ISSN 1110-0419

Annals Of Agric. Sc., Moshtohor,
Vol. 44(3): 1323-1344, (2006).

EFFECT OF SOURCE AND RATE OF K-FERTILIZER UNDER SOIL WATER STRESS CONDITIONS ON MAIZE GROWTH AND PHYSIOLOGICAL CHARACTERISTICS

BY

Milad, R.A.
Soil & Water Dept., Faculty of Agric., El-Tahadi Univ., Sirt, Libya.

ABSTRACT

Two pot experiments were conducted to study the effects of soil water stress, and rate and source of K-fertilizer on some growth and physiological traits of two Maize (*Zea mays* L.) hybrids S.C.10 and T.W.C310. Three soil moisture regimes (100, 75 and 50% of soil field capacity), four K application rates (0, 15, 30 and 45 mg K/kg soil.) and four types of K sources (KCl, K_2SO_4, KNO_3 and a 1:1:1 mixture of them) were applied in a factorial split experiment for each hybrid. Total chlorophyll a and b, fresh and dry weight were measured as growth parameters and leaf area ratio, net assimilation and relative growth rates were measured as physiological parameters. There were significant effects for moisture stress on fresh and dry weight of both S.C.10 and T.W.C.310 maize plants in the three growth stage and total chlorophyll content only in the third growth stage for both maize hybrids. Potassium fertilization level effects were significant on the three characters in second and third growth stages in S.C.10 and in the first and second growth stages for fresh and dry weight besides the three growth stages for total chlorophyll content in T.W.C.310. differences between potassium fertilizer source were significant on total chlorophyll content in the third growth stage, only for both maize hybrids. Potassium source had significant effect on fresh and dry weight in the three growth stages in S.C.10 and the first and second growth stages in T.W.C.310. Non-water stressed treatment (100% of field capacity), highest of potassium level as potassium nitrate or sulphate produced the highest values of the tested traits. Increasing K application rate was found to decrease the adverse effect of soil moisture stress, Selection of suiTable K source has a beneficial effect for plant growth. Potassium nitrate produced the highest values of the most studied growth characters.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in the world. It ranks the third of the world cereal crops because it has a vital role filling the food gab for human and animal. Although, maize production began in Libya several years ago but there is a gap between maize production and consumption. Covering this gab can be achieved through improving all the cultural practices starting from seed bed preparation to harvesting, choosing the high yielding maize hybrids, as well as increasing maize cultivation area in the newly reclaimed lands, in Sirt region such as Bishr, Al-Nufalyah and Kardabia (Sandy to sandy loam soils). Therefore, efforts should be focused on increasing productivity of this essential crop by growing new hybrids as single and three way crosses (S.C. and T.W.C) under the most favorable cultural treatments.

Because maize is very sensitive to water stress, irrigation and drought are the most important environmental factors limiting maize productivity in semiarid regions in the world. Moreover, water remains the single most important factor threatening food security of people in the developing world. Kramer (1963) surveyed water general functions in plants as follows: (a) It is the major constituent of physiologically active tissue. (b) It is a reagent in photosynthesis and in hydrolytic processes such as starch digestion. (c). It is the solvent in which salts, sugars and other solutes move from cell to cell and organ to another. (d). It is essential for the maintenance of the turgidity necessary for cell enlargement and growth.

Nomir (1994) reported that plant leaf pigments (chlorophyll a, b and carotenoids) concentrations, decreased with increasing soil moisture stress.

Moursi (1997),, showed that chlorophyll a, b and carotenoids significantly differed among maize genotypes, and added that water stress at pre-tassling stage decreased photosynthetic pigments by 15.8, 23.73 and 12.24% for chlorophyll a, b and carotenoids, respectively. Jurisic *et al.* (1998) concluded that increasing water deficit decreased maize grain yield.

Zhang *et al.* (1998), subjects two halves of the root system one to drying soil and the other to water of 55 to 65% of its field capacity, they, found that total biomass production was reduced by 6, to 100% compared to the well-watered plants. Fiechtinger and Scheidl (1999), pointed out that inadequate water supply limits maize production. Essa (2003), reported that severe water deficit resulted in lower biomass production and short plant height. Andria *et al.* (1997), in sandy clay soil, concluded that increasing irrigation numbers from non-irrigation (rainfed) to two, four or weekly irrigation for a maize hybrid gave gradual increases in leaf area index and the highest was obtained with weekly irrigation. Moursi (1997), indicated that reducing number of irrigation decreased ear leaf area in maize with reduction percentage of 6.99% to 12.97%. Dunn and Fremmelt (1998) studied the effect of soil moisture on photosynthesis and water relations of maize and concluded that when water was withheld, photosynthesis and stomata conductance were significantly reduced. El-Ganayni (2000), reported that increasing irrigation intervals of maize from 7 to up to 22 days resulted in significant decrease in leaf area/plant. Irrigation every seven days gave the highest growth.

Debreczeni (1998), reported that that Potassium fertilizers significantly increased maize yields grown on calcareous soils, but had a much smaller effects on strongly acidic and brown forest soils. Howard *et al.* (1998), in reported that 15 to 59 kg p and 28 to 112 kg k/ha increased maize yield by up to 14%. El-Bana and Gomaa (2000), reported increases in maize grain yield of 13 to 15 % by increasing K levels from 20 to 40 kg K/fed.

Plants well supplied with K lost less water since and had a positive influence on stomatal closure (Kramer, 1959; and Hale and Orcutt, 1987). The role of K in the cation-anion balance is also reflected in nitrate metabolism, in which K often is the predominant centurion for NO_3^- in long-distance transport as well as for storage in vacuoles (Aslam, 1975; Howard *et al.*, 1998). The role of K as the dominant counter ion to light-induced H^+ flux across the thylakoid membranes and the establishment of the transmembrane pH gradient necessary for the synthesis of ATP, (Garcia, 1983). With respect to potassium sources, many researchers indicated that some potassium sources are more favorable to uptake by specific plant species than others.

The main objectives of the present investigation were as follows:

1- To study the effect of soil water stress on maize growth as well as on its physiological traits.
2- To study the effects of type and rate potassium fertilizer on some maize characters.

MATERIALS AND METHODS

1- Location:

The present study was conducted at the Faculty of Agriculture, Saba Basha, Alexandria University, to study the effect of soil moisture content, potassium fertilizer levels and sources on plant growth, some physiological traits of maize (*Zea mays* L.).

2- Soil:

A sandy soil sample was collected from the upper 30 cm soil surface from a field in Al-Bostan, at El-Nubaria governorate. The main soil physical and chemical properties are shown in Table (1).

3- Experimental Layout:

Two pot experiments were carried out in the greenhouse for two maize cultivars including: single cross (S.C.10) and three way cross (T.W.C.310). Plastic pots (30 cm in diameter) were used in the two experiments. Each pot was uniformly filled with 10 kg air-dried soil leaving 5 cm. of free upper space for irrigation practice. Five grains were seeded on July, 24th and the seeding were thinned to 3 plants per pot after three weeks.

Before sowing, 1.5 g/pot super phosphate (6.5 P) was incorporated with soil to gave a P/rate of 10 mg P/kg, and ammonium nitrate (33.5% N) was added to gave a rate of 120 mg N/Kg in two equal doses (after thinning and 45 days from sowing). Four potassium sources (potassium chloride: 50% K, potassium sulfate: 42% K, potassium nitrate: 37% K and a mixture of 1:1:1 from the three forms (K_{-mix}): 43% K) were applied in a single dose after thinning (21 days after sowing) at different rates (0, 15, 30, 45 mg K/kg)., Three moisture regimes (to maintain the following % of field capacity,) were tested: 100%, 75%, and 50%. Each experiments laid out in a split-split plot design with three replicates. Moisture stress occupied the main plots, potassium rates were allocated to the subplots and potassium sources treatments occupied the sub-subplots.

Table (1): Physical and chemical properties of the soil.

