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EFFECT OF INDOLE ACETIC ACID ON SOME ENDOGENOUS COMPOUNDS AND ITS RELATION TO COTTON YIELD

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Abstract

Two field experiments were carried out at Giza Agricultural Research Station during 1997 and 1998 seasons on Giza-85 cv. to study the response of cotton plants to the natural auxin indole acetic acid (IAA) during the flowering period. IAA was applied at start of flowering at rates of 0, 25, 50, 75 and 100 ppm as foliar spray.

The obtained results revealed that IAA application affected significantly most of the chemical constituents of cotton leaves i.e., chlorophyll a, total soluble sugars and phenolic compounds especially polyphenols. Changes in levels of promoters and inhibitors in cotton leaves were studied. Auxin-treated plants contained less levels of inhibitors and application of 75 and 100 ppm IAA exerted higher concentration of promoters which enhanced the vegetative growth and resulted in significant increases in plant height and dry matter production. IAA application of 50 ppm was resulted in plants producing higher numbers of flowers and total bolls per plant as well as higher boll setting percentage. Applying 100 ppm IAA produced less number of open bolls/plant. Boll weight, seed index, earliness percentage were increased by IAA application. Application of 50 ppm of IAA increased significantly seed cotton yield (kentar/feddan), however application of 100 ppm produced less yield as high concentration induced the vegetative growth on the expense of fruiting growth. However, lint percentage and fiber properties showed no significant response due to IAA application.

INTRODUCTION

The physiological effects of indole acetic acid (IAA) are complex since different tissues respond to it in different ways i.e. promotion of cell enlargement (growth of stem and coleptile), cell differentiation (root and bud fromation) and promotion of protoplasmic streaming. However, the straightforwardness of these effects is soon complicated by the results of time- and dose-response. Moreover, IAA is also thought to play a part in abscisson of leaves and flowers (Goodwin and Mercer, 1985).

Wiese and De Vay (1970) reported that polyphenols and other derivatives from shikimate metabolism play an important role in decreasing IAA degradation in healthy cotton plants and might contribute to the increase of IAA and decease IAA decarboxylation. On the other hand, Lah and Shastri (1976) found application of 150 ppm IAA at the flowering stage of cotton plants reduced the percentage of boll shedding. Krishnamorothy *et al.* (1982) reported that while ethrel promoted the dehiscence of excised fruits of cotton, IAA inhibited it. Abdel-Al (1981) showed that spraying cotton plants with 25, 50 and 100 ppm of IAA at the start of flowering increased the polyphenols content in bolls.

Concerning yield and yield components several investigators (Abdel-Al *et al.*, 1982, Fadl *et al.*, 1982, Osman *et al.*, 1985, Sawan *et al.*, 1989) reported that most of yield components of cotton plant i.e. boll weight, seed index, seed cotton yield, and lint percentage were increased with application of IAA. Sawan (1986) reported that foliar application of IAA generally had practically no effect on fiber properties. The aim of this study was to investigate the effect of enhancing practically this natural auxin, especially during the flowering period in promoting plant metabolism and boll setting, which may lead an increase in the yield of cotton plants.

MATERIALS AND METHODS

Two field experiments were carried out at Giza Agricultural Research Station of A.R.C. during the two successive seasons of 1997 and 1998 to study the response of cotton plants to the exogenous application of IAA at start of flowering in an attempt to raise the level of natural auxins during flowering and fruiting stages in such plants.

Seeds of Giza 85 cv were sown on the second and first of April in 1997 and 1998 seasons, respectively. The experimental unit was 4X3 meters. It contained five rows with a distance of 20 cm between hills and 10-15 seeds per hill, thinned to two seedlings. After planting all agricultural practices were carried out as usual.

The plant growth regulator indole acetic acid (IAA) at rates of 0, 25, 50, 75 and 100 ppm was used as a foliar spray and tap water as a control at the start of flowering using hand operated compressed air sprayer. Every experiment contained the afore-mentioned 5 treatments with 4 replications for each, arranged in completely random-ized block design. In order to estimate the chemical changes in cotton leaves, five pl-ants were chosen randomly from each plot. Leaves from the main stem on the fourth node from the apex were taken after 15 days from IAA application to determine the chemical constituents: chlorophyll a and b according to Arnon (1949), Carotenoides according to Rolbelen method (1957), Total soluble sugars according to Smith *et al.* (1956). However, reducing sugars were determined according to the method of A.O.A.C. (1965), total phenols and polyphenols were determined in the ethanolic ex-tract according to the methods described by Simons and Ross (1971) and A.O.A.C. (1965), respectively.

