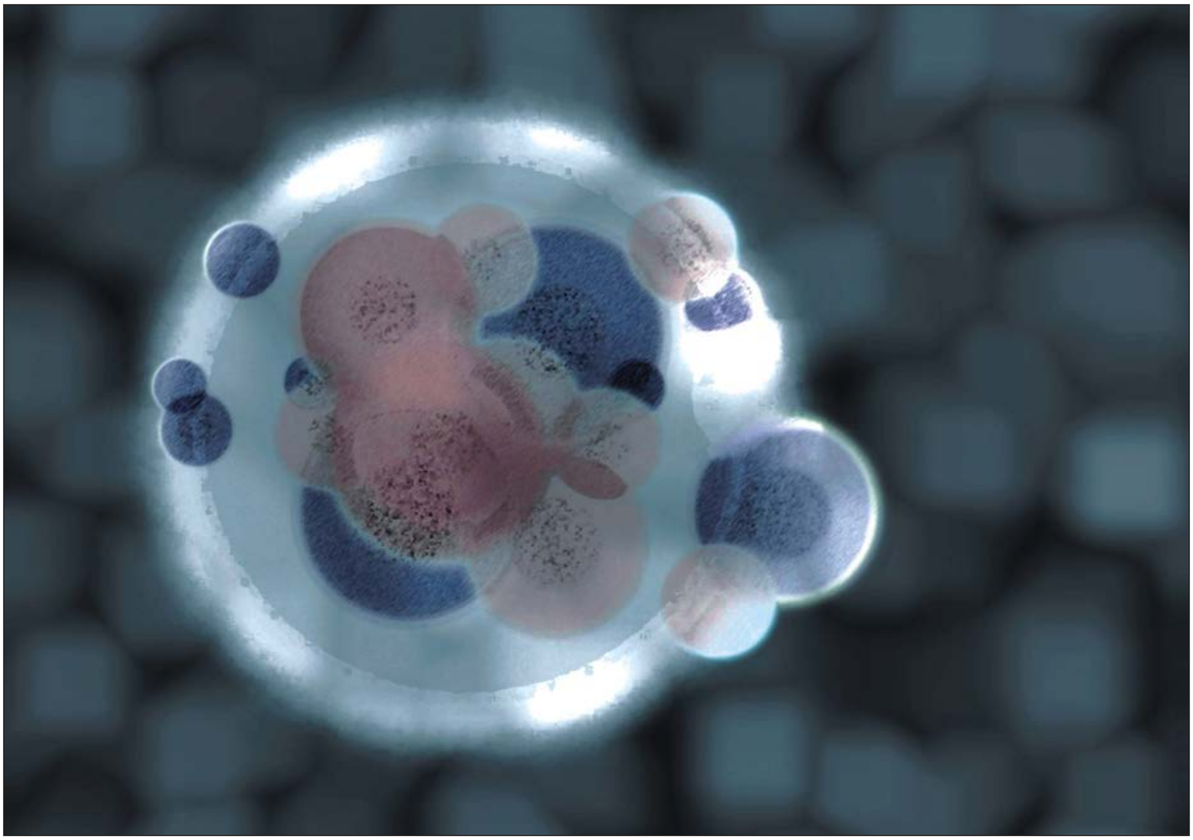

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Physiological Responses of Maize Plants (*Zea mays* L.) To Foliar Application of Morphactin CF_{125} and Indole-3-butyric Acid

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Abstract: Field experiment was conducted for two successive seasons during (2004/2005) at the Shalakan Experimental Station, Kalubia Governorate, Egypt, to study the effect of morphactin (CF_{125}), indole-3-butyric acid and their interaction at the concentrations of 0.0, 25, 50 and 100 mg L^{-1} in every case, on vegetative growth characteristics, yield and yield components as well as some bio-chemical constituents of maize grains. Foliar application of morphactin or indole-3-butyric acid had significant effect in increasing plant height, number of leaves/plant, stem diameter, Leaf Area (LA), Leaf Area Index (LAI), Net Assimilation Rate (NAR), flag leaf area, specific leaf weight, total dry weight/plant, as well as photosynthetic pigments at different stages of growth as compared with those of the control. Moreover, morphactin at 25 mg L^{-1} and indole-3-butyric acid at 100 mg L^{-1} recorded the maximum responses in most growth parameters at the three physiological stages of growth. Yield and yield components, i.e., ear length, ear diameter, number of grains/row, number of rows/ear, 100 grains weight, grain yield/plant, grain yield/fed., harvest index and shelling percentage as well as crude protein, total carbohydrates and oil percentage were also significantly increased by the increase of morphactin and indole-3-butyric acid concentrations up to 100 mg L^{-1} in maize plants as compared to untreated plants and other treatments. Data suggest that indole-3-butyric acid, morphactin and their interaction play a significant role in determining total yield in maize plants and that increasing their concentrations up to 100 mg L^{-1} result in increase total grain yield/fed (46.70, 43.55%) and oil yield/fed (72.72, 63.63%) at 100 mg L^{-1} of indole-3-butyric acid and morphactin, respectively as compared to control. Generally, foliar application of maize plants cv., single cross 10 with morphactin and indole-3-butyric acid at 100 mg L^{-1} singly or together with 50 mg L^{-1} of morphactin were the most effective treatments to get better results in increasing growth characteristics, yield and its components in addition to some metabolic constituents of maize grains. The increase in growth processes associated with these treatments are the consequence of a number of effects on the major physiological processes of plant like photosynthesis.