Criteria	Values	Criteria	Values
Particle-size distribution:		**Soluble cations, meq/100**	
Sand %	92.80	**Ca^{++}**	0.27
Silt %	5.40	**Mg^{++}**	0.13
Clay %	1.80	**Na^{+}**	0.14
Texture class	Sand	**K^{+}**	0.03
Saturation percentage, %	16.00	**Soluble Anions, meq/100g**	
Field capacity, %	9.50	**$CO^{-2}_3 + HCO^-_3$**	0.37
Wilting point	2.50	**Cl^-**	0.20
EC (1:1 water extract), dS/m	0.30	**SO_4^{-2}**	0.12
pH (1:1 water suspension)	8.50	**Available nutrients, mg/kg**	
Organic matter, %	0.15	**N**	20
$CaCO_3$ %	3.58	**P**	5
		K	40

* extracts being: KCl (for N),. Na HCO_3 (for P), NH_4 acetate (for K)

4- Sampling and Analyses:

Soil and plant samples were collected after 45, 60 and 75 days of sowing at the(at I. E. the 1st, 2nd and 3rd growth stages, respectively). Total chlorophyll content in plant was determined using Chlorophyll meter (SPRD-502). (Minolta Camera Co. 1989). At each the fresh weight yield per pot recorded, washed with distillated water, oven dried at 65°C weighed and ground to pass through 40 mesh screen for nutrient contents determination.

The following plant growth traits were determined:

1- Total chlorophyll content (mg/ gm).
2- Fresh weight: After taking the sample (a plant) and washing its roots with distillated water the whole plant weighed in grams.
3- Dry weight In addition, three physiological parameters were calculated according to the following formula according to Radford (1967) as follows:

1. Leaf area ratio (L.A.R.) desi.^{2}/gm $= \dfrac{(\log_e W_2 - \log_e W_1)}{(\log_e A_2 - \log_e A_1)} \quad \dfrac{(A_2 - A_1)}{(W_2 - W_1)}$

2. Net assimilation rate (N.A.R.) gm/m^2/week $= \dfrac{(W_2 - W_1)}{(A_2 - A_1)} \quad \dfrac{(\log_e A_2 - \log_e A_1)}{(t_2 - t_1)}$

3. Relative growth rate (R.G.R.) gm/gm/week $= \dfrac{(\log_e W_2 - \log_e W_1)}{(t_2 - t_1)}$

Where W_1, A_1 and W_2, A_2, are dry weight and leaf area at time t_1 and t_2 (weeks) respectively

5- Statistical analysis:

Recorded data were statistically analyzed according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

A. Growth Characters:

1. Total Chlorophyll Content (Table 2):

Total chlorophyll content as affected by the main effects of water stress, potassium fertilizer levels and sources in the three plant ages three plant stages (45, 60 and 75 days after sowing) are shown in Table (2). Generally total chlorophyll content significantly increased with increasing potassium fertilization up to 45 mg/kg

Increasing water stress from 100 to 50% of water field capacity decreased total chlorophyll content by 9.3, 4.5 and 4.5% in the three growth stages, respectively. Water stress had significant effect only in the third growth stage where the total chlorophyll content of the 100 and 75% of field capacity were similar and surpassed the 50% field capacity. That might be due to an increased plant size increasing the evapotranspiration rate in that stage (anthesis), where water is a reagent in photosynthesis (Kramer, 1963). Similar results were obtained by El-Zainy (1981), Ragab *et al.* (1986), Nomir (1994), Moursi (1997), Gutierrez-Rodriguez *et al.* (1998).

As for potassium fertilizer levels, data show that increasing potassium from 0.00 rates up to increased total chlorophyll content by 2.33, 3.46 and 3.41 mg/gm, in the three stages. Increasing potassium rates did not affected the total chlorophyll content in the first growth stage. But in the second growth stage, potassium application by any of the three levels, of 15, 30 or 45 mg K/kg had the same significance level compared to the check treatment (control). On the other hand, in the third growth stage, 45 or 30 mg K /kg produced the highest total chlorophyll contents (22.53 and 21.74 mg/gm).

With respect to potassium fertilizer sources, there were no significant differences between the studied sources on total chlorophyll content in the first and second stages. However, the chloride form surpassed the other three forms of potassium for total chlorophyll content in the third growth stage (22.62 mg/gm). and there were no statistical differences between the other potassium sources (sulphate, nitrate and the mixture). This could be explained on the basis that the chloride anion has faster absorption than the other sources (Kochian and Lucas, 1988). Also, chloride influences the plant's water relations and has no effect on metabolism (Von Braunscheig, 1986).

For T.W.C.310, the same trend in total chlorophyll content was observed where that trait was significantly affected by water stress and potassium fertilizer sources only in the third growth stage Means of total chlorophyll content of T.W.C.310 under the three studied factors, i.e., water stress, potassium fertilizer rates and sources effects during the three growth stages are presented in Table (2). Data in that Table show that increasing water stress up to 50% of field capacity decreased total chlorophyll content by 11.2, 19.9 and 44.0% (compared to unstressed treatment of 100% of field capacity) in the three successive growth stages. Respectively, Several researchers reported a decrease in total chlorophyll content under water stress condition (Maranvill and Paulsen, 1970; Albert *et al.*, 1977; El-Zainy, 1981; Nomir, 1994; Moursi, 1997 and Gutierrez-Rodriguez *et al.*, 1998). According to Virgin (1965), the pigment formation mechanism localized to the chloroplasts is sensitive to the changes in water content whereas the photochemical transformation of protochlorophyll to chlorophyll is little influenced. There are some indications revealing the effect of water stress on chlorophyll content which may be attributed to a disturbance of chlorophyll synthesis rather than a destruction, of it.

Table (2): Chlorophyll content (mg/gm) of S.C.10 and T.W.C.310 maize hybrid plants in the three growth stages@.

Treatments	S.C.10			T.W.C310		
	1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
Water stress (% of Field capacity)						
100	21.34	19.34	21.41 a	21.10	20.38	34.11 a
75	19.38	19.26	21.19 a	17.70	16.59	21.68 b
50	19.35	18.47	20.45 b	18.73	16.32	19.11 b
L.S.D.0.05	as	ns	0.57	ns	ns	3.37
K-rates (mg/kg.)x						
0	19.08	17.03 b	19.12 c	18.25 b	17.62 b	22.54 b
15	19.13	18.89 a	20.67 b	18.90ab	17.16 b	25.86 a
30	20.49	19.41 a	21.74 ab	18.83ab	17.21 b	25.64 a
45	21.41	20.49 a	22.53 a	20.73 a	19.06 a	25.80 a
L.S.D.0.05	ns	1.59	1.52	1.74	1.20	1.80
K-sources						
KCl	21.15	19.54	22.62 a	19.96	18.89	25.15 ab
K_2SO_4	18.75	18.83	21.19 b	20.29	18.16	23.98 b
KNO_3	20.75	18.94	20.20 b	18.71	17.27	25.88 a
1:1:1	19.44	18.54	20.05 b	17.75	16.73	24.84 ab
L.S.D.0.05	ns	ns	1.34	ns	ns	1.29

* Means followed by the same letter (s) are not significantly different according to L.S.D.0.05

@ 1st, 2nd, 3rd stages represent the first, second and third samplings on the plants aged 45, 60 and 75 days old, respectively.

With respect to water stress and potassium level any of the four potassium levels under adequate water (100% of water field capacity) produced the highest total chlorophyll content. However potassium application of 15 mg K/kg soil. under 50% of field capacity, and 45 and 30 mg K/kg soil under 75% field capacity produced averages 20.65, 19.00 and 24.00 mg chlorophyll/g, respectively. Reduction for total chlorophyll content under water stress (50% and partially 75% of field capacity) at any potassium level indicate that chlorophyll content is more sensitive to changes in water content than potassium fertilizer rates (Virgin, 1965; Nussell and Staples, 1979). This holds true, because potassium increases water use efficiency in maize especially under non moisture stress, and that water stressed plants are more a depted to water deficit at high potassium levels. (Mottram, 1985; Premachandra *et al.*, 1991).

