil moisture level seemed to be suitable in consuming water compared with either low water deficit or severe soil moisture stress. In this connection Vites (1965) concluded that water use efficiency is not clearly depend on the water available if the supply is within evapotranspiration limit, even the crop yields and the opportunity to increase crop yields do depend on the adequacy of water supply.

As for the effect of potassium fertilizer on the values of water use efficiency, results of Table (8) show that foliar spray of potassium increased the water use efficiency values. Such results may be due to the higher grain yield more than the increase in water consumed by maize plants. In this respect Welch and Flannery (1985) concluded that potassium supply increased water use efficiency.

Regarding the interaction effect between water stress and foliar spray of potassium on water use efficiency values, results show that the maximum value was gained from treatment received irrigation at 55-60 % deplaetion in A.S.M. and sprayed with 3 % K_2O.

CONCLUSION

Fig (1) emphasizes clearly that the maximum grain yield of maize was gained from wet treatment which was irrigated at 35 – 40 % depletion in available water and received 3 % K_2O as foliar spray. However, it could be concluded that medium irrigation treatment i.e. irrigated at 55-60 % depletion in A.S.M. and received 3 % K_2O seemed to be more efficient with respect to water use.

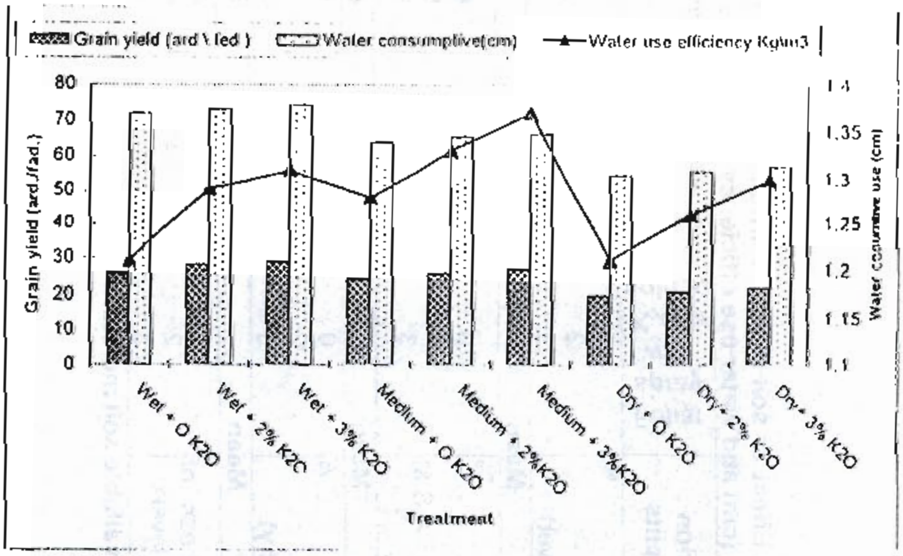

Fig (1) Effect of the interactionbetween available soil water and foliar spray of potassium on grain and some water relation of maize plants.

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استجابة نبات الذرة إلى إجهاد الرطوبة الأرضية والرش بالبوتاسيوم

السث عبد الفتاح عبد العزيز* و أسامة صلاح الدين البيلي**

*** قسم بحوث فسيولوجيا المحاصيل- معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – الجيزة – مصر.**

**** قسم بحوث كيمياء وطبيعة الأراضي – معهد بحوث الأراضي والمياه والبيئة – مركزالبحوث الزراعية- جيزة – مصر**

أجريت تجربتان حقليتان بالمزرعة البحثية لمركز البحوث الزراعية بالجيزة خلال موسمي ٢٠٠١، ٢٠٠٢ بهدف دراسة استجابة الذرة للرش بالبوتاسيوم تحت مستويات مختلفة من الرطوبة الأرضية وكانت المعاملات الرئيسية للرطوبة الأرضية ، الحالة الرطبة (تمثل نقص قدره ٣٥ – ٤٠ % من الرطوبة الأرضية الميسرة) ، الحالة المتوسطة (تمثل نقص قدرة ٥٠ – ٦٠ % من الرطوبة الأرضية الميسرة) والحالة الجافة (تمثل نقص قدره ٧٥ – ٨٠ % من الرطوبة الأرضية الميسرة). وتتمثل معاملات الرش بالبوتاسيوم في المعاملة الكنترول (بدون تسميد) ، الرش بتركيز قدره ٢ % K_2O ،الرش بتركيز قدره ٣ % K_2O - وشملت الدراسة استجابة محصول الذرة من حيث قياسات (النمو ، وتحليل النمو ، مكونات المحصول و المحصول مع دراسة بعض العلاقات المائية الخاصة بمحصول الذرة . وقد اظهرت نتائج التحليل التجميعي لموسمي الدراسة الاتجاهات الآتية :-

١ – تأثرت قياسات النمو معنويا بمعاملات الرطوبة الأرضية حيث كانت أعلى قيم لطول النبات وقطر الساق عند الحالة الرطبة (٣٥ – ٤٠ % نقص في الرطوبة الميسرة) – كما ازدادت قيم طول النبات وقطر الساق تدريجيا ومعنويا عندما ازداد تركيز K_2O في محلول الرش من صفر – ٣ % . ولوحظ أن تأثير التفاعلات بين معاملات الإجهاد الرطوبي والرش بالبوتاسيوم لم يكن لها تأثير معنوي على هاتين الصفتين.

