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ETHEPHON AND ZINC SULPHATE CONCENTRATION INFLUENCE ON GROWTH, YIELD AND ITS COMPONENTS AND CHEMICAL CONSTITUENTS OF MAIZE PLANTS

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ABSTRACT: Two field of experiments were conducted during two successive growth seasons 1997 and 1998 at the Experimental Station of the National Research Centre to study the effect of ethephon and zinc sulphate concentration as well as their combination on vegetative growth, yield and its attributes and some biochemical constituents of maize plants.

The data indicated that spraying ethephon with different concentration led to significant increases in stem diameter at all growth stages while, foliar application of ethephon at concentration 100 g/fed to maize plants caused a significant reduction in vegetative growth characteristics, i.e. plant height, leaf area, leaf area index, specific leaf weight, crop growth rate, and dry weight/plant at the different stages of growth compared with 50 g/fed ethephon. However, increasing concentration of ethephon up to 150 g/fed had no significant effect on number of leaves/plant and net assimilation rate of elongation stage.

chemical constituents of grains, i.e. crude protein, oil percentage and Zn content were increased by increasing foliar application of ethephon up to 150 g/fed., while, total carbohydrate percentage tended to decrease with increasing foliar application of ethephon from 50 to 150 g/fed. Measurements of growth characters (at the different stages of growth) and yield and its attributes as well as chemical constituents significantly responded to foliar application of zinc sulphate. However, the maximum values were obtained with zinc sulphate treatments at 4000 mg/l.

The interaction effect between ethephon and zinc sulphate concentration showed a significant effect on some growth characters and yield components whereas, it caused a significant increase in total dry weight/plant at the different stages of growth, plant height at silky stage, stem diameter at milky ripe stage, specific leaf weight at elongation and silky stages, crop growth rate at silky stage , ear diameter, number of kernels/row, 100-grain weight, grain yield per plant and per feddan, shelling percentage and crude protein, total carbohydrate, oil percentage and Zn content in maize grains

INTRODUCTION

There is considerable interest in the use of ethephon as a plant growth regulator to reduce plant height, lodging and enhance yield for several crops. Ethephon (2-chloroethyl phosphonic acid) is a synthetic plant growth retardant that releases ethylene directly into plant tissues (Warner and Leopold, 1969). Many studies have high lighted the use of ethephon to improve growth, yield and quality (Shang, 1986, on several crops and D' Andria *et al.*, 1997 on corn). Plant growth retardants such as ethephon are currently used successfully on grain crop grown under intensive management practices (such as high N fertilizer rate and greater plant densities) to reduce plant size and to increase yield and its components (Gaska and Oplinger, 1988 and Konsler and Grabau , 1989). Ethylene a naturally occurring plant hormone, is responsible for shortening the internode regions by impeding cell elongation and division (Burg *et al.*, 1971). Also, Bolmquist *et al.*, (1973) found that ethephon increased the activity of several enzymes responsible for lignin production. This suggests that ethephon increases stem strength. Ethephon have been shown to increase photosynthetic parameters of maize leaves, always this was accompanied by a reduction in growth and dry matter production (Gaska and Oplinger, 1988). However, D'Andria *et al.*, (1997) and Al - Jamali *et al.*, (2002) found that increasing ethephon rates caused a significant reduction in LAI, plant height and dry matter accumulation while, yield and its components increased.

The commonly used growth retardants are categorized as gibberellin biosynthesis inhibitors or inhibit the biosynthesis of gibberellin in the plant (Izumi *et al.*, 1984) and limit cell expansion and division in the subapical meristematic zone of the stem (Sachs *et al.*, 1960).

Micronutrients of Zn is required in small amounts, and it is essential for plant metabolism particulary in the plant growth hormones. Maize is considered as one of the more susceptible species for zinc deficiency. Several investigators found the positive effect of zinc application in enhancing the most growth characters and thereby increasing grain yield and its components of maize (Ashoub *et al.*, 1996, El-Sheikh *et al.*, 1999 and Shams, 2000). On this regard, Badr , (1987) sprayed maize plants with three zinc concentration (0 , 0.4 % and 0.8 % $ZnSO_4$). He found that growth characters increased significantly as zinc level increased up to 0.04% Zn SO_4. He added that ear length, ear diameter, 100-grain weight, shelling percentage and grain yield/fed. were increased as zinc sulphate increased up to 0.4 % Zn SO_4. Similar results were obtained by (Allam and El-Naggar, 1992 , El-Sheikh , 1993 and Abo El-Kheir, 2000).

