Research Article

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Foliar Application of Organic Compounds Stimulate Cotton (*Gossypium barbadense* L.) to Survive Late Sown Condition

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Abstract: Application of organic compounds in cotton balances its vegetative and reproductive growth, as well as to improve the seed cotton yield and lint quality properties. Field experiments were conducted with some organic compounds to determine their effects on cotton yield and quality properties of cotton under two sowing times. The experiment was conducted at Sakha Agricultural Research Station, Cotton Research Institute, Egypt in 2015 and 2016. In these studies, two sowing times viz. optimum and delay sowing and two levels (200 and 400 ppm) of organic compounds viz. ascorbic, ascobine and salicylic acids were used. The results indicated that the optimum sowing date gave the largest area of single leaf at 90 and 120 DAS, as well as it induced an increase in dry weight (g) of plant organs at 120 DAS, while, the late sowing significantly reduced the leaves dry weight both at 90 and 120 DAS. Both seed cotton yield and lint cotton yield (kentar feddan⁻¹) were significantly increased in optimum sowing condition and sharply declined as delayed sowing date. The number of opened bolls plant⁻¹ were also significantly reduced in late sowing. Lint percentage, seed index and seed cotton weight boll⁻¹ were also significantly affected by sowing dates. Leaf pigment (total chlorophyll) was significantly affected by sowing date recorded at 90 and 120 DAS, while lower values of total chlorophyll was recorded in late sown plants. Also, sowing dates had no significant effect on both oil and protein seed content. This study has shown that timely sowing of cotton seed and foliar

application of ascorbic acid, ascobine or salicylic acid with concentration of 200 or 400 ppm at flower initiation stage and peak of flowering stage had significant positive effects on seed cotton yield and lint quality properties. According to these results it can be suggested that usage of organic compounds to improve the yield and quality properties, especially in late sowing for 'Giza 94' cotton cultivar at Kafr- Elsheikh district, Egypt.

Keywords: Ascorbic acid, ascobine, cotton, foliar application, organic compounds, sowing dates, salicylic acid

Abbreviation

DAS, Days after sowing; K/F, kentarfeddan¹; SCY, Seed cotton yield; SLA, Single leaf area; PH, Plant height; SDW/P, stem dry weight/plant; LDW/P, Leaf dry weight/plant; SCYK/F, Seed cotton yield k/fed; LCY, Lint cotton yield; NOB/P, Number of opened bolls/plant; LP, Lint percentage; SI, Seed index; SCW/B, Seed cotton weight/boll.

1 Introduction

Cotton (*Gossypium hirsutum* L.) as an annual crop is mostly grown for the purpose of fiber and oil production (Bardak and Bolek 2012). It is one of the important cash crops of the world. While in arid and semi-arid region of the world, high temperature combined with drought affects growth and productivity of cotton through influencing morphological, physiological and biochemical processes (Karim and Rahman 2015; Fahad et al. 2017). Cotton can overcome many stresses, if it has adequate soil and air temperatures for plant growth. The best practice is to plant according to soil temperature, not only following to the crop calendar. For example, early planting may cause stand loss and cold temperature stress, which reduce yield potential (Boman and Lemon 2005).

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In Egypt, it is an important cash crop by earning significant foreign exchange, through use as a textile fiber crop in textile industries as well as second most important oil seed crop. Traditionally cotton growers in Egypt are sown cotton in delay to get extra cut from Berseem (*Trifolium alexandrinum* L.) as green forage and sometimes lost the optimum sowing date, due to waiting for the harvest of full season winter crops. More than 50% total annual area of cotton in Egypt was sown during late May to early June in the last two decades (CRI 2016). It is reported that sowing date is one of the most important management factors contributed to high-yield and quality of cotton (Dong et al. 2006). Generally sowing dates of cotton ranging from mid-April to mid-May, but early and delayed sowing reduced the yield due to less accumulation of heat units (Ullah et al. 2015). Plants suffer drought and high temperature stress due to early and late sowing. Hence, it is the most important task to avoid drought and high temperature stress at the critical growth stages of crop plants. However, as abiotic stresses are unpredictable, the best way to cope with them is to develop tolerant varieties that perform well under stress (Prasad et al. 2008; Nouri et al. 2011; Ruan and Teixeira da Silva 2011; Hossain and Teixeira da Silva 2012; 2013). So, the enhancing of tolerance to high temperature of plant is a viable approach to resolve this problem induced by global warming.

Effective management strategies are also important to ensure optimum yield and fiber quality of cotton under abiotic stress conditions. However, the management practices are still needed further improvement for producers to increase productivity of cotton. Application of defoliant and time of application has a significant effect on cotton yield and quality (Gormus et al. 2017a; b). Nevertheless, development of tolerant cultivars to abiotic stresses is a time consuming and lengthy process. Therefore, the best way to adjust seeding date, or by growing short duration varieties, or develop different management strategies (Hossain et al. 2012 a; b). Exogenous application of osmoprotectants can alleviate the adverse effects of abiotic stresses as reported by Ashraf and Foolad (2007). Enhancing tolerance to stress environment of plant using different osmoprotectants are a viable approach to resolve this problem induced by climate change (EL Sabagh et al. 2017). Implementation of foliar spraying is an important crop managing strategy, which can help to maximize yield and other beneficial substances in different crops. Foliar spraying of ascobine improved the productivity of wheat as well as quality properties in rice (Gharib et al. 2016; Gharieb et al. 2016). There are some known organic compounds like ascorbic

acid (AA), ascobine (ASc) and salicylic acid (SA) having protective functions against the heat stress. Ascorbate is an important metabolite in plants performing a key role in the protection of plant against various environmental stresses like high temperature (Vwioko et al. 2008). Salicylic acid (SA) is known to influence of different physiological and biochemical activities of plants, and could play a key role in regulating their growth and yield (Hayat 2010). Application of antioxidants, ascorbic acid was achieved healthy plants and leading to improve the ability for uptake of elements in plants (Rady and El Sawah 2009). The application (spraying) of SA was effective for improving the growth and productivity of cotton (Noreen et al. 2013). Considering the above previous findings, the present study was planned to develop a proper technique to overcome the negative effects of late sowing by using some organic compounds having proven protective functions against the late sowing damage to adopt cotton cultivation in Egypt.

