RESULTS AND DISCUSSION

I. Growth attributes

Effect of years:

The characters studied for growth of maize plants were dry weight/plant, leaf area/plant and leaf area index at 60, 75 and 90 days from sowing, chlorophyll a,b and (a+b), carotenoids, crop growth rate, relative growth rate, net assimilation rate, time of silking, plant height, ear height and stem diameter. Effects of years are presented in Table (4).

All characters were significantly affected due to years except stem diameter. The average values of dry weight/plant, leaf area/plant and leaf area index in the three stages, carotenoids, time of silking and plant height were high values in the third season.

However, high mean values for chlorophyll a, b, (a+b), crop growth rate, relative growth rate, net assimilation rate were detected in the first season. It could be concluded that the differences in these characters of maize plants owing to different growing seasons might be due to the differences in prevailing edaphic conditions especially to solar radiation and mean temperature of day and night.

Table 4: The average values of growth atributes of maize as affected by years in combined analysis of the three seasons.

Characters	Growth stage (day)	Years		
		1988	1989	1990
Dry weight/plant (g)	60	76.86c	104.73b	166.16a
	75	144.28c	165.52b	225.16a
	90	248.59b	260.51b	318.97a
Leaf area/plant (dm^2)	60	45.55b	86.92a	86.38a
	75	95.82b	107.38a	106.65a
	90	83.25c	87.29b	99.53a
Leaf area index	60	2.17b	4.14a	4.11a
	75	4.56b	5.11a	5.08a
	90	3.96c	4.16b	4.74a
Chl. a mg/dm^2 L.A.		2.40a	2.03c	2.34b
Chl. b mg/dm^2 L.A.		1.88a	0.88b	1.80a
Car. mg/dm^2 L.A.		2.21b	1.92c	2.32a
Chl. (a+b) mg/dm^2 L.A.		4.28a	2.91b	4.14a
Chl. (a+b) Car. ratio		1.95a	1.53c	1.79b
CGR g/m^2/day		21.40a	19.29b	18.72b
R.G.R. mg/g/day		0.415a	0.312b	0.200c
N.A.R. g/m^2/day		6.78a	4.30b	4.01b
Time of silking		62.77b	65.62a	65.92a
Plant height cm		231.90b	239.96a	243.37a
Ear height cm		125.94c	141.89a	135.10b
Stem diameter cm		2.08a	2.09a	2.11a

1. Dry matter accumulation and distribution:

A. Effect of water stress:

The average values of dry weight/plant, the percentage of leaves and stem from total dry weight of plant at 60 days after sowing, and dry weight/plant, the percentage of leaves, stem, ears and tassel at 75 and 90 days from sowing date as affected by irrigation levels are presented in Table (5).

The differences between the mean values of dry weight/plant at 60, 75 and 90 days after sowing and the percentage of leaves, stem, ears and tassel at 90 days after sowing were significantly affected by irrigation levels. On the other hand, the percentage of leaves and stem at 60 days from sowing, also the percentage of leaves, stem, ears and tassel at 75 days after sowing were not significantly affected by increasing depletion of available soil moisture from 40 to 80%.

The highest values of dry weight/plant were 123.65, 194.36 and 300.49 (g), obtained when maize plants were irrigated at 40% available soil moisture depletion after 60, 75 and 90 days from sowing, respectively. Whereas the lowest ones were 107.50, 158.06 and 243.18 (g) at the same order, respectively, gained when plants were irrigated at 80% available soil moisture depletion.

After 90 days from sowing, the percentage of leaves, stem and tassel significantly increased by increasing available soil moisture depletion from 40 to 80%, but the percentage of ears significantly decreased by increasing depletion of available soil moisture.

Water deficit caused a loss in cell turgidity and this in turn resulted in a decrease in cell division and vegetative growth is particularly sensitive to water deficit because growth is closely related to turgor and the loss of turgidity stops all enlargements. Similar results were reported by Kramer (1963), Boyer (1968), Ainer (1976), El-Nomany (1978), Mahgoub (1979) Salwau (1985), Sobrado (1986), Rizk *et al.* (1987) and El-Shenawy (1990).

B. <u>Varietal differences:</u>

Table (5) shows that the differences between maize cultivars under study was significant in dry weight/plant at 60, 75 and 90 days after sowing as well as the percentage of stem and leaves at 60 days and the percentages of leaves, stem, ears and tassel at 75 and 90 days from sowing in combined analysis over the three seasons. Three Way Cross 310 cultivar gave the highest mean value of dry weight/plant in the three samples, but Karnak cultivar gave the lowest one.

Giza 2 cultivar significantly surpassed T.W.C.310 and Karnak cultivars in the percentages of ears and stem per total dry weight of plant at 75 and 90 days after sowing in combined analysis over the three seasons. While, T.W.C.310 cultivar gave the highest mean value of the percentage of stem and Karnak cultivar gave the higher percentage of leaves/total dry weight of plant at 75 and 90 days from sowing. On the other hand, Giza 2 cultivar had the lowest values in the percentages of leaves and stem at 75 and 90 days from sowing in the combined analysis between 1988, 1989 and 1990 seasons when compared with T.W.C.310 and Karnak cultivars.

In this connection, it could be noticed that these differences may be due to the genetical between cultivars of maize. Similar trend was also realized by El-Nomany (1978), Abou-Khadrah (1984), Bedeer (1984), Kamel *et al.* (1986), Raghip *et al.* (1989) and El-Shenawy (1990).

C. Effect of zinc levels:

The data reported in Table (5) show the average values of dry weight/plant and the percentage of different plant fraction at 60, 75 and 90 days from sowing time as affected by foliar application of zinc sulphate concentration in combined analysis over the three seasons.

At 60 days from sowing date there were no significant difference between the average values of dry weight/plant, leaves and stem % as affected by zinc levels. The average values of dry weight/plant at 75 days after sowing and the

Table 5: The average values of dry matter accumulation and distribution at different growth stages as affected by water stress cultivars and foliar application of zinc sulphate in combined analysis between 1988, 1989, and 1990 seasons.

Treatments	Growth stages												
	60 days			75 days					90 days				
	Dry weight g/plant	Leaves %	Stem %	Dry weight g/plant	Leaves %	Stem %	Ears %	Tas-sels %	Dry weight g/plant	Leaves %	Stem %	Ears %	Tas-sels %
Water stress													
40% ASMD	123.65a	41.84a	58.16a	194.36a	24.15a	50.05a	22.37a	3.44a	300.49a	18.86b	34.54ab	44.44a	2.21b
60% ASMD	116.60b	43.21a	56.79a	182.55b	24.20a	50.35a	22.13a	3.33a	284.40b	19.09b	32.90b	45.67a	2.35a
80% ASMD	107.50c	44.27a	55.77a	158.06c	24.91a	49.39a	22.32a	3.51a	243.18c	20.26a	35.96a	41.36b	2.42a
Irrig. x Years	N.S.	N.S	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**
Cultivars													
Giza 2	114.89ab	40.47b	59.57a	172.04b	23.94b	47.54b	24.61a	3.94a	273.51b	18.38b	31.43c	47.75a	2.48a
T.W.C.310	120.98a	42.38b	57.62a	192.18a	22.66b	53.20b	21.10b	3.17b	301.92a	18.24b	38.04a	41.37b	2.34ab
Karnak	111.88b	46.47a	53.53b	170.74b	26.65a	49.05a	21.10b	3.19b	252.64c	21.59a	33.93b	42.34b	2.16b
Cult. x years	N.S.	N.S	N.S.	**	*	**	**	*	N.S.	N.S.	**	**	*
Zinc levels													
0.0%	113.41a	43.38a	56.62a	174.36a	25.22a	49.35a	21.99a	3.44a	261.71b	19.72a	35.09a	42.80a	2.39a
0.3%	120.14a	42.54a	57.50a	186.54a	23.58a	50.24a	22.80a	3.31a	292.48a	19.24a	33.73a	44.88a	2.19a
0.6%	114.20a	43.40a	56.60a	174.07a	24.45ab	50.20a	21.94a	3.54a	273.88b	19.24a	34.58a	43.78a	2.40a
Zn x years	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.
Interactions													
Ir.x C.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**	*	N.S.
Ir.x C.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.
Zn x Ir.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x Ir.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.x Ir	N.S.	*	*	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.xIr.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.

Ir. = Irrigation
C. = Cultivars.
Y = Years.
ASMD = Available soil moisture depletion

percentage of stem, ears and tassel at 75 and 90 days after sowing were not significant due to foliar application of zinc. On the other hand, the mean values of dry weight/plant significantly increased by increasing zinc concentration up to 0.3% and significantly decreased by increasing zinc levels up to 0.6% because the high concentration of zinc led to a poisonous influence on the plant. These results are in accordance with the results obtained by Takahashi and Ito (1976), Baza (1981), Abd El-Aziz *et al.* (1986), El-Sayed *et al.* (1986), Kamel *et al.* (1986), and Badr (1987) who found that dry matter accumulation and distribution significantly increased by zinc application up to 0.4% zinc sulphate. On the other hand, Ohki *et al.* (1976), Bedeer (1984) and Younis (1985) indicated that application of zinc sulphate did not exert any significant effect on dry matter/plant and different plant fraction.

It could be concluded that zinc played an important role in metabolic process and this in turn plant growth.

2. Leaf area/plant and leaf area index:

The mean values of leaf area/plant and leaf area index at 60, 75 and 90 days after sowing as affected by irrigation levels, maize cultivars and foliar application of zinc sulphate in combined analysis of 1988, 1989 and 1990 seasons are illustrated in Table (6).

Table 6: The average values of leaf area (dm^2)/plant and leaf area index at different growth stages as affected by water stress, cultivars and foliar application of zinc sulphate in combined analysis between 1988, 1989 and 1990 seasons.

Treatments	Leaf area (dm^2)/plant			Leaf area index		
	Growth stages (days)					
	60	75	90	60	75	90
Water stress						
40% ASMD	77.26a	111.02a	95.28a	3.68a	5.29a	4.54a
60% ASMD	73.25b	103.21b	92.44a	3.49b	4.91b	4.40a
80% ASMD	68.34c	95.63c	82.35b	3.25c	4.55c	3.92b
Irrigation x years	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Cultivars						
Giza 2	71.20a	96.92b	83.67b	3.39a	4.61b	3.99b
T.w.C.310	75.11a	107.59a	94.35a	3.58a	5.12a	4.49a
Karnak	72.54a	105.35a	92.05a	3.45a	5.02a	4.38a
Cultivars x years	**	**	N.S.	**	**	N.S.
Zinc levels						
0.0%	71.04b	99.99b	83.67a	3.38b	4.76b	4.21a
0.3%	75.52a	106.45a	94.35a	3.60a	5.07a	4.39a
0.6%	72.29ab	103.42ab	92.05a	3.44ab	4.92ab	4.26a
Zn x years	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction						
Ir.x C.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Ir.x C.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x Ir.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x Ir.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.x Y	N.S.	N.S.	*	N.S.	N.S.	*
Zn x C.x Ir	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.xIr.x Y	N.S.	*	N.S.	N.S.	*	N.S.

Ir. = Irrigation
C. = Cultivars.
Y = Years.
ASMD = Available soil moisture depletion

These results are in agreement with those obtained by El-Nomany (1978), Aly (1981), Ainer (1983), Salem *et al.* (1983), Bedeer (1984), Salwau (1985), Younis (1985), Aly (1988) and Shams (1988).

C. <u>Effect of zinc levels:</u>

Table (6) shows that the average values of leaf area/plant and leaf area index significantly increased by increasing foliar application of zinc sulphate concentration up to 0.3% in the two samples out of three in the combined analysis over the three seasons. Application of 0.3% zinc sulphate increased leaf area/plant and leaf area index due to the role of zinc as an essential component for the activity of some dehydrogenases, proteinases, peptidases and alcohol dehydrogenase (Vallee and Wacker, 1970). On the other hand, the highest zinc sulphate rate (0.6%) significantly decreased leaf area/plant and leaf area index. This reduction may be due to slight toxic of the highest zinc level. Similar results were obtained by Dibrova (1978), Kamel *et al.* (1986) and Badr (1987) who found that leaf area significantly increased as the zinc level increased up to 0.4% zinc sulphate, whereas a further increase in the concentration of zinc sulphate up to 0.8% decreased them.

3. Chlorophyll content:

The data reported in Table (7) show that the average values of chlorophyll content in ear leaves of maize plant at

75 days after sowing date as affected by irrigation levels, maize cultivars and zinc levels in combined analysis between 1988, 1989 and 1990 seasons.

A. <u>Effect of water stress:</u>

It was evident that the average values of chlorophyll a and carotenoids significantly decreased by increasing available soil moisture depletion from 40 to 80%, but the irrigation after 40 or 60% available soil moisture depletion gave the same trend in the mean values of chlorophyll a and carotenoids. On the other hand, the differences between the mean values of chlorophyll b, (a+b) and the ratio of chlorophyll (a+b) to carotenoids were not significantly affected by irrigation levels. The soil moisture depletion not only inhibits the metabolism of chlorophyll in the leaves of plant but also leads to dissociation of the chlorophyll previously formed. These results were in accordance with various authors including Barnett and Nylor (1966), Hsiao (1973), Zhekov and Kimenov (1980), Gomaa (1981), Salwau (1985), Nour El-Din *et al.* (1986), and Ragab *et al.* (1986).

B. <u>Varietal differences:</u>

There were no significant differences between the mean values of chlorophyll content as affected by cultivars except chlorophyll a, (Table 7). Karnak cultivar surpassed significantly Giza 2 cultivar in the mean values of chlorophyll a due to superiority of Karnak cultivar in leaf area/plant. Chlorophyll concentration was correlated with leaf area which absorbed more photosynthetically active radiation. Similar results was obtained by Fleming and Palmer (1975) and Moursi *et al.* (1979) they found that the contents of total chlorophyll and its components per unit area of blades of Giza hybrid 186 exceeded those in open pollinated variety American Early. They also found that there were no statistical significant differences between varieties in the ratio of chlorophyll (a+b) to carotenoids. The higher chlorophyll content of Giza hybrid 186 might be attributed to the superiority of Giza hybrid 186 in stability of chlorophyll, carotenoids content and protein content than American Early. On the other hand, Salwau (1985) found that the differences between Pioneer 514 and Giza 2 cultivars were not significant in chlorophyll a, b (a+b) and carotenoids content in leaves of maize plant.

C. <u>Effect of zinc levels:</u>

The effect of foliar application of zinc sulphate at different concentrations was not significant on the average values of chlorophyll a, b, (a+b), carotenoids and the ratio of chlorophyll (a+b) to carotenoids in the combined analysis over the three seasons. But chlorophyll content was increased by increasing levels of zinc sulphate as foliar application. The same trend was reported by Takahashi and Ito (1976) who found that chlorophyll contents in leaves was highest with 0.05 ppm Zn. Biswas and Chouduri (1981) found that spraying rice plants with zinc sulphate at different growth stages

Table 7: The average values of photosynthetic pigments of leaves of maize at 75 days from sowing as influenced by water stress, cultivars and zinc sulphate concentration in combined analysis of the three seasons 1988, 1989 and 1990.

