Journal of Applied Life Sciences and Environment
https://jurnalalse.com

Article
https://doi.org/10.46909/alse-564118
Vol. 56, Issue 4 (196) / 2023: 579-599

EFFECT OF SALICYLIC ACID APPLICATION ON COTTON (*Gossypium hirsutum* L.) YIELD AND FIBRE QUALITY

Rukiye KILIÇ and Çetin KARADEMİR*

Department of Field Crops, Faculty of Agriculture, Siirt University, Siirt, 56100, Turkey; email: rukiye.kilic@siirt.edu.tr

*Correspondence: cetinkarademir@siirt.edu.tr

Received: Nov. 15, 2023. Revised: Dec. 12, 2023. Accepted: Jan. 05, 2024. Published online: Jan. 31, 2024

ABSTRACT. This study was carried out to determine the effect of SA (salicylic acid) application on the yield, yield components, and fibre quality characteristics of cotton at different growth stages (squaring, flowering and squaring + flowering). The experiment was carried out at Siirt University, Faculty of Agriculture, Department of Field Crop's experimental area during the 2022 cotton growing season. The experimental design was a split-plot design with four replications. The main plot and sub-plots consisted of SA applications [Control (0.0 mM), squaring (1.0 mM), flowering (1.0 mM), squaring (0.5 mM) + flowering (0.5 mM)] and varieties (MAY 455, Stoneville 468, Fiona), respectively. SA application and variety interactions were significant in terms of the first boll opening days and the number of nodes. There were significant differences between varieties, except for the number of monopodial branches, number of bolls, chlorophyll content value, normalised difference vegetation index value, and micronaire and fibre strength. The MAY 455 cotton variety had the highest values in terms of seed cotton yield (2993.1 kg ha^{-1}) plant height (62.14 cm), boll weight (6.51 g), seed cotton weight per boll (4.90 g), number of seeds per boll (29.46), number of nodes to first fruiting branch (8.65), fibre yield (1361.0 kg ha^{-1}) and 100-seed weight (8.82 g), while the Fiona variety came to the fore in terms of number of days to first boll opening (118.0 d), number of sympodial branches (7.56), number of nodes per plant (17.79), ginning percentage (46.45%), fibre length (828.52 mm) and fibre reflectance (82.18 Rd). There was a slight increase in yield (223.8 kg ha^{-1}) compared to the control. SA application may show different effects on each cotton variety, and the positive effect may increase by applying SA at different intervals.

Keywords: cotton; fibre quality; growth; physiology; salicylic acid; yield.

INTRODUCTION

Cotton fibre is a valuable agricultural product that can be produced more than other natural fibres. Its fibre is used extensively in the field of textiles, and its seed, which is obtained as a by-product, provides an important raw material in animal nutrition and oil production. Cotton, which constitutes 25% of the total fibre in the world, is one of the most important textile fibres (ICAC, 2022). World production of cotton fibre in the 2021-2022 planting season is 25.7 million tonnes.

According to the world ranking, Türkiye holds an important place in cotton production and ranked 8th with its 2.25 million tonnes of seed cotton production in 2021. Cotton meets almost all fibre production as a fibre source in Türkiye (TUIK, 2022).

Since climate characteristics are an important limiting factor in cotton cultivation, it is cultivated in 3 regions in our country, namely the Southeastern Anatolia, Egean and Cukurova Regions (Karademir *et al.*, 2015). At the global level, agriculture cannot meet increasing demands due to continuous population growth. Due to the intense consumption of natural resources, agriculture is under great pressure (Sharma, 2013).

The need for the development of agriculture necessitates searching for different solutions. Many scientific studies have been carried out to increase the yield and quality of cotton. Plant growth regulators used for this purpose can contribute to the development of cotton yield components.

To adapt to the changing environment, plants have evolved well-developed mechanisms that help sense stress signals and ensure an optimal growth response.