2. Fresh Weight (Table 3):

Means of S.C.10 plant fresh weight under the three studied factors, i.e., water stress, potassium fertilizer levels and sources effects in the three growth stages are presented in Table (3). With regard to water stress, increasing water deficit from 100% to 50% of field capacity, fresh weight of S.C.10 maize plant significantly decreased from 21.00 to 15.80; 53.01 to 35.07 and 160.81 to 120.11g in the three growth stages, respectively. However, plant fresh weights were statistically similar at both (100% and 75%) of field capacity in the three growth stages. Similar findings were obtained by El-Maghraby (1966), Musick and Dusek (1980), El-Sheikh (1994), Jurisic *et al.* (1998), Gencoglan and Yazar (1999), and Essa (2003) who reported that water is essential for the maintenance of turgidity necessary for all enlargement and growth.

Concerning to potassium fertilizer rates, the data in Table (3) show that increased potassium application, increased maize plant fresh weight in the three growth stages; however, this increase was not significant in the first growth stage. In the second growth stage, 30 and 45 mg N/kg produced higher fresh weight (52.07 and 54.91gm) than given by 15 mg K/kg (43.15 gm) or the non – fertilized (37.76 gm). In and, in the third growth stage 45 mg K/kg. produced the highest fresh weight (167.19gm) and there were insignificant differences between the other three potassium rates where plant fresh weights were 123.48; 143.05 and 142.20 gm, for the (0,15, and 30 mg K /kg respectively. These results agree with those obtained by Ibrahim (1982), Ogunlela and Yusuf (1988), Bar-Tal *et al.* (1991), Marsh and Pierzynski (1998), and El-Bana and Gomaa (2000). However, Hamissa *et al.* (1975), Santhy *et al.* (1998) and Ning and Dai (1999) concluded that potassium fertilizer levels did not affect maize plant weight. With respect to potassium source, effect on S.C.10 maize plant fresh weight, potassium nitrate produced the heaviest plant weight in the first and third growth stages (22.04 and 165.90 gm, respectively). Potassium sulphate, nitrate and the mixture produced heavier plant fresh weight (50.41, 48.30 and 46.94 gm) than potassium chloride (42.25 gm) in the second growth stage. Miley and Oosterhius (1994) and Howard *et al.* (1998) reported that potassium nitrate increased plant weight and yield compared to potassium sulphate, carbonate and chloride.

Potassium application, in general, produced the heaviest plants under adequate moisture treatment (100% of water field capacity) followed by the higher potassium application rates under (75% field capacity in both growth stages and high stress treatment of 50% field capacity in the third growth stage. The lowest fresh weights resulted under the highest moisture stress of without potassium application. Moderate plant fresh weight resulted under 75% field capacity without potassium fertilization in both growth stages. Results of other waters show water stressed plants having great adaptation to water deficits at high potassium levels be due to adverse effects of water stress on the photosynthetic rate (Dekov and Velichkov, 1992, Yapa *et al.* 1991) Water stress and potassium fertilizer sources in the three growth stages and potassium levels only in the second and third growth stage of S.C.10 had significant effect on fresh weight.

Table (3): Means of plant fresh weight (gm) of S.C.10 and T.W.C.310 maize hybrids plants in the three growth stages@.

Treatments	S.C.10			T.W.C.310		
	1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
Water stress (% of field capacity)						
100	21.00 a	53.01 a	160.81 a	22.00 a	60.12 a	420.25 a
75	20.63 a	52.84 a	151.02 a	16.56 b	40.51 b	177.51 b
50	15.80 b	35.07 b	120.11 b	12.32 c	31.57 b	89.54 b
L.S.D.0.05	3.55	7.94	17.10	2.31	9.68	95.74
K-rates (mg/kg.)						
0	20.84	37.76 c	123.48 b	13.41 b	36.81 b	169.86
15	16.58	43.15 b	143.05 b	15.78 b	41.79 b	204.60
30	19.00	52.07 a	142.20 b	16.06 b	46.89 ab	241.22
45	20.16	54.91 a	167.19 a	22.59 a	50.77 a	300.72
L.S.D.0.05	--	5.36	19.76	2.29	6.02	--
K-sources						
a. KCl	18.61 b	42.25 b	142.85 b	18.33 a	46.34 a	207.71
b. K_2SO_4	18.72 b	50.41 a	126.44 b	17.67 ab	45.33 a	195.16
c. KNO_3	22.04 a	48.30 ab	165.90 a	15.99 ab	45.56 a	325.45
1:1:1	17.21 b	46.94 ab	140.73 b	15.84 b	39.04 b	188.07
L.S.D.0.05	2.14	5.65	17.67	2.48	5.80	--

* Means followed by the same letter (s) are not significantly different according to L.S.D.$_{0.05}$

@ 1st, 2nd, 3rd stages represent the first, second and third harvests on the plants aged 45, 60 and 75 days old, respectively.

With regard to T.W.C.310 fresh weight, Table (5) shows that water stress had significant effects in the three growth stages; however, potassium fertilizer rates and sources besides the water stress x potassium levels interactions had significant effects in the first and second growth stages. Conversely, other two and three factors interactions did not reach the significance level. These results pointed out that there were significant differences between the two studied maize crosses, i.e., S.C.10 and T.W.C.310 in their response to the factors under study and this is confirmed with Kamel *et al.* (1986). As for water stress, means of T.W.C.310 plant fresh weight in Table (4) show that increasing water stress from (100% to 50%) of field capacity led to significant decrease in fresh weight from 22.00 to 12.32; 60.12 to 31.57 and 420.25 to 89.54,, in the three growth stages respectively. However, T.W.C.310 plant fresh weights were insignificantly differed between M2 (75%) and M3 (50%) of water field capacity in the second and third growth stages. This means that T.W.C.310 is more drought tolerant than S.C.10 and these differences in response of each cross to water stress could be attributed to genetical factors which were reflected on growth characteristics (Kamel *et al.*, 1986). Many researchers reported that increasing water stress led to decrease in fresh weight (Mederisk and Wilson, 1960, Abou-Ellil, 1992, Mokadem and Salem 1994, Mapfumo *et al.*, 1998, Yang and Chen, 1998 and Fiechtinger and Scheidl, 1999).

With respect to effect of potassium fertilization levels, data presented in Table 3 show that T.W.C. 310 plants significantly responded to higher potassium levels (45 mg/kg). in the first and 30 and 45 mg/kg. in the second growth stages), but the response was insignificant in the third growth stage. Increase percentages in plant fresh weight at 30 and 45 mg/kg were19.8, 68.5, 27.4, 37.9; 42.0 and 77.0 in the three successive growth stages as compared to check treatment. These increases might be due to the importance of potassium role in carbohydrate metabolism and starch translocation in plants (Woodruf *et al.*, 1987). These results are in general agreement with those obtained by Sweeney (1989), Bar-Tal *et al.* (1991), and Aly *et al.* (1999). Hover, Hamissa *et al.* (1975), Santhy *et al.* (1998) and Ning *et al.* (1999) reported that potassium fertilization did not significantly affect maize plant weight.

With respect to potassium fertilizer sources, data presented in Table 3 show that any of the three potassium forms (chloride, sulphate and nitrate) produced greater yield than the K.- miks – treatment (18.33, 17.67, 15.99; 46.34, 45.33, 45.56; 207.71, 195.16, 325.45 g/pot, respectively, in the three growth stages). The K – miks produced the lower yields(15.84, 39.04 and 188.07 g/pot) in the three successive growth stages, respectively These findings agree with those obtained by Mullins and Barmester (1995) who pointed out that there were no differences between K_2SO_4. $K_2S_2O_3$, KCl and KNO_3 on yield and Howard *et al.* (1998) who reported that all mentioned potassium sources led to increase the biological yield.