2 Materials and Methods

2.1 Experiment site and plant materials:

A two-year field experiment was conducted at the research field of Sakha Agricultural Research Station, Cotton Research Institute, Egypt, in two consecutive seasons (2015 and 2016) to study the effect of some organic compounds to reduce the harmful effects of late sowing. Two sowing dates viz. optimum sowing (April 25), and late sowing (May 25) were selected for the study, and recommended optimum sowing date was considered as the standard to compare the effect of heat stress due to late sowing date on cotton growth, yield and its components and fiber quality. Three organic compounds i.e. ascorbic acid (AA), ascobine (ASc) and salicylic acid (SA) were used as a foliar application on cotton plants with two concentrations of 200 ppm and 400 ppm for each compound. A new commercially available long-staple cotton cultivar 'Giza 94' was used as a plant material. Fiber quality characteristics of that cultivar are shown in Table 1.

2.2 Climatic conditions and soil texture

The meteorological data during experimental time were recorded and are presented in Table 2. The daily maximum and minimum temperatures were recorded by the meteorological station at Rice Research Center in 2015 and 2016 seasons, and amounts of heat unit (HU) were

Table 1: Fiber quality characteristics of the Egyptian long staple cotton cultivar ‘Giza 94’

Cultivar	Color	Values of color attributes		Micronaie value	Maturity ratio (MR)	Fiber strength		Fiber strength	
		Brightness (Rb%)	Yellowness (+b)			UHM (mm)	Uniformity % (uni)	Strength (g/tex)	Elongation (%)
Giza 94	White	78.6	8.6	4.3	0.95	34.0	87.6	43.7	7.2

Table 2: Monthly means of both air and soil temperatures, relative humidity and pan evaporation during the two growing season, 2015 and 2016

Month	2015 season						2016 season					
	Air temp. oC		Soil Temp oC	R.H%		Pan evap. mm	Air temp. oC		Soil Temp oC	R.H%		Pan evap. mm
	Max.	Min.		7:30 am	13.30 pm		Max.	Min.		7:30 am	13.30 pm	
Apr.	25.64	13.70	22.30	78.3	48.5	606.7	30.03	18.62	27.05	81.6	41.8	593.8
May	30.19	18.79	27.10	77.3	46.1	715.0	30.40	22.80	28.60	71.0	45.8	647.0
Jun.	30.85	21.40	29.62	78.8	51.2	965.0	33.60	26.30	32.21	75.7	46.6	806.8
Jul.	33.00	22.40	31.50	85.2	54.3	686.4	33.70	26.10	31.65	82.7	56.8	783.
Aug.	35.10	25.00	32.16	83.8	51.7	814.7	33.60	26.00	31.14	84.3	56.3	773.6
Sept.	34.60	23.80	31.90	82.7	46.5	663.7	32.60	24.30	29.50	83.1	51.8	590.5
Oct.	29.90	20.60	26.13	80.9	54.0	452.9	29.80	21.70	28.30	82.4	55.3	356.9

calculated in each 30 day-intervals as growth periods from sowing date to picking time (Table 3) according to the following formula (Sutherland, 2012).

Where, GDD=Growing degree – Days = Heat Unit (HU), T_{max} =Daily maximum temperature, T_{min} =Daily minimum temperature, T_{base} =Minimum or base temperature for growth. Base temperature for cotton crop is 60°F =15.6°C.

Physical and chemical soil properties of the experimental site were determined and are shown in Table 4. The soil texture is clay and level of salinity ranged from 3.30 to 3.75 EC (dS m⁻¹) according to the depth of soil.

2.3 Experimental design and crop management

A split plot design with four replications was adopted, the main plots were randomly assigned to the two sowing dates and the sub-plots were randomly assigned for seven treatments as follows: i) AA 200 ppm, ii) AA 400 ppm, iii) ASc ppm, iv) ASc 400, v) SA 200 ppm, vi) SA 400 ppm, and vii) control (without foliar application).

Seeds were established in the field by 5-rows sub-plot¹ (4.5 m X 0.7 m) keeping 0.25 m distance among hills. Hand thinning was practiced at 30 days after sowing (DAS), leaving two vigorous a seedling in each hill. The outer rows of each sub-plot served as border and the rest inner rows with an area of 9.45 m² utilized for determining yield and yield component characterization.

Organic compounds (exogenous treatments) were imposed at flower initiation stage (75 DAS) and at the peak of flowering stage (105 DAS). Fifteen days after each foliar application (90 and 120 DAS, respectively), four guarded plants were randomly taken from each sub-plot, to measure growth characteristics. All cultural practices were done according to the recommended management practices for cotton cultivar ‘Giza 94’.

2.4 Data collection

2.4.1 Growth characteristics

Plant height and leaf area were measured on the fifth leaf from the plant top. Stem dry weight, leaves dry weight and total chlorophyll content were from the fourth leaf from the tip of cotton plant according to von Wististien et al. (1957).

2.4.2 Yield and yield component characteristics

Seed cotton yield (kantar/feddan), lint cotton yield (kantar/feddan), number of opened bolls plant¹, lint percentage, seed index and seed cotton weight boll¹ were recorded.

Table 3: Mean of 30 days' periods of heat units for Sakha district in 2015 and 2016 growing season.