Determination of endogenous growth active substances in cotton leaves was carried out according to Hartman *et al.* (1967). The calculation of the unit of promotion for leaf extracts was based upon the relative amount of endogenous promoters and inhibitors extracted from the leaves using the cowpea test. From the rooting results, expressed as histograms, the area between promotion and inhibition was calculated.

To estimate growth and yield ten plants were chosen randomly from each plot and the following characters were recorded at harvest, except number of flowers per plant. Yield of seed cotton in kentar per feddan was determined for each plot.

A. Vegetative and fruiting characters: Number of flowers/plant, Number of fruiting branches/plant, Plant height (cm), Dry weight of plant (stem+branches), (gm), Number of total bolls/plant, and Boll setting percntage was calulated as

$$\frac{\text{No. of total bolls/plant}}{\text{No. of flowers / plant}} \times 100$$

B. Yield and yield components: Number of open bolls/plant, Average boll weight Seed index (gm), Lint percentage were measured.

$$\text{Earliness\% as} \frac{\text{Seed cotton yield of the } 1^{st} \text{ pick}}{\text{Total seed cotton yield for the } 1^{st} + 2^{nd} \text{ picks}} \times 100,$$

Fiber fineness (micronaire value) and fiber strength (Pressely index) were measured according to the standard methods of testing A.S.T.M. (1967).

Statistical analysis was carried out for the obtained data according to the methods of Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Chemical constituents of cotton leaves

Data presented in Table 1 show clearly that IAA application at start of flowering affected significatly most of the chemical constituents of cotton leaves except chlorophyll b and carotenoides.

A. Chlorophylls

The results reveal that chlorophyll a was affected significantly and increased as IAA concentration was increased and reached its maximum level (4.4 - 4.6 mg/g dry weight) when 100 ppm IAA was applied in two seasons. Chlorophyll b was not affected significantly in the two seasons. It is worth to note that applying 25 ppm IAA did not exert any increase in chlorophyll b contents as compared to control plants, while higher concentrations of IAA increased it. However, the increase in a/b ratio in treated plants is mainly due to the more formation of chlorophyll a rather than chlorophyll b.

B. Carotenoids

The obtaind data reveal also that IAA application had no significant effects on carotenides content in the two seasons however slight increases were observed with the application of 100 ppm of IAA.

C. Soluble sugars

Stimulative and significant effects of IAA application on the metabolism of reducing sugars and total sugars were more clear (Table 1) and depended mainly on the concentration of IAA applied at the start of flowering, where the highest IAA concentration was more active in increasing such carbohydrate components. These increases may be due to either the stimulation of carbohydrate formation by photosynthesis as a result of IAA application or the induce of the hydrolytic enzymes to break down polysaccharides to soluble carbohydrates. However, Bonner and Varner (1976) pointed out that treating pea stems with IAA caused a 2 - 4 fold increase in the activity of cellulase synthase (Uridine diphosphate-forming).

D. Phenols

Concerning phenols, results show that the IAA in all concentrations stimulated significantly the biosynthesis of phenol compounds i.e. polyphenols and total phenols, in the two seasons. The increase in ploypenol/total phenol ratio (P/T) in treated plants (except to 100 ppm IAA) as compared to control plants, may be due to the synthesis of more polyphenols from related compounds such as carbohydrates. In this concern, Wiese and De Vay (1970) reported that polyphenols play an important role in decreasing IAA degradation in healthy cotton plants and may decrease IAA decarboxylation. In this repect, Abdel-Al *et al.* (1998) reported that foliar spray of polyphenols on cotton plants increased its auxin content.

Table 1. Effect of application of IAA at the start of flowering of cotton plants on the chemical constituents (as mg/dry weight) of cotton leaves in 1997 and 1998 seasons