Results of T.W.C.310 plants show that fresh weight at 45 mg k /kg in the first growth stage and both 15 or 45 mg k /kg in the second growth stage under 100% field capacity produced the highest plant fresh weights (31.79, 73.91 and 64.23 g/pot, respectively). Conversely, the 75 and 50% field capacity gave the low plant fresh weights under without potassium application Potassium application under 75% field capacity produced intermediate fresh weights in the second growth stage (40.24, 44.34 and 51.12 gm) under 15, 30 and 45 mg k /kg respectively. These results indicate that potassium application could overcome the deleterious effects of soil moisture (Yapa *et al.*, 1991) and reduce the adverse effects of inadequate moisture on the photosynthetic rate (Dekov and Velichkov, 1992). These results were in general agreed with those obtained by Mottram (1985), Faizy *et al.* (1986), and Li *et al.* (1996).

3. Dry Weight (Table 4):

Water stress and potassium fertilization sources in the three growth stages and potassium levels in the second and third growth stages had significant effects on S.C.10 maize plant dry weight. Increasing water stress from 100% to 50% field capacity led decreasing plant dry weight in S.C10 maize hybrid during the three growth stages. Plant dry weights under 100% filed capacity were 8.84, 25.42 and 96.41 g/pot, comparaple for 50% filed capacity weights were 6.68, 18.86 and 54.72 g/pot, respectively, comparable values for 75% field capacity were 7.70, 22.00 and 76.29 g/pot respectively. These results indicate the function of water in photosynthesis and in starch digestion (Kramer, 1963). these results are similar to those obtained by Va'Clavik (1967), Robertson and Lurdy (1973), Ainer (1976), Kolev *et al.* (1998), Gencoglan and Yazar (1999) and Essa (2003).

With regard to potassium fertilization, the highest level produced the heaviest plant dry weights in the second and third growth stages. Conversely, check treatment (unfertilized) produced the lightest plant dry weights in the two successive growth stages. Intermediate potassium fertilizer levels produced intermediate dry weights in the second and third growth stages. These results might be due to the role of potassium in carbohydrate metabolism and translocation in plants. This results similar to those of Ogunlela and Yusuf (1988), Sweeney (1989), Bar-Tal *et al.* (1991), Debreczeni (1998), Aly *et al.* (1999) and El-Bana and Gomaa (2000). In connection to potassium fertilization sources, nitrate form produced the maximum plant dry weights, respectively, in the three growth stages followed the mixture of chloride, sulphate and nitrate forms (7.43, 17.86 and 78.43 gm) in the three growth stages and chloride form in the three growth stages. Miley and Oosterhius (1994) reported that nitrate form increased growth and yield. These results agree with those obtained by Howard *et al.* (1998) and Mohamed (1998).

Table (4). Means of plant dry weight (gm) of S.C.10 and T.W.C.310 maize hybrids plants in the three growth stages@.

Treatments	S.C.10			T.W.C.310		
	1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
Water stress (% field capacity)						
100	8.84 a	25.42 a	96.41 a	9.25 a	25.53 a	150.20 a
75	7.70 b	22.00 ab	76.29 b	6.87 b	14.83 b	78.93 b
50	6.68 c	18.86 b	54.72 c	6.03 c	10.31 c	32.75 c
$L.S.D._{0.05}$	0.64	4.14	16.24	0.81	0.87	34.65
K-rates (mg/kg.)						
0	7.76	16.11 c	67.96 b	6.65 b	14.28 b	69.00
15	7.78	23.08 b	78.27 ab	6.92 b	14.54 b	82.65
30	7.76	22.45 b	75.25 ab	6.98 b	16.94 b	96.55
45	7.66	26.72 a	81.73 a	8.99 a	21.80 a	100.97
$L.S.D._{0.05}$	ns	2.54	9.32	0.77	4.48	ns
K-Sources						
KCl	7.43 b	17.86 c	78.43 b	7.87 ab	18.60 a	90.50
K_2SO_4	7.33 b	21.31 b	61.41 c	7.35 b	16.03 b	86.12
KNO_3	8.49 a	24.24 a	91.78 a	8.76 a	18.11 a	91.37
1:1:1	7.71 ab	24.96 a	71.60 b	5.56 c	14.82 b	81.19
$L.S.D._{0.05}$	0.89	2.83	9.62	0.92	2.37	ns

* Means followed by the same letter (s) are not significantly different according to $L.S.D._{0.05}$

@ 1st, 2nd, 3rd stages represent the first, second and third harvests on the plants aged 45, 60 and 75 days old, respectively.

In the second or third growth stage, application of 45 mg K/kg under nonstressed plants produced the heaviest dry weights in the second and third growth stages in S.C.10 hybrid. In the contrary, stressed plants under 50% of water field capacity under without potassium application gave the lowest dry weight plants in the second and third growth stages, respectively. On the other hand, potassium fertilizer application to moisture stressed plants (75 and 50% of water field capacity) decreased the adverse effects of drought on plant dry weight. Increasing percentages in plant dry weight under 50% water field capacity in the second growth stage were 28.4, 21.5 and 67.6%, respectively, under K application compared to non K fertilization these increasing percentages were 50.6, 57.4 and 27.2%, respectively, in the third growth stage. These results show the importance of potassium, for compensation of inadequate soil moisture, on plant growth (Yapa *et al.*, 1991 and DeKov and Velichkov, 1992). These findings are in agreement with those obtained by Mottram (1985), Premachandra *et al.* (1991) and Li *et al.* (1996).

As for T.W.C.310 hybrid, mean squares of the analysis of variance of plant dry weight show that water stress had significant effects on that trait in the three growth stage while both potassium fertilizer levels and sources had significant effects in the first and second order interactions, only water stress x potassium rates had significant effects on plant dry weight in the first and second growth stages.

Means of plant dry weight as affected by the three studied factors, i.e., three water stress, four potassium fertilizer levels and four potassium fertilizer sources during the three growth stages are illustrated in Table (5). Increasing moisture stress from 100 to 75% of water field capacity decreased plant dry weights by 25.7, 41.9 and 47.45%, respectively, in the three growth stages. Increasing water stress up to 50% of water field capacity decreased plant dry weights by 34.8, 59.6 and 78.2% in the three successive growth stages compared to the unstressed plants (100% of water field capacity). This result agree with those of El-Maghraby (1966), Va'Clavik (1967), Ainer (1976), Musick and Dusek (1980), El-Sheikh (1994), Kolev *et al.* (1998), Rafailov *et al.* (1998), Tolk *et al.* (1998), Fiechtinger and Scheidl (1999) and Essa (2003).

Data in Table (4) show that increasing potassium rates gradually increased plant dry weights, but increases did not reach significance in the third growth stage. The highest potassium level produced the heaviest dry weights in the three growth stages, respectively, also, differences between 0, 15 and 30 mg K/kg. in the first and second growth stages were insignificant. Woodruff *et al.* (1987) referred plant dry weight increases under high potassium fertilization rates to the essential role of potassium in carbohydrate metabolism and starch translocation in plants. Many researcher reported similar results such as Ibrahim *et al.* (1989), Sweeney (1989 and 1993), Debreczeni (1998), Aly *et al.* (1999) and El-Bana and Gomaa (2000). On the other hand, Hamissa *et al.* (1975), Santhy *et al.* (1998) and Ning *et al.* (1999) indicated that potassium fertilization did not have significant effects on maize plant dry weight. With respect to potassium fertilizer sources, both nitrate and chloride potassium sources produced the heaviest dry weight maize plants for the two forms in the three growth stages, respectively. However, the differences between the were not significant in the third growth stage.

B. Physiological parameters:

1. Leaf Area Ratio (LAR) Table 5:

The analysis of variance show that potassium fertilization levels and had significant effects on leaf area ratio (LAR.) calculated in the second and third growth stages of S.C.10 maize plants, but soil water stress had significant effects at second growth stage only. On the contrary, any of potassium fertilization forms, first and second order interactions did not reach significance level.