SA (salicylic acid) is an important endogenous signalling molecule in plants that not only regulates some plant growth and development processes but also plays an important role in plant stress resistance (Hu *et al.*, 2022). SA has emerged as an important plant defence hormone with critical roles in different aspects of plant immunity (Zhang and Li, 2019). SA is considered a signalling molecule that plays a key role in plant growth, development and defence responses under stress conditions (Dong *et al.*, 2015). SA plays a vital role in photosynthesis and the functioning of the protective cells required for the closure of stomata (Melotto *et al.*, 2006; Sharma *et al.*, 2022a, b; Vlot *et al.*, 2009).

SA is a hormone that mediates the plant's defence against pathogens. SA also plays an active role in the plant's response to a variety of abiotic stressors, including cold, drought, salinity and heavy metals (Bagautdinova *et al.*, 2022).

SA can positively affect seed germination, cell growth, seedling formation, expression of senescence-related genes and fruit yield in legumes (Vlot *et al.*, 2009). SA application at appropriate concentrations in herbaceous plants improves stomatal conductivity, electron transport and antioxidant activities and thus increases photosynthetic efficiency (Aamer *et al.*, 2022; Janda *et al.*, 2014; Korndörfer and Oliveira, 2010). It has also been stated that SA plays an important role in photosynthesis by affecting the leaf and chloroplast structures (Uzunova and Popova, 2000).

Cotton plants can be exposed to many stressors during the growing season. In addition, the high temperatures that the summer season can bring and the limited water can cause both heat and water stress in plants. Plants can activate their defence mechanisms during these stressful times. SA is one of the hormones secreted by plants during stress. The application of SA may be important in reducing the negative effects of stressors on cotton yield. The effect of SA application depends on many factors, such as the type and developmental stage of the plant and the concentration of applied and endogenous SA levels (Hara *et al.*, 2012).

The objective of this study was to examine the effects of SA applications on different cotton cultivars during squaring, flowering and squaring + flowering periods to determine the changes in cotton yield, quality and some physiological parameters with SA applications, the effects of SA application on fibre quality in cotton, and the interaction between cultivar and SA application.

MATERIALS AND METHODS

Experimental Site

The experimental area is in the Siirt University trial area at 37° 58' north latitude, 41°51' east longitude, and 930 m above sea level. The results of the soil analysis are presented in Table 1. The soil analyses were carried out in the university laboratory, and the results are listed in *Table 1*.

Climate Data

In the region where Siirt province is located, summers are hot and dry, and winters are very cold and generally partly cloudy. The temperature normally varies between −2 and 37°C throughout the year. Although it can drop below −8°C in winter, it can be over 40°C in summer (WeatherSpark, 2022). The climate data of Siirt province obtained by the Siirt Meteorology Directorate station are given in *Table 2*.

Plant Materials

Cotton varieties 'May 455', 'Stoneville 468' (MAY Company Bursa/Türkiye) and 'Fiona' (BASF Company) were obtained from the private sector and used in this study. These varieties were selected because they are widely planted in the region and have high adaptability.

Experimental Design, Treatment Details and Cultural Practices

In the experiment, sowing operations were carried out on 13 May 2022 with a seeder. Each parcel consisted of 16.8 m^2, with a width of 2.8 m and a length of 6 m. There were 4 rows in each parcel. The spacing between the rows was fixed at 0.7 m during planting, and a 2 m space was left between the blocks.

According to the soil analysis results, the amount of fertiliser needed by the cotton plant was determined, and 140 kg ha^{-1} nitrogen (N) and 80 kg ha^{-1} phosphorus (P_2O_5) were applied.

Drip irrigation started during the squaring period before the first flowering stage, after which water was applied at 7-day intervals. During the 10% boll-opening stage, irrigation was terminated. Plants were checked regularly throughout the developmental period.

For SA applications, crystalline SA ($C_7H_6O_3$) was prepared with 0.5 mM and 1.0 mM distilled water. Spraying was applied to each plot using 500 mL of water. Only water was applied to the control plots.