Periods	Heat units 2015		Heat units 2016	
	Optimum sowing (25 Apr.)	Late sowing (25 May)	Optimum sowing (25 Apr.)	Late sowing (25 May)
From 25 Apr. to 30 Apr.	43.75	-	57.20	-
From 25 May to 31 May	-	73.15	-	76.10
From 1 May to 31 May	283.25	-	337.15	-
From 1 June to 30 June	316.00	316.00	430.90	430.90
From 1 July to 31 July	374.80	374.30	451.77	451.77
From 1 Aug. to 31 Aug.	447.10	447.10	439.45	439.45
From 1 Sept. to 30 Sept. (a)	407.25	407.25	396.70	396.90
From 1 Oct. to 10 Oct. (b)	107.20	107.20	113.05	113.05
From 11 Oct. to 25 Oct. (c)	-	156.3	-	156.1
Total accumulation heat units	1979.35	1881.30	2226.22	2064.07

(a)1st pick for both sowing dates (159 and 129 DAS in both sowing date, respectively; (b)2nd pick for normal sowing only (169 DAS); (c)2nd Pick for late sowing only (184 DAS).

Table 4: Physical and chemical analysis of soil paste extract of the experimental site pre-sowing the cotton crop.

Depth (cm)	pH	EC, dS m-1	Anions (meq/L)				Cations (meq/L)				Sand %	Silt %	Clay %
			CO3=	HCO3-	Cl-	SO4=	Ca++	Mg++	Na+	K+			
0-30	7.9	3.30	-	9.90	19.10	5.15	10.05	3.69	19.90	0.83	23.80	24.90	51.30
30-60	7.93	3.60	-	9.70	21.30	6.15	11.04	4.70	20.92	0.81	22.50	25.55	51.95
60-90	7.98	3.75	-	9.55	22.60	7.30	12.10	5.74	23.48	0.75	20.19	27.15	52.66

2.4.3 Seed quality

Oil percentage was determined according to the method outlined by Kates (1972) and Protein percentage was determined by using Kjeldahl method according to AOAC (1990).

2.4.4 Fiber characteristics

Fiber fineness (Mic), fiber length mm (UHM), uniformity index, fiber strength and fiber elongation were also recorded during data collection.

2.5 Statistical analysis

Recorded data were tabulated in proper form for statistical analysis and analyzed by analysis of variance with the help of computer package MSTATCOSTAT program according to Snedecor and Cochran (1990). The least significant differences (LSD) at 5% level of probability were used to compare between treatment means.

Ethical approval: The conducted research is not related to either human or animal use.

3 Results and discussion

All studied growth, yield and quality traits were significantly influenced by planting time, organic copund applications and their interaction. The results of growth, yield and quality, along with statistical analysis indicated that the difference due to sowing dates as well as organic compounds were significant.

3.1 Effect on growth and physiological characteristics

3.1.1 Plant height

The plant height for sowing dates of both years was shown in Tables 5. Data indicated that sowing dates and foliar application treatments had significant effects on plant height at 90 and 120 DAS in 2015 season. Meanwhile, it was non-significant in 2016 season. The late sowing date (May 25) increased the plant height (154cm and 183 cm)

at 90 and 120 DAS, respectively in 2015 season. Foliar application treatments, (AA 200, and SA 200 ppm) and (AA 200, AA 400, ASC 200, SA 200 and SA 400 ppm) gave the tallest plants in 2015 season at 90 and 120 DAS, respectively compared with control and other treatments. It is clear that late sowing date increased plant height than did the normal sowing date, this may be due to the mean diurnal temperature range and sunshine hours during the whole growing season accumulated temperature. Also, might be due to the wide fluctuations of climatic conditions and the increment of air temperature in late sowing as showed in Table 3. Similar results were obtained by Emara (2012), Elayan *et al.* (2015), and Huang (2016), who reported that sowing date significantly influenced the growth and yield, indicating an important factor affecting the yield and reproductive phase. El-Hindi *et al.* (2006) reported significant increase in cotton plant height due to delaying cotton planting. Application of ascorbic acid positively increased the plant height and other traits were also reported by Ghourab and Wahdan (2000), Gamalat (2000).

3.1.2 Single leaf area (cm²)

Leaf area is considered the dynamic indicator of the growth status of a crop. Data in Table 5 showed that the biggest single leaf area was significantly influenced by the sowing dates at 90 DAS only in 2016 season, however the trend of expanded area for the single leaf was in favor of optimum sowing date (normal) at 90 and 120 DAS in both seasons. Foliar application treatments with (ascorbic acid, ascorbine and salicylic acid) were significantly induced the single leaf area at 90 DAS in 2015 season, and at 90 and 120 DAS in 2016 season. The treatment of AA 200 ppm showed the biggest single leaf area at 90 DAS in 2015 and 2016 seasons, while salicylic acid SA400 ppm showed the biggest leaf area at 90 DAS and 120 DAS in 2016 season compared to controlled plants and other treatments. It is evident that delay sowing reduced single leaf area on cotton plants according to El-Ashmouny (2014). The increment of the area of single leaf of cotton plants treated with SA might be due to the physiological role of SA in enhancing the cell division and cell enlargement, as well as the ASc treated plants showed significant improvement in vegetative growth, might be due to enlargement of plant organs (Sanjeev *et al.* 2011).

3.1.3 Stem dry weight/plant (SDW/P):

The data regarding stem dry weight/plant have been presented in Table 5. It was observed that the stem dry weight including vegetative and reproductive organs were significantly affected by normal and late sowing dates at 120 DAS in 2015 and 2106 seasons. The normal sowing (April 25) plants exhibited higher stem dry weight compared to that of the late sowing (May 25) plants at 90 DAS in both seasons. The higher stem dry weight at optimum sowing date was due to the availability of favorable environmental conditions prevailing at optimum sowing time, which was comparable to the findings of El-Tabbakh (2000) who reported that seed cotton yield traits and fiber qualities could be significantly altered by a number of agronomic practices. All foliar applied treatments had a significant effect on the stem dry weight at 90 DAS, where AA 400, AA 200, SA 400 ppm, and SA 400, SA 200, AA 200, AA 400 induced significantly higher stem dry weights compared with the control and other treatments in 2015 and 2016 season, respectively. The same trends of stem dry weights were observed with the foliar application treatments at 120 DAS in both seasons.