Key words: Maize (*Zea mays* L.), morphactin CF_{125}, indole-3-butyric acid, growth characteristics, photosynthesis, yield, biochemical constituents

INTRODUCTION

The regulation of plant growth and biosynthesis of important economic chemical constituents could be achieved through many group of growth regulating substances. Applying growth regulators may modify morphological and physiological characteristic of plant and may also induce better adaptation of plants to environment which could improve the growth and yield. Morphactins are new groups of synthetic plant growth regulators with a high potency, which effect almost every phase of plant growth and development (Sundberge *et al*., 1994). When morphactin applied to intact plants, it inhibits shoot growth by reducing both the length of the newly formed internodes and their number. At very low concentrations, it promote shoot growth. Leaves of plants treated with morphactin remain green for a longer duration due to the delay in the breakdown of chlorophyll. In addition, morphactin reduces apical dominance and leads to the emergence of numerous branches. Also, in pea plants, morphactin inhibits basipetal transport of auxin and decrease auxin content in the plant body by increasing the activity of the enzyme, IAA oxidase (Krishnamoorthy, 1981). Moreover, some investigators showed that morphactin effect positively stem diameter, fresh and dry weight, number of shoots/plant, chlorophyll a, b and carotenoids content as well as seed yield, protein, carbohydrate and oil content El-Bassiouny (1992) on sunflower and Ali *et al*. (2003) on maiz.

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On the other hand, auxins has been shown to influence cell division, elongation, differentiation and hence the dry matter accumulation of different organs, they are also implicated in various other metabolic processes as nucleic acid synthesis and protein content (Krishnamoorthy, 1981) and thus could be expected to influence the growth and yield of maize plants.

The use of morphactin and indole-3-butyric acid to improve growth and yield of various crops have yielded very encouraging results with some plants and the beneficial effects of morphactin upon growth and productivity have been reported by El-Masry *et al.* (1994) and Ali *et al.* (1994) on *Vicia faba* and Nepalia *et al.* (1996) on *Phaseolus mungo*. On the other hand, indole-3-butyric acid significantly increased vegetative growth, seed yield per plant and per feddan, seed oil and seed protein content in cotton (Sawan, 1978; Sawan *et al.*, 1980) and in *oryza sativa* (Chhun *et al.*, 2003, 2004).

Traditional or commercial products are based on certain endosperm properties and quality parameters. Quality factors that influence the choice and suitability of maize varieties for various uses include chemical, physical, biochemical, physico-chemical, organoleptic and rheological properties. Fortunately, a number of these properties can be influenced and altered favorably through breeding and other agronomic practices and hence the use of indole-3-butyric acid, morphactin and their interactions to improve the growth and yield of maize plants cv. single cross 10.

Thus, the present research was undertaken to study the effect of spraying maize (variety single cross 10) plants with morphactin and IBA, individually or in combination on some morphological criteria, yield and oil production, as well as some metabolic constituents to improve maize grain quality and nutritional value.

MATERIALS AND METHODS

Two field experiments were carried out at the experimental Station of National Research Centre, Shalakan Kalubia Governorate during the two successive seasons of 2004 and 2005, to study the effect of foliar application of different concentration of morphactin (CF_{125}) , indole-3-butyric acid (IBA) and interaction between morphactin and IBA on vegetative growth, photosynthetic pigments content, yield and its component as well as crude protein, total carbohydrate and oil content of maize grains.

