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ALEXANDRIA UNIVERSITY
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MAIZE RESPONSE TO WATER STRESS IN CALCAREOUS SOILS

A Thesis

Presented to the Graduate School
Faculty of Agriculture (Saba Basha), Alexandria University
In Partial Fulfillment of the
Requirements for the Degree

of

Doctor of Philosophy of Agricultural Sciences

In

Agronomy

Presented by

Hany Abd El-Aatty Abd El-Rahman Darwesh

2006

جامعة الإسكندرية
قسم الإنتاج النباتي
كلية الزراعة – سابا باشا

إستجابة الذرة الشامية للإجهاد الرطوبى
فى الأراضى الجيرية

رسالة علمية

مقدمة إلي الدراسات العليا بكلية الزراعة (سابا باشا) جامعة الإسكندرية
إستيفاءً للدراسات المقررة للحصول علي درجة
دكتور الفلسفة في العلوم الزراعية

في

(المحاصيل)

مقدمة من

هاني عبد العاطي عبد الرحمن درويش

٢٠٠٦

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للحصول علي درجة

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كلية الزراعة (سابا باشا) جامعة الإسكندرية

٢٠٠٦/ ١٠ / ٨

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8 / 10 / 2006

7. ARABIC SUMMARY

الملخص العربي

I. INTRODUCTION

1. INTRODUCTION

Maize (*Zea mays*, L.) is one of the most important grain crops in Egypt. It ranks the third among the world cereal crops . In Egypt , it is used mainly for human consumption and animal feed. Therefore, efforts are focused on increasing productivity of such crop by growing high yielding hybrids under the most favorable cultural treatments.

Maize productivity in Egypt has increased in the last 10 years and reached 8.0 tons per hectare . Total national production of maize is about 6.0 million tons , mostly of white grain , while the annual demand is about 8.0 million tons . Accordingly about 2.0 million tons are annually imported , all of yellow grain and totally consumed in the feed industry .

Plants vary in the timing of their need for water, that timing depends on how much moisture stress they are able to tolerate at any particular stage of growth. If water supply is actually inadequate, care should be taken at least to provide water at the critical stages of growth, thus the knowledge about the sensitive plant stages to water deficit is very important for judicious water management.

Water, is often the primary limiting factor in crop production, irrigation water resources are limited in Egyptian cultivation area as a result of agricultural expansion in the newly reclaimed lands and increasing water consumption. Irrigation and cultivars are the most factors that play a great role in maize production.

Maintenance of water resources is one of the most important national aims to face the great demand for irrigation water. More attention was paid to maintain the water resources by minimizing losses, decreasing the water consumption and cultivating more adapted varieties to water stress.

So, irrigation management is very important nowadays in Egypt to determine the optimum water requirements and planning the best irrigation regime that can be used in the grow of maize to obtain maximum yield.

Maize is known to be sensitive to deficits in soil moisture. Plant growth and grain yield are known to be adversely affected by water deficits, especially during reproductive growth stage. In new reclaimed lands maize is often produced in areas of limited water supply , additional yield increases may be achieved by selecting cultivars with greater productivity under deficit soil moisture **(Boyer, 1982)**.

The objective of the present investigation was to precisely evaluate the recommended maize cultivars under different irrigation water treatment.

2. REVIEW OF LITERATURES

2. REVIEW OF LITERATURES

Water is the most limiting factor for crop production in arid and semiarid lands . If sufficient water is not available application of high optimal agriculture practices and the use of yielding crop varieties are useless. Drought is the most important factor limiting maize crop productivity in many areas of the world and great yield losses can occur when maize is exposed to drought conditions especially around flowering growth stage .

2.1. Effect of irrigation :

Alberte and Thornber (1977), found that the majority of chlorophyll lost in response to water stress occurs in the mesophyll cells with a lesser amount being lost from the bundle sheath cells. All of the chlorophyll loss could be accounted for by reduction in the lamellas content of the light harvesting chlorophyll a/b. Protein is a rather specific target for water stress. The decreased content of this chlorophyll protein accounts for the elevated chlorophyll a/b ratios and the reduced photosynthetic unit sizes of the two cell types in stressed plants.

Schobert and Tscheschesche (1978), concluded that proline posses high solubility in water. The hydrophilic behavior of proline is unusual because it's molecule posses a hydrophobic as well as a hydrophobic plant. They arrived at the conclusion that the actions of praline in proteins is therefore different from that of detergents , it does not interfere with intra molecular hydrophobic interactions of protein (which leads to the denaturation) but binds instead only with hydrophobic residues. They hypothezied that these properties of praline aggregates are preserved even with lowering of water potential in the cell and increase of the salt concentration.

Dorrenbos and Kassam (1979), reported that maize appears to be relatively tolerant to water deficits during the vegetative and ripening periods.

Kassam (1979), reported that maize appears to be relatively tolerant to water deficits during the vegetative and ripening periods. The greatest decrease in grain yields is caused by water deficits during the flowering period including tasselling silking and pollination.

Shalaby and Mikheil (1979), reported that increasing the number of waterings during vegetative growth, flowering and fruiting periods of maize plant led to higher grain yield/plant , increases were 15.5 and 37.9% for 8 and 10 waterings, respectively, as compared to 6 waterings.

Abd El-Gawad *et al.* (1980), studied the effect of skipping one of 6 irrigations on yield of maize hybrid D.C. 355. They found that grain yield, ear diameter, 100-kernel weight, ear number and the number of double-eared plants/feddan were decreased. However, the number of kernels/row were not affected. Skipping the 3^{rd} , 4^{th} or 5^{th} irrigation reduced grain yield by 21.0, 19.9 and 17.0%, respectively. The greatest reduction in 100-kernel weight resulted from omitting the 5^{th} or 6^{th} irrigation.

Hall *et al.* (1980), found that the decreased pollen grains due to water stress was in proportion to drought susceptibility of the varieties.

Moustafa and Seif El-Yazal (1980), studied the effect of irrigation intervals of 9, 12, 15, 18 or 21 days on vegetative, flowering or maturity growth stages of hybrid D.C. 186. They found that grain yield was decreased with increased irrigation intervals at all growth stages. The greatest effect on grain yield resulted from the effect on flowering stage. The best irrigation intervals of 12, 9 and 15 days were recommended, respectively, for vegetative, flowering and maturity stages.

Gardner *et al.* (1981), stated that the greatest reduction was obtained when water stress occurred during the pollination or grain-filling periods.

Herrero and Johnson (1981), suggest that due to delay in silking, pollen may be exhausted before the silks appear and this was the reason for reduced grain number under drought. However, when pollen from fully watered plants was added to plants under drought stress at different stages of silk development , zygotes were formed but failed to develop even when the stress was relieved prior to pollination.

Herrero and Johnson (1981), reported that stressed plants maintained a low leaf water potential so their silk elongation rate was lower than the well watered plants . Severe stress caused delay in silking until all or most of the pollen had shed , therefore large numbers of barren stalks or poorly filled ears were obtained at harvest .

Labanauskas *et al.* (1981), found that water stress during the flowering and pod-filling stages of cow pea plants increased the free amino acids pool. Proline, arginine, threonine, serine, cystire valine, methionine and isoleucine were significantly affected by water stress. However, there were no consistent patterns in the effect of water stress on the individual amino acids. The sum of protein amino acids in the cow pea seeds was not significantly influenced by various treatments, since some of the protein amino acids increased and others decreased producing an averaging effect on the sum of the amino acids.

Ainer (1983), indicated that irrigation at 20% deficit of the available soil moisture for the upper 60 cm layer of the soil significantly increased ear diameter, number of kernels/row, number of ears/plant, 100-kernel weight and grain yield/fed., as compared to irrigation at deficits of 40, 60 or 90%. However, the crude protein percentage decreased by increasing the amount of available moisture at irrigation time.

Aly (1984), applied irrigation at 20%, 50% and 80% deficits from the available soil moisture for the upper 60 cm layer of the soil. He found that ear length and grain yield were increased by increasing the soil moisture content at irrigation time, while kernels number/ear and weight of 100-kernels were not affected.

Chang and Lieu (1984), studied the effect of leaf position on proline accumulation and the differences in proline accumulating abilities among ten soybean cultivars under drought stress conditions. They noticed that old and mature leaves contained more proline than young leaves. On the other hand, the increase of proline was paralled to the decrease of leaf water potential under drought conditions. Roots could not synthesize proline, but proline could be transported from leaves to roots. Proline could be accumulated pronouncedly under moderate to severe drought but the content of proline could also be reduced among soybean cultivars under the same drought conditions.

El-Sahookie and Wasson (1988), showed that soil moisture stress decreased grain yield/plant, grain yield and its efficiency (grain yield/unit leaf area).

Mohamed (1984), in Egypt, indicated that yields of grain, stalks and total DM increased with increasing irrigation and fertilizer application. At 300 m^3 irrigation / feddan , water use efficiency increased with increase in N application but at 400 and 500 m^3 , water use efficiency was greatest at 50 kg urea/feddan.

Bhaskaran *et al.* (1985), stated that in ten varieties of sorghum grown as callus culture, proline levels increased due to water stress induced by the addition of polyethylene glycol (PEG) to the medium. They also observed that the magnitudes of these increases were not correlated with stress tolerance of the individual varieties in culture.

El-Kassaby *et al.* (1985), found that increasing the available soil moisture deficit decreased plant height, dry weight of plant, weight of grain/plant, weight of 100-grains and consequently the grain yield (ard./fed.).

Salwau (1985), found that 100-kernel weight was consistently decreased by skipping one irrigation during flowering and maturity stages.

Westgate and Boyer (1985), concluded that early kernel development was highly dependent upon the supply of assimilates from because plant reserves were not sufficient to maintain kernel growth at low water potential .

Harold (1986), found that water deficit during the vegetative growth had little effect on kernel weight . Grain yield reduction was proportional to reduction in kernel weight .

Mohamed *et al.* (1986), found that the maximum 50-53% and minimum 8% reduction in ear yield was detected by skipping the 3^{rd} or 4^{th} irrigation and the 2^{nd} one, respectively. For straw yield the reduction amounted from 36, 33 and 28% by skipping 2^{nd}, 3^{rd} and 4^{th} irrigation respectively. Number of 21-23 folds of the control treatment as earn plants deprived of 3^{rd}, 4^{th} or 5^{th} irrigation.

Nour El-Din *et al.* (1986), mentioned that effect of drought was significant on ear and straw yields when maize plants imposed to drought during ear formation or grain filling stages and during vegetative stage.

Ragab *et al.* (1986), found that maximum (50–53%) and minimum (8%) reduction in ear yield was detected by skipping the 3^{rd} or 9^{th} irrigation and 2^{nd} one, respectively.

Saeed (1986), reported that soil moisture was depleted during mid season more than during vegetative growth stage will definitely affect crop yield depending upon the degree of stress.

Sobrado (1986), found a strong relationship between leaf expansion rate under drought and pre drown leaf turgid potential elongation ceasing at turgid potential of less than –0.2 M pa. Water stress accelerates the senescence of lower leaves in maize and cultivars with increased capacity for asthmatic stalk compared with control plants. However accumulation of TEC and TKN in excess of control values in the isolated plants did not prevent kernel loss.

Soliman (1986), found that water deficit shortened the effective filling-period and reduced grain yield. However, the period involving silk emergence and pollen shedding has bean identified as the most sensitive to drought. Substantial yield losses have been observed even when drought occurs during the vegetative or the grain filling periods.

Westagate and Boyer (1986b),found that varied the time around pollination when low W was present. As the time 4- increased after pollination exposure to low W resulted in less abortion by 10-14d after pollination exposure to low W rarely caused abortion.

Ouattar *et al.* (1987), found that maize kernel development was not affected when severe water stress was imposed during either early or mid grain filling. Maintenance of a high stalk moisture content in spite of severe leaf dehydration, may had facilitated translocation of assimilates from the stalk to the grain.

Schoper *et al.* (1987), reported a sensitivity of pollen to high temperatures and indicated that there was genotypic variation for this sensitivity.

Fredrick *et al.* (1989), reported that water stress delayed silking and antithesis dates in addition to its effect on shortening the grain filling period.

Fischer *et al.* (1989), reported that after three cycles of improvement , grain yield of maize was increased by 1.8, 7.8 and 20.6% under mild, medium and severe moisture deficits, respectively. Also, they reported significant changes in drought correlated traits but there was no significant change in days to flowering under normal irrigated conditions.

Gieant *et al.* (1989), reported that kernel number of maize ears was sensitive to moisture stress at intervals of 2 to 7 days after silking and ended 16 to 22 days after silking. Yield decrease resulting from soil moisture deficit depends upon numerous factors, such as growth stage at which the moisture deficit develops, the severity and duration of water deficiency, and the susceptibility of the examined genotypes .

Vassey and Sharkey (1989), showed that in phaseolus this decrease induced an inhibition of sucrose phosphate synthase (SPS) activity when measured in normal air. The SPS inhibition was relieved by a 5 h exposure to 1% CO_2.

Sinclair *et al.* (1990), majored both grain yield and total accumulated biomes at crop maturity were measured and the examined relationship between these two parameters . In all cases high linear correlation between grain yield and accumulated biomes was obtained. At moderate stress harvest index of the crop was stable-under , severe stress the accumulated biomes was less than but grain yield decreased to a greater extent than accumulated biomes.

Sinclair *et al.* (1990), reported that severe water stress during the R_1 (silking) to R_3 (early grain-fill) reduced grain dry matter accumulation more than total dry matter accumulation because of premature senescence.

Sobrado (1990), studied the effect of three water regimes, i.e., weekly irrigation (IRR) no irrigation between 30 to 56 days from sowing (D_1); no irrigation from 15 to 56 days from sowing (D_2) on six maize varieties and hybrids. He observed that kernel number and kernel size were reduced under water stress as compared to the IRR regime . Kernel number and kernel size were more reduced in D_2 than in D_1. A strong correlation between leaf area at anthesis and grain yield was observed, suggesting that small leaf area, as a consequence of water deficit during vegetative development of the crop decreased the carbohydrate source available for kernel growth.

Ashour (1991), found that drought stress increased soluble protein content, peroxidase activity, total free amino nitrogen and free proline, these changes were more pronounced in Clark than in Call variety. He reported that free proline content in stressed Clark plants was 9.4 times greater than control at 29 days old. Also, he mentioned that adapted plants of both soybean varieties accumulated more free proline as compared to non-adapted plants at the age of 37 days in response to drought stress for one day. Moreover, he reported that drought stress increased the relative percentage of some amino acid, e.g., proline while decreased others in both soybean and maize. He concluded that the response of biochemical constituents in plant cells to drought stress varied widely among soybean and maize plants and also within a tissue over time course.

Helweg (1991), indicated that in case of high water use efficiency, the highest feasible crop production can be obtained. Schedules most of plants must be adjusted according to the changes in crop water requirement over the growing periods.

Ober *et al.* (1991), showed that there was no difference in water potential among basal kernels from these two treatments. The anatomy of the developing kernel is such that after pollination, the majority of water is presumably channeled through the placental chalazal /region of the kernel.

Schussler and Westgate (1991), showed that plant water deficit during flowering and early kernel growth, reduced maize yield by decreasing kernel number per ear.

Zinselmeier (1991), reported that water deficit prior to pollination decreased ovary water content by about 3-4% (87% to 83% moisture) and that enough to cause abortion of nearly all pollinated florets.

Bassetti and Westgate (1993), found that silks lost receptivity to pollen as they aged if plants were subjected to water limitation. Much emphasis has been placed on minimizing these asynchronous effects by genetic selection for drought tolerant plants.

Bolanos *et al.* (1993), reported that good grain yield and normal antithesis silking interval (ASI) were not a consequence of improved water relations but rather were due to improved partitioning of biomes toward the female inflorescence at flowering.

Many plants , including halophytes , when exposed to drought or salinity stress accumulate compatible osmolytes , such as amino acids , sugar alcohols (e.g. pinital) , other sugars (e.g.,fructose) and quaternary ammonium compounds (e.g., glycine betaine)

Delauney and Verma , (1993) . Although many workers have reported positive correlations between the capacity for praline accumulation and drought or salinity tolerance of different varieties of some species **O'regan *et. al.*, (1993)** and **Vanrensburg *et. al* ., (1993)** . Others have defined the value of proline accumulating potential as positive index for tolerance to osmolic stress **Delauney & Veramd (1993) and Hever (1994)**.

Edmeades *et al.* (1993), reported that kernel set in maize grown under drought or high plant density was decreased to a greater extent in genotypes whose average spi kelet biomes was less than 1.0 mg at silk emergence.

Hefini *et al.*(1993), showed that ear length, ear height, number of kernels/row, 100-kernel weight, grain yield/plant and straw yield/feddan were significantly decreased by increasing the depletion of available soil moisture from 40 to 80%.

Jones (1993), noted that high water use efficiency (WUE) may be associated with low productivity and decreased water use. Paradoxically is often positively associated with biomes and grain yield under drought.

Keller and Ludlow (1993), observed an increase of activity for starch hydrolyzing enzymes, sucrose synthesis and sucrose content in drought stressed leaves of pigeons tropical legume. Moreover, the changes were associated with an increased activity of SPS and the pinitol synthetic pathway.

Abdalla *et al.* (1994), evaluated twenty sorghum biocolor genotypes, 13 locally adapted landraces and 7 commercial cultivars in four water stress treatment. He reported that in general, water deficit at all stages adversely affected the agronomic traits although the degree to which they were affected varied according to the growth stage at which the water stress was applied. Grain protein content was decreased in plants that were water stressed at flowering, grain filling and physiological maturity stages.

Schussler and Westgate (1994), found that the brief water deficit decreased Kernels per ear by 45% in the controls, 72% in the shade treatment and 49% in the isolated treatment. Low kernel set in the shade treatment was associated with low levels of total extractable carbohydrate (TEC) and total kyeldahl nitrogen (TKN) in stalk leaves and reproductive stage.

Varvel (1994), reported precipitation use efficiency (PUE) of 36-137 kg ha^{-1} cm^{-1} for growing continuous maize as compared to 57-165 kg ha^{-1} cm^{-1} in maize-soybean rotation. Adjustment of water supply have been shown to have a delayed leaf senescence under drought.

Westgate (1994), found that drought during booting and flowering stages in sorghum greatly reduced grain yield.

Dhopte *et al.* (1995), reported that the increase of amino acids (proline, glycine and phenylalanine) was similar in both tolerant and susceptible grain sorghum genotypes, under normal and water stressed conditions. They found that lysine and valine contents were considerably affected. The former being reduced and the latter being increased under stress conditions in the susceptible genotype (R-208). They proposed supplementing crop with lysine may probably endure stress conditions.

Sadek *et al.* (1995), showed that the maximum water use efficiency was obtained when using 7 irrigations. Skipping one irrigation at (silking + 5 days) regime was applied in both seasons of the study.

Varvel (1995), found that PUE for soybean averaged 30 kg ha^{-1} cm^{-1} whereas sorghum was 89 kg ha^{-1} cm^{-1} during 8 years period studies.

Attaallah (1996), reported that plant height, ear height, ear leaf area, number of ears/plant, number of rows/ear, grain yield/plant and grain yield/feddan were significantly decreased with increasing irrigation interval.

Bolanos and Edmeades (1996), studied the drought tolerance in six tropical maize populations and found that grain yield, kernels/cob, kernels/plant, and kernel weight were decreased with increasing drought.

Chapman *et al.* (1996), stated that maize crop was found to be susceptible to drought several weeks before and after flowering.

Chementi *et al.* (1996), found some variability for Osmotic Adjustment (OA) in 20 maize inbred characterized by either high or low OA in yield.

Eyherabide *et al.* (1996), reported that 34 – 40% of the inter annual variability of yield in the principal maize growing region of Argentine are explained by variations in rainfall in the 30 days period immediately prior to and just after flowering of the crop.

Khedr *et al.* (1996), found that irrigation at 25% or 50% water depletion gave similar yields which were significantly higher than irrigation at 75% depletion. Water use efficiency (WUE) was the highest when irrigation was done at 50% water depletion, and was higher for cultivars S.C.9 and T.W.C. 320.

Abdul-Salam and El-Naim (1997), studied the effect of cutting height (at the soil surface and 15 cm above) on the chemical composition of leaves, stem and whole plant of grain sorghum and pop corn. Percentage of crude protein was higher in pop corn leaves and stem, whereas total ash was the highest in maize but crude fiber was the highest in grain sorghum. The highest amounts of total carbohydrate and total ash was in leaves, stem but the highest amount of total protein was in grain.

El-Karamity and Attaallah (1997), revealed that leaf area/plant, plant height, grain yield and its components (except ear length), protein and oil percentage in grains were significantly affected by irrigation treatments, while number of days to 50% tasselling and silking was not affected in both seasons.

Ribaut *et al.* (1997), reported that drought at flowering time of maize in some cases, have severe effect on the crop. Trials with F_3 families were conducted in the field under well watered conditions (WW) and two other water stress regimes affecting flowering (intermediate stress [IS] and severe stress [SS]). Drought resulted in 60% decrease of grain yield under severe stress conditions (SS). The F_3 families that performed as the best under (WW) conditions were found to be proportionately more affected by stress and the yield reductions due to (SS) conditions were inversely proportional to the performance under drought.

Saied (1997), found that grain yield of maize was significantly decreased when plants were subjected to drought when withholding one irrigation at vegetative, flowering and grain formation stages. Reduction in yield was more pronounced when withholding irrigation coincided flowering and vegetative stages. Effect of water regime on grain yield and weight of 100-kernels was highly significant. He ascribed the decrease in grain yield to the decrease in available water in the root zone, which reduced uptake of water and nutrients.

Tollenaar *et al.* (1997), reported a greater number of ears and kernels in a stress tolerant hybrid than a stress susceptible hybrid.

Wesgate (1997), reported that a decrease in as simulates production in drought plants under drought coupled with inhibition of the carbohydrate metabolism in the fertilized ovaries lead to a decrease of carbohydrate partitioning to the ear and eventually to kernel abortion.

El-Sayed (1998), reported that reduction in yield due to drought at different growth stages was accompanied by losses in grain yield components, i.e., number of ears/plant, rows/ear, kernel/row, and 100-kernel weight. The reduction in ears/plant was higher than reduction in all other yield components at all stressed moisture regimes. In contrast water stress caused significant increase (delay) in silking date by 7.4, 6.1 and 6.7 days and elongation in anthesis silking intervals (ASI) by 5.4, 5.9 and 5.9 days when water stress was imposed at pre-flowering, flowering and post flowering stages , respectively. Also, he observed an increase in leaf temperature relative to air temperature by 114, 113 and 117 due to drought stress imposed at pre-flowering, flowering and post flowering stages, respectively.

Lemcoff *et al.* (1998), concluded, through analysis of a multiplication data base trial and measurements of capacity for Osmotic Adjustment (OA) in several hybrids, that genetic variation for (OA) exists in temperate maize and that high yield stability.

Voleti *et al.* (1998), studied the proline accumulation under moisture stress at three different growth stages in young and mature leaf tissues of *Brassica carinata* hybrids of tropical origin and their parents. They reported that proline accumulated significantly in young leaves at pre-flowering stage and immature leaves at flowering stage. They also observed maternal influence for this character.

Abu-Grab and Othman (1999), reported that grain and stover yields were the most affected characters by moisture stress at all tested drought stages. Reduction in grain yield were 24.27, 34.39 and 20.54% when plants were subjected to drought at vegetative, flowering and grain filling stages, respectively.

Al-Naggar *et al.* (1999), found that grain yield was significantly reduced by soil moisture stress at both GS_2 and GS_3 stages, but GS_3 (grain filling stage) was more sensitive to stress than the GS_2 (pre-flowering stage). They attributed this contrast in results to anther factor i.e., the drought severity at GS_3 due to length of stress period, which was 45 days at GS_2 while was 55 days at GS_3.

Abdalla Abou Elazem *et al*. (2000), studied the effect of skipping irrigation at the different plant growth stages of maize on yield, they indicated that skipping on irrigation at grain filling stage, i.e., milk ripe or dough stage produced the highest yields which were 17.59 and 18.00 percent of the control. Water stress during the vegetative and flowering stages caused the highest yield reduction, which was 37.98 percent of the control. They concluded that the more the soil moisture stress the more was the grain yield reduction. Moreover both vegetative and flowering stages are the most critical stages, where plants suffered from drought stress and yield decreased more than any other stage of plant growth during the growing season.

El-Ganayni *et al.* (2000), mentioned that flowering stage was the most sensitive to water deficit, where the reduction was 68% in grain yield and 53% in number of ears per plant. They added that grain filling stage was also sensitive. The pre-flowering and flowering stages were equal in sensitivity to water deficit effect on anthesis silking interval and number of rows/ear. When water stress elongated it reduced number of rows/ear by 4% as compared to the control. Moreover, severe stress experienced from the beginning of flowering stage until maturity showed maximum reduction in grain yield (75%) ears/plant (56%) and rows/ear (5%) as compared to the control. Also, prolonged irrigation interval of 22 days significantly reduced grain yield/plant and number of kernels/ear as compared to irrigation at 12 days.

Young *et al.* (2000), examined the effects of water stress on the contents of proline, ornithine, arginine and glutamic acid in detached rice leaves. They concluded that in water stressed leaves, the proline content of was elevated to approximately 8, 14 and 17 fold higher than in control leaves after 4, 8 and 12 h., respectively. Also, they observed that ornithine and arginine contents were much higher under water stress than in control leaves. Moreover, the contents of glutamic acid in water stressed leaves was higher after 4 and 8 h and lower after 12 h than that in control leaves.

Asch *et al.* (2001), found that leaf water potential decreased slowly as a function of available soil water content and resulted in 0.4 Mpa at the end of the longest irrigation period and 0.12 Mpa at the end of the shortest irrigation period. Under fully water conditions plot yields averaged 1400 gm^{-2} for total dry matter (DM) and 700 gm^{-2} for grain yield with a harvest index of about 0.5. Initiation of drying cycle close to flowering did not change yields while long drying cycles resulted in significant yield reductions up to 70% of the fully watered control. Kernel number per cob was reduced up to 60%under long drought conditions and not affected under short term drought.

Berengur and Faci (2001), found that water stress produced a decrease of the seasonal evapotranspiration , total dry, matter grain yield and harvest index. The relationships between the total dry matter, grain yield and harvest index versus the seasonal irrigation water applied was linear in the four sorghum plant densities.

Berengur and Faci (2001), showed that the differential irrigation treatments significantly affected the productive parameters and the grain yield of sorghum. Water stress produced a decrease of the seasonal evapotranspiration, total dry matter, grain yield and harvest index. The important decrease of the harvest index as water stress increased, indicated that grain yield was more sensitive to water stress than dry matter production.

Ober and Sharp (2001), found that at a low water potential (LWP) of -1.6 Mpa, the rate of pro deposition in the root tip was decreased by 75% in flurid one (FLU) treated compared to untreated roots. FLU treatment increased root diameter and therefore water content per unit length. But water deposition rates decreased longitudinal expansion. Thus the decrease in pro concentration was attributable entirely to the decrease in pro deposition**.**

Zeinab (2001), studied the effect of drought stress on the accumulation of free amino acids and described difference between drought tolerant and susceptible genotypes. In general, absolute amount of most free amino acids increased under stress compared to control. The maximum increase in free amino acids due to water stress occurred in proline content and lower increase was in glutamic acid.

Banziger *et al.* (2002), found that heavier kernel weights were likely the result of delayed leaf senescence and increased assimilate supply during grain filling. They concluded that decreased ear abortion and increased assimilate supply during grain filling of maize was due to good water supply. Selection for tolerance to mid season drought also provide tolerance to nitrogen stress and therefore may contribute to increased yield and yield stability.

Khalifa *et al*. (2002), indicated that there was significant difference between the two stress levels for all studies traits except for ear diameter, number of rows per ear in one grown season while no. of days to mid silking and leaf proline content (LPC) in another season. Water stress resulted in (30.3 %– 43.2 %) reduction in grain yield in 2000 season and 11.6% - 20.0% in 2001 grow season. Reductions due to water stress in no of ears /100plants , ear length and diameter , no. of rows per ear , no. of kernel per row, 100 kernel weight and plant height were (8.1 – 20.8 % , 9.1 – 14.3% , 0.7 – 4.5% , 1.4 – 3.7% , 13.1 – 23.6% , 6.4 – 12.8% and 0.2 – 10%) ,respectively . Considerable changes in LPC at flowering stage. LPC increased by (10.7% - 41.1% and 19.9%), at 52, 62 and 90 days, respectively as compared to values under normal irrigation.

Claudio *et al.* (2005), reported that the components of yield and their determinants (i.e., floret number/ear, grain set, grain number and weight per grain) exhibited differential responses with timing of the drought and in response to level of Osmotic Adjustment (OA). They concluded that (OA) can contribute to drought tolerance in maize exposed to water deficit both before and during flowering.

2.2. Effect of maize varieties:

Maize crop is known to be sensitive to available soil moisture, since plant growth, grain yield and yield components are known to be diversely affected by water deficits. The effect of water stress on yield and its components of maize was found a relation between the tested genotypes, severity of water stress and plant growth stage.

Herrero and Johnson (1981), used the single cross (FR632xFR 619) to study the effect of different soil moisture treatments at tassel emergence. Mild and severe drought increased the interval from initial silking to initial pollen shed by an average of 3 and 4 days, respectively. Plants under stress maintained a low leaf water potential, so their silk elongation a rate was lower than the well-watering plants. Severe stress delayed silking until after all or much of the pollen had shed therefore, large numbers of barren or poorly filled ears were noticed at harvest. They concluded that the effect of drought that begins at anther's shedding was greater on female floral development than on male ones.

Ihsan and Dorffling (1982), found that proline levels increased continuously during the stress period in the four varieties but with different amounts. The drought susceptible varieties Shaheen and Goldprinz produced higher levels of proline than the drought resistant varieties Swabi white and Garbo.

Patil (1983), studied 3 genotypes of maize under three moisture regimes. He found that grain yield was generally reduced under water stress. Reduction in case of composite varieties was lower than in hybrids. He attributed this result to better penetration and distribution of the root composites.

Dow *et al.* (1984), identified the morphological and physiological traits related to drought tolerance in maize. They found that the drought index was correlated negatively with date of mid anthesis. Selection for early selling related to antithesis could be beneficial in breeding for drought resistance.

Villegas *et al.* (1985), compared some cultivars of maize under irrigated and stress conditions. They suggested that the most drought resistant cultivar had the least delay in silking under stress conditions.

El-Hattab *et al.* (1986), reported significant differences in grain yield/plant and grain yield/feddan among maize cultivars grown under different soil moisture stress.

Lorens *et al.* (1987), identified a difference in dry matter accumulation between the two maize hybrids Pioneer Brands 3192 and 3165 when subjected to water stress. Under drought grain yield of the hybrid 3165 was higher than of hybrid 3192. This finding was explained on the basis of higher plant growth and final biomes rate of hybrid 3165.

Undersader (1987), detected no differences in yield and yield components of maize hybrids involving different heat-and drought- susceptible lines. He declared that number of ears per plant was more important than number of kennels per ear.