Therefore, the purpose of this study was to investigate the response of maize plants (variety single cross 10) to foliar application with ethephon and zinc at different concentrations as well as their combinations on vegetative growth, yield and biochemical constituents.

MATERIALS AND METHODS

Two field experiments were carried out at the Agricultural Experimental Station, National Research Center at Shalakan, Kalubia Governorate, Egypt during two successive seasons of 1997 and 1998 to study the response of maize plants to foliar application of ethephon and zinc sulphate with different concentrations on growth, yield and its components, as well as chemical constituents. Maize grains (*Zea mays* L.) cv. Single Cross 10 were sown on the 5th and 10th of June after berseem and faba bean in the first and the second seasons, respectively . Each experiment included twelve treatments which were the combination of four concentrations of ethephon (2-chloroethyl phosphonic acid) i.e. 0.0 , 50,100 and 150 g/fed. and three concentrations of zinc sulphate i.e. 0.0 , 2000 and 4000 mg/l Zn SO_4 (Zn SO_4 . $7H_2O$). The plants of 0.0 concentration was sprayed with distilled water (control treatment). The plants were sprayed twice at elongation stage (30 and 50 days after sowing). The experimental design was split-plot with four replications. The main plots assigned to zinc sulphate and the sub-plots devoted to ethephon treatments. Calcium superphosphate (15.5 % P_2O_5) was added pre-sowing at 100 kg/fed. Ammonium nitrate fertilizer (33.5% N) at a rate 120 kg N/fed. was applied in two equal doses, before the first and the second irrigation. Growth characters were measured at elongation stage (60 days after sowing), Silky stage (75 days after sowing) and milky ripe stage (90 days after sowing) where the following characters were determined, i.e., plant height (cm), stem diameter (cm), No. of leaves/ plant, leaf area/plant (dm^2), leaf area index (LAI), total dry weight (g)/plant, specific leaf weight (SLW, mg/cm^2), net assimilation rate NAR ($mg/dm^2/day$) and crop growth rate (CGR g/day) according to (Watson, 1958 and Radford, 1967). At harvest (120 days) ,samples of 10 plants were taken randomly and the following data were taken; ear length and diameter, No. of grains/row, No., of rows/ear, 100-grain weight (g), grain yield per plant (g) and per feddan (ton), harvest index and shelling percentage. Grain samples from all plots were dried at 70 ^{o}C for constant weight and ground to determine the following chemical constituents: total carbohydrate content was determined colorimetrically according to the method described by Dubois et al., (1956), meanwhile crude protein percentage, according to the method of A.O.A.C. (1988) and calculated by multiplying the values of total nitrogen content by 6.25. In addition, oil percentage in maize grains was extracted by using solvent hexanol in a Soxhlet apparatus according to the method of A.O.A.C. (1988). Zinc content (mg/g dry weight (DW)) was determined spectrophotometric according to the method described by Chapman and Pratt (1961).

The data were statistically analyzed for each season and then combined analysis of the two seasons was carried out according to procedure outlined by Snedecor and

Table (1) : Effect of ethephon and zinc sulphate concentrations on growth characters at the different stages of growth of maize plants.
(Combined analysis of 1997 and 1998 seasons)

