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EFFECT OF CERTAIN GROWTH SUBSTANCES ON GROWTH, CHEMICAL COMPOSITION, AND PRODUCTIVITY OF EGYPTIAN COTTON, GIZA 95 VARIETY UNDER TWO PLANTING DATES

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ABSTRACT: Two field experiments were executed during the 2021 and 2022 seasons at Sids Agricultural Research Station, in Beni-Suef Governorate, Egypt to study the effect of foliar spraying with two growth regulators, i.e. indole -3- butyric acid (IBA) at two levels (20 and 50 ppm) and 1-naphthalene acetic acid (NAA) at two levels (30 and 50 ppm) in addition to the control (spraying only water) under two planting dates (during April and May) and their interactions, on growth, chemical composition, water relations, fiber quality, and productivity of cotton Giza 95 var. Data indicated that early planting date (1st April), foliar spraying with 50 ppm of IBA and their interactions resulted in significant increase on leaf photosynthetic pigments, total soluble sugars, N, P, K, IAA, GA3, and kinetin concentration, leaves total water content and relative water content in both seasons and significantly decreased proline, phenols, ABA, and plasma membrane permeability (which supports and confirms membrane integrity). In addition, early planting date (1^{st} April) and foliar spraying with 50 ppm of IBA resulted in a significant increase in sympodia, open bolls number/plant, earliness percentage, and seed cotton yield/fed in both seasons, boll weight, and seed index in the second season only. The interaction between them gave the best results. It is advisable to apply early sowing and spraying IBA at 50 ppm twice (at start and top of flowering) to realize the most efficient effects on improving productivity and increasing the efficiency use of heat units.

Key words: Cotton; Indole -3- butyric acid (IBA); Growth regulators; IAA, Kinetin; Abscisic acid; Proline; Phenols.

INTRODUCTION

Cotton fibers and seeds are important for the local textile industry, export, oil production for Egyptian food, and residual meals from oil extraction is use for animal feed (Mahdy *et al*., 2017). Cotton requires good management practices to attain a good yield. The tolerable of the variety in the district is essentially due to planting time management (Sekloka *et al*., 2008). It is quite sensitive to climatic situations (Gormus and Yucel, 2002). Cotton seeds were sown before or after the optimal time and conducted poor production (Soomro *et al*., 2000) as a result of disease and pest problems. Sowing too early relates to risks inclusive of cool ambient and soil temperatures (Pettigrew, 2002; Bozbek *et al*., 2006), humid climate and physical resistance (Guthrie, 1991), seedling disease, and insect pressure (Pettigrew, 2002). It has been found that late sowing in general leads to lower production and quality due to the short period of fruiting (Bange *et al*., 2008), frequent infestation by late-season insects, particularly bollworms, and retarded maturity due to retarded flowering that prompts boll-grown inside windy cold weather (Gormus and Yucel, 2002). The temperature had a significant effect on planting time management. O'Berry *et al*. (2008) indicated that early planting is more beneficial when more amount of heat units accumulated early in the season because the plants mature and harvest before the stormy weather subsides. In environments like Sids, Egypt 'The cumulation of thermal units was higher near planting, and even a one -week delay in planting led to a noticeable decrease in cotton productivity" (Soomro *et al*., 2000). Early planting cotton production system has the potency to ameliorate

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yield and quality due to ideal climatic situations (Bozbek *et al*., 2006), shift the flowering period earlier and allow the crop to grow under a more favorable climate pattern and escape late-season insects due to extended flowering period and bolls retention (Killi and Bolek, 2006). Dong *et al*. (2006) also described a more frequent appearance of early senescence in early plants. Rahman *et al*. (2007) reported that the reproductive phase of early planted cotton synchronizes with the hottest month of the year causing a severe decline in the production.

In recent years, heat strain has been known as a main abiotic factor of worry for cotton output in the arid area. This issue becomes more severe during the summer monsoon months as air temperatures and relative humidity rise. The main effect of heat strain on cotton is reduced fruit retention, resulting in decreased fiber quality and yield (Brown, 2008). Cotton yield relies on rates of growth and flower production, rates of flower and boll retention, as well as the individual bolls size through the reproductive stage (Reddy *et al.,* 1992 a). Each of these processes is affected by various abiotic factors, of which the ambient air temperature has been known as the main factor (Reddy *et al*., 1992 b). Mahdi *et al*. (2019) reported that early planting (1st April) is suitable for the Egyptian cotton genotypes, especially Giza 95, through the appropriate climatic window that corresponds to the different growth stages to produce higher production by creating a good equilibrium between vegetative growth and fruiting ability and maximizing the activity utilization of heat thermal units. The most important and most manageable factor for cotton yield is the optimal time to plant the new variety in the area (Iqbal *et al*., 2023). The environment change affects agricultural production by affecting managing practices like planting time. Sowing time is also one of the major factors affecting the yield of seed cotton. Cotton production is a form of production that depends on environmental conditions. Cotton should be planted from beginning March to mid of April for maximum yield and quality (Iqbal *et al*., 2021).

Plant growth substances are considered one of the most important factors that affect the plant's physiological and morphological characteristics and have an important role in cotton production and quality. Naphthalene Acetic Acid (NAA) as an exogenous auxin plays a key role in cell elongation and division, vascular tissue, discrimination, root initiation, apical dominance, leaf senescence, leaf and fruit abscission, fruit set, and flowering (Davies, 1987). Parveen *et al.* (2017) found that NAA application significantly increased growth, chlorophyll content, yield, and yield components. The use of growth regulators causes difference in chlorophyll content in the plant via increasing synthesis of chlorophyll and decreasing chlorophyll degradation. Application of synthetic auxin such as NAA may induce rapid cell division and elongation in the developing part of plants due to effective transport and utilization of the metabolic products of photosynthesis and by enhancing the rate of photosynthesis (Nateh *et al*., 2005). Sawan and Sakr (1998) found that NAA increased the open bolls number/plant, boll weight, seed index, and seed cotton yield ha^{-1}. Lint%, fibre length traits and micronaire value were not significantly affected by NAA. Abdel-Al *et al*. (1982) found that the lowering shedding of young bolls in the case of NAA application is associated with a rise in the content of total phenols and polyphenols in young bolls. This may be due to the indirect effect of polyphenols in preventing indole acetic acid (IAA) oxidase activity, but it tends to minimize the incidence of the bolls shedding% (Addicott,1970). Exogenous auxin enhances chloroplasts photophosphorylation (Tamas *et al*., 1972), carbon dioxide fixation (Bidwell and Turner, 1966) and activates photosynthetic products transport to flowering buds (Zheng and Zu, 1982). Varma (1979) stated that NAA as an auxin preserves continuous function of physiological and biochemical and mobilizes nutrients through drawing assimilates to stronger sinks. This in turn leads to an increase the formation and weight of fully matured bolls. However, Sarlach and Sharma (2012) found that NAA application did not have any significant effect on quality parameters such as lint percentage and seed index. Moreover, it was found that indole-3-butyric acid is perhaps the best substance for general use, because it is non-toxic to plants in a wide concentration range and is effective in encouraging the rooting of many plant species (Hartmann and Kester, 1990).

This study aimed to assess the proper planting date and the effect of foliar spraying with two growth regulators indole -3- butyric acid (IBA) and 1-naphthalene acetic acid (NAA) at two levels on morphophysiological and yield characteristics of the Egyptian cotton cultivar Giza 95 grown under the environmental conditions of Sids region.