Values are presented in Table 5. With regard to soil water stress effect. LAR significantly decreased with increasing soil water stress below 75% of field capacity in the second growth stage. However, the differences between the three soil moisture stress did not reach significance in the third growth stage. Unstressed water treatment (100% of field capacity) produced the largest leaf area ratio and the highest water stress produced the smallest. These results could be due to the effect of soil water deficiency on increasing the pigments in leaf plastids and photochemical activity of leaf tissue homogenates and decreasing plant productivity (Tkachuk, 1971). Many researchers reported that increasing soil water stress led to decrease in LAR such as Ainer (1976), Moursi *et al.* (1983), Shahin (1985), Porro and Cassel (1986), Kheiralla *et al.* (1989), Hefni *et al.* (1993) Moursi (1997), Ibrahim (1998) and Hassan and Gaballah (1999).

As for potassium fertilization levels effect, results show that increasing potassium levels increased (LAR) particularly in the second and third stages. In the second stage, both 30 and 45 mg/kg. produced the largest LAR while both zero and 15 mg/kg produced the lowest LAR. On the other hand, only 45 mg/kg. produced larger LAR than 0, 15 and 30 kg K/fed. These results agree with those obtained by Vilela and Bull (1999). With regard to potassium fertilization form the four our results are similar to those of Mullins and Barmester (1995). In case of T.W.C. 310 maize hybrid potassium fertilization levels had significant effects on LAR.

Means of leaf area ratio (L.A.R.) of T.W.C.310 hybrid under the three factors under study, i.e., soil water stress, potassium fertilization levels and forms during the second and third growth stages are illustrated in Table (5). Data in that Table show that the adequate soil moisture treatment surpassed the two water stresses in the third growth stage. However, the differences between the three soil moisture contents did not reach significance in the second growth stages. The largest leaf area ratio occurred under the adequate moisture treatment in the second and third growth stages. In contrast, the smallest LAR resulted under the highest moisture stress in the second and third growth stages the moderate soil moisture produced intermediate LAR values. Results are agreement with those obtained by Ainer (1983), Refay (1989), Ibrahim *et al.* (1992), Wery *et al.* (1994), El-Marsafawy (1995), Atta Allah (1996), Andria *et al.* (1997), Tolk *et al.* (1998), Yang and Chem (1998) and Essa (2003).

Table (5): Means of leaf area ratio (desi²/gm) of S.C.10 and T.W.C.310 maize hybrids plants in the second and third growth stages@.

Treatments	S.C.10		T.W.C.310	
	2nd stage	3rd stage	2nd stage	3rd stage
Water Stress (% of field capacity)				
100	1.075 a	1.127	1.281	1.591 a
75	1.030 a	1.039	1.268	1.450 b
50	0.946 b	1.026	1.036	1.143 c
L.S.D.$_{0.05}$	0.082	ns	ns	0.017
K-Rates (mg/kg.)				
0	0.921 b	0.955 b	0.925 c	1.194 c
15	0.928 b	0.949 b	1.084 b	1.283 c
30	1.106 a	1.30 b	1.395 a	1.485 b
45	1.113 a	1.321 a	1.376 a	1.616 a
L.S.D.$_{0.05}$	0.110	0.116	0.150	1.125
K-Sources				
KCl	1.029	0.101	1.171	1.356
K_2SO_4	1.050	0.110	1.470	1.426
KNO_3	1.140	0.112	1.258	1.448
1:1:1	0.849	0.102	1.172	1.348
L.S.D.$_{0.05}$	ns	ns	ns	ns

@ 1st, 2nd, 3rd stages represent the first, second and third harvests on the plants aged 45, 60 and 75 days old, respectively.

Increasing potassium rates increased leaf area ratio in the second and third growth stages. These results agree with Vilela and Bull (1999). With respect to potassium fertilization source the four studied potassium sources were not significantly. These results agree with those obtained by Mullins and Barmester (1995).

2. Net Assimilation Ratio (NAR) (Table 6:

For S.C.10 maize hybrid, NAR values were significantly affected by potassium fertilization source and soil water stress in the second and third growth stages, (Table 6) NAR values, decreased with increasing soil water stress from 100 to 50% of field capacity in both second and third growth stages, however differences did not reach significance in the second growth stage. Decreasing N.A.R. with increasing soil water stress might be due to reduction the hill reaction activity of the chloroplasts (Fry, 1970) and increasing the pigments in the leaf plastids and photo chemical activity of leaf tissue homogenates and decreasing plant productivity (Tkachuk, 1971)., Dekov and Velichkov (1992) reported that water stress caused ultrastructural damage to chloroplasts and reduced photosynthetic rate and photochemical activity in maize plants. Similar results obtained by Porro and Cassel (1986), Hale and Orcutt (1987) Rizk *et al.* (1987) and Dunn and Frommelt (1998).

Increasing potassium rate led to significant increases in N in the second and third growth stages of S.C. 10 cultivar. These results could be attributed to potassium effects on one or more of the following physiological functions: (a) Carbohydrate metabolism or formation breakdown and translocation of starch (b) Control and regulation of activities of various essential elements and (c) Activation of various enzymes (Ibrahim, 1982).

Regarding to the effect of potassium fertilizer form potassium sulphate and nitrate produced the highest N.A.R. However, the differences in NAR. values did not reach the significance level in the third growth stage according to potassium forms. These results might be due to the effect of sulphate anion on soil pH decreasing and increasing absorption ability of the microelements. Nitrate anion may increase the rate of carbohydrate formation. These results could be due to reducing the adverse effects of water stress on chlorophyll a and b, photosynthetic rate and the ultrastructural damage to chloroplasts (Dekov and Velichkov, 1992). These results agree with those obtained by Premachandra *et al.* (1993) who concluded that higher levels of potassium fertilizer application may be beneficial for maize plants to tolerate water stress conditions.

With respect to T.W.C.310 maize plants, data showed that potassium fertilizer levels and forms had significant effects that increasing moisture stress decreased N.A.R. values. However these reductions did not reach the significance level. Nir and Poljakoff Mayber (1967) concluded that loss of water from leaves resulted in a considerable reduction in photophosphorylation and photo-reductive activity of chloroplast and severe dehydration stopped these activities almost completely.Potassium fertilizer application by any of the studied levels especially 30 and 45 mg/kg. in the two growth stages, significantly increased N.A.R. values. The highest N.A.R. values occurred at 45 mg/kg. in the second growth stage and 30 and 45 mg/kg. in the third growth stage. Non potassium application showed the lowest NAR in the second and third. Increasing NAR values as a result of potassium application could be due to its effect on carbohydrate metabolism, translocation of starch, activation of various enzymes and regulation of activities of various essential elements (Ibrahim, 1982).

Potassium nitrate gave significantly higher in NAR. values followed by potassium sulphate. Potassium chloride and the mixture of the three forms gave lower values. This shows the essential effect of nitrate (as a source of nitrogen) on respiration reactions, enzymes and chlorophyll structure. Also, sulphate anion is considered important component in some growth hormones as thiamin, lipoic acid and acetyl co-enzyme A. Non-potassium application produced the lowest NAR. values this result similar those of Yapa *et al.* (1991) who concluded that high potassium application could overcome the deleterious effects of soil moisture stress. Premachandra *et al.* (1993), stated that high rates of potassium could be beneficial for maize to tolerate to water stress conditions.

3. Relative Growth Rate (RGR) (Table 7):

Soil moisture stress had significant effect on relative growth rate (RGR) in the second growth stage of S.C.10 maize plants. Potassium fertilization rates and sources had significant effects on that trait in the third growth stage. Means of RGR. values of S.C.10 plants under the three studied factors, i.e., soil moisture stress, potassium fertilization levels and forms effects in the second and third growth stages are presented in Table (7). Concerning to soil moisture stress, increasing water stress from 100 to 50% of field capacity significantly decreased R.G.R. values such reductions did not reach to the significance level in that growth stage. Because RGR is a resultant of LAR. and NAR, so the effect of soil water stress on the three characters was similar.

Table (6): Means of net assimilation rate (gm/m²/week) of S.C.10 and T.W.C.310 maize hybrids plants in the second and third growth stages@.