Grains of maize (*Zea mays* L.) cv. single cross 10 were sown on the 8th June in both season in rows 70 cm apart and the distance between hills along the row 20 cm apart. Plot area was 10.5 m^2 (3.0 m in width and 3.5 m in Length). Pre-sowing, 100 kg/fed. of Calcium super-phosphate (15.5% P_2O_5) was applied to the soil. While, for nitrogen fertilizer, 120 kg N/fed. Ammonium nitrate (33.5% N) was applied in two equal doses before the first and second irrigation, respectively.

Maize plants were foliar sprayed with morphactin CF_{125} (2-Chloro-9-hydroxyfluorene-9-carboxylic acid) supplied by E-Merck Co, at the concentration of 25, 50 and 100 mg L^{-1} and/or indole-3-butyric acid at 25, 50 and 100 mg L^{-1}. Interaction treatments of the different concentrations of the two factors were also carried out. Control plants were foliar sprayed with distilled water and the volume of the spraying solution was maintained just to cover completely the plant foliage till drip.

In both seasons, foliar application of morphactin as well as indole-3-butyric acid were sprayed at three different stages of growth (30, 45 and 60 days from sowing). After 15 days from each spray, photosynthetic pigments content were determined in fresh leaves samples. Growth characters were measured at silky stage (75 days after sowing), milky stage (90 days after sowing) and Ripe stage (105 days after sowing).

Plant growth parameter were recorded in terms of, plant height, stem diameter, number of leaves/plant, dry weight/plant, leaf area (cm^2/plant) according to (Bremner and Taha, 1966), Leaf Area Index (LAI) (Watson, 1952), Specific Leaf Weight (SLW) (mg/cm^2) (Pearce *et al.*, 1969), Crop Growth Rate (CGR) (mg/cm^2/days) (Abd-El-Gawad *et al.*, 1980) and net assimilation rate (NAR) (mg/cm^2/day) as given by (Watson, 1958). At harvest time, the mean values of yield and yield characters, i.e., plant height, stem diameter, number of rows/ear, number of grains/row, 100-grain weight, grain yield/plant, grain yield/fed., harvest index and shelling percentage were determined. Plant samples were dried in an electric oven with drift fan at 70°C for 48 h till constant dry weight. Representative fresh samples of grains were taken from each treatment for determination of oil percentage by Soxhlet apparatus and oil yield/fed were calculated.

Total carbohydrate was determined in the dried grains, using phenol sulphuric method (Dubois *et al.*, 1956). Crude protein percentage was calculated by multiplying the values of total nitrogen by 6.25 (AOAC 1988). Photosynthetic pigments of fresh leaves; chlorophylls a, b and carotenoides were determined and calculated according to Saric *et al.* (1967) at three stages of maize growth.

The experimental design was split plot with six replication. The morhpactin treatment occupies the main plots and indole-3-butyric acid treatments were allocated at random in sub-plots. Combined analysis of data for two growing seasons was carried out according to Snedecor and Cochran (1980) and the values of least significant differences (LSD at 5% level) were calculated to compare the means of different treatments.

RESULTS AND DISCUSSION

Growth parameters: Data presented in Table 1 and 2 show that foliar application of morphactin and indole-3-butyric acid alone at 0.0, 25, 50 and 100 mg L^{-1} promoted growth criteria (plant height, stem diameter, number of leaves/plant, 4th leaf area, total dry weight/plant, flag leaf area, leaf area index, net assimilation rate and specific leaf weight at the three physiological stages of growth) compared to corresponding untreated plants. In all cases, the increments in growth parameters were often highly significant in comparison with untreated ones. The most effective treatments on growth parameters was indole-3-butyric acid at 100 mg L^{-1}. It could also be observed that morphactin singly caused moderate effects in increasing growth characters, as compared to other applied treatments or the control plants, especially at 25 mg L^{-1} and these results were true at silky, milky and ripe stages. Many investigators suggest that foliar application of morphactin greatly promote the vegetative growth due to increase in the dry matter production through the enhancement of cell division and chlorophyll accumulation of plants like sunflower (El-Bassiouny, 1992), *Vicia faba* L. (El-Masry *et al*., 1994), *Boronia megastigma* (Day *et al*., 1994) and maize (Ali *et al*., 2003). On the other hand, high concentration of morphactin decreases plant height, number of leaves/plant, dry weight/plant and shoot length of sunflower, soybean and tea plants, respectively (Lord *et al*., 1985; Bruce, 1990; Mahanta and Sarma, 1996).