MATERIAL AND METHODS

Two field experiments were conducted during the two growing seasons of 2021 and 2022. The experiment took place at Sids Agricultural Research Station, ARC at Beni-Suef Governorate; 29°06'20.4" N; 31°07'21.6" E, Egypt using the Egyptian cotton cultivar Giza 95 (*Gossypium barbadense* L.) to study the effect of foliar spraying with two growth regulators indole -3- butyric acid (IBA) at two levels (20 and 50 ppm) and 1-naphthalene acetic acid (NAA) at two levels (30 and 50 ppm) in addition to the control (spraying water) under two planting dates (during April and May) and their interactions on growth, chemical composition, water relations, fiber quality and productivity of cotton. Treatments were arranged in a split plot design with three replicates. The main plots were assigned for the two planting dates as follows:

a_1- Early planting date (first April in both seasons) serving as a control.

a_2- Late planting date (10 May in the first season and 16 May in the second season).

The sub-plots contained the growth substances treatments as follows:

b_1- Sprayed with tap water as a control.

b_2- Foliar spraying with 1-naphthalene acetic acid (NAA) at 30 ppm.

b_3- Foliar spraying with 1-naphthalene acetic acid (NAA) at 50 ppm.

b_4- Foliar spraying with indole -3- butyric acid (IBA) at 20 ppm.

b_5- Foliar spraying with indole -3- butyric acid (IBA) at 50 ppm.

Indole -3- butyric acid (IBA) and 1-naphthalene acetic acid (NAA) were obtained from El-Gomhouria Company for Chemicals - Tanta City - Arab Republic of Egypt.

The plot area was 12 m^2, (5 ridges, 4 m long and 60 cm apart). Distance between hills was 25 cm leaving two plants per hill at thinning time (after 21 days from sowing).

The two growth substances were foliar spraying two times (at the start of flowering and the top of flowering) using Tween 20 as a non-ionic surfactant at a concentration of 0.05% on the leaves till dropping using hand-operated sprayer compressed at a low volume of 200 liters per feddan. Other cultural practices were carried out as recommended for the conventional planting.

Before sowing, soil samples representing the surface layer (0-30 cm) were collected and analyzed according to the procedures described by Estefan *et al*. (2013), and the data are shown in Table 1.

Crop management: Recommended fertilization of N and P (45 kg N +22.50 kg P_2O_5/fed) were used as reported by Cotton Research Institute, Agricultural Research Center, Egypt. Phosphorus fertilizer as calcium superphosphate (15.5% P_2O_5) was added before sowing. Nitrogen was applied in urea form (46% N) in two equal splits, immediately before the first and the second irrigations. Potassium fertilizer was foliar sprayed three times (at the squaring stage, flowering initiation, and 15 days later) as Potassein P at a rate of one liter/feddan.

Table 1. Mechanical and chemical analysis of the two experimental soil sites.

Particulars	Season	
	2021	**2022**
Mechanical analysis		
Clay%	52.31	53.42
Silt%	30.45	30.39
Sand%	17.24	16.19
Texture	Clayey	Clayey
Chemical analysis		
pH	7.60	7.39
EC ds/m	0.95	1.13
Organic matter %	1.23	1.33
Available N (ppm)	23.05	29.00
Available P (ppm)	11.9	12.8
Exchangeable K (ppm)	215	225

Climatic conditions and heat unit accumulations

Climatic conditions and heat unit accumulations (Degree-day heat units) were monitored using in Department of Meteorology, Agricultural Research Center. Monthly average of maximum (Max. T.), minimum (Min. T.) and mean air temperatures (Mean, T.) in the Sids station during the 2021 and 2022 seasons are shown in Table (2). The data covered the period from the start of sowing to the harvesting stage. Average air temperatures (°C) through the growing seasons were recorded to calculate heat units (HU). Heat units (HU) were calculated according to Sutherland (2012) equation as follows:

Degree-day heat units (HU) = mean daily temperature – Base temperature

(Base temperature = zero growth =15.6 °C).

The efficiency use of heat units through the growing season by cotton plants estimated by the following equation referred by (Makram *et al*., 2001):

Efficiency use of heat units (HU/boll) = total heat units through the whole season/number of open bolls per plant

Monthly accumulation and total heat units (HU) during the cotton growth period in Sids station during the 2021 and 2022 seasons are shown in Table (2).

Data measurements

I-Chemical composition of leaf: Twenty leaves representing the upper fourth leaf were collected after 15 days from the second application of growth regulators to determine leaves chemical composition (chlorophyll a, chlorophyll b, carotenoids, total soluble sugars (mg/g d. wt.), N%, P%, K%, phenols (mg Caticole/100 g d. wt.), proline (µg Leucine/g d. wt.), and endogenous phytohormones content indole acetic acid (IAA), GA_3, Kinetin and abscisic acid (ABA) (µg / 100 g f. wt.) according to AOAC (2005).

II- Water relations: Total water content (TWC, %) was determined according to the methods described by Gosev (1960) and Kreeb (1990). Relative water content (RWC, %) was determined by using the method of Barrs and Weatherley (1962). Plasma membrane permeability (PMP, %) was determined according to Yan *et al*. (1996).

III- Plant growth parameters: At harvesting final plant height (cm) and sympodia number/plant were determined.

VI-Yield and yield components: Number of open bolls/plant, boll weight (g), and seed index (g) were recorded. Seed cotton yield in kg per sub-plot transformed into kentars per fed and yield earliness was estimated as the percentage of 1st pick yield to total yield.

V- Fiber properties: The following properties of the fiber samples were made at the laboratories of the Cotton Technology Research Division, Cotton Research Institute, ARC, Egypt according to ASTM (2012). Fiber upper half mean length in mm (UHML) and uniformity index (%) were measured on a digital fibrograph. Fiber fineness (micronaire reading) was tested on a micronaire instrument. Fiber strength (Pressley index) was tested by the Pressley tester.

Statistical analysis

All collected data were statistically analyzed with a split-plot design according to Snedecor and Cochran (1989). The treatment means were compared using LSD at a 5% level of probability.

Table 2. Monthly average of maximum, minimum, and mean air temperatures (°C), monthly accumulation and total heat units (HU) during the cotton growth period in Sids station during the 2021 and 2022 seasons.