Treatments	S.C.10		T.W.C.310	
	2nd stage	3rd stage	2nd stage	3rd stage
Water stress (% of field capacity)				
100	29.63	35.33 a	33.83	31.53
75	28.88	33.15 a	27.00	30.83
50	27.23	22.20 b	26.10	30.68
L.S.D.0.05	--	3.98	--	--
K-rates (mg/kg.)				
0	24.00 b	26.10 b	26.48 b	25.35 b
15	27.15 b	28.40 b	27.98 ab	29.78 ab
30	29.70 ab	33.40 a	28.88 ab	34.05 a
45	33.47 a	33.02 a	32.48 a	34.86 a
L.S.D.0.05	4.80	4.73	4.05	6.75
K-Sources				
KCl	20.93 b	27.30	26.40 b	29.10 b
K_2SO_4	35.10 a	31.88	31.05 ab	30.98 ab
KNO_3	37.80 a	31.05	32.93 a	37.20 a
1:1:1	20.55 b	30.75	25.50 b	26.55 b
L.S.D.0.05	7.13	--	5.69	6.38

@ 1st, 2nd, 3rd stages represent the first, second and third harvests on the plants aged 45, 60 and 75 days old, respectively.

With respect to potassium fertilization levels, the highest level produced the highest RGR. values in the second and third growth stages, The zero or 15 mg/kg. produced the lowest RGR. values. These increases in RGR. values did not reach to the significance level in the second growth stage. Potassium fertilizer levels effect on RGR. was similar to its effects on LAR. and NAR. traits. With regard to the effect of potassium fertilizer form, potassium nitrate produced the highest RGR. values followed by potassium sulphate in the second and third growth stages, Potassium chloride and the mixture of the three potassium sources showed lower RGR values in both growth stages, although, the differences were not statistically significant in the second growth stage. This might be due the effect of nitrogen nitrate on chlorophyll, enzymes structure and respiration reactions and the importance of sulphate anion in some growth hormones as thiamin and acetyl co-enzyme A.

Soil moisture stress had significant effects in the second and third growth stages, Increasing water stress decreased RGR values in the second and third growth stages, respectively. These results show the important role of water availability on RGR. and its components.

As for potassium fertilizer forms, nitrate anion produced the highest R.G.R. (in the second and third growth stagers. These results point out the importance of nitrate anion as a source of nitrogen which affects on chlorophyll structure, L.A.R. and N.A.R. Supplies of potassium nutrition may increase plant production during periods of water stress. These results are in agreement with the findings of Yapa *et al.* (1991), Dekov and Velichkov (1992), Li *et al.* (1996) and Bordoli and Mallarino (1998).

Table (7). Means of relative growth rate (gm/gm/week) of S.C.10 and T.W.C.310 maize hybrids plants in the second and third growth stages@.

Treatments	S.C.10		T.W.C.310	
	2nd stage	3rd stage	2nd stage	3rd stage
Water Stress (% of field capacity)				
100	0.75 a	0.90	0.48 a	0.98 a
75	0.60 ab	0.60	0.32 b	0.78 a
50	0.45 b	0.60	0.32 b	0.52 b
$L.S.D._{0.05}$	0.20	--	0.02	0.25
K-Rates (mg/kg.)				
0	0.53	0.60 b	0.34	0.70
15	0.53	0.60 b	0.36	0.68
30	0.60	0.68 ab	0.38	0.78
45	0.75	0.90 a	0.42	0.88
$L.S.D._{0.05}$	--	0.23	--	--
K-Sources				
KCl	0.45	0.60 b	0.37	0.74 b
K_2SO_4	0.60	0.75 ab	0.38	0.71 b
KNO_3	0.75	0.90 a	0.41	0.95 a
1:1:1	0.53	0.53 b	0.33	0.65 b
$L.S.D._{0.05}$	--	0.23	--	0.17

@ 1st, 2nd, 3rd stages represent the first, second and third harvests on the plants aged 45, 60 and 75 days old, respectively.

REFERENCES

Abou-Ellil, A.A. (1992): Response of certain maize varieties to water stress. M.Sc. Thesis, Fac. Agric., Ain-Shams Univ., Egypt.

Ainer, N.G. (1976): Effect of irrigation and fertilizer treatments on growth and yield of corn. M.Sc. Thesis, Fac. Agric. Tanta Univ., Egypt.

Aly, S.S.M.; El-Akel, E.A. and El-Ghanddour, I.A. (1999): A role of potassium in ameliorating iron nutrition of corn plants in calcareous soils. Bull. Fac. Agric., Cairo Univ., 50 (1): 131-145.

Andria, R.D.; Chiaranda, F.Q.; Lavini, A. and Mori, M. (1997): Grain yield and water consumption of ethephon-treated corn under different irrigation regimes. Agron.. J., 89: 104-112.

Aslam, M. (1975): Potassium and sodium interrelations in growth and alkali cation content of sunflower. Agron. J., 67: 262-264.

Atta Allah, S.A.A. (1996): Effect of irrigation intervals and plant densities on growth, yield and its components of some maize varieties. Proc. 7th Conf. Agron., 9-10 Sept., 59-70.

Bar-Tal, A.; Feigenbaum, S. and Sparks, D.L. (1991): Potassium-salinity interactions in irrigated corn. Irr. Sci., 12 (1): 27-35.

Bordoli, J.M. and Mallarino, A.P. (1998): Deep and shallow banding of phosphorus and potassium as alternatives to broadcast fertilization for no-till corn. Agron. J., 90: 27-33.

Debreczeni, K. (1998): Efficiency of K fertilization under different agroecological conditions studied with maize. Agrokemia es Talajtan, 47 (1/4): 157-164. (C.F. Field Crop Absts., 52 (2): 844, 1999).

Dekov, I. and Velichkov, D. (1992): Ultrastructure and functional changes in the chloroplasts of maize plants at various levels of potassium nutrition and water stress. Fiziologiya-na-Rasteniyata, 18 (1):٣ -9.

Dunn, J.P. and Frommelt, K. (1998): Effect of below-ground herbivory by *Diabrotica virgifera* and soil moisture on leaf gas exchange of maize. J. Appl. Entom., 122 (4): 179-193.

El-Bana, A.Y. A. and Gomaa, M.A. (2000): Effect of N and K fertilization on maize grown in different populations under newly reclaimed sandy soil. Zagazig J. Agric. Res., 27 (5): 1179-1190.

El-Maghraby, M.T.M. (1966): Studies on the critical moisture periods in the growth seasons of some economical crops. M.Sc. Thesis, Fac. Agric. Ain Shams Univ., Egypt.

El-Marsafawy, Samia. M.S. (1995): Scheduling irrigation of maize using the evaporation pan method under different fertilization regime and their effect on soil characteristics. Ph.D. Thesis, Fac. Agric., Moshtohor, Zagazig Univ., Egypt.

El-Sheikh, M.H. (1994): Response of two maize varieties to plant densities and irrigation treatments. J. Agric. Sci., Mansoura Univ., 19 (2): 413-422.

El-Zeiny, H.A. (1981): Some physiological studies on growth regulation of maize in relation to drought resistance. Ph.D. Thesis, Fac. Agric. Ain-Shams Univ., Egypt.

Essa, T.A. (2003): Evaluation of growth and dry matter production of cereal crops under severe drought stress. Annals Agric. Sci., Ain Shams Univ., 48 (1): 173-184.

Faizy, S.E.; Ibrahim, D.A.M.; Gaheen, S. and El-Yamani, N. (1986): Effect of interval irrigation, levels of nitrogen and potassium fertilization on yield and nitrogen uptake by maize. J. Agric. Res., Tanta Univ., 12 (4): 1228-1240.

Feichtinger, F. and Scheidl, A. (1999): Pay attention to the soil during dry periods of the soil has a drastic effect on maize. Mois Bi. 1, 8-10 (1999). (C.F. Field Crop Abst., (52) 9: 6399, 1999).