Furthermore, indole-3-butyric acid was more effective than morphactin treatments in increasing vegetative growth of maize plants at the different stages of growth. The increment in growth characters (i.e., plant height, stem diameter, number of leaves/plant, 4th leaf area, total dry weight/plant, flag leaf area, leaf area index, NAR and SLW) reached its maximum values at 100 mg L^{-1} IBA treatment compared to control plants and this could be due to the better physiological conditions which affect the balance between plant hormones and hence caused an increase in the growth promoting substances which reflect on the photosynthetic activity, causing an accumulation in the dry matter and in turn affect the vegetative growth (Sawan *et al*., 1980; Wiesman *et al*., 1988; Ludwig-Muller, 2000; Chhun *et al*., 2003).

Concerning the interaction between morphactin and indole-3-butyric acid on vegetative growth, similar significant increases have been obtained in the same mentioned characteristics of growth using different concentrations, while, number of leaves/plant, 4th leaf area, CGR, SLW and LAI showed insignificant response at the three physiological stages of growth. In addition, the highest values of stem diameter and total dry weight/plant was obtained by the interaction of indole-3-butyric acid at 50 mg L^{-1} + morphactin at 100 mg L^{-1} (Table 3).

Photosynthetic pigments: The effect of foliar spray of morphactin, IBA and their interaction on photosynthetic pigments of maize plants at different stages of growth are shown in Table 4 and 6. Generally, there was a gradual increase in chl. a, chl. b and carotenoids with increasing concentration of morphactin and IBA, reaching a maximum value at 100 mg L^{-1}, during silky, milky and ripe stage.

The highest recorded value of chl a in maize was obtained in leaves of the plants treated with 100 mg L^{-1} morphactin + 50 mg L^{-1} IBA treatment. Also, carotenoid content was similar to single treatments of morphactin and IBA but, it did not induce any significant change in chl. b content compared to other treatments and control plants at silky stage.

Moreover, morphactin was more effective than IBA in increasing chl a content at silky, milky and ripe stage of plant growth. This may be due to stimulation of biosynthesis of chla at silky and milky stages and delay its breakdown at ripe stage. Similarly, Jain and Mukherjee (1981), Dybing and Yarrow (1984) and Zayed *et al.* (1985) reported that morphactin significantly increased photosynthetic pigments in the leaves of soybean, cucumber and tomato plants, respectively. In addition, lower concentration of morphactin stimulated chlorophylls a, b and carotenoids synthesis, while, the higher concentrations had no effect on sunflower plants (Lord *et al*., 1985, El-Bassiouny, 1992 and Sundberg *et al*., 1994).

Furthermore, the results obtained indicate that different photosynthetic pigments (chl. a; chl. b as well as carotenoids) were significantly increased with increasing the applied concentration of IBA up to 100 mg L^{-1} in the leaves of maize plants over their corresponding control at different stages of growth. In accordance, Sawan *et al.* (1980), Epstein and Ludwig-Muller (1993) and Ludwig-Muller (2000) found that IBA at 50 mg L^{-1} gave the highest photosynthetic pigments content due to the stimulatory effect on the amount of metabolites synthesized through enhancement of cell division and chlorophyll accumulation which leads to higher rate of photosynthesis.

Table 1: Effect of foliar spray of morphactin and indol-3-butyric acid on growth characters of maize plants at different stages of growth (Combined analysis of 2004-2005 seasons)

Stages of growth		Plant height (cm) A	Plant height (cm) B	Plant height (cm) C	Stem diameter (cm) A	Stem diameter (cm) B	Stem diameter (cm) C	No. of leaves/plant A	No. of leaves/plant B	No. of leaves/plant C	4th leaf area (cm^2) A	4th leaf area (cm^2) B	4th leaf area (cm^2) C	Total dry weight (g)/plant A	Total dry weight (g)/plant B	Total dry weight (g)/plant C
Morphactin	Control	178.06	248.93	264.88	1.69	1.76	2.01	14.72	15.32	15.26	362.27	494.51	426.21	184.24	268.63	347.14
(mg L^{-1})	25	188.58	269.54	287.66	1.81	1.86	2.08	16.10	16.67	15.42	423.71	499.36	436.57	186.85	272.65	350.35
	50	185.52	266.58	285.24	1.85	1.94	2.18	15.47	15.80	15.26	398.16	493.07	426.92	192.96	281.38	355.73
	100	183.22	262.45	280.31	1.92	2.01	2.26	14.70	15.59	15.09	390.8	458.68	415.83	199.26	285.66	357.31
LSD at 5%		1.75	2.04	2.64	0.11	0.13	0.06	0.12	0.21	n.s.	3.81	2.72	1.13	2.06	1.45	2.30
IBA (mg L^{-1})	25	189.33	257.10	278.87	1.80	1.88	2.07	14.68	15.41	15.11	389.54	487.60	406.68	188.11	275.73	348.79
	50	193.66	270.04	288.38	1.84	1.92	2.12	15.55	16.09	15.22	404.82	495.59	435.49	192.37	277.30	361.59
	100	197.04	276.74	293.82	1.89	1.95	2.17	15.88	16.47	15.28	432.90	516.26	450.26	196.51	281.74	366.69
LSD at 5%		1.50	2.06	2.04	0.09	0.11	0.03	0.17	0.23	n.s.	2.69	2.01	n.s.	3.75	1.55	1.24