Treatments		Plant height (cm)	Stem diameter (cm)	No. of leaves/plant	LA dm^2/plant	(LAI)	SLW mg/cm^2	Dry weight g / plant	CGR (g/day)	NAR (mg/dm^2/day)
		Elongation stage								
Ethephon (g/fed.)	0.0	195.63	2.09	14.45	102.95	5.79	8.39	195.12	4.02	2.32
	50	218.14	2.34	15.58	99.07	6.17	7.72	191.91	3.34	2.16
	100	204.19	2.49	15.08	95.95	5.34	7.65	187.93	2.70	2.51
	150	192.28	2.58	14.20	93.51	5.05	7.52	185.41	3.08	2.14
L.S.D. at 5%		4.33	0.10	N.s.	4.72	0.44	0.56	3.77	0.4	N..s.
Zinc sulphate (mg/l)	0.0	200.49	2.25	14.37	99.41	6.01	7.42	189.03	3.20	1.56
	2000	221.86	2.38	15.00	103.96	6.50	8.76	195.09	4.62	2.20
	4000	232.06	2.50	15.11	105.49	6.96	8.98	201.23	4.63	3.09
L.S.D. at 5%		4.47	0.08	0.59	3.97	0.30	0.31	3.11	0.41	0.19
Interaction (Z × E)		N.S.	N.S.	N.S.	N.S.	N.S.	0.61	2.51	N.S.	N.S.
		Silky stage								
Ethephon (g/fed.)	0.0	244.92	2.26	13.83	99.18	5.38	12.85	255.49	2.33	1.78
	50	265.25	2.41	14.14	97.19	5.85	12.47	237.17	2.78	1.58
	100	254.78	2.56	14.36	94.55	5.08	10.90	231.42	2.74	1.44
	150	241.52	2.66	14.60	89.20	4.67	10.76	228.59	2.19	1.38
L.S.D. at 5%		6.71	0.08	n.s.	4.52	0.29	0.96	6.28	n.s.	0.20
Zinc sulphate (mg/l)	0.0	250.92	2.38	13.69	96.43	5.60	12.54	239.47	2.41	1.81
	2000	269.62	2.49	14.35	99.03	5.78	12.64	264.40	3.01	1.70
	4000	275.20	2.59	14.66	102.08	6.18	13.38	271.60	2.10	1.84
L.S.D. at 5%		3.03	0.05	N.S.	2.52	0.34	0.79	5.64	0.42	N.S.
Interaction (Z × E)		6.07	N.S.	N.S.	N.S.	N.S.	0.68	6.24	0.85	N.S.

Cochran (1990). For comparison between means, L.S.D. test at 5 % level was calculated.

RESULTS AND DISCUSSION

1- Effect of ethephon and zinc sulphate on growth characteristics :

Data in Table (1) cont. show that leaf area, leaf area index, crop growth rate, specific leaf weight and total dry weight per plant were significant decreased as a result of foliar application with ethephon at the concentration of 50 to 150 g/fed. when applied at elongation stage of maize growth compared with control treatments. While, number of leaves per plant and net assimilation rate had no significant affected by ethephon application. However, foliar application at the concentration of 100 and 150 g/fed. to maize plants were the most effective treatments for increasing stem diameter at the different stages of growth as compared with control. Gaska and Oplinger (1988) found that high rate of ethephon (0.42 kg/ha) reduced lodging, plant height, ear height and increased stem diameter and brace root development. Also, Norberg *et al.*, (1989) indicated that increasing of ethephon concentration from 0.14 to 0.56 kg/ha led to significant decreases in plant height, ear height and length of internodes whereas, diameter and weight length of internodes increased when applied at tassel elongation stage. However, the highest promotion effect on growth characters was obtained from foliar application with ethephon at the concentration 50 and 100 g/fed. when compared to the results obtained at the different stages of growth (Table 1) cont. This effect could be attributed to that ethephon increased the activity of several enzymes and turn reflected on improve growth pattern and enhance grain yield of corn (Blomquist *et al.*, 1973 and Norberg *et al.*, 1988).