IAA treatments (ppm)	Season	Chlorophylls			Carote- noides	Reducing sugars	Total souluble sugars	polyphen- ols (p)	Total phe- nols(T)	P/T ratio
		Chl. a	Chl b	Chl.a/ Chl.b						
O(control)	1997	3.3	1.51	2.18	0.66	9.2	17.0	7.2	11.8	0.61
	1998	3.6	1.40	2.57	0.70	10.6	18.1	7.7	12.1	0.63
25	1997	3.5	1.51	2.31	0.69	10.0	18.2	7.9	12.2	0.64
	1998	3.7	1.40	2.64	0.76	11.7	19.0	8.2	12.5	0.65
50	1997	3.8	1.53	2.50	0.72	12.3	19.4	9.0	13.1	0.69
	1998	4.1	1.52	2.69	0.82	12.9	20.2	9.2	13.2	0.70
75	1997	4.0	1.57	2.54	0.69	12.8	19.7	8.6	13.0	0.66
	1998	4.4	1.63	2.80	0.74	13.3	20.6	8.5	12.9	0.66
100	1997	4.4	1.59	2.76	0.78	13.0	20.0	7.1	11.8	0.60
	1998	4.6	1.64	2.82	0.81	13.6	21.0	7.4	12.0	0.62
LSD at 0.05	1997	0.27	NS	-	NS	0.25	0.28	0.34	0.29	-
	1998	0.16	NS	-	NS	0.33	0.39	0.22	0.15	-

E. Endogenous phytohormones

Changes in level of promoters and inhibitors in cottons leaves due to the application of different concentrations of IAA were obtained from the cowpea seedings growth assay and illustrated in Figure (1.a). It is clear that the control plants contained higher levels of inhibitors as compared to other IAA-treated plants. However, higher concentration of IAA (75 and 100) contained only promoters like substances. On the other hand, Figure (1.b) showed the changes in the units of promotion and inhibition in cotton leaves under investigation. It is obvious that the control plants (untreated) contained more units of inhibition and began to decrease with 25 and 50 ppm of IAA and reached a value of zero with 75 and 100 ppm. On the other hand, the increase in units of promotion was connected with the increase of IAA concertration used, where application of 100 ppm IAA produced more units of promotion.

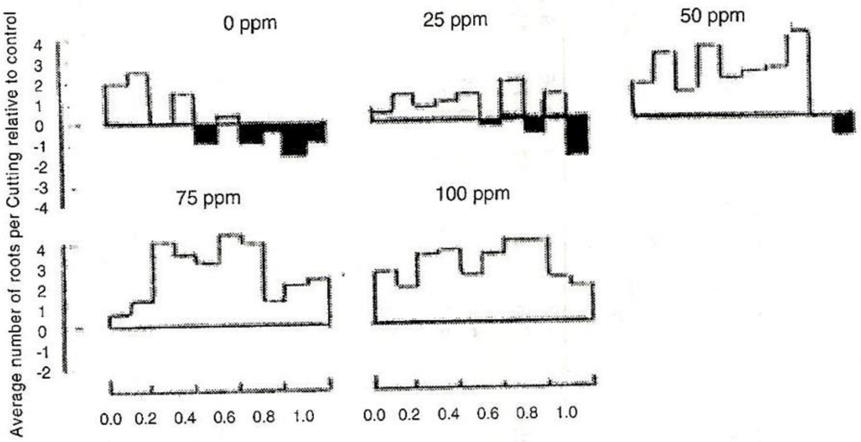

Figure (1.a) Histograms showing the biological activity at different Rfs of extracts of mature cotton leaves sprayed with IAA at the start of flowering as bioassayed by cowpea test.

Such results, in general, confirm the conception that IAA plays a part in the abscission of leaves as reported by Goodwin and Mercer (1985), who observed that the sequence of events leading to leaf abscission commences with a marked reduction in the production of auxin in the leaf. This allows progressive senescence of the leaf to take place. Thus, application of auxin may delay leaf abscission by delaying the onset of senescence.

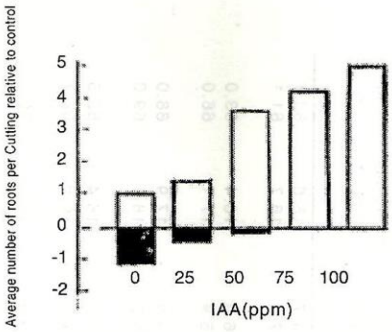

Figure (1.b) Changes in endogenous units of promotion and inhibition.

Vegetative and growth characters

Data presented in Table (2) show clearly the ability of IAA to stimulate cell elongation. It increased significantly cotton plant height, gradually as IAA concentration was raised. The increase in plant height amounted to 27.8 - 28.3% in plants treated with 100 ppm IAA as compared to the control plants. Osman *et al.* (1985) reported that IAA at 25 and 50 ppm increased significatly cotton plant height. On the other hand, similar results were observed for dry weight of cotton plants and such results may be attributed to the fact that IAA stimulates the synthesis of all types of RNA (mRNA, tRNA and rRNA) in elongating sections of cotton plants and this will lead to synthesize new cell wall polysaccharides, which could be accomplished by promoting the sythesis of more polysaccharide-synthesizing enzymes or by activation of those already present.