Month	Air temperature (°C)			Monthly accumulation of heat units	Monthly accumulation of heat units
	Max. T.	Min. T.	Mean T.	Early sowing	Late sowing
2021 season					
April	32	17	24.5	267.0	-----
May	38	23	30.5	461.9	327.8
June	37	23	30.0	432.0	432.0
July	39	26	32.5	523.9	523.9
August	40	26	33.0	539.4	539.4
September	37	23	30.0	432.0	432.0
			Total heat units (HU)	**2656.2**	**2255.1**
2022 season					
April	35	18	26.5	327.0	----
May	36	20	28.0	384.4	198.4
June	39	24	31.5	477.0	477.0
July	39	25	32.0	508.4	508.4
August	40	25	32.5	523.9	523.9
September	38	24	31.0	462.0	462.0
			Total heat units (HU)	**2682.7**	**2169.7**

RESULTS AND DISCUSSION

I- Chemical composition

I-1. Effect of planting date

Early planting date (1st April) resulted in a significant increase in leaf photosynthetic pigments (chlorophyll a, chlorophyll b, and carotenoids), total sugars, N, P, K, IAA, GA3, and kinetin concentration in both seasons, and significantly decreased proline, phenols and ABA compared to late planting date in May, (Tables 3, 4, 5, and 6). These results may be due to an increase in the air temperature and heat units, where in delaying planting date accumulated temperatures degrees above the zero point of growth were increased and consequently respiration increased and in turn leaf total carbohydrate content decreased. Leaf photosynthesis is an important biological process that directly influences plant growth and productivity (Wilson *et al*., 2012). In our results, concentrations of leaf photosynthetic pigment significantly increased when cotton plants were exposed to low temperature with planting early on 1st April compared to late planting date in May (Table 2). These results could be elucidated on the basis that by lowering the temperature, respiration may increase up to an optimal degree. In this concern, Perry and Krieg (1981) reported that temperatures above 32°C, are related with decreased photosynthesis and carbohydrate production. Burke *et al*. (1988) reported that the temperature range of cotton for optimal metabolic activity, known as the thermokinetic window, is between 23-32 °C, and the optimum temperature for photosynthesis is 28°C. Al-Khatib and Paulsen (1984) and Harding *et al.* (1990) discovered comparable variations in photosynthesis under thermal stress that were linked to chlorophyll loss and the alteration of chlorophyll a to b ratio. El-Shazly *et al.* (1998) found that the early planting date (March 15th) significantly increased leaf concentration of N, P, and K in both seasons as compared to mid and late-sowing dates (April 5th and April 26th). Ali (2012) reported that average total soluble carbohydrates tended to decrease drastically as the planting date is delayed. El-Ashmouny (2014) reported that planting cotton on 15th April gives the highest values in leaf chlorophyll a, chlorophyll b, total chlorophyll, and carotenoids content compared to the other planting dates (30th April or 15th May). Delaying the planting date significantly increased leaf proline and phytohormone ABA concentration (Tables 4, 5, and 6), which indicated unfavorable plant conditions, and this reflects on the increased environmental stress effect.

Table 3. Effect of planting date and certain growth substances as well as their interactions on photosynthesis pigments (mg/g d. wt.) in the leaves of Egyptian cotton, Giza 95 variety in 2021 and 2022 seasons.

Traits / Treatments		Chlorophyll a	Chlorophyll b	Carotenoids	Chlorophyll a	Chlorophyll b	Carotenoids
		Season 2021			Season 2022		
A-Planting date:							
a_1-Early		3.89	1.24	2.49	4.81	2.04	3.46
a_2-Late		3.10	1.14	1.97	3.16	1.43	2.32
LSD at 5%		**0.21**	**0.02**	**0.24**	**0.93**	**0.19**	**0.02**
B- Growth substances concentration:							
b_1-Control		3.22	1.15	2.09	3.24	1.40	2.21
b_2- NAA 30 ppm		3.37	1.18	2.16	3.76	1.59	2.56
b_3-NAA 50 ppm		3.48	1.20	2.20	4.04	1.72	3.05
b_4-IBA 20 ppm		3.54	1.22	2.26	4.36	1.82	3.24
b_5-IBA 50 ppm		3.86	1.24	2.44	4.54	2.17	3.40
LSD at 5%		**0.07**	**0.05**	**0.13**	**0.08**	**0.04**	**0.02**
A B Interaction:							
a_1	b_1	3.64	1.22	2.38	3.76	1.68	2.70
	b_2	3.81	1.22	2.45	4.43	1.79	2.82
	b_3	3.88	1.24	2.45	4.99	1.99	3.64
	b_4	3.92	1.26	2.51	5.26	2.08	3.94
	b_5	4.18	1.28	2.66	5.59	2.67	4.21
a_2	b_1	2.80	1.07	1.80	2.72	1.11	1.72
	b_2	2.93	1.13	1.87	3.08	1.39	2.30
	b_3	3.07	1.15	1.95	3.08	1.44	2.46
	b_4	3.16	1.18	2.01	3.45	1.56	2.54
	b_5	3.53	1.19	2.21	3.49	1.66	2.58
LSD at 5%		**0.10**	**0.07**	**0.18**	**0.11**	**0.06**	**0.03**

Table 4. Effect of planting date and certain growth substances as well as their interactions on total soluble sugars, N, P, K, phenols, and proline concentration in leaves of Egyptian cotton, Giza 95 variety in 2021 season.

Traits / Treatments		Total soluble sugars	N	P	K	Phenols	Proline
		(mg/g d. wt.)	(%)			(mg Caticole /100 g d. wt.)	(µg Leucine/g d. wt.)
A-Planting date:							
a_1-Early		26.52	2.62	0.486	3.56	27.00	337.76
a_2-Late		23.52	1.92	0.397	2.77	32.57	545.58
LSD at 5%		**0.58**	**0.03**	**0.01**	**0.58**	**0.01**	**7.09**
B- Growth substances concentration:							
b_1-Control		22.40	2.01	0.414	2.92	32.03	535.00
b_2- NAA 30 ppm		24.83	2.12	0.424	3.00	30.78	520.61
b_3-NAA 50 ppm		25.80	2.30	0.439	3.15	28.99	401.67
b_4-IBA 20 ppm		25.64	2.29	0.449	3.26	28.62	394.50
b_5-IBA 50 ppm		26.44	2.65	0.484	3.48	28.52	356.59
LSD at 5%		**0.18**	**0.03**	**0.001**	**0.18**	**0.06**	**4.85**
A B Interaction:							
a_1	b_1	25.71	2.33	0.457	3.28	28.28	507.50
	b_2	25.89	2.47	0.469	3.41	28.20	487.63
	b_3	26.52	2.61	0.485	3.57	26.27	286.00
	b_4	26.98	2.72	0.495	3.71	26.20	239.00
	b_5	27.49	2.99	0.524	3.81	26.07	168.67
a_2	b_1	19.09	1.68	0.371	2.56	35.78	562.50
	b_2	23.77	1.76	0.378	2.59	33.36	553.58
	b_3	25.08	1.99	0.393	2.73	31.71	517.33
	b_4	24.30	1.85	0.402	2.81	31.03	550.00
	b_5	25.38	2.30	0.443	3.15	30.97	544.50
LSD at 5%		**0.25**	**0.04**	**0.002**	**0.26**	**0.08**	**6.79**

Regarding leaf proline content, data in Tables 4 and 5 showed that planting date had a determining impact on leaf proline content. Delaying planting date significantly increased leaves proline content, where the values increased from 337.76 and 401.06 µg Lucine/g d. wt. in the early planting date to 545.58 and 557.23 µg Lucine/g d. wt. in the late planting date in 2021 and 2022 seasons, respectively. Direct damages caused by high temperatures include denaturation of protein, aggregation, and increased membrane lipids fluidity. Indirect or slower heat damages include enzymes inactivation in chloroplast and mitochondria, protein synthesis suppression, protein decay and membrane integrity injury (Howarth *et al.*, 2005). Proline is an amino acid and appropriate solute that typically accumulates in plants exposed to unsuitable temperatures. Higher leaf concentration of proline under late sowing a good biochemical index for the temperature stress effect. The higher proline accumulation is favorable to cotton plants, due to its effect on the stabilization of proteins, macromolecules protection of denaturation and osmosis as well as protection of membranes. It acts as a free radical scavenging, anti-oxidation and as a readily available energy supply and power limitation (Stewart and Lee, 1974). Proline can act as an electron receptor preventing photosystem injuries in dealing with ROS function (Jamal *et al*., 2015). In this concern, Paleg *et al.* (1981) demonstrated that several solutes, including proline, protected enzymes isolated from various tissues from inactivation by heat. de Ronde *et al*. (2000) added that proline can be accumulated under high temperature in cotton leaves.