Treatments	Chl. a mg/dm^2 LA	Chl. b mg/dm^2 LA	Chl. (a+b) mg/dm^2 LA	Car. mg/dm^2 LA	Chl.(a+b)/ Car. ratio
Water stress					
40% ASMD	2.32a	1.53a	3.84a	2.18a	1.76a
60% ASMD	2.26b	1.54a	3.80a	2.17a	1.75a
80% ASMD	2.19c	1.49a	3.68a	2.10b	1.76a
Irrig. x years	*	N.S.	*	**	**
Cultivars					
Giza 2	2.19b	1.47a	3.66a	2.10a	1.74a
T.w.C.310	2.26ab	1.54a	3.79a	2.15a	1.77a
Karnak	2.32a	1.54a	3.87a	2.20a	1.76a
Cult. x years	**	**	**	**	N.S.
Zinc levels					
0.0%	2.20a	1.47a	3.67a	2.10a	1.76a
0.3%	2.29a	1.54a	3.83a	2.19a	1.75a
0.6%	2.28a	1.54a	3.82a	2.16a	1.76a
Zn x years	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction					
Ir.x C.	N.S.	N.S.	N.S.	N.S.	N.S.
Ir.x C.x Y	**	*	**	**	N.S.
Zn x Ir.	N.S.	N.S.	N.S.	N.S.	*
Zn x Ir.x Y	N.S.	N.S.	N.S.	N.S.	**
Zn x C.	*	N.S.	N.S.	*	*
Zn x C.x Y	**	*	**	N.S.	N.S.
Zn x C.x Ir	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.xIr.x Y	N.S.	N.S.	N.S.	*	N.S.

Ir. = Irrigation
C. = Cultivars.
Y = Years.
ASMD = Available soil moisture depletion

caused an increase in chlorophyll contents at seedling and pre-flowering stages.

It could be concluded that the increase of chlorophyll content in leaves fed by zinc might be attributed to the known role of zinc in chlorophyll synthesis and increased photosynthetic pigments content of maize blades and stability of chlorophyll a.

4. Crop growth rate:

The results in Table (8) indicated that the mean values of crop growth rate was significantly affected by soil moisture depletion or maize cultivars, but not significantly affected by zinc levels in combined analysis of the three growing seasons 1988, 1989 and 1990.

A. Effect of water stress:

The average values of crop growth rate significantly decreased by increasing available soil moisture depletion up to 80%, (Table 8). The highest mean value of crop growth rate was 22.44 $g/m^2/day$, obtained from irrigation at 40% depletion in available water, but irrigation at 80% soil moisture depletion gave the lowest one 16.04 $g/m^2/day$. The results were in good connection with those obtained by Hsiao (1973), Mahrous (1977), El-Nomany (1978) and Ali (1985) who concluded that crop growth rate increased with the increase of available soil moisture. It was observed that the availability of water is an important factor in the growth of maize plants which increase dry matter content of plant and its different parts, leaf area and leaf area index, and these characters were associated with the increase in crop growth rate.

B. Varietal differences:

Table (8) shows that the differences among maize cultivars were significant for crop growth rate in combined analysis over the three seasons. Maize cultivar T.W.C.310 gave the highest mean value of crop growth rate and Karnak cultivar ranked the second. The same trend was also realized by Raghib (1979), Gouda (1982), Bedeer (1984), Younis (1985) and Aly (1988) they showed that significant differences were detected in crop growth rate among tall and short varieties as well as among hybrid and the open pollinated varieties. It could be noticed that these differences may be due to the genetical between cultivars of maize.

C. Effect of zinc levels:

The average values of crop growth rate was not significantly affected by foliar application of zinc sulphate. These results may be due to dry matter of plant at different stages of maize plants was not significantly affected by zinc levels and crop growth rate is correlated to dry matter of plant. Similar trend was obtained by Younis (1979), Orabi *et al.* (1981), El-Attar *et al.* (1982), and Bedeer (1984) who indicated that crop growth rate of maize was not significantly affected by application of zinc.

5. Relative growth rate:

The differences between the mean values of relative growth rate was not significantly affected by water stress, maize cultivars and zinc levels in combined analysis of 1988, 1989 and 1990 seasons as shown in Table (8).

Similar results were obtained by Mahrous (1977) and Ali (1985). They indicated that irrigation levels failed to exhibit significant differences in relative growth rate.

Regarding to maize cultivars, similar trend was obtained by Kamel *et al.* (1986). On the other hand, Raghib (1979), Gouda (1982), Bedeer (1984), Younis (1985) and Aly (1988) who found that varieties differed significantly in relative growth rate. These differences may be due to the genetical between cultivars of maize.

Regarding to zinc levels, similar results were obtained by Younis (1979), Orabi *et al.* (1981), El-Attar *et al.* (1982), Bedder (1984) and Younis (1985), who reported that relative growth rate of maize was not significantly affected by application of zinc.

6. Net assimilation rate:

A. Effect of water stress:

Exposing maize plants to water stress significantly decreased the average values of net assimilation rate in the combined analysis over the three seasons as indicated in Table (8).

The decrease of net assimilation rate could be attributed to mutual shedding which in turn might decreased net photosynthesis. Irrigation after 40% soil moisture depletion gave the highest mean values of net assimilation rate due to more vigorous growth expressed in largest leaf area/plant and highest leaf area index. These findings are in accordance with Nour El-Din *et al.* (1986) and Ragab *et al.* (1986).

B. Varietal differences:

The combined analysis show in table (8) that the difference between the three cultivars not differed significantly in the mean values of net assimilation rate. These results are in good agreement with those obtained by Kamel *et al.* (1986) who found that the difference between the averages of Giza 2 and Pioneer 514 cultivars on net assimilation rate was not significant. Aly (1988) also found that the differences among the averages of maize cultivars namely Double Cross 204, Giza 2, American Early, Nab El-Gamal and Ciba 4405 were not significant in net assimilation rate. On the other hand, Yakout (1977), Raghib (1979), Gouda (1982) and Bedeer (1984) indicated that varieties differed significantly in net assimilation rate. These differences may be due to the genetical between maize varieties.

C. Effect of zinc levels:

It was observed from the results in Table (8) that the average values of net assimilation rate was not significantly affected by increasing zinc sulphate rate as foliar application up to 0.6% in the combined analysis over the three seasons. Similar results were obtained by Orabi *et al.* (1981), El-Attar *et al.* (1982) and Younis (1985) who found that leaf area/plant, leaf area index, dry matter accumulation and distribution and net assimilation rate were not significantly affected by zinc application. On the other hand, Kamel *et al.* (1986) showed that foliar application of maize plants with 0.5% zinc sulphate caused an increase in net assimilation rate.

7. Time of silking:

The average values of number of days from sowing to 50% silking as affected by irrigation levels, maize cultivars and zinc levels in the combined analysis between 1988, 1989 and 1990 seasons are shown in Table (8).

A. Effect of water stress:

There was a significant delay in time of silking by increasing depletion of available soil moisture before irrigation. The highest number of days for silking was 65.59, obtained by irrigation at 80% depletion in available water, whereas the lowest one was 64.10, obtained by irrigation after 40% available soil moisture depletion. But no significant differences between the averages of silking time, obtained from irrigation at 40 and 60% depletion in available water. Decreasing soil moisture before irrigation inhibit the meristimatic activity and retard plant growth. Similar results were obtained on time of silking by Kassem *et al.* (1977), Shalaby and Mikhail (1979), Rizk *et al.* (1987), El-Sabbagh (1988) and El-Shenawy (1990), they mentioned that increasing number of watering during growth of maize plants hastened significantly silking date.

B. Varietal differences:

Data indicate that time of silking was earlier in Giza 2 than T.W.C.310 and Karnak cultivars by 2.07 and 4.56 days, respectively. These differences may be due to the genetical differences between varieties. These results are in agreement with those obtained by Kassem *et al.* (1977), Gouda (1982), Ainer (1983), Bedeer (1984), Salwau (1985), Younis (1985) and Aly (1988).

C. Effect of zinc levels:

The average values of time of 50% silking significantly decreased when zinc level increased up to 0.3% zinc sulphate. Whereas no significant differences between zero and 0.6% zinc sulphate or between 0.3% and 0.6% zinc sulphate on the mean values of number of days to 50% silking. These results are in harmony with those obtained by Allam (1983) and Badr (1987) who found that time of 50% silking decreased when zinc level increased. On the other hand, Younis (1985) found that zinc application did not exert any significant effect on the number of days to 50% silking.

8. Height of plant and ear:

Data collected on the mean values of plant and ear heights as affected by irrigation levels, maize cultivars and zinc levels in the combined analysis over the three seasons are shown in Table (8).

A. Effect of water stress:

It was obvious that decreasing the content of soil moisture before irrigation caused a significant dwarfing of maize plant and decreasing ear height. The highest mean values of plant and ear height were 248.40 and 140.94 cm., respectively, obtained when irrigation after 40% available soil moisture depletion. On the contrary, the lowest one were 228.25 and 127.58 cm, respectively, obtained from 80% soil moisture depletion. Plant height is a resultant of the increase in the number and length of internodes of maize plant. Since the number of internodes are fixed early so the dwarfing effect was due to the decrease in the length of internode which is the resultant of the number and size of the cells. The increase in ear height may be a consequence of raising the height of plant as a whole due to irrigation levels. Many investigators discussed the effect of soil moisture stress on the number and size of cells. Kramer (1963) reported that exposing plants to drough caused a reduction in plant height as a result of losing turgidity and cell enlargement. These results agree with those obtained by Ainer (1976), Ashoub (1977), Gomaa (1981), Salwau (1985), Nour El-Din *et al.* (1986), Rizk *et al.* (1987), El-Refaie *et al.* (1988), Nissen *et al.* (1988) and Meleha (1992). They found that high soil moisture tended to increase plant and ear height.

B. Varietal differences:

Three Way Cross 310 cultivar surpassed significantly Giza 2 and Karnak cultivars in plant and ear heights. Giza 2 cultivar ranked the second, while Karnak cultivar gave the lowest one. Such differences might be due to their genetic constitution which may be manifested in lower number and shorter internodes. These results are in good agreement with those obtained by Kassem *et al.* (1977), Gomaa (1981), Gouda (1982), Ainer (1983), Salem *et al.* (1983), Abou-Khadrah (1984), Bedeer (1984), Salwau (1985), younis (1985), Aly (1988) and El-Shenawy (1990).

C. Effect of zinc levels:

It was clear that the differences between the mean values of plant and ear height were not significant due to foliar application of zinc sulphate at different concentrations, but these characters increased by increasing zinc sulphate up to 0.6%. The same trend was also realized by Younis (1979), Bedeer (1984) and Younis (1985) who indicated that plant and ear height were not affected by zinc level.

9. Stem diameter:

Table (8) indicates the average values of stem diameter was significantly affected by irrigation levels, maize cultivars, and zinc levels in the combined analysis between the three seasons.

A. Effect of water stress:

Irrigation maize plants at 40% soil moisture depletion gave the highest mean value of stem diameter equal to 2.17 cm, whereas the lowest one was 2.01 cm, obtained from 80% soil moisture depletion. Water deficit caused a loss in cell turgidity and this in turn resulted in cell division, resulted in a decreasing the growth of stems. These results are in harmony with those recorded by Ashoub (1977), Gomaa (1981), Nour El-Din *et al.* (1986) and El-Shenawy (1990).

B. Varietal differences:

Three Way Cross 310 cultivar gave the highest mean value of stem diameter which equal to 2.29 cm, but Karnak cultivar gave the lowest one (1.97 cm). On the other hand, no significant differences between Giza 2 and Karnak cultivars in this character. In this connection, it could be noticed that these

Table 8: The average values of crop growth rate, relative growth rate and net assimilation rate at (60-75) days from sowing, time of silking, plant height, ear height and stem diameter at harvesting time as affected by water stress, cultivars and foliar application of zinc sulphate in combined analysis between 1988, 1989 and 1990 seasons.

Treatments	Crop growth rate $g/m^2/day$	Relative growth rate mg/g/day	Net assimilation rate $g/m^2/day$	No. of days to 50% silking	Plant height cm	Ear height cm	Stem diameter cm
Water stress							
40% ASMD	22.44a	0.322a	5.25a	64.10b	248.40a	140.94a	2.17a
60% ASMD	20.93a	0.319a	5.40a	64.61b	238.59b	134.41b	2.11a
80% ASMD	16.04b	0.286a	4.45b	65.59a	228.25c	127.58c	2.01b
Irrig. x years	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Cultivars							
Giza 2	18.14b	0.285a	4.71a	62.56c	241.78b	136.12b	2.03b
T.w.C.310	22.59a	0.334a	5.48a	64.63b	251.51a	141.41a	2.29a
Karnak	18.68b	0.307a	4.91a	67.12a	221.94c	125.40c	1.97b
Cult. x years	*	N.S.	N.S.	**	**	**	N.S.
Zinc levels							
0.0%	19.34a	0.310a	5.17a	65.01a	236.69a	133.01a	2.06b
0.3%	21.07a	0.316a	5.13a	64.45b	239.15a	134.81a	2.13a
0.6%	19.00a	0.300a	4.79a	64.84ab	239.39a	135.11a	2.10a
Zn x years	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction							
Ir.x C.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Ir.x C.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x Ir.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x Ir.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.x Ir	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.xIr.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Ir. = Irrigation
C. = Cultivars.
Y = Years.
ASMD = Available soil moisture depletion

differences may be due to the genetical differences between cultivars. Similar results were reported by Gomaa (1981), Gouda (1982), Salem *et al.* (1983), Salwau (1985) and El-Shenawy (1990).

C. <u>Effect of zinc levels:</u>

The mean values of stem diameter was significantly increased by increasing level of zinc sulphate as foliar application up to 0.3% zinc sulphate. Similar trend was obtained by Baza (1981), El-Sayed *et al.* (1986), Badr (1987) and Khalil (1992) who indicated that stem diameter significantly increased by increasing zinc level up to 0.9%, 0.8%, 0.4% zinc sulphate and 10 kg zinc sulphate/feddan, respectively.

D. <u>Effect of the interactions:</u>

i. <u>Interaction effect between water stress and cultivars:</u>

Data in Table (9) show that the percentage of stem and ears at 90 days from sowing were highly significantly affected by the interaction between water stress and maize cultivars in the combined analysis of the three growing seasons. The highest percentage of stem was 40.54, obtained from irrigation at 40% available soil moisture depletion with T.W.c.310 cultivar, but the lowest one was 28.96%, obtained when plants irrigated at 60% available soil moisture depletion with Giza 2 cultivar. On the other hand, Giza 2 cultivar with irrigation at 40% or 60% depletion of soil moisture gave the highest percentage of ears (50.41 or 50.11), respectively.

The interaction between water stress, maize cultivars and years gave a significant effect on the percentage of stem, chlorophyll a, b, (a+b) and carotenoids. These results may be due to meteorological factors between years.

ii. <u>Interaction effect between water stress and zinc sulphate:</u>

Table (10) shows that the average value of chlorophyll (a+b) to carotenoids ratio were significant as affected by the interaction between water stress and zinc sulphate concentration. The maximum mean value of the ratio of chlorophyll (a+b) to carotenoids was 1.80, obtained from 0.3% zinc sulphate and 40% available soil moisture depletion, whereas the minimum one was 1.69, obtained from foliar application of zinc sulphate at 0.6% and irrigation at 40% soil moisture depletion. However, no significant difference was obtained from the effect of interaction between water stress and zinc sulphate on the other growth characters.