The results also show that IAA application increased significantly the number of fruiting branches per plant in the two seasons. This effect was more pronounced when 50 ppm IAA was applied. Similar significant effects were observed for number of flowers per plant as well as number of total bolls per plant producing the highest boll setting percentage especially in plants treated with 50 ppm IAA. This may be due to the fact that higher contents of polyphenols were translocated from site of synthesis in leaves (Table 1) to their site of action in boll, and the decrease in boll shedding (Abdel-Al, 1981; Fadl *et al.*, 1982). On the other hand, Abdel-Al *et al.* (1982) added that the reduction in young boll shedding was connected with an increase in total polyphenols in such bolls.

Table 2. Effect of application of IAA at the start of flowering of cotton plants on the vegetative and growth characters of cotton in 1997 and 1998 seasons (measured at harvest).

IAA treatments (ppm)	Season	Plant height (cm)	Dry weight (stem + branches) gm	Number of fruiting branches/ plant	Number of flowers per plant	Number of total bolls per plant	Boll setting %
O(control)	1997	115.7	108.2	14.3	24.7	15.6	63.1
	1998	120.2	112.6	15.2	27.3	16.7	61.1
25	1997	122.2	158.4	15.5	26.0	16.4	63.0
	1998	131.6	164.6	16.2	25.9	17.1	66.0
50	1997	133.7	166.1	16.3	26.3	17.9	68.0
	1998	136.4	178.6	17.0	26.2	18.1	69.0
75	1997	138.0	179.7	15.0	25.8	16.4	63.5
	1998	140.4	189.3	16.0	27.2	16.9	62.1
100	1997	148.5	206.6	12.0	20.6	10.3	50.0
	1998	153.7	213.4	13.7	20.7	11.0	53.1
LSD at 0.05	1997	3.35	1.06	1.43	0.32	1.47	2.08
	1998	2.31	0.98	1.37	0.30	0.81	1.86

Yield and yield components

It could be noticed from Table (3) that most concentrations of IAA increased significantly the number of open bolls per plant, with applying 50 ppm IAA producing the highest number of open bolls/plant during the two seasons. On the other hand, applying 100 ppm IAA produced less number of open bolls/plant. It appears that IAA at high concentration acts as an inhibitor that depresses fruiting capacity and on the contrary, it could act as a promoter for the vegetative growth (Table 2).

Results also show that boll weight was increased significantly during the two seasons when IAA was applied with various concentrations. The heaviest bolls were produced from plants treated with 100 ppm IAA. In this concern, Fadl *et al.* (1982) and Osman *et al.* (1985) showed that all doses of IAA increased the number of bolls and boll weight. Similar significant effects were observed for increasing seed index in two successive seasons. Mohamed *et al.* (1990) attained similar results, but they sprayed IAA at 50 and 100 ppm after one week from start of flowering. However, Sawan *et al.* (1989) reported that seed index was increased with IAA application.

Data in Table (3) show that different concentrations of IAA did not exert significant effects on lint percentage during two seasons as compared with the control plants. The results also reveal that earliness was significantly affected by different concentrations of IAA applied at start of flowering. It is worth to note that plants treated with 50 ppm IAA achieved the earliest yield.

Concerning the effect of IAA on seed cotton yield of cotton plants, the data reveal that IAA in general seemed to increase significantly seed cotton yield (kentar/feddan) especially when applied at rates of 25, 50 or 75 ppm at flowering stage. The highest yield was obtained from plants treated with a concentration of 50 ppm. The increase in yield may be mainly due to the increase in one or more of the flowering characters i.e. number of flowers/plant, number of open bolls/plant, setting percentage, average of boll weight or seed index produced from healthy treated plants in two seasons. However, the lowest yield was recorded for plants treated with the higher rate of IAA (100 ppm) and such decrease may be due mainly to that IAA induced the vegetative growth in these plants on the expense of the fruiting growth. This was more pronounced with plants of high dry weight with lower boll setting (Table 2). In this concern, Sawan *et al.* (1989 reported that seed cotton yield increased with application of IAA. On the other hand, Lah and Shastri (1976) pointed out that application of 150 ppm IAA at the flowering stage reduced the percentage of boll shedding and consequently increased seed cotton yield.