Table (1) Cont. Effect of ethephon and zinc sulphate concentrations on growth characters at milky ripe stage of maize plants.
(Combined analysis of 1997 and 1998 seasons)

Treatments		Plant height (cm)	Stem diameter (cm)	No. of leaves/plant	LA dm^2/plant	(LAI)	SLW mg/cm^2	Dry weight g / plant
	Milky ripe stage							
Ethephon (g/fed.)	0.0	259.89	2.25	13.3	94.4	5.24	12.24	280.37
	50	273.45	2.47	13.18	91.5	5.04	11.89	278.68
	100	254.39	2.55	13.35	85.82	4.75	10.58	268.19
	150	249.89	2.61	13.46	81.27	4.58	10.97	261.99
L.S.D. at 5%		4.44	0.07	N.S.	3.56	N.S.	0.74	6.56
Zinc sulphate (mg/l)	0.0	264.52	2.34	13.07	92.56	4.96	11.83	277.36
	2000	272.81	2.46	13.36	96.6	5.34	12.56	296.39
	4000	282.97	2.52	13.58	94.05	5.41	12.34	300.40
L.S.D. at 5%		5.24	0.06	0.37	2.95	N.S.	N.S.	4.21
Interaction (Z x E)		N.S.	0.42	N.S.	N.S.	N.S.	N.S.	8.43

In addition, D'Andria *et al.*, (1997) reported that increasing ethephon rates caused a significant reduction in leaf area index, plant height and dry matter accumulation and Kasele *et al.*, (1995) found that ethephon spraying maize plants with the plant growth retardant application reduce plant size, leaf size, dry weight,concentrated hotosynthetic pigments and enzymes and increased specific leaf weight. Similar results were obtained by Langan and Oplinger (1987), Mori *et al.*, (1996), Habba *et al.*, (2001) on wheat.

Furthermore, foliar application with zinc sulphate treatment caused significant increase in growth characteristics as its concentration increased from 2000 to 4000 mg/l. The increase in these growth characters by zinc sulphate treatment could be due to zinc plays important in root extension, cell division, respiration, N metabolism and activation of enzymes in plant growth and this in turn on their growth characters. Also, they have structural role in chloroplast in the leaf. Similar results for the imported role of Zn on maize plant growth were obtained by Gardner *et al.*, (1985) and Marschner, (1986).

However, found that foliar application with 2000 and 4000 mg/l zinc sulphate caused significant increases in plant height, stem diameter, number of leaves/plant, leaf area, leaf area index, specific leaf weight, net assimilation rate, crop growth rate and dry weight of maize plant at the different stage of growth. Whereas, foliar application with 4000 mg/l zinc sulphate gave the highest values of growth characteristics compared with other treatments and this was clearly true at the different stages of growth. Badr, (1987), El-Sheikh, (1993) and Abo El-Kheir (2000) found that spraying maize plants with zinc sulphate up to 300 ppm caused gradual increase in the aforementioned growth parameters. The positive effect of zinc on the vegetative growth parameters of maize plants were recorded by Mekki and El-Sayed (1998). Such enhancement effect might be attributed to its effect on producing growth substances i.e. auxins which in turn encourage the meristematic activity of the plant which resulted in more cell division and enlargement (Devlin and Witham, 1983). Concerning the combined effect of ethephon and zinc sulphate treatments data in Table (3) showed that ethephon at the concentration 0.0 and 50 g/fed and zinc sulphate at 2000 and 4000 mg/l gave the highest values of total dry weight/plant at the different stages of growth, plant height at silky stage, specific leaf weight at elongation and silky stages whereas the greatest value from crop growth rate at the silky stage, also, foliar application with 150 g/fed ethephon and 4000 mg/l zinc sulphate gave the highest value from stem diameter at milky ripe stage compared with other treatment under stage. While , number of leaves/plant, leaf area, leaf area index, net assimilation rate showed insignificant response to the interaction between ethephon and zinc sulphate concentration at the different stages of growth.