Table 1 – Properties of the soil on which the experiment was performed

Analysis	Analysis results
pH	7.70
EC (dS/m)	0.09
Lime (%)	2.55
Texture (%)	Sand: 27.3 Silt: 20.0 Clay: 52.7
Organic Matter (%)	0.94
P_2O_5 (kg ha^{-1})	29.60
K_2O (kg ha^{-1})	1366.50

pH: Potential Hydrogen, EC: Electrical Conductivity

Table 2 – Siirt province 2022, monthly temperature, rainfall, humidity values and long-term average from 1950 to 2015 (Meteorological Service, Siirt)

Month	Maximum temperature (˚C)	Average temperature (°C)	Long-term average temperature (°C)	Rainfall (mm)	Long-term average rainfall (mm)	Relative humidity (%)	Long-term average humidity (%)
April	28.80	17.40	13.80	10.00	50.40	38.90	104.30
May	34.80	18.60	19.30	55.20	41.50	50.20	62.00
June	39.50	28.30	26.00	1.40	24.10	26.80	8.70
July	42.20	31.90	30.60	0.00	18.10	19.50	1.60
August	41.30	32.50	30.00	0.00	17.20	19.70	1.00
September	41.30	27.80	25.00	0.40	24.00	22.70	5.20
October	34.90	20.60	17.90	54.00	45.30	42.80	50.90

The experiment was carried out in randomised complete blocks according to the split-plot design with 4 replications. In the experiment, the main plots were formed by 4 SA applications (control, squaring period 1.0 mM, flowering period 1.0 mM, and squaring + flowering period 0.5 mM ×2), and sub-plots were cultivars (May 455, Stoneville 468 and Fiona).

Harvesting was performed manually in two stages: on 4 October 2022, when 60% of the bolls were open, and the remaining product was harvested on 18 October 2022 in the second-hand harvest.

Data Collection

Seed cotton yield: Seed cotton collected in the first and second hands was weighed separately and then converted into total yield.

Plant height, monopodial branches, sympodial branches, number of bolls (number/plant), boll weight, seed cotton weight per boll, number of seeds per boll, number of nodes for the first fruiting branch and node number per plant were measured from 10 randomly selected plants from each plot, and the average was calculated.

Number of days to first boll opening: The number of days to the first boll opening was recorded as the day when 1 opened boll per meter was seen in the plot.

Chlorophyll content in leaves (SPAD value): The chlorophyll content of 10 randomly selected plants from each plot was determined using a Minolta SPAD-502 instrument in the top 5th newly opened and fully grown leaf during the flowering period (Johnson and Sounders, 2002).

Normalised difference vegetation index (NDVI): The NDVI value in each plot was determined during the flowering period with the help of the Green Seeker instrument.

Quality parameters: Fibre analyses were performed using a HVI (High Volume Instrument) 1000 instrument in the GAP International Agricultural Research and Training Center's fibre quality analysis laboratory.

Statistical analysis: The data obtained from the experiment were analysed using analysis of variance (ANOVA) with the JMP 7 (data analysis software) statistical programme using the experimental design of split plots in randomised blocks, and the least significant difference (LSD $_{0.05}$) test was used to identify significant differences between means.

RESULTS AND DISCUSSION

The yield and yield components, physiological parameters and fibre quality criteria are given in the tables below.

Yield and Yield Components

SA applications did not create statistically significant differences in seed cotton yield, yield components or fibre quality properties. The differences between cultivars were statistically significant in terms of seed cotton yield, plant height (*Table 3*), number of sympodial branches (*Table 4*), boll weight (*Table 5*), seed cotton boll weight, number of seeds per boll (*Table 6*), number of days to first boll opening, number of nodes of first fruiting branches (*Table 7*), 100-seed weight, first picking percentage (*Table 8*), number of nodes, height /node ratio (HNR) (*Table 9*), ginning percentage and fibre yield (*Table 10*), while the SA application × cultivar interaction was only significant for number of days to first boll opening (*Table 7*) and number of nodes (*Table 9*).

The average values regarding the seed cotton yield obtained from SA applications varied between 2621.4 and 2845.2 kg ha^{-1}, and the general average of the experiment was 2728.7 kg ha^{-1}. The yield difference between the SA treatment during squaring + flowering and the control was 223.8 kg ha^{-1}.

Table 3 shows that differences between varieties were significant at the $p<0.01$ probability level for seed cotton yield. The highest seed cotton yield was obtained from the May 455 variety (2993.1 kg ha^{-1}), followed by the Stoneville 468 variety (2831.2 kg ha^{-1}), and these cotton varieties shared the same statistical group. The lowest yield was obtained with the Fiona variety (2361.9 kg ha^{-1}).