A: Silky stage (at 75 days after sowing), B: Milky stage (at 90 days after sowing), C: Ripe stage (at 105 days after sowing)

Table 2: Effect of foliar spray of morphactin and indol-3-butyric acid on growth characters of maize plants at different stages of growth (Combined analysis of 2004-2005 seasons)

Stages of growth		Crop growth rate (mg/cm^2/day) A-B	Crop growth rate (mg/cm^2/day) B-C	Flag leaf area (cm^2) A	Flag leaf area (cm^2) B	Flag leaf area (cm^2) C	Leaf area index A	Leaf area index B	Leaf area index C	Net assimilation rate (mg/cm^2/day) A-B	Net assimilation rate (mg/cm^2/day) B-C	Specific leaf weight (mg cm^2) A	Specific leaf weight (mg cm^2) B	Specific leaf weight (mg cm^2) C
Morphactin	Control	5.89	5.65	133.43	164.67	156.07	3.48	4.92	4.21	5.22	5.69	6.50	7.38	6.68
(mg L^{-1})	25	5.91	5.13	141.27	173.13	158.75	4.28	5.21	4.26	6.43	5.97	6.83	7.53	7.27
	50	5.84	4.83	138.10	171.98	156.68	4.01	5.15	4.22	6.01	5.77	7.12	7.92	7.56
	100	5.46	4.64	136.50	170.46	154.02	3.93	4.78	4.18	5.81	5.55	7.43	8.32	8.15
LSD at 5%		n.s.	n.s.	1.89	1.81	1.62	0.28	0.36	0.34	0.76	0.18	0.29	0.36	0.54
LIBA (mg L^{-1})	25	5.82	5.40	136.01	170.73	158.40	3.92	4.98	4.33	5.67	5.39	6.97	7.66	7.43
	50	5.88	4.94	142.02	175.40	164.90	4.29	5.06	4.48	6.08	5.82	7.94	8.16	8.01
	100	5.91	4.85	142.78	177.47	166.67	4.46	5.12	4.54	6.41	6.07	7.97	8.38	8.16
LSD at 5%		n.s.	n.s.	1.91	1.94	1.53	0.33	0.41	0.12	0.45	0.13	0.34	0.23	0.50

A: Silky stage (at 75 days after sowing), B: Milky stage (at 90 days after sowing), C: Ripe stage (at 105 days after sowing)

Table 3: Effect of interaction between indol-3-butyric acid and morphactin on some growth characters of maize plants at different stages of growth (Combined analysis of 2004-2005 seasons)