2- Effect of ethephon and zinc sulphate on yield and its components :

Data in Table (2) show that yield and its components i.e., number of kernels/row, 100-grain weight, grain yield / plant and grain yield / fed. were significantly increased with foliar application of ethephon as compared to those of control plants. Meanwhile, ear length, ear diameter, number of rows/ear, shelling percentage and harvest index were not significantly affected by ethephon treatment. Shanahan and Nielsen (1987) and Habba *et al.*, (2001) found that low rate of ethephon increased the yield components while, high rates of ethephon showed depressed effect on grain yield. Langan and Oplingor (1987) reported that plant and ear height of two field corn hybrids decreased with ethephon application at tassel elongation. Results also indicate that yield and its components increased at low rates of ethephon, but decreased at higher rates. However, foliar ethephon application at the concentration 50 and 100 g/fed to maize plants at elongation stage were the most effective treatments for increasing yield parameters as compared with those of control. While, these results suggest that high application of ethephon up to 150 g/fed. decreased productivity of maize plant. Similar finding was reported by Earley and Slife , (1969) and Kasele *et al.*, (1994) found that ethephon has been shown to increases number of kernels/ear, weight of individual kernels and grain yield kg/ha.

Concerning the effect of zinc sulphate application, data presented in Table (2) showed that maize plants sprayed with 2000 to 4000 mg/l zinc sulphate significantly exceeded control treatment in the following yield and its components, i.e. ear length, ear diameter, number of rows/ear, number of grains/row, 100-grain weight, and grain yield per plant and per feddan . While, the increase in shelling percentage and harvest index was not enough to reach the level of significance. The results reveal that spraying maize plants with zinc sulphate up to 4000 mg/l significantly increased the aforementioned yield characters as compared to the untreated ones. Similar results were recorded by Ashoub *et al.* (1996), Mekki and El-Sayed (1998) and Abo El-Kheir (2000). The favourable effects of zinc on yield characters of maize plants may be attributed to its effect on most of growth parameters which in turn improve yield and yield components. In this concern,

Table (2) : Effect of ethephon and zinc sulphate concentration on yield and its components of maize plants
(Combined analysis of 1997 and 1998 seasons)

Treatments		Ear length (cm)	Ear diameter (cm)	No. of rows/ear	No. of grains/row	100-grain weight (g)	Grain yield/plant (g)	Grain yield (ton/fed.)	Shelling %	Harvest index
Ethephon (g/fed.)	0.0	22.49	4.85	14.12	44.01	38.80	202.65	3.63	84.46	46.96
	50	22.07	4.86	14.29	46.03	39.61	209.19	4.01	85.42	50.93
	100	22.05	4.98	14.41	45.19	40.03	234.11	4.28	86.29	48.24
	150	21.83	5.22	14.32	45.33	39.96	226.59	3.97	85.40	48.16
L.S.D. at 5%		N.S.	N.S.	N.S.	0.30	0.76	4.83	0.28	N.S.	N.S.
Zinc sulphate (mg/l)	0.0	21.37	4.84	13.87	43.90	38.19	211.33	3.73	84.67	46.88
	2000	22.09	4.99	14.33	45.35	39.54	239.73	4.03	85.47	47.97
	4000	22.86	5.10	14.56	46.24	40.23	240.37	4.16	86.04	50.80
L.S.D. at 5%		0.61	1.66	0,25	0.33	0.71	3.48	0.24	N.s.	N.s.
Interaction (Z × E)		N.S.	0.27	N.S.	0.34	0.46	6.96	0.28	0.13	N.S.

Table (3) : Effect of the interaction between foliar application of ethephon and zinc sulphate concentrations on maize growth characters.
(Combined analysis of 1997 and1998 seasons)

Treatments		Plant height (cm)	Stem diameter (cm)	Dry weight (g) /plant			Specific leaf weight (mg/cm²)	Specific leaf weight (mg/cm²)	Crop growth rate (g / day)
Zinc sulphate (mg/l)	Ethephon (g/fed.)	B	C	A	B	C	A	B	B
0.0	0.0	246.61	2.26	186.68	221.04	258.83	7.30	11.94	2.86
2000		252.1	2.39	192.96	241.49	248.83	8.01	12.60	2.14
4000		262.15	2.35	196.11	255.24	292.4	8.29	12.87	1.99
0.0	50	243.92	2.49	185.27	219.54	254.76	7.29	11.20	2.52
2000		255.06	2.55	191.36	235.22	286.53	7.59	11.78	3.31
4000		259.38	2.45	193.64	250.46	283.14	8.17	12.25	2.48
0.0	100	239.91	2.59	184.9	214.43	245.81	7.26	10.28	2.09
2000		243.61	2.60	187.07	231.47	286.59	8.18	11.55	3.68
4000		251.24	2.50	191.82	240.01	272.19	7.53	10.86	2.44
0.0	150	236.69	2.68	180.48	211.23	240.07	7.17	10.04	2.17
2000		240.11	2.71	190.34	234.89	278.35	7.51	10.34	2.90
4000		247.77	2.76	185.43	248.67	267.57	7.87	11.89	1.51
L.S.D. at 5%		6.07	0.42	2.51	6.24	8.43	0.61	0.68	0.85