In this study, the seed cotton yield was not significantly different among SA applications. Some previous studies have revealed non-significant differences between SA and control applications (Aziz *et al.*, 2018; Sarwar *et al.*, 2018; Barros *et al.*, 2019). Different results have been obtained in previous studies showing that SA applications increase yield efficiency (Hussain *et al.*, 2020; Borzouyi *et al.*, 2021). Although there was no significant difference, a yield increase of 223.8 kg ha^{-1} was achieved between the SA application during the squaring + flowering period and the control application. As shown in *Table 3*, the highest plant height was obtained from the May 455 variety (62.14 cm), followed by the Stoneville 468 variety (60.12 cm). They shared the same statistical group, while the lowest plant height was obtained with the Fiona variety (55.65 cm).

SA application did not have a significant effect on plant height. Borzouyi et al. (2021) reported that SA application (2 mmol L^{-1}) significantly increased plant height: 61.3 cm in the control and 69.5 cm in the SA application. Barros *et al.* (2019), Borzouyi *et al.* (2021) and Heidari *et al.* (2022) confirmed these results.

The number of monopodial branches obtained as a result of SA application varied between 0.70 and 1.00. SA applications and varieties did not have a significant effect on the number of monopodial branches (*Table 4*). There were no significant interactions between SA applications and varieties. Some researchers revealed that SA application increased the number of monopodial branches compared to the control, and the differences between applications were significant (Borzouyi *et al.*, 2021; Heidari *et al.*, 2022; Hussain *et al.*, 2020). However, Kassem (2008), Aziz *et al.* (2018) and Sarwar *et al*. (2018) found no significant difference in the number of monopodial branches between control and SA applications, and these research findings seem to be similar.

Table 4 shows that the difference between cultivars is significant in terms of the number of sympodial branches. The Fiona cultivar (7.56) had the highest value among cultivars in terms of the number of sympodial branches, followed by Stoneville 468 (6.46) and May 455 (6.34). Aziz *et al.* (2018) reported 3.87 sympodial branches after SA application and 3.00 sympodial branches in the control, but there were no significant differences between the applications. Similar results were obtained in the present study.

As shown in *Table 5*, the differences between the cultivars and SA applications were not significant in terms of the number of bolls. While the lowest value in the number of bolls was obtained by May 455 with 8.06, the highest value was obtained by the STV 468 cotton variety with 8.91.

Aziz *et al.* (2018) and Heitholt *et al.* (2001) stated that there was a non-significant difference between the number of bolls in the plant with the application of SA, and the results of these studies were similar with the present study. Barros *et al.* (2019) and Borzouyi *et al.* (2021) found that the difference between the control and SA applications was important for the number of bolls, and the results of these studies were not similar with the present study.

There were statistically significant differences between the cultivars in terms of boll weight. May 455 (6.51 g) had the highest boll weight, followed by Fiona (5.90 g) and Stoneville 468 (5.0 g) in group c, which contained the variety with the lowest value (5.45 g). There were non-significant differences between SA treatments in terms of boll weight in present study. The results of this study were similar to those of observed by Aziz *et al.* (2018), Barros *et al.* (2019), Hussain *et al.* (2020) and Sarwar *et al.* (2018).

Table 3 – Average values and statistical groupings of the seed cotton yield and plant height

Treatment		Seed cotton yield (kg ha^{-1})				Plant Height (cm)			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
Control		2925.3	2686.6	2252.4	2621.4	62.75	59.55	55.35	59.22
Squaring		2966.4	2729.5	2431.3	2709.0	63.25	58.38	57.65	59.76
Flowering		2914.3	3125.6	2177.7	2739.2	59.90	61.45	53.85	58.40
Squaring + Flowering		3166.4	2783.0	2586.4	2845.2	62.65	61.10	55.75	59.83
Mean		2993.1^a	2831.2^a	2361.9^b		62.14^a	60.12^a	55.65^b	
General Mean		2728.7				59.30			
CV %		12.16				6.55			
LSD (0.05)	T	NS				NS			
	V	242.1				2.83			
	T × V	NS				NS			
P value	T	0.29				0.08			
	V	15.62**				11.69**			
	T × V	1.12				0.72			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