A significant effect of the interaction between water stress, zinc levels and years on the average values of chlorophyll (a+b) to carotenoids ratio. These results may be due to meteorological factors between years.

iii. <u>Interaction effect between cultivars and zinc levels:</u>

There were significant differences between the mean values of chlorophyll a, carotenoids and the ration of chlorophyll (a+b) to carotenoids due to the interaction between maize cultivars and zinc sulphate in the combined analysis between 1988, 1989 and 1990 seasons, (Table 11). The highest values of chlorophyll (a) and the ratio of chlorophyll (a+b) to carotenoids were 2.39 and 1.82 mg/dm^2 leaf area, obtained when applied 0.3% zinc sulphate as foliar application with T.W.C.310 cultivar, also the highest mean value of carotenoids was 2.37 mg/dm^2 leaf area, obtained from foliar application of zinc sulphate at 0.3% with Karnak cultivar. On the other hand, the lowest mean value of chlorophyll a was 2.13 mg/dm^2 leaf area, obtained from zero zinc with T.W.C.310 cultivar and the lowest ratio of chlorophyll (a+b) to carotenoids was 1.68 mg/dm^2 leaf area, obtained from Karnak cultivar and applied zinc sulphate at 0.6%.

The differences between the average values of leaf area/plant, leaf area index, chlorophyll a, b and (a+b) were highly significant affected by the interaction of cultivars, zinc sulphate and years. These results may be due to meteorological factors between years.

Table 9: Stem and ears % at 90 days from sowing as affected by the interaction of water stress and maize cultivars.

Water stress	Stem %			Ears %		
	Cultivars					
	Giza 2	T.W.C.310	Karnak	Giza 2	T.W.C.310	Karnak
40% ASMD	29.66de	40.54a	33.42bc	50.41a	39.97b	42.93b
60% ASMD	28.96e	36.97b	32.77cd	50.11a	42.49b	44.39b
80% ASMD	35.67bc	36.62b	35.59bc	42.72b	41.65b	39.70b

ASMD: Available soil moisture depletion.

Table 10: Chlorophyll (a+b)/carotenoids ratio as affected by the interaction of foliar application of zinc sulphate and water stress.

Character	Chlorophyll (a+b)/carotenoids ratio		
Water stress	Zinc sulphate concentration		
	0.0	0.3%	0.6%
40% ASMD	1.79a	1.80a	1.69b
60% ASMD	1.73ab	1.73ab	1.79a
80% ASMD	1.76ab	1.73ab	1.79a

AMSD = Available soil moisture depletion.

Table 11: Chlorophyll a, carotenoids and chlorophyll (a+b)/ carotenoids ratio as affected by the interaction of foliar application of zinc sulphate and maize cultivars.

Zinc levels	Maize cultivars	Chlorophyll a mg/dm^2 LA	Carotenoids mg/dm^2 LA	Ch. (a+b)/ carotenoids ratio
0.0%	Giza 2	2.20bc	2.15b	1.71bc
	T.W.C.310	2.13c	2.07b	1.76abc
	Karnak	2.27abc	2.07b	1.80ab
0.3%	Giza 2	2.11c	2.03b	1.76abc
	T.W.C.310	2.39a	2.17b	1.82a
	Karnak	2.37ab	2.37a	1.68c
0.6%	Giza 2	2.26abc	2.14b	1.76abc
	T.W.C.310	2.25abc	2.19b	1.73abc
	Karnak	2.33ab	2.15b	1.78ab

iv. <u>Interaction effect between water stress, maize cultivars and zinc sulphate:</u>

Table (12) shows the differences between the percentage of leaves and stem at 60 days after sowing and stem percentage at 75 days from sowing were significantly affected due to the interaction between water stress, maize cultivars and zinc sulphate in the combined analysis over the three growing seasons.

It was evident from Table (12), at 60 days after sowing that the highest percentage of leaves was 48.74, obtained from the interaction between 80% available soil moisture depletion, 0.3% zinc sulphate and Karnak cultivar. But the lowest percentage of leaves was 34.83, obtained from 60% soil moisture depletion, zero zinc sulphate and Giza 2 cultivar.

The highest percentage of stem was 65.17, obtained from the effect of interaction between irrigation at 60% soil moisture depletion, zero zinc with Giza 2 cultivar. Whereas the lowest one was 51.26% obtained from the effect of interaction between water stress at 80% soil moisture depletion, 0.3% zinc sulphate with Karnak cultivar.

At 75 days from sowing time, the effect of interaction between foliar application of zinc sulphate at 0.6% and irrigation at 60% soil moisture depletion with T.W.C.310 cultivar gave the highest value of stem percentage (56.02). Whereas the lowest one was 43.82, obtained from zero zinc sulphate, irrigation at 80% soil moisture depletion and Karnak cultivar.

The differences between the average values of tassels percentage, leaf area/plant, leaf area index and carotenoids content in leaves of maize plant were significant due to the effect of the interaction between water stress, maize cultivars, zinc sulphate and years. These results may be due to meteorological factors between years.

The interaction between water stress and years gave a significant effect on the average values of leaves percentage at 75 days from sowing, tassels percentage at 90 days from sowing, chlorophyll a, (a+b), carotenoids and the ratio of chlorophyll (a+b) to carotenoids (Tables 5 and 7). The interaction between maize cultivars and years gave a significant effect on the average values of dry matter accumulation and distribution/plant at 75 days from sowing, the percentage of stem, ears and tassels at 90 days from sowing, chlorophyll contents, leaf area/plant, leaf area index, crop growth rate, plant height, ear height and time of silking (Tables 5, 6, 7 and 8). There was a significant differences between the percentage of tassels at 75 days from sowing as affected by the interaction between zinc sulphate and years (Table 5).

These results may be due to meteorological factors between years.

Table 12: Leaves and stem % at 60 days and stem % at 75 days from sowing as affected by the interaction of water stress, cultivars and zinc sulphate.

Characters		Leaves % at 60 days age			Stem % at 60 days age			Stem % at 75 days age		
Water stress	Cultivars	Zinc concentration								
		0.0%	0.3%	0.6%	0.0%	0.3%	0.6%	0.0%	0.3%	0.6%
40% ASMD	Giza 2	40.51b-f	36.13ef	40.77b-f	59.49a-f	63.87ab	59.23a-g	44.88ef	50.92a-e	46.63def
	T.W.C.310	40.89b-f	39.54c-f	42.78a-d	59.11a-g	60.46a-d	57.22c-h	50.86a-e	54.52ab	52.68a-d
	Karnak	45.32a-d	46.59ab	44.05a-d	54.68c-h	53.41fgh	55.95c-h	50.26a-f	47.53c-f	52.20a-d
60% ASMD	Giza 2	34.83f	42.52a-e	44.79a-d	65.17a	57.48b-h	55.21c-h	47.36c-f	48.99b-f	47.53c-f
	T.W.C.310	44.97a-d	38.75def	41.66b-e	55.03c-h	61.25abc	58.34b-g	52.12a-d	53.46a-d	56.02a
	Karnak	48.72a	46.12abc	46.54ab	51.28gh	53.88d-h	53.46e-h	50.88a-e	49.78a-f	47.00def
80% ASMD	Giza 2	43.78a-d	40.46b-f	40.46b-f	56.22c-h	59.87a-e	59.54a-f	49.79a-f	46.87def	44.85ef
	T.W.C.310	44.15a-d	44.05a-d	44.63a-d	55.85c-h	55.95c-h	55.37c-h	54.13abc	50.11a-f	54.90a
	Karnak	47.27ab	48.74a	44.89a-d	52.73fgh	51.26h	55.11c-h	43.82f	50.02a-f	49.98a-f

ASMD: Available soil moisture depletion.

II. Yield and yield components

Effect of years:

Results in Table (13) represent averages of the three growing seasons of the study concerning yield and its components. From the results it is evident that yield and its components were differed significantly from season to another except ear length.

The higher average values were detected for ear diameter, ear weight, 100-grain weight, grain yield/plant and grain yield/feddan in the first season, plants carry more than one ear percentage, late wilt disease percentage, number of grains/row and straw yield ton/feddan in the second season and number of rows/ear in the third season. The more suitable environmental conditions encourage growth of plant which in turn affect on metabolites synthesized by maize plants. In addition light intensity and proper temperature governs differentiation of reproductive organs. On the other hand, favorable growth conditions favors production of organic matter which in turn increased biosynthesis of organic components. Therefore, fluctuation of the different environment factors can explain the differences between the averages of different yield components from year to another.

Table 13: The average values of yield and its components of maize as affected by years in combined analysis over the three years.

Characters	Years		
	1988	1989	1990
Plants carry more than one ear %	1.92b	5.19a	4.94a
Late wilt disease %	2.64b	4.81a	4.47a
Ear length cm	20.25a	20.49a	20.55a
Ear diameter cm	5.06a	4.87b	4.91b
Ear weight (g)	305.30a	285.69b	276.23c
No. of rows/ear.	13.45b	13.75a	13.78a
No. of grains/row	42.36c	45.00a	44.39b
100-grain weight (g).	41.94a	38.93b	38.26b
Grain yield/plant (g)	173.31a	158.15b	172.18a
Grain yield (kg/fed)	3379.05a	3201.08b	3357.58a
Straw yield (ton/fed.)	5.98a	6.05a	5.52b

1. The percentage of plants carried more than one ear:

A. Effect of water stress:

The results in Table (14) indicate clearly that the differences between the average values of plants carried more than one ear percentage was significantly decreased by increasing soil moisture depletion in the combined analysis of the three seasons. The highest percentage of plants carried more than one ear was 5.22, obtained from exposing plants to 40% available soil moisture depletion. Whereas the lowest one was 3.18%, obtained from irrigation after depletion 80% of soil moisture. There is no significant difference between 60% and 80% soil moisture depletion. This is to be expected since water deficit inhibited stem elongation and leaf enlargement which in turn affected the size of photosynthate surface causing a reduce in crop growth rate and producing plants with lower percentage of two-ears. These results are in accordance with those obtained by El-Noamny (1978), Shalaby and Mikhail (1979), Salwau (1985) and Ouattar *et al.* (1987).

B. Varietal differences:

Table (14) shows that the differences between maize cultivars were significant for the percentage of plants carried more than one ear. It is clear that T.W.C.310 cultivar had the highest mean value for the percentage of plants carried more than one ear (6.65%), while the lowest percentage

(1.58%) was obtained from Karnak cultivar. These differences may be due to differences in development processes and their ability to thrive and benefit from the available nutrients which are controlled genetically to a large extent. Ainer (1983), Salem *et al.* (1983), and Kamel *et al.* (1986) obtained similar conclusions.

C. Effect of zinc levels:

There was no significant difference in the percentage of plants carried more than one ear which were not affected by foliar application of zinc sulphate at different concentration in the combined analysis over the three seasons, (Table 14). Baza (1981), Allam (1983), Bedeer (1984) found that the percentage of plants carried more than one ear was not affected by adding zinc sulphate at any concentration.

2. Late wilt disease:

A. Effect of water stress:

The results presented in Table (14), indicate in the combined analysis of 1988, 1989 and 1990 seasons, that the percentage of late wilt disease significantly increased by increasing depletion of available soil moisture from 40 to 80%. The lowest value of late wilt disease percentage was 2.50, obtained from irrigation after 40% depletion of soil moisture. The maximum percentage (5.78) was obtained when exposing plants to water stress at 80% soil moisture depletion. This could be attributed to more favorable environmental conditions affecting the growth of the causal fungus by good aeration in case of 80% soil moisture depletion.

These results are in harmony with those obtained by Kassem *et al.* (1977) who found that increasing or decreasing number of irrigation than 9 irrigations resulted in increasing significantly the percentage of infection. El-Sabbagh (1988) obtained the highest degree of infection by late wilt disease when maize plants was irrigated at 50% of field capacity.

B. Varietal differences:

Giza 2 cultivar significantly exceeded the other maize cultivars in the percentage of late wilt disease followed by Karnak and T.W.C.310 cultivars. Superiority of T.W.C.310 in this trait may be attributed to gene control and heterosis effect for late wilt resistance of T.W.C.310 cultivar.

C. Effect of zinc levels:

The average values of late wilt disease percentage significantly increased by increasing level of zinc sulphate as foliar up to 0.6% $ZnSO_4$ (Table 14). It is evident from these results that increasing nutrients of plants caused an increase in the percentage of late wilt disease. Such apparent controdication in results could be attributed to several factors such as: different genotypes or environmental conditions and cultural practices.

3. Ear characters:

The mean values of ear length, ear diameter, ear weight, number of rows/ear and number of grains/row as affected by water stress, maize cultivars and zinc levels in combined analysis between the three growing seasons are presented in Table (14).

A. Effect of water stress:

The effect of water stress treatments on the average values of ear length, ear diameter, ear weight, number of rows/ear and number of grains/row were significant in the combined analysis over the three seasons (Table 14).

Irrigation after 40% soil moisture depletion gave the highest mean value of ear length (20.94 cm), ear diameter (5.03 cm), ear weight (304.94 g), number of rows/ear (13.80) and number of grains/row (44.70). These characters decreased when irrigated at 80% soil moisture depletion. This is to be expected since water plays an important role in plants and moisture deficit can have a deleterious on most physiological process. Similar trend was reported by Ashoub (1977), Metwally (1977), Shalaby and Mekhail (1979), Gomaa (1981), Ainer (1983), Moursi *et al.* (1983), Salwau (1985), Eweida *et al.* (1986), Nour el-Din *et al.* (1986), Ouattar *et al.* (1987), El-Sabbagh (1988), Grant (1989), El-Shenawy (1990) and Meleha (1992).

B. Varietal differences:

There was a highly significant differences between the three maize cutlivars on the average values of ear characters. T.W.C.310 cultivar gave the highest ear length (22.34 cm), ear weight (313.27 g), and number of grains/row (48.59). Whereas Karnak cultivar gave the lowest average value for ear length (19.17 cm) and Giza 2 cultivar gave the lowest value of ear weight (265.03 g) and number of grains/row (41.57). It is clear that Karnak cultivar surpassed significantly Giza 2 and T.W.C.310 cultivars in the mean values of ear diameter and number of rows/ear. On the contrary, T.W.C.310 cultivar gave the lowest mean value of ear diameter (4.79 cm) and number of rows/ear (12.84). The differences between maize cultivars were mainly due to genetical constituents. These results are similar with those obtained by younis (1985), El-Deepah *et al.* (1989) and El-Shenawy (1990).

C. Effect of zinc levels:

It is clear from Table (14) that there was a significant effect of the applied zinc sulphate as foliar on the average values of ear length and ear weight. On the other hand, ear diameter, number of rows/ear and number of grains/row were not significantly affected by foliar application of zinc sulphate at different concentration. These results may be due to the fact that these characters are genetically controlled. The highest mean values of ear length and ear weight were 20.74 cm and 295.11 g, respectively, obtained from applied zinc sulphate as foliar at 0.3% $ZnSO_4$. But no significant differences between zero and 0.6% zinc sulphate on the average values of ear length and ear weight. These results are in agreement with those obtained by Younis (1979), Baza (1981), Allam (1983), El-Beshbeshy (1983), Bedeer (1984), Younis (1985), El-Sayed *et al.* (1986), Kamel *et al.* (1986), Badr (1987) and Kabesh *et al.* (1988) who reported that ear length and ear weight significantly increased as zinc sulphate increased but the other ear characters were not affected.

4. 100-Grain weight:

A. Effect of water stress:

The differences between the mean values of 100-grain weight were significantly affected by exposing plants to water stress in the combined analysis between 1988, 1989 and 1990 seasons (Table 14).