3.1.4 Leaf dry weight/plant (LDW/P) (g):

The sowing dates and all foliar application treatments had significant effect on the leaf dry weight in both seasons at 90 and 120 DAS. Late sown plants induced lesser estimates of leaf dry weight compared with normal sowing at 90 and 120 DAS in both seasons. Organic compounds treated plants significantly increased the leaf dry weight/plant compared with those untreated plants. Organic compounds ameliorated the harmful effects of abiotic stress due to late sowing (heat stress) and positively increased the studied traits. These results are supported by Hakoomat *et al.* (2009) and Dewdar and Rady (2013).

3.1.5 Total chlorophyll (TChl.) (mg/dm²)

Total chlorophyll was significantly affected by sowing dates in 2016 season at 90 and 120 DAS, while it was not significantly affected by sowing dates in 2015 season at 90 and 120 DAS (Table 7). Generally, late sowing plants gave lower values of total chlorophyll comparing to optimum sowing. This might be attributed to high temperature stress prevailing in late sowing caused degradation of chlorophyll content in plant leaves. With respect to foliar application treatments, both SA and AA significantly

Table 5: Means of cotton growth characteristics as affected by foliar applications of ascorbic, ascorbine and salicylic acids under optimum and late sowings dates in 2015 and 2016 seasons.

Characters	PH (cm)		SLA cm ²				SDW gm.				LDW gm.			
	90 DAS	120 DAS	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Sowing dates (SD)	Treatments (T)	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2016
Optimum Sowing (25 April)	AA.200 ppm.	136	137	174	154	176.7	153.4	158.5	163.1	183.8	169.4	337.5	355.6	60.0
	AA.400 ppm.	128	138	175	155	177.0	152.5	159.8	165.3	182.0	166.2	314.1	375.6	55.9
	ASC.200 ppm.	130	133	175	141	169.1	144.7	155.5	163.1	183.9	154.5	314.6	277.4	50.1
	ASC.400 ppm.	128	139	180	158	169.0	144.6	163.4	172.9	166.1	158.1	335.5	308.8	46.3
	SA.200 ppm.	134	136	183	151	173.7	153.3	163.3	173.7	179.8	172.2	274.5	354.1	46.7
Optimum sowing Mean	SA.400 ppm.	132	137	178	146	165.0	164.2	162.1	180.1	171.8	182.9	323.9	385.4	53.9
	Control	127	137	158	147	151.4	142.5	143.9	154.9	142.4	148.2	255.9	275.5	48.35
		130	137	175	150	168.8	150.7	158.0	167.6	172.8	164.5	307.9	333.2	51.6
	AA.200 ppm.	163	143	193	156	173.0	127.6	144.7	152.6	104.1	169.4	274.4	214.5	38.8
	AA.400 ppm	161	134	193	160	161.9	125.5	161.8	160.4	112.0	166.2	273.0	249.1	41.3
Late Sowing (25 May)	ASC.200 ppm	154	143	185	171	160.1	116.4	155.3	165.3	97.8	154.5	252.7	211.2	35.7
	ASC.400 ppm.	150	132	174	169	154.8	118.1	133.0	157.0	101.5	158.1	242.1	227.6	40.6
	SA.200 ppm.	156	139	187	153	144.8	123.3	154.9	152.1	104.8	172.2	251.4	270.4	34.4
	SA.400 ppm.	152	147	176	172	167.0	128.9	163.7	169.0	113.5	183.0	263.3	275.1	44.8
	Control	150	141	172	169	159.9	115.2	162.0	137.7	94.4	148.2	241.3	190.6	33.2
Late sowing Mean		154	140	183	164	160.2	122.1	153.6	156.3	104.0	130.0	256.9	234.1	38.4
	AA.200 ppm.	149	140	183	155	174.8	140.5	151.6	157.3	143.9	169.4	305.9	285.1	49.4
	AA.400 ppm.	144	136	184	158	169.4	139.0	160.8	162.9	147.0	166.2	293.6	312.3	48.6
	ASC.200 ppm.	141	138	180	156	164.6	130.6	155.4	164.2	140.8	154.5	283.6	244.3	42.9
	ASC.400 ppm.	139	136	177	163	162.0	131.4	148.2	165.0	133.8	158.1	288.8	268.2	43.4
General means of tr'ts (T)	SA.200 ppm.	145	138	185	152	159.3	138.3	159.1	162.9	142.3	172.2	262.9	312.2	40.5
	SA.400 ppm.	141	142	176	159	165.0	146.5	162.9	174.5	142.7	183.0	293.6	330.3	49.3
	Control	138	139	165	158	155.6	128.8	153.0	146.3	118.4	148.2	248.6	233.0	40.8
	SD	2.2	NS	7.1	NS	NS	20.30	NS	NS	NS	NS	41.9	98.0	5.3
	T	6.8	NS	12.0	NS	11.77	9.08	NS	8.66	15.0	11.6	26.8	29.45	5.7
LSD_(0.05)	SD×T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Plant height (PH; cm), Single leaf area (SLA; cm²), Stem dry weight (SDW; g), and Leaves dry weight (LDW; g), NS, non-significant

increased total chlorophyll content in cotton plant leaves compared with untreated plants control. Growth regulators produce higher chlorophylls content in cotton leaves (Abdallah and Mohamed 2013).