IBA (mg L^{-1})	Morphactin (mg L^{-1})	Plant height (cm) A	Plant height (cm) B	Plant height (cm) C	Stem diameter (cm) A	Stem diameter (cm) C	Total dry weight/plant (g) A	Total dry weight/plant (g) B	Total dry weight/plant (g) C	CGR (mg/cm^2/day) B-C	Flag leaf area (cm) A	Flag leaf area (cm) B	Flag leaf area (cm) C
0.0	0.0	175.68	244.31	265.21	1.57	1.90	170.27	255.30	344.07	5.92	136.01	155.53	152.13
	25	188.57	271.44	286.33	1.69	2.08	186.85	274.44	357.74	5.67	139.23	173.23	160.77
	50	188.12	263.64	282.82	1.73	2.12	192.14	279.75	360.01	5.62	136.70	169.27	157.07
	100	183.02	256.37	279.90	1.79	2.18	196.02	284.72	364.37	5.56	134.67	160.63	154.37
25	0.0	190.71	276.64	281.71	1.77	1.99	176.52	257.09	336.86	5.99	141.27	172.30	155.40
	25	196.24	279.20	296.71	1.79	2.01	186.85	277.89	339.75	5.45	146.70	174.02	163.64
	50	187.11	272.84	286.66	1.83	2.11	193.47	282.12	344.83	4.18	143.63	173.63	155.45
	100	183.14	269.72	280.28	1.86	2.22	195.60	285.80	359.01	4.15	139.53	169.04	152.60
50	0.0	192.62	278.43	286.87	1.80	2.11	187.45	266.94	341.08	5.41	142.47	174.57	157.30
	25	188.44	272.49	288.11	1.81	2.13	188.04	279.51	348.05	4.94	146.63	176.63	160.00
	50	183.07	268.24	283.31	1.89	2.20	194.39	280.51	353.35	4.56	140.87	173.03	153.77
	100	179.68	264.82	278.64	1.99	2.36	205.85	290.85	373.71	4.50	138.10	170.27	150.73
100	0.0	196.39	280.01	291.32	1.84	2.18	188.17	272.62	347.24	5.30	144.13	176.33	156.43
	25	180.33	269.36	286.50	1.89	2.22	196.57	282.12	351.76	4.91	142.77	175.70	155.33
	50	178.25	262.69	279.62	1.96	2.27	198.45	284.95	351.92	4.74	139.12	171.93	152.27
	100	173.03	255.04	271.00	1.91	2.27	199.58	287.37	364.44	4.30	136.50	167.23	149.33
LSD at 5%		15.80	20.81	20.50	0.08	0.27	19.10	25.10	32.28	1.16	10.41	15.48	13.76

A: Silky stage (at 75 days after sowing), B: Milky stage (at 90 days after sowing), C: Ripe stage (at 105 days after sowing)

Interaction treatments of morphactin and IBA show insignificant effect on chlorophyll b in maize leaves at silky, milky and Ripe stage, while Chl. a and carotenoids content increased significantly with all interaction treatments compared to other treatments and control plants at silky stage (Table 6). The accumulation of photosynthetic pigments as a result of these interaction treatments may be due to increase in photosynthetic efficiency as reflected by increase in both chl a and carotenoids content in maize plants.

Yield and its components: Data presented in Table 5 show that foliar application of morphactin or IBA, especially at 100 mg L^{-1} resulted in the highest increase

Table 4: Effect of foliar spray of morphactin and indol-3-butyric acid on photosynthetic pigments of maize plants at different stages of growth

		Chl. (a)			Chl. (b)			Total carotenoids		
Treatments		at 45 days	at 60 days	at 75 days	at 45 days	at 60 days	at 75 days	at 45 days	at 60 days	at 75 days
Morphactin	Control	1.23	1.33	1.48	0.34	0.43	0.50	0.62	0.76	0.81
(mg L^{-1})	25	1.40	1.47	1.64	0.37	0.47	0.55	0.68	0.78	0.82
	50	1.67	1.72	1.67	0.46	0.55	0.63	0.70	0.81	0.88
	100	1.71	1.78	1.85	0.51	0.61	0.69	0.74	0.87	0.91
LSD at 5%		0.03	0.04	0.05	0.02	0.03	0.03	0.02	0.04	0.03
IBA	25	1.34	1.42	1.63	0.35	0.47	0.56	0.70	0.79	0.87
(mg L^{-1})	50	1.49	1.52	1.66	0.39	0.47	0.59	0.77	0.83	0.89
	100	1.51	1.58	1.72	0.57	0.68	0.70	0.80	0.86	0.92
LSD at 5%		0.04	0.08	0.06	0.03	0.04	0.04	0.04	0.03	0.04

Table 5: Effect of foliar spray of morphactin and indol-3-butyric acid on yield and its components of maize plants (Combined analysis of 2004-2005 seasons)

		Yield characters						
Treatment		Plant height (cm)	Stem diameter (cm)	Ear length (cm)	Ear diameter (cm)	No. grains /row	No. rows /ear	100 grains weight (g)
Morphactin	Control	286.46	2.56	22.60	4.30	41.98	13.48	38.54
(mg L^{-1})	25	296.47	2.77	23.02	4.62	42.37	14.04	39.11
	50	289.92	2.82	23.07	4.97	44.28	14.40	39.48
	100	285.99	2.90	24.53	5.26	44.76	14.71	40.19
LSD at 5%		3.08	1.05	0.11	0.26	n.s.	n.s.	0.14
IBA	25	297.90	2.76	22.83	4.68	42.57	13.88	38.86
(mg L^{-1})	50	301.50	2.81	23.87	4.83	43.20	14.51	39.51
	100	303.43	2.86	24.77	5.33	45.03	14.53	40.50
LSD at 5%		4.06	0.55	0.16	0.22	n.s.	n.s.	0.17