It is evident that the highest mean value of 100-grain weight was 41.27 g, obtained when irrigation after 40% depletion of available water, whereas the lowest one was 37.95 g, obtained from exposing plants to 80% soil moisture depletion. This was expected since drought stress during grain filling may be affected greatly on the amount of photosynthates in the grains. This result was in harmony with those obtained by Kassem *et al.* (1977), El-Nomany (1978), Shalaby and Mikhail (1979), Gomaa (1981), Ainer (1983), Moursi *et al.*

(1983), Eweida *et al.* (1986), Bajwa *et al.* (1987), Grant (1989), El-Shenawy (1990) and Meleha (1992).

B. Varietal differences:

Maize cultivars of T.W.c.310 surpassed significantly than the other cultivars under study in the mean value of 100-grain weight. Karnak cultivar gave the lowest value of 100-grain weight. These results may be due to the cultivars genetical effects. Similar results were obtained by Ainer (1983), Abou-Khadra (1984), Bedeer (1984), Khalifa *et al.* (1984), Younis (1985), El-Hattab *et al.* (1986) and El-Shenawy (1990).

C. Effect of zinc levels:

The average values of 100-grain weight increased by increasing level of zinc sulphate as foliar application up to 0.3% $ZnSO_4$. On the other hand, no significant difference between 0.3% and 0.6% zinc sulphate on the mean values of 100-grain weight. The effect of zinc on 100-grain weight could be interpreted through the role of zinc as an essential component for the activity of some dehydrogenases, proteinases, peptidases and alcohol dehydrogenase (Vallee and Wacker, 1970). The same result was reported by Ashour *et al.* (1983), Abd El-Aziz *et al.* (1986), El-Sayed *et al.* (1986), Kamel *et al.* (1986), Badr (1987) and Kabesh *et al.* (1988), who found that 100-grain weight significantly increased by increasing zinc sulphate up to 0.2%, 10 kg zinc sulphate/feddan, 0.8%, 0.5%, 0.4% and 0.1%, respectively.

5. Grain yield/plant:

Table (14) indicated that the average values of grain yield/plant was highly significantly affected by water stress treatments, maize cultivars and zinc levels in the combined analysis of 1988, 1989 and 1990 seasons.

A. Effect of water stress:

The maximum value of grain yield/plant was 191.30 g, obtained from irrigation after 40% soil moisture depletion, whereas the minimum value was 141.91 g, obtained when irrigated at 80% soil moisture depletion. Increasing soil moisture depletion depressed grain yield/plant owing to its detrimental effect on ear length, ear diameter, number of grains/row, reduction ear weight, 100-grain weight and number of ears/plant. The increase in the grain yield/plant resulted from the increase in available soil moisture and this in turn increased the total leaf area which improved the photosynthetic capacity of the plant. These results agree with those obtained by Kassem *et al.* (1977), El-Nomany (1978), Shalaby and Mikhail (1979), Gomaa (1981), Ainer (1983), Salwau (1985), Eweida *et al.* (1986) and El-Shenawy (1990).

B. Varietal differences:

T.W.C.310 cultivar gave the highest mean value of grain yield/plant 191.51 g, but Giza 2 had the lowest one 155.33 g. On the other hand, the differences between Giza 2 and Karnak cultivars in the average values of grain yield/plant was not

Table 14: The average values of the percentage of plants carried more than one ear, late wilt disease percentage, ear characters, 100-grain weight and grain yield/plant as affected by water stress, maize cultivars and foliar application of zinc sulphate in combined analysis of 1988, 1989 and 1990 seasons.

Treatments	Plants carried more than one ear %	Late wilt disease %	Ear length cm	Ear diameter cm	Ear weight g	No. of rows/ear	No. of grains/row	100-grain weight g	Grain yield/plant g
				Water stress					
40% ASMD	5.22a	2.50b	20.94a	5.03a	304.94a	13.80a	44.70a	41.27a	191.30a
60% ASMD	3.65b	3.64b	20.52b	4.97a	293.73b	13.67ab	44.27a	39.92b	170.43b
80% ASMD	3.18b	5.78a	19.83c	4.85b	268.56c	13.51b	42.77b	37.95c	141.91c
Irrig. x Years	N.S.	N.S	*	N.S	N.S.	N.S.	N.S.	N.S.	*
				Cultivars					
Giza 2	3.82b	6.22a	19.79b	4.91b	265.03c	13.55b	41.57b	39.75b	155.33b
T.W.C.310	6.65a	2.03c	22.34a	4.79c	313.27a	12.84c	48.59a	41.67a	191.51a
Karnak	1.58c	3.67b	19.17c	5.15a	288.93b	14.59a	41.58b	37.72c	156.81b
Cult. x years	**	N.S	**	**	N.S.	**	N.S.	N.S.	*
				Zinc levels					
0.0%	3.77a	3.24b	20.15b	4.92a	282.72b	13.63a	43.76a	39.14b	164.05b
0.3%	4.36a	3.91b	20.74a	4.97a	295.11a	13.65a	44.15a	40.20a	171.47a
0.6%	3.92a	4.77a	20.40b	4.95a	289.40ab	13.69a	43.83a	39.80ab	168.11a
Zn x years	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
				Interactions					
Ir.x C.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Ir.x C.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x Ir.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x Ir.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*
Zn x C.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**	**
Zn x C.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*
Zn x C.x Ir	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.
Zn x C.xIr.x Y	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	**

Ir. = Irrigation
C. = Cultivars.
Y = Years.
ASMD = Available soil moisture depletion

significant. Superiority of T.w.C.310 cultivar in grain yield/plant may be due to the superiority in the percentage of plants carried more than one ear, ear length, number of grains/row and 100-grain weight and decreased the percentage of late wilt disease. This result is in accordance with that recorded by Ainer (1983), Abou-Khadrah (1984), Bedeer (1984), Khalifa *et al.* (1984), Younis (1985), El-Hattab *et al.* (1986), Kamel *et al.* (1986) and El-Shenawy (1990).

C. <u>Effect of zinc levels:</u>

The maximum value of grain yield/plant was 171.47 g, obtained from applied zinc sulphate at 0.3%, whereas the minimum one was 164.05, obtained from zero zinc sulphate. On the other hand, there was no significant difference in grain yield/plant as a result of applying 0.3% and 0.6% zinc sulphate. This finding could be attributed to observe significant increases in ear length, ear weight and 100-grain weight as foliar application of zinc sulphate up to 0.3%. These results are in harmony with the finding obtained by Baza (1981), Abd El-Aziz *et al.* (1986), El-Sayed *et al.* (1986), Kamel *et al.* (1986), and Badr (1987).

6. Grain yield kg/feddan:

A. <u>Effect of water stress:</u>

The effect of irrigation treatments on the average values of grain yield per feddan was highly significant in the three seasons as well as the combined analysis over the three seasons as shown in Table (15).

The maximum mean values of grain yield kg/feddan were 3789, 3573, 3984 and 3783 kg/feddan in 1988, 1989, 1990 and the combined analysis over the three seasons, respectively, obtained from irrigation after 40% available soil moisture depletion. The combined analysis show that the highest decrease in the percentage of grain yield was 26.41%, obtained from irrigation at 80% depletion of available water when compared with 40% soil moisture depletion. This is to be expected since the average number of plants which carried more than one ear, ear length, ear weight, number of rows/ear, number of grains/row, 100-grain weight and grain yield/plant decreased by increasing soil moisture depletion up to 80%. Moreover, drought stress might reduce translocation of assimilates from leaves, and as drought hasten maturation, this response in addition to reduced photosynthesis in the grains itself contribute to lower grain yield. In this respect, Pierre *et al.* (1966) pointed that maize is a crop with high production potential when its requirements for growth and reproduction are met. Moisture is a common limiting factor even in the more humid regions. In semiarid and subhumid regions irrigation is essential for high yields. They added also that the critical period in maize plant development is the 3-4 weeks during tasseling, silking and ear development. Any deficiencies of moisture that occur during this period will have the greatest effect on final yields. Vasic and Videnovic (1980) reported that water shortage causes stomatal closure and this in turn prevents CO_2 diffusion into the air inside the tissue of the plants and consequently the photosynthetic efficiency becomes low. These results are in harmony with those obtained by Classen and Shaw (1970), Downey (1971), Kaul *et al.* (1972), Onofrii (1975), Ashoub (1977), Metwally (1977), Gardner *et al.* (1981), Gomaa (1981), Harder *et al.* (1982), Ainer (1983), Moursi *et al.* (1983), Papendick *et al.* (1985), Patel *et al.* (1985), Eweida *et al.* (1986), Ragab *et al.* (1986), Bajwa *et al.* (1987), Puste and Kumer (1988) and Meleha (1992).

B. <u>Varietal differences:</u>

Table (15) indicates that the differences between the three cultivars on the mean values of grain yield kg/feddan was significant in 1988, 1989 and 1990 as well as the combined analysis over the three seasons. T.W.C.310 cultivar significantly surpassed Giza 2 and Karnak cultivar in grain yield kg/feddan by 19.15 and 18.83%, respectively, whereas the difference between the other two cultivars was not significant in the average values of grain yield kg/feddan. The increase in yield of T.W.C.310 cultivar may be due to the increase in the percentage of plants carried more than one ear, ear length, ear weight, number of grains/row, 100-grain weight and grain yield/plant. Similar results were obtained by Raghib (1979), Ewies (1980), Mtui *et al.* (1981), Ainer (1983), Salem *et al.* (1983), Abou-Khadra (1984), Khalifa *et al.* (1984), Younis (1985), El-Hattab *et al.* (1986).

C. <u>Effect of zinc levels:</u>

The differences between the mean values of grain yield kg/feddan was highly significantly affected by foliar application of zinc sulphate, (Table 15). The average values of grain yield/feddan increased by increasing the level of zinc sulphate up to 0.3%. The highest increase in the percentages of grain yield kg/feddan were 3.79, 5.44, 5.02 and 4.83% as compared with the control treatment (Zero zinc sulphate). From these above mentioned results it can be concluded that zinc played an important role in metabolic processes and this in turn in plant growth. Peyve (1969) reported that foliar application of micronutrients such as Zn, Mn and B seems to stimulate the metabolic process within the plant through their direct effect on the enzymatic reactions. The same results were obtained by Dornescu *et al.* (1972), Osiname *et al.* (1973), Singh and Sharma (1976), Ghaly *et al.* (1977), Khan *et al.* (1980), Baza (1981), Ashour *et al.* (1983), El-Beshbeshy (1983), Sakal and Singh (1984), Badr (1987), Genaidy *et al.* (1987), Kabesh *et al.* (1988) and El-Awady and Abd El-Naim (1990).

7. Straw yield/feddan:

It was clear from Table (15) that the average values of straw yield/feddan was highly significantly affected by water

Table 15: The average values of grain yield kg/feddan and straw yield ton/feddan as affected by water stress, maize cultivars and foliar application of zinc sulphate in 1988, 1989 and 1990 seasons as well as combined analysis over the three seasons.

Treatments	Grain yield kg/feddan				Straw yield ton/feddan			
	1988	1989	1990	Comb.	1988	1989	1990	Comb.
Water stress								
40% ASMD	3789a	3573a	3984a	3783a	6.28a	6.70a	6.07a	6.35a
60% ASMD	3501b	3249a	3366b	3372b	5.94b	6.27a	5.57b	5.93b
80% ASMD	2847c	2784b	2724c	2784c	5.72b	5.19b	4.91b	5.28c
Irrig. x Years	-	-	-	N.S.	-	-	-	*
Cultivars								
Giza 2	3090c	2997b	3117b	3066b	5.97b	5.63b	5.36b	5.66b
T.W.C.310	3795a	3825a	3753a	3792a	6.60a	7.98a	5.89a	6.83a
Karnak	3252b	2781b	3204b	3078b	5.36c	4.55c	5.30b	5.07c
Cult. x years	-	-	-	**	-	-	-	**
Zinc levels								
0.0%	3321a	3090b	3285b	3231c	5.64b	5.65b	5.30b	5.53b
0.3%	3447a	3258a	3450a	3387a	6.15a	6.34a	5.87a	6.12a
0.6%	3366a	3252a	3339b	3321b	6.15a	6.17a	5.38b	5.90a
Zn x years	-	-	-	N.S.	-	-	-	N.S.
Interactions								
Ir.x C.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Ir.x C.x Y	-	-	-	N.S.	-	-	-	N.S.
Zn x Ir.	N.S.	N.S.	**	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x Ir.x Y	-	-	-	*	-	-	-	N.S.
Zn x C.	N.S.	N.S.	**	*	N.S.	N.S.	N.S.	N.S.
Zn x C.x Y	-	-	-	*	-	-	-	*
Zn x C.x Ir	N.S.	N.S.	**	N.S.	N.S.	N.S.	N.S.	N.S.
Zn x C.xIr.x Y	-	-	-	*	-	-	-	N.S.

Ir. = Irrigation
C. = Cultivars.
Y = Years.
ASMD = Available soil moisture depletion

stress, maize cultivars and zinc sulphate in the three seasons as well as the combined analysis between the three seasons.

A. <u>Effect of water stress:</u>

Irrigation after 40% soil moisture depletion resulted in increasing significantly the mean values of straw yield ton/feddan. The highest decrease in the percentage of straw yield were 8.92, 22.54, 19.11 and 16.85% in 1988, 1989, 1990 and the combined analysis over the three seasons, respectively, obtained from irrigation after 80% available soil moisture depletion as compared with 40% soil moisture depletion. This result may be expected because the dry weight/plant at different stages, leaf area/plant, crop growth rate, plant height and stem diameter were decreased by increasing soil moisture depletion up to 80%. The same results were reported by Ashoub (1977), Shalaby and Mikhail (1979), Gomaa (1981), Moursi *et al.* (1983), Salwau (1985) and Nour El-Din *et al.* (1986).

B. <u>Varietal differences:</u>

T.W.C.310 cultivar had the highest value of straw yield/feddan which were 6.60, 7.98, 5.89 and 6.83 ton/feddan in 1988, 1989, 1990 seasons and the combined analysis over the three seasons, respectively. Whereas Karnak cultivar gave the lowest value of straw yield/feddan (5.07 t/feddan) and Giza 2 ranked between T.W.C.310 and Karnak cultivars (5.66 t/feddan). The increase in straw yield of T.W.C.310 cultivar resulted from the increase in dry weight/plant, leaf area/plant, plant height and stem diameter. The same trend was obtained by Gomaa (1981) and Salwau (1985).

C. Effect of zinc levels:

The results in Table (15) indicate that the average values of straw yield/feddan significantly increased by increasing the level of zinc sulphate as foliar up to 0.3%. Application zinc sulphate at 0.3% as foliar gave the highest average value of straw yield/feddan (6.12 ton) in the combined analysis over the three seasons. However, increasing zinc sulphate up to 0.6% caused a decrease in the mean value of straw yield/feddan, whereas the differences between 0.3% and 0.6% $ZnSO_4$ were not significant on the average value of straw yield/feddan. It could be concluded that this rate of Zn (0.3% zinc sulphate) could be suitable for the enhancement of photosynthesis and the accumulation of metabolites in maize organs. Similar results were obtained by El-Beshbeshy (1983), Abd El-Aziz *et al.* (1986) and Kabesh *et al.* (1988).

D. Effect of the interactions:

i. Interaction effect between water stress and cultivars:

The differences between the average values of yield and its components were not significant due to the interaction between water stress and cultivars. This result indicates that the cultivars response to irrigation treatments.

ii. Interaction effect between water stress and zinc levels:

The differences between the averages of data under study were not significant due to the interaction between water stress and zinc levels.