3.2 Effect on yield and yield components characteristics

3.2.1 Seed cotton yield (k/fed)

Seed cotton yield (kentars/feddan) was significantly affected by both sowing dates and organic compounds in 2015 and 2016 growing seasons (Table 6). The results revealed that seed cotton yield was drastically decreased by delay sowing plants. However, the averages of seed cotton yield was 8.71 and 7.64 for late sowing (May 25) in 2015 and 2016 season, respectively. On the other hand, normal sowing (April 25) plants produced 12.29 and 14.37 kentar/feddan in both seasons, respectively. These data indicated that seed cotton yield was reduced due to delayed sowing, the reason might be due to less accumulation of heat units, and development of various uncontrollable environmental conditions. These results were in agreements by Ullah *et al.* (2015) and Huang (2016). Further, SA at the concentrations of 200 and 400 ppm showed increase in averages of seed cotton yield of 11.74 and 11.65 (K/F), in 2015 season, respectively and 12.47 and 12.00 (K/F), for SA 400 and AA200, respectively in 2016 season. Overall, all foliar application treatments were significantly different from untreated control. This might be due to decreasing transpiration rate of cotton plants under high temperature stress which might be increased yield (Heitholt 2001). In addition, SA treated plants showed significantly improved healthy growth due to proven protective functional properties against abiotic stress (Upadhyaya *et al.* 2010). Exogenous application of ascorbic acid significantly increased the number of fruiting branches/plant, no. of open bolls/plant as a result of reducing boll shedding and seed cotton yield (Ghourab and Gamalat 2000). Foliar applications of growth regulators had a significant influence on the major traits, no. of open bolls/plant, seed index, boll weight, seed cotton yield/fed, lint % and Earliness percentage in both seasons (Abdallah and Mohamed 2013).

3.2.2 Lint cotton yield (k/f)

Lint cotton yield (k/f) was significantly increased by differentiating sowing time, while, it was drastically

decreased in delayed sowing time. The average yields of 15.48 and 18.16 k/f at optimum sowing time and 11.20 and 9.73 k/f at late sowing were recorded in 2015 and 2016 season, respectively (Table 6). These results were in compatible with those achieved by Emara (2012); Elayan *et al.* (2015) and Huang (2016). Foliar application treatments of AA 400, SA 200 and SA 400 ppm increased lint cotton yield compared with the control and other treatments in 2015 season, and for SA 400 and AA 200 ppm, in 2016 season. The results revealed that there is an enhancing effect of sub-main foliar application treatments on both seed and lint cotton yields, which were mainly attributed to their positive action on enhancing growth characteristics (Table 5) and leaf photosynthetic pigments, our results were supported by Dewedar and Rady (2013).

3.2.3 Number of opened bolls/plant (No OB/P)

The optimum sowing date significantly increased the number of opened bolls/plant in 2015 and 2016 seasons (Table 6)., The number of opened bolls/plant drastically decreased with the late sowing treatment in both seasons. Delayed sowing reduced the number of bolls/plant due to less accumulation of heat unit. Therefore, an appropriate sowing date might play a significant role to ensure optimum number of bolls/plant and sufficient seed cotton yield. Number of bolls/plant were influenced only by planting date while total bolls/plant were more in late planting than in early planting (Saleem *et al.* 2009).

The number of opened bolls/plant was significantly increased by the foliar application of organic compounds as compared to control. This could be explained on the basis of that cotton plants sown too late might be due to expose to heat stress causing negative effects on such characters. Accordingly, spraying of these organic compounds on cotton plants might be reduced the harmful effects of high temperature stress. Similar results were observed by Heitholt *et al.* (2001) who showed that SA might have increased bolls and yield by decreasing transpiration of cotton plants under high temperature stress.

3.2.4 Lint percentage

Lint percentage was not remarkably influenced by sowing dates as well as among foliar application treatments in both 2015 and 2016 seasons (Table 6). This might be due to the no stable effect of sowing dates on lint traits as reported by Bridge *et al.* (1971). Our data also indicate

Table 6: Means of yield and yield component characteristics as affected by foliar applications of ascorbic, acobine and salicylic acids under optimum and late sowing dates in 2015 and 2016 seasons.