Garcia, F.G. (1983): The importance of potassium in the physiological factors concerned in the fruiting of the olive. Potash Review. Subj. 8, 36th suite pp. 1-5.

Gencoglan, C. and Yazar, A. (1999): The effect of deficit irrigation on maize yield and water use efficiency. Turkish J. Agric. Forestry, 23 (2): 233-241, 1999. (C.F. Field Crop Absts., 52 (9): 6343, 1999).

Gutierrez-Rodriguez, M.; San Miguel-Chavez, R. and Larque-Saavedra, A. (1998): Physiological aspects in Tuxpeno maize with improved drought tolerance Maydica, 43 (2): 137-141. (C.F. FIELD Crop Absts., 52 (2): 888, 1999).

Hale, M.G. and Orcutt, D.M. (1987): The physiology of plants under stress. John Wiley and Sons, Inc., New York, USA.

Hamissa, M.R.; Abdel-Samie, M.E.; El-Banna, E.; Abdel-Bari, S. and Abdel-hadi, A.H. (1975): Corn fertilization program in Egypt. Response of corn to N, P and K. Egypt. J. Soil Sci. (Special issue), pp. 417-434.

Hassan, A.A. and Gaballah, A.B. (1999): The effect of irrigation interval on grain yield and its attributes in six recently released maize hybrids. Zagazig J. Agric. Res., 26 (4): 963-973.

Hefni, E.H.M.; El-Hosary, A.A.; Salwau, M.I.M. and El-Sabbagh, A.A. (1993): Effect of soil moisture stress and foliar application of zinc on some maize varieties. I. Growth measurements. Ann. Agric. Sci., Moshtohor, 31 (4): 1813-1828.

Howard, D.D.; Chambers, A.Y. and Lessman, G.M. (1998): Rotation and fertilization effects on corn and soybean yields and soybean cyst nematode population in a no-tillage system. Agron. J., 90 (4): 518-522.

Ibrahim, M.E.; El-Naggar, H.M.M. and El-Hosary, A.A. (1992): Effect of irrigation intervals and plant densities on some varieties of corn. Monofiya J. Agric. Res., 17 (3): 1083-1098.

Ibrahim, S.A. (1982): Combined effect of K-fertilizer and foliar application with commercial compounds on corn plants. Egypt. J. Agron., 7 (2): 121-129.

Jurisic. M.; Vidacek, Z.; Bukvic, Z.; Brkic, D. and Emert, R. (1998): Relation of soil water deficit, involved by precipitation and corn yield on vinkovic area (Eastern Croatia): Cereal Res. Com., 26 (3): 289-296, 1998. (C.F. Field Crop Absts., 52 (4): 2429, 1999).

Kamel, M.S.; Ashour, N.I.; Shaban, Sh. A. and Abdel-Lateef, E.M. (1986): Soil and foliar fertilization studies on maize. II- Growth analysis. Proc. 2nd Conf. Agron., Alex., Egypt, Vol. 263-276.

Kheiralla, K.A.; Bakheit, B.R. and Dawood, R.A. (1989): Response of wheat to drought conditions at different growth stages. Assiut. J. Agric. Sci., 20 (1): 161-175.

Kochian, L.V. and Lucas, W.J. (1988): Potassium transport in roots. Adv. Bot. Res., 15: 93-177.

Kolev, B.; Rafailov, R. and Bainov, I. (1998): Some ecological problems in maize grain production on calcareous chernozem. Pochvoznanie Agrokhimiya Y Ekologiya, 33 (5): 10-13, 1998. (C.F. Field Crop Absts., 52 (6): 3958, 1999).

Kramer, P.J. (1959): The role of water in the physiology of plant. Adv. In Agron., XI.

Kramer, P.J. (1963): Water stress and plant growth. Agron. J., 55: 31-35.

Li., M.; Sh. Zheng; M.D.Li and S.X. Zheng (1996): Influence of potassium nutrition on growth and drought resistance of maize. Soil and Fert. Beijing, 4: 10-12.

Mapfumo, P.; Mpepereki, S.and Mafongoya, P. (1988): Pigeonpea in Zimbabwe: A new crop with potential. CIMMYT Maize Res. Stn. (1998). 93-98. (C.F. Field Crop Absts., 52 (2): 1138, 1999).

Marsh, B.H. and Pierzynski, G.M. (1998): Root response to rates of banded nitrogen and phosphorus fertilizers. Dev. Plant and Soil Sci. Vol. 82, 1998. (C.F. Field Crop Absts., 52 (7): 4713, 1999).

Mederski, H.J. and Wilson, J.H. (1960): Relation of soil moisture to ion absorption by corn plants. Soil Sci. Soc. Amer. Proc., 24: 149-152.

Miley. W.N. and Ootherhuis, D.M. (1994): Three year comparison of foliar feeding of cotton with five potassium sources. pp. 1534-1536. In D.J. Herber (ed.) 1994 Proc. Beltwide Cott. Conf., San Diego. CA. 5-8 Jan. 1994. Nat. Cott. Council of America, Memphis, TN

Minolta Camera Co. (1989): Manual for chlorophyll meter SPAD-502.. Minolta Camera Co., Osaka, Japan.

Mohamed, E.S.I. (1998): Response of maize (*Zea mays* L.) to potassium fertilization and foliar spray of urea + Mn + Zn solution. Ssiut. J. Agric. Sci., 29 (3): 135-145.

Mokadem, Sh.A. and Salem, M.A. (1979): Effect of planting dates watering intervals and nitrogen rates on maize. II- Yield components characters. Ann. Agric. Sci., Moshtohor, 11: 12-23.

Mottram, R. (1985): Influence of potassium on the plant water relation of maize. Proc. 15th ann. Cong. South African Soc. Crop. Prod., 145-157.

Moursi, A.M. (1997): Studies on drought tolerance in Maize. M.Sc. Thesis, Fac. Agric., Zagazig Univ., Egypt.

Moursi, M.A.; Nour El-Din, N.A.; El-Bagoury, O.H. and El-Sayed, A.A. (1983): Water requirement of wheat. II- Effect of drought conditions at different stages of plant age on growth, yield and grain quality. Proc. 1st Conf. Agron. Cairo, Vol. 1 (B) Cereal Crops: 303-315.

Mullins, G.L. and Barmester, C.H. (1995): Response of cotton to the source of foliar potassium. pp. 1313-1315. In D.A. Richter (ed.) 1995 Proc. Beltwide Cott. Conf., San Antonio. Tx. 4-7 Jan., 1995. Nat. Cott. Council of America, Memphis, T.N.

Musick, J.T. and Dusek, D.A. (1980): Planting date and water deficit effects on development and yield of irrigated winter wheat. Agron. J., 27: 45-52.

Ning, Y.; Li, L. and Dai, G. (1999): Influence of K application on yield of cotton and maize in potassium enriched soil. Jiangsu Agric. Sci. No. 1: 45-46. 1999. (C.F. Field Crop Abst., (52) 10: 7696, 1999).

Nir, I. and Poljakoff-Mayber, A. (1967): Effect of water stress on the photochemical activity of chloroplasts. Nature, 28: 418-419.

Nomir, S.A. (1994): Physiological studies on Kali. Ph.D. Thesis, Fac. Agric. Zagazig Univ., Egypt.

Nussell, H. and Staples, R.C. (1979): Stress physiology in Crop Plants. pp. 284-342. In a Wiley-Inter science Publication, New York.

Ogunlela, V.B. and Yusuf, Y. (1988): Yield and growth response to potassium of grain sorghum as influenced by variety in a Savanna soil of Nigeria. Fertilizer Res., 16 (3): 217-226.

Porro, I. and Cassel, D.K. (1986): Response of maize to tillage and delayed irrigation. Agron. J., 78 (4): 688-693.

Premachandra, G.S.; Saneoka, H.; Fujita, K. and Ogata, S. (1991): Osmotic adjustment and stomatal response to water deficits in maize. J. Exp. Bot. Oxford, 43 (256): 1451-1456.