There was a significant differences between the average values of grain yield/plant and grain yield/feddan due to the interaction between water stress, zinc sulphate and years. These results may be due to meteorological factors between years.

iii. Interaction effect between cultivars and zinc levels:

Data illustrated in Table (16) show that the average values of 100-grain weight, grain yield/plant and per feddan were significantly affected by the interaction between maize cultivars and zinc levels in the combined analysis over the three seasons.

It is clear from Table (16) that the highest mean values of 100-grain weight, grain yield/plant and per feddan were 42.46 g, 195.25 g and 3867 kg, respectively, obtained from T.W.C.310 cultivar with applied 0.6% zinc sulphate as foliar application. Whereas, the differences between 0.3% and 0.6% zinc sulphate with T.W.C.310 cultivar on the above characters were not significant. On the other hand, the lowest value of 100-grain weight was 38.25 g, obtained from Karnak cultivar and applied 0.6% zinc sulphate. Giza 2 cultivar without applied zinc sulphate had the lowest mean values of grain yield/plant and per feddan 149.08 g and 2940 kg/feddan, respectively. The interaction between Giza 2 without zinc sulphate and Karnak cultivar with applied 0.6% zinc sulphate were not significant on the average values of grain yield/plant and per feddan.

The interaction between maize cultivars, zinc sulphate and years was statistically significant for grain yield/plant, grain yield/feddan and straw yield/feddan. These results may be due to meteorological factors between years.

iv. <u>Interaction effect between water stress, maize cultivars and zinc sulphate:</u>

Table (17) shows that there was a significant difference between the average values for number of grains/row in the combined analysis due to the interaction between water stress, maize cultivars and zinc sulphate concentration. The highest value for number of grains/row of T.w.C.310 cultivar was 49.63, obtained from irrigation after 40% soil moisture depletion with zinc sulphate at 0.6%, whereas the lowest one was 39.75, obtained from 80% depletion of soil moisture and zero zinc sulphate with Karnak cultivar.

The interactions between water stress, maize cultivars, zinc sulphate and years were significant on the average values of 100-grain weight, grain yield/plant and per feddan. These results may be due to meteorological factors between years.

The interactions between water stress and years were significant on the average values of ear length, grain yield/plant and straw yield/feddan, (Tables 14 and 15). The interaction between maize cultivars and years were significant on the average values of plants carried more than one ear percentage, ear length, ear diameter, number of rows/ear, grain yield/plant or feddan and straw yield/feddan (Tables 14 and 15).

These results may be due to meteorological factors between years.

Table 16: The average values of 100-grain weight, grain yield/plant and grain yield/feddan as affected by the interaction between maize cultivars and foliar application of zinc sulphate in combined analysis over the three seasons.

Characters		100-grain weight g	Grain yield/plant g	Grain yield/feddan kg
Cultivars	Zinc levels			
Giza 2	0.0%	40.03d	149.08f	2940f
	0.3%	40.53b	159.86cd	3165cd
	0.6%	38.69e	157.06cde	3099cde
T.W.C.310	0.0%	40.13c	187.25b	3705b
	0.3%	42.42a	192.03ab	3801ab
	0.6%	42.46a	195.25a	3867a
Karnak	0.0%	37.25h	155.81de	3054d-f
	0.3%	37.65g	162.53c	3192c
	0.6%	38.25f	152.03ef	2994ef

Table 17: Number of grains/row as affected by the interaction of water stress, cultivars and zinc sulphate in combined analysis over the three seasons.

Characters		Number of grains/row		
Water stress	Cultivars	Zinc sulphate concentration		
		0.0	0.3%	0.6%
40% ASMD	Giza 2	41.83d-h	43.06d	42.38def
	T.W.C.310	48.69ab	48.76ab	49.63a
	Karnak	42.62de	43.08cd	42.21d-g
60% ASMD	Giza 2	41.95d-h	42.28def	41.70d-i
	T.W.C.310	48.61ab	49.54a	48.39ab
	Karnak	42.50def	42.40def	41.08d-i
80% ASMD	Giza 2	40.68e-i	40.25ghi	40.00hi
	T.W.C.310	47.18b	47.98ab	48.54ab
	Karnak	39.75i	40.02hi	40.58f-i

ASMD = Available soil moisture depletion.

III. Chemical Composition

1. Crude protein percentage and protein yield/feddan:

A. Effect of water stress:

Results in Table (18) indicates that crude protein percentage in grains of maize was increased by increasing depletion of available soil moisture from 40 to 80%.

The above mentioned results can be explained by the report of Kramer (1978) who concluded that in stressed plants there was a rapid drop in water content and a small increase in protein, possibly due to the continued synthesis of RNA. During stress there was a hydrolysis of protein. Finally, an apparent increase in protein occurred, although this may have been an increase in peptides rather than protein. These results are in harmony with those obtained by Metwally (1977), El-Nomany (1978), Gomaa (1981), Harder *et al.* (1982), Ainer (1983), Salwau (1985), Rizk *et al.* (1987) and Meleha (1992).

On the other hand, irrigation after 40% soil moisture depletion produced the highest significant mean value of protein yield kg/feddan (324 kg) in the combined analysis over the three seasons. The lowest mean value was 265 kg/feddan, obtained from irrigation after 80% depletion in available soil moisture.

These results may be due to the increase in maize grain yield, resulted from irrigation after 40% soil moisture depletion. These results are in full agreement with those obtained by Abd El-Raouf (1973) and Salwau (1985).

B. Varietal differences:

Karnak cultivar was superior than Giza 2 in crude protein percentage of maize grains, while T.W.C.310 cultivar ranked the second in this trait (Table 18). The superiority of Karnak cultivar may be due to genetical constituents. These results are similar to those obtained by El-Nomany (1978), Gomaa (1981), Ainer (1983), Bedeer (1984) and El-Hattab *et al.* (1986). They reported that crude protein content in grains of hybrid cultivars produced higher than that of open-pollinated cultivars.

T.W.C.310 cultivar significantly surpassed Karnak and Giza 2 cultivars in protein yield kg/feddan in the combined analysis over the three seasons. These results may be due to the increase in grain yield/feddan of T.W.C.310 cultivar.

C. Effect of zinc levels:

The average values of crude protein content in maize grains increased by application zinc sulphate as compared without application. The highest mean value of crude protein was 9.25%, obtained from application zinc sulphate at 0.3% as foliar (Table 18).

The differences between the mean values of protein yield kg/feddan was significantly affected by foliar application of zinc sulphate. The highest value was 311 kg/feddan, obtained from application zinc sulphate at 0.3%.

These results may be due to the increase in grain yield/feddan and protein contents. In this connection, Vallee and Wacker (1970), reported that zinc functions in plants are largely associated with enzymes. It plays an important role in protein synthesis from amino acids and decarboxylation of pyrouvate.

The same results were reported by Younis (1979), Baza (1981), El-Beshbeshy (1983), Bedeer (1984), Abd El-Aziz *et al.* (1986), El-Sayed *et al.* (1986), Kamel *et al.* (1986), Badr (1987), and Kabesh *et al.* (1988).

2. Oil percentage and oil yield/feddan:

The average values of oil percentage and oil yield kg/feddan as affected by water stress, maize cultivars and zinc levels are shown in Table (18).

A. Effect of water stress:

The average value of oil percentage in maize grains decreased by increasing depletion of soil moisture from 40 to 80%. Irrigation after 40% soil moisture depletion gave the highest mean value of oil percentage (5.70%). These results emphasize that the oil percentage of maize grains increased as irrigation intervals reduced.

The previous results may be due to the accumulation of fat during the development of storage organs (grains). This accumulation is probably due to the transformation of sugar to fat in the grain itself. Moreover, reducing irrigation intervals enhanced carbohydrate accumulation, which in turn increased grain oil percentage. In this respect, Kramer (1978) reported that water stress caused a considerable reduction in the organic compounds translocation in the plants. These results are in harmony with those obtained by Metwally (1977), Gomaa (1981), Ainer (1983), Khedr (1986), Rizk *et al.* (1987) and Meleha (1992).

The differences between the mean values of oil yield kg/feddan was significant due to irrigation treatments in combined analysis over the three seasons. The highest mean value was 214.8 kg/feddan, obtained from irrigation after 40% soil moisture depletion. Whereas, the lowest one was 140.7 kg/feddan, obtained from exposing plants to 80% soil moisture depletion.

These results may be due to the high grain yield and maximum oil percentage, resulted from irrigation at 40% soil moisture depletion. These results are in full agreement with those obtained by Abd El-Raouf (1973) and Salwau (1985) who reported that oil expressed in kg/feddan were increased by frequent irrigation.

B. Varietal differences:

It was clear from Table (18) that Karnak cultivar gave the highest oil percentage in grains, while Giza 2 cultivar had the lowest one. These differences between cultivars under study may be due to genetical constituents. These results are similar with those obtained by Gomaa (1981), Ainer (1983), Salwau (1985) and kamel *et al.* (1986).

There was a highly significant difference between the three maize cultivars on the mean values of oil yield kg/feddan in the combined analysis over the three seasons. T.W.C.310 cultivar gave the highest mean value 209.1 kg. Whereas, Giza 2 cultivar had the lowest one 158.7 kg. The increase in oil yield kg/feddan of T.W.C.310 cultivar may be mainly due to the increase in grain yield kg/feddan.

C. Effect of zinc levels:

The average values of oil percentage in maize grains increased by increasing level of zinc sulphate as foliar application up to 0.3%. These results may be due to the importance of zinc for the biochemical reactions in many plants and its action as a coenzyme in some biologically important enzymes in most plants. In this respect, Vallee and Wacker (1970) and Amberger (1974) stated that zinc is an essential component of some enzymes and DNA polymerase, which require zinc for their activity. The same trend was obtained by Kamel *et al.* (1986) and Kabesh *et al.* (1988).

The average values of oil yield kg/feddan significantly increased by increasing the level of zinc sulphate as foliar up to 0.3% in the combined analysis between the three seasons. These results may be due to the increase in grain yield/feddar and oil contents.

3. Zinc content in grains:

A. Effect of water stress:

The results in Table (18) indicate clearly that the average values of zinc content in maize grains was decreased by increasing soil moisture depletion in combined analysis over the three seasons. The highest mean value of zinc content was 40.78 ppm, obtained from irrigation after 40% soil moisture depletion. While, the lowest one was 38.81 ppm, obtained from exposing maize plants to 80% soil moisture depletion. These results may be due to the relationship between zinc element absorption as well as translocation and the water deficit.

B. Varietal differences:

Data presented in Table (18) show that T.W.C.310 cultivar gave the maximum content of zinc in grains 40.76 ppm. Whereas, the minimum content was 39.33 ppm, obtained from Giza 2

Table 18: The average values of crude protein %, protein yield kg/feddan, oil percentage, oil yield kg/feddan and zinc content in maize grains (ppm) as affected by water stress, maize cultivars and foliar application of zinc sulphate in combined analysis over the three seasons.

Characters / Treatments	Crude protein %	Protein yield kg/fed.	Oil %	Oil yield kg/fed.	Zn content in maize grains (ppm)
Water stress					
40% ASMD 60% ASMD 80% ASMD	8.58 9.20 9.51	324a 309b 265c	5.70 5.46 5.04	214.8a 183.9b 140.7c	40.78 40.09 38.81
Irrigation x years		N.S.		N.S.	
Cultivars					
Giza 2 T.W.C.310 Karnak	8.88 9.15 9.26	270c 345a 282b	5.13 5.50 5.57	158.7c 209.1a 171.9b	39.33 40.76 39.58
Cultivars x years		**		**	
Zinc levels					
0.0% 0.3% 0.6%	8.87 9.25 9.16	285c 311a 303b	5.27 5.49 5.44	171.3c 187.2a 181.2b	37.86 40.70 41.12
Zinc x years		**		**	
Interactions					
Ir.x C. Ir.x C.x Y Zn x Ir. Zn x Ir.x Y Zn x C. Zn x C.x Y Zn x C.x Ir Zn x C.xIr.x Y		N.S. N.S. * ** ** ** ** N.S.		** N.S. *. ** ** ** ** N.S.	

Ir. = Irrigation
C. = Cultivars.
Y = Years.
ASMD = Available soil moisture depletion

cultivar. The differences between maize cultivars were mainly due to genetical constituents.

C. Effect of zinc levels:

The average values of zinc content in maize grains was increased by increasing level of zinc sulphate as foliar application up to 0.6%. The highest mean value was 41.12 ppm, obtained from applied 0.6% zinc sulphate. Similar trend was reported by Awad (1976), El-Beshbeshy (1983), Abd El-Aziz *et al.* (1986) and Badr (1987).

D. Effect of the interactions:

i. Interaction effect between water stress and cultivars:

The effect of the interaction between water stress and maize cultivars was significant on the average values of oil yield kg/feddan in the combined analysis over the three seasons as presented in Table (19).

It is obviously clear that the maximum mean value of oil yield/feddan was 243.58 kg, obtained from irrigation after 40% soil moisture depletion with T.W.C.310 cultivar. Whereas, the minimum one was 129.33 kg/feddan, obtained when irrigation after 80% soil moisture depletion with Karnak cultivar. On the other hand, the average values of protein yield/feddan was not significant as affected by the interaction between water stress and maize cultivars.

ii. <u>Interaction effect between water stress and zinc levels:</u>

There was a significant difference of the average values of protein yield and oil/feddan in the combined analysis due to the interaction between water stress and zinc levels as shown in Table (20).

The highest values of protein and oil yield/feddan were 342 kg and 225.83 kg/feddan, respectively, obtained from exposing plants to 40% soil moisture depletion and applied 0.3% zinc sulphate as foliar. On the other hand, the lowest ones were 254 kg and 131.17 kg/feddan, respectively, obtained from irrigation after 80% soil moisture depletion without application of zinc sulphate.

The interaction between water stress, zinc sulphate and years were significant on the average values of protein yield and oil yield/feddan. These results may be due to meteorological factors between years.

iii. <u>Interaction effect between maize cultivars and zinc levels:</u>

The data illustrated in Table (21) show that the average values of protein and oil yield kg/feddan were significantly affected by the interaction between maize cultivars and zinc levels in the combined analysis over the three seasons.

Table 19: Oil yield kg/feddan as affected by the interaction of water stress and maize cultivars in the combined analysis over the three seasons.

Character / Water stress	Oil yield kg/feddan		
	Cultivars		
	Giza 2	T.W.C.310	Karnak
40% ASMD	195.42d	243.58a	205.67c
60% ASMD	157.75g	213.67b	180.67e
80% ASMD	122.67i	170.25f	129.33h

ASMD: Available soil moisture depletion.

Table 20: The average values of protein yield and oil yield kg/feddan as affected by the interaction of water stress and zinc sulphate in the combined analysis of 1988, 1989 and 1990 seasons.

Characters / Water stress	Protein yield kg/feddan			Oil yield kg/feddan		
	Zinc sulphate concentration					
	0.0%	0.3%	0.6%	0.0%	0.3%	0.6%
40% ASMD	303e	342a	329b	202.99c	225.83a	215.83b
60% ASMD	299f	322c	309d	180.08f	188.08d	183.92e
80% ASMD	254i	270h	271g	131.17i	147.33g	143.75h

ASMD : Available soil moisture depletion.

Table 21: The average values of protein yield and oil yield kg/feddan as affected by the interaction of maize cultivars and zinc sulphate in the combined analysis over the three seasons.