Ashraf (1989), found that the leaf water potential and turgor potential can be employed as a criterion to determine drought resistance of maize cultivars and lines during early vegetative growth.

Gie *et al.* (1989), evaluated the response to drought stress at different separate growth stages of the single crosses Danyh 13, Yudan8, Zhengdan 8, 171x330, and the inbred Baiha. Yield of the 5 varieties and inbreds were reduced significantly when water stress was imposed at the grain filling stage.

Fischer *et al.* (1989), evaluated the full-Sib progenies of the tropical low land Tuxpeno population under low, medium and severe moisture-deficit treatments. Average yields were 6.1, 4.3 and 1.61 T/ha, respectively. The interaction between yield of the genotypes and soil moisture deficit was significant.

Frederick *et al.* (1989), subjected four hybrids to soil moisture deficit from early vegetative development until pollination. They found that drought stress delayed silking and anthesis dates and reduced grain-filling period of each hybrid, but had little effect on the date of phepiological maturity. The period between anthesis and silking was increased under drought in the two single crosses (B73 x LH38) and FS854, but was not changed in the single cross (B73 x Mo 17) and decreased in U 513. Results of this study showed that the delayed- senescence hybrids B73 x LH 38 and FS 854 were the most resistant to drought imposed during the vegetative and early reproductive development.

Nigem (1989), reported that, significant differences were found among nine maize varieties. In general D.C.202, Giza-2 and Cairo-1 were superior in grain yield, ear length, number of green leaves and leaf area/plant as compared with “Local-1, Local-2, Sabeeny, Nab EL-Gamal’’ Pioneer 514 and Pop. 45.

El-Bialey *et al.* (1991), revealed that there were varietal differences in growth and yield plants of both S.C. 10 and D.C.215. They were taller and had lower number of rows/ear than those of Giza-2 but had taller ear length and higher number of grain/row. With respect to grain yield S.C.10 produced higher yield followed by D.C.215 while Giza-2 gave the lowest yield.

Bedeer *et al.* (1992), found that maize hybrid D.C.204 and 215 produced higher grain yield than the open-pollinated variety Giza-2. D.C.204 was the most productive hybrid (25.17ard/fed) followed by D.C.215 and Giza-2 (24.37 and 23.5 and/fed), respectively.

Ibrahim *et al.* (1992) found significant differences among five maize varieties under different irrigation treatments in number of ears/plant, number of rows/ear, number of kernel/row, and grain yield over two seasons.

Nesmith and Ritichie (1992), studied the effect of several soil water deficts during the grain- filling period in two maize hybrids. Reduction in yield ranged from (21% to 40%) according to the stress treatment. Kernel weight was the most decreasing trait as a result of the short grain filling period.

Shalaby (1992) reported significant differences among maize genotypes under different drought treatments. The studied genotypes differed greatly under drought stress for 100-kernel weight and grain yield.

Weerath-Aworn (1992), studied water stress for a prolonged period before or after flowering stage. They found that prolonged water stress before flowering reduced grain yield due to lower kennel number and 100-kernel weight. Post flowering stress mainly reduced 100-kernel weight. They mentioned that some cultivars were tolerent to water stress at the pre- flowering stage while others were tolerent at post flowering.

Bolanos *et al.* (1993), conducted eight cycles of full-sib recurrent selection in the population Tuxpeno grown under stress at flowering and grain filling stages. They studied also the direct and correlated selection response in number of days to flowering, days from 50% antithesis to 50% silking (ASI) and biomes of reproductive organs at antithesis. Grain yield and its components especially kernels/plant showed a strong dependance upon ASI.

Camacho and Caraballo (1994), subjected 10-maize cultivars to increasing water deficit in a late growth stage. The cultivars differed significantly in all growth parameters except length of the roots. Cargill-163 hybrid, was the least sensitive to water deficit. It was suggested that measurement of the root dry weight was the most appropriate criterion for selection of maize genotypes to drought tolerant.

Mitu *et al.* (1994), found that the cumulative effect of drought stress during growth period in the drought years of 1987 and 1988 resulted in (73% - 88%) yield reduction when compared to condition in normal year. Some hybrids showed good tolerance to drought under field conditions, reduction in yield ranged from (21% to 40%) according to the stress treatment. Kernel weight was the most decreasing trait as a result of the short grain-filling period**.**

El-Karamity and Atta-Allah (1997), found that the highest grain yield and its components were recorded with S.C.10 cultivar irrigated with fresh water over the season, followed by those irrigated with drainage water after receiving two irrigations with fresh water. So, one-third of fresh water could be replaced by drainage water in irrigation with no sacrifice in yield. The lowest values for the studied were produced by Giza-2 cultivar, irrigated with drainage water over the whole growing season. The highest grain protein was recorded with SC. 10 cultivar irrigated with drainage water over the growing season, while the highest oil percent was obtained with Giza-2 irrigated with drainage.

Moursi (1997), found that maize genotypes differed significantly under water stress in number of rows/ear, ear weight, number of kernels/row, 100 kernel weight, and grain yield.

Subramanian and Charest (1997), subjected two different sensitive maize cultivars to drought stress for 3 weeks following tasselling (75-95 days) after sowing. Grain yield of a sensitive cultivar was reduced by 55%.

El-Sayed (1998), evaluated 18 open-pollinated populations of maize under different soil moisture regains. Based on high absolute yield the local cultivars Giza-2 and the CIMMYT'S drought-tolerant populations DTP-l and DTP-2 were considered as the most drought resistant genotypes. On the other hand some populations behaved as highly susceptible under pre-flowering stage and some others were high susceptible at either flowering or post flowering stages.

El-Sheikh (1999), found that late- season water stress had more severe effects on grain yield than early- season water stress. Grain yield of hybrids S.C.10 and T.W.C. 73 and four double cross was less than single crosses. Single crosses exhibited severe reduction in the early season stress treatment (skipping the second irrigation, 80 days from planting). Reductions in grain yield as a percentage of the control were 5% and 16% in 1995 season 8% and 22% in 1996 season for early-and late season stress treatments, respectively. The most sensitive period was flowering stage therefore, tolerant cultivars would be affected by reduction in kernel dry matter accumulation and consequently kernel weight.

Ibrahim *et al.* (2001), reported that Giza-2 was more tolerant than S.C 155 since 50% of its grains have greminated at the water potential 0.8Mpa, while the germination percentage of S.C 155 was reduced to 30% at soil water potential-0.6MPa, and 100 %inhabited at –0.8 Mpa treatment. The photosynthetic efficiency of Giza-2 leaves was higher than S.C 155 hybrid at all levels of soil water potentials.

Mahgoub *et al*.(2001), found that the behavior of coardo populations under the two irrigation levels differed from one populations to another, moreover , response of different traits to selection for drought tolerance varied considerably among populations and between the two irrigation levels . Reduction in yield under drought stress was less for C1 (29.6%) of Giza 2 C6 , Giza 2 C8 , DTP. 1 C7 (Y) and DTP.2 C5 (W) populations . Average gain cycle for grain yield under draught stress was 10% improved performance under drought stress of the four populations was mainly due to an improvement in number of ears per plant and – or 100 kernels weight . The selection succeeded to reduce the silk tassel interval under drought stress by 1-3and 5 days. Giza-2 C8 is the best population for the development of drought tolerance inbred lines.

3. MATERIALS AND METHODS

3. MATERIALS AND METHODS

Two field trials were conducted at the Experimental Farm of Nubaria Agricultural Research Station ARC, which represent calcareous soil of newly reclaimed land of Nubaria and north west Egypt. Trials were conducted in 2002, 2003 and 2004 growing seasons to evaluate the effect of some drought treatments on growth and yield of 4 maize (*Zea mays*, L.).cultivars

Due to failure in applying some of the irrigation treatments at the proper time in 2004, the results presented and discussed are those of 2002 and 2003 only.

The preceded crop was wheat in the two seasons. Sowing date was 20^{th} and 15^{th} of June in the two successive seasons. Two seeds were hand-sown in hills spaced 25 cm on ridges of 0.70 m apart. Hills were thinned to one plant after 21 days from planting. The recommended cultural practices for Nubaria region were followed. Harvest was done on the 21^{st} and 14^{th} of October for the two successive years.

3.1. Soil type

The soil in which the experiments were conducted is calcareous . The physical and chemical analysis of the soil is given in **Table (1)**.

The experimental design was spli-plot with four replicates. Irrigation treatments were randomly assigned to main plots while hybrids were assigned to sub-plots. Each sub-plot consisted of 3 rows of 6 m., long and 0.70 m. apart. The two central rows were harvested for grain yield data.

3.2. Treatments and experimental layout

Two experimental factors including irrigation treatments and cultivars were studied in the present experiment. The levels or treatments of each factor was as follow :

3.2.1. Irrigation treatments :

Skipping one irrigation at each of the following growth stages **Table (2)**.

1- The conventional irrigation practices applied in Nubaria Region, i.e., the first irrigation at 21 days from sowing, the following 6 irrigations were given at 15 days intervals.

2- Pre-flowering, 35-50 days from planting (skipping 2^{nd} irrigation).

3- Flowering 50-65 days from planting (skipping 3^{rd} irrigation).

5- Early grain filling 65-80 days from planting (skipping 4^{th} irrigation).

6- Late grain filling 80-95 days from planting (skipping 5^{th} irrigation).

7- Skipping irrigation at pre-flowering + early grain filling (the 2^{nd} and 4^{th} irrigations).

8- Skipping irrigation at flowering + late grian filling (3^{rd} and 5^{th} irrigations).

9- Skipping irrigation at pre-flowering + late grian filling (the 2^{nd} and 5^{th} irrigations).

Table (1): Soil chemical and mechanical analysis of the two experimental sites in 2002 and 2003 seasons.

Variables	0 – 30 cm		30 – 60 cm	
	2002	**2003**	**2002**	**2003**
E.C.ds m-1-paste ext.	3.60	4.26	3.09	4.16
pH (1 : 2.5 soil : water)	8.4	8.45	8.00	8.10
OM (%)	0.51	0.49	0.53	0.50
$CaCO_3$ (%)	21.90	23.85	22.98	24.05
Available P ug P/g soil	6.5	7.16	6.2	6.2
Available N ug N/g soil	46.00	28.00	50.00	24.00
Soluble cations (meq/l) :				
Ca^{++}	17.40	12.09	17.04	12.19
Mg^{++}	12.06	10.05	16.43	9.09
Na^{++}	5.04	4.36	4.00	4.06
K^{+}	0.98	1.00	1.30	0.90
Soluble anions (meq/l) :				
CO_3^{-2}	0.00	0.00	0.00	0.00
HCO_3^{-}	3.59	4.30	2.05	3.20
Cl^{-}	29.00	20.35	32.12	21.00
SO_4^{-}	1.98	3.99	1.50	0.99
DTPA-Fe, ext., ppm	3.20	3.40	3.40	3.30
DTPA-Zn, ext., ppm	0.40	0.46	0.79	0.80
DTPA-Cu, ext., ppm	0.70	0.78	0.55	0.60
DTPA-Mn, ext., ppm	1.31	1.15	1.39	1.29
Mechanical analysis :				
Sand %	47.00	5000	56.00	50.50
Silt %	29.00	30.00	26.00	29.50
Clay %	24.00	20.00	18.00	20.00
Texture order	**Sandy clay loam**		**Sandy clay loam**	

Table (2): Irrigation treatments involved in the study in 2002 and 2003 seasons.

Irrigation treatments	Growth stage			
	Pre-flowering 35-50 days from planting	**Flowering 50-65 days from planting**	**Early Grain filling 65-80 days from planting**	**Late grain filling 80-95 days from planting**
A1- Skipping 2nd irrigation	**X**			
A2- Skipping 3rd irrigation		**X**		
A3- Skipping 4th irrigation			**X**	
A4- Skipping 5th irrigation				**X**
A5- Skipping 2nd in 4th irrigation	**X**		**X**	
A6- Skipping 3rd in 5th irrigation		**X**		**X**
A7- Skipping 2nd in 5th irrigation	**X**			**X**
A8- Control				

To avoid water leakage from irrigated to non-irrigated plots, a ditcher and two border ridges were aligned between each two main plots. Also, a parallel irrigation ditch was digged between each two main plots.

3.2.2. Maize hybrids :

Four different maize hybrids were used in all experiments. These hybrids may be classified according to the following :

Hybrids	Plant height	Maturity	Kernel color
S.C. 123	**Tall**	**Intermediate**	
T.W.C. 321	**Tall**	"	**White**
Giza 2	**Tall**	"	
DTP-1	**Intermediate**	"	

The objectives of the present investigation were :

1- To study the effect of different water stress treatments (skipping certain irrigation) on yield, yield components and different growth characters.

2- To determine the best cultivars from among the studied cultivars to be recommended for farmers in Nubaria area which have irrigation problems

3.3. Data recorded

The following data were recorded for each plot.

3.3.1.Agronomic characteristics: This part includes the following agronomic

Characteristics :

1. Plant height: The height from the soil surface to the base of the flag leaf in cm (from 5 guarded plants/sub-plot).

2. Ear height (cm.): The distance from soil surface up to the node of the top most ear.

3. Stem diameter: The diameter of the stem in the middle of the internode under the ear position (cm).

4. Leaf area index: The leaf area index was determined as follows:

$$LAI = (\frac{LA}{GA})$$

LA. Leaf area (cm^2): was estimated at anthesis growth stage as the average of five plants leaves taken randomly from each sub plot. It was measured using electrical apparatus (LI-3000 portable Area Meter, LI-3050. The methods recommended by **Radford (1967)**.

GA = ground area (cm^2)

5. Days to 50 percent tasselling : Expressed as the number of days from planting to the day when 50% of the plants had tasseled in each sub-plot.

6. Days to 50 percent silking : Expressed as the number of days from planting to the day when 50% of the plants had silk emergence.

7. Chlorophyll determination : Chlorophyll content was determined as a SPAD unit (Soil Aplant Analysis Departement) of Minolta Co. This unit was trasnformed to mg/gm as described by Monge and Bugbe, (1992) as follows:

Chl. =80.05 + 10.4 (SPAD 502)

8. Leaf water potential (-bar): It was determined using a pressure meter (plant water status console model 3005, Santa Barbara, Ca. U.S.A) at four times during the growing seasons (after each of the drought treatment)

(1) Pre-flowering (35-50 days)**.**

(2) Flowering (50-65 days).

(3) Early grain filling (65-80 days).

(4) Late grain filling (80-95 days).

3.3.2.Chemical characters:

1. **Leaf proline content:** Three fresh-leaf samples were taken for physiological determination of percentage leaf proline content (LPC, (g\g) as physiological indicators of the plant status under the implemented water stress treatments. Sampling time was at 49, 65, and 80 days after planting (DAP) representing pre-flowering, flowering and early grain filling stages. Samples were collected between 11: 00 am and 2:00 pm. Leaf disks were taken from two plants in each plot. The leaf disk were immersed immediately in the cooled proline extraction solution (3% aqueous sulfosalicylic acid solution). Samples were taken to the cooled conditions and were kept refrigerated until extraction and determination of leaf proline content (Bates *et al.* 1973). Samples were measured by spectrophotometer and repeated twice .
2. **Pollen grain viability (%):** The number of pollen grain per scop as described by Walden and Everett (1961).

3.3.3. Yield and yield components :

This part of the study includes the following :

1. **Ear length :** length of the ear (cm), measured from 5 random ears/sub-plot.
2. **Cobe diameter :** was measured in cm., as an average of the same five cobes used in ear length estimation.
3. **Number of kernels per row :** was estimated from the samples taken before.
4. **Weight of 100-kernels (gm):** taken randomly from the some five ears used in the length estimation.
5. **Grain yield/hectare (ton/ha):** The yield of grain/sub-plot (kg) was adjusted to 15.5% moisture content and than transformed to ton/hectare.
6. **Straw yield (ton per hectare):** Straw yield, estimated as weight of straw of the two middle raws after harvesting ears.

Reduction percentage (RD%) was calculated as the following :

$$\mathbf{RD\% = (Y_c - Y_d)/Y_c \ X \ 100}$$

where :

$\mathbf{Y_c}$ = Normal irrigation

$\mathbf{Y_d}$ = Skipping irrigation

Drought susceptibility index (DI) was calculated for grain yield and yield components according to Fischer and Maurer (1978) as the following :

$$\mathbf{DI = (1 - Y_d/Y_c) / D}$$

where :

Y_c = grain yield of the same genotype in the control treatment.

Y_d = grain yield of the same genotype in the drought treatment.

$$\mathbf{D = drought\ intensity = 1 - \frac{(Mean\ Y_d\ of\ all\ genotypes)}{(Mean Y_c\ of\ all\ genotypes)}}$$

3.4. Statistical analysis

Data of all studied characteristics were analyzed according to the model for split-plot design described by **Snedecor and Cochran (1969)**. Means for the different treatments were compared using L.S.D. values at 0.05 level of probability.

4 RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

The main objectives of the present investigation were to study the effect of drought treatments and cultivars on yield and some agronomic characters of maize (*Zea mays*, L.).

The results of each studied characteristics will be presented and discussed separately. Significant differences at 0.05 level of probability will be considered as true differences.

4.1. Agronomic characteristics

This part includes the following agronomic characteristics:

- Plant height (cm.).
- Ear height (cm.).
- Stem diameter (cm.).
- Number of leaves.
- Leaf Area index.
- Days to 50 percent tasselling.
- Days to 50 percent silking.
- Chlorophyll content.
- Leaf water potential (LWP).

4.1.1. Plant height:

Means of plant height, as affected by different irrigation treatments and varieties are presented in **Table (3)**.

Data in **Table (3)** indicated clearly that plant height of the studied cultivars in 2002 and 2003 seasons was significantly affected by different irrigation treatments.

The highest significant reduction in plant height was obtained from the 1st, 5th and 7th irrigation treatments. This coincided with pre-flowering, and pre-flowering + early grain filling and pre-flowering + late grain filling. The corresponded means were 218.00, 218.94 and 218.19 versus 247.75 cm for the control treatment (2002 season), and 211.13, 208.88, 212.25 versus 239.25 cm for the control treatment (2003 season), respectively. The reduction percentage relative to the control were 8.80, 8.82 and 8.81% in 2002 season, and 8.83, 8.73 and 8.87% in 2003 season, respectively. The least reduction in plant height was obtained from the 4th irrigation treatment (late grain filling) where plant height was nearly the same as that of the control treatment.

Skipping irrigation at flowering and flowering + late grain filling (the 2nd and 6th irrigation) followed the previous treatments in lowering plant height. Means of this treatment were 229.19 and 229.19 cm in 2002, 229.69 and 225.81 cm in 2003 season, respectively. This finding are supported with those obtained by **Mokadem and Salem (1994); Esmail (1996) and El-Ganayni *et al.* (2000)** whom mentioned that the pre-flowering stage was the most sensitive to water stress and plant height was reduced by 23%.

The reduction in plant height may be attributed to the loss of cell turner which affects rates of cell division and cell enlargement. The lowest plant height resulted from water treatment that included skipping the 1st irrigation (pre-flowering growth). The finding might be attributed to skrinkage of cells and reductions of elongation caused by inadequate watering during vegetative growth more than other growth stages. These findings are in agreement with those obtained by **Ashoub (1977)** who found that plant height was decreased with the increase in the level of soil moisture deficit before irrigation. **Mahgoub (1979)** found that water stress during vegetative growth stage caused significant reduction in plant height. **Ainer (1983); Aly (1984); Salwau (1985)** found that skipping two or three irrigations during flowering and maturity stages caused significant reduction in plant height. Also, **Porro and Cassel (1986)** reported that delaying irrigation during a dry growing season reduced plant height. **Salem (1993 a)** showed that increasing irrigation in-interval from 12 days to 18 days decreased plant height significantly. **Atta-Allah (1996)** indicated that plant height was significantly increased with shortining irrigation intervals from 20 to 10 days.

The results presented in **Table (3)** indicated that maize varieties varied significantly in plant height in both seasons across all irrigation treatments. S.C. 123 and TWC 321 cultivars had the tallest plant height (245.65 and 245.25cm.) , respectively , as an average of the two seasons. Difference in plant height between varieties is mainly attributed to the genetic make up of these varieties. **Shalaby and Omar (1981)** reported that the late varieties were taller than medium ones, while the early variety was the shortest one. Similar results were obtained by **Ibrahim *et al.* (1992)** and **Moursi (1997)** who found significant differences in plant height among five maize varieties under different irrigation treatments.

Irrigation treatments X cultivars interactions (I X C) was insignificant in both seasons, indicating similar performance of the studied cultivars under the studied irrigation treatments.

4.1.2. Ear height:

The analysis of variance showed significant effect for both skipping irrigation treatments and maize cultivars on ear height in both seasons.

Different irrigation treatments resulted in highly significant differences for ear height of cultivars in 2002 and 2003 seasons **Table (3)**.

Skipping any irrigation in 2002 and 2003 seasons resulted in significant decrease in ear height as compared to the control treatment except treatment A4 (skipping irrigation at late grain filling) in 2002 and treatment A3 (skipping irrigation at early grain filling) in 2003 where they showed insignificant ear height reduction as compared to the control treatment. The highest reduction in ear height in 2002 was obtained by skipping irrigation at pre-flowering + early grain filling, flowering and pre-flowering + late grain filling stages (the 5th , 2nd and 7th irrigations treatments). Means of these treatments and the control were 126.65, 127.31 , 127.75 cm and 146.25 cm., respectively. The relative reduction was 8.65, 8.71 and 8.74% as compared to the control.

Table (3): Effect of drought treatments on plant height and ear height (cm.) of four maize cultivars in 2002 and 2003 seasons.

Characters studied / Treatments	Plant height (cm.)		Ear height (cm.)	
	2002	**2003**	**2002**	**2003**
Drought treatments (A) :				
Skipping 2nd irrigation A_1	218.44 c	211.13 c	130.13 cd	117.19 e
Skipping 3rd irrigation A_2	229.19 b	229.69 b	127.31 d	126.69 c
Skipping 4th irrigation A_3	243.81 a	234.50 a	136.88 bc	135.81 ab
Skipping 5th irrigation A_4	245.56 a	235.87 a	141.94 ab	133.50 b
Skipping 2nd and 4th irrigation A_5	218.94 c	208.88 c	126.56 d	117.38 de
Skipping 3rd and 5th irrigation A_6	229.19 b	225.81 b	134.06 cd	125.88 c
Skipping 2nd and 4th irrigation A_7	218.19 c	212.25 c	127.75 d	123.25 cd
Control (give all irrigation) A_8	247.75 a	239.25 a	146.25 a	141.75 a
L.S.D. 0.05	**9.69**	**8.48**	**9.03**	**5.98**
Cultivars (B) :				
S.C. 123	247.44 a	243.69 a	146.31 a	139.41 a
T.W.C. 321	250.75 a	237.72 b	149.53 a	136.91 a
Giza -2	221.03 b	217.75 c	123.34 b	123.09 b
DTP –1	206.38 c	197.53 d	116.25 c	111.31 c
L.S.D. 0.05	**4.66**	**3.89**	**4.58**	**4.44**
Interaction :				
A X B	**N.S.**	**N.S.**	**N.S.**	**N.S.**

N.S. : Not significant.

Means followed by the same letter, within each column are not significantly different from each other according to L.S.D. at 0.05 level of probability.

In 2003 season, the highest reduction in ear height as compared to the control was obtained by skipping irrigation at pre-flowering growth, pre-flowering + early grain filling and pre-flowering + late grain filling stages (the 1st , 5th and 7th irrigations) treatments.

Means of these treatments and the control treatment were 117.19, 117.38 , 123.25 and 141.65 cm., respectively. The relative reduction was 8.27, 8.28 and 8.70% as compared to the control.

It can be concluded that skipping irrigation in earlier stages of plant growth reduced ear height and produce shorter plants. These results are in accordance with those obtained by **Ashoub (1977)** who found that ear height was decreased with the increase in the level of soil moisture deficit. Also, **Salwau (1985)** found that skipping two or three irrigations during flowering and maturity stages caused significant reduction in ear height.

El-Ganayni *et al.* (2000) mentioned that the pre-flowering stage was the most sensitive to water stress causing reduction of 25% for ear height, **Balba (2002)** found that the highest significant reduction for ear height was obtained by skipping irrigation at vegetative, seed setting and grain maturity stages (the 3rd , 5th and 7th irrigations).

Means of ear height for hybrids are presented in **Table (3)**. Results showed that T.W.C. 321 and S.C. 123 had the highest ear height in 2002 season (149.53 and 146.31 cm). Giza 2 population ranked second (123.34 cm), while DTP-1 population produced the shortest ear height (116.25 cm). In 2003 season, S.C. 123 had the highest ear height (139,42 cm.) as compared to the other cultivars. No significant differences were detected between the S.C. 123 and T.W.C. 321. DTP-1 population had the lowest ear height (111.31 cm). Similar results were reported by **Badr *et al.* (1993)** and **El-Sheikh (1999)**.

Ibrahim *et al.* (1992) found significant differences for ear height among five maize varieties under different irrigation treatments. **Moursi (1997)** found that maize genotypes differed significantly for ear height under water stress treatments, **Balba (2002)** reported that S.C. 10 had the highest ear height under water stress as compared to T.W.C. 324 and S.C. 160.

The effect of the interaction between skipping irrigation treatments and cultivars on ear height was insignificant in both seasons of study. Showed that irrigation treatment and varieties acted independently on the previous character.

4.1.3. Stem diameter.

Mean of stem diameter in 2002 and 2003 as affected by skipping irrigation treatment and varieties and their interaction is given in **Table (4)**.

Stem diameter results showed that maximum stem diameter of the studied maize cultivars was obtained from the 4th irrigation treatment (skipping irrigation at late grain filling) in the two successive seasons. The decrease in stem diameter due to 1st irrigation treatment (skipping irrigation at pre-flowering) during both seasons. These findings are in harmony with those obtained by **Herrero and Johnson (1981); Ainer (1983); Ibrahim *et al.* (1992)** and **Atta-Allah (1996).**

Differences in stem diameter among the studied varieties were significant in 2002 and 2003 seasons, respectively. Giza 2 and DTP-I varieties had the smallest stem diameter in both seasons. However T.W.C. 321 and S.C. 123 gave the highest stem diameter in 2002 and 2003 seasons, respectively. Similar results were obtained by **El-Hattab *et al.*(1985); Nigm (1989)** and **El- Bialy *et al.* (1991)**.

The first order interaction between drought treatments X varieties was insignificant in 2002 and 2003 seasons.

4.1.4. Leaf Area index :

Data in **Table (4)** revealed the presence of significant differences in leaf area index of some varieties of zea maize due to different irrigation treatments in both seasons of the study. The differences between the control treatment and each of skipping irrigation treatments was significant, except for skipping the 3rd and 4th irrigation treatments in both seasons. The highest reduction in leaf area index resulted from skipping irrigation at pre-flowering , pre-flowering+ late grain filling and pre-flowering + early grain filling stages (the 1st, 7th and 5th irrigation treatments). Seed setting and grain maturity stages corresponds with the 5th and 7th irrigation treatments. Means of LAI at 1st, 5th and 7th irrigation treatments in 2002 were 5.49, 5.61 and 5.42 as compared to 6.31 for the control treatment. The corresponding values in 2003 season were 4.98, 5.02 and 4.97 versus 5.50 for the control treatment. The reduction in leaf area as compared the control were 8.7, 8.9 and 8.6 % in 2002 and 9.1, 9.11 and 9.03% in 2003 season, respectively. Skipping irrigation at early grain filling and late grain filling stages (skipping the 3rd and 4th irrigation treatments) had almost no reduction in leaf area as compared to control treatment. Leaf area index for the two stages and the control treatment were 5.98, 6.08. and 6.31, respectively. It was clear from the obtained results that the highest effect of skipping one irrigation was obtained when skipping occurred at the pre-flowering growth stage.

Atta-Allah (2001), stated that smaller leaf area index may be advantageous under water stress conditions, due to less water requirements and less transpiration area. Reduction in leaf area was also reported by **Sobrado (1990)**, he suggested that smaller leaf area caused by water deficit during vegetative development decreased the carbohydrate source available for grain growth. **El-Marsafawy (1995)**. also, reported that prolonged irrigation interval resulted in lower leaf area index. **Mohammad *et al.* (1998)** found that leaf area index was reduced by water stress during the reproductive development. This result as well as that of **El-Ganayni *et al.* (2000)** agreed well with our finding that the pre-flowering stage was the most sensitive to water stress. **Dow *et al.* (1984)** identified morphological and physiological traits related to drought tolerance in maize hybrids. They found that the drought index was correlated negatively with leaf area index. **Nesmith and Ritichie (1992)** also, found that plants grown under irrigation water deficit during grain filling had less green leaf area, while, **Wery *et al.* (1994)** found that severe water stress caused the older leaves of plant to senescence early leaving only the younger leaves to support the plant. They added that the loss of the older leaves appears to be an effective adaptation since the top leaves which are more active in photosynthesis are retained. Moreover, reduction of growth and acceleration of leaf senescence are common response to water deficit and the reduction in leaf area.

Data recorded in **Table (4)** showed that the studied maize varieties differed significantly from each other in leaf area index across all water stress treatments. T.W.C.321 had the highest leaf area index (6.71 and 6.01) in both successive seasons. On the other hand, the DTP-I variety had the lowest leaf area index (4.96 and 4.44) in 2002 and 2003 seasons, respectively. These differences are mainly attributed to the genetic constitution of the 4 varieties since two of them, i.e. S.C. 123 and T.W.C. 321 are hybrids while the other two, i.e. Giza-2 and DTP-1 are populations and expected to have less plant growth as compared to hybrids. These results are in harmony with those of **Nigem (1989) and Atta-Allah (1996).**

The effect of the interaction between some irrigation treatments and varieties on leaf area index was significant in 2002 season only as shown in **Table (5)**.

Salem *et al.* (1983) suggested that the difference in this trait among varieties is generally attributed to the difference in their genetic make up, **Ibrahim *et al.* (1992)**, found significant differences in leaf area of five maize varieties under different irrigation treatments. **Moursi (1997)** found that maize genotypes differed significantly in leaf area under water stress.

Drought susceptibility index (DI) has been used to characterize relative drought tolerance of grain maize genotypes. Low drought susceptibility index (DI < 1) is synonymous with higher stress tolerance.

Table (6) indicated that grain maize genotype could be categorized into two groups , high and low values according to drought susceptibility index (DI) and reduction percentage (RD%) in leaf area index for each irrigation treatment in 2002 season. For treatment (skipping 3^{rd} irrigation) the highest values of DI and RD% were for Giza-2 (1.13 and 15.5%, respectively), while the lowest values were for S.C.123 (0.88 and 12.1%, respectively).

For treatment (skipping 4^{th} irrigation) the highest values of DI and RD% were for DTP-1 population (1.96 and 21.8%, respectively), the lowest values of the two parameters were for T.W.C.321 (0.43 and 4.8%, respectively). For treatment (skipping 5^{th} irrigation) showed that the highest values of DI and RD% were 1.39 and 8.4%, respectively for DTP-1 population, while the lowest values were 0.86 and 5.12%, respectively for Giza-2 population. Regarding treatment (skipping 6^{th} irrigation) indicated that the highest values of DI and RD% were 1.82 and 7.9%, respectively for DTP-1 population, while the lowest values were 0.03 and 0.14%, respectively for T.W.C.321.