A : Elongation stage
B : Silky stage
C : Milky ripe stage

Devlin and Witham (1983) reported that zinc participates in the metabolism of plants as an activator of several enzymes and directly involved in the biosynthesis of growth substances such as auxins which reflected on the growth for producing more plant cells, more dry matter production and more energy formation which in turn will be stored in the maize grains as a sink and consequently, the increase in grains and weight is more expected. Allam and El-Naggar (1992) and Ashoub *et al.*, (1996) found that Zn application produced the highest values of ear length, ear diameter, 100-grain weight, number of kernels/row, ear weight and kernels weight/ear and grain yield per plant and per feddan. While shelling percentage was not affected by Zn application to maize plants. Concerning the combined effect between ethephon and zinc sulphate data in Table (5) reveal that significant effect on ear diameter, number of kernels/row, 100- grain weight, grain yield per plant and per feddan and shelling percentage, while, ear length, number of rows/ear and harvest index showed insignificant response to the interaction. It could be concluded that foliar application with 100 g/fed ethephon and 4000 mg/l zinc sulphate was the most effective treatment to gave the greatest means values from 100 – grain weight, grain yield ton/fed, and shelling percentage, meanwhile, spraying maize plants with 50 g/fed. ethephon and 4000 mg/l zinc sulphate produced the highest number of Kernels/row, meanwhile, 100 g/fed ethephon and 2000 mg/l zinc sulphate gave the greatest value from grain yield/plant. On the other hand, the greatest mean value of ear diameter was obtained by spraying maize plants with 150 g/fed ethephon and 2000 mg/l zinc sulphate.

Table (4) : Effect of ethephon and zinc sulphate concentration on crude protein, total carbohydrate, oil percentage and Zn content of maize grains.
(combined analysis of 1997 and 1998 seasons)

Treatments		Crude protein %	Total carbohydrate %	Oil %	Zn content (mg/g DW)
Ethephon (g/fed.)	0.0	10.82	71.24	6.74	1.06
	50	11.56	73.94	7.61	1.60
	100	12.56	68.32	7.54	1.72
	150	12.05	67.53	7.21	1.74
L.S.D. at 5%		0.75	1.91	0.51	0.12
Zinc sulphate (mg/l)	0.0	11.08	71.44	6.60	1.30
	2000	12.24	69.87	7.55	1.62
	4000	12.37	70.46	7.67	1.67
L.S.D. at 5%		0.47	1.41	0.34	0.19
Interaction (Z × E)		1.8	2.81	0.67	0.98

Table (5) : Effect of the interaction between foliar application of ethephon and zinc sulphate concentrations on yield and its components and chemical constituents of maiz grains

(Combined analysis of 1997 and1998 seasons)