Characters / cultivars	Protein yield kg/feddan			Oil yield kg/feddan		
	Zinc sulphate concentration					
	0.0%	0.3%	0.6%	0.0%	0.3%	0.6%
Giza 2	255i	329c	272g	143.75i	198.92c	171.58e
T.W.C.310	287e	346b	301d	168.83g	218.25a	174.17d
Karnak	270h	362a	278f	163.25h	210.33b	169.92f

It is clear that the maximum mean value of protein yield/feddan was 362 kg, obtained from Karnak cultivar with applied zinc sulphate at 0.3%. Also, the maximum mean value of oil yield/feddan was 218.25 kg, obtained from T.W.C.310 cultivar with applied 0.3% zinc sulphate as foliar application. Whereas, the minimum mean values of protein and oil yield/feddan were 255 kg and 143.75 kg/feddan, obtained from Giza 2 cultivar without application of zinc sulphate.

The interaction between maize cultivars, zinc sulphate and years were significant on the average values of protein yield and oil yield/feddan. These results may be due to meteorological factors between years.

iv. <u>Interaction effect between water stress, maize cultivars and zinc levels:</u>

The data presented in Table (22) show that the average values of protein and oil yield/feddan were significantly affected by the interaction between water stress, maize cultivar and zinc levels in the combined analysis of 1988, 1989 and 1990 seasons.

The interaction between irrigation after 40% available soil moisture depletion with T.W.C.310 and applied 0.6% zinc sulphate as foliar gave the highest mean values of protein yield and oil yield/feddan (395.25 kg and 262.75 kg), respectively. On the other hand, the minimum mean value of protein yield/feddan was 224 kg, obtained from exposing plants to 80% soil moisture depletion with Karnak cultivar and without application of zinc sulphate. Also, the lowest mean value of oil yield/feddan was 99.00 kg, obtained from irrigation after 80% soil moisture depletion with Giza 2 cultivar and without application of zinc sulphate.

The interaction between maize cultivars and years as well as between zinc sulphate and years were significant on the average values of protein yield and oil yield/feddan (Table 18). These results may be due to meteorological factors between years.

Table 22: The average values of protein yield and oil yield kg/feddan as affected by the interaction of water stress, maize cultivars and zinc sulphate in the combined analysis over the three seasons.

Characters		Protein yield kg/feddan			Oil yield kg/feddan		
Water stress	Cultivars	Zinc sulphate concentration					
		0.0%	0.3%	0.6%	0.0%	0.3%	0.6%
40% ASMD	Giza 2	268.50	312.75	299.25	183.25	204.50	198.50
	T.W.C.310	243.50	366.50	395.25	208.75	259.25	262.75
	Karnak	297.00	345.50	293.25	217.00	213.75	186.25
60% ASMD	Giza 2	271.50	304.25	273.50	149.00	162.75	161.50
	T.W.C.310	332.75	355.50	360.00	224.00	217.50	199.50
	Karnak	294.25	307.00	292.75	167.25	184.00	190.75
80% ASMD	Giza 2	227.50	244.25	236.75	99.00	139.25	129.75
	T.W.C.310	310.25	315.00	329.50	164.00	178.00	168.75
	Karnak	224.00	252.00	247.00	130.50	124.75	132.75
L.S.D. at 5%		12.0			6.0		
at 1%		15.0			9.0		

ASMD: Available soil moisture depletion.

Table 23: Seasonal consumptive use (cm) and its rate cm/day for maize as affected by water stress, maize cultivars and foliar application of zinc sulphate over the three seasons.

Water stress		40% ASMD				60% ASMD				80% ASMD				Total mean cm
Seasons	Cultivars	Zinc sulphate concentration												
		0.0%	0.3%	0.6%	Mean	0.0%	0.3%	0.6%	Mean	0.0%	0.3%	0.6%	Mean	
1988	Giza 2	63.23	63.92	64.70	63.95	57.06	57.19	57.39	57.21	48.38	48.55	48.73	48.55	56.57
	T.W.C.310	64.15	64.67	64.28	64.37	57.50	57.79	57.62	57.64	48.17	48.68	48.53	48.46	56.82
	Karnak	63.55	64.17	64.01	63.91	57.57	57.31	57.48	57.45	48.10	48.25	48.36	48.24	56.53
1989	Giza 2	64.52	64.58	64.45	64.52	58.52	58.67	58.62	58.60	49.27	49.16	49.09	49.17	57.43
	T.W.C.310	64.55	64.67	65.34	64.85	58.36	58.34	58.57	58.42	49.42	49.24	49.30	49.32	57.53
	Karnak	64.78	64.83	64.54	64.72	57.62	58.29	58.37	58.09	49.18	49.08	49.11	49.12	57.31
1990	Giza 2	64.24	64.45	64.36	64.35	58.95	58.89	59.13	58.99	49.64	49.56	49.50	49.57	57.64
	T.W.C.310	65.16	64.77	64.75	64.89	58.59	58.45	58.90	58.65	49.90	49.51	50.12	49.84	57.79
	Karnak	64.12	64.25	64.69	64.35	58.23	58.41	58.30	58.31	49.79	49.96	49.66	49.80	57.49
Total mean cm		64.25	64.48	64.57	64.43	58.04	58.15	58.26	58.15	49.09	49.11	49.16	49.12	57.23
Seasonal consumptive use rate cm/day		0.53	0.53	0.53	0.53	0.48	0.48	0.48	0.48	0.41	0.41	0.41	0.41	
No. of irrigation		10	10	10	10	6	6	6	6	4	4	4	4	

ASMD : Available soil moisture depletion.

in between. This trend shows that the increment in water consumptive depends on the availability of soil moisture in the root zone. In other words, when soil was kept wet by frequent irrigations, higher seasonal consumptive use was obtained. These findings resulted in ascribed to high availability of soil moisture to the plants as well as high evaporation opportunity from a wet rather than a dry condition.

In this respect, Doorenbos and Pruitt (1977) gave an extensive explanation of the effect of available soil water on evapotranspiration, they stated that after irrigation or rain, the soil water content will be reduced primarily by evapotranspiration. As the soil dries, the rate of water transmitted through the soil will reduce. The effect of soil water content on evapotranspiration varies with crop and soil type, as well as water holding characteristics.

Regarding to maize cultivars and zinc application, it is clear that there was a slight inconsistent affect on the values of consumptive use. So, it could be seen that maize cultivars and zinc application had no obvious effect on this trait.

The average values of seasonal consumptive use rate in cm/day for maize during the three seasons were 0.53, 0.48 and 0.41 cm/day under the different irrigation treatments equal to

40%, 60% and 80% depletion in available water. It was observed that irrigation levels exhibited the large difference in consumptive use rate.

Regards to maize cultivars and zinc application, the average value for both was 0.47 cm/day.

It is clear that the availability of soil moisture is the most effective factor influencing seasonal consumptive use rate cm/day.

The previous results are in full agreement with those obtained by Downey (1971), Ibrahim (1974), Metwally (1977), Ainer (1983), Jana and Puste (1985), El-Refaie *et al.* (1988), Nissen *et al.* (1988) and Meleha (1992). They mentioned that more frequent irrigations provided a chance for more luxuriant use of soil moisture, which ultimately resulted in increasing transpiration.

B. <u>Daily rates:</u>

The daily water consumptive use by maize as a function of soil moisture stress, maize cultivars and foliar application of zinc sulphate is presented in Tables (24, 25 and 26) and Figure (1).

Results indicated that the daily consumptive use started with small value at initial stage because soil moisture loss is only by evaporation from the time of seed sowing until plants emerge. Then, transpiration ensues and the daily consumptive use increase as plant foliage develops. Soil moisture depletion in this phase is due to both evaporation and transpiration. The daily consumptive use reaches its peak value in the middle of the growing season, which consider the critical period in the demand of water by maize. Then, it declines at the end of the growing season as the crop becomes mature and the consumptive use losses are due to evaporation from soil surface only.

The average values of the daily consumptive use in the three growing seasons at the initial, mid season and full maturity were 0.34, 0.70 and 0.39 cm/day, respectively when irrigated at 40% soil moisture depletion. The corresponding values were 0.34, 0.43 and 0.35 cm/day when watering at 80% depletion in available water.

Regarding to the effect of maize cultivars and zinc sulphate it could be seen that they had no obvious effect upon daily rates.

It is clear that the daily water used reached maximum value at pollination stage because the maize needs largest quantities of water in this period and this in turn affected the generative parts which are the basis of the yield. The

Table 24: Daily consumptive use in cm as affected by foliar application of zinc sulphate and maize cultivars at 40% available soil moisture depletion (comined three seasons 1988, 1989 and 1990).

Cultivars / Months	Giza 2				T.W.C.310				Karnak				Total mean cm/day
	Zinc sulphate concentration												
	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	
June	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
July	0.41	0.41	0.41	0.41	0.41	0.41	0.42	0.41	0.42	0.42	0.42	0.42	0.41
Aug.	0.70	0.70	0.70	0.70	0.70	0.70	0.71	0.70	0.70	0.71	0.70	0.70	0.70
Sept.	0.61	0.62	0.61	0.62	0.62	0.62	0.62	0.62	0.61	0.61	0.61	0.61	0.62
Oct.	0.38	0.39	0.39	0.39	0.40	0.40	0.40	0.40	0.39	0.39	0.39	0.39	0.39

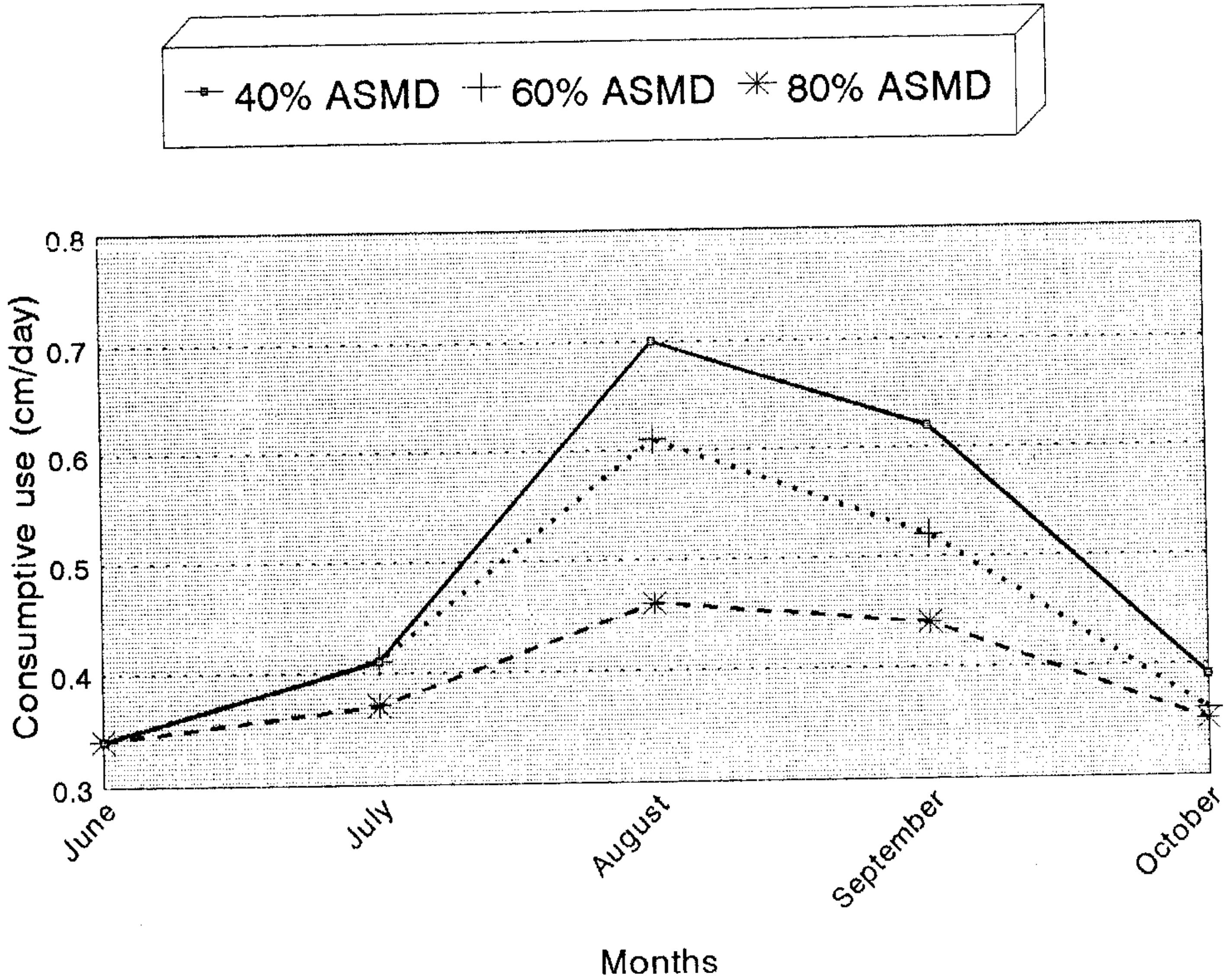
Table 25: Daily consumptive use in cm as affected by foliar application of zinc sulphate and maize cultivars at 60% available soil moisture depletion (combined three seasons 1988, 1989 and 1990).

Cultivars / Months	Giza 2				T.W.C.310				Karnak				Total mean cm/day
	Zinc sulphate concentration												
	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	
June	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
July	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
Aug.	0.62	0.62	0.62	0.62	0.61	0.61	0.62	0.61	0.61	0.61	0.62	0.62	0.61
Sept.	0.53	0.53	0.53	0.53	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
Oct.	0.35	0.36	0.36	0.36	0.38	0.37	0.37	0.37	0.36	0.37	0.36	0.36	0.36

Table 26: Daily consumptive use in cm as affected by foliar application of zinc sulphate and maize cultivars at 80% available soil moisture depletion (combined three seasons 1988, 1989 and 1990).

Cultivars / Months	Giza 2				T.W.C.310				Karnak				Total mean cm/day
	Zinc sulphate concentration												
	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	
June	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
July	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Aug.	0.47	0.46	0.46	0.46	0.46	0.46	0.47	0.46	0.46	0.46	0.46	0.46	0.46
Sept.	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Oct.	0.35	0.35	0.35	0.35	0.35	0.35	0.34	0.34	0.34	0.35	0.35	0.35	0.35

Fig. 1:Daily consumptive use cm/day as affected by water stress as the combined between the three growing seasons



daily consumptive use affected by moisture content, climatic conditions and growth stage of plants.

These results are in accordance with those reported by Ainer (1983), Jana and Puste (1985), El-Sabbagh (1988) and Meleha (1992), who found that daily water use has the same direction with the available soil moisture.

In this respect, Lemon *et al.* (1959) reported that the gradual increase in evapotranspiration from planting to the maturity can be explained on the basis of percent cover. The decrease in evapotranspiration, after maturation is probably resulted from the plant development factor. However, in many studies the soil water is not maintained at a high level condition after maturation.

C. <u>Monthly rates:</u>

Monthly consumptive use by maize under the different treatments is illustrated in Tables (27, 28 and 29). The average values of the monthly consumptive use for maize in the three seasons were 0.79, 12.83, 21.77, 18.43 and 10.61 cm for the months June, July, August, September and October, respectively when irrigation was practiced at 40% available soil moisture depletion. The corresponding values were 0.79, 11.45, 14.32, 13.19 and 9.37 cm when watering was at 80% soil moisture depletion. The results indicate that the higher monthly values of evapotranspiration were recorded during

August and September which represent the period of maximum demand for water by maize. This trend was found to be true in the various treatments. Such trend could be explained on percent cover basis.

The previous results are in harmony with those reported by Metwally (1977), Ainer (1983), Ali (1984), el-Refaie *et al.* (1988) and Meleha (1992).