Concerning treatment (skipping 3^{rd} and 5^{th} irrigations) the highest values of DI and RD% were 1.30 and 17.6%, respectively for DTP-1 population, while the lowest values were 0.85 and 11.5%, respectively for T.W.C.321. For treatment (skipping 4^{th} and 6^{th} irrigations) showing the highest values of DI and RD% were 1.20 and 10.7%, respectively for DTP-1 population, but the lowest values were (0.69 and 5.7%), respectively for Giza-2 population. For the last treatment (skipping 3^{rd} and 6^{th} irrigations) the highest values of DI and RD% were 1.46 and 23.33% , respectively for T.W.C.321, while the lowest values were 0.63 and 10.0%, respectively for S.C.123.

Table (4): Effect of drought treatments on stem diameter (cm.) and leaf area index of four maize cultivars in 2002 and 2003 seasons.

Characters studied / Treatments		Stem diameter (cm.)		Leaf area index	
		2002	**2003**	**2002**	**2003**
Drought treatments (A) :					
Skipping 2nd irrigation	A_1	2.39 c	2.43 d	5.49 d	4.98 c
Skipping 3rd irrigation	A_2	2.56 a	2.53 bc	5.70 bcd	5.18 abc
Skipping 4th irrigation	A_3	2.50 ab	2.49 cd	5.98 abc	5.36 ab
Skipping 5th irrigation	A_4	2.59 a	2.60 a	6.08 ab	5.35 ab
Skipping 2nd and 4th irrigation	A_5	2.39 c	2.46 cd	5.61 cd	5.02 c
Skipping 3rd and 5th irrigation	A_6	2.53 ab	2.57 ab	5.83 bcd	5.10 bc
Skipping 2nd and 4th irrigation	A_7	2.43 bc	2.48 cd	5.42 d	4.97 c
Control (give all irrigation)	A_8	2.54 a	2.59 ab	6.31 a	5.50 a
L.S.D. 0.05		**0.09**	**0.07**	**0.47**	**0.33**
Cultivars (B) :					
S.C. 123		2.51 a	2.57 a	6.21 a	5.65 a
T.W.C. 321		2.53 a	2.57 a	6.71 a	6.01 a
Giza -2		2.45 b	2.47 b	5.32 b	4.63 b
DTP –1		2.48 ab	2.46 b	4.96 b	4.44 b
L.S.D. 0.05		**0.06**	**0.04**	**0.52**	**0.41**
Interaction :					
A X B		**N.S.**	**N.S.**	******	**N.S.**

N.S. : Not significant.
**** : Significant at 0.01 level of probability.**

Means followed by the same letter, within each column are not significantly different from each other according to L.S.D. at 0.05 level of probability.

Table (5): The effect of interaction between drought treatments and varieties on leaf area index /plant of four maize cultivars in 2002 and 2003 seasons.

Treatments		Leaf area index /plant	
Skipping Irrigation	**Varieties**	**2002**	**2003**
A_1	S.C. 123	5.88	5.49
A_2		5.89	5.56
A_3		6.33	6.00
A_4		6.36	5.94
A_5		5.83	5.42
A_6		6.15	5.46
A_7		6.02	5.56
A_8		6.69	6.02
A_1	T.W.C. 321	6.43	5.93
A_2		6.98	6.08
A_3		6.94	6.45
A_4		7.32	6.37
A_5		6.49	5.77
A_6		6.69	5.84
A_7		5.62	5.37
A_8		7.33	6.09
A_1	Giza 2	4.85	4.29
A_2		5.29	4.74
A_3		5.44	4.79
A_4		5.43	4.61
A_5		5.01	4.57
A_6		5.41	4.58
A_7		4.97	4.53
A_8		5.74	4.89
A_1	DTP 1	4.80	4.19
A_2		4.43	4.35
A_3		5.19	4.49
A_4		5.22	4.46
A_5		4.67	4.26
A_6		5.06	4.50
A_7		4.76	4.41
A_8		5.67	4.77
L.S.D. 0.05		**0.18**	**N.S.**

Table (6): Drought susceptibility index (DI) and reduction percentage (RD%) for leaf area index season 2002.

Leaf area index 2002								
	S.C. 123		**T.W.C. 321**		**Giza 2**		**DTP-1**	
	DI	**RD%**	**DI**	**RD%**	**DI**	**RD%**	**DI**	**RD%**
A1	0.88	12.1	0.90	12.3	1.13	15.5	1.12	15.3
A2	1.07	11.4	0.43	4.8	0.70	7.8	1.96	21.8
A3	0.89	5.4	0.88	5.3	0.86	5.12	1.39	8.4
A4	1.13	4.9	0.03	0.14	1.24	5.4	1.82	7.9
A5	0.95	12.8	0.85	11.5	0.94	12.7	1.30	17.6
A6	0.96	8.1	1.04	8.7	0.69	5.7	1.20	10.7
A7	0.63	10.0	1.46	23.33	0.84	13.4	1.00	16.0

4.1.5. Days to 50% tasselling :

Significant differences among the studied irrigation treatments for number of days to 50 % tasselling were obtained as shown in **Table (7)**. Moreover, differences among the 4 studied cultivars across different irrigation treatments were significant **Table (7)**.

In 2002 season, skipping irrigation at flowering stage caused significant delay in tasselling .The relative reduction as compared to the control was (-6.3%) .

In 2003 season ,skipping irrigation at pre-flowering and flowering stages (3^{rd} and 4^{th} irrigations) caused significant delay in tasselling. The relative reduction compared to the control were (-4.22% and -8.57% respectively).

El-Nigoly (1975) found the moisture stress delayed tasseling in most of varieties abd F_1 crosses tasseling date were considerably earlier in autumn than summers season. **Frederick *et al.* (1989)** also, reported that water stress delayed tasseling dates, beside its effect on shorting grain filling period. Also, **Moursi (1997)** found that water stress increased number of days to 50% tasseling. **Dow *et al.* (1984)** identified the morphological and physiological traits related to drought tolerance in maize hybrid. They found that the drought index was correlated negatively with date of mide anthesis.

Differences among cultivars were significant when Giza-2 was the earliest in both growing seasons (52.41 and 54.3 days), respectively. S.C.123 was the latest tasselling (59.47 days) in season 2002, while T.W.C. 321 and S.C. 123 were the latest (59.56 and 59.28 days respectively) in season 2003.

The results indicate that drought stress caused earlier tasseling which is confirmed by **El-Sheilh (1999)**, he explained that early season skipping irrigation (at 35 days from planting, 2^{nd} irrigation) resulted in earlier plants than conventional and late season (skipping the fifth irrigation, 80 days from planting) stress treatment **Mourad *et al* (1999)** reported that early flowering and short periods of antithesis are the most mechanisms of resistance and tolerance the stress conditions.

Early tasseling shorten vegetative growth stage of maize indicating earlier maturity **El-Nigoly (1975)** evaluated forty-four elite maize varieties of diverse genetic origin, and obtained significant differences in number of days to tasseling among varieties.

The interaction between irrigation treatments and cultivars was significant as shown in **Table (8)** which indicates that cultivars pre-formed differently across different irrigation treatments. S.C. 123 and DTP-1 cultivars had significant delayed tasseling (63.25, 62.50 and 63.25, 63.7 days) respectively in both seasons when the fourth irrigation was skipped (flowering stage), while T.W.C. 321 showed significant delayed tasseling (61.75 days) in 2003 only when the same irrigation was skipped. Skipping the third irrigation (pre-flowering stage) caused significant delay in tasseling for T.W.C.321 and DTP-1 cultivars (60.5 and 59.0 days respectively in 2003 season.

4.1.6. Days to 50% silking :

The main effects of the different factors for number of days to 50% silking, and their analysis of variance are given in **Table (7)**, respectively.

The analysis of variance for such trait indicated that there were significant differences for the effect of the two factors on number of days to silking during 2002 and 2003 seasons.

In both seasons skipping irrigations at flowering (skipping 4th irrigation) caused significant delay in silking (62.38 and 64.5 days respectively. The relative reduction compared to the control were (-7.8% and -10.8% respectively), while skipping irrigation at pre-flowering (skipping 3th irrigation) caused significant delay in silking (60.50 day) in season 2003 only. Increase in number of days to 50% silking (delay silking) due to drought stress during the pre-flowering and flowering, the plant became more delayer. This result and conclusion is in accordance with that stated by El-Sayed (1998), who reported that water stress caused significant increase (delay) in silking date when water stress was imposed at pre-flowering, flowering and post-flowering stages.

Frederick *et al.* (1989) who identified the morphological and physiological traits related to drought tolerance in maize hybrids and found that the drought index was correlated negatively with day from mid anthesis and mid silking. Therefore, selection for early silking related to anthesis could be beneficial in breeding for drought resistance.

Differences among cultivars were significant when Giza-2 was the earliest in both growing seasons (54.81 and 56.91 days), respectively. S.C.123 was the latest silking (61.91 days) in season 2002, while T.W.C. 321 and S.C. 123 were the latest (61.91 and 61.81 days respectively) in season 2003 as shown in **Table (7).**

Khalifa *et al.* (1984 a) who reported that varieties significantly differed in number of days to 50% silking. **Frederick *et al.* (1989)** reported that the time between anthesis and silking was increased by drought stress in some maize genotypes. **Bolanes and Edmeadres (1996)** who found that drought tolerant genotypes were characterized having shorter anthesis silking interval (ASI). **Gaafar (1993)** found that Giza 2 latter than Alex-11 by about 16.10 days as an average of the two seasons. **Atta-Allah (2001)** found that the most tolerant genotypes had a shorter ASI the most susceptible ones by about 1.4 days under water stress.

It was also shown that the interaction between irrigation treatments X varietiey was significant in both seasons of this studying. **Table (8)** reveals highly significant differences for number of days to 50% silking due to different irrigations treatments in both seasons of study.

S.C.123 and DTP-1 cultivars had significant delayed silking (67.0, 66.25 and 66.0, 66.5 days respectively) in both seasons when the fourth irrigation was skipped (flowering stage), while Giza-2 was the earliest one which reached to 50% silking under the same skipping irrigation treatments (pre-flowering and flowering) in both seasons.

Table (7): Effect of drought treatments on number of days to 50% tasselling and days to 50% silking of four maize cultivars during 2002 and 2003 seasons.

Characters studied / Treatments		Days to 50% tassel ling		Days to 50% silking	
		2002	2003	2002	2003
Drought treatments (A) :					
Skipping 2nd irrigation	A_1	55.94 bc	58.50 b	58.25 c	60.50 c
Skipping 3rd irrigation	A_2	59.19 a	60.94 a	62.38 a	64.50 a
Skipping 4th irrigation	A_3	55.63 bc	55.75 d	57.75 cd	57.81 e
Skipping 5th irrigation	A_4	55.31 c	55.81 d	57.44 d	58.00 e
Skipping 2nd and 4th irrigation	A_5	55.88 bc	57.19 c	58.25 c	59.44 d
Skipping 3rd and 5th irrigation	A_6	59.00 a	58.63 b	62.25 a	61.88 b
Skipping 2nd and 4th irrigation	A_7	56.31 b	58.00 b	59.00 d	60.31 c
Control (give all irrigation)	A_8	55.69 bc	56.13 d	57.88 cd	58.19 de
L.S.D. 0.05		**0.81**	**0.75**	**0.73**	**0.78**
Cultivars (B) :					
S.C. 123		59.47 a	59.28 a	61.91 a	61.81 a
T.W.C. 321		57.97 b	59.56 a	60.84 b	61.91 a
Giza -2		52.41 d	54.28 c	54.81 d	56.91 c
DTP –1		56.63 c	57.34 b	59.03 c	59.69 b
L.S.D. 0.05		**0.35**	**0.30**	**0.42**	**0.41**
Interaction :					
A X B		**	*	**	**

*** : Significant at 0.05 level of probability.**
**** : Significant at 0.01 level of probability.**
Means followed by the same letter, within each column are not significantly different according to L.S.D. at 0.05 level of probability.

Table (8): Interaction between drought treatments and varieties on number of days to 50% tassling and 50% silking of studied maize varieties during 2002 and 2003 seasons.

Treatments		Days to 50% tassling		Days to 50% silking	
Skipping Irrigation	**Varieties**	**2002**	**2003**	**2002**	**2003**
A_1	**S.C. 123**	58.50	58.25	60.50	60.25
A_2		63.25	62.50	67.00	66.25
A_3		58.75	57.25	60.75	59.25
A_4		58.00	58.25	60.00	60.25
A_5		58.25	58.00	60.25	60.50
A_6		62.75	61.00	66.25	64.00
A_7		58.75	60.00	60.50	62.75
A_8		57.75	59.00	60.00	61.25
A_1	**T.W.C. 321**	58.75	60.50	60.50	62.50
A_2		58.50	61.75	62.50	65.00
A_3		58.00	58.50	60.00	60.50
A_4		56.75	57.25	59.50	59.50
A_5		57.50	58.75	60.50	60.75
A_6		58.00	61.50	61.75	64.75
A_7		58.00	59.25	61.75	61.25
A_8		58.25	59.00	60.25	61.00
A_1	**Giza 2**	52.75	56.25	55.50	58.25
A_2		51.75	55.75	54.00	57.25
A_3		51.75	52.75	53.75	54.75
A_4		52.50	52.25	54.00	54.75
A_5		53.00	53.50	55.50	56.00
A_6		52.00	53.50	55.25	56.50
A_7		53.00	56.25	55.75	58.75
A_8		52.50	54.00	54.75	56.00
A_1	**DTP 1**	53.75	59.00	56.50	61.00
A_2		63.25	63.75	66.00	66.50
A_3		54.00	54.50	56.50	56.75
A_4		54.00	55.50	56.75	57.50
A_5		54.75	54.50	56.75	56.50
A_6		63.25	58.50	65.75	62.25
A_7		55.75	56.50	58.00	58.50
A_8		54.25	56.50	56.50	58.50
L.S.D. 0.05		**0.98**	**1.09**	**1.18**	**1.15**

4.1.7. Chlorophyll content:

Results of analysis of variance at 2002 and 2003 seasons are presented in **Table (9)** indicated clearly that photosynthetic pigments of maize leaves were affected significantly by irrigations treatments especially in 2003 season. Chloropyhll content reached its maximum concentration using normal irrigation treatment (control treatment) whereas the lowest concentration was obtained by skipping, 5th irrigation treatment in 2002 and 1st and 2th irrigation treatments in 2003. In 2002 season, skipping irrigation at the early grain filling stage and pre-flowering + early grain filling had resulted in significant decrease in chlorophyll content while in 2003, skipping irrigation mainly at the pre-flowering and flowering growth stages reduced significantly leaf chlorophyll content **Table (9)**. Leaf chlorophyll content was determined on the same leaves sampled for water potential measurements. We attempted to select leaves of the same physiological age by sampling the leaf appearing in the same position relative to the top of the plant. During the latter stages of the experiment, the leaves being sampled were physiologically somewhat more mature than those sampled at the start and were gradually accumulating more chlorophyll. This accumulation is typical response for growing leaves **(Maksymowych, 1973)**. These results are in harmony with those reported by **Alberte and Thornber (1977); Bakelana *et al.* (1986); Ragab *et al.* (1986); and El-Sheikh (1994)**.

The lower concentration of chlorophyll under water stress conditions might be attributed to low rate of synthesizing photo-chrome under such conditions . These results are in agreement with those reported by **Abd El-Gawad and Abo Shetiaia (1995)** .

Regarding varieties results presented in **Table (9)** for 2002 season indicated that DTP-1 population gave the highest chlorophyll content (642.07 ug/mg2) while S.C.123 gave the highest content in 2003 (544.51 ug/mg2) as compared to other varieties involved in the study in both seasons. Similar trend was reported by **Gardner *et al.* (1981) and Attia (1999)**.

It was noticed that the first order interaction between the drought treatments and cultivars for this character was not significant in both seasons as shown in **Table (9)**.

4.1.9. Leaf water potential (LWP).

Leaf water potential (LWP) for different irrigation treatments was measured at 49 days (pre-flowing), 65 days (flowring), 79days (pre-grain filling) and 94 days (end of grain filling period) from planting in 2002 and 2003 growing seasons **Table (10) and Figures (1, 2, 3 and 4)**.

Results in **Table (10)** indicated significant differences in LWP due to drought stress treatments when LWP was measured at 49, 65, 79 and 94 days from planting in both seasons of study. LWP was significantly higher for drought treatments than control treatment at all growth stages in both seasons. In 2002 when LWP was measured at 49 days from planting , it was found that the highest LWP (11.46 bar) was obtained at the pre-flowering stage (35-50 days) . At 65 days the highest LWP (17.96 bar) was obtained from skipping the 4th irrigation (50-65 days) which corresponds with the flowering stage . At 79 days , skipping the 5th irrigation (65-80 days) which corresponds with the early grain filling stage resulted in the highest LWP (20.64 bar) . At 94 days the highest LWP (21.49 bar) was obtained when the 6th irrigation (late grain filling stage) was skipped . similar results were obtained in 2003 season.

Table (9): Effect of drought treatments on chlorophyll content (μg/mg) of four maize varieties in 2002 and 2003 seasons.

Characters studied / Treatments		Chlorophyll content (μg/mg)	
		2002	**2003**
Drought treatments (A) :			
Skipping 2nd irrigation	A_1	621.16 ab	511.75 bc
Skipping 3rd irrigation	A_2	609.93 ab	500.21 c
Skipping 4th irrigation	A_3	606.50 b	529.12 ab
Skipping 5th irrigation	A_4	630.00 ab	538.79 a
Skipping 2nd and 4th irrigation	A_5	600.54 ab	516.23 bc
Skipping 3rd and 5th irrigation	A_6	613.46 ab	516.95 bc
Skipping 2nd and 4th irrigation	A_7	612.63 ab	516.14 bc
Control (give all irrigation)	A_8	638.32 a	537.96 a
L.S.D. 0.05		**30.34**	**20.70**
Cultivars (B) :			
S.C. 123		615.44 b	544.51a
T.W.C. 321		610.66 b	514.04 b
Giza 2		605.67 b	508.66 b
DTP 1		642.07 a	516.12 b
L.S.D. 0.05		**14.66**	**11.44**
Interaction :			
A X B		**N.S.**	**N.S.**

N.S. : Not significant.

Means followed by the same letter, within each column are not significantly different according to L.S.D. at 0.05 level of probability.

Table (10): Effect of drought treatments on leaf water potential (-bar) at different growth stages of four maize varieties during 2002 and 2003 seasons.

Treatments	49 days from planting		64 days from planting		79 days from planting		94 days from planting	
	2002	2003	2002	2003	2002	2003	2002	2003
Irrigation (A) :								
A_1	11.46 a	11.67 a	14.68 bc	15.23 bc	16.58 c	18.24 b	17.17 bc	18.49 b
A_2	7.24 b	7.91 c	17.76 a	18.88 a	15.93 cd	18.54 b	17.01 b	18.84 b
A_3	7.29 b	7.74 c	14.05 c	14.53 c	20.64 a	20.79 a	17.54 bc	18.35 b
A_4	7.10 b	8.24 c	14.82 b	15.04 bc	15.68 d	18.66 b	21.49 a	20.79 a
A_5	10.06 a	11.00 a	15.69 b	15.33 bc	20.13 a	20.36 a	17.88 b	18.36 b
A_6	7.21 b	7.89 c	17.46 a	18.14 a	17.47 b	18.23 b	21.17 a	21.29 a
A_7	10.43 a	10.86 b	14.75 bc	15.63 b	15.98 cd	18.61 b	20.48 a	20.99 a
A_8	7.22 b	7.96 c	14.13 c	15.58 b	16.08 cd	18.18 b	16.91 c	14.75 c
L.S.D. 0.05	**0.68**	**0.57**	**1.07**	**0.97**	**0.70**	**0.69**	**0.79**	**0.78**
Cultivars (B) :								
S.C. 123	8.86 a	9.22 b	16.12 a	15.69 a	17.63 a	19.07 ab	19.31 a	18.87 ab
T.W.C. 321	8.68 a	8.73 c	13.98 c	15.98 a	17.57 a	19.54 a	19.30 a	19.02 ab
Giza 2	7.71 b	9.26 ab	16.46 a	15.82 a	17.29 a	18.67 bc	18.18 b	18.64 b
DTP 1	8.75 a	9.65 a	15.22 b	16.19 a	16.72 b	18.53 c	16.88 c	19.38 a
L.S.D. 0.05	**0.43**	**0.40**	**0/52**	**0.52**	**0.55**	**0.53**	**0.40**	**0.64**
Interaction :								
A X B	**	**	**	N.S.	**	N.S.	**	N.S.

N.S. : Not significant.
**** : Significant at 0.01 level of probability.**
Means followed by the same letter, within each column are not significantly different according to L.S.D. at 0.05 level of probability.

Table (11): interaction between drought treatments and varieties on leaf water potential of maize plant during 2002 and 2003 seasons.

Treatments		49 days from growth		64 days from growth		79 days from growth		94 days from growth	
Skipping Irrigation	**Varieties**	**2002**	**2003**	**2002**	**2003**	**2002**	**2003**	**2002**	**2003**
A1	**S.C. 123**	10.50	11.38	15.25	14.30	16.55	18.31	18.25	18.37
A2		8.27	8.45	18.03	18.25	15.98	18.80	17.98	18.75
A3		7.65	7.85	13.93	14.47	20.85	21.05	18.40	17.97
A4		7.75	8.30	15.75	14.50	15.13	18.65	21.03	20.87
A5		11.00	11.55	16.00	14.82	20.00	20.80	18.80	18.62
A6		7.50	8.00	19.60	18.30	20.00	18.17	21.53	21.32
A7		10.15	10.30	15.10	15.12	15.98	18.62	20.73	20.00
A8		8.03	7.90	15.28	15.17	19.38	18.15	17.80	15.65
A1	**T.W.C. 321**	11.80	12.50	14.25	18.95	16.70	18.37	17.93	18.10
A2		6.28	6.35	15.93	18.07	15.95	19.50	17.75	18.85
A3		7.45	6.78	13.30	14.07	21.18	21.00	18.18	18.30
A4		6.75	6.15	14.15	14.70	15.25	19.20	21.25	20.67
A5		12.00	12.35	13.65	15.10	20.40	21.32	18.40	18.37
A6		7.00	6.35	15.80	19.15	17.70	19.52	22.40	21.55
A7		11.75	11.50	13.35	14.95	16.70	18.92	20.55	21.62
A8		6.45	6.65	11.40	15.70	16.70	18.50	17.95	14.65
A1	**Giza 2**	8.50	10.65	15.25	15.42	17.50	18.40	18.35	18.17
A2		7.30	8.00	18.28	17.05	15.85	18.00	17.85	18.62
A3		6.90	7.85	15.00	14.65	20.30	20.80	18.35	17.40
A4		7.18	8.55	15.18	15.40	16.33	18.55	19.63	20.80
A5		9.60	11.65	18.50	15.40	21.00	19.07	18.50	18.07
A6		7.18	8.442	18.48	17.32	16.18	17.37	20.38	20.42
A7		8.00	9.98	15.90	15.82	16.00	18.387	20.03	21.02
A8		7.05	8.95	15.10	15.50	15.20	18.25	17.38	15.35
A1	**DTP 1**	11.05	11.20	13.95	16.00	15.55	17.90	14.15	19.32
A2		7.13	8.65	17.68	17.25	15.95	17.85	14.45	19.72
A3		7.18	8.48	13.98	14.92	20.23	20.32	15.23	19.72
A4		6.73	8.95	14.20	15.55	15.00	18.25	20.08	20.80
A5		11.63	11.13	14.63	16.00	19.13	20.25	15.63	18.92
A6		7.18	8.80	17.98	17.77	15.77	17.85	20.38	21.83
A7		11.8	11.65	14.65	16.05	16.25	18.00	20.60	21.32
A8		7.35	8.32	14.73	16.00	15.85	17.80	14.53	13.35
L.S.D. 0.05		**1.21**	**1.14**	**1.44**	**N.S.**	**1.54**	**N.S.**	**1.13**	**N.S.**

It was clear from the previous results that skipping any of the 3rd, 4th, 5th or 6th irrigation or any combination among them, resulted in higher LWP at the corresponding growth stage as compared to the control treatment (normal irrigation). Leaf water potential is important because of its relation to cell turgor pressure and osmotic potential. The turgor component is important in cell expansion and cell division, while the osmotic component influences cell metabolism and enzyme activity **(Moustafa *et al.*, 1996)**. The present results are in a agreement with those obtained by **Lehman *et al.* (1993); Tollenaar *et al.* (1994a)** and **Asch *et al.* (2001)**.

Begg and Tuiner (1976) noticed that the use of total water potential was the best single indicator of plant water status has its limitation when attempting to understand the effect of water deficits on the various physiological process involved in plant growth.

Data in **Table (10)** indicated that little differences among the four cultivars effect for LWP accross the 7 irrigation treatments in both seasons. Giza-2 and DTP-I cultivars produced the highest LWP at 49 65 days from planting but T.W.C. 321 cultivar produced the highest LPW at 79 and 94 days from planting as an average for both seasons, respectively. Differences in leaf water potential (LWP) may, be explained in part by differences in rate of water use and soil water content at the time that measurements were made.

These results are in general agreement with those obtained by **Lehmen *et al.* (1993); Moustafa *et al.* (1996),** and **Ogola *et al.* (2002).** It is important to report that skipping 5th irrigation treatment (pre-flowering + early grain filling) with T.W.C. 321 variety gave the highest LWP at 49 days from growth in both seasons **Table (11) and Figures (5. 6. 7 and 8)**. But skipping the 6th irrigation treatment (flowering + late grain filling) with S.C.123 variety in **Table (11)** was obtained the greatest LWP at 65 and 94 days in 2002 season only. At 79 days skipping 5th (pre-flowering + early grain filling)with Giza 2 variety gave the highest LWP in the first season. **Moustafa *et al.* (1996)** found that the differences among the cultivars were not significant in the well watered treatment as compared to the water stressed treatments. They found that Giza 165 and Geimiza had low leaf water potential than klassic and Sphe-3 in the water stress treatments.

4.2. Chemical characters:

- Leaf proline contents.
- Pollen grain viability

4.2.1. Leaf proline content (LPC)

Leaf proline content was measured at 49 and 65days from planting. Results presented in **Table (12) and Figures (9 and 10)** showed that leaf proline content (LPC) was affected significantly by irrigation treatments.

Table (12): Effect of drought treatments on leaf proline content mg/g of four maize varieties grown in 2002 and 2003 seasons.

Treatments / Characters studied	49 days from planting		64 days from planting	
	2002	2003	2002	2003
Drought treatments (A) :				
Skipping 2nd irrigation A_1	42.08	35.80	19.43	14.83
Skipping 3rd irrigation A_2	29.24	22.92	20.66	16.78
Skipping 4th irrigation A_3	30.33	24.50	16.47	14.04
Skipping 5th irrigation A_4	29.93	22.02	16.08	12.62
Skipping 2nd and 4th irrigation A_5	43.31	37.88	18.17	16.19
Skipping 3rd and 5th irrigation A_6	28.91	20.74	19.99	17.38
Skipping 2nd and 4th irrigation A_7	41.01	33.7	17.62	14.20
Control (give all irrigation) A_8	20.03	20.96	14.17	15.27
L.S.D. 0.05	**2.08**	**3.1**	**2.05**	**3.24**
Cultivars (B) :				
S.C. 123	40.08	30.91	18.88	17.29
T.W.C. 321	40.53	30.48	18.73	16.34
Giza 2	29.34	23.33	18.39	14.34
DTP 1	25.96	22.67	15.65	12.17
L.S.D. 0.05	**1.40**	**1.92**	**1.35**	**1.29**
Interaction :				
A X B	**	**	**	**

N.S. : Not significant.
**** : Significant at 0.01 level of probability.**
Means followed by the same letter, within each column are not significantly different according to L.S.D. at 0.05 level of probability.

Leaf proline content as an indicator of drought stress at 49 days was increased significantly by skipping 1st, 5th and 7th irrigation treatments as compared to other treatments. Leaf proline content reached its maximum value (43.31 and 37.80 mg/g) when irrigation was skipped at the pre-flowering and/or early grain filling stages followed by skipping irrigation at both pre-flowering and late grain filling stage (41.01 mg/g) in both seasons.At 65 days leaf proline content was increased significantly by skipping 2th or 6th irrigation treatments as compared to control (8th treatment).At 65 days leaf proline content reached its maximum value (20.66 mg/g) when irrigation was skipped at flowering stage in the first seasons as well as by skipping irrigation at flowering + late grain filling stage (17.38 mg/g) in season 2003. Proline is considered to be involved in adaptation mechanisms in drought stress. These results are in harmony with those reported by **Stewart and lee (1974); Hahi and Doiffing (1982); Chang and lieu (1984); Bhaskaran *et al.* (1985) and Ashour (1991)**.

Schobert (1979) reported that a protective function for enzymes in the cytoplasm is to bind water to the proteins and thus maintain their hydration. Results of leaf proline content (LPC) for the four varieties at 49 days after planting in 2002 and 2003 seasons, are presented in **Table (12)**. Single cross 123 and T.W.C 321 varieties produced the highest LPC (35.49 and 35.51 mg/g), while DTP-I population produced the lowest LPC (24.31 mg/g) as an average of both seasons. At 65 days after planting in the same seasons, are presented in **Table (12)** S.C.123 produced the highest LPC (18.88 and 17.29 mg/g respectivly) while DTP-1 population produced the lowest LPC (15.65 and 12.17 mg/g respectivly) in both seasons. Results of proline content indicated that the two studied populations i.e. , Giza 2 and DTP.1 were less sensitive to drought stress treatments especially DTP.1 population which is used mainly as drought tolerant population . the two hybrids , i.e. , SC. 123 and TWC 321 were more sensitive to drought stress as they have narrow genetic base as compared to Giza-2 and DTP.1 populations. Results of LPC are encouraging but need to be confirmed over more growing seasons and over a wide rang of genotypes before deciding the most at critical period of plant growth that can be used as an indication of plant water status under drought stress.

The most sensitive physiological process to drought is photosynthesis. This process could be affected markedly due to less water availability especially in C_4 plants such as maize. So ,water shortage lead to inhibited photosynthetic activities of maize plants and as a result, less assimilates, therefore, the whole plant growth and yield are affected. These results are in good agreement with those reported by **Cavalier and Hang (1979); Sinclair and Ludlow (1985); Ekana and Maloy (1990); and Tollenaar *et al.* (1994)**.

Hahi and Dorffling (1982), found that proline levels increased continuously during the stress period in all the 4 varieties used in their study. The drought susceptible varieties Shaheen and Goldprinz produced higher levels of proline than the drought resistant varieties “Swabi white and Garbo”.

Singh *et al.* (1973) reported that barley varieties which accumulated larger concentrations of proline were found to be able to survive more extreme stress conditions than these with lower proline levels. On the contrary **Hanson *et al.* (1977)** was not able to confirm a positive correlation between proline accumulating potential and drought resistance capacity in barley.