Table 5. Effect of planting date and certain growth substances as well as their interactions on total sugars, N, P, K, phenols, and proline concentration in **leaves of Egyptian cotton, Giza 95 variety in 2022 season.**

Treatments \ Traits		Total soluble sugars	N	P	K	Phenols	Proline
		(mg/g d. wt.)	(%)			(mg Caticole /100 g d. wt.)	(µg Leucine/g d. wt.)
A-Planting date:							
a_1-Early		23.15	2.64	0.500	3.32	30.41	401.06
a_2-Late		21.58	2.04	0.422	2.62	38.17	557.23
LSD at 5%		**0.14**	**0.05**	**0.01**	**0.14**	**0.02**	**9.11**
B- Growth substances concentration:							
b_1-Control		21.02	2.10	0.434	2.74	36.19	535.33
b_2- NAA 30 ppm		22.40	2.23	0.444	2.85	35.83	574.45
b_3-NAA 50 ppm		22.66	2.37	0.458	2.95	33.72	443.42
b_4-IBA 20 ppm		22.76	2.39	0.473	3.08	33.43	460.59
b_5-IBA 50 ppm		23.01	2.63	0.498	3.25	32.28	381.95
LSD at 5%		**0.11**	**0.05**	**0.01**	**0.11**	**0.06**	**5.43**
A B Interaction:							
a_1	b_1	22.80	2.37	0.473	3.04	33.33	524.23
	b_2	22.92	2.50	0.482	3.19	32.81	566.98
	b_3	23.07	2.63	0.500	3.34	29.45	367.82
	b_4	23.38	2.78	0.509	3.50	28.98	320.70
	b_5	23.60	2.94	0.535	3.55	27.48	225.57
a_2	b_1	19.23	1.82	0.395	2.44	39.05	546.43
	b_2	21.87	1.95	0.406	2.51	38.85	581.92
	b_3	22.24	2.11	0.415	2.56	37.99	519.02
	b_4	22.13	2.00	0.436	2.65	37.88	600.47
	b_5	22.41	2.32	0.460	2.94	37.08	538.33
LSD at 5%		**0.15**	**0.08**	**0.014**	**0.16**	**0.08**	**7.60**

Table 6. Effect of planting date and certain growth substances as well as their interactions on endogenous phytohormones content in leaves of Egyptian cotton, Giza 95 variety in 2022 season.

Phytohormones / Treatments		Activators			Inhibitor
		IAA	GA_3	Kinetin	ABA
		(µg / 100 g f. w.)			
A-Planting date:					
a_1-Early		837.82	17673.4	2409.32	18.62
a_2-Late		438.5	11909.8	941.08	44.86
B- Growth substances concentration:					
b_1-Control		419.3	12549	946.55	46.55
b_2- NAA 30 ppm		511.35	13380.7	1241.05	37.15
b_3-NAA 50 ppm		607.2	14812.1	1527.5	34.4
b_4-IBA 20 ppm		724.25	16267.3	2029.2	22.25
b_5-IBA 50 ppm		928.7	16949	2631.7	18.35
A B Interaction:					
a_1	b_1	657.4	15689.1	1713.9	22.8
	b_2	677.2	16682.2	1726.7	19.8
	b_3	703.0	17075.2	2102.0	19.8
	b_4	900.0	19045.5	2672.3	16.8
	b_5	1251.5	19875.2	3831.7	13.9
a_2	b_1	181.2	9408.9	179.2	70.3
	b_2	345.5	10079.2	755.4	54.5
	b_3	511.4	12549.0	953.0	49.0
	b_4	548.5	13489.1	1386.1	27.7
	b_5	605.9	14022.8	1431.7	22.8

I-2. Effect of the growth substances used

Tables 3, 4, 5, and 6 showed that NAA or IBA increased concentrations of photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids), total soluble sugars, N, P, K, IAA, GA3, and kinetin in the leaves. However, they significantly decreased concentrations of proline, phenols, and ABA. In this regard, it was found that foliar application of NAA improved nutrient content in cotton (Patel, 1992). Abd El-Al *et al.* (1989) found that spraying cotton with 20 ppm IBA resulted in an increase in leaves pigments. The accumulation of more pigments in IBA treated plants may be due to increased utilization of this substance in metabolism or increased transfer rate from leaves to the developing plant. The rise in pigment level due to NAA application can be referred to its effect on the promotion of synthesis and/or delaying pigment degradation (Sharma *et al.*, 1995). Abdel-Gayed (2013) reported that IBA at 20 ppm significantly enhanced chlorophyll (a), and carotenoids. Parveen *et al*. (2017) found that the application of NAA causes a difference in plants chlorophyll content through increasing the chlorophyll synthesis and decreasing chlorophyll degradation. Volpert *et al*. (1995) and Arnaidos *et al.* (2001) attributed the positive effect of IBA on plant growth to the enhancing effect of IBA on cell division and its differentiation but not on biomass production after rooting. They added that phenolics are modulators of IBA catabolism. Some monophenols such as synaptic acid and ferulic acid, at low concentrations, inhibit enzymatic oxidation. The promoting effects of NAA on photosynthetic ability can be related to its stimulatory effects on tryptophan efficiency and pigment content (Khodary, 2004) in addition to increasing the assimilation of carbon dioxide, photosynthetic rate and increasing mineral uptake by the plant (Szepesi *et al*., 2005).

2-Effect of the interaction

The results in Tables (3, 4, 5, and 6) indicated that early sowing plants that received NAA or IBA at the high level (50 ppm) significantly increased cotton leaf photosynthetic pigments (chlorophyll a, chlorophyll b, and carotenoids), total soluble sugars, N, P, K, IAA, GA3, and kinetin, and significantly decreased proline, phenols, and ABA concentration in leaves as compared with the other interactions in both seasons.

II-Leaves water relations

II.1- Effect of planting date

Early planting date (1st April) significantly increased total and relative water content in cotton leaves and significantly decreased leaves' plasma membrane permeability (PMP, %) in both seasons (Table 7).

II.2- Effect of the growth substances used

Foliar spraying with NAA or IBA at 50 ppm resulted in a significant increase in total and relative water content in cotton leaves and a significant decrease in leaf plasma membrane permeability (which supports membrane integrity) in both seasons (Table 7).

II.3- Effect of the interaction

The results in Table 7 indicated that early sowing plants that received NAA or IBA at 50 ppm significantly increased leaf content of total water and relative water whereas significantly decreased leaf plasma membrane permeability (which supports and confirms the integrity of the membrane) in both seasons.

Table 7. Effect of planting date and certain growth substances as well as their interactions on water relations in leaves of Egyptian cotton, Giza 95 variety in 2021 and 2022 seasons.