Finally, it could be concluded that:

1. Seasonal consumptive use amounts increased as the availability of soil moisture increased in the root zone. The highest values of consumptive use was 64.43 cm when plants were irrigated at 40% depletion in available water, while the lowest one was 49.12 cm when watering at 80% soil moisture depletion.
2. Maize cultivars and zinc application had no obvious effect on water consumptive use.
3. The highest value of seasonal consumptive use rate was 0.53 cm/day accompanied by irrigation at 40% depletion in available water, while the lowest value was 0.41 cm/day related to irrigation at 80% soil moisture depletion.
4. The daily consumptive use increased gradually as plant growth increased and reached its maximum at about silking and seed formation.
5. Monthly consumptive use reached its maximum values during August when sowing in June.

Table 27: Monthly consumptive use in cm as affected by foliar application of zinc sulphate and maize cultivars at 40% available soil moisture depletion (combined three seasons, 1988, 1989 and 1990).

Cultivars / Months	Giza 2				T.W.C.310				Karnak				Total mean cm
	Zinc sulphate concentration												
	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	
June	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
July	12.78	12.74	12.82	12.78	12.81	12.78	12.85	12.81	12.92	12.95	12.86	12.91	12.83
Aug.	21.82	21.68	21.82	21.77	21.69	21.70	21.90	21.76	21.59	21.93	21.82	21.78	21.77
Sept.	18.34	18.46	18.42	18.41	18.48	18.64	18.47	18.53	18.37	18.36	18.35	18.36	18.43
Oct.	10.27	10.64	10.65	10.52	10.85	10.80	10.78	10.81	10.49	10.40	10.59	10.49	10.61
Total cm	64.00	64.31	64.50	64.27	64.62	64.71	64.79	64.70	64.16	64.43	64.41	64.33	64.43

Table 28: Monthly consumptive use in cm as affected by foliar application of zinc sulphate and maize cultivars at 60% available soil moisture depletion (combined three seasons, 1988, 1989 and 1990).

Cultivars / Months	Giza 2				T.W.C.310				Karnak				Total mean cm
	Zinc sulphate concentration												
	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	
June	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
July	12.72	12.72	12.80	12.75	12.61	12.71	12.71	12.68	12.69	12.70	12.70	12.69	12.71
Aug.	19.21	19.20	19.31	19.24	18.83	19.03	19.17	19.01	18.92	18.92	19.24	19.03	19.09
Sept.	16.00	15.88	15.86	15.91	15.58	15.60	15.72	15.63	15.73	15.71	15.72	15.72	15.75
Oct.	9.46	9.67	9.60	9.58	10.34	10.07	9.98	10.13	9.69	9.88	9.59	9.72	9.81
Total cm	58.18	58.26	58.36	58.27	58.15	58.20	58.37	58.24	57.82	58.00	58.04	57.95	58.15

Table 29: Monthly consumptive use in cm as affected by foliar application of zinc sulphate and maize cultivars at 80% available soil moisture depletion (combined three seasons, 1988, 1989 and 1990).

Cultivars / Months	Giza 2				T.W.C.310				Karnak				Total mean cm
	Zinc sulphate concentration												
	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	
June	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
July	11.46	11.46	11.46	11.46	11.44	11.45	11.46	11.45	11.46	11.43	11.46	11.45	11.45
Aug.	14.40	14.24	14.39	14.34	14.34	14.27	14.22	14.28	14.30	14.27	14.46	14.34	14.32
Sept.	13.04	13.13	13.09	13.09	13.04	13.26	13.28	13.19	13.27	13.30	13.26	13.28	13.19
Oct.	9.41	9.47	9.38	9.42	9.55	9.38	9.56	9.50	9.21	9.31	9.09	9.20	9.37
Total cm	49.10	49.09	49.11	49.10	49.16	49.15	49.31	49.21	49.03	49.10	49.06	49.06	49.12

2. Water use and yield relationship:

It has been mentioned previously that soil moisture levels comprise the main constrain in maize production. Thus, it seems advisable to find out the relationship between actual consumptive use and maize grain yield. Chang (1971) concluded that when the actual evapotranspiration falls short of the potential, the actual yield will also be less than the maximum.

Therefore, it is possible to correlate the yield of maize in each soil moisture levels with actual water consumed by the crop. Linear regression has generally proved to give the best description of crop to water use. The relation between consumptive use in cm (X) and maize grain yield kg/feddan (Y) for all soil moisture stress was linear and could be described by the following linear equation:

$$\hat{Y} = \bar{Y} + b\,(X-\bar{x})$$

Where:

$\hat{Y}$: Predicted maize yield in kg.

$\bar{Y}$: Observed mean yield.

X : Seasonal consumptive use of maize in cm.

b : The linear regression coefficient.

$\bar{x}$: Mean consumptive use of maize in cm.

The association between response of yield and seasonal consumptive use of maize used to illustrate the simple linear regression analysis as follows:

$$\hat{Y} : -420.68 + 65.24\,x$$

The correlation coefficient for the two variables was significant positive and equal (0.999).

Thus, the results indicates the goodness of a prescribed relationship to the two variables. The linear coefficient value (by.X) was significant and equal to (65.24 kg/feddan). Thus, increasing one unit (cm) of seasonal consumptive use of maize increased 65.24 kg of grain yield/feddan.

3. Water uptake by maize roots:

Data of soil moisture extraction percentage in the soil layers are listed in Table (30) and illustrated in Figure (2). The data reveals that most of the consumed water by maize was removed from the surface soil layer. The highest percentage of moisture uptake occurred at the surface 15 cm of the soil profile. Less water was extracted from the successive depths. The moisture extraction pattern was similar for all different irrigation levels in the three growing seasons.

For the upper 30 cm soil layer the average percentage values of water extracted by maize roots in the three seasons were 83.33%, 76.54% and 73.56% when irrigation was practiced at 40%, 60% and 80% soil moisture depletion, respectively. While the respective values were 16.67, 23.46% and 26.44% withdrawn from the lower 30-60 cm.

These values indicate that when the soil is kept wet as adopted in 40% depletion in available water, more water is extracted from the upper 30 cm soil depth. Whereas, increasing soil moisture stress as adopted in 80% soil moisture depletion, plants tended to extract more water from lower 30-60 cm in spite of less root distribution at the lower layers of the soil and more energy must be required for extraction.

In this respect, Israelson and Hansen (1962) reported that, in arid regions, more water was extracted from the first foot of soil, whenever it is kept moist by frequent irrigations.

Regarding to the effect of maize cultivars and zinc application on water uptake from different layers of soil profile, The results show no effect of such factors in the removal of moisture and the values were about the same.

From the previous results, it could be concluded that about of 83.00% of the storage water used by maize was obtained from the upper foot and about 17.00% from the second foot when maize irrigated at 40% depletion in available water.

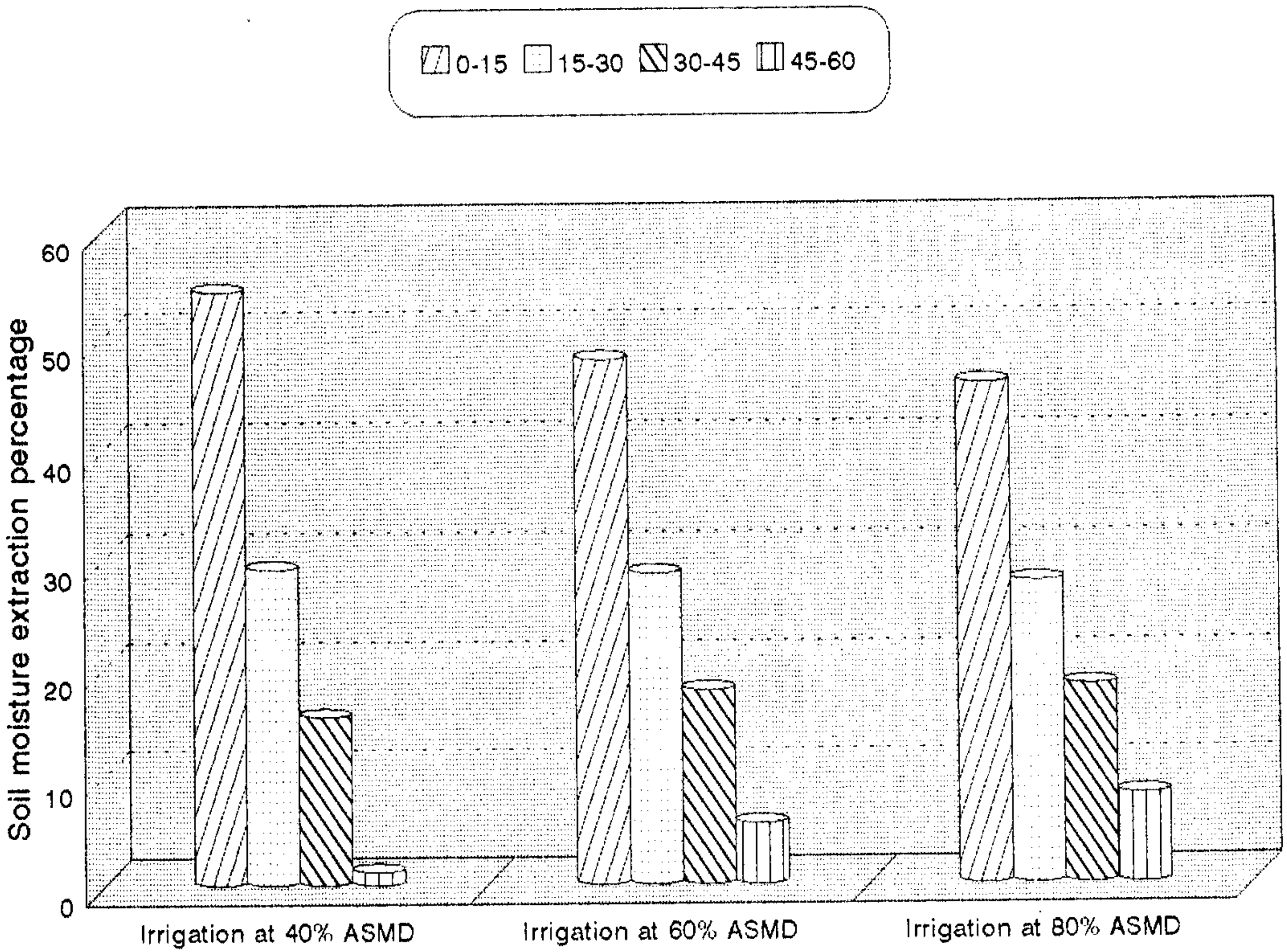
Drought stress i.e. 80% soil moisture depletion reduce the rate of moisture extraction in the upper soil layer to about 74.00%, while more moisture was extracted from lower soil depths (26.00%).

Table 30: Percentages of soil moisture extraction by maize roots from different soil layers as affected by water stress, maize cultivars and foliar application of zinc sulphate (combined three seasons, 1988, 1989 and 990).

Cultivars		Giza 2				T.W.C.310				Karnak				Total mean
Water stress	Depth cm	Zinc sulphate concentration												
		0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	
40% ASMD	0-15	54.87	53.80	53.59	54.08	53.38	55.50	53.81	54.23	54.32	54.91	53.99	54.41	54.24
	15-30	29.06	29.43	28.92	29.14	29.40	28.53	29.07	29.00	29.29	29.09	29.01	29.13	29.09
	30-45	15.07	15.63	16.24	15.65	15.75	14.95	15.80	15.50	15.32	15.16	15.61	15.36	15.50
	45-60	1.00	1.14	1.25	1.13	1.47	1.02	1.33	1.27	1.07	0.84	1.39	1.10	1.17
60% ASMD	0-15	47.56	47.79	47.87	47.74	47.56	47.76	48.05	47.79	47.83	47.73	49.35	48.30	47.94
	15-30	28.58	28.96	28.34	28.63	28.83	28.60	28.50	28.64	28.75	28.47	28.38	28.53	28.60
	30-45	17.71	18.31	18.09	18.03	17.71	18.10	18.25	18.02	17.89	18.19	17.01	17.70	17.92
	45-60	6.15	4.94	5.70	5.60	5.90	5.54	5.20	5.55	5.53	5.61	5.26	5.47	5.54
80% ASMD	0-15	45.36	45.67	45.69	45.57	45.97	45.55	44.80	45.44	46.26	46.30	46.09	46.22	45.74
	15-30	28.12	27.71	28.21	28.01	26.82	27.77	28.42	27.67	27.62	27.65	28.02	27.76	27.82
	30-45	18.76	18.04	18.12	18.31	18.80	18.14	18.37	18.44	18.24	18.11	18.03	18.13	18.29
	45-60	7.76	8.58	7.98	8.11	8.41	8.54	8.41	8.45	7.88	7.94	7.86	7.89	8.15

ASMD: Available soil moisture depletion.

Fig. 2: Water extracted by maize from each depth of the root-zone for different irrigation levels as the combined between the three growing seasons



These results are in good agreement with those obtained by Ibrahim (1974), Ainer (1983), Jana and Puste (1985), Shaviv and Hagen (1991) and Meleha (1992). They concluded that a relatively high water uptake from the top layers occurred when compared with deep layers, as a result of the concentrated roots in the upper depth.

4. Water use efficiency:

Water use efficiency has been used to evaluate various agronomic practices with respect to water consumptive use. Water use efficiency can be increased by increasing crop production and or by decreasing evapotranspiration. Crop production can be upgrade by the best high yielding cultivars, adaptation to the environment as well as by effective water management, air and nutrient supply to the roots and of both light and CO_2 to the foliage.

Table (31) illustrates the water use efficiency values of grain yield kg/m^3 of consumed water as influenced by soil moisture stress, maize cultivars and foliar application of zinc sulphate.

Soil moisture levels induced a great response on water use efficiency by maize. The highest water use efficiency value was 1.40 kg/m^3 of consumed water scored from the treatment which irrigated at 40% soil moisture depletion followed by the medium level i.e. 60% depletion in available water 1.38 kg/m^3 of consumed water, whereas the least value was 1.35 kg/m^3 of consumed water produced from the dry one i.e. 80% soil moisture depletion.

These results could be attributed to the highly significant differences among the maize grain yield values as well as differences between the consumptive use.

Regarding to maize cultivars the mean values were 1.27, 1.58 and 1.28 kg/m^3 of consumed water for Giza 2, T.W.C.310 and Karnak cultivars, respectively. It is clear the T.W.C.310 cultivar is the highest in water use efficiency among other cultivars.

The mean values of water use efficiency for zinc applied as foliar i.e. 0.0, 0.3% and 0.6% were 1.34, 1.40 and 1.38 kg/m^3 of consumed water, respectively. It is evident that applying zinc sulphate at 0.3% resulted in producing the highest water use efficiency than other concentration due to high yield production.

The previous results are in accordance with those reported by Musick and Dusek (1980), Ainer (1983), Jana and Puste (1985), Miseha *et al.* (1988) and Meleha (1992).

Table 31: Water use efficiency by maize kg/grains/m^3 of water consumed as affected by water stress, maize cultivars and foliar application of zinc sulphate (combined three seasons, 1988, 1989 and 1990).