Table (13): Interaction between some drought treatments and varieties on leaf proline content (mg/g) of 4 maize varieties grown in 2002 and 2003 seasons.

Treatments		49 days from proline		64 days from proline	
Skipping Irrigation	**Varieties**	**2002**	**2003**	**2002**	**2003**
A_1	**S.C. 123**	56.55	42.95	17.52	16.29
A_2		29.95	22.38	12.47	17.60
A_3		32.18	24.05	16.97	15.17
A_4		33.13	27.03	14.30	15.20
A_5		55.95	40.93	17.67	18.40
A_6		28.93	24.65	22.22	17.80
A_7		50.10	40.55	19.38	19.47
A_8		33.90	24.73	14.01	15.52
A_1	**T.W.C. 321**	46.43	49.93	21.35	18.20
A_2		38.75	17.85	18.77	20.47
A_3		34.45	25.95	13.87	10.79
A_4		37.75	26.53	13.75	11.70
A_5		47.95	40.60	16.52	19.45
A_6		38.30	18.88	18.50	19.18
A_7		46.33	45.58	20.68	18.15
A_8		34.03	18.55	14.35	13.70
A_1	**Giza 2**	33.13	31.63	20.57	19.95
A_2		26.38	17.18	18.50	19.30
A_3		25.55	20.73	11.15	15.26
A_4		26.40	20.53	13.57	12.30
A_5		34.80	26.78	17.10	16.03
A_6		27.80	18.93	18.55	17.87
A_7		34.08	31.08	23.42	18.62
A_8		26.60	19.78	13.27	12.42
A_1	**DTP 1**	33.03	26.70	11.25	12.85
A_2		21.88	19.08	11.90	13.75
A_3		21.15	19.28	14.90	12.95
A_4		22.43	22.00	13.20	10.70
A_5		34.53	27.23	13.38	14.60
A_6		20.63	20.53	12.70	14.93
A_7		33.23	25.73	15.03	14.55
A_8		20.80	21.00	12.35	10.33
L.S.D. 0.05		**3.98**	**5.44**	**3.81**	**3.66**

Table (13) and Figures (11 and 12) showed that (at 49 and 65) days. The first order interaction between some drought treatments and cultivars on such characteristic was significant in 2002 and 2003 seasons. The 4 varieties behaved differently at different drought stress treatments according to their genetic constitution . At 49 days, S.C.123 variety gave the highest value (56.55 mg/g) with skipping irrigation at pre-flowering (the 1^{st} irrigation treatment) in the first season, while T.W.C.321 gave the highest value (49.93 mg/g) in the second season with the same treatment. At 65 days, S.C.123variety gave the highest value (22.22 mg/g) with skipping irrigation at flowering + late grain filling (the 6^{th} irrigation treatment) in the first season, while skipping irrigation at flowering (the 2^{th} irrigation treatment) gave the highest value (20.47 mg/g) with the T.W.C.321 variety. The proline levels in the four varieties were found to be inversely correlated to their capacity to withstand severe water stress.

4.2.2. Pollen grain viability

Analysis of variance presented showed in **Table (14) and Figure (13)** that this characteristic was significantly affected by the skipping irrigation treatments in 2002 and 2003 seasons. The interaction between skipping irrigation x cultivars was not significant in both seasons.

Data presented in **Table (14)** revealed significant differences due different irrigation treatments in both seasons of study. Skipping irrigation at flowering (50-65 days from planting) resulted in a significant reduction in pollen grain viability (7.51%) as compared to the control treatment, while skipping irrigation at early grain filling stage (65-80 days from planting) resulted in 2.92% reduction in pollen grain viability. The mean values were 76.89, 69.38 , 73.97% (2002) and 76.62, 68.91, 74.20% (2003) for the control treatment, flowering and early grain filling stages, respectively. Moreover, no significant reduction in pollen grain viability was detected due to irrigation treatments that involved skipping irrigation at pre-flowering or late grain filling stages (The 3^{rd} or 6^{th} irrigation) as compared to the control treatment in both seasons.

Grain numbers on the ear decrease because several developmental changes especially ovary abortion and increased pollen sterility as a result of water stress. These results are in agreement with the obtained by Hall *et al* 1982. Wastage 1984, Schoper *et al* 1986 and Boyer and Wastage 2004.

Johnson and Herrero 1981, who studied the effect of water and heat stress on pollen viability and found that the magnitude of their effect on pollen viability remains unclear.

Results in **Table (14)** indicated that T.W.C. 321 produced the highest pollen grain viability in both seasons (76.43 and 75.74% , respectively) while DTP-I variety gave the lowest viability (69.49 and 71.10%, respectively) in the two growing seasons. Pollen grain viability of SC-123 and Giza-2 variety was similar in both seasons. Differences among the studied varieties in pollen grain viability , across all irrigation treatments, indicated that these differences are due differences in the genetic make-up of these varieties.

Table (14): Effect of drought treatments on pollen grain viability (%) of four maize varieties in 2002 and 2003 seasons.

Treatments \ Characters studied		Pollen grain viability (%)	
		2002	2003
Drought treatments (A) :			
Skipping 2nd irrigation	A_1	75.01 ab	75.74 b
Skipping 3rd irrigation	A_2	69.38 d	68.91 d
Skipping 4th irrigation	A_3	73.97 bc	74.20 b
Skipping 5th irrigation	A_4	75.19	75.26 a
Skipping 2nd and 4th irrigation	A_5	72.43 c	72.89 c
Skipping 3rd and 5th irrigation	A_6	67.78 d	68.96 d
Skipping 2nd and 4th irrigation	A_7	74.97 ab	74.82 b
Control (give all irrigation)	A_8	76.89 a	76.62 a
L.S.D. 0.05		**2.24**	**1.50**
Cultivars (B) :			
S.C. 123		73.82 b	73.25 b
T.W.C. 321		76.43 a	75.74 a
Giza 2		73.05 b	73.11 b
DTP 1		69.49 c	71.10 c
L.S.D. 0.05		**1.49**	**1.20**
Interaction :			
A X B		**N.S.**	**N.S.**

N.S. : Not significant.

Means followed by the same letter, within each column are not significantly different according to L.S.D. at 0.05 level of probability.

These results are in agreement with those obtained by **Wastaget and Boyer (1986b) Wastage (1994) and Zinselemein *et al* (2002) Edmeades *et al* (1993)** found that the genotypes that exhibit early silk emergence (silks appear before pollen shed begins) remain within the pollen-shed interval and this is evident in many modern maize hybrids and contributes significantly to their improved drought performance.

The interaction between "skipping irrigation treatments x cultivars was not significant for pollen grain percentage in both seasons **Table (14)**. This showed that skipping irrigation and cultivars acted independently on pollen grain viability.

4.3. Yield and yield components:

This part of the study includes the following:

- Ear length, (in centimeters).
- Cob diameter, (in centimeters).
- Number of kernels per raw .
- One hundred- kernels weight (in grams).
- Grain yield (tons per hectar).
- Straw yield (tons per hectar).

4.3.1. Ear length:

The analysis of variance presented in **Table (15)** showed that ear length was significantly affected by the two studied factors in both seasons of this study.

The interaction between irrigation and cultivars was significantly affected only in 2003 season.

Table (15) showed that ear length was significantly affected by different irrigation treatments in both seasons of study.

Table (15) showed that irrigation treatments in 2002 season resulted in significant lower means of ear length. The greatest significant decrease in ear length was obtained by skipping irrigation at early grain filling, flowering, pre-flowering + late grain filling and pre-flowering stages (the 3rd , 2nd, 7th and 1st irrigation treatments) followed by skipping irrigation at pre-flowering + early grain filling, flowering + late grain filling and late grain filling (5th , 6th and 4th irrigation treatments). Ear length of those treatments were (17.46, 17.60, 17.75, 18.03, 18.12 and 18.34 cm) while the mean of the control treatment was 18.91 cm. The reduction percent were (9.23, 9.31, 9.39, 9.48, 9.53, 9.58 and 9.70%) less than the control treatment, respectively.

In 2003 season skipping irrigation at flowering, early grain filling and pre-flowering + early grain filling stages (the 2nd , 3rd and 5th irrigation treatments) caused the highest significant decrease in ear length followed by skipping irrigation at pre-flowering, pre-flowering + late grain filling and flowering + late grain filling stages (the 1st , 7th and 6th irrigations treatments). The respective 15.70, 15.96, 15.97, 16.05, 16.40 and 16.68 versus 17.53 cm for the control with relative reductions 9.07, 9.10, 9.11, 9.16, 9.36 and 9.50%. These results are in accordance with those obtained by **Mahgoub (1979); Gomaa (1981); Moursi *et al.* (1983); Aly (1984); El-Sabbagh (1988); Abdel-Mawgood *et al.* (1992) and Mahgoub *et al.* (2001).** They reported significant ear length reduction as a result of water stress during different growth and maturity stages.

Regarding varieties the results in **Table (15)** indicated that T.W.C. 321 gave the tallest ears length, across all water stress treatments, as compared to the other varieties in both seasons.

Means of ear length for the four varieties, i.e., S.C.123, T.W.C. 321, Giza 2 and DTP-1 were 18.45, 18.90, 16.62 and 14.96 cm as an average of the two seasons, respectively. DTP-1 variety had the shortest ear length in both seasons (15.74 and 14.18 cm. respectively) Ear length is an indicator for the number of kernels/raw and number of kernels/ear which considered among the major yield components. Similar trend was a reported by **Badr *et al.* (1993); Atta-Allah (1996) and Abo-zahra (2003)** found that variety h.sh.2 had the highest panicle length (35 and 37.7 cm) in both seasons. Moursi (1997) found that genotypes differed significantly under water stress for ear length.

On the other contrary the ICSB-I genotypes had the lowest panicle length (18.8 and 18cm) as compared with all tested genotypes in the two succession seasons, respectively.

Analysis of variance of ear length data **Table (16)** revealed highly significant differences among the studied maize varieties under the different drought treatment on ear length in 2003 season. Meanwhile irrigation treatments X cultivars interaction was not significant in 2002 season.

Drought susceptibility index (DI) has been used to characterize relative drought tolerance of grain maize genotypes. Low drought susceptibility index (DI<1) is synonymous with higher stress tolerance.

Table (17) reveal that cultivars could be classified into two groups, high and low values according to drought susceptibility index (DI) and reduction percentage (RD%) for each irrigation treatment in 2003 season. For (skipping 3rd irrigation) the highest values of DI and RD% were for DTP-1 population (1.38 and 11.4%, respectively), while the lowest values were for T.W.C.321 (0.63 and 5.3%, respectively) with the same treatment. For treatment (skipping 4th irrigation) the highest values of DI and RD% were for T.W.C.321 (1.38 and 14.2%, respectively). The lowest values of the two parameters were for S.C.123 (0.79, 8.1%, respectively). Treatment (skipping 5th irrigation) recorded that the highest values of DI and RD% were 1.49 and 13.1%, respectively for S.C.123, while the lowest values were 0.72 and 6.3%, respectively for Giza-2, respectively. Regarding treatment (skipping 6th irrigation) showed that the highest values of DI and RD% were 2.09 and 8.4%, respectively for S.C.123, while the lowest values were 0.34 and 1.3%, respectively for T.W.C.321. Concerning treatment (skipping 3rd and 5th irrigations) the highest values of DI and RD% were 1.35 and 11.8%, respectively for S.C.123, while the lowest values were

0.78 and 6.8%, respectively for T.W.C.321. For treatment (skipping 4th and 6th irrigations) the highest values of DI and RD% were 1.32 and 6.2%, respectively for DTP-1 population, but the lowest values were (0.45 and 2.1%), respectively for T.W.C.321. For the last treatment (skipping 3rd and 6th irrigations) the highest values of DI and RD% were 1.5 and 9.4% , respectively for DTP-1 population, while S.C.123 gave the lowest values which were 0.5 and 3.1%, respectively under the same treatment.

4.3.2. Cob diameter (cm.):

Means of cob diameter as affected by different skipping irrigation treatments and varieties are given in **Table (15)**, results reveal highly significant differences in cob diameter due to different irrigation treatments in both seasons of study (2002 and 2003 seasons).

All skipping irrigation treatments in 2002 and 2003 seasons resulted in significant lower means of cob diameter. The greatest significant decrease during 2002 season was obtained from skipping irrigation at pre-flowering + early grain filling, pre-flowering + late grain filling and early grain filling stages (the 5th, 7th and 3rd irrigation treatments) followed by skipping irrigation at pre-flowering, (the 1st and 2nd irrigation treatments), at late grain filling and flowering grain + filling stages (the 4th and 6th irrigation treatments). No significant differences were detected between these treatments. Cob diameter of these treatments were 2.81 and 2.81 cm. The mean of control treatment was 2.92 cm. The reduction percentages were 9.62 and 9.62%, respectively.

In the 2003 season skipping irrigation at pre-flowering and early grain filling (the 2nd and 3rd irrigation treatments) caused the highest significant decrease in cob diameter followed by skipping irrigation at pre-flowering + late grain filling, flowering + late grain filling and pre-flowering + early grain filling stages (the 7th, 6th and 5th irrigation treatments) and at late grain filling and vegetative growth stages (the 4th and 1st irrigation treatments). Mean values were (2.76, 2.78, 2.83, 2.84, 2.85, 2.86 and 2.88) cm with reductions percentage of 9.26, 9.33, 9.50, 9.53, 9.53, 9.56 and 9.60% from the control treatment, respectively.

Regab *et al.* (1986); Esmail (1996); and Atta-Allah (1996) reached the same conclusion.

Concerning the variety effect, Giza 2 had the largest cob diameter in both seasons (2.93 and 2.96 cm), respectively. The S.C.123 had the smallest cob diameter (2.62 cm) in 2002 and T.W.C.321 (2.73 cm) in 2003 season, respectively this finding may be attributed to better environmental conditions especially irrigations or moisture. The effect of the interaction between skipping irrigation treatments and varieties on cob diameter was significant in 2002 season only. The largest cob diameter was obtained by growing Giza-2 under the control treatment (normal irrigation), while the lowest one was obtained by growing SC123 under the treatment of skipping irrigation at early grain filling stage as shown in **Table (16).**

Table (15): Effect of drought treatments and varieties on ear length and cob diameter (cm) during 2002 and 2003 seasons.

Treatments \ Characters studied	Ear length		Cob diameter (cm)	
	2002	2003	2002	2003
Drought treatments (A) :				
Skipping 2nd irrigation A_1	17.93 bcd	16.05 de	2.74 bcd	2.88 b
Skipping 3rd irrigation A_2	17.60 bc	15.70 e	2.78 bc	2.76 c
Skipping 4th irrigation A_3	17.46 d	15.96 e	2.73 cd	2.78 bc
Skipping 5th irrigation A_4	18.34 b	16.80 b	2.81 b	2.86 b
Skipping 2nd and 4th irrigation A_5	18.03 bc	15.97 e	2.70 d	2.85 bc
Skipping 3rd and 5th irrigation A_6	18.12 bc	16.68 c	2.81 b	2.84 bc
Skipping 2nd and 4th irrigation A_7	17.75 cd	16.40 cd	2.70 d	2.83 bc
Control (give all irrigation) A_8	18.91 a	17.53 a	2.92 d	2.98 a
L.S.D. 0.05	**0.53**	**0.39**	**0.07**	**0.09**
Cultivars (B) :				
S.C. 123	19.17 b	17.73 a	2.62 b	2.76 b
T.W.C. 321	19.86 a	17.94 a	2.66 b	2.73 b
Giza 2	17.55 c	15.69 b	2.93 a	2.96 a
DTP 1	15.74 d	14.18 c	2.88 a	2.95 a
L.S.D. 0.05	**0.39**	**0.29**	**0.05**	**0.05**
Interaction :				
A X B	**N.S.**	**	*	**N.S.**

N.S. : Not significant.
*** : Significant at 0.01 level of probability.**
**** : Significant at 0.05 level of probability.**
Means followed by the same letter, within each column are not significantly different according to L.S.D. at 0.05 level of probability.

Table (16): Interaction between some drought treatments and varieties on ear length and cob diameter (cm) of maize plant during 2002 and 2003 season.

Treatments		**Ear length**		**Cob diameter (cm)**	
Skipping Irrigation	**Varieties**	**2002**	**2003**	**2002**	**2003**
A_1	**S.C. 123**	18.95	17.75	2.60	2.83
A_2		18.32	17.55	2.68	2.67
A_3		17.82	16.60	2.50	2.82
A_4		18.31	17.50	2.63	2.80
A_5		17.80	16.85	2.68	2.75
A_6		18.75	18.00	2.65	2.67
A_7		18.62	18.50	2.50	2.72
A_8		19.51	19.10	2.73	2.80
A_1	**T.W.C. 321**	19.10	18.00	2.60	2.75
A_2		17.72	16.30	2.68	2.65
A_3		18.65	17.65	2.70	2.70
A_4		19.50	18.75	2.70	2.70
A_5		18.77	17.70	2.60	2.73
A_6		19.24	18.60	2.65	2.75
A_7		18.45	17.55	2.55	2.70
A_8		19.77	19.00	2.78	2.85
A_1	**Giza 2**	16.10	14.85	2.85	2.95
A_2		16.77	15.20	2.83	2.80
A_3		15.87	15.60	2.88	2.83
A_4		17.27	16.35	2.95	3.02
A_5		16.36	15.48	2.88	2.97
A_6		16.51	15.73	3.03	2.97
A_7		16.43	15.65	2.90	3.00
A_8		17.60	16.65	3.12	3.12
A_1	**DTP 1**	14.30	13.60	2.90	2.97
A_2		14.80	13.75	2.93	2.92
A_3		14.50	14.00	2.83	2.77
A_4		15.20	14.60	2.95	2.93
A_5		15.05	13.85	2.65	2.97
A_6		15.10	14.40	2.90	2.97
A_7		14.17	13.90	2.85	2.90
A_8		15.97	15.35	3.05	3.15
L.S.D. 0.05		**N.S**	**0.84**	**0.14**	**N.S**

Table (17) showed that cultivars could be classified into two groups, (high and low values) according to drought susceptibility index (DI) and reduction percentage (RD%) for each irrigation treatment in 2002 season. For (skipping 3rd irrigation) the highest values of DI and RD% were for Giza-2 population (1.38 and 8.7%, respectively), while the lowest values of DI and RD% were for S.C.123 (0.76 and 4.8%, respectively). Treatment (skipping 4th irrigation) the highest values of DI and RD% were for Giza-2 population (1.94 and 9.3%, respectively). The lowest values of the two parameters were for S.C.123 (0.38 and 1.8%, respectively). Treatment (skipping 5th irrigation) showed that the highest values of DI and RD% were 1.28 and 8.4%, respectively for S.C.123, while the lowest values were 0.44 and 10.9%, respectively for T.W.C.321. Regarding treatment (skipping 6th irrigation) recorded that the highest values of DI and RD% were 1.43 and 5.4%, respectively for Giza-2 population, while the lowest values were 0.76 and 2.9%, respectively for T.W.C.321. Concerning treatment (skipping 3rd and 5th irrigations) the highest values of DI and RD% were 1.76 and 13.1%, respectively for DTP-1, while the lowest values were 0.24 and 1.8%, respectively for S.C.123. For treatment (skipping 4th and 6th irrigations) the highest values of DI and RD% were 1.27 and 4.9%, respectively for DTP-1, while the lowest values were (0.74 and 2.9%), respectively for Giza-2 population. For treatment (skipping 3rd and 6th irrigations) indicating the highest values of DI and RD% were (1.12 and 8.4%), respectively for S.C.123, while the lowest values of them were (0.87 and 6.6%, respectively in DTP-1 population in the same season.

<u>4.3.3. Number of kernels per raw:</u>

The effects of skipping irrigation treatments and cultivars on number of kernels per row for the two growing seasons are presented in **Table (18).**

Data in **Table (18)** revealed highly significant differences in number of kernels/row due to different irrigation treatments in both seasons of the study.

The lowest number of kernels/row in 2002 season was obtained from skipping irrigation at flowering, early grain filling, pre-flowering + late grain filling and pre-flowering + late grain filling stages. The reduction percentage compared with the control treatment were 9.02, 9.13, 9.13, and 9.16% their respective means were 34.44, 34.88, 35.88, and 35.01 versus 38.19 for control treatment. No significant difference was found between skipping the 1st and 6th irrigation treatments, and 2nd and 4th irrigation treatments under the control treatment, ears had highly significant number of kernels/row than under any of the skipping irrigation treatments.

In 2003 season, the lowest mean of number of kernels/row was given by skipping irrigation at flowering, early grain filling, flowering + late grain filling and pre-flowering + early grain filling stages (the 2nd, 3rd , 6th and 5th irrigation treatments) followed by the mean of skipping irrigation at pre-flowering , pre-flowering + late grain filling and late grain filling stages (the 1st,7thand 4th irrigation treatments), the means were 32.94, 33.00, 33.01, 33.03, 34.31, 34.88 and 35.56 versus 38.19 for the control treatment.

The percent reduction than the control were 8.62, 8.64, 8.66, 8.65, 8.98, 9.13 and 9.31%. The control treatment in both seasons had the highest significant number of kernels/row than other treatments.

These results may be due to the abortion of some flowers as a result of relationship between soil moisture stress via skipping irrigation and different physiological processes that occurs in the plant. These results were in harmony with those obtained by **EKanoyake *et al.* (1990); Schussler and Vestgate (1995); and Boonjung and Fukai (1996)**. **Larson (1975)**, who declared that drought stress especially at anthesis reduces the number of kernels/row because of the dehydration of pollen grain or wilting of the styles which interferes with pollen tube growth, a response which is more pronounced in maize which possess long style. **Mahgoub (1979),** found that water stress during the vegetative growth stage of maize caused significant reduction in number of kernels/row. Also, **Ainer (1983)** indicated that irrigation at 20% water deficit in the upper 60 cm layer of the soil significantly increased number of kernels/row, as compared to irrigation at deficit of 40, 60 or 90 percent. **Bolanos and Edmendes (1996)** found that grain number per ear under water deficit, maize appears to dependent directly on the rate of photosynthisis during the two weeks around flowering. Also, **El-Ganayni *et al.* (2000)** indicated that pre-flowering stress caused 22% reduction in number of kernels/row.

Results also indicated that T.W.S. 321 had the highest number of kernels/row of i.e., 39.34 and 39.31 kernels in the two successive seasons, followed by S.C. 123 (38.91 and 39.59) kernels and Giza-2 (33.59 and 30.31) kernels. The DTP-1 had the lowest number of kernels/row of 31.89 and 29.63 kernels in both seasons, respectively. these results are in agreement with those of **El-Hattab *et al*. (1985); Nigem (1989); and Bialy *et al.* (1991); Fredrick *et al.* (1989)** who found that drought stress caused a decrease in number of kernels/row. The delayed senescence of hybrids (B 73 X LH 38 and FS 854) were due to resistance to drought which was imposed during vegetative and early flowering development. Also, **Ibrahim *et al.* (1992) and Moursi (1997)** found that number of kernels/row was significantly reduced in maize varieties under different irrigation treatments.

The interaction between skipping irrigation treatments X cultivars was highly significant in 2003 season only showing that cultivars and irrigation treatments acted dependently on number of kernels/row (**Table 20)**.

Table (20) showed that T.W.C. 321 variety produced the highest number of kernels per row under normal irrigation (control), while the lowest number was obtained by skipping irrigation at pre-flowering + late grain filling stage in Giza-2 population.

Table (21) showed that cultivars could be categorized into two groups , high and low values according to drought susceptibility index (DI) and reduction percentage (RD%) for each irrigation treatment in 2003 season. For A_1 treatment (skipping 3rd irrigation) the highest values of DI and RD% were for Giza-2 population (1.61 and 16.6%, respectively), while the lowest values of DI and RD% were for T.W.C.321 (0.64 and 6.6%, respectively). For treatment (skipping 4th irrigation) the highest values of DI and RD% were for Giza-2 population (1.39 and 19.3%, respectively). The lowest values of the two parameters were for T.W.C.321 (0.34 and 5.0%, respectively). Treatment (skipping 5th irrigation) showed that the highest values of DI and RD% were 1.63 and 18.6%, respectively for Giza-2, while the lowest values were 0.63 and 7.2%, respectively for T.W.C 321. Regarding treatment (skipping 6th irrigation) indicated that the highest values of DI and RD% were 1.96 and 13.8%, respectively for Giza-2 population, but the lowest values were 0.26 and 1.8%, respectively for S.C.123. Concerning treatment (skipping 3rd and 5th irrigations) the highest values of DI and RD% were 1.35 and 15.7%, respectively for DTP-1 population, while the lowest values were 0.73 and 8.4%, respectively for S.C.123. For treatment (skipping 4th and 6th irrigations) the highest values of DI and RD% were 2.01 and 20.7%, respectively for Giza-2 population, but the lowest values were (0.53 and 5.4%), respectively in S,C.123, for the last treatment (skipping 3rd and 6th irrigations) the highest values of DI and RD% were 1.91 and 26.9% , respectively for Giza-2 population, while the lowest values were 0.47 and 6.6%, respectively in S.C.123.

4.3.4. 100-kernels weight (gm.):

Results of the effect of different irrigation treatments on 100-kernels weight in both seasons of the study are presented in **Table (18) and Figure (14)**.

Date presented in **Table (18)** showed that skipping irrigation at flowering + late grain filling, early grain filling and pre-flowering + late grain filling stages (the 6th, 3rd and 7th irrigations treatments) resulted in the lowest 100-kernels weight in 2002 followed by skipping irrigation at pre-flowering + early grain filling, flowering and late grain filling stages (the 5th, 2nd and 4th irrigations treatments). The means were (35.36,35.45, 35.47, 35.62, 35.68 and 35.84 gm versus 38.86 gm to the control treatment, respectively.

The reduction percentage as compared to the control treatment were 9.10, 9.12, 9.13, 9.17, 9.18 and 9.22%, respectively. Results of 2003 season, showed nearly the same trend as in 2002.The reduction percentage as compared to the control were 9.00, 9.01, 9.05, 9.06, 9.16 and 9.17%, respectively.

In 2002 and 2003 seasons, skipping irrigation at pre-flowering (the 1st irrigation treatment)resulted in highest means of kernels weight than all other skipping irrigation treatments. These means were 37.05 and 36.34 gm for the two successive seasons, respectively.

According to the results shown in **Table (18)** the following conclusions could be also detected (a) The lowest means of 100-kernels weight were obtained by skipping irrigation two times including flowering or early grain filling stages. (b) The mean for control was significantly higher than all other skipping treatments. (c) Reduction in 100-kernel weight was higher in 2002 than 2003.

Thus, the higher concentration of dry weigh were probably due to suspended accumulation of structural dry matter in response to the water stress treatments. Similar results were obtained by **Abdel-Raouf (1973).** He concluded that drought during the growing period of 49-70 days from planting (flowering and kernel-formation)decreased 1000-kernel weight. The effect of drought was more severe during flowering and kernel formation stages. Also, **Abdel Gawad *et al* (1980)** studied the effect of skipping one of 6 irrigations on maize hybrid D.C.355, they found that 100-kernel weight was decreased. They added that the greatest reduction in 100-kernel weight resulted from emitting the 5th and 6th irrigations. **Gomaa (1984)** reported that 100-kernel weight was reduced significantly by exposing plants to water stress at vegetative, flowering and maturity stages. **Bolanos and Edmeades (1996)** reported that grain weight decreased by increasing drought period.

Table (18): Effect of drought treatments and varieties on number of kernels/row and 100-kernels weight of maize plant during 2002 and 2003 seasons.

Characters studied / Treatments		Number of kernels/row		100-kernels weight	
		2002	**2003**	**2002**	**2003**
Drought treatments (A) :					
Skipping 2nd irrigation	A_1	35.87 bcd	34.31 bc	37.05 b	36.34 b
Skipping 3rd irrigation	A_2	34.44 b	32.94 d	35.68 bc	35.68 bc
Skipping 4th irrigation	A_3	34.88 d	33.08 cd	35.45 c	35.00 c
Skipping 5th irrigation	A_4	36.25 bc	35.56 b	35.84 bc	35.29 bc
Skipping 2nd and 4th irrigation	A_5	35.06 cd	33.03 cd	35.62 bc	35.24 bc
Skipping 3rd and 5th irrigation	A_6	35.01 bcd	33.01 bc	35.36 c	35.72 bc
Skipping 2nd and 4th irrigation	A_7	34.88 d	34.88 d	35.47 c	35.09 bc
Control (give all irrigation)	A_8	38.19 a	38.19 a	38.86 a	38.95 a
L.S.D. 0.05		**1.25**	**1.37**	**1.50**	**1.27**
Cultivars (B) :					
S.C. 123		38.91 a	38.59 s	35.02 c	35.30 c
T.W.C. 321		39.34 a	39.31 a	37.94 b	37.37 b
Giza 2		33.59 b	30.31 b	40.23 a	38.65 a
DTP 1		31.89 c	29.63 b	31.44 d	32.35 d
L.S.D. 0.05		**0.77**	**0.83**	**0.69**	**0.75**
Interaction :					
A X B		**N.S.**	**	**N.S.**	**N.S.**

N.S. : Not significant.
**** : Significant at 0.01 level of probability.**
Means followed by the same letter, within each column are not significantly different according to L.S.D. at 0.05 level of probability.

On the other hand, **Aly (1984)** found no effect on 100-kernel weight under irrigation at 20%, 50% and 80% water deficits for the available soil moisture from the upper 60 cm. layer of the soil.

The reduction in 100-kernel weight due to irrigation treatments may be attributed to the reduction of assimilate translocation from the plant canopy to the developing grain **(1997).** Under high water stress conditions photosynthetic activity is low and metabolites translocation to the grain was not enough to attain its maximum weight.

Results in **Table (18)** indicated that Giza 2 variety produced the highest 100-kernels weight in both seasons (40.23 and 38.65 gm. respectively), while DTP-I variety gave the lowest values (31.44 and 32.35 gm. respectively) in both seasons of the study. The most sensitive period to water stress for maize plant is the reproductive growth stage. Therefore tolerant cultivars would be less affected by the reduction in kernel weight. These results are in harmony with those obtained by **Nigem (1989). Breeder *et al* (1992), Shalaby (1992). Moursi (1979). El-sheikh (1999) and Ibrahim and El-Semary (2001)** who reported significant differences among maize genotypes in 100-kernel weight under different drought treatments.

It is noteworthy to record that the interaction between skipping irrigation treatments x cultivars for 100-kernels weight was not significant in both seasons 2002 and 2003. These results indicated that both factors acted independently regarding their effect on 100-kernel weight **(Table 18).**

4.3.5. Grain yield .

Mean grain yield per hectar for the two factors of study and their interactions is shown in **Table (19) and Figures (15)**.