Radford, P.J. (1967): Gross analysis formula. Their use and abuse. Crop Sci., 7: 71-76.

Rafailov, R.; Banov, Y. and Kolev, B. (1998): The influence of water availability in maize grain production on leached chernozem. Pchvoznonie, Agrokhimiya Y Ekologiya, 33 (5): 14-17. (C.F. Field Crop Absts., 52 (6): 3957, 1999).

Ragab, M.A.; Noureldein, N.A. and El-Abou Gabal (1986): Deficit of soil water on maize plant. Proc. 2nd Conf. Agron., Alex., Egypt, Vol. 1: 295-308.

Refay, Y.A. (1989): The influence of variable amounts of irrigation water and nitrogen fertilizer and their interaction on the development, growth and nitrogen uptake of grain sorghum, Diss. Absts. Int. B. Sc. And Eng., 5: 1701.

Rizk, M.A.; Dawla, N.F.; Darwish, N.M. and Shahin, M.M.A. (1987): Influence of plant population and different soil moisture contents on plant characters and quality of maize. Ann. Agric. Sci., Moshtohor, 25 (1): 87-102.

Robertson, W.K. and Lurdy, H.F. (1973): Influence of water management through irrigation and subsurface asphalt layer on seasonal growth and nutrient uptake of corn. Agron. J., 65: 866-868.

Santhy, P.; Muthuvel, P.; Murugappan, V. and Selvi, D. (1998): Long-term effects on continuous cropping and fertilization on crop yields and soil fertility status. J. India Soc. Soil Sci., 46 (3): 391-395. (C.F. Field Crop Absts., 52 (2): 1542, 1999).

Shahin, M.M.A. (1985): Effect of plant population and irrigation at different soil moisture levels on corn (*Zea mays* L.). Ph.D. Thesis, Fac. Agric. Al-Azhar Univ., Egypt.

Steel, R.G.D. and Torrie, J.H. (1980): Principles and Procedures of Statistics. 2nd ed., McGraw Hill, New York.

Sweeney, D.W. (1989): Suspension N-P-K placement methods for grain sorghum in conservation tillage systems. J. of Fertilizer Issues, 6 (4): 83-88.

Sweeney, D.W. (1993): Fertilizer placement and tillage effects on grain sorghum growth and nutrient uptake. Soil Sci. Soc. Am. J., 57 (2): 532-537.

Tkachuk, E.S. (1971): Activity of photosynthetic apparatus and productivity of winter wheat and spring barley grown under irrigated conditions. Fiziologiya I. Biokhimiya Kul'turnykh Rastenii, 3 (2): 171-175. (C.F. Field Crop Absts., 25 (2): 1454, 1971).

Tolk, J.A.; Howell, T.A. and Evett, S.R. (1998): Evapotranspiration and yield of corn grown on three High Plains soils. Agron. J., 90 (4): 447-454.

Va'Clavik, G. (1967): Growth response to different constant soil moisture levels in maize (*Zea mays* L.). Biological Planetarium, 9: 462-471.

Vilela, E.F. and Bull, L.T. (1999): Evaluation of maize growth as a function of potassium rates and water stress. Revista Brasileira de Ciencia do Solo, 23 (2): 281-289.

Virgin, H.L. (1965): Chlorophyll formation and water deficit. Physiologia Plantarum, 18: 994-1000.

Von Braunscheueig, L.C. (1986): Types of K-fertilizers in the K-replacement strategy (IPI-Colloquium 1986 in France). Potash Review, No. 2, 1987. Published by International potash Institute, CH-3048 Worblaufen-Bern, Switzerland.

Wery, J.; Silim, S.N.; Kinghts, E.J.; Malthotra, R.S. and Cousin, R. (1994): Screening techniques and sources of tolerance to extremes of moisture and air temperature in cool season food legumes. Euphytia, 73: 73-83.

Yang, J.P. and Chen, J. (1998): Effects of soil water logging at different growth stages on the growth and development of spring maize. Acta Agric. Zheijiangensis, 10 (4): 188-192, 1998. (C.F. Field Crop Abst., (52) 11: 8077, 1999).

Yapa, L.G.G.; Wanasundora, W.M.U.N. and Punyardena, B.V.R. (1991): The role of K fertilizer in drought tolerance of corn grown in noncalcic brown soils (Haplustalfs). J. Soil Soc. Sri-Lanka, 7: 76-90.

Zang, K.S.; Liang, S.; Wei, H. and Zhang, J. (1998): Water use efficiency of controlled alternate irrigation on root divided maize plants. Agric. Water Manag., 38 (1): 69-76, 1998.

تأثير نوع ومعدل إضافة الأسمدة البوتاسية تحت ظروف الشد الرطوبى للتربة على النمو والخصائص الفسيولوجية المميزة لنبات الذرة الشامية

رمضان على ميلاد

قسم التربة والمياه، كلية الزراعة-جامعة التحدى- سرت - ليـبيـا.

أجريت هذه الدراسة والتي تضمنت تجربتان في أصص داخل صوبات كلية الزراعة - سابا باشا - جامعة الإسكندرية - بهدف دراسة تأثير كل من الإجهاد الرطوبي للتربة ومستويات وصور السماد البوتاسي على مقاييس النمو لنبات الذرة وبعض الخصائص الفسيولوجية وذلك لاثنين من هجن الذرة الشامية هما هجين فرد S.C.10 وهجين ثلاثى T.W.C.310 تم زراعتهما في أصص مملوءة بتربة جيرية رملية جلبت من منطقة البستان بالنوبارية.

وقد استخدم تصميم القطع المنشقة مرتين في ثلاث مكررات في كلا التجربتين. وقد وزعت معاملات الإجهاد الرطوبي للتربة (١٠٠ ، ٧٥ ، ٥٠%) من السعة الحقلية عشوائيا على القطع الرئيسية. في حين وزعت مستويات السماد البوتاسي الأربعة وهي (صفر ، ١٥ ، ٣٠ ، ٤٥ كجم/فدان) عشوائيا على القطع الفرعية. أما صور السماد البوتاسي (كلوريد ، سلفات ، نترات ، مخلوط بنسب متساوية من الصور الثلاثة) فقد احتلت القطع تحت الفرعية. وقد تم تقدير الصفات خلال ثلاث فترات للنمو وهي ٤٥ ، ٦٠ ، ٧٥ يوما بعد الزراعة. وقد أوضحت الدراسة وجود تأثير معنوى لمستويات الشد الرطوبى بالتربة على الوزن الطازج و الجاف لكلا الصنفين فى فترات النمو الثلاثة. وعلى محتوى النباتات من الكلوروفيل خلالا فترة النمو الثالثة. كما وجد

تأثير معنوى لمعدل إضافة الأسمدة البوتاسية على الثلاث صفات السابقة خلال فترتى النمو الثانية والثالثة لصنف S.C.10 وخلال فترتى النمو الأولى والثانية لصنف T.W.C.310 لصفتى الوزن الرطب والجاف وعلى المحتوى الكلى من الكلوروفل خلال فترة النمو الثالثة. وكان تأثير نوع السماد البوتاسى المضاف معنوي على زيادة محتوى الكلوروفيل الكلى فقط خلال فترة النمو الثالثة لكلا الصنفين. كما أدى هذا العمل إلى فروق معنوية فى قيم الوزن الرطب والجاف خلال فترات النمو الثلاثة لصنف S.C.10 وخلال فترتى النمو الأولى والثانية لصنف T.W.C.310 وعموما فقد أدت معاملة الرى بدون وجود شد رطوبى مع إضافة ٤٥ كجم من عنصر البوتاسيم/فدان من سلفات او نترات البوتاسيوم إلى الحصول على أعلى القيم من الصفات التى تم دراستها فى هذه التجربة. ونخلص من هذه الدراسة أن زيادة معدل التسميد البوتاسى يقلل من التأثير السلبى للشد الرطوبى فى التربة لكلا الصنفين المختبرين من نبات الذرة.