Treatments		Ear diameter	No. of grains/row	100-grain weight (g)	Grain yield (g)/plant	Grain yield ton/fed	Shelling	Crude protein	Total carbohydrate	Oil	Zn content
Zinc sulphate (mg/fed)	Ethephon (g/fed.)	(cm)					%	%	%	%	(mg/g DW)
0.0	0.0	4.77	43.70	38.68	197.13	3.12	83.65	9.93	64.82	5.89	0.83
2000		4.83	45.35	38.74	200.53	3.74	84.57	11.07	68.11	6.71	1.12
4000		4.94	46.24	39.09	223.29	4.04	85.20	12.24	76.02	7.62	1.22
0.0	50	4.71	44.31	38.95	198.53	3.92	84.63	10.45	72.99	6.87	1.32
2000		4.79	46.54	39.57	211.66	3.99	85.31	12.49	73.97	7.83	1.68
4000		5.09	47.73	40.31	219.37	4.12	86.33	11.74	70.87	8.15	1.80
0.0	100	4.42	44.39	39.62	227.41	4.01	85.30	11.80	73.64	7.18	1.55
2000		5.07	45.99	39.75	240.37	4.32	86.57	13.05	70.35	8.08	1.77
4000		5.15	47.49	40.71	234.54	4.53	87.00	12.81	69.74	7.36	1.85
0.0	150	5.16	45.47	39.53	222.26	3.88	85.09	11.09	70.32	6.48	1.51
2000		5.29	46.51	40.09	226.35	4.08	85.48	12.38	67.07	7.59	1.91
4000		5.23	46.30	40.26	231.15	3.96	85.63	12.69	65.22	7.55	1.81
L.S.D. at 5%		0.27	0.34	0.46	6.96	0.28	0.13	1.80	2.81	0.67	0.98

3- Effect of ethephon and zinc sulphate on chemical constituent of maize grains:

Data in Table (4) indicate that foliar application of ethephon at the concentration of 50 and 100 g/fed gave the highest values for crude protein, total carbohydrate and oil percentage compared with control treatment. While, increasing ethephon concentration up to 150 g/fed led to slight decrease on the above mentioned characters. While spraying maize plants with ethephon at the concentrations 150 g/fed caused a significant increase in Zn content of maize grains. The enhancement of growth and yield parameters in response to ethephon treatments at the concentrations of 50 and 100 g/fed when applied as foliar application at elongation stage was accompanied with similar changes on crude protein, total carbohydrate and oil percentage in maize grain. In this respect Bullock and Raymer (1989) found that mineral analysis of the harvested corn grain showed a linear increase of N,P,K and Zn concentrations with increasing ethephon concentration. Also, Norberg *et al.*, (1988) on corn and Habba *et al.*, (2001) on wheat , found that protein percentage was significant increase with foliar application of ethephon, while total carbohydrate in grains decreased by increasing foliar application of ethephon. However, Earley and Slife (1969) indicated that protein and oil percentages of the corn grain was not affected by ethephon . The same Table show that spraying maize plants at elongation stage with zinc sulphate up to 4000 mg/l significantly increased crude protein, total carbohydrate, oil percentage and Zn content in maize grains as compared with untreated plants. However, foliar application of zinc sulphate at the concentration of 2000 and 4000 mg/l gave the highest values for crude protein, total carbohydrate, oil percentage and Zn content. This may be due to the Zinc play important role in N metabolism i.e., protein, tryptophan and IAA synthesis eventually zinc stimulates vegetative growth and increased protein, carbohydrate and zinc accumulation in maize grains (Gardner *et al.*, 1985 and Marschner, 1986). Jyung *et al.*, (1975) reported that zinc has a possible role in plant metabolism involved in starch formation. Also, Mekki and El-Sayed (1998) reported that foliar fertilization with zinc can be efficiently used as a good management tool to overcome the soil constraints that can reduced micronutrients availability to maize plants. Concerning increasing zinc sulphate concentration up to 4000 mg/l led to increase in protein, oil and Zn percentage were obtained at 2000 and 4000 mg/l zinc sulphate these results are supported by those obtained by El-Sheikh (1993) and Shams (2000). Abd El-Aziz *et al.*(1982) indicated that the highest effect on protein and total carbohydrate in maize plan were observed with the addition of Zn at 5.0 ppm as compared to the control. Also, Badr (1987) and Abo El-Kheir (2000) found that nitrogen content, total carbohydrate, oil percentage and Zn content of maize grains were increased significantly as $ZnSO_4$ increased up to 0.4 %. The combined effect between ethephon and zinc sulphate treatments had a significant effect on protein, carbohydrate, oil percentage and Zn content in maize grains. The highest values of crude protein and/or Zn percentage was obtained as a result of ethephon at 100 and/or 150 g/fed with zinc sulphate at 2000 mg/l., while, the highest values of total carbohydrate and/or oil percentage were obtained with ethephon 0.0 and/or 50 g/fed combined with zinc sulphate 4000 mg/l.