Table (19) revealed highly significant differences between irrigation treatments for grain yield in 2002 and 2003 seasons. Grain yield was significantly higher for normal irrigation as compared to the other treatments. Skipping any of the scheduled irrigations treatments significantly decreased grain yield in both seasons. In 2002 the treatment of skipping irrigation at the pre-flowering + late grain filling, flowering + late grain filling and pre-flowering + early grain filling stages (the 7^{th} , 6^{th} and 5^{th} irrigation treatments) had the highest reduction in grain yield followed by skipping irrigation at early grain filling, pre-flowering, late grain filling and flowering stage (the 3^{rd} ,1^{st}, 4^{th} and 2^{nd} treatments). That means values for grain yield of these treatments were 8.21, 8.87, 9.10, 9.03, 9.48, 9.75 and 9.80 ton/ha versus 10.67 ton/ha for the control treatment. The corresponding reduction percentages were 7.70, 8.31, 8.46, 8.53, 9.14, 9.19 and 9.35% respectively.

In 2003, the same trend was obtained by skipping irrigation at the pre-flowering + late grain filling , pre-flowering + early grain filling and flowering + late grain filling stages (the 7^{th}, 5^{th} and 6^{th} treatments) had the highest reduction in grain yield followed by skipping irrigation at early grain filling, flowering, pre-flowering and late grain filling (the 3^{rd} , 2^{nd} , 1^{st} and 4^{th} treatments) that means values for grain yield of these treatments were

(7.41, 7.70, 7.77, 8.06, 8.17, 8.30 and 8.94 ton/ha) respectively versus 9.55 ton/ha for the control treatment.

In both seasons, skipping the 4th irrigation treatment resulted in the lowest reduction in grain yield as compared to the other skipping irrigation treatments. Grain yield for this treatment were 9.80 and 8.94 t/ha for the two successive seasons, respectively. The results indicated that maize grain yield is severely affected by drought stress at anthesis or early, grain, filling stages. This is the period for maximum rates of biomass accumulation. Similar results were reported by **El-Sahookie and Wassam (1984)**; **Sinclair *et al.* (1990)**; **Hefini et al. (1993)**; and **Bolanos and Edmeades (1996)**.

Abu-Grab and Othman (1999) reported that grain yield was the most affected trait by moisture stress at all tested drought treatments. Reductions in grain yield were 24.27, 34.39 and 20.54% when plants were subjected to drought at pre-flowering, flowering and grain filling stages respectively. Also, **El-Sheikh (1999)** found that the reduction in grain yield were 5%, 16%, 8% and 22% when skipping the second (35 days from planting) and the fifth irrigation (80 days from planting), respectively. **El-Ganayni et al (2000)**, reported that flowering and grain filling growth stages were the most sensitive to water deficit.

Differences among the 4 studied varieties across all irrigation treatments were significant as shown in **Table (20)**, results indicated that T.W.C.321 variety produced the highest grain yield (10.95 and 9.79 ton/ha.) in 2002 and 2003, respectively), while DTP-1 population produced the lowest grain yield per hectar (7.47 and 6.32 ton/ha.) in the two growing seasons, respectively. The differences among the 4 varieties in grain yield constitution of this varieties rather than irrigation treatments. It was expected that S.C.123 would produce the highest grain yield however, T.W.C.321 produced the highest yield across all irrigation treatments. This may be due to the wide genetic base of the three-way crosses as compared to single crosses. This reflected the growth characteristics of T.W.C.321 and the consequently the grain yield and its components. Similar results were obtained by **Badr *et al*. (1993)**; **Tantawy (1994)**; **Kamel (1995)**; **Atta-allah (1996)**; **El-Karamity and Atta-Allah Radwan (1998)**; and **Attia (1999)**.

Data in **Table (20) and Figures (16)** the effect of the interaction between some drought treatment and cultivars was significant for grain yield/ha. In season 2002 only. It can be seen from the previous results that maize grain yield was decreased significantly when plants subjected to drought conditions for more than one irrigation especially at pre-flowering, flowering and early grain filling stage.

Almost all biochemical and physiological processes in plants are relevant to physiological components of yields. These processes which are associated with crop growth and development are influenced by drought stress. One of the important indicators of drought tolerance which is used in breeding programs is drought susceptibility index (DI) which represents the grain yield measured under control and stressed conditions **(Bruckuer and Frohberg, 1987)**. DI was used as a parameter to provide a measure of stress tolerance based on minimization of yield loss under stress as compared to the optimum conditions rather than on yield level under non-stress conditions (control). **Table (21)** indicated that grain yield of maize genotypes could be categorized into two groups high and low values according to drought susceptibility index (DI) and reduction percentage (RD%) for each irrigation treatment in 2002 season. For A_1 treatment (skipping 3rd irrigation) the highest values of DI and RD% were for Giza-2 population (1.21 and 10.9%, respectively), while the lowest values of DI and RD% were for T.W.C.321 (0.76 and 6.8%, respectively). For treatment (skipping 4th irrigation) the highest values of DI and RD% were for Giza-2 population (1.60 and 10.0, respectively). The lowest values of the two parameters were for DTP-1 population (0.26 and 1.66, respectively). Treatment (skipping 5th irrigation) showed that the highest values of DI and RD% were 1.20 and 17.6%, respectively for S.C.123, while the lowest values were 0.74 and 10.9%, respectively for Giza-2 population. Regarding treatment (skipping 6th irrigation) indicated that the highest values of DI and RD% were 2.36 and 18.9%, respectively for DTP-1 population, but the lowest values were 0.18 and 1.4%, respectively for Giza-2 population. Concerning treatment (skipping 3rd and 5th irrigations) the highest values of DI and RD% were 1.4 and 21.2%, respectively for DTP-1 population, while the lowest values were 0.75 and 11.4%, respectively for T.W.C.321. For treatment (skipping 4th and 6th irrigations) the highest values of DI and RD% were 1.49 and 24.8%, respectively for S.C.123 , but the lowest values were 0.60 and 10.0% , respectively for Giza-2 population. For the last treatment (skipping 3rd and 6th irrigations) the highest values of DI and RD% were 1.48 and 26.3% , respectively for S.C.123, while the lowest values were 0.74 and 16.9%, respectively for Giza-2 population.

4.3.6. Straw yield (ton/ha):

The analysis of variance presented in **table (19)** showed that this characteristic was significantly affected by the two studied factors.

The interaction between the two irrigation treatments X cultivars were insignificant in both seasons with regard to the effect of skipping irrigation treatments it was observed that the straw yield was significantly affected in both seasons of study 2002 and 2003. The highest straw yield was produced using normal treatment (control treatment) while skipping irrigation at pre-flowering + late grain filling and flowering + late grain filling produced the lowest straw yield in 2002 and 2003 seasons **Table (20).** In both seasons, insignificant differences were found in straw yield between normal treatment and skipping 4th treatment (late grain filling).

This results are in accordance with the findings of **Wastage (1994)**; **Atta-Allah (1996)**; and **Bolanos and Edmeades (1996).**

Regarding varieties the results in **Table (19)** indicated that **T.W.C.321** variety gave the highest straw yield/ha as compared to DTP-1 population in both seasons. The main grain yield/ha as of the four varieties S.C.123, T.W.C.321, Giza-2, and DTP-1 were 28.27, 30.57, 25.68 and 21.62 as an average of the two growing 2002 and 2003 seasons, respectively. These results are in agreement with those obtained by **Shalaby and Omar (1981)**; **Khalifa *et al*. (1983)** and **Abd El-Galil *et al*. (1990)**.

Table (19): Effect of drought treatments and varieties on grain yield and straw yield (ton/ha) of maize plant during 2002 and 2003 seasons.

Characters studied / Treatments	Grain yield (ton/ha)		Straw yield (ton/ha)	
	2002	**2003**	**2002**	**2003**
Drought treatments (A) :				
Skipping 2nd irrigation A_1	9.75 b	8.30 c	28.61 ab	23.75 de
Skipping 3rd irrigation A_2	9.48 bc	8.17 c	27.97 bc	26.01 bc
Skipping 4th irrigation A_3	9.10 c	8.06 cd	27.13 bc	25.96 bc
Skipping 5th irrigation A_4	9.80 b	8.94 b	29.23 ab	27.76 ab
Skipping 2nd and 4th irrigation A_5	9.03 c	7.70 de	27.02 bc	25.50 cd
-Skipping 3rd and 5th irrigation A_6	8.87 c	7.77 cde	24.98 cd	23.20 e
Skipping 2nd and 4th irrigation A_7	8.21 d	7.41 e	23.48 d	23.40 de
Control (give all irrigation) A_8	10.67 a	9.55 a	31.48 a	29.06 a
L.S.D. 0.05	**0.641**	**0.55**	**3.06**	**2.14**
Cultivars (B) :				
S.C. 123	10.53 b	9.26 b	29.68 b	27.48 b
T.W.C. 321	10.95 a	9.79 a	31.99 a	29.15 a
Giza 2	8.75 c	7.57 c	26.17 c	25.19 c
DTP 1	7.47 d	6.32 d	22.08 d	21.16 d
L.S.D. 0.05	**0.32**	**0.29**	**2.31**	**1.98**
Interaction :				
A X B	*	**N.S.**	**N.S.**	**N.S.**

N.S. : Not significant.
*** : Significant at 0.05 level of probability.**
Means followed by the same letter, within each column are not significantly different according to L.S.D. at 0.05 level of probability.

Table (20): Interaction between drought treatments and varieties on number of kernels/row and grain yield (ton/ha) of maize plant during 2002 and 2003 season.

Treatments		Number of kernels/row		Grain yield (ton/ha)	
Skipping Irrigation	**Varieties**	**2002**	**2003**	**2002**	**2003**
A_1	**S.C. 123**	38.00	37.25	11.19	9.21
A_2		37.00	35.50	11.13	9.04
A_3		37.50	37.75	9.99	8.74
A_4		40.25	40.75	11.30	.10.62
A_5		38.00	38.00	10.48	8.72
A_6		39.77	39.25	9.12	8.42
A_7		38.25	38.75	8.93	8.28
A_8		41.62	31.50	12.12	11.07
A_1	**T.W.C. 321**	39.25	39.00	11.32	9.72
A_2		40.00	39.75	11.58	9.54
A_3		39.00	38.75	10.37	9.75
A_4		39.75	40.75	11.34	10.35
A_5		38.00	37.50	10.77	9.22
A_6		38.37	38.25	10.86	9.62
A_7		38.62	38.75	9.21	8.81
A_8		41.63	41.75	12.15	11.34
A_1	**Giza 2**	31.87	30.25	8.62	7.93
A_2		32.12	29.25	8.70	7.63
A_3		30.62	29.50	8.62	7.34
A_4		33.00	31.25	9.53	8.26
A_5		31.00	30.75	8.07	6.84
A_6		30.87	28.75	8.70	7.35
A_7		29.62	26.50	8.03	6.46
A_8		36.50	36.25	9.67	8.78
A_1	**DTP 1**	31.25	30.75	7.86	6.34
A_2		29.62	27.25	8.52	6.46
A_3		30.37	29.50	7.41	6.41
A_4		30.63	29.50	7.02	6.55
A_5		30.37	28.25	6.82	6.01
A_6		31.62	31.00	6.82	5.67
A_7		29.00	27.50	6.66	6.11
A_8		33.00	33.50	8.66	7.02
L.S.D. 0.05		**N.S**	**2.35**	**0.91**	**N.S.**

4.4. Correlation between traits.

Phenotypic correlation between grain yield and 100 kernals weight, ear length, leaf area, proline content and plant height were positive and significant in both seasons of the study. The result in the first season were (0.40, 0.80, 0.68, 0.41 and 0.76 respectively), the result in the second season were (0.46, 0.82, 0.82, 0.17 and 0.77 respectively) **Tables (22 and 23)**.

These results indicated that ear length, leaf area and plant height are highly correlated with grain yield at the two growing seasons 2002 and 2003.

One hundred-kernals weight and leaf proline content had intermediate positive phenotypic correlation values with grain yield in both seasons (0.40, 0.46 – 0.41 and 0.17 respectively).

5. SUMMARY AND CONCLUSION

5. SUMMARY AND CONCLUSION

A sound understanding of plant growth and development is an essential element of efficient and economic maize management system .The impact of drought could be more accurately predicted with a clear picture of the relationships between growth stage and plant response to stress. The optimum timing, dose of fertilizers application and irrigation determined by crop growth stage. Two field experiments were carried out in the new lands at Nubaria Agriculture Research Station, Agriculture Research Center, Egypt during the growing summer seasons of 2002 and 2003

The objectives of the present investigation were:

To study the effect of different water stress treatments (skipping certain irrigation) on yield, yield components and different growth characters.

To determine the best drought tolerant hybrids that can be recommended for farmers in Nubaria area which have irrigation problems.

The experimental design was split-plot with four replicates in. Eight irrigation treatments were randomly assigned to the main plots and four hybrids occupied the sub-plot.

The studied characters are:

1. Agronomic characteristics

1.1. Plant height (cm).
1.2. Ear height (cm).
1.3. Stem diameter(cm).
1.4. Leaf area index.
1.5. Number of days to 50% tasseling (day).
1.6. Number of days to 50% silking (day).
1.7. Chlorophyll content.
1.8. Leaf water potential (-bar).

2. Chemical characters.

2.1. Leaf proline content.
2.2. Pollen grain viability.

3. Yield and yield components.

3.1. Ear length (cm).
3.2. Cob diameter (cm).
3.3. Number of kernels.
3.4. 100-kernels weight (gm).
3.5. Grain yield (ton/ha).
3.6. Straw yield (ton/ha).

4. Correlation analysis.

The obtained results could be summarized as follows :

1. Agronomic characteristics

1.1. Plant height : The highest significant reduction in plant height was obtained by skipping the 1st , 5th and 7th irrigation treatments. These irrigation coincided with pre-flowering, pre-flowering + early grain filling and pre-flowering + late grain filling stages. S.C.123 and T.W.C.321 hybrids had the tallest plant height than other cultivars as an average in the two seasons, followed by Giza2 population. DTP-1 population had the shortest plant height in both seasons.

1.2. Ear height : Skipping any irrigation in both growing seasons resulted in significant decrease in ear height than control treatment. The lowest values of ear height was obtained by skipping irrigation at pre-flowering, early grain filling + pre-flowering and late grain filling + pre-flowering stages (The 1st , 5th and 7th treatments). The control treatment in both seasons had the highest ear height. S.C.123 and T.W.C.321 hybrids had the highest significant ear height followed by Giza2 and DTP.1 populations in both seasons.

1.3. Stem diameter : The maximum stem diameter was obtained from skipping irrigation at late grain filling (The 4th irrigation treatment), while the minimum stem diameter was obtained from skipping at pre-flowering stage (The 1st irrigation treatment) in both growing seasons. T.W.C.321 and S.C.123 hybrids had significantly higher stem diameter in 2002 and 2003 seasons. No significant differences were detected between the Giza2 and DTP.1 populations in both seasons. T.W.C321 produced the highest number of leaves/plant, while the lowest DTP-1 population as an average in both seasons. The first order interaction between irrigation treatments and cultivars was significant for number of leaves/plant in 2003 season only.

1.4. Leaf area index : The irrigation treatments resulted in significant decrease in leaf area index as compared to the control irrigation. The greatest significant decrease in leaf area index was obtained by skipping irrigation at pre-flowering + late grain filling and pre-flowering + early grain filling stages (The 7th and 5th irrigation treatments) in the two growing seasons. T.W.C.321 hybrid had the highest significant leaf area as compared to the other cultivars in the two seasons, on the other hand DTP-1 population had the lowest leaf area/plant in both seasons. The data showed that the interaction between skipping irrigation and cultivars was significant for leaf area/plant when skipping irrigation at flowering (the 4th irrigation treatment) with T.W.C.321 hybrid, while the lowest one was obtained by skipping irrigation at pre-flowering (the 1st irrigation treatment) with DTP-1 population in 2002 season.

1.5. Number of days 50% tasselling : The data indicated that skipping irrigation at flowering stage caused significant delay in tasselling in 2002 season. Skipping irrigation at pre-flowering and flowering stages caused significant delay in tasselling in 2003 . Giza2 population gave the earliest tasselling in both seasons, while the latest tasselling cultivar was T.W.C.321 in 2003 season and S.C.123 hybrid in both seasons. The interaction between irrigation treatments with cultivars was significant for number of days to 50% tasselling. S.C.123 and DTP-1 cultivars had significant delayed tasselling in both seasons when the 4th irrigation was skipped.

1.6. Number of days to 50% silking : The data indicated that, in both seasons, skipping irrigation at flowering stage caused significant delay in silking, while skipping irrigation at pre-flowering caused significant delay in silking. Giza2 population was the earliest silking in both seasons. S.C.123 was the latest silking in season 2002 while S.C.123 and T.W.C.321 were the latest silking in season 2003. The interaction between irrigation treatments with cultivars was significant on number of days to 50% of silking for S.C.123 and DTP-1 cultivars.Significant delayed silking was obtained in both seasons when the 4th irrigation was skipped.

1.7. Chlorophyll content : The highest Chlorophyll content was obtained with the normal irrigation treatment whereas the lowest concentration was obtained by skipping 5th irrigation treatment (pre-flowering + early grain) in 2002 and skipping irrigation at the pre-flowering growth and flowering growth stages in 2003 season. DTP-1 population gave the highest content of chlorophyll in the first season, and S.C.123 in the second season.

1.8. Leaf water potential (L.W.P.) : When L.W.P. was measured at 49 days from planting the highest values was obtained at the pre-flowering stage (35-50 days). When measured at 65 days, the highest L.W.P. was obtained from skipping at the flowering stage (50-65) days. Measuring L.W.P. at 79 days, skipping irrigation at early grain filling stage (65-80 days) gave the highest L.W.P., while at 94 days, the highest L.W.P. was obtained when skipping irrigation at the late grain filling stage. Giza2 and DTP-1 cultivars had the highest L.W.P. at 49 and 65 days from planting, but T.W.C.321 cultivar produced the highest L.W.P. at 79 and 94 days from planting as an average for both seasons. The first-order interaction between the skipping irrigation at pre-flowering + early grain filling stage (5th irrigation treatment) with T.W.C.321 variety gave the highest L.W.P. at 49 days from planting in both seasons, but the skipping irrigation at flowering + late grain filling stage (6th irrigation treatment) with S.C.123 variety gave the highest L.W.P. at 65 and 94 days in 2002 season only. At 79 days skipping irrigation at pre-flowering + early grain filling stage (5th irrigation treatment) with Giza2 variety gave the highest L.W.P. in the first season only.

2. Chemical characters:

2.1. Leaf proline content : Leaf proline content was increased significantly by skipping irrigation at pre-flowering stage when measured at 49 days from planting. At 65 days, leaf proline content was the highest when skipping irrigation at flowering stage. S.C.123 produced the highest leaf proline content at 49 days, while DTP-1 gave the lowest value in the both seasons in same period. Similar results was obtained at 65 days. The first order interaction between drought treatments and cultivars on leaf proline content was significant in 2002 and 2003 seasons.

2.2. Pollen grain viability : The highest significant reduction in pollen grain viability was obtained by skipping irrigation at flowering stage in both seasons. T.W.C.321 hybrid produced the highest pollen grain viability, while the DTP-1 population gave the lowest one in the two growing seasons. The interaction between skipping irrigation treatments with cultivars was not significant for pollen grain viability in both seasons.

3. Yield and yield components

3.1. Ear length : Skipping irrigation treatments in 2002 and 2003 resulted insignificant decrease in ear length as compared to the control treatment. The hightest significant decrease in ear length was obtained from skipping irrigation at early grain filling, flowering, pre-flowering + early grain filling and late grain filling stages, in both seasons. T.W.C. 321 gave the tallest ears as compared to other varieties in both seasons. Interaction between skipping irrigation and cultivar had significant effect on ear length in 2002 season only.

3.2. Cob diameter : All skipping irrigation treatments in 2002 and 2003 seasons resulted in significant smaller cob diameter. The greatest significant decreases were obtained from skipping irrigation at early grain filling, pre-flowering + early grain filling and pre-flowering + late grain filling stages during both seasons. Giza2 had the largest cob diameter, in both seasons, than other studied cultivars in the control irrigation treatment while the lowest cob diameter was obtained by skipping irrigation at early grain filling stage (the 3rd irrigation treatment) for S.C.123 hybrid.

3.3. Number of kernels/row : The lowest number of kernels/row was found when skipping irrigation at flowering, early grain filling, pre-flowering + early grain filling and flowering + late grain filling stages (The 2nd, 3rd,5th, and 7th irrigation treatments). T.W.C.321 showed higher significant number of kernels/row than all other cultivars in the two seasons followed by S.C.123 and Giza2. DTP-1 had the lowest number of kernels/row in both seasons. The interaction between skipping irrigation treatments with cultivars was highly significant in 2003 season only.

3.4. 100-kernels weight (gm) : Skipping irrigation at early grain filling, flowering + early grain filling and pre-flowering + late grain filling stages (skipping the 3rd, 6th and 7th irrigation treatments) resulted in the lowest 100-kernals weight in both seasons. Giza2 had significantly higher values for 100-kernals weight than all other cultivars in the two seasons. DTP-1 had the lowest values for 100-kernels weight in both seasons.

3.5. Grain yield (ton/ha) : Skipping any of the scheduled irrigations significantly decreased grain yield. Skipping the 5th, 6th and 7th treatments resulted in the lowest grain yield in 2002. Skipping irrigation at the pre-flowering + early grain filling, flowering + late grain filling and pre-flowering + late grain filling stages produced 9.03, 8.87 and 8.21 ton/ha, respectively as compared to 10.67 ton/ha from the control treatment in 2002 season.. In 2003, skipping irrigation at pre-flowering + late grain filling, pre-flowering + early grain pre-flowering + late grain filling and flowering + late grain filling stage (the 7th , 5th and 6th irrigation treatments resulted in the lowest grain yield (7.41, 7.70 and 7.70 ton/ha, respectively). Results showed that T.W.C.321 had the highest grain yield in both seasons (10.95 and 9.79, respectively) while DTP-1 produced the lowest grain yield (7.47 and 6.32 ton/ha, respectively) in the two successive seasons.

Data showed that T.W.C.321 was the yielding hybrid under the drought stress treatment used in the study and conditions of the newly reclaimed lands of Nubaria area.

3.6. Straw yield (ton/ha) : The highest straw yield was obtained from normal irrigation treatment while skipping irrigation at pre-flowering + late grain filling and flowering + late grain filling produced the lowest straw yield in 2002 and 2003 seasons. T.W.C.321 had the higest straw yield per hectar in both seasons (31.99 and 29.115 ton/ha, respectively) as compared to the other cultivars.

4. Correlation between traits : Phenotypic correlation coefficients between grain yield and 100-kernals weight, Ear length, leaf are, proline content and plant height were positive and significant in both seasons.

Conclusion

It could be concluded that leaf water potential, leaf proline content and could be recommended as a selection criteria for grain yield breeding program.

Maize crop responds to water stress, but irrigation management is important to produce consistently high yields with minimum number of irrigation.

Checking the water stress to plant leaves at different growth stages as an indicator of how plant need irrigation.

Water stress pre-flowering and flowering stages limits potential yield that is not regained when water stress is relieved. Therefore, irrigation to prevent stress during pre-flowering and flowering would be more advisable than delaying irrigation until grain filling.

Found that Giza-2 population gave the minimum value of number of 50% tassalling, silking and maximum value of 100- kernel weight.

Data showed that T.W.C.321 hybrid was the best yielding under the different drought stress treatments used in the study and conditions of Nubaria region.

6. LITERATURE CITED

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Using: A:\CORR.DT

Variable: Elongation

Source	SS	df	MS	F	P
Main Effects					
Grad	**1.4095238095**	**5**	**0.2819047619**	**1.2573451327**	**.2901 ns**
*** Var.**	**3.456031746**	**6**	**0.576005291**	**2.5690855457**	**.0247**
Interaction					
Grad x Var.	**4.0782539683**	**30**	**0.1359417989**	**0.6063244838**	**.9381 ns**
Error	**18.833333333**	**84**	**0.2242063492**		
Total	**27.777142857**	**125**			

Duncan's Multiple Range Test

Factor: Grad

Error mean square = 0.2242063492

Degrees of freedom = 84

Significance level = .05

LSD .05 = 0.2905887858

Rank	Trt#	Mean	n	Non-significant ranges
1	5	5.7523809524	21	a
2	3	5.6714285714	21	a
3	6	5.6476190476	21	a
4	1	5.5666666667	21	a
5	4	5.4666666667	21	a
6	2	5.4666666667	21	a

Duncan's Multiple Range Test

.Factor: Var

Error mean square = 0.2242063492

Degrees of freedom = 84

LSD .05 = 0.3138717617

Rank	Trt#	Mean	n	Non-significant ranges
1	5	5.8222222222	18	a
2	3	5.6888888889	18	a
3	4	5.6888888889	18	a
4	7	5.6888888889	18	a
5	6	5.4944444444	18	ab
6	2	5.4944444444	18	ab
7	1	5.2888888889	18	b

Using: A:\CORR.DT

Variable: Uniformity

Source	SS	df	MS	F	P
Main Effects					
***** Grad**	**190.96920635**	**5**	**38.19384127**	**41.985901239**	**.0000**
***** Var.**	**737.43634921**	**6**	**122.9060582**	**135.10873611**	**.0000**
Interaction					
***** Grad x Var.**	**652.93412699**	**30**	**21.7644709**	**23.925347525**	**.0000**
Error	**76.413333333**	**84**	**0.9096825397**		
Total	**1657.7530159**	**125**			

Duncan's Multiple Range Test

Factor: Grad

Error mean square = 0.9096825397

Degrees of freedom = 84

Significance level = .05

LSD .05 = 0.5853287096

Rank	Trt#	Mean	n	Non-significant ranges
1	1	87.285714286	21	a
2	2	87.104761905	21	a
3	3	85.428571429	21	b
4	6	84.966666667	21	bc
5	4	84.661904762	21	c
6	5	83.961904762	21	d

Duncan's Multiple Range Test

.Factor: Var

Error mean square = 0.9096825397

Degrees of freedom = 84

LSD .05 = 0.6322272651

Rank	Trt#	Mean	n	Non-significant ranges
1	1	87.888888889	18	a
2	7	87.788888889	18	a
3	2	87.444444444	18	a
4	3	86.455555556	18	b
5	4	85.116666667	18	c
6	6	83.294444444	18	d
7	5	80.988888889	18	e

S.E. of r S.E. of b P

X Variable Y Variable Corr (r) Slope (b) Y Int (a) n-2

Mic.	**O**		**0.303776526**	**0.1002889717**	**0.2693980382**	**124**
		*******	**0.0855588753**	**0.0282464605**	**5.442205E-04**	
Mic.	**P.M.**		**0.5783220405**	**8.691589035**	**53.814547423**	**124**
		*******	**0.073261772**	**1.1010495359**	**1.325875E-12**	
Mic.	**H.W.**		**0.5926406839**	**18.073370901**	**53.608468037**	**124**
		*******	**0.0723330681**	**2.2058937289**	**2.66347E-13**	
Mic.	**O//**		**0.7779714413**	**0.1616700549**	**0.0507356437**	**124**
		*******	**0.0564229732**	**0.0117252443**	**-1.887229E-17**	
Mic.	**P.M.//**		**0.6764356201**	**15.770087503**	**14.087038829**	**124**
		*******	**0.0661398111**	**1.5419510406**	**-8.232015E-17**	
Mic.	**H.W.//**		**0.9262719532**	**32.114978092**	**2.0258495308**	**124**
		*******	**0.0338426469**	**1.1733658339**	**5.200213E-17**	
O	**Mic.**		**0.303776526**	**0.9201428248**	**2.8895120154**	**124**
		*******	**0.0855588753**	**0.2591588832**	**5.442205E-04**	
O	**P.M.**		**0.2848218306**	**12.965932171**	**75.868288452**	**124**
		******	**0.0860830678**	**3.9187558603**	**0.0012272125**	
O	**H.W.**		**0.2961567082**	**27.357115646**	**99.223497489**	**124**
		*******	**0.085774047**	**7.9232732436**	**7.596755E-04**	
O	**O//**		**0.462844192**	**0.2913411177**	**0.4300484321**	**124**
		*******	**0.0796046306**	**0.0501077953**	**4.848096E-08**	

O	P.M.//		0.4361364703	30.79860681	49.621048725	124
		***	0.0808116577	5.7066689935	3.311582E-07	
O	H.W.//		0.2880384002	30.249662863	94.391675941	124
		**	0.0859967122	9.0313359288	0.001073186	

P.M.	Mic.		0.5783220405	0.0384804644	0.2295423776	124
		***	0.073261772	0.004874701	1.325934E-12	
P.M.	O		0.2848218306	0.0062566635	0.0913747553	124
		**	0.0860830678	0.0018909814	0.0012272125	
P.M.	H.W.		0.2926844224	0.593906213	66.273919498	124
		***	0.0858701114	0.1742449847	8.817413E-04	
P.M.	O//		0.4544923185	0.0062843887	0.0825419061	124
		***	0.0799917704	0.0011060679	8.999541E-08	
P.M.	P.M.//		0.401578558	0.622943575	16.356589816	124
		***	0.0822434752	0.1275791334	3.154382E-06	
P.M.	H.W.//		0.4680782724	1.0798368871	22.475935094	124
		***	0.0793574361	0.1830742674	3.262241E-08	

H.W.	Mic.		0.5926406839	0.019433175	1.2006171947	124
		***	0.0723330681	0.0023718607	2.662261E-13	
H.W.	O		0.2961567082	0.0032060688	0.2438829807	124
		***	0.085774047	9.28554E-04	7.596755E-04	
H.W.	P.M.		0.2926844224	0.1442385502	67.113029969	124
		***	0.0858701114	0.0423178667	8.817413E-04	

H.W.	O//		0.4860340961	0.0033119591	0.2250836854	124
		***	0.0784821151	5.34797E-04	7.959431E-09	
H.W.	P.M.//		0.4225921072	0.3230586071	31.094504564	124
		***	0.0813899371	0.0622200918	8.254888E-07	
H.W.	H.W.//		0.6859362945	0.7798394469	22.505512603	124
		***	0.0653459405	0.0742916543	3.710116E-17	

O//	Mic.		0.7779714413	3.7436714181	1.174492342	124
		***	0.0564229732	0.2715126301	-5.295987E-18	
O//	O		0.462844192	0.7353055681	0.167845495	124
		***	0.0796046306	0.1264652968	4.848096E-08	
O//	P.M.		0.4544923185	32.869269769	63.82111176	124
		***	0.0799917704	5.785072646	8.999541E-08	
O//	H.W.		0.4860340961	71.32610446	72.601390297	124
		***	0.0784821151	11.517347421	7.959431E-09	
O//	P.M.//		0.9010281413	101.08345057	6.9811983826	124
		***	0.0389528549	4.369995571	4.762414E-17	
O//	H.W.//		0.7653137909	127.68583601	35.198871384	124
		***	0.0578021376	9.6437753329	1.488369E-17	
P.M.//	Mic.		0.6764356201	0.0290147501	1.466112358	124
		***	0.0661398111	0.0028369737	-8.232015E-17	
P.M.//	O		0.4361364703	0.0061760917	0.1923891061	124
		***	0.0808116577	0.0011443671	3.311582E-07	