Treatments \ Traits		TWC	RWC	PMP	TWC	RWC	PMP
		%					
		Season 2021			Season 2022		
A-Planting date:							
a_1-Early		86.97	75.56	44.30	82.15	70.95	35.37
a_2-Late		81.82	71.15	53.70	78.74	58.69	45.34
LSD at 5%		**0.21**	**0.02**	**1.24**	**0.93**	**0.19**	**0.02**
B- Growth substances concentration:							
b_1-Control		83.17	71.51	52.08	79.36	60.24	43.62
b_2- NAA 30 ppm		83.49	71.98	51.58	79.82	61.26	42.66
b_3-NAA 50 ppm		84.06	73.81	49.15	80.25	64.85	40.14
b_4-IBA 20 ppm		84.05	74.18	48.25	80.37	65.92	39.81
b_5-IBA 50 ppm		87.21	75.32	43.95	82.45	71.84	35.56
LSD at 5%		**0.07**	**0.19**	**0.43**	**0.80**	**0.04**	**0.02**
A B Interaction:							
a_1	b_1	85.89	73.84	49.09	81.02	65.05	38.89
	b_2	86.30	74.41	48.71	81.32	66.09	38.01
	b_3	86.67	75.67	44.96	81.55	68.98	35.66
	b_4	87.09	76.80	42.41	82.07	74.13	33.83
	b_5	88.90	77.07	36.35	84.81	80.52	30.48
a_2	b_1	80.44	69.18	55.07	77.69	55.42	48.34
	b_2	80.67	69.54	54.44	78.32	56.43	47.30
	b_3	81.45	71.94	53.34	78.95	60.72	44.62
	b_4	81.01	71.55	54.09	78.67	57.71	45.79
	b_5	85.51	73.56	51.54	80.08	63.15	40.63
LSD at 5%		**0.10**	**0.27**	**0.62**	**1.13**	**0.06**	**0.03**

III. Growth characters

III.1- Effect of planting date

Tables 8 and 9 showed that late sowing of cotton in May led to a significant increase in plant height (131.89 and 131.22 cm) in 2021 and 2022 seasons, respectively. Plant height decreased considerably to 123.13 and 122.97 cm at early sowing on 1^{st} April in the first and second seasons, respectively. The significant increase in plant height at harvest due to delayed planting could be related to increased internode length and rapid vegetative growth compared to early sowing which is exposed to comparatively low air temperature. On the other hand, it was found that early sowing on 1^{st} April significantly increased the sympodial branches number per plant by 16.90% and 14.73% than late sowing in May in both seasons (Tables 8 and 9). These increments may be due to the effect of temperature which was not very high at the early growth stage. Planting on 1^{st} April increased growth. For the early planting, most of the heat units were consumed to establish fruiting capacity while in the late planting time, they were used for excessive vegetative growth. Thus, early planting maximized the use of air heat units by increasing the efficiency use of heat units during the growing season which reduced the amount of heat units for bolls production. The plants grow well and possess more sympodial branches than late planting. Similar results were reported by Deho (2023) who evaluated two planting dates *viz*. 1^{st} April and 1^{st} May. He found that the crop sown on 1^{st} April produced more sympodial branches plant^{-1} while the number of sympodial branches plant^{-1} decreased in 1^{st} May sowing.

Plant height plays an important role in determining the morphological framework relating to plant type and canopy development in cotton. Final plant height is the function of main stem nodes and elongation of internodal space (Hake *et al*., 1989). Early sowing produced compact plants with a higher number of sympodia because of a longer growth period compared with late or unnormal planted cotton. Late planting obtained the highest number of heat units and led to increased vegetative growth (Makram *et al*., 2001).

III.2- Effect of the growth substances used

Data in Tables 8 and 9 showed that IBA at 50 ppm significantly increased number of sympodia/plant and reduced plant height at harvest. Revanappa (1993) reported that the effectiveness of NAA on increasing growth was mainly due to an increase in cell division, cell differentiation and cell expansion which enhance plant growth. Application of synthetic auxin like NAA may cause rapid cell division and cell elongation in the growing part of plants due to efficient translocation and utilization of photosynthetic metabolic products and by enhancing the rate of photosynthesis (Nateh *et al*., 2005).

Kumar *et al*. (2006) found that application of NAA (20 ppm) at 90 days after sowing (DAS) recorded higher plant height, number of main stem nodes and number of sympodia compared to control. Naphthalene acetic acid had a significant effect on plant height and division, cell differentiation and cell expansion which enhance the number of sympodia (Abro *et al*., 2004). Abdel-Gayed (2013) reported that IBA at 20 ppm significantly enhanced plant height, number of internodes/plant, and internode length. However, the number of sympodia responded only in one season.

III.3-Effect of the interaction

Results in Tables 8 and 9 indicated that early sowing plants that received IBA at 20 ppm significantly reduced plant height at harvesting. Early planting which received IBA at 50 ppm significantly increased the number of sympodia per plant in the second season, while the lowest value was obtained from untreated plants at the late planting.

VI. Yield and its components

VI.1- Effect of planting date

Time of planting exhibited significant differences in seed index and boll weight in the second season (Tables 8 and 9). The highest values resulted from the early planting date (first of April) and the lowest values were obtained from the late planting date. The positive effect of early planting on seed index and boll weight may be due to an increase in photosynthetic activity which increases accumulation of metabolites with direct impact on seed index. These increases may be due to the higher photosynthate build-up and prolonged boll development time as well as bigger boll size (Patel *et al*., 2015). High temperatures have a detrimental effect on boll development.

The same tables in this study indicated that the maximum numbers of open bolls (18.57 and 15.98 bolls/plant) were produced when the crop was sown on 1st April as compared with 14.37 and 12.39 bolls obtained from late-planted cotton in the first and second seasons, respectively. It was revealed that early planting had more ideal conditions that allowed the plant to produce a greater number of bolls per plant. An early sowing date significantly increased the open bolls number/plant due to the higher temperature to which plants were exposed when their bolls were maturing. Furthermore, the high temperatures reduce the time between flowering and boll opening, minimizing the time to maturity. In addition, high temperatures can reduce photosynthesis and increase respiration, resulting in reduced seed production, reduced lint development and unexpectedly lower yield. In the same order, high temperatures can reduce boll growth and retention due to reduced net photosynthesis after decreased growth and respiration at night, which reduces sink demand and prevents starch formation in the leaves (Yeates *et al*., 2013).

Table 8. Effect of planting date and certain growth substances as well as their interactions on growth and productivity of Egyptian cotton, Giza 95 variety in 2021 season.