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تأثير استخدام الإثيفون والزنك على النمو والمحصول ومكوناته والتركيب الكيميائى لنباتات الذرة الشامية

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أجــريت هذه الدراسة بمحطة التجارب الزراعية بالمركز القومى للبحوث – بشلقان محافظــة القــليوبية خــلال موسمى ١٩٩٧ ، ١٩٩٨ بهدف دراسة تأثير الرش بالتركيزات المختــلفة لمــادة الإثيفــون والــزنك وكذلك التفاعل بينهما على النمو والمحصول ومكوناته والتركيب الكيميائى لنبات الذرة الشامية . وكانت أهم النتائج المتحصل عليها كالآتى :-

١- أدى معامــلة نــباتات الذرة الشامية بالتركيزات المختلفة من الإثيفون خلال مراحل النمو المختلفة إلى زيادة معنوية فى قطر الساق بينما أدى زيادة تركيز الإثيفون من ٥٠ إلى ١٠٠ جــرام / فدان خلال مرحلة الاستطالة (٣٠ ، ٥٠ يوم من الزراعة) إلى حــدوث نقــص معــنوى فى صفات النمو المتمثلة فى ارتفاع النبات ، مساحة الورقــة ، دليل مساحة الأوراق ، والكثافة النوعية للورقة ، معدل نمو المحصول ، والــوزن الجاف الكلى لنبات ، بينما لم تظهر عدد الأوراق للنبات ، ومعدل التمثيل الضوئى أى استجابة معنوية نتيجة لزيادة تركيز الأثيفون إلى ١٥٠ جرام / فدان .

٢- أدى معاملة نباتات الذرة الشامية بالتركيزات المنخفضة من الإثيفون (٥٠ ، ١٠٠ جرام / فدان) إلى حدوث زيادة معنوية للمحصول ومكوناته ، حيث زاد عدد الحبوب بالصف ، وزن ١٠٠ حبة ، محصول الحبوب / نبات ، محصول الحبوب / فدان.

٣- حققت معاملة نباتات الذرة الشامية بالتركيزات المختلفة من الزنك (٢٠٠٠ ، ٤٠٠٠ ملليجرام/لتر) خلال مرحلة الاستطالة (٣٠ - ٥٠ يوم من الزراعة) إلى زيادة معنوية فى معظم صفات النمو والمحصول ومكوناته وكذلك محتوى الحبوب من البروتين ، والزنك ، والكربوهيدارت والزيت.

٤- أشارت نتائج التحليل الكيميائى إلى حدوث زيادة معنوية فى محتوى الحبوب من البروتين و الزنك والزيت بينما اتجه محتوى الحبوب من الكربوهيدرات إلى النقص مع زيادة تركيز الأثيفون إلى ١٥٠ جرام / فدان .

٥- وجد أن هناك تأثير معنوى وموجب للتفاعل بين معاملة نباتات الذرة الشامية بالإثيفون والزنك لصفات الوزن الجاف الكلي للنبات خلال مراحل النمو المختلفة ، وارتفاع النبات خلال مرحلة ظهور الحريرة ، ومعدل نمو المحصول خلال مرحلة ظهور الحريرة ، قطر الساق خلال مرحلة النضج التام ، قطر الكوز ، عدد الحبوب بالصف ، وزن ١٠٠ حبة ، محصول الحبوب / النبات ، محصول الحبوب / فدان ، محتوى الحبوب من البروتين والزنك والزيت والكربوهيدرات .

مما سبق يتضح أن استخدام مادة الإثيفون بتركيز ٥٠ - ١٠٠ جرام / فدان والزنك بتركيز ٢٠٠٠ - ٤٠٠٠ ملليجرام / لتر خلال مرحلة الاستطالة فى نباتات الذرة أدى إلى تحسين النمو الخضرى وبالتالى زيادة المحصول ومكوناته والتركيب الكيميائى لحبوب الذرة الشامية.