P.M.//	P.M.		0.401578558	0.2588763168	66.098360427	124
		***	0.0822434752	0.0530179899	3.154382E-06	
P.M.//	H.W.		0.4225921072	0.5527916147	78.158178736	124
		***	0.0813899371	0.1064659609	8.254888E-07	
P.M.//	O//		0.9010281413	0.0080314998	0.0586113683	124
		***	0.0389528549	3.472143E-04	4.762414E-17	
P.M.//	H.W.//		0.6733595535	1.0014021232	44.336283122	124
		***	0.0663924617	0.098737074	1.636158E-17	
H.W.//	Mic.		0.9262719532	0.0267158747	0.4367493006	124
		***	0.0338426469	9.76102E-04	-5.677102E-17	
H.W.//	O		0.2880384002	0.0027427122	0.3060327792	124
		**	0.0859967122	8.188639E-04	0.001073186	
H.W.//	P.M.		0.4680782724	0.2028984856	60.922823092	124
		***	0.0793574361	0.034399169	3.262241E-08	
H.W.//	H.W.		0.6859362945	0.6033403439	47.882944921	124
		***	0.0653459405	0.0574774108	9.350096E-17	
H.W.//	O//		0.7653137909	0.0045870804	0.0910624918	124
		***	0.0578021376	3.464501E-04	1.488369E-17	
H.W.//	P.M.//		0.6733595535	0.4527782374	17.418061147	124
		***	0.0663924617	0.0446434028	1.636158E-17	

End of Correlation

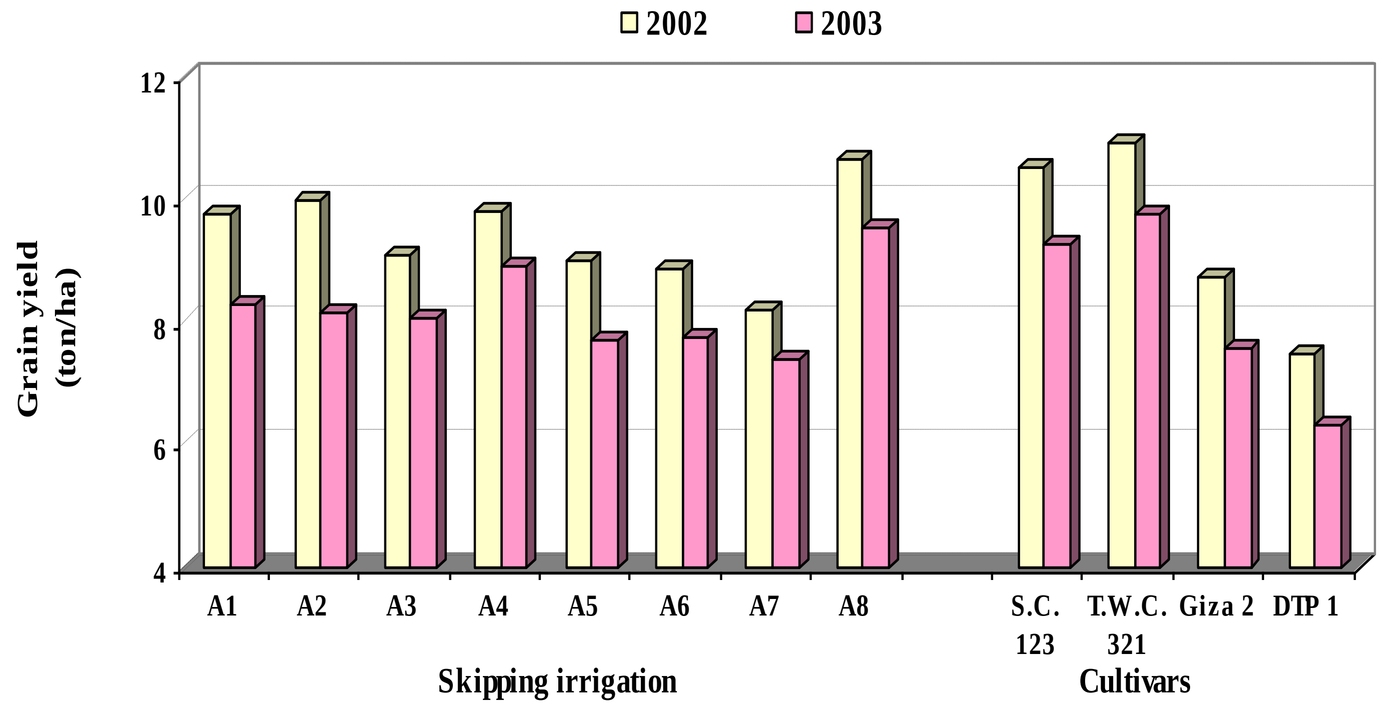

Figure (1): Effect of some drought treatments and varieties on grain yield (ton/ha) of maize plant during 2002 and 2003 seasons

رسم توضيحي ١

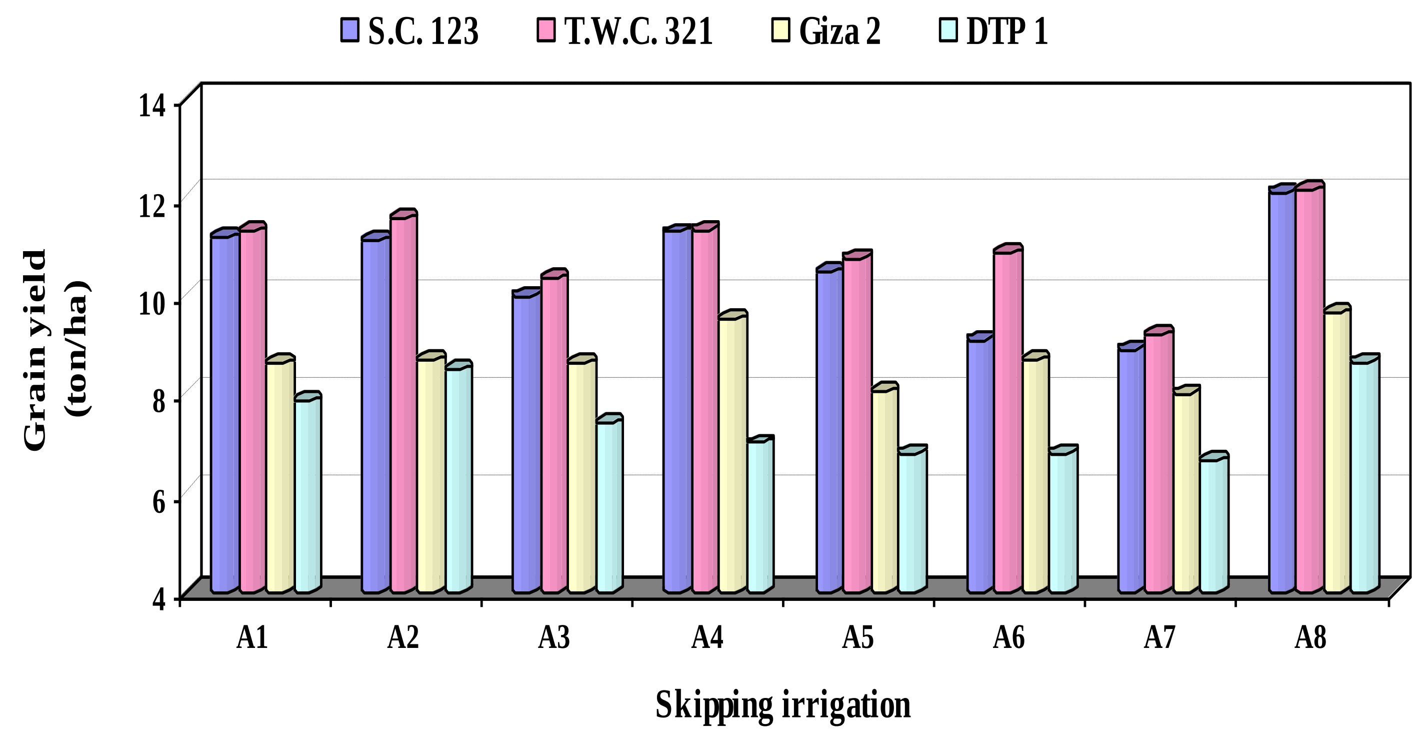

Figure (2): Interaction between some drought treatments and varieties on grain yield (ton/ha) of maize plant during 2002 season.

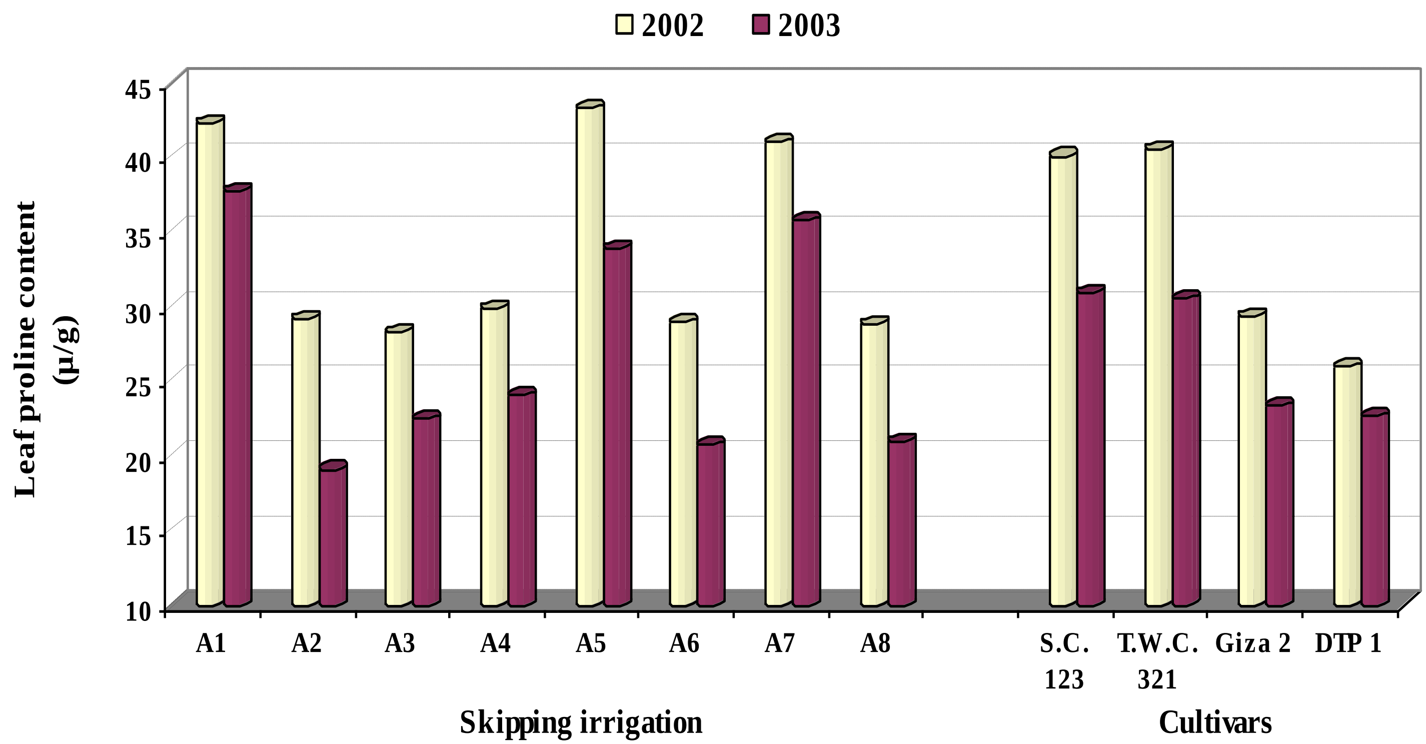

Figure (3): Effect of some drought treatments and varieties on leaf proline content of maize plant during 2002 and 2003 seasons

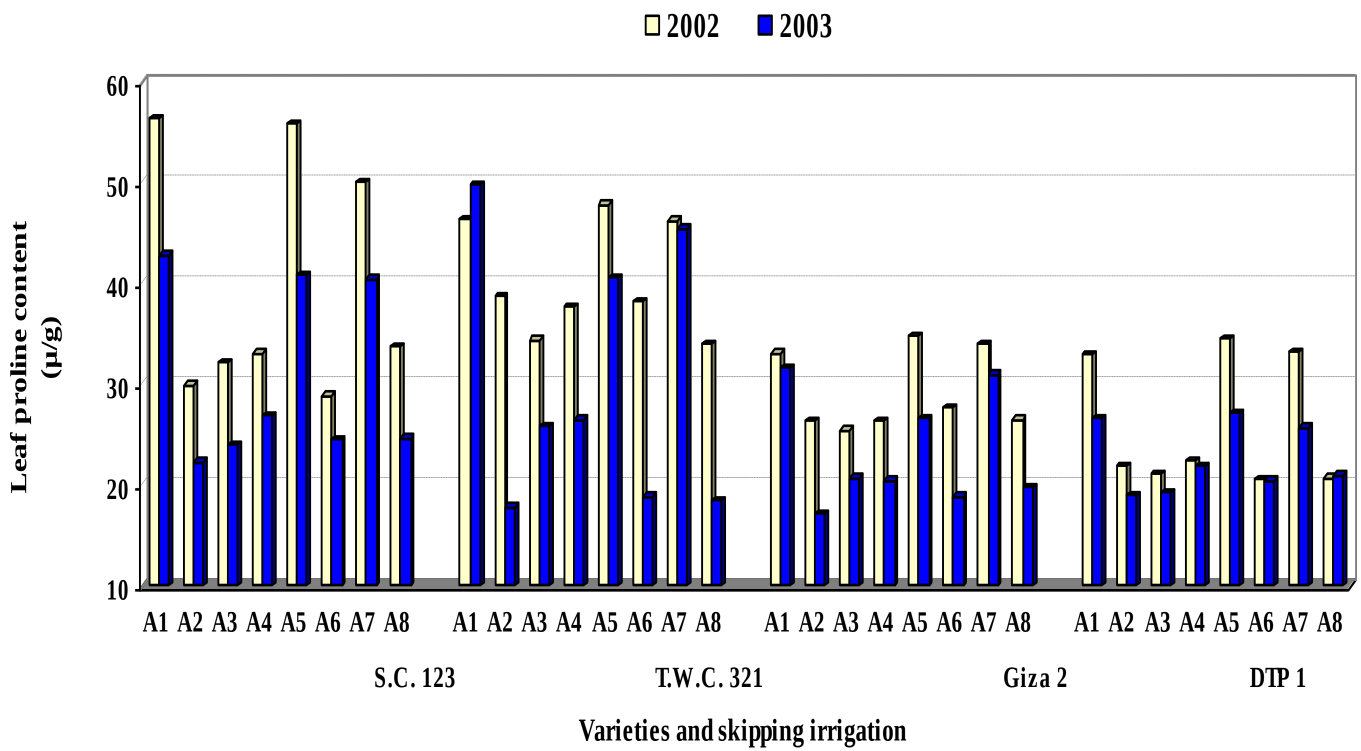

Figure (4): Interaction between some drought treatments and varieties on leaf proline content (µ/g) of maize plant during 2002 and 2003 seasons

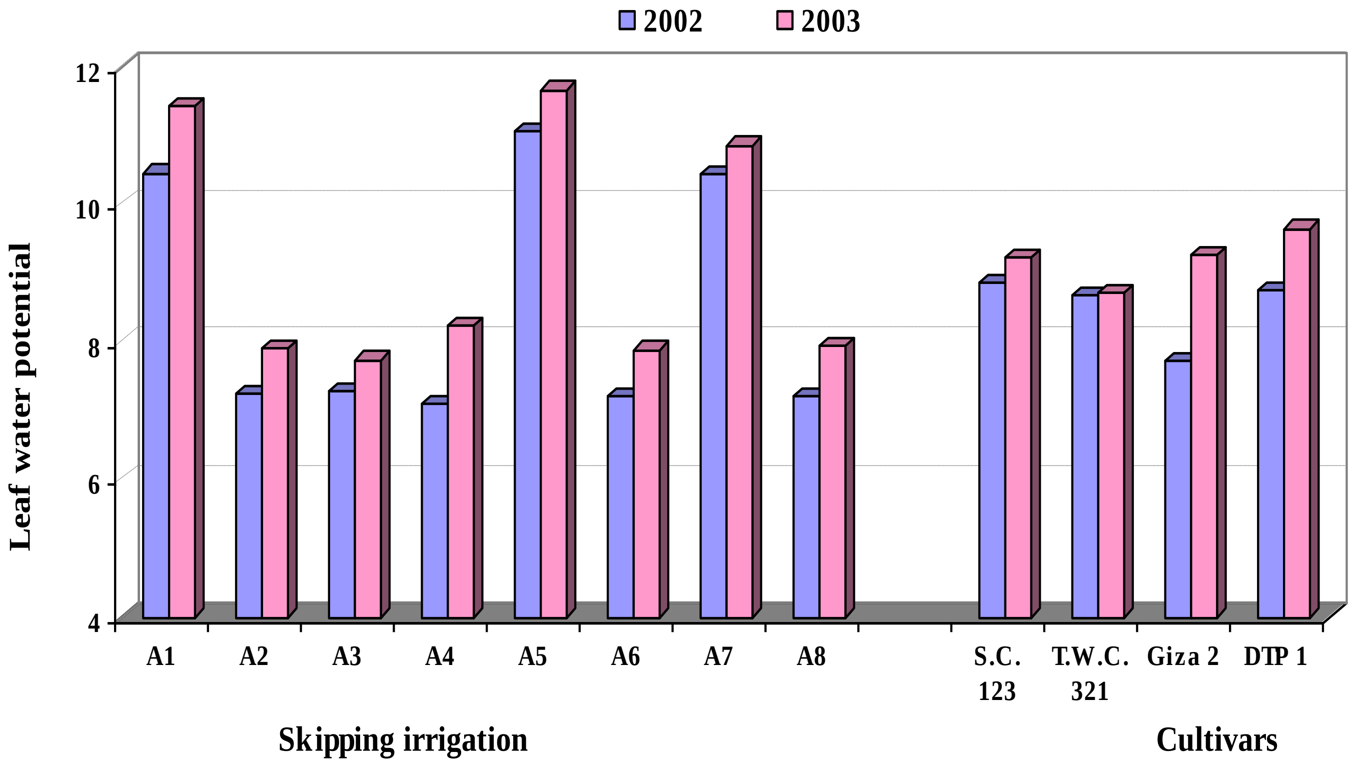

Figure (5): Effect of some drought treatments and varieties on leaf water potential at stage (49 days from growth) of maize plant during 2002 and 2003 seasons

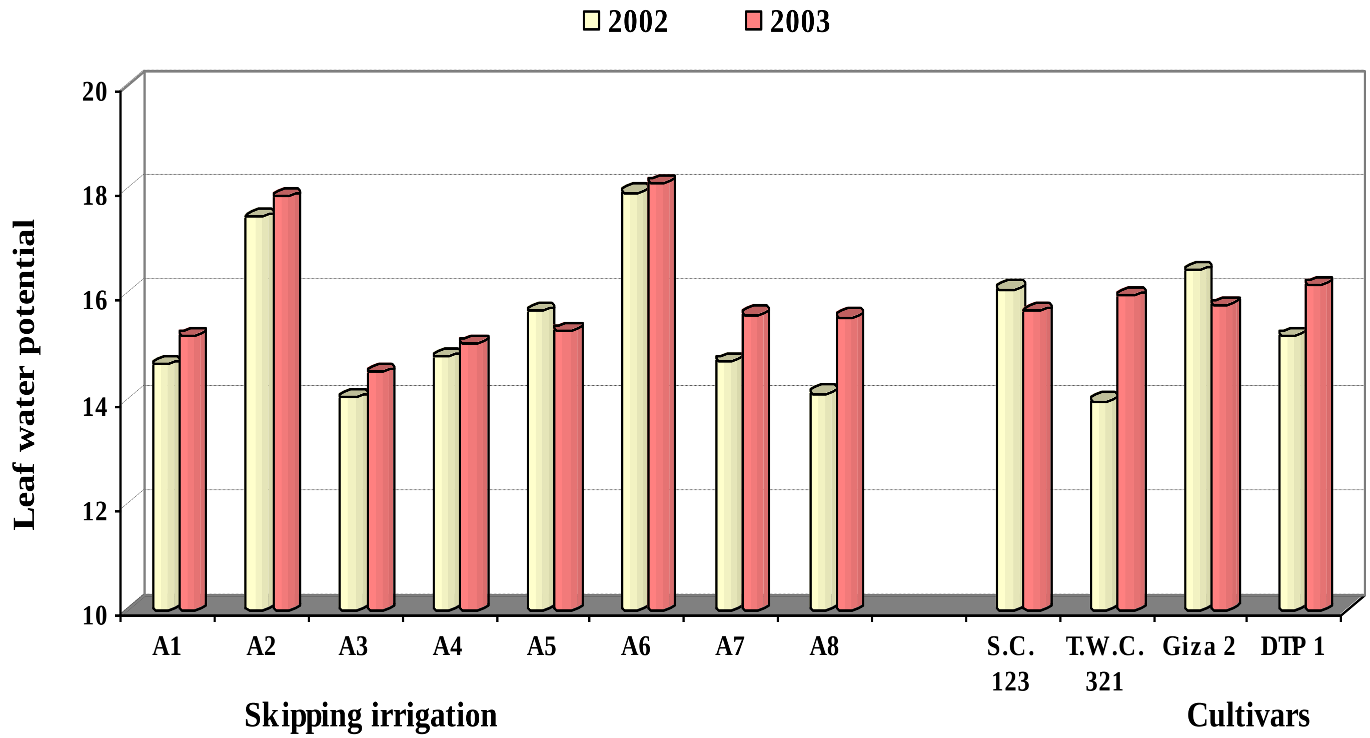

Figure (6): Effect of some drought treatments and varieties on leaf water potential at stage (65 days from growth) of maize plant during 2002 and 2003 seasons

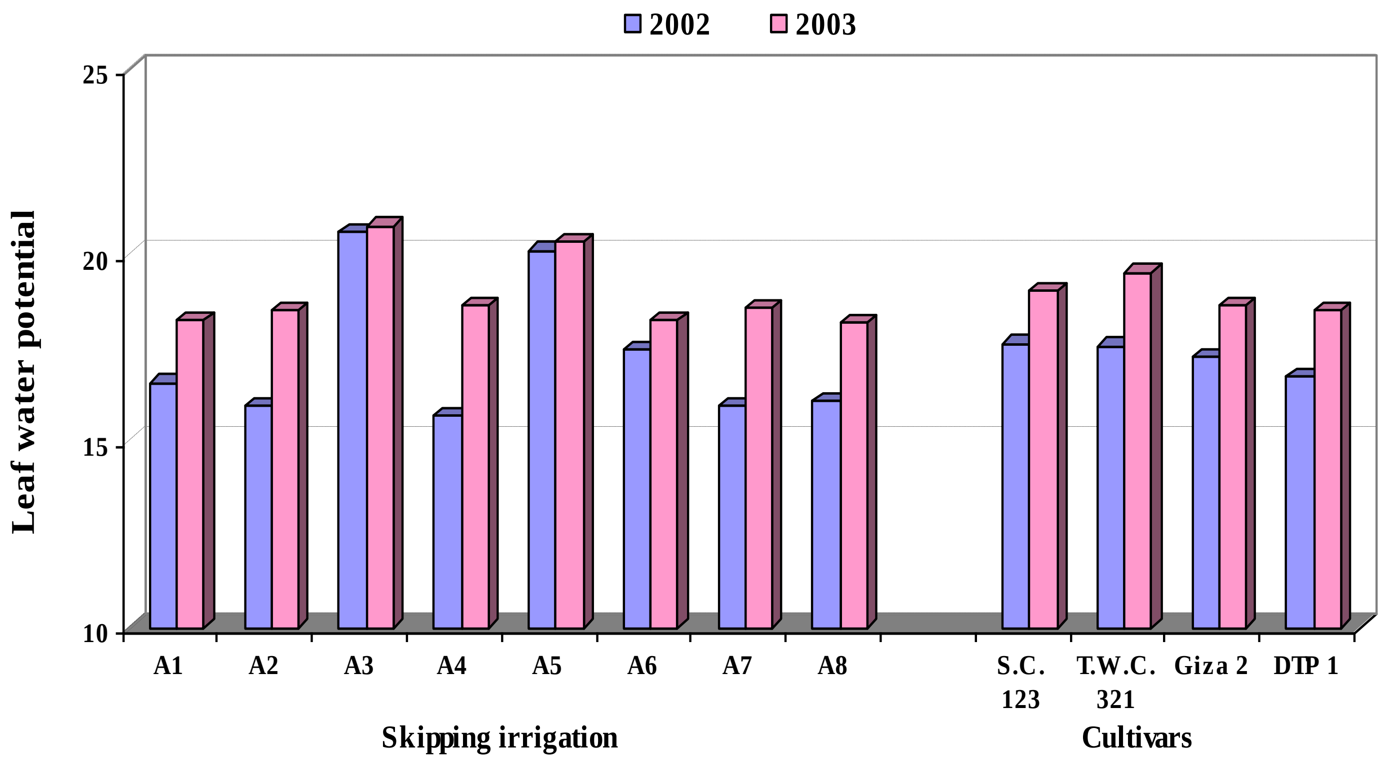

Figure (7): Effect of some drought treatments and varieties on leaf water potential at 79 days from growth of maize plant during 2002 and 2003 seasons

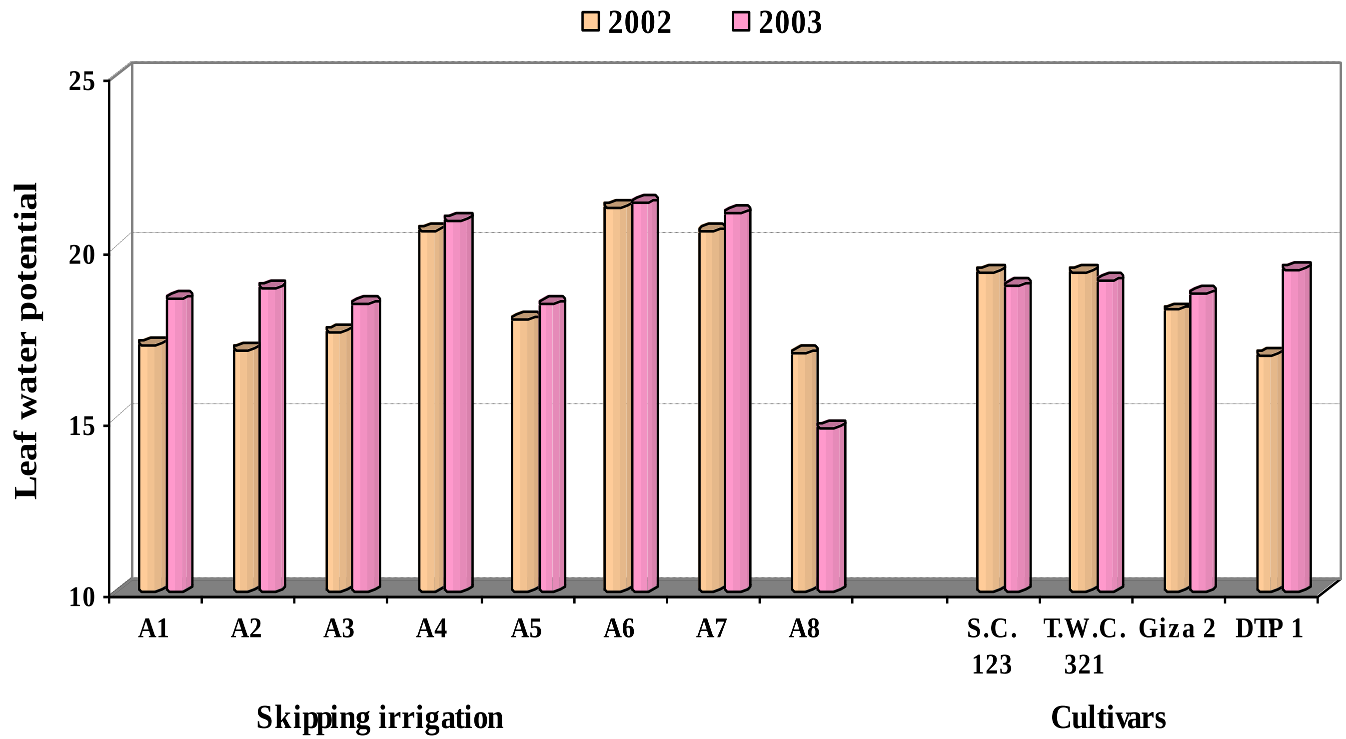

Figure (8): Effect of some drought treatments and varieties on leaf water potential at stage (94 days from growth) of maize plant during 2002 and 2003 seasons

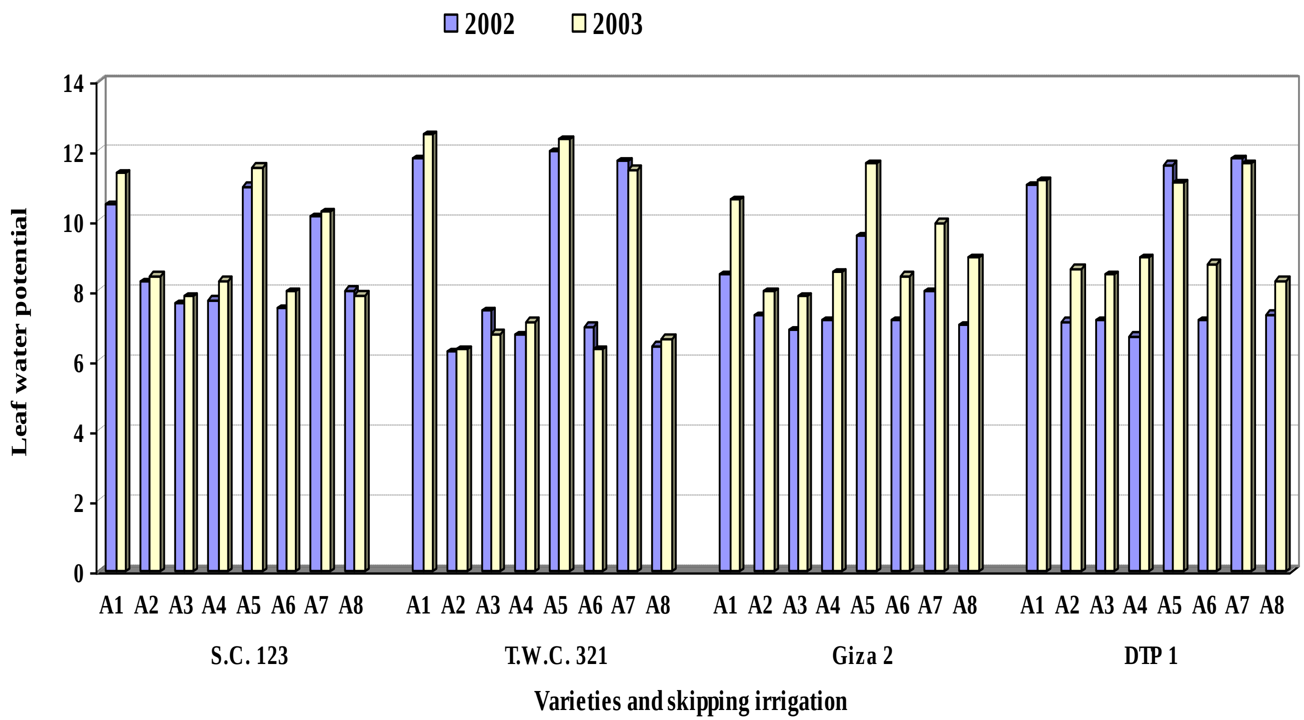

Figure (9): Interaction between some drought treatments and varieties on leaf water potential of maize plant at 49 days from growth during 2002 and 2003 seasons