		Grain yield/ Plant (g)	Grain yield/ fed (ton)	Harvest index	Shelling percentage	Total carbohydrate	Crude protein%	Oil%	Oil yield/fed. (ton)
Morphactin	Control	248.15	3.49	0.69	82.07	74.66	9.11	6.44	0.22
(mg L^{-1})	25	251.67	4.22	0.71	83.36	75.83	9.76	6.80	0.29
	50	260.59	4.76	0.73	83.84	76.32	10.41	7.08	0.34
	100	269.72	5.01	0.79	85.21	78.57	10.59	7.15	0.36
LSD at 5%		1.77	0.21	0.01	1.33	0.12	0.60	0.28	0.14
IBA	25	259.27	4.24	0.69	83.06	76.99	9.84	6.44	0.27
(mg L^{-1})	50	269.17	4.92	0.75	85.47	79.82	9.86	7.01	0.34
	100	274.47	5.12	0.79	87.48	81.20	10.17	7.33	0.38
LSD at 5%		2.40	0.26	0.02	0.79	0.17	0.36	0.22	0.18

Table 6: Effect of interaction between indol-3-butyric acid and morphactin on some yield characters of maize plants (Combined analysis of 2004-2005 seasons)

		Yield characters						
IBA (mg L^{-1})	Morphactin (mg L^{-1})	Plant height (cm)	Stem diameter (cm)	100- grains weight (g)	grain yield/plant (g)	Shelling percentage	Chl. (a) at 75 days	Carotenoides at 75 days
0.0	0.0	279.77	2.57	36.67	239.20	79.40	1.03	0.66
	25.0	295.10	2.81	38.40	260.63	84.79	1.32	0.76
	50.0	289.92	2.84	39.87	263.68	85.44	1.67	0.77
	100.0	285.99	2.88	40.50	270.17	84.75	1.88	0.90
25	0.0	298.73	2.64	37.50	261.24	84.81	1.22	0.72
	25.0	299.70	2.79	38.51	242.07	81.08	1.37	0.79
	50.0	294.50	2.82	39.53	246.60	82.76	1.46	0.82
	100.0	291.93	2.85	39.57	259.17	83.57	1.66	0.86
50	0.0	290.01	2.67	38.70	272.63	84.62	1.44	0.79
	25.0	295.65	2.79	39.37	249.77	80.93	1.47	0.80
	50.0	290.47	2.87	39.70	258.13	82.89	1.56	0.84
	100.0	286.73	2.96	40.55	279.97	87.98	1.97	0.91
100	0.0	287.37	2.70	39.13	276.07	84.62	1.49	0.82
	25.0	292.27	2.88	39.57	259.43	81.49	1.62	0.84
	50.0	287.30	2.91	41.57	269.47	82.03	1.69	0.87
	100.0	284.43	2.93	40.49	271.23	85.44	1.76	0.89
LSD at 5%		17.02	0.30	3.17	26.91	6.98	0.69	0.18

in yield and its components (i.e., stem diameter, ear length, ear diameter, No. of grains/row, No. of rows/ear, 100-grains weight, grain yield/plant, grain yield/fed, harvest index and shelling percentage) as compared to their corresponding controls at ripe stage.

In support, Dybing and yarrow (1984) and Ali *et al.* (2003) found that low concentration of morphactin (50 and 100 mg L^{-1}) increased yield and its components in soybean and maize plants, respectively and attributed this to the increasing ability of plants in building metabolites, retardation of senescence and promoting vegetative growth (Zayed *et al.*, 1985; El-Bassiouny, 1992; Nepalia *et al.*, 1996). On the other hand, morphactin application at (100-200 ppm) sharply suppressed vegetative growth and pod formation in *Vicia faba* plants (El-Desoki *et al.*, 1994).

Concerning the effect of indole-3-butyric acid on yield and its components, similar results have been obtained, using different concentrations of indole-3-butyric acid and different modes of application by Ramdas *et al.* (1972) and Sawan *et al.* (1980) on cotton. Moreover, Ludwig-Muller (2000) mentioned that auxins (IBA) are a class of phytohormones which are involved in many aspects of growth and development of plants whereas, Baraldi *et al.* (1993), Shafey *et al.* (1994) and Chhun *et al.* (2004) indicated that the increase in yield and its components by IBA treatment could be due to the stimulation in dry matter production resulted from the enhancement of cell division as well as chlorophyll accumulation which leads to higher photosynthetic activity and accumulation of dry matter and in turn reflected on the increasing in translocation and accumulation of certain microelements in plant organs and this in turn on their yield and its components.