Treatments \ Traits		Plant height (cm)	No. of sympodia plant^{-1}	No. of open bolls/plant	Boll weight (g)	Seed index (g)	Earliness %	Seed cotton yield (kentar/feddan)
A-Planting date:								
a_1-Early		123.13	15.91	18.57	2.53	10.42	83.69	12.56
a_2-Late		131.89	13.61	14.37	2.45	10.22	68.19	10.53
LSD at 5%		**0.33**	**0.69**	**0.88**	**NS**	**NS**	**0.85**	**0.31**
B-Growth substances concentration:								
b_1-Control		128.32	13.28	13.95	2.40	10.24	74.46	10.02
b_2- NAA 30 ppm		127.07	14.35	16.32	2.47	10.37	75.45	11.61
b_3-NAA 50 ppm		127.68	14.63	16.73	2.53	10.35	76.70	11.92
b_4-IBA 20 ppm		127.65	15.08	17.39	2.52	10.24	75.96	12.04
b_5-IBA 50 ppm		126.85	16.45	17.95	2.55	10.41	77.15	12.15
LSD at 5%		**0.62**	**0.26**	**0.28**	**NS**	**NS**	**0.53**	**0.71**
A B Interaction:								
a_1	b_1	122.50	14.33	15.63	2.45	10.29	82.99	10.87
	b_2	126.23	15.57	18.57	2.50	10.61	83.04	12.72
	b_3	123.30	15.87	19.03	2.55	10.16	84.07	12.97
	b_4	120.73	16.37	19.60	2.55	10.35	83.60	13.05
	b_5	122.90	17.43	20.00	2.60	10.69	84.77	13.21
a_2	b_1	134.13	12.23	12.27	2.35	10.18	65.92	9.17
	b_2	127.90	13.13	14.07	2.44	10.13	67.85	10.50
	b_3	132.07	13.40	14.43	2.50	10.54	69.32	10.87
	b_4	134.57	13.80	15.17	2.48	10.14	68.32	11.02
	b_5	130.80	15.47	15.9	2.50	10.12	69.53	11.10
LSD at 5%		**0.87**	**NS**	**0.40**	**NS**	**0.35**	**0.75**	**1.00**

NS= not significant at 5% level of probability.

Table 9. Effect of planting date and certain growth substances as well as their interactions on growth and productivity of Egyptian cotton, Giza 95 variety in 2022 season.

Treatments \ Traits		Plant height (cm)	No. of sympodia plant^{-1}	No. of open bolls /plant	Boll weight (g)	Seed index (g)	Earliness %	Seed cotton yield (kentar/feddan)
A-Planting date:								
a_1-Early		122.97	15.81	15.98	2.41	9.43	74.49	7.69
a_2-Late		131.22	13.78	12.39	2.32	9.22	59.17	6.82
LSD at 5%		**0.64**	**0.31**	**0.09**	**0.05**	**0.07**	**1.13**	**0.21**
B- Growth substances concentration:								
b_1-Control		127.65	13.47	10.65	2.25	9.29	64.82	5.91
b_2- NAA 30 ppm		126.67	13.98	13.75	2.32	9.37	65.98	7.05
b_3-NAA 50 ppm		127.77	15.00	14.95	2.36	9.36	68.05	7.57
b_4-IBA 20 ppm		126.78	15.13	15.52	2.42	9.23	67.20	7.77
b_5-IBA 50 ppm		126.62	16.40	16.05	2.50	9.38	68.09	7.97
LSD at 5%		**0.50**	**0.22**	**0.33**	**0.04**	**0.02**	**0.50**	**0.10**
A B Interaction:								
a_1	b_1	122.10	14.73	11.80	2.26	9.40	73.27	6.17
	b_2	125.73	15.00	15.07	2.35	9.61	73.79	7.65
	b_3	123.83	16.03	17.30	2.40	9.16	75.3	8.15
	b_4	120.70	16.23	17.70	2.45	9.33	74.76	8.12
	b_5	122.50	17.07	18.03	2.60	9.65	75.31	8.37
a_2	b_1	133.20	12.20	9.50	2.23	9.18	56.37	5.65
	b_2	127.60	12.97	12.43	2.29	9.13	58.17	6.45
	b_3	131.70	13.97	12.60	2.31	9.57	60.8	6.98
	b_4	132.87	14.03	13.33	2.38	9.13	59.63	7.42
	b_5	130.73	15.73	14.07	2.40	9.12	60.87	7.57
LSD at 5%		**0.70**	**0.31**	**0.48**	**0.05**	**0.05**	**0.71**	**0.14**

The maximum values of earliness (83.69% and 74.49%) were produced when the crop was sown on 1st April as compared with 68.19% and 59.17% obtained from late-planted cotton in the first and second seasons, respectively (Tables 8 and 9). It was revealed that early planting has better conditions that permitted the plant to produce a greater number of bolls per plant. Early planting significantly increased earliness% compared to late planting. This may be due to the relative decrease in air temperature at the beginning of the season for early planting (Table 2), which directs the cotton plants to maintain a balance between vegetative growth and fruiting ability and cotton plants took merit of soil moisture and nutrients for a longer growing season and produced more bolls. In contrast, late planting experienced a shorter reproductive period due to higher air temperatures and decreased photosynthesis in the canopy due to lower radiation objection (Gormus and Yucel, 2002; Liu *et al.*, 2015).

The yield of seed cotton is an additive result of its components in a particular environment. A highly considerable impact of planting dates on cotton productivity was observed (Tables 8 and 9). Early planting (1st April) enhanced seed cotton yield by 19.28% and 12.76% over late planting in 2021 and 2022 seasons, respectively. There was a significant decline in yield of seed cotton when cotton planting was delayed until May. Early sowing is associated with favorable environmental conditions before the start of monsoon and high temperatures during flowering and fruit development. Giza 95 variety, which was planted early on 1st April, caused a decrease in the efficiency values of heat units to produce one open boll which means an increase in the efficiency of using thermal air units, the data in Table (10) cleared that the minimum heat units required for producing one open boll (143.04 and 167.88 HU/boll) were produced when the crop was sown on 1st April as compared with 156.93 and 175.12 HU/boll obtained from late-planted cotton in the first and second seasons, respectively. Early sowing caused a decrease in the values of heat units required for producing one open boll, that means the increase in efficiency use of thermal air units. Therefore, most of the remaining heat units were consumed during the fruiting stage. This situation was not achieved in the case of delay in planting, because most of the thermal units were consumed in vegetative growth. The increased yield in the early sowing date can be explained by the fact that the early planted cotton benefited from maximum production air temperature (AT), and early harvest in the fall, which allowed the last bolls to develop. When the cotton was sown several weeks earlier, plants were able to gain the additional benefit of soil moisture and nutrients during the extended growing season, which allowed more flower buds to form and the last bolls to mature because of sufficient AT. Raising the daily minimum temperatures from the boll opening to stop growing could delay maturity and lengthen the growing season. Longer growing seasons increased the AT obtainable, resulting in more bolls reaching maturity. When planting was delayed, the time required for cotton buds to form was reduced due to the warmer days. While, at the end of the season, delayed sowing forced the bolls to develop into cooler weather and prolonged the time required from the anthesis to the first boll opening, resulting in lower yield. The yield increases with the length of growing season, depending on the planting dates. Gwathmey and Clement (2010) pointed out that, late planting, usually reduces cotton productivity due to delayed physiological maturity and lack of carbohydrates. Early-planted crops produced significantly higher yields and their components than late-sown crops (Tables 8 and 9).

Table 10. Effect of planting date on the efficiency use of heat units by cotton plant during 2021 and 2022 seasons.