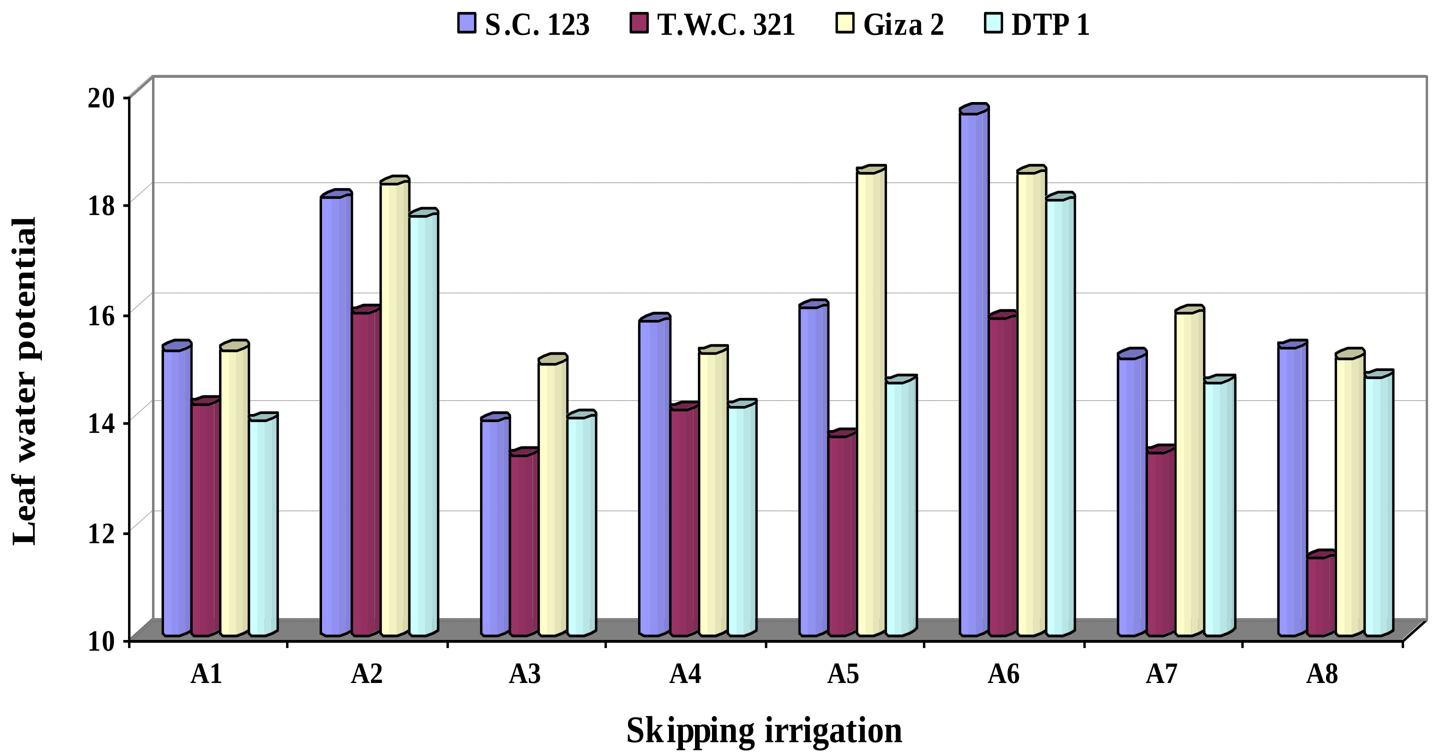

Figure (10): Interaction between some drought treatments and varieties on leaf water potential of maize plant at 65 day from growth during 2002 season

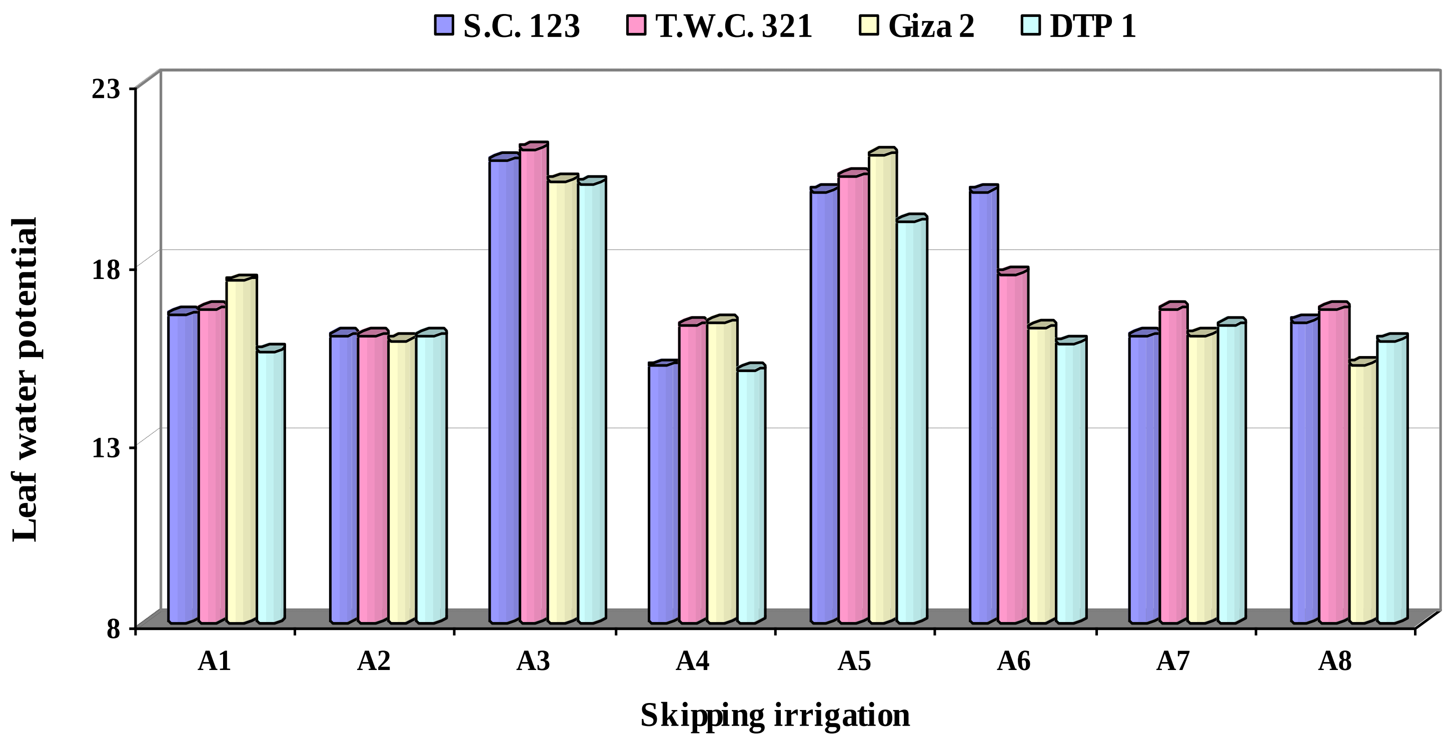

Figure (11): Interaction between some drought treatments and varieties on leaf water potential of maize plant at 79 days from growth during 2002 season

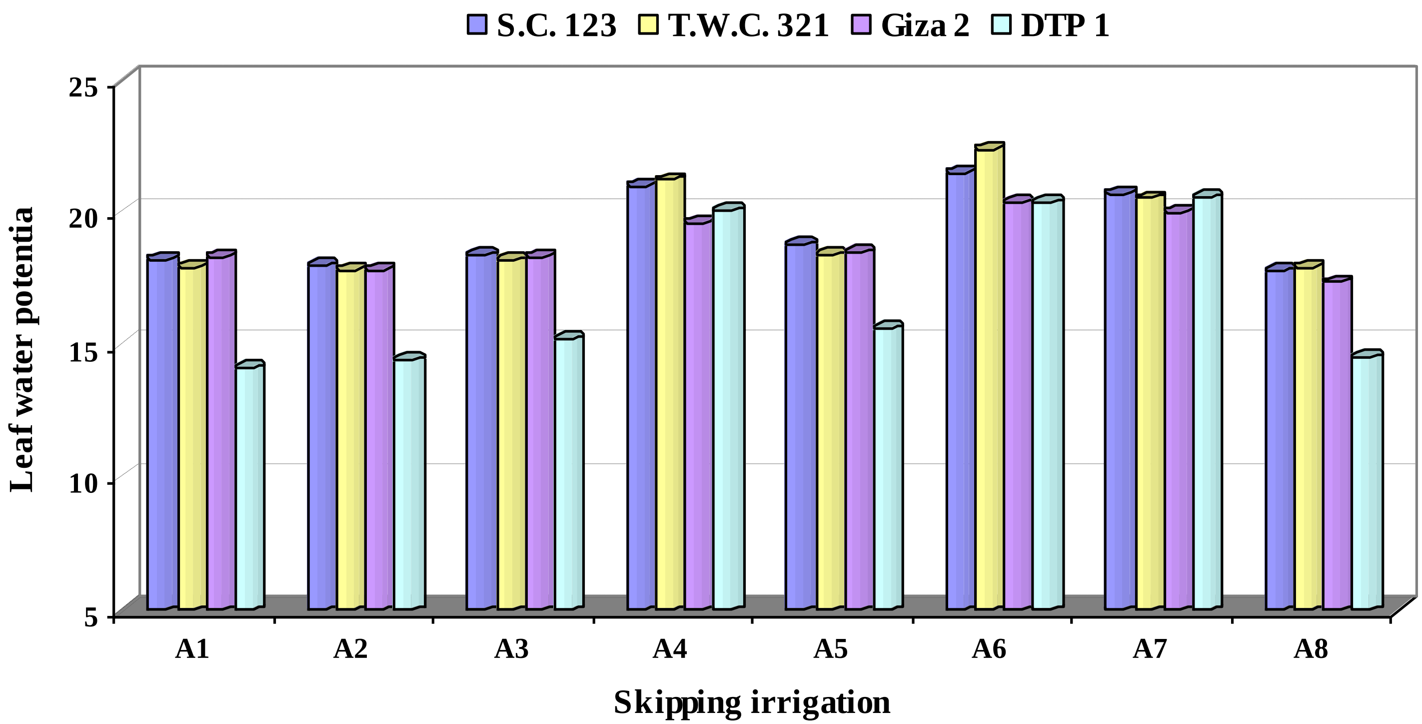

Figure (12): Interaction between some drought treatments and varieties on leaf water potential of maize plant at 94 days from growth during 2002 season

Table (17): Drought susceptibility index (DI) and reduction percentage (RD%) for ear length season 2003 and cob diameter season 2002.

	Ear Length 2003								Cob Diameter 2002							
	S.C.123		T.W.C.321		Giza 2		DTP-1		S.C.123		T.W.C. 321		Giza 2		DTP	
	DI	RD%	DI	RD%	DI	RD%	DI	RD%	DI	RD%	DI	RD%	DI	RD%	DI	RD%
A_1	0.85	7.1	0.63	5.3	1.30	10.8	1.38	11.4	0.76	4.8	1.04	6.5	1.38	8.7	0.79	4.9
A_2	0.79	8.1	1.38	14.2	0.85	8.7	1.01	10.4	0.38	1.8	0.75	3.6	1.94	9.3	0.82	3.9
A_3	1.49	13.1	0.81	7.1	0.72	6.3	1.00	8.9	1.28	8.4	0.44	2.9	1.17	7.7	1.09	7.2
A_4	2.09	8.4	0.34	1.3	0.45	1.8	1.22	4.9	0.96	3.7	0.76	8.9	1.43	5.4	0.86	3.4
A_5	1.35	11.8	0.78	6.8	0.80	7.0	1.12	9.8	0.24	1.8	0.87	6.5	1.03	7.7	1.76	13.1
A_6	1.23	5.8	0.45	2.1	1.18	5.5	1.32	6.2	0.76	2.9	1.21	4.7	0.74	2.9	1.27	4.9
A_7	0.50	3.1	1.21	7.6	0.96	6.0	1.50	9.4	1.12	8.4	1.10	8.3	0.94	7.1	0.87	6.6

Table (21): Drought susceptibility index (DI) and reduction percentage (RD%) for grain yield season 2002 and no. of kernels/row season 2003.

	Grain yield								No. Kernel/row							
	S.C.123		T.W.C.321		Giza 2		DTP-1		S.C.123		T.W.C. 321		Giza 2		TP-1	
	DI	RD%	DI	RD%	DI	RD%	DI	RD%	DI	RD%	DI	RD%	DI	RD%	DI	RD%
A_1	0.86	7.7	0.76	6.8	1.21	10.9	1.03	9.2	0.99	10.2	0.64	6.6	1.61	16.6	0.79	8.2
A_2	1.30	8.2	0.75	4.7	1.60	10.0	0.26	1.6	1.04	14.4	0.34	5.0	1.39	19.3	1.34	18.7
A_3	1.20	17.6	1.00	14.6	0.74	10.9	0.98	14.4	0.79	9.0	0.63	7.2	1.63	18.6	1.04	11.9
A_4	0.85	6.9	0.83	6.7	0.18	1.4	2.36	18.9	0.26	1.8	0.34	2.4	1.96	13.8	1.70	11.9
A_5	0.89	13.5	0.75	11.4	1.09	16.5	1.4	21.2	0.73	8.4	0.88	10.2	1.31	15.2	1.35	15.7
A_6	1.49	24.8	0.64	10.6	0.60	10.0	1.27	21.2	0.53	5.4	0.81	8.4	2.01	20.7	0.72	7.5
A_7	1.48	26.3	1.05	24.2	0.74	16.9	1.01	24.8	0.47	6.6	0.51	7.2	1.91	26.9	1.27	17.9

Table (22): Correlation on grain yield (ton/ha) of maize plant during 2002 season.

	G.Y.	100 KW	E.L	L.A.	LPC	LWP_1	LWP_2	LWP_3	LWP_4	P.H.
G.Y.										
100 KW	0.40**									
E.L	0.80*9*	0.47**								
L.A.	0.68**	0.41*9*	0.65**							
LPC	0.41**	0.14	0.49**	0.14						
LWP_1	-014	-0.18*	-0.01	-0.37**	0.62**					
LWP_2	-0.25*	-0.02	-0.13	-0.24**	-0.21*9	-0.13				
LWP_3	-0.05	-0.03	0.04	0.03	0.13	0.12	0.03			
LWP_4	-0.10	0.13	0.35**	0.24**	0.22*	-0.03	0.20*	-0.02		
P.H.	0.76**	0.33**	0.74**	0.77**	0.23**	-0.31**	-0.27**	0.05	0.24**	

G.Y. : Grain Yield (ton/ha).
100 KW : One Hundred Kernels Weight (gm.).
E.L : Ear Length (cm.).
L.A. : Leaf Area (cm^2).
LPC : Leaf Proline Content (%).
LWP_1 : Leaf Water Potential P_1
LWP_2 : Leaf Water Potential P_2
LWP_3 : Leaf Water Potential P_3
LWP_4 : Leaf Water Potential P_4
P.H. : Plant Height (cm.).

Table (23): Correlation on grain yield (ton/ha) of maize plant during 2003 season.

	G.Y.	100 KW	E.L	L.A.	LPC	LWP_1	LWP_2	LWP_3	LWP_4	P.H.
G.Y.										
100 KW	0.46**									
E.L	0.82**	0.44**								
L.A.	0.82**	0.33**	0.77**							
LPC	0.17*	0.03	0.29**	0.09						
LWP_1	-0.30**	-0.18*	-0.21*	-0.42**	0.68**					
LWP_2	-0.15	-0.06	-0.11	-0.12	-0.35**	-0.22				
LWP_3	0.13	-0.03	0.07	0.23*	0.11	-0.01	-0.20*			
LWP_4	-0.23*	-0.34**	0.35**	-0.14	0.06	0.68	0.17*	-0.03		
P.H.	0.77**	0.38**	0.78**	0.67**	0.01	0.47**	-0.07	0.11	-0.18*	

G.Y. : Grain Yield (ton/ha).
100 KW : One Hundred Kernels Weight (gm.).
E.L : Ear Length (cm.).
L.A. : Leaf Area (cm^2).
LPC : Leaf Proline Content (%).
LWP_1 : Leaf Water Potential P_1
LWP_2 : Leaf Water Potential P_2
LWP_3 : Leaf Water Potential P_3
LWP_4 : Leaf Water Potential P_4
P.H. : Plant Height (cm.).

الملخص العربى

تأثير الإجهاد الرطوبى على الذرة الشامية
فى الأراضى الجيرية.

إن المفهوم الدقيق لنمو وتطور النبات يعد عاملاً أساسياً فى إنتاجيات وإقتصاديات محصول الذرة الشامية ، ويلعب الماء دورا مهما فى عملية توزيع وإنتشار المحاصيل الزراعية على سطح الكرة الأرضية ، بالأضافة إلى أن الإهتمام بحسن إستغلال الموارد المائية وتوظيفها توظيفاً سليماً وإضافتها للنبات بالكميات المناسبة فى مراحل نموه المختلفة حسب حساسية كل مرحلة ومدى تأثيرها على النمو والمحصول يعتبر عاملاً مهماً ، خاصة مع النمو المستمر لمعدلات السكان فى العالم ، وهذا الأمر يتطلب توفير الغذاء لهؤلاء السكان مما يؤدى إلى إستهلاك الكثير من مصادر المياة وعليه أصبحت الحاجة ملحة لترشيد إستخدام المياه لأن الماء يؤثر على النبات تأثيراً مباشراً الأمر الذى يؤدى الى توقف كمية المحصول وجودته على مقدار الماء الميسر بالأرض خلال مراحل نمو وتطور النبات المختلفة.

ويتلخص التأثير المباشر للماء بأنه الوسط الذى يتم فيه حدوث جميع التفاعلات الكيماوية والحيوية الخاصة بالنبات ، وفى إنتقال العناصر الغذائية والتأثير على عملية النتح والتمثيل الضوئى ، التنفس ، أيض البروتينات ، النشاط الأنزيمى ، النمو وغير ذلك مما يؤثر على المحصول الذى هو فى النهاية عبارة عن محصلة للعمليات الفسيولوجية الدائرة داخل النبات خلال أطوار نموه المختلفة ، لذا فإن دراسة تأثير الجفاف على النبات من خلال العلاقة بين طور نمو النبات وإستجابته للإجهاد الرطوبى يعتبر مهماً خاصةً فى المناطق التى تعانى من ضعف الموارد المائية يعتبر إستنباط أصناف جديدة من الذرة الشامية مقاومة للجفاف من الأهداف الرئيسية التى يجب على مربى الذرة أن يأخذها فى الإعتبار. ومن المعروف أنه يوجد تباين ملحوظ فى درجة المقاومة للجفاف تتوقف على التركيب الوراثى للصنف والظروف الجوية وظروف التربة والمعاملات الزراعية.

على ضوء ذلك أقيمت تجربتان حقليتان تحت ظروف الأراضى الجديدة وذلك بالمزرعة البحثية بمحطة البحوث الزراعية بالنوبارية (أرضى جيرية) خلال الموسمين ٢٠٠٢،٢٠٠٣ وذلك لمعرفة تأثير الحرمان من الرى خلال مراحل نمو محصول الذرة الشامية على كمية محصول الحبوب ومكوناته المختلفة وصفات النبات الفسيولوجية والكيميائية وتحديد المرحلة أو المراحل الأشد حساسية للإجهاد الرطوبى.

وكان التصميم المستخدم فى هذه التجربة تصميم القطع المنشقة مرة واحدة فى أربع مكررات على النحو التالى:

القطع الرئيسية: إحتوت على معاملات الإجهاد الرطوبى التالية :

١- تعريض النباتات للإجهاد الرطوبى أثناء مرحلة قبل التزهير (تحريم ريه قبل التزهير ٣٥-٥٠ يوم "حرمان الرية الثانية").

٢- تعريض النباتات للإجهاد أثناء طور الإزهار (تحريم ريه أثناء التزهير ٥٠-٦٥ يوم "حرمان الرية الثالثة").

٣- تعريض النباتات للإجهاد أثناء الطور اللبنى للحبوب (تحريم ريه أثناء الإمتلاء اللبنى للحبوب ٦٥-٨٠ يوم "حرمان الرية الرابعة").

٤- تعريض النباتات للإجهاد أثناء طور الإمتلاء النهائى للحبوب (تحريم ريه أثناء الإمتلاء النهائى للحبوب ٨٠-٩٥ يوم "حرمان الرية الخامسة").

٥- تعريض النباتات للإجهاد أثناء مرحلة قبل التزهير ومرحلة الإمتلاء اللبنى للحبوب (حرمان من ريه فى مرحلة قبل التزهير + الحرمان من ريه فى مرحلة الإمتلاء اللبنى للحبوب "حرمان الرية الثانية والرية الرابعة").

٦- تعريض النباتات للإجهاد أثناء مرحلة التزهير ومرحلة الإمتلاء النهائى للحبوب (تحريم ريه أثناء التزهير وريه أثناء الإمتلاء النهائى للحبوب "حرمان الرية الرابعة والسادسة").

٧- تعريض النباتات للإجهاد الرطوبى أثناء مرحلة قبل التزهير ومرحلة الإمتلاء النهائى للحبوب (تحريم ريه أثناء التزهير وريه أثناء الإمتلاء النهائى للحبوب "حرمان الرية الثانية والرية الخامسة").

٨- توفير الرطوبة الأرضية المناسبة بالحقل فى أطوار نموه المختلفة (مقارنة) وتمت وفقاً للرى المتبع بالمزرعة البحثية حيث تعطى أول رية بعد ٢١ يوما من الزراعة ثم ٦ ريات بمعدل رية كل ١٥ يوم.

أما القطع المنشقة من التجربة فخصصت لدراسة مدى تأثير الهجن بمعاملات الإجهاد الرطوبى السابقة وتحديد الهجن أو العشائر التى تتحمل معاملات التعطيش عن غيرها وفى أى مرحلة نمو، وشملت الهجن والعشائر (هجين فردى ١٢٣ ، هجين ثلاثى ٣٢١ ، جيزة-٢ وعشيرة DTP-1 وهى أحد العشائر المستوردة المتحملة للجفاف.

وأجريت كافة العمليات الزراعية الأخرى كما هو موصى به للأراضى الجديدة بالنوبارية.

<u>الصفات المدروسة:</u>

- أرتفاع النبات.
- أرتفاع الكوز.
- قطر الساق.
- المساحة الورقية.
- عدد الأيام لظهور ٥٠% من النورات المذكرة.
- عدد الأيام لخروج ٥٠% من النورات المؤنثة.
- قياسات الكلوروفيل.

- الإجهاد المائى للأوراق (– بار)
- محتوى الأوراق من الحمض الأمينى برولين.
- حيوية حبوب اللقاح.

المحصول و مكونات المحصول :

١- طول الكوز (سم).

٢- قطر القولحة (سم).

٣- عدد الحبوب لكل صف.

٤- وزن ال١٠٠ حبة (جم).

- محصول الحبوب (طن/هكتار).
- وزن محصول القش (طن/هكتار).

و تتلخص نتائج الدراسة كالتالى :-

١- القياسات الفسيولوجية:

– **إرتفاع النبات :**

أدى تعرض نباتات الذرة للأجهاد الرطوبى الى أعلى نقص معنوى فى أرتفاع النبات بحرمان الرى فى مرحلة قبل التزهير ، و مرحلة قبل التزهير + الإمتلاء المبكر (اللبنى) للحبوب ، ومرحلة قبل التزهير و أتضح أن أعلى أرتفاع للنبات تم التحصل عليه من هجين فردى ١٢٣ وهجين ثلاثى ٣٢١ مقارنة بأرتفاع النباتات فى الأصناف الأخرى. وأعطت العشائر جيزة ٢ والعشيرة المقاومة للجفاف (DTP-1 أقصر طول للنبات خلال موسمى الزراعة.

– **طول الكوز :**

أدى الإجهاد الرطوبى لنباتات الذرة الشامية عند الحرمان من الرى فى أى مرحلة من مراحل النمو المختلفة الى أنخفاض معنوى فى أرتفاع الكوز بالمقارنة مع معاملة المقارنة (عدم تعريض النباتات للإجهاد الرطوبى) خلال موسمى ٢٠٠٢ ، ٢٠٠٣ وكانت أقل قيمة تم الحصول عليها فى أرتفاع الكوز عند الحرمان من الرى فى مرحلة قبل التزهير ، مرحلة الإمتلاء المبكر للحبوب + قبل التزهير ، مرحلة قبل التزهير + مرحلة الإنتهاء النهائى للحبوب وأعطى هجين فردى ١٢٣ وهجين ثلاثى ٣٢١ أعلى أرتفاع معنوى خلال موسمى النمو.

– **قطر الساق :**

أشارت النتائج أن أقل قطر الساق تم الوصول اليه عند الحرمان من الرى فى مرحلة قبل التزهير فى الموسمين ، بينما الحرمان من الرى فى مرحلة الإمتلاء النهائى للحبوب أدى إلى الحصول على أقل تأثير على قطر للساق. وكانت الأصناف الأكثر قطرا للساق هى هجين ثلاثى ٣٢١ وهجين فردى ١٢٣

فى موسمى ٢٠٠٢ و ٢٠٠٣ ، بينما لم تظهر أى أختلافات معنوية بين عشائر جيزة ٢ و العشيرة المقاومة للجفاف DTP-1 فى موسمى الزراعة.

– **دليل المساحة الورقية :**

فى موسمى الدراسة وجد أن هناك أنخفاض معنوى فى المساحة الورقية على النبات مقارنة بمعاملة المقارنة (عدم تعريض النبات للإجهاد الرطوبى) وكان الحرمان من الرى فى مرحلة قبل التزهير + الإمتلاء النهائى للحبوب وكذلك مرحلة قبل التزهير + الإمتلاء المبكر للحبوب أعطى أقل أنخفاض معنوى خلال موسمى الدراسة. وكان أعلى الأصناف فى صفة المساحة الورقية/نبات كمتوسط لكل معاملات الإجهاد المائى هو هجين ثلاثى ٣٢١ مقارنة بباقى الأصناف الأخرى فى كلا الموسمين ، وعلى الجانب الآخر وجد أن أقل مساحة ورقية/نبات كانت للعشيرة مقاومة للجفاف DTP-1 خلال الموسمين ، كما أوضحت النتائج أنه كان هناك تداخل ما بين معاملات الرى المختلفة والأصناف و سجلت أعلى مساحة ورقية/نبات مع الحرمان من الرى عند مرحلة التزهير مع صنف هجين ثلاثى ٣٢١ ، بينما كان أقل تداخل معنوى سجل عند الحرمان من الرى فى مرحلة قبل التزهير مع صنف العشيرة المقاومة للجفاف DTP-1 وذلك خلال موسم ٢٠٠٢ فقط .

– **عدد الأيام لظهور ٥٠% من النورات المذكرة :**

أشارت النتائج أن الحرمان من الرى فى مرحلة التزهير أدى الى تأخير عدد الأيام لظهور ٥٠% من النورات المذكرة خلال موسمى الزراعة ،كما وجد أن الحرمان من الرى فى مرحلة قبل التزهير أدى لتأخير معنوى لعدد الأيام لظهور ٥٠% من النورات المذكرة فى موسم ٢٠٠٣ فقط وكان أبكر الأصناف فى ظهور ٥٠% من النورات المذكرة هو صنف عشيرة جيزة ٢ فى كلا الموسمين بينما أكثر الأصناف تأخيراً فى عدد الأيام لظهور النورة المذكرة هو صنف هجين ثلاثى ٣٢١ وذلك فى موسم ٢٠٠٣ ، صنف هجين فردى ١٢٣ فى كلا الموسمين. وكان التداخل من الدرجة الأولى ما بين معاملات الرى المختلفة والأصناف لصفة عدد الأيام لظهور ٥٠% من النورات المذكرة و كان التأخير معنوياً للأصناف هجين فردى ١٢٣ و العشيرة المقاومة للجفاف DTP-1 فى كلا الموسمين .

– **عدد الأيام لظهور ٥٠% من الحريرة (النورة المؤنثة) :**

أشارت النتائج أن الحرمان من الرى فى مرحلة التزهير أعطى تأخير معنوى فى عدد الأيام لظهور ٥٠% من النورة المؤنثة بينما الحرمان من الرى فى مرحلة قبل التزهير أعطى أيضا تأخر معنوى فى عدد الأيام لظهور ٥٠% نورة مؤنثة ولكن فى موسم ٢٠٠٣ فقط ، أما الأصناف فكان أبكرهم فى عدد أيام ظهور ٥٠% من الحريرة (النورة المؤنثة) هو الصنف جيزة -٢ خلال موسمى النمو و على الجانب الأخر فأن صنف هجين فردى ١٢٣ كان المتأخر فى عدد أيام ظهور ٥٠% من الحريرة فى موسم ٢٠٠٢ ، بينما كانت الأصناف هجين ثلاثى ٣٢١ وهجين فردى ١٢٣ أكثرهم تأخراً لظهور

٥٠% من النورة المؤنثة موسم ٢٠٠٣. وكان هناك تداخل معنوى ما بين معاملات الرى المختلفة والأصناف لعدد أيام ظهور ٥٠% من الحريرة حيث أعطت أصناف هجين فردى ١٢٣ وعشيرة مقاومة للجفاف (DTP-1) تأخر معنوى فى عدد أيام ظهور ٥٠% من النورة المؤنثة فى كلا الموسمين عند الحرمان من الرى فى مرحلة التزهير.

– **محتوى الكلوروفيل فى الأوراق** :

كانت أعلى القراءات لمحتوى الكلوروفيل للنبات عند عدم تعرض النباتات للإجهاد (معاملة مقارنة) ، بينما كان أقل تركيز تم الحصول عليه عند الحرمان فى مرحلة قبل التزهير + مرحلة الإمتلاء المبكر للحبوب و ذلك فى موسم ٢٠٠٢ وأدى الحرمان من الرى فى مرحلتى قبل التزهير ، والتزهير موسم ٢٠٠٣ الى أنخفاض محتوى للأوراق فى الكلوروفيل وكانت أعلى الأصناف لمحتوى الكلوروفيل هى العشيرة المقاومة للجفاف (DTP-1) فى الموسم الأول ، وهجين فردى ١٢٣ فى الموسم الثانى مقارنة بباقى الأصناف تحت الدراسة.