Sowing dates (SD)	Treatments (T)	Seed cotton yield (kentar/ feddan (SCY) K/F		Lint cotton yield (kentar/feddan (LCY)) K/F		Number of opened bolls plant-1		Seed cotton weight boll-1 (SCW/B; g)		Lint percentage (LP %)		Seed index (SI; g)	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Optimum sowing (25 April)	AA.200 ppm.	12.23	14.63	15.63	18.56	27.35	24.58	2.97	3.25	40.68	40.32	13.53	12.49
	AA.400 ppm.	13.95	14.6	17.73	18.57	27.78	3.07	3.06	40.91	40.45	13.54	12.74	
	ASC.200 ppm.	11.83	13.71	15.23	17.11	28.7	2.97	3.22	40.94	39.70	13.04	12.26	
	ASC.400 ppm.	10.72	14.96	13.85	19.04	24.63	2.92	3.39	40.98	40.50	13.33	12.69	
	SA.200 ppm.	14.08	15.08	16.96	18.93	28.5	2.96	3.32	40.79	40.06	13.87	12.75	
	SA.400 ppm.	13.65	15.22	16.68	19.32	25.9	2.96	3.38	40.99	40.38	13.47	12.92	
Optimum sowing mean	Control	9.57	12.35	12.28	15.59	21	2.69	3.12	39.88	40.10	12.90	11.38	
	AA.200 ppm.	12.29	14.37	15.48	18.16	26.26	24.09	2.93	3.25	40.74	40.21	13.38	12.46
	AA.400 ppm	8.78	9.36	11.49	11.98	16.05	14.9	2.96	3.57	39.87	40.71	13.85	12.20
	ASC.200 ppm	8.96	6.74	11.53	8.77	16.78	15.78	3.09	3.65	39.66	41.38	14.04	12.39
	ASC.400 ppm.	8.33	5.94	10.93	7.48	15.38	12.13	2.86	3.63	40.70	40.00	13.86	11.75
	SA.200 ppm.	8.57	7.19	10.98	9.08	15.23	13.68	3.10	3.74	40.29	40.38	13.69	11.61
Late sowing (25 May)	AA.200 ppm.	9.4	8.19	12.06	10.52	16.9	16.35	2.93	3.65	40.07	40.69	13.72	12.60
	AA.400 ppm.	9.66	9.72	12.17	12.07	16.98	17.45	3.01	3.56	40.13	39.49	13.34	12.35
	ASC.200 ppm.	7.25	6.36	9.23	8.21	14.25	13.15	2.66	3.35	40.48	40.67	13.43	10.71
	ASC.400 ppm.	8.71	7.64	11.2	9.73	15.94	14.78	2.94	3.59	40.17	40.47	13.70	11.94
	Control	10.51	12	13.56	15.27	21.7	19.74	2.97	3.41	40.28	40.52	13.69	12.34
	General means of tr'ts (T)	11.45	10.67	14.63	13.67	22.28	20.28	3.08	3.35	40.29	40.91	13.79	12.56
Late sowing mean	AA.200 ppm.	10.08	9.8	13.08	12.3	22.04	17.91	2.91	3.43	40.82	39.85	13.45	12.00
	AA.400 ppm.	9.65	11.08	12.42	14.06	19.93	18.48	3.01	3.57	40.64	40.44	13.51	12.15
	ASC.200 ppm.	11.74	11.64	14.51	14.72	22.7	21.3	2.95	3.49	40.43	40.37	13.80	12.67
	ASC.400 ppm.	11.65	12.47	14.42	15.69	21.44	20.6	2.99	3.47	40.56	39.93	13.40	12.64
	Control	8.41	9.36	10.75	11.9	17.63	17.71	2.67	3.24	40.18	40.38	13.16	11.05
	SD	2.31	3.85	2.89	4.86	8.95	2.25	NS	NS	NS	NS	NS	0.35
LSD(0.05)	T	1.06	1.2	1.24	1.59	2.46	1.94	0.19	0.17	NS	NS	NS	0.52
	SDxT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*One Faddan = 4200 m²; **one Kentar seed cotton=157.5 kg; ** one Kentar lint cotton=50 kg; NS, non-significant

that there was a slight decrease in lint percentage in favor of the late sowing in 2015, and gave an opposite trend in 2016 season. This could be explained on the basis of that lint percentage is a complex character, since it depends on two primary factors, weight of lint and weight of seed. It is expected considerable variations according to fluctuation of the two factors. The amount of lint depends on the weather conditions prevailing during the development of the secondary wall. Therefore, the comparatively lower air temperature and the short period of sunshine prevailing during the fiber maturity stage of late sowing date may result in undeveloped fiber and consequently lower lint percentage. Similar finding were observed by Emara, (2012) who reported that early cotton planting afforded cotton plants more vegetative growth, resulting in greater accumulation of dry matter, which improved cotton fiber length.

3.2.5 Seed index (g)

The weight of 100 seeds (seed index) was not significantly affected by both sowing dates and foliar application treatments in 2015 season (Table 6). However, it was significantly influenced by both sowing dates and foliar application treatments in 2016 season. Data indicated that SI higher in optimum sowing date compared with late sowing. This might be attributed to more accumulation of heat units and consequently, increase in the concentration of total soluble carbohydrates in the cotton plant tissues of optimum sowing date. Similar results were observed by Emara (2012) and Elayan (2015), who recorded the highest average 100-seed weight (10.19 g) at first planting date (15 April), while the lowest average weight (9.17 g) was obtained from the third planting date (15 May) in 2012 season.

3.2.6 Seed cotton weight/boll (g)

Seed cotton weight/boll was not significantly affected by sowing dates in 2015 and 2016 growing seasons, however, Seed cotton weight/boll a slight increase of this trait was observed in late sowing (Table 6). An insignificant increase in seed cotton weight/boll in late sowing might be due to the lower number of bolls on cotton plant in case of late sowing and the net assimilated produced distributed on this lower number. Similar results were obtained by Hakoomat et al. (2009) and El-Sayed and El-Menshawi (2005) who reported that planting on 15 April resulted increased in boll weight (2.76 and 3.04 g) in 2012 and 2013

seasons, respectively. Data indicate that the treatments of AA 400 and ASC 400 ppm increased significantly seed cotton weight/boll in 2015 season, while, ASC 400, SA 200 and SA 400 ppm produced the significantly seed cotton weight/boll (g) as compared to control in 2016 season. The improving effect of AA, ASC and SA were mainly attributed to their positive action on enhancing and synergistic effect on the biosynthesis of carbohydrates. Similar results were observed by Dewdar and Rady (2013).

3.3 Effect on Seed chemical characteristics

3.3.1 Oil percent

The oil percentages were increased in optimum sowing compared to late sowing in 2015 and 2016 seasons (Table 7). Optimum (normal) sowing induced higher oil values of 23.87 and 23.62% in 2015 and 2016 seasons, respectively. On the other hand, the values of oil percent slightly decreased (23.28 and 22.40%) due to late sowing in 2015 and 2016 seasons, respectively. These findings could be attributed to increase total photo-assimilates (e.g. lipids) in cotton plants sown in optimum time, and timely sowing plants produced completely mature seeds, free from aborted ones and characterized with healthy seeds and may have high content of both oil and protein percent. Nonetheless, late sowing may produce unfilled and immature seeds, aborted and light ones consequently have low content of oil and protein as a result of heat stress. Oil and protein are the two most important products for commercial consideration (Chen et al. 2015). Accumulation of oil and protein was faster for the early sowing date, as the temperature was the main factor caused by different sowing date altering the dynamic accumulation of seed dry matter (Chen et al. 2015).