Season	Early sowing (HU/boll)	Late sowing (HU/boll)
2021	143.04	156.93
2022	167.88	175.12

The significant increase in yield of seed cotton fed^{-1} of early planting compared to late planting dates is mainly due to the promoting effect of early planting on plant growth (Tables 8 and 9), leaves total sugar content (Tables 4 and 5) due to its promoted effect on leaves' photosynthetic pigments content; chlorophyll a, b, and carotenoids (Table 3), which reflects on the increase of photosynthates, N, P, and K concentrations due to early planting (Tables 4 and 5), which led to the significant increase in plant growth, highest open bolls number and heaviest bolls (Tables 8 and 9). Wright *et al*. (2015) reported that there are some reasons to set the cotton crop as quickly as probable and avoid depending on a late or top crop. Pest numbers tend to increase as the seasons progresses. Saving squares and young bolls late in the growing seasons is harder (and costly) than keeping an early crop. The increase may have been because the abscission-promoting effects of abscisic acid were counteracted when NAA was applied to either flower buds or young bolls (Varma, 1978). The higher seed cotton yield on the planting date (1st April) may be due to the availability of a longer growth period and establishment of good yield under moderate temperature at the beginning of the season. Late sowing of cotton reduces the traits sharing in the yield and finally the yield of seed cotton. Deho (2023) evaluated two planting dates *viz*. 1st April and 1st May. The data depicted those crops sown on the 1st April give rise to more seed cotton yield than those sown on the 1st May. The maximum values of bolls number plant^{-1}, ginning out turn percentage, and seed index were obtained on the 1st April sowing date while the minimum values of bolls number plant^{-1}, ginning out turn percentage and seed index took in 1st May sown crop. Jamro *et al*. (2017) investigated the impacts of sowing dates (1st, 10th, 20th, and 30th May) on the expansion and productivity of some cotton varieties and found that the 1st May was the most promising date for sowing as compared to the remaining sowing dates.

VI.2- Effect of the growth substances used

Tables 8 and 9 showed that the open bolls number/plant, earliness index, and yield of seed cotton fed^{-1} in both seasons, boll weight, and seed index in the second season were increased due to the application of IBA at 50 ppm two times. Several open bolls/plant (17.95 and 16.05 boll), earliness index (77.15 and 68.09%) and yield of seed cotton fed^{-1} (12.15 and 7.97 kentar) in 2021 and 2022 seasons, respectively, seed index (9.38 g) and boll weight (2.50 g) in the second season were also, increased. The comparison treatment (untreated plants) registered the lowest values regarding these traits. The favorable effect of IBA on cotton yield may be due primarily to the increase in several sympodia/plant, seed index, and lint% which lead to a significant increase in boll weight. It was found that these treatments increased photosynthetic pigments (Table 3) which reflects a significant increase in the assimilates production by the leaves (source) due to an increase in carbon dioxide assimilation and the rate of photosynthetic which increased mineral absorption by the plant. The activating influence of growth substances used may also be due to maintaining the permeability of plant membranes (Table 7) and promoted nutrients uptake (Tables 4 and 5). The favorable influence on cell membrane functions by promoting nutrient absorption, respiration, nucleic acid biosynthesis, absorption of ions, enzyme, and hormone-like substances. They improve the primary nutrients supply like nitrogen, phosphorus, and potassium which promote the impedance to reverse conditions. The high leaves nitrogen content resulting from these treatments (Tables 4 and 5) makes these plants utilize the absorbed light energy in electron transport and tolerate photo-oxidative damage under high-intensity light, thus increasing photosynthesis ability. It enhanced the chlorophyll content which reflects its role in improving the nutritional status of leaves (Tables 4 and 5) particularly, nitrogen as an important part of the chlorophyll molecule. This result can be explained based on the experimental soil being low in organic matter and available nitrogen (Table 1). The yield of seed cotton in expression of kentar per fed due to the growth substances treatments used in the 2021 and 2022 seasons is shown in Tables (8 and 9). Significant distinctions could be detected amongst the five treatments for seed cotton yield/fed in support of applying IBA as foliar spraying at 50 ppm two times. The increase in seed cotton yield/fed due to applying IBA at 50 ppm was mainly due to the physiological and biochemical functions of IBA to mobilize nutrients into cotton bolls by pulling assimilates to storage sinks and is known to increase fruit set resulting in increased seed cotton yield (Bhardwaj *et al*., 1963). Tamas *et al*. (1972) stated that NAA stimulated the photosynthetic capacity of the chloroplast. Sawan (1978) pronounced that the boll weight and seed cotton yield significantly increased when cotton plants were sprayed with IBA at a rate of 5 or 10 parts per million (ppm) after 55, 70, and 85 days from planting. Abd El-Al *et al.* (1989) pointed out that the reduced shedding of young bolls may be due to the indirect influence of polyphenols in preventing the IAA oxidase action. Sawan and Sakr (1998) found that applying NAA twice or thrice at a rate of 15-20 mg/L gave the best results on yield components (open bolls number/plant, boll weight, and seed index) for Egyptian cotton plants. Comparable results were obtained by Cothren (1999) who found that growth regulators increased productivity and earliness by flowering, assimilation partitioning and enhancing yield. Brar *et al*. (2001) and Turkhede *et al*. (2003) noted that the application of NAA (30 ppm) at 60 and 80 DAS resulted in a significant increase in seed cotton yield. Similarly, Abro *et al*. (2004) found that naphthalene acetic acid had a significant effect on boll size and cotton productivity. Kumar *et al*. (2006) reported that applying NAA (20 ppm) at 90 days after sowing (DAS) recorded greater bolls number/plant, boll weight, and yield of seed cotton compared to the control. Abdel-Gayed (2013) reported that IBA at 20 ppm significantly increased open bolls number/plant, boll weight, and yield of seed cotton. Parveen *et al*. (2017) found that yield and yield components showed a significant increase with NAA application. Deol *et al*. (2018) found that foliar spraying with NAA at 20 ppm resulted in a 43 % increase higher than the control due to the high number of bolls/plant and boll weight.

VI.3- Effect of the interaction

Tables 8 and 9 indicated that early sowing plants that received IBA at 50 ppm significantly increased the number of opened bolls per plant, earliness%, seed index, and seed cotton yield/fed in both seasons and boll weight in the second season. The lowest values of these traits were obtained from late planting without growth substances application.

V- Fiber quality traits

V.1- Effect of planting date

Staple length (UHML, mm) in the second season and fiber strength (Pressly index) in both seasons were comparatively greater in cotton sown early (Table 11). This result may be due to the high air temperature in late planting (Table 2) which led to insufficient carbohydrate production (Tables 4 and 5) to satisfy the plant’s needs and reduce size of seed, fibers/seed, and length of fiber. The uniformity index, and fiber fineness (micronaire reading) were not influenced by the planting date in both seasons (Table 11). In this concern, Hesketh and Low (1968) found that fiber strength was increased with increasing temperature, while differences in fiber length and micronaire were less consistent. Oosterhuis (1999) concluded that high temperature led to a decrease in cotton seeds carbohydrates, fibers per seed, and bolls. Planting date did not affect fibre fineness, fibre length, fibre strength and uniformity ratio (El-Tabbakh, 2001; Gormus and Yucel, 2002). However, Bauer *et al.* (2000) found that naturally grown and late grown cotton differed in their fibre properties particularly those associated to secondary wall deposits which determine fibre fineness and maturity. In contrast, Wrather *et al*. (2008) observed higher fibre lengths in late planting compared to early planting, while Dong *et al.* (2006) found that planting date did not significantly influence length of fibre. Davidonis *et al*. (2004) also found inconsistent results as the average fiber length in dry year (1997 season) was longer for early planted cotton and in late-planted cotton (1999 season), the fibre length was longer. Norton and Clark (2004) noted that late planting cotton has higher fibre strength compared to early planting. In contrast, Killi and Bolek (2006) reported decreased strength of fiber with late sowing compared to early sowing. Wrather *et al*. (2008) observed no significant difference in fibre strength due to planting date, although these results have not been consistent over the years. Deho (2023) evaluated two planting dates viz. April 1 and May 1. The data depicted that crop sown on 1st April produced more staple length, but minimum staple length produced from crop sown on 1st May. Early sowing allowed cotton plants greater vegetative growth, resulting in more accumulation of dry matter, which enhanced the properties of cotton fibers (Zhiguo *et al*., 2011).