– **الإجهاد المائى للنبات** :

الحرمان من الرى عند ٤٩ يوم من الزراعة أعطى أعلى إجهاد مائى للنبات فى مرحلة ما قبل التزهير وعند ٦٥ يوم لوحظ أن أعلى إجهاد مائى للنبات كان مع حرمان النبات من الرى فى مرحلة التزهير وفى ٧٩ يوم من الزراعة وجد أن الحرمان من الرى فى مرحلى الإمتلاء المبكر للحبوب أعطى أعلى أجهاد مائى للنبات ، بينما عند ٩٤ يوم من الزراعة سجلت أعلى إجهاد مائى للنبات عند مرحلة الإمتلاء النهائى للحبوب ، وأشارت النتائج أن أعلى الأصناف فى الإجهاد المائى للنبات هما عشيرة جيزة–٢ والعشيرة المقاومة للجفاف(DTP-1) وذلك عند ٤٩ يوم وكذلك عند ٦٥ يوم من الزراعة. كان أعلى الأصناف فى إجهادها المائى هو هجين ثلاثى ٣٢١ خلال ٧٩ و ٩٤ يوم من الزراعة فى كلا الموسمين.

والتداخل من الدرجة الأولى ما بين معاملات الرى المختلفة والأصناف حيث وجد أن الحرمان من الرى فى مرحلة قبل التزهير + الإمتلاء المبكر للحبوب مع صنف هجين فردى ثلاثى أعطى أعلى إجهاد مائى للنبات خلال ٤٩ يوم من الزراعة فى كلا الموسمين ، بينما الحرمان من الرى فى مرحلتى التزهير + الإمتلاء النهائى للحبوب مع صنف هجين فردى ١٢٣ أعطى أعلى إجهاد مائى للنبات عند ٦٥ و ٩٤ يوم من الزراعة فى موسم ٢٠٠٢ فقط ، بينما عند ٧٩ يوم من الزراعة وجد أن الحرمان من الرى فى مرحلة قبل التزهير + الإمتلاء المبكر للحبوب مع صنف هجين فردى ثلاثى أعطى أعلى إجهاد مائى للنبات خلال ٤٩ يوم من الزراعة فى كلا الموسمين، بينما الحرمان من الرى فى مرحلتى التزهير + الإمتلاء النهائى للحبوب مع صنف هجين فردى ١٢٣ أعطى أعلى إجهاد مائى للنبات عند ٦٥ و ٩٤ يوم من الزراعة فى موسم ٢٠٠٢ فقط ، بينما عند ٧٩ يوم من الزراعة وجد أن الحرمان من

الرى فى مرحلة قبل التزهير + الإمتلاء المبكر للحبوب مع صنف جيزة-٢ أعطى أعلى إجهاد مائى للنبات فى الموسم الأول فقط.

٢- الخصائص الكيميائية

- **محتوى الأوراق من البرولين.**

أوضحت النتائج ظهور زيادة معنوية فى محتوى الورقة من البرولين عند الحرمان من الرى فى مرحلة قبل التزهير عند عمر ٤٩ يوم من الزراعة بينما عند ٦٥ يوم من الزراعة وجد أن محتوى الورقة من البرولين أعطى أعلى تأثير معنوى مع الحرمان من الرى فى مرحلة التزهير و كانت أكثر الأصناف فى محتواها من البرولين هو هجين فردى ١٢٣ بينما كان أقلهم فى محتواها من البرولين العشيرة المقاومة للجفاف (DTP-1) و ذلك بالقياس عند ٤٩ يوم من الزراعة خلال الموسمين و نفس النتائج تم التوصل اليها بالقياس عند ٦٥ يوم من الزراعة وكان التفاعل من الدرجة الأولى ما بين بعض معاملات الرى و الأصناف فى محتواها من البرولين خلال موسمى الزراعة.

- **حيوية حبوب اللقاح.**

تم التوصل الى أعلى أنخفاض معنوى فى حيوية حبوب اللقاح عند الحرمان من الرى خلال مرحلة التزهير خلال موسمى الزراعة و أتضح أن أعلى الأصناف فى حيوية حبوب اللقاح هو هجين ثلاثى ٣٢١ بينما كان أقلهم فى حيوية حبوب اللقاح العشيرة المقاومة للجفاف (DTP-1) خلال موسمى النمو و كان التداخل ما بين معاملات الرى و الأصناف غير معنوى فى موسمى النمو فى صفة حيوية حبوب اللقاح.

٢- المحصول و مكوناته :

- **طول الكوز :**

أشارت الدراسة أن معاملات الحرمان من الرى خلال الموسمين نتج منها أنخفاض معنوى فى طول الكوز مقارنة بمعاملة المقارنة و تم الحصول على أقل طول كوز عند الحرمان من الرى فى مرحلة الإمتلاء المبكر للحبوب ، التزهير ، مرحلة قبل التزهير + الإمتلاء المبكر للحبوب و مرحلة الإمتلاء النهائى للحبوب فى كلا الموسمين . و أعطى الصنف هجين ثلاثى ٣٢١ أعلى طول للكوز مقارنة بالأصناف الأخرى خلال الموسمين.

وكان هناك معنوى للتداخل ما بين معاملات الرى المختلفة والأصناف على طول الكوز فى موسم ٢٠٠٢ فقط.

- **قطر القولحة :**

معاملات الحرمان من الرى جميعها أعطت أنخفاض معنوى فى متوسط قطر القولحة خلال الموسمين و كان أعلى أنخفاض معنوى تم الوصول اليها من خلال الحرمان من الرى فى مرحلة الإمتلاء المبكر للحبوب ، مرحلة قبل التزهير + مرحلة الإمتلاء المبكر للحبوب ، مرحلة قبل التزهير + مرحلة الإمتلاء النهائى للحبوب فى كلا الموسمين. و أشارت النتائج أن أكبر قطر للقوالح كان مع صنف عشيرة جيزة-٢ كمتوسط لكل معاملات الإجهاد المائى مقارنة بباقى الأصناف خلال الموسمين. و تم الحصول على أكبر قطر للقولحة من معاملة المقارنة (عدم الحرمان) مع صنف جيزة-٢ فيما كان أقل الأصناف فى قطر القولحة صنف هجين فردى ١٢٣ عند حرمانه من الرى فى مرحلة الإمتلاء المبكر للحبوب.

- **<u>عدد الحبوب/صف</u>** :

تم الحصول على أقل عدد حبوب من الحرمان من الرى فى مرحلة التزهير والإمتلاء المبكر للحبوب ، مرحلة قبل التزهير + الإمتلاء المبكر للحبوب ، مرحلة التزهير + مرحلة الإمتلاء النهائى للحبوب ، و سجلت أعلا القيم لعدد الحبوب/ صف مع صنف هجين ثلاثى ٣٢١ مقارنة بباقى الأصناف تحت الدراسة خلال الموسمين يليها هجين فردى ١٢٣ ، جيزة-٢ و كان أقل الأصناف فى عدد الحبوب/صف العشيرة المقاومة للجفاف (DTP-1) خلال الموسمين. ووجدت زيادة جوهرية لعدد الحبوب/صف فى التداخل ما بين معاملات الرى تحت الدراسة والأصناف فى موسم ٢٠٠٣ فقط.

- **<u>وزن ال١٠٠ حبه</u>** :

تأثرت صفة وزن ال ١٠٠ حبة جوهريا بالحرمان من الرى فى مراحل الإمتلاء المبكر ، التزهير + الإمتلاء المبكر للحبوب ، و مرحلة قبل التزهير + الإمتلاء المتأخر للحبوب حيث أنخفض وزن ال١٠٠ حبة فى كلا الموسمين.

أعطى صنف جيزة-٢ أعلى قيمة معنوية لوزن ال١٠٠ حبه مقارنة بباقى الأصناف فى كلا الموسمين على الجانب الأخر فأن عشيرة مقاومة للجفاف (DTP-1) أقل وزن ١٠٠ حبه مقارنة بباقى الأصناف فى كلا الموسمين.

٣- **<u>محصول الحبوب (طن/هكتار)</u>** :

أدى الحرمان من الرى الى أنخفاض معنوى فى محصول الحبوب فالحرمان من الرى فى مرحلة قبل التزهير ، الإمتلاء المبكر للحبوب ، التزهير + الإمتلاء النهائى للحبوب أدى الى أنخفاض فى محصول الحبوب (٨,٢١ ، ٨,٨٧ طن/هكتار على التوالى) مقارنة بمعاملة المقارنة (عدم تعريض النباتات للأجهاد الرطوبى) و التى أعطت ١٠,٦٧ طن/هكتار و ذلك خلال موسم ٢٠٠٢. فى الموسم الثانى (٢٠٠٣) وجد أن ال حرمان من الرى فى مراحل قبل التزهير + الإمتلاء النهائى للحبوب

و قبل التزهير + الإمتلاء المبكر للحبوب ، التزهير + الإمتلاء النهائى للحبوب أعطى أكبر أنخفاض معنوى فى محصول الحبوب (٧,٤١ ، ٧,٧٠ و ٧,٧٧ طن/ هكتار على التوالى.

وكانت أعلا النتائج المتحصل عليها فى محصول الحبوب هى لصنف هجين ثلاثى ٣٢١ وكان متوسط الأنتاج ١٠,٩٥ ، ٩,٧٩ طن/هكتار خلال موسمي الزراعة على الترتيب بينما كان أقل الأصناف فى محصول الحبوب العشيرة المقاومة للجفاف ((DTP-1حيث أعطى ٧,٤٧ ، ٦,٣٢ طن/هكتار فى كلا الموسمين على التوالى. و أوضحت النتائج أن أفضل الأصناف فى محصول الحبوب هو هجين ثلاثى ٣٢١ تحت ظروف الإجهاد الرطوبى فى الأراضى الجديدة بمنطقة النوبارية.

– **وزن محصول القش (طن/هكتار) :**

أعلى أنتاج من محصول القش تم الحصول عليه من معاملة المقارنة (عدم تعريض النباتات للأجهاد الرطوبى) بينما الحرمان من الرى فى مرحلة قبل التزهير + الإمتلاء النهائى للحبوب ، التزهير + الإمتلاء النهائى للحبوب أعطى أقل محصول للقش خلال الموسمين وكان أعلى الأصناف فى محصول القش هجين ثلاثى ٣٢١ فى كلا الموسمين (٣١,٩٩ و٢٩,١٥ طن/هكتار على التوالى) مقارنة بباقى الأصناف.

– **الأرتباط ما بين محصول الحبوب وبعض الصفات المدروسة:**

أوضحت الدراسة أن الأرتباط معنوى وقوى ما بين صفات محصول الحبوب من جهة وصفات وزن ال١٠٠ حبه ، طول الكوز ، و مساحة الورقة ، و محتوى الأوراق من البرولين وطول النبات فى كلا الموسمين.

الخلاصة

بناء على النتائج المتحصل عليها :

- فانه يمكن اعتبار محتوى الأوراق من الحامض الأمينى البرولين لصفة الإجهاد المائي للأوراق مقياسا للأنتخاب فى برنامج تربية محصول الذرة الشامية.
- محصول الذرة الشامية يستجيب للأجهاد الرطوبى لذا فأدارة الرى عملية هامة وذلك للحصول على أعلى أنتاجية بأقل عدد ممكن من الريات.
- لابد من قياس الجهد المائى لأوراق النبات فى أطوار النمو المختلفة حيث أنه مؤشر على احتياج النبات للرى.
- احداث اجهاد رطوبى للنبات أثناء مرحلتى النمو الخضرى والأزهار يقلل من القدرة الأنتاجية للمحصول واالذى لا يستطيع المحصول تعويضه حتى بعد ازالة فترة التعطيش.

ولذلك يوصى برى المحصول أثناء مرحلتى النمو الخضرى والتزهير وذلك لعدم تعريض النبات للإجهاد الرطوبى فى هاتين المرحلتين .

- وجد أن أبكر الأصناف لظهور ٥٠% من النورة المذكرة و المؤنثة وأيضا أعلاهم فى وزن ١٠٠ حبة تحت ظروف الإجهاد هو صنف "عشيرة جيزة ٢"
- وجد أن أفضل الأصناف فى محصول الحبوب هو صنف "هجين ثلاثى ٣٢١" وذلك تحت ظروف الإجهاد و ذلك فى الأراضى المستصلحة حديثا بمنطقة النوبارية

Summary (1000 words)

Maize response to water stress in calcareous soils

A sound understanding of plant growth and development is an essential element of efficient and economic maize management system .The impact of drought could be more accurately predicted with a clear picture of the relationships between growth stage and plant response to stress. The optimum timing, dose of fertilizers application and irrigation determined by crop growth stage. Two field experiments were carried out in the new lands at Nubaria Agriculture Research Station, Agriculture Research Center, Egypt during the growing summer seasons of 2002 and 2003 The objectives of the present investigation were: To study the effect of different water stress treatments (skipping certain irrigation) on yield, yield components and different growth characters. To determine the best drought tolerant hybrids that can be recommended for farmers in Nubaria area which have irrigation problems. The experimental design was split-plot with four replicates in. Eight irrigation treatments were randomly assigned to the main plots and four hybrids occupied the sub-plot.

The obtained results could be summarized as follows :

1. Agronomic characteristics

1.1. Plant height : The highest significant reduction in plant height was obtained by skipping the 1st , 5th and 7th irrigation treatments. These irrigation coincided with pre-flowering, pre-flowering + early grain filling and pre-flowering + late grain filling stages. S.C.123 and T.W.C.321 hybrids had the tallest plant height than other cultivars as an average in the two seasons, followed by Giza2 population. DTP-1 population had the shortest plant height in both seasons.

1.2. Ear height : Skipping any irrigation in both growing seasons resulted in significant decrease in ear height than control treatment. The lowest values of ear height was obtained by skipping irrigation at pre-flowering, early grain filling + pre-flowering and late grain filling + pre-flowering stages (The 1st , 5th and 7th treatments). The control treatment in both seasons had the highest ear height. S.C.123 and T.W.C.321 hybrids had the highest significant ear height followed by Giza2 and DTP.1 populations in both seasons.

1.3. Stem diameter : The maximum stem diameter was obtained from skipping irrigation at late grain filling (The 4th irrigation treatment), while the minimum stem diameter was obtained from skipping at pre-flowering stage (The 1st irrigation treatment) in both growing seasons. T.W.C.321 and S.C.123 hybrids had significantly higher stem diameter in 2002 and 2003 seasons.

1.4. Leaf area index : The irrigation treatments resulted in significant decrease in leaf area index as compared to the control irrigation. The greatest significant decrease in leaf area index was obtained by skipping irrigation at pre-flowering + late grain filling and pre-flowering + early grain filling stages (The 7th and 5th irrigation treatments) in the two growing seasons. T.W.C.321 hybrid had the highest significant leaf area as compared to the other cultivars in the two seasons, on the other hand DTP-1 population had the lowest leaf area/plant in both seasons.

1.5. Number of days 50% tasselling : The data indicated that skipping irrigation at flowering stage caused significant delay in tasselling in 2002 season. Skipping irrigation at pre-flowering and flowering stages caused significant delay in tasselling in 2003 .Giza2 population gave the earliest tasselling in both seasons, while the latest tasselling cultivar was T.W.C.321 in 2003 season and S.C.123 hybrid in both seasons.

1.6. Number of days to 50% silking : The data indicated that, in both seasons, skipping irrigation at flowering stage caused significant delay in silking, while skipping irrigation at pre-flowering caused significant delay in silking. Giza2 population was the earliest silking in both seasons. S.C.123 was the latest silking in season 2002 while S.C.123 and T.W.C.321 were the latest silking in season 2003. **1.7. Chlorophyll content :** The highest Chlorophyll content was obtained with the normal irrigation treatment whereas the lowest concentration was obtained by skipping 5th irrigation treatment (pre-flowering + early grain) in 2002 and skipping irrigation at the pre-flowering growth and flowering growth

stages in 2003 season. DTP-1 population gave the highest content of chlorophyll in the first season, and S.C.123 in the second season.

1.8. Leaf water potential (L.W.P.) : When L.W.P. was measured at 49 days from planting the highest values was obtained at the pre-flowering stage (35-50 days). When measured at 65 days, the highest L.W.P. was obtained from skipping at the flowering stage (50-65) days. Measuring L.W.P. at 79 days, skipping irrigation at early grain filling stage (65-80 days) gave the highest L.W.P., while at 94 days, the highest L.W.P. was obtained when skipping irrigation at the late grain filling stage. Giza2 and DTP-1 cultivars had the highest L.W.P. at 49 and 65 days from planting, but T.W.C.321 cultivar produced the highest L.W.P. at 79 and 94 days from planting as an average for both seasons.

2. Chemical characters:

2.1. Leaf praline content : Leaf praline content was increased significantly by skipping irrigation at pre-flowering stage when measured at 49 days from planting. At 65 days, leaf praline content was the highest when skipping irrigation at flowering stage. S.C.123 produced the highest leaf proline content at 49 days, while DTP-1 gave the lowest value in the both seasons in same period. Similar results was obtained at 65 days. The first order interaction between drought treatments and cultivars on leaf proline content was significant in 2002 and 2003 seasons.

1.2. Pollen grain viability : The highest significant reduction in pollen grain viability was obtained by skipping irrigation at flowering stage in both seasons. T.W.C.321 hybrid produced the highest pollen grain viability, while the DTP-1 population gave the lowest one in the two growing seasons.

3. Yield and yield components

3.1. Ear length : Skipping irrigation treatments in 2002 and 2003 resulted insignificant decrease in ear length as compared to the control treatment. The hightest significant decrease in ear length was obtained from skipping irrigation at early grain filling, flowering, pre-flowering + early grain filling and late grain filling stages, in both seasons. T.W.C. 321 gave the tallest ears as compared to other varieties in both seasons.

3.2. Cob diameter : All skipping irrigation treatments in 2002 and 2003 seasons resulted in significant smaller cob diameter. The greatest significant decreases were obtained from skipping irrigation at early grain filling, pre-flowering + early grain filling and pre-flowering + late grain filling stages during both seasons. Giza2 had the largest cob diameter, in both seasons, than other studied cultivars in the control irrigation treatment while the lowest cob diameter was obtained by skipping irrigation at early grain filling stage (the 3^{rd} irrigation treatment) for S.C.123 hybrid.

3.3. Number of kernels/row : The lowest number of kernels/row was found when skipping irrigation at flowering, early grain filling, pre-flowering + early grain filling and flowering + late grain filling stages (The 2^{nd}, 3^{rd},5^{th}, and 7^{th} irrigation treatments). T.W.C.321 showed higher significant number of kernels/row than all other cultivars in the two seasons followed by S.C.123 and Giza2. DTP-1 had the lowest number of kernels/row in both seasons.

3.4. 100-kernels weight (gm) : Skipping irrigation at early grain filling, flowering + early grain filling and pre-flowering + late grain filling stages (skipping the 3^{rd}, 6^{th} and 7^{th} irrigation treatments) resulted in the lowest 100-kernals weight in both seasons. Giza2 had significantly higher values for 100-kernals weight than all other cultivars in the two seasons. DTP-1 had the lowest values for 100-kernels weight in both seasons.

3.5. Grain yield (ton/ha) : Skipping any of the scheduled irrigations significantly decreased grain yield. Skipping the 5^{th}, 6^{th} and 7^{th} treatments resulted in the lowest grain yield in 2002. Skipping irrigation at the pre-flowering + early grain filling, flowering + late grain filling and pre-flowering + late grain filling stages produced 9.03, 8.87 and 8.21 ton/ha, respectively as compared to 10.67 ton/ha from the control treatment in 2002 season. In 2003, skipping irrigation at pre-flowering + late grain filling, pre-flowering + early grain pre-flowering + late grain filling and flowering + late grain filling stage (the 7^{th} , 5^{th} and 6^{th} irrigation treatments resulted in the lowest grain yield (7.41, 7.70 and 7.70 ton/ha, respectively). Results showed that T.W.C.321 had the highest grain yield in both seasons

(10.95 and 9.79, respectively) while DTP-1 produced the lowest grain yield (7.47 and 6.32 ton/ha, respectively) in the two successive seasons. Data showed that T.W.C.321 was the yielding hybrid under the drought stress treatment used in the study and conditions of the newly reclaimed lands of Nubaria area.

3.6. Straw yield (ton/ha) : The highest straw yield was obtained from normal irrigation treatment while skipping irrigation at pre-flowering + late grain filling and flowering + late grain filling produced the lowest straw yield in 2002 and 2003 seasons. T.W.C.321 had the higest straw yield per hectar in both seasons (31.99 and 29.115 ton/ha, respectively) as compared to the other cultivars.

4. Correlation between traits : Phenotypic correlation coefficients between grain yield and 100-kernals weight, Ear length, leaf are, praline content and plant height were positive and significant in both seasons.

Conclusion

It could be concluded that leaf water potential, leaf proline content and could be recommended as a selection criteria for grain yield breeding program.

Maize crop responds to water stress, but irrigation management is important to produce consistently high yields with minimum number of irrigation.

Checking the water stress to plant leaves at different growth stages as an indicator of how plant need irrigation.

Water stress pre-flowering and flowering stages limits potential yield that is not regained when water stress is relieved. Therefore, irrigation to prevent stress during pre-flowering and flowering would be more advisable than delaying irrigation until grain filling.

Found that Giza-2 population gave the minimum value of number of 50% tassalling, silking and maximum value of 100- kernel weight.

Data showed that T.W.C.321 hybrid was the best yielding under the different drought stress treatments used in the study and conditions of Nubaria region.

Summary (1500 words)

Maize response to water stress in calcareous soils

A sound understanding of plant growth and development is an essential element of efficient and economic maize management system .The impact of drought could be more accurately predicted with a clear picture of the relationships between growth stage and plant response to stress. The optimum timing, dose of fertilizers application and irrigation determined by crop growth stage. Two field experiments were carried out in the new lands at Nubaria Agriculture Research Station, Agriculture Research Center, Egypt during the growing summer seasons of 2002 and 2003 The objectives of the present investigation were: To study the effect of different water stress treatments (skipping certain irrigation) on yield, yield components and different growth characters. To determine the best drought tolerant hybrids that can be recommended for farmers in Nubaria area which have irrigation problems. The experimental design was split-plot with four replicates in. Eight irrigation treatments were randomly assigned to the main plots and four hybrids occupied the sub-plot.

The obtained results could be summarized as follows :

1. Agronomic characteristics

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1.2. Ear height : Skipping any irrigation in both growing seasons resulted in significant decrease in ear height than control treatment. The lowest values of ear height was obtained by skipping irrigation at pre-flowering, early grain filling + pre-flowering and late grain filling + pre-flowering stages (The 1st , 5th and 7th treatments). The control treatment in both seasons had the highest ear height. S.C.123 and T.W.C.321 hybrids had the highest significant ear height followed by Giza2 and DTP.1 populations in both seasons.

1.3. Stem diameter : The maximum stem diameter was obtained from skipping irrigation at late grain filling (The 4th irrigation treatment), while the minimum stem diameter was obtained from skipping at pre-flowering stage (The 1st irrigation treatment) in both growing seasons. T.W.C.321 and S.C.123 hybrids had significantly higher stem diameter in 2002 and 2003 seasons. No significant differences were detected between the Giza2 and DTP.1 populations in both seasons. T.W.C321 produced the highest number of leaves/plant, while the lowest DTP-1 population as an average in both seasons.

The first order interaction between irrigation treatments and cultivars was significant for number of leaves/plant in 2003 season only.

1.4. Leaf area index : The irrigation treatments resulted in significant decrease in leaf area index as compared to the control irrigation. The greatest significant decrease in leaf area index was obtained by skipping irrigation at pre-flowering + late grain filling and pre-flowering + early grain filling stages (The 7th and 5th irrigation treatments) in the two growing seasons. T.W.C.321 hybrid had the highest significant leaf area as compared to the other cultivars in the two seasons, on the other hand DTP-1 population had the lowest leaf area/plant in both seasons. The data showed that the interaction between skipping irrigation and cultivars was significant for leaf area/plant when skipping irrigation at flowering (the 4th irrigation treatment) with T.W.C.321 hybrid, while the lowest one was obtained by skipping irrigation at pre-flowering (the 1st irrigation treatment) with DTP-1 population in 2002 season.

1.5. Number of days 50% tasselling : The data indicated that skipping irrigation at flowering stage caused significant delay in tasselling in 2002 season. Skipping irrigation at pre-flowering and flowering stages caused significant delay in tasselling in 2003 .Giza2 population gave the earliest tasselling in both seasons, while the latest tasselling cultivar was T.W.C.321 in 2003 season and S.C.123 hybrid in both seasons. The interaction

between irrigation treatments with cultivars was significant for number of days to 50% tasselling. S.C.123 and DTP-1 cultivars had significant delayed tasselling in both seasons when the 4th irrigation was skipped.

1.6. Number of days to 50% silking : The data indicated that, in both seasons, skipping irrigation at flowering stage caused significant delay in silking, while skipping irrigation at pre-flowering caused significant delay in silking.

Giza2 population was the earliest silking in both seasons. S.C.123 was the latest silking in season 2002 while S.C.123 and T.W.C.321 were the latest silking in season 2003. The interaction between irrigation treatments with cultivars was significant on number of days to 50% of silking for S.C.123 and DTP-1 cultivars.Significant delayed silking was obtained in both seasons when the 4th irrigation was skipped.

1.7. Chlorophyll content : The highest Chlorophyll content was obtained with the normal irrigation treatment whereas the lowest concentration was obtained by skipping 5th irrigation treatment (pre-flowering + early grain) in 2002 and skipping irrigation at the pre-flowering growth and flowering growth stages in 2003 season. DTP-1 population gave the highest content of chlorophyll in the first season, and S.C.123 in the second season.

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2.1. Leaf praline content : Leaf praline content was increased significantly by skipping irrigation at pre-flowering stage when measured at 49 days from planting. At 65 days, leaf praline content was the highest when skipping irrigation at flowering stage. S.C.123 produced the highest leaf proline content at 49 days, while DTP-1 gave the lowest value in the both seasons in same period. Similar results was obtained at 65 days. The first order interaction between drought treatments and cultivars on leaf proline content was significant in 2002 and 2003 seasons.

1.2. Pollen grain viability : The highest significant reduction in pollen grain viability was obtained by skipping irrigation at flowering stage in both seasons. T.W.C.321 hybrid produced the highest pollen grain viability, while the DTP-1 population gave the lowest one in the two growing seasons. The interaction between skipping irrigation treatments with cultivars was not significant for pollen grain viability in both seasons.

3. Yield and yield components

3.1. Ear length : Skipping irrigation treatments in 2002 and 2003 resulted insignificant decrease in ear length as compared to the control treatment. The hightest significant decrease in ear length was obtained from skipping irrigation at early grain filling, flowering, pre-flowering + early grain filling and late grain filling stages, in both seasons. T.W.C. 321 gave the tallest ears as compared to other varieties in both seasons. Interaction between skipping irrigation and cultivar had significant effect on ear length in 2002 season only.

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3.4. 100-kernels weight (gm) : Skipping irrigation at early grain filling, flowering + early grain filling and pre-flowering + late grain filling stages (skipping the 3rd, 6th and 7th irrigation treatments) resulted in the lowest 100-kernals weight in both seasons. Giza2 had significantly higher values for 100-kernals weight than all other cultivars in the two seasons. DTP-1 had the lowest values for 100-kernels weight in both seasons.

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<u>ملخص المجلة</u> رسالة دكتوراه (المحاصيل) من فسم الإنتاج النباتي للدارس / هاني عبد العاطي عبد الرحمن درويش

إستجابة الذرة الشامية للإجهاد الرطوبي في الأراضي الجيرية

أجريت هذه الدراسة بإقامة تجربتان حقليتان تحت ظروف الأراضى الجديدة وذلك بالمزرعة البحثية بمحطة البحوث الزراعية بالنوبارية (أرضى جيرية) خلال الموسمين ٢٠٠٢ ؛ ٢٠٠٣ وذلك لمعرفة تأثير الحرمان من الرى خلال مراحل نمو محصول الذرة الشامية على كمية محصول الحبوب ومكوناته المختلفة وصفات النبات الفسيولوجية والكيميائية وتحديد المرحلة أو المراحل الأشد حساسية للإجهاد الرطوبى ؛ وكان التصميم المستخدم فى هذه التجربة تصميم القطع المنشقة مرة واحدة فى أربع مكررات على النحو التالى: القطع الرئيسية: إحتوت على معاملات الإجهاد الرطوبى التالية : تعريض النباتات للإجهاد الرطوبى أثناء مرحلة قبل التزهير؛ تعريض النباتات للإجهاد أثناء طور الإزهار؛ تعريض النباتات للإجهاد أثناء الطور اللبنى للحبوب؛ تعريض النباتات للإجهاد أثناء طور الإمتلاء النهائى للحبوب (تحريم ريه أثناء الإمتلاء النهائى للحبوب ٨٠-٩٥ يوم ؛ تعريض النباتات للإجهاد أثناء مرحلة قبل التزهير ومرحلة الإمتلاء اللبنى للحبوب ؛ تعريض النباتات للإجهاد أثناء مرحلة التزهير ومرحلة الإمتلاء النهائى للحبوب (تحريم ريه أثناء التزهير وريه أثناء الإمتلاء النهائى للحبوب ؛ تعريض النباتات للإجهاد الرطوبى أثناء مرحلة قبل التزهير ومرحلة الإمتلاء النهائى للحبوب ؛ توفير الرطوبة الأرضية المناسبة بالحقل فى أطوار نموه المختلفة (مقارنة) وتمت وفقاً للرى المتبع بالمزرعة البحثية حيث تعطى أول رية بعد ٢١ يوما من الزراعة ثم ٦ ريات بمعدل رية كل ١٥ يوم - أما القطع المنشقة من التجربة فخصصت لدراسة مدى تأثير الهجن بمعاملات الإجهاد الرطوبى السابقة وتحديد الهجن أو العشائر التى تتحمل معاملات التعطيش عن غيرها وفى أى مرحلة نمو، وشملت الهجن والعشائر (هجين فردى ١٢٣ ، هجين ثلاثى ٣٢١ ، جيزة-٢ وعشيرة DTP-1 وهى أحد العشائر المستوردة المتحملة للجفاف. وأجريت كافة العمليات الزراعية الأخرى كما هو موصى به للأراضى الجديدة بالنوبارية.

Maize response to water stress in calcareous soils

A sound understanding of plant growth and development is an essential element of efficient and economic maize management system .The impact of drought could be more accurately predicted with a clear picture of the relationships between growth stage and plant response to stress. The optimum timing, dose of fertilizers application and irrigation determined by crop growth stage. Two field experiments were carried out in the new lands at Nubaria Agriculture Research Station, Agriculture Research Center, Egypt during the growing summer seasons of 2002 and 2003 The objectives of the present investigation were: To study the effect of different water stress treatments (skipping certain irrigation) on yield, yield components and different growth characters. To determine the best drought tolerant hybrids that can be recommended for farmers in Nubaria area which have irrigation problems. The experimental design was split-plot with four replicates in. Eight irrigation treatments were randomly assigned to the main plots and four hybrids occupied the sub-plot.

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