٢ – كانت هناك فروق معنوية بين المعاملة الرطبة والمعاملتين الأخريين لحالة الرطوبة الأرضية (المتوسطة والجافة) على كل بيانات تحليل النمو خلال جميع فترات النمو المختلفة تحت الدراسة وكانت هناك علاقة طردية بين زيادة مستوى الرطوبة الأرضية وبين كل من معامل مساحة الورقة L. A. I. ، ومعدل التمثيل النهائي N. A. R. و معدل نمو المحصول C. G. R. . وعندما رشت نباتات الذرة بمحلولK_2O أدى الى زيادة معنوية في صفة L. A. I. خلال فترات النمو المختلفة فيما حدث نقص معنوي وتدريجي في صفة N. A. R عند زيادة تركيز K_2O من صفر إلى ٣ % عند فترات النمو (٣٥ – ٥٠) ، (٥٠ – ٦٠) يوما بعد الزراعة كما لوحظ أن N. A. R حقق أعلي قيمة معنوية خلال فترتي نمو (٥٠ – ٨٠) يوم بعد الزراعة عندما رشت بمحلول تركيزه ٢ % K_2O وخلال فترة النمو الأخيرة (٨٠ – ٩٠) يوم بعد الزراعة حدثت زيادة معنوية في N. A. R عندما ازداد تركيز البوتاسيوم حتى ٣ % K_2O . وكانت هناك استجابة موجبة ومعنوية لصفة C. G. R عند رش نباتات الذرة بمحلول البوتاسيوم خلال جميع فترات النمو المختلفة .

ولقد أختلف تأثير التفاعل بين معاملات الإجهاد الرطوبي وبين معاملات الرش بالبوتاسيوم علي بيانات تحليل النمو خلال فترات النمو المختلفة ولقد لوحظ أن خلال فترات النمو المختلفة أن اعلى قيم لكل بيانات تحليل النمو تم الحصول عليها عندما رشت نباتات الذرة بمحلول تركيزه ٣ % K_2O تحت مستوى رطوبة رطب (٣٠ – ٤٠ % نقص في الرطوبة الأرضية الميسرة).

٣ – تأثرت جميع صفات محصول الذرة التي تم دراستها معنويا حيث زادت عندما زاد محتوى الرطوبة الأرضية الميسرة وحدث نفس التأثير لزيادة تركيز K_2O . ولم يكن هناك أي تأثير معنوي للتفاعل بين معاملات الإجهاد الرطوبي ومعاملات الرش بالبوتاسيوم.

٤ – كان هناك استجابة معنوية لإنتاجية محصول الذرة والتي تمثلت في محصول الحبوب (أردب / فدان) ومحصول العيدان (طن / فدان) نتيجة معاملات الرطوبة الأرضية وكانت هناك زيادة مطردة نتيجة زيادة محتوي الرطوبة الأرضية الميسرة. وكان لمعاملات الرش بالبوتاسيوم نفس التأثير المعنوي فحدث زيادة في محصول نبات الذرة عند زيادة تركيز K_2O في محلول الرش ولكن لم يكن هناك تأثير معنوي للتفاعل بين المعاملات .

٥ – لوحظ زيادة في محتوى حبوب الذرة من البروتين كلما حدث نقص في محتوى الرطوبة الميسرة حيث كانت أعلى قيمة له عند حالة الرطوبة الجافة (٧٥ – ٨٠ % نقص في الرطوبة الأرضية الميسرة) .

كما لوحظ أن هناك نقص تدريجي في محتوي البروتين في حبوب الذرة عندما أزداد تركيز K_2O في محلول الرش من صفر إلى ٣ %. وحدثت أعلى قيمة في محتوى البروتين في حبوب الذرة نتيجة لتأثير التفاعل بين معاملة الرطوبة الجافة ومعاملة الكنترول بالرش بالبوتاسيوم مقارنة بالمعاملات الأخرى .

٦ – كان هناك اتجاه معاكس بالنسبة لمحتوى حبوب الذرة من الكربوهيدرات الكلية مقارنة بمحتواها من البروتين وكان التفاعل بين المعاملة الرطبة والرش بالبوتاسيوم بتركيز ٣ %K_2O له أعلى قيمة لمحتوي الحبوب من الكربوهيدرات الكلية .

٧ – كانت أعلي وأقل قيم للاستهلاك المائي لنبات الذرة خلال موسم النمو عندما عوملت النباتات بمعاملة الرطوبة الرطبة والجافة على التوالي وكذلك حدثت زيادة في الاستهلاك المائي نتيجة زيادة تركيز K_2O محلول الرش من صفر – ٣ % وكان التفاعل بين معاملة الرطوبة الارضية والرش بالبوتاسيوم بمحلول تركيزه ٣ % K_2O اعلي قيمة للاستهلاك المائي خلال موسم النمو لمحصول الذرة . ولقد وصلت أعلى قيمة لكفاءة استخدام المياه (كجم / م^3) لنبات الذرة عند معاملة الرطوبة المتوسطة (٥٥ – ٦٠ % نقص في الرطوبة الميسرة) مقارنة بالمعاملة الرطبة والجافة . وكان للرش بالبوتاسيوم تأثير ايجابي على كفاءة استخدام المياه .

ومن الناحية الاقتصادية والرجوع إلى إنتاجية محصول الذرة فإن التفاعل بين معاملة الرطوبة المتوسطة ومعاملة الرش بالبوتاسيوم بتركيز ٣ % K_2O يعتبر الأفضل مقارنة بالمعاملات الأخرى تحت الدراسة.