Table 4 – Average values and statistical groupings of the number of monopodial branches and sympodial branches

Treatment		Monopodial Branches Per Plant				Sympodial Branches Per Plant			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
Control		1.00	1.15	0.87	1.00	6.58	7.03	8.03	7.20
Squaring		0.92	0.85	0.92	0.90	5.73	6.18	7.85	6.58
Flowering		0.72	0.72	0.67	0.70	6.40	6.30	6.80	6.50
Squaring + Flowering		0.42	0.80	0.90	0.70	6.65	6.35	7.58	6.86
Mean		0.76	0.88	0.84		6.34^b	6.46^b	7.56^a	
General Mean		0.82				6.79			
CV %		25.51				13.66			
LSD (0.05)	T	NS				NS			
	V	NS				0.68			
	T × V	NS				NS			
P value	T	0.62				0.53			
	V	0.45				8.44**			
	T × V	0.82				0.72			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

Table 5 – Average values and statistical groupings of the number of bolls and boll weight

Treatment		Number of Bolls (number/plant)				Boll Weight (g)			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
Control		8.00	8.90	8.85	8.58	6.53	5.49	5.83	5.95
Squaring		8.60	8.05	8.70	8.45	6.49	5.55	5.98	6.02
Flowering		7.70	9.30	8.22	8.40	6.60	5.36	5.99	5.99
Squaring + Flowering		7.95	9.42	8.80	8.72	6.41	5.38	5.79	5.87
Mean		8.06	8.91	8.64		6.51[a]	5.45[c]	5.90[b]	
General Mean		8.54				5.95			
CV %		20.27				5.52			
LSD $_{(0.05)}$	T	NS				NS			
	V	NS				0.24			
	T × V	NS				NS			
P value	T	0.03				0.19			
	V	1.01				41.97**			
	T × V	0.36				0.23			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

Table 6 – Average values and statistical groupings of the seed cotton weight per boll and the number of seeds per boll

Treatment		Seed Cotton Weight Per Boll (g)				Number of Seeds Per Boll			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
Control		4.92	4.13	4.24	4.43	29.29	25.52	27.99	27.60
Squaring		4.87	4.16	4.37	4.47	29.94	26.50	27.77	28.07
Flowering		4.99	4.02	4.43	4.48	29.78	26.36	24.77	26.97
Square + Flowering		4.81	4.00	4.30	4.37	28.83	26.08	27.29	27.40
Mean		4.90[a]	4.08[c]	4.34[b]		29.46[a]	26.11[b]	26.95[b]	
General Mean		4.44				27.51			
CV %		5.80				5.56			
LSD $_{(0.05)}$	T	NS				NS			
	V	0.18				1.12			
	T × V	NS				NS			
P value	T	0.19				0.54			
	V	42.55**				20.73**			
	T × V	0.35				1.72			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

Table 7 – Average values and statistical groupings of the number of days to first boll opening and the number of nodes for the first fruiting branch

Treatment		Number of Days to First Boll Opening				Number of Nodes for First Fruiting Branch			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
Control		111.0^{cd}	109.5^{cde}	116.50^{b}	112.33	8.80	7.87	8.22	8.30
Squaring		108.0^{e}	109.0^{de}	120.5^{a}	112.50	8.50	8.00	9.00	8.50
Flowering		109.0^{de}	109.0^{de}	119.5^{a}	112.50	8.52	8.07	9.25	8.61
Square + Flowering		112.0^{c}	111.0^{cd}	115.5^{b}	112.83	8.80	7.00	8.12	7.97
mean		110.00^{b}	109.63^{b}	118.00^{a}		8.65^{a}	7.73^{b}	8.65^{a}	
General Mean		112.54				8.34			
CV %		1.76				9.60			
LSD $_{(0.05)}$	T	NS				NS			
	V	1.45				0.58			
	T × V	2.89				NS			
P value	T	0.02				0.72			
	V	90.78**				6.95**			
	T × V	4.95**				1.09			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