Table 11. Effect of planting date and certain growth substances as well as their interactions on fiber quality traits of Egyptian cotton, Giza 95 variety in 2021 and 2022 seasons.

Traits / Treatments		Micronaire reading		Fiber strength (Presley units)		Upper half mean length (UHML, mm)		Uniformity index (UI, %)	
		2021	2022	2021	2022	2021	2022	2021	2022
A-Planting date:									
a_1-Early		4.63	4.61	10.33	10.29	31.35	31.31	83.31	83.29
a_2-Late		4.63	4.60	10.19	10.16	30.85	30.95	82.89	83.03
LSD at 5%		**NS**	**NS**	**0.13**	**0.12**	**NS**	**0.30**	**NS**	**NS**
B- Growth substances concentration:									
b_1-Control		4.77	4.75	10.18	10.05	30.75	30.65	83.40	83.47
b_2- NAA 30 ppm		4.57	4.55	10.42	10.37	31.08	31.17	82.95	82.87
b_3-NAA 50 ppm		4.62	4.57	10.22	10.37	30.38	30.37	82.62	82.72
b_4-IBA 20 ppm		4.63	4.60	10.23	10.10	31.33	31.40	83.42	83.42
b_5-IBA 50 ppm		4.57	4.55	10.27	10.22	31.93	32.05	83.13	83.30
LSD at 5%		**NS**	**NS**	**NS**	**0.23**	**0.84**	**0.76**	**NS**	**NS**
A B Interaction:									
a_1	b_1	4.87	4.80	10.20	10.05	31.03	31.00	83.57	83.85
	b_2	4.53	4.60	10.50	10.40	31.10	30.95	82.77	82.55
	b_3	4.57	4.45	10.30	10.50	30.00	29.95	83.00	82.70
	b_4	4.73	4.70	10.33	10.25	32.10	31.95	83.40	83.30
	b_5	4.47	4.50	10.33	10.25	32.50	32.70	83.83	84.05
a_2	b_1	4.67	4.70	10.17	10.05	30.47	30.30	83.23	83.10
	b_2	4.60	4.50	10.33	10.35	31.07	31.40	83.13	83.20
	b_3	4.67	4.70	10.13	10.25	30.77	30.80	82.23	82.75
	b_4	4.53	4.50	10.13	9.95	30.57	30.85	83.43	83.55
	b_5	4.67	4.60	10.20	10.20	31.37	31.40	82.43	82.55
LSD at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**1.07**	**NS**	**0.92**

NS= not significant at 5% level of probability.

V.2- Effect of the growth substances used

Significant differences were detected because of growth substances used on upper half mean length (UHML) in both seasons, Pressley index in the second season (Table 11), in favor of applying IBA at 50 ppm two times for UHML (31.93 and 32.05 mm) in 2021 and 2022 seasons, respectively. However, applying NAA at 50 ppm gave the lowest values (30.38 and 30.37 mm) in 2021 and 2022 seasons, respectively. Applying NAA at 50 ppm gave the highest value of fiber strength (10.37 Pressley unit) without significant difference with applying IBA at 50 ppm, while the control treatment (untreated plants) recorded the lowest value (10.05 Pressley unit) regarding this trait. In this regard, Sawan (1978) stated that IBA had no significant effects on fiber length and micronaire value. Mehetre *et al*. (1990) found that strength of fibre bundle was higher when NAA was foliar spraying at 20 ppm.

While, average fibre length, uniformity ratio, fineness, and maturity coefficient were not influenced by the treatments. Similar results were reported by Sawan and Sakr (1998) where they added that applying NAA once at 10-25 mg/L significantly increased flat bundle strength. Sief *et al*. (2021) reported that foliar application of IBA resulted in a significant increase in fiber length along the different boll ages and accelerated the rate of fiber elongation.

V.3- Effect of the interaction

The interaction exhibited significant differences in the upper half mean length (UHML, mm) and uniformity index (UI, %) in the second season (Table 11). Maximum values of UHML (32.70 mm) and UI (84.05%) were achieved with the interaction of early sowing (1^{st} April) and spraying IBA at 50 ppm twice.

CONCLUSION

It is advisable to apply early sowing plants by spraying IBA at 50 ppm twice (at start and top of flowering) to achieve the best efficient improvement effects on growth, chemical composition, water relations, productivity as well as fiber properties of cotton Giza 95 var.

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تأثير بعض مواد النمو النباتية على نمو وإنتاجية القطن المصري صنف جيزة ٩٥ تحت ميعادى زراعة

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الملخص العربى

نفذت تجربتان حقليتان خلال الموسمين ٢٠٢١ و ٢٠٢٢ في محطة البحوث الزراعية بسدس- مركز البحوث الزراعية - محافظة بنى سويف - باستخدام صنف القطن المصري جيزة ٩٥ لدراسة تأثير ميعادين للزراعة (أبريل و مايو) والرش الورقي بمنظمي النمو الإندول -٣ - حامض البيوتيريك (IBA) بمستويين (٢٠ و ٥٠ جزء في المليون) و ١- نفثالين حامض الخليك (NAA) بمستويين (٣٠ و ٥٠ جزء في المليون) مقارنة بمعاملة الكنترول (رش الماء فقط) على التركيب الكيميائي للأوراق والعلاقات المائية للأوراق وصفات النمو والمحصول ومكوناته وخصائص الألياف. أوضحت النتائج أن ميعاد الزراعة المبكرة (أول أبريل) والرش الورقي بمستوى ٥٠ جزء في المليون من IBA بالإضافة إلى تفاعلهما أدى إلى زيادة معنوية في أصباغ التمثيل الضوئي للأوراق (الكلوروفيل أ والكلوروفيل ب والكاروتينيدات)، والسكريات الكلية ، K ،P ،N، IAA، GA3، الكينيتين، المحتوى المائي الكلي، المحتوى المائي النسبي في الأوراق في كلا الموسمين وانخفاض ملحوظ في تركيز البرولين والفينولات والهرمون النباتى ABA في الأوراق، ونفاذية الغشاء البلازمى (مما يدعم ويؤكد سلامة الغشاء).

أعطى ميعاد الزراعة المبكرة (أول أبريل) وكذلك الرش الورقي بمستوى ٥٠ جزء في المليون من إندول -٣ - حامض البيوتيريك (IBA) زيادة معنوية فى عدد الافرع الثمرية/النبات، عدد اللوز المتفتح/النبات، نسبة التبكير، محصول القطن الزهر (قنطار/فدان) فى الموسمين وفى وزن اللوزة ومعامل البذرة في الموسم الثانى كما أعطى التفاعل بينهما أفضل النتائج.

ينصح بالزراعة المبكرة ورش IBA على النباتات بمستوى ٥٠ جزء في المليون مرتان (عند بداية التزهير وقمة التزهير) لتحقيق التأثيرات الأفضل كفاءة على تحسين الإنتاجية وزيادة كفاءة استخدام الوحدات الحرارية.