Foliar application treatments had significant effect on oil content in both seasons. The highest oil content of 24.83 and 24.40% was recorded with the SA 400 ppm treatment compared to untreated control (21.62 and 21.09%) in 2015 and 2016 seasons, respectively. Overall, foliar application of organic compounds used as foliar application on cotton plants resulted in significant increment in seed oil content compared to control. It is also noted by Abdallah and Mohamed (2013).

3.3.2 Protein percent

Sowing dates had no significant effect on seed protein content (Table 7). However, late sown plants had lower percent of protein content compared with optimum sown

Table 7: Total Chlorophyll content, oil (%) and protein (%) in cotton seeds as influenced by foliar applications of ascorbic acid, ascobine and salicylic acid under optimum and late sown heat stress condition in both the years

Sowing dates (SD)	Treatments (T)	Total Chlorophyll (mg/dm ²)				Oil (%)		Protein (%)	
		90 DAS		120 DAS		2015	2016	2015	2016
		2015	2016	2015	2016				
Optimum Sowing (25 April)	AA.200 ppm.	19.78	19.04	17.73	18.12	23.85	23.13	25.2	25.83
	AA.400 ppm.	19.62	19.44	17.24	18.41	24.36	24.25	25.98	25.83
	ASC.200 ppm.	19.37	18.18	17.4	17.53	24.02	23.5	23.64	24.25
	ASC.400 ppm.	19.9	18.95	17.33	17.87	23.13	23.41	24.05	24.68
	SA.200 ppm.	19.95	18.53	18.4	18.05	24.66	24.36	23.78	25.98
	SA.400 ppm.	20.1	20.37	19.32	19.1	25.04	25.13	25.69	26.9
	Control	17.8	16.77	16.32	16.43	22.05	21.57	23.41	22.93
Optimum sowing Mean		13.99	18.75	12.38	17.93	23.87	23.62	24.53	25.2
Late Sowing (25 May)	AA.200 ppm.	19.17	14.75	16.88	15.55	23.04	22.36	23.9	24.2
	AA.400 ppm	19.71	14.11	18.37	14.84	23.49	22.56	26.2	25.48
	ASC.200 ppm	17.63	14.76	14.99	15.47	22.39	21.89	22.5	22.93
	ASC.400 ppm.	18.16	14.14	17.02	14.38	23.57	22.41	23.52	23.85
	SA.200 ppm.	18.89	15.05	16.72	14.51	24.65	23.31	25.62	25.68
	SA.400 ppm.	19.68	12.29	18.37	15.91	24.63	23.67	26.14	25.75
	Control	16.05	12.43	14.72	12.06	21.19	20.62	23.42	22.83
Late sowing mean		12.02	13.93	10.73	14.67	23.28	22.4	24.47	24.39
General means of tr'ts (T)	AA.200 ppm.	19.48	16.89	17.31	16.83	23.44	22.74	24.55	25.01
	AA.400 ppm.	19.67	16.77	17.8	16.63	23.93	23.4	26.09	25.65
	ASC.200 ppm.	18.5	16.47	16.2	16.5	23.21	22.69	23.07	23.59
	ASC.400 ppm.	19.03	16.54	17.17	16.12	23.35	22.91	23.78	24.26
	SA.200 ppm.	19.42	16.79	17.56	16.28	24.65	23.84	24.7	25.83
	SA.400 ppm.	19.89	16.33	18.85	17.5	24.83	24.4	25.92	26.33
	Control	16.92	14.60	15.52	14.24	21.62	21.09	23.41	22.88
LSD(0.05)	SD	NS	1.00	NS	0.87	NS	NS	NS	NS
	T	0.88	1.03	1.18	1.46	0.83	0.76	1.52	0.71
	SD×T	NS	NS	NS	NS	NS	NS	NS	NS

plants in both seasons. In foliar application treatments, AA 400, SA 400 and SA 200 ppm resulted in the higher percent of seed protein content compared to control in 2015 and 2016 growing seasons. Wei et al. (2017) reported that embryo oil and protein contents significantly decreased with the delaying of sowing dates, compared with the early sowing dates (25 April). Oil accumulation in embryo was more sensitive than protein accumulation in response to sowing date, as well as the reasons as temperature and solar radiation, the primary factors for oil accumulation (Chen et al. 2015). The qualities of cotton seed and fiber were the co- estimation traits, so, the optimum quality seed in the early stage ensured the fiber improvement (Li et al. 2009; Wei et al. 2017).

3.4 Effect on fiber characteristics

3.4.1 Fiber fineness (micronaire value, Mic)

Fiber fineness indicated as micronaire values which were significantly affected by sowing dates only in 2015 season. However, micronaire values slightly increased with delayed sowing (Table 8). This might be attributed to high air temperature during growth stage and fiber development. In general, cotton cultivation in a hot climate will have a higher micronaire values due to the thicker rings of cellulose that are deposited daily in fiber (Hake and Silvertooth 1990: 81). These results are in contrary with Elayan et al. (2015) while are in agreement

with Emara (2012). Further, foliar treatments had no significant effect on micronaire values in 2015 and 2016 growing seasons. It is clear that organic compounds did not have a definite effect on fiber fineness. Similar results were observed by Ghourab and Wahdan (2000), showing an insignificant effect of ascorbine and ascorbic acid on fiber properties.

sowing time as observed by Emara (2012) and Elayan et al. (2015). Organic compounds had no significant effects on fiber length in both seasons. It is obvious that organic compounds did not have a constant effect on fiber length. Elayan and Sohair (2008) depicted that application of auxin significantly influenced the fiber length and fiber fineness.