Furthermore, maize yield is far more sensitive to the interaction treatments of morphactin at 50+100 mg L^{-1} IBA than is to morphactin or IBA recording the highest increase in stem diameter, shelling percentage, 100-grains weight, grain yield/fed. as well as dry weights/plant compared to their relative controls at ripe stage (Table 3 and 6). On the other hand, the interaction between morphactin and indole-3-butyric acid resulted in a general decrease in crop growth while, ear length, ear diameter, No. of grain/row, No. of rows/ear, grain yield/fed and harvest index showed insignificant response compared to their relative controls at ripe stage. In this connection, morphactin inhibits shoot growth, delay the breakdown of chlorophyll, reduces apical dominance, inhibits basipetal transport of auxin and decrease auxin content in the plant body (Krishnamoorthy, 1981). On the other hand, IBA influence cell division, elongation, differentiation and hence the dry matter accumulation of different organs, it is also implicated in various other metabolic processes as nucleic acid synthesis and protein content, so when both are applied to the plant, the effect of one is reversed by other, and thus influence the growth and yield of maize plants (Ludwig-Muller *et al.*, 1993).

Oil content: Data presented in Table 5 shows that oil% and total oil yield per feddan were significantly increased as a result of foliar spray of morphactin and IBA. All treatments gave higher amounts of oil than control, especially morphactin and IBA at 100 mg L^{-1}.

It is also clear that the highest recorded values of fixed oil percent was obtained in the grains of plants treated with IBA followed by morphactin at 100 mg L^{-1}. This increase in oil percentage might be attributed to morphactin or IBA which activate the enzymes responsible for oil biosynthesis and consequently increase oil content of maize grains (Dybing and Lay, 1982a).

On the other hand, the highest oil yield of grain maize per fed (72.73, 63.63%) compared to their controls were obtained from the plants sprayed with IBA and morphactin at 100 mg L^{-1}, respectively. This may be attributed to an increase in the grains production/plant and/or percentage of oil formation. Similarly, morphactin increased oil content of sunflower plants and maize grains (El-Bassiouny, 1992; Ali *et al.*, 2003). Also, maximum oil percent of flx, soybean, wheat and oats was obtained by foliar application of morphactin at 100 mg L^{-1} (Dybing and Lay, 1982b). On the other hand, the interaction between morphactin and IBA treatment showed no significant effect on oil percentage.

Carbohydrate content and crude protein: Foliar application of both morphactin and IBA at (25-100 mg L^{-1}), individually caused an increase in carbohydrates and protein content of maize grains as compared to their controls (Table 5).

The effect of morphactin and IBA on the total carbohydrate content was accompanied by similar effects on the protein. Observation showed that maximum values of carbohydrates and crude protein content of maize grains were obtained by foliar application of IBA at 100 mg L^{-1} followed by morphactin at 100 mg L^{-1}. In accordance, Jain and Mukherjee (1981) and Bruce (1990) found that increasing morphactin concentration was accompanied with similar increase in proteins content in tomato, soybean grains, respectively.

Moreover, foliar spray of IBA significantly increased carbohydrates and crude protein content in maize grains. Similarly, the highest values of carbohydrates and crude protein content of flx, soybean, wheat, oats, *Arabidopsis thaliana* and *Oryza sativa* was obtained by foliar application of IBA at 100 mg L^{-1} (Dybing and Lay, 1982 a,b ; Sawan *et al.*, 1980; Ludwig-Muller *et al.*, 1993, 2000 and Chhun *et al.*, 2004). On the other hand, the interaction between morphactin and IBA treatment showed no significant effect on crude protein and total carbohydrate.

From the preceding results and discussion, it can be concluded that foliar application of maize plants with morphactin and IBA, individually (up to 100 mg L^{-1}) or their interaction at elongation stage, stimulate the growth of maize plants via the enhancement of the biosynthesis of photosynthetic pigments and photosynthetic rate. In addition, it improved yield by increasing grain protein, carbohydrate and oil content of maize grains per feddan. Also, there were slight increase with the used interaction concentrations especially with 50 mg L^{-1} indole-3-butyric acid + 100 mg L^{-1} morphactin which gave the largest total dry weight, stem diameter, photosynthetic pigments, grain yield/plant as well as 100-grains weight and thus morphactin and/or IBA treatments improved maize grain quality and nutritional value.

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