Table 3. Effect of application of IAA at the start of flowering of cotton plants on yield and yield components as well as fiber properties of cotton in 1997 and 1998 seasons

IAA (ppm)		NO. of Bolls/ plant	Boll weight (gm)	Seed index (gm)	Lint %	Earliness %	Seed cotton yield kentar/fed.	Fiber properties	
								Micronaire reading	Pressely index
0 (control)	1997	14.2	2.55	8.82	35.4	60.0	6.4	3.6	9.8
	1998	15.3	2.62	9.31	35.0	60.4	6.6	4.0	11.1
25 ppm	1997	15.7	2.64	9.03	36.1	61.2	6.7	3.7	9.8
	1998	16.4	2.83	9.79	35.1	26.1	6.8	4.1	10.2
50 ppm	1997	17.0	2.82	9.14	36.9	69.3	7.3	3.9	9.2
	1998	17.8	2.96	9.98	35.5	69.0	7.4	4.3	10.1
75 ppm	1997	15.2	2.88	9.25	36.8	63.5	6.8	3.8	9.6
	1998	15.6	3.00	10.00	35.4	62.2	6.9	4.0	10.3
100 ppm	1997	9.1	2.96	9.39	36.2	67.5	5.0	3.7	9.7
	1998	10.1	3.04	10.10	35.3	65.4	5.2	3.9	10.2
LSD at 0.05	1997	0.20	0.17	0.16	NS	0.42	0.20	NS	NS
	1998	0.13	0.12	0.07	NS	0.20	0.16	NS	NS

Fiber properties

Data presentted in Table 3 showed that during the two seasons, no significant differences were observed in fiber properties i.e. micronaire reading or Pressely index due to the application of different concentrations of IAA at the start of flowering. Sawan (1986) reported that foliar application of IAA generally had no effects on fiber properties with slight improvement.

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تأثيرأندول حمض الخليك على بعض المكونات الداخلية وعلاقتها بمحصول القطن

جمالات عبد العزيز وهدان

معهد بحوث القطن – مركز البحوث الزراعية – الجيزة

أجريت تجربتان حقليتان عامى ١٩٩٧ و ١٩٩٨ على صنف القطن صنف جيزة ٨٥ لدراسة تأثير رش الأكسين الطبيعى إندول حمض الخليك على نباتات القطن فى بداية مرحلة التزهير فى محطة البحوث الزراعية بمركز البحوث الزراعية بالجيزة رشاً بخمسة تركيزات (صفر ، ٢٥ ، ٥٠ ، ٧٥ ، ١٠٠ جزء فى المليون) وقد أوضحت النتائج ما يلى :

إن إضافة حمض الخليك كان له أثرا معنوياً على معظم المكونات الكيمائية لأوراق القطن مثل الكلورفيل أ والسكريات الذائبة الكلية والمركبات الفينولية وخاصة العديدة . وتم أيضاً دراسة التغير فى مستوى المواد المنشطة فى هذه الأوراق حيث أحتوت الأوراق المعاملة بالأكسين أقل كمية من المثبطات وعند رش النباتات بمعدل ٧٥ و ١٠٠ جزء فى مليون من الأكسين الطبيعى إحتوت أوراقهاعلى تركيز عالى من المواد المنشطة والتى دفعت النباتات إلى النمو الخضرى حيث أدت إلى زيادة معنوية فى طول النباتات وأيضا فى الوزن الجاف . وكان انسب تركيز للاكسين عند معدل ٥٠ جزء فى المليون حيث أدت إلى زيادة فى عدد الأزهار وعدد اللوز الكلى للنبات الواحد وأيضا زيادة نسبة العقد بينما أدت معاملة النباتات بالاكسين بمعد ل ١٠٠ جزء فى المليون إلى إنتاج أقل عدد من اللوز المتفتح لكل نبات . وعموما أدت المعاملة بالأكسين إلى زيادة معنوية فى متوسط وزن اللوزة ووزن كل بذرة والتبكير فى المحصول وكانت الزيادة معنوية فى محصول القطن الزهر عند إستخدام تركيز ٥٠ جزء فى المليون من الأكسين بينما أدى إستخدام تركيز ١٠٠ جزء فى المليون إلى إنخفاض فى المحصول وهذا راجع إلى النمو زيادة النمو الخضرى على حساب النمو الثمرى كما أن لم يكن لهذه المعاملات أى تأثير معنوى على نسبة تصافى الحليج أو صفات التيلة.