3.4.2 Fiber length (mm)

As shown in the Table 8, fiber length was significantly affected by sowing dates only in 2015 season, while in 2016 season sowing date did not affect significantly on fiber length. In both seasons, late sowing causes slight increase in fiber length compared with optimum sowing. The increase in fiber length due to the delay in

3.4.3 Uniformity index (%)

Uniformity index was not significantly affected by both sowing dates and foliar application treatments in both seasons (Table 8). The data revealed that there is no constant effect on such trait by sowing dates or foliar application treatments. Bridge et al. (1971) reported that there was no stable effect of sowing dates on fiber

Table 8: Fiber fineness (Mic), fiber length mm (UHM), uniformity index (UI%), fiber strength (Str g/tex.) and fiber elongation (Elong. %) as affected by foliar applications of ascorbic, ascorbine and salicylic acids under optimum and late sown heat stress condition in both seasons

Characters		Fiber fineness (Mic)		Fiber length (mm)		Uniformity index (UI %)		Fiber strength (Str g/tex.)		Fiber elongation (Elong. %)	
Sowing dates (SD)	Treatments (T)	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Optimum Sowing (25 April)	AA.200 ppm.	4.63	4.56	34.48	35.21	84.60	87.75	46.60	43.33	6.18	7.35
	AA.400 ppm.	4.70	4.62	35.15	34.50	85.73	88.40	45.20	43.23	6.38	7.15
	Asc.200 ppm.	4.70	4.62	34.08	34.52	84.75	88.35	46.50	42.80	6.33	6.58
	Asc.400 ppm.	4.68	4.65	34.83	35.29	84.55	88.93	44.80	43.50	6.35	6.70
	SA.200 ppm.	4.68	4.48	34.85	34.43	84.90	87.98	47.53	43.85	6.18	7.23
	SA.400 ppm.	4.75	4.48	34.80	34.83	85.78	87.90	47.45	44.93	6.35	7.28
	Control	4.65	4.52	34.40	34.88	85.20	89.23	45.53	40.25	6.65	5.95
Optimum sowing mean		4.68	4.56	34.65	34.81	85.07	88.36	46.23	43.13	6.34	6.89
Late sowing (25 May)	AA.200 ppm.	4.83	4.61	35.33	35.64	86.23	88.90	46.58	43.33	6.55	6.30
	AA.400 ppm.	4.83	4.63	36.23	35.48	87.80	89.00	45.83	44.45	6.60	6.28
	Asc.200 ppm.	4.95	4.51	35.35	35.90	87.05	89.40	45.75	43.43	6.63	5.80
	Asc.400 ppm.	4.93	4.75	35.93	35.05	85.75	88.18	45.30	43.68	6.55	5.95
	SA.200 ppm.	4.83	4.59	35.73	35.72	86.33	90.13	47.83	44.65	6.58	6.28
	SA.400 ppm.	4.83	4.65	35.35	36.36	86.23	89.10	45.28	44.70	6.65	6.45
	Control	4.95	4.72	35.58	35.49	87.95	89.03	45.68	42.20	6.70	5.80
Late sowing mean		4.88	4.64	35.64	35.66	86.76	89.10	46.03	43.78	6.61	6.12
General means of tr'ts (T)	AA.200 ppm.	4.73	4.58	34.90	35.42	85.41	88.33	46.59	43.33	6.36	6.83
	AA.400 ppm.	4.76	4.63	35.69	34.99	86.76	88.70	45.51	43.84	6.49	6.71
	Asc.200 ppm.	4.83	4.57	34.71	35.21	85.90	88.88	46.13	43.11	6.48	6.19
	Asc.400 ppm.	4.80	4.70	35.38	35.17	85.15	88.55	45.05	43.59	6.45	6.33
	SA.200 ppm.	4.75	4.53	35.29	35.07	85.61	89.05	47.68	44.25	6.38	6.75
	SA.400 ppm.	4.79	4.56	35.08	35.60	86.00	88.50	46.36	44.81	6.50	6.86
	Control	4.80	4.62	34.99	35.19	86.58	89.13	45.60	41.23	6.68	5.88
LSD (0.05)	SD	0.13	NS	0.79	NS	NS	NS	NS	NS	0.17	0.18
	T	NS	NS	NS	NS	NS	NS	NS	0.80	NS	0.25
	SD×T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*NS, non-significant

properties in *hirsutum* cotton. Emara (2012) mentioned that sowing dates did not exhibit any significant effect on uniformity index and elongation.

3.4.4 Fiber strength (g/tex)

Data presented in Table 8 indicated that sowing dates had no significant effect on fiber strength in both seasons. Similar results were obtained by Emara (2102). In addition, foliar application treatments had significant effects on fiber strength in both seasons. Organic compound treatments improved fiber strength compared with untreated control.

3.4.5 Fiber elongation (%)

Fiber elongation (%) was significantly affected by sowing dates, in 2015 season. Late sowing exhibited higher value of fiber elongation (6.61%) compared to that of optimum sowing by 6.34%, whereas reverse result was recorded in 2016 growing season i.e. normal sowing showed higher value of fiber elongation (6.89%) compared to that of late sowing (6.12%) (Table 8). Emara (2012) concluded that delayed planting date increased fiber elongation percent. With respect to cotton fiber quality, in general, is much less sensitive to high temperature prevailing during boll development stage in late sowing than yield (Hake and Silvertooth 1990). The foliar application treatments had a significant effect on fiber elongation (%) only in 2016 season. All organic compounds significantly enhanced fiber elongation (%) compared to untreated control.

4 Conclusion

Based on our results of the study, late sowing caused negative impacts on cotton yield and its related components. However, foliar application of ascorbic acid or salicylic acid on cotton plants at flowering initiation stage and at peak of flowering stage with concentration 200 or 400 ppm had significant positive effects on seed cotton yield and lint quality properties. According to these results it can be suggested that usage of organic compounds to improve the yield and quality properties especially in late sowing for 'Giza 94' cotton cultivar at Kafr- Elsheikh district, Egypt.

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