Water stress / Cultivars	40% ASMD				60% ASMD				80% ASMD				Total mean
	Zinc sulphate concentration												
	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	0.0%	0.3%	0.6%	mean	
Giza 2	1.24	1.34	1.32	1.30	1.23	1.33	1.31	1.29	1.19	1.28	1.22	1.23	1.27
T.W.C.310	1.51	1.62	1.59	1.57	1.52	1.51	1.61	1.55	1.60	1.61	1.63	1.61	1.59
Karnak	1.32	1.40	1.24	1.32	1.30	1.34	1.28	1.31	1.18	1.23	1.21	1.21	1.28
Mean	1.36	1.45	1.38	1.40	1.35	1.39	1.40	1.38	1.32	1.37	1.35	1.35	1.38

ASMD : Available soil moisture depletion.

5. Crop coefficient (Kc):

Amounts of irrigation water can be calculated with the aid of climatological elements. The following two steps can be handled:

1. Determination of potential evapotranspiration (ETp).
2. Estimation of the convenient crop coefficient (Kc) values.

Crop coefficient (Kc) is presented to account for the effect of crop characteristics on crop water requirements. It relates potential evapotranspiration (ETp) to crop consumptive use (C.U.) or to soil moisture depletion (S.M.D.) by crops. Factors affecting the value of the crop coefficient (Kc) are mainly crop characteristics, crop planting or sowing date, rate of crop development, length of growing season, climatic conditions and frequency of irrigation.

Values of crop coefficient (Kc) are listed in Table (32) and illustrated in Figure (3). The values were calculated according to the actual evapotranspiration (ETc) of maize that derived from the treatment which irrigated at 40% soil moisture depletion to potential evapotranspiration (ETp).

In this study, potential evapotranspiration has been estimated by four methods namely modified Penman, Radiation, modified Blaney-Criddle and the class A pan during the growth period of maize. Values of (ETp) are presented in Table (32) and illustrated in Figure (4). The results indicated that estimation of potential evapotranspiration by Blaney-Criddle and the class A Pan methods were lower than those obtained by Penman and Radiation methods. These findings can be attributed to that Blaney Criddle and the class A pan may not be enough to give accurate estimate of evapotranspiration. These results are in full agreement with those obtained by Meleha (1992) who concluded that Blaney-Criddle and the class A pan methods gave lower values of potential evapotranspiration.

The average values of seasonal crop coefficient (Kc) for maize in the three seasons were 0.88, 0.89, 1.07 and 1.12 for Penman, Radiation, Blaney-Criddle and the class A pan methods, respectively.

It is clearly that (Kc) values for Penman and Radiation methods were lower than those obtained by Blaney-Criddle and the class A pan methods. This is mainly due to lower estimated value of potential evapotranspiration obtained by the last two methods. Seasonal (Kc) values calculated by Penman or Radiation methods were similar to the value of (0.75-0.90) recommended by Doorenbos and Pruitt (1977).

Results indicated that crop coefficient (Kc) was reached the least value at earlier stages of growth, then increased gradually and reached its maximum in the mid season since pollination and seed formation, and then decline to reach lower value at maturity.

The previous results had been explained by Jensen (1968) who concluded that seasonal evapotranspiration for most common crops will be less than potential because the soil may be completely bare for some time after sowing and the effective resistance to transpiration increased when the crop started to mature. Burch *et al.* (1978), found that the rate of actual evapotranspiration to the potential evapotranspiration, increased from 0.2 in the early period of the season to about 1.2 at later stages for well watered plants.

It could be concluded that the calculated value of 0.88 for (Kc) could be used in calculating the consumptive use of maize in North Delta area as estimated by the aid of Penman or Radiation methods.

Table 32: Crop coefficient (Kc) and potential evapotranspiration (ETp) mm/day at different months (combined three seasons, 1988, 1989 and 1990).

Months	Actual evapo-transpiration (ETc) mm/day	Potential ET. (ETp) mm/day				Crop coefficient (Kc)			
		Penman	Radiation	Blaney Criddle	Pan evaporation	Penman	Radiation	Blaney Criddle	Pan evaporation
June	3.40	7.88	7.76	6.99	6.61	0.43	0.44	0.49	0.51
July	4.10	6.83	6.38	4.90	5.58	0.60	0.64	0.84	0.74
Aug.	7.00	5.95	5.83	4.55	4.77	1.18	1.20	1.54	1.47
Sep.	6.20	5.15	5.09	4.45	4.01	1.20	1.22	1.39	1.55
Oct.	3.90	3.99	4.02	3.57	2.88	0.98	0.97	1.09	1.35
Seasonal crop coefficient (Kc)						0.88	0.89	1.07	1.12

Fig. 3: Crop coefficient (Kc) of maize during different months of growth

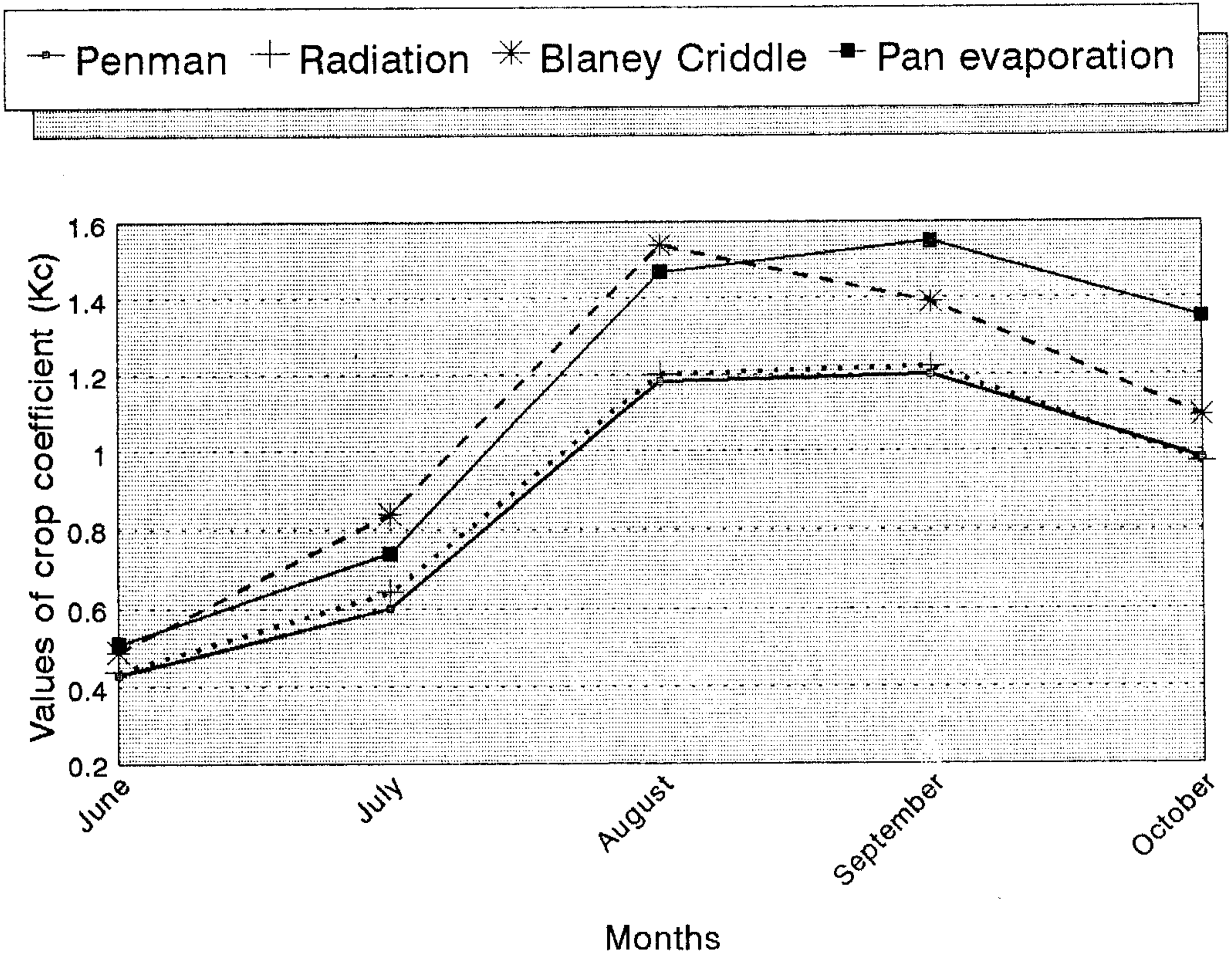
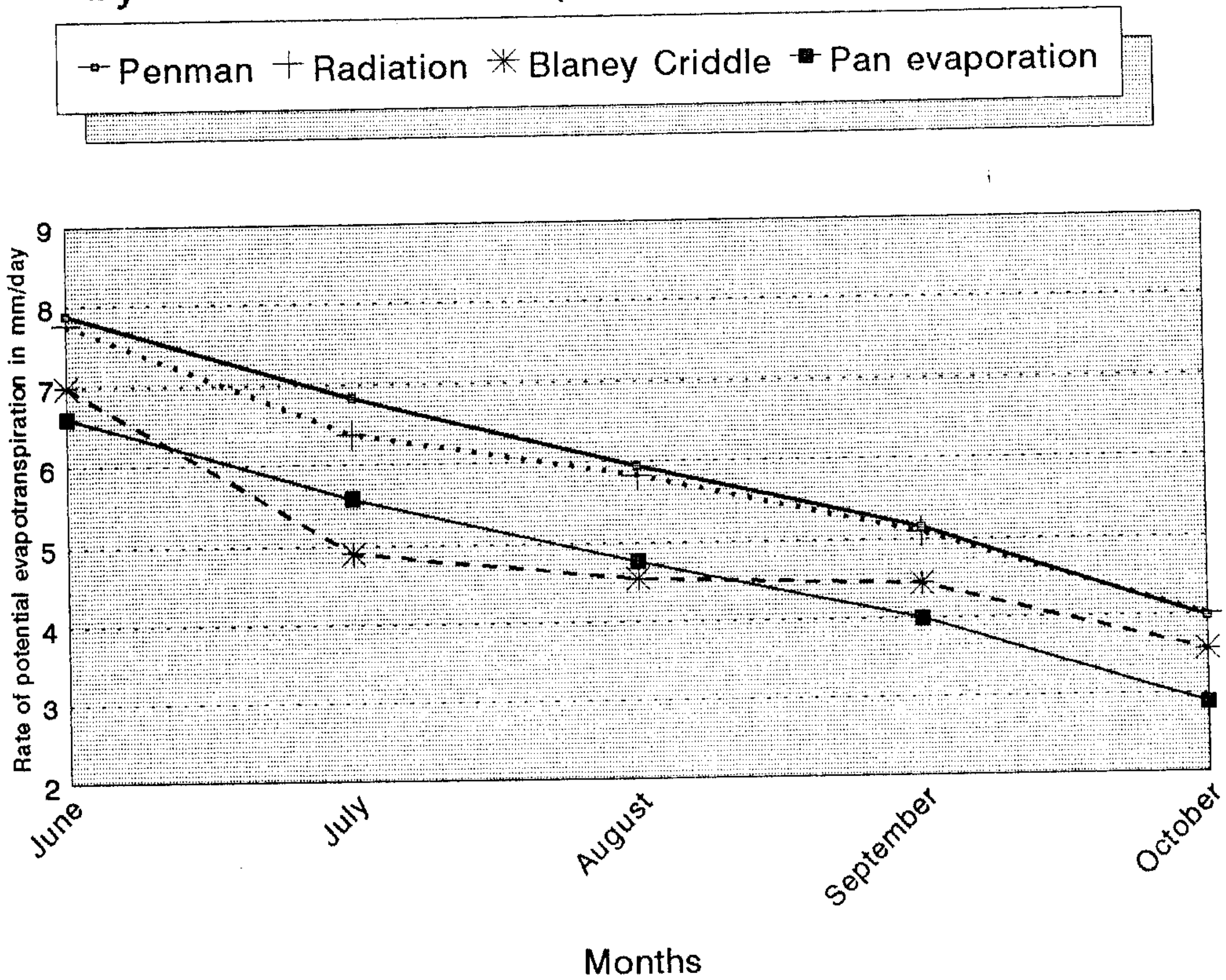


Fig. 4: Potential evapotranspiration (ETp) calculated by different methods (Combined three seasons)



V. Simple phenotypic correlations

The simple correlation coefficient between grain yield/feddan and each of other characters studied were computed over the three growing seasons, (Table 33).

Significant positive correlation values were detected between grain yield/feddan and each of straw yield (ton/feddan), grain yield/plant, plants carry over one ear percentage, 100-grain weight, ear length, ear weight, number of grains/row, plant height, ear height, stem diameter and dry matter/plant, leaf area/plant, leaf area index at 75 days from sowing, crop growth rate, relative growth rate and net assimilation rate. This result indicates that selection for one or more of these characters would be accompanied by high grain yield/feddan. The present results are in agreement with those obtained by Eraky *et al.* (1983) who found that dry weight, leaf area, crop growth rate, plant and ear height were positively correlated with grain yield and its components, i.e. number of grains/row and 100-grain weight. Nawar *et al.* (1984), El-Hosary *et al.* (1989) and Sary *et al.* (1990) found that number of grains/row and 100-grain weight were positive correlated with grain yield. Kuldeep *et al.* (1987) found that yield was positively and significantly correlated with some yield components. Rizk *et al.* (1987) indicated that plant height, leaf area/plant, leaf area index and dry weight/plant was positively associated with the available soil moisture content of irrigation time. Tya Gl *et al.* (1988) indicated that plant height, ear length, number of grains/row and 100-grain weight significantly affected grain yield. Foliar application of zinc had a positive effect on plant growth through its effect on plant metabolism. In this connection, Takaki and Kushizaki (1970) reported that zinc has a possible role in plant metabolism involved in tryptophan and starch formation.

Insignificant positive correlation coefficients were detected between grain yield/feddan and each of chlorophyll a,b, (a+b) and carotenoids indicating that the increasing of these traits had no effects of grain yield/feddan.

Insignificant negative phenotypic correlation coefficient was found between grain yield/feddan and number of days to 50% silking. The same trend was also realized by Eraky *et al.* (1983), Rizk *et al.* (1987), Ali (1985) and Tya Gl *et al.* (1988) who indicated that number of days to 50% silking were negatively correlated with grain yield and its components.

Significant negative phenotypic correlation value was found between grain yield/feddan and late wilt disease percentage. This result indicates that a high grain yield/feddan may be accompanied by a low percentage of late wilt disease. Similar trend was obtained by Kassem *et al.* (1977) and El-Sabbagh (1988).

Table 33: Correlation coefficient values between grain yield kg/feddan and other characters studies in combined analysis over the three growing seasons 1988, 1989 and 1990.

Characters	Grain yield
Straw yield (t/fed.)	0.893**
Grain yield/plant (g)	0.999**
Plants carry over one ear (%)	0.760**
100-grain weight (g)	0.837**
Ear length (cm)	0.817**
Ear weight (g)	0.881**
No. of grains/row	0.786**
Plant height (cm)	0.806**
Ear height (cm)	0.823**
Stem diameter (cm)	0.849**
Dry matter/plant (g) at 75 days from sowing	0.869**
Leaf area/plant (dm^3) at 75 days from sowing	0.804**
Leaf area index at 75 days from sowing	0.806**
Crop growth rate (g/m^2/day)	0.810**
Relative growth rate (mg/g/day)	0.552**
Net assimilation rate (g/m^2/day)	0.571**
Days to 50% silking	-0.276
Chlorophyll a (mg/dm^2 LA)	0.350
Chlorophyll b (mg/dm^2 LA)	0.312
Carotenoids (mg/dm^2 LA)	0.248
Chlorophyll (a+b) (mg/dm^2 LA)	0.370
Late wilt disease %	-0.767**