Table 8 – Average values and statistical groupings of the 100-seed weight and first picking percentage

Treatment		100-seed weight (g)				First picking percentage (%)			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
Control		8.81	8.05	7.36	8.07	96.71	97.80	95.39	96.78
Squaring		8.42	8.02	8.54	8.33	97.56	95.99	93.85	95.80
Flowering		8.96	8.29	7.45	8.23	96.76	97.80	95.39	96.65
Square + Flowering		9.11	8.70	7.92	8.58	95.10	96.16	93.49	94.92
Mean		8.82^{a}	8.26^{b}	7.82^{b}		96.53^{a}	96.87^{a}	94.71^{b}	
General Mean		8.30				96.04			
CV %		8.15				1.88			
LSD $_{(0.05)}$	T	NS				NS			
	V	0.49				1.32			
	T x×V	N.S.				NS			
P value	T	0.94				2.05			
	V	8.83**				6.54**			
	T × V	1.51				0.75			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

The results of Borzouyi *et al.* (2021), who reported that significant differences in terms of boll weight, is not consistent with the result of present study. *Table 6* shows that the difference between cultivars is significant in terms of seed cotton weight per boll. The highest seed cotton weight per boll was obtained by the May 455 variety in group a (4.90 g), followed by Fiona variety (4.34 g) in group b. Stoneville 468 variety (4.08 g) had the lowest seed cotton weight per boll.

Heidari *et al.* (2022) observed a seed cotton weight per boll of 12.07 g after SA application (150 ppm) and 9.24 g in the control. The reason why this result does not coincide with the results of the study may be due to the varieties used and the environment in which the study was conducted.

The difference between varieties in terms of the number of seeds in the boll was significant. The highest number of seeds in the boll was obtained in the May 455 variety (29.46) in group a, followed by the Fiona (26.95) and Stoneville 468 varieties (26.11).

The number of days to first boll opening, first picking percentage and number of nodes of the first fruiting branch are important parameters in terms of showing earliness in cotton. In *Table 7* and *Table 8*, there were significant differences between the cultivars in terms of the number of days to the first boll opening and the first picking percentage. SA applications did not affect these earliness parameters.

The earliest boll opening days and the highest rate of first picking percentage were obtained with Stoneville 468 and May 455 varieties, which constituted the same group. The Fiona variety had the highest number of boll opening days and the lowest first picking percentage.

The application also had different interactions. This was statistically significant in terms of the number of days to the first boll opening (*Table 7*). The earliest first boll opening days were obtained from the SA application during the squaring period in the May 455 variety (108.00 days), and the highest number of first boll opening days was obtained by the SA application during the squaring and flowering period in the Fiona variety.

The difference between the cultivars was significant in terms of the number of nodes on the first fruiting branch. The highest number of nodes on the first fruiting branch was obtained from May 455 and Fiona (8.65), while the lowest value was obtained from the Stoneville 468 variety (7.73) in group b.

Noreen *et al.* (2013) reported that they achieved 10 days of earliness with SA application and a significant difference between SA applications. Aziz *et al.* (2018) reported that the number of days to the first boll opening varied between 113.2 and 118.5 days, with no significant difference between applications. In the present study, the number of days to the first boll opening did not change with the SA application, but the number of days to the first boll opening of the cultivars varied depending on the SA application period. Similar results have also been reported by Aziz *et al.* (2018).

Table 7 shows that the differences between SA applications were not significant; however, there were significant differences between cultivars in terms of the number of nodes for first fruiting branches. Aziz *et al.* (2018) showed similar results for the number of nodes on the first fruiting branch and obtained 6.75 from the control application and 6.25 from the SA application but with insignificant differences.

Table 8 shows that the differences between cultivars were significant for 100-seed weight. The highest 100-seed weight was obtained by the May 455 variety in group a (8.82 g), followed by Stoneville 468 (8.26 g) and Fiona varieties (7.82 g) in group b. Borzouyi *et al.* (2021) and Heidari *et al.* (2022) reported significant differences between the SA application and the control. According to the results of this research there was not significant differences between treatments for 100-seed weight. The results of this study showed parallelism with that of Kassem (2008), who reported that SA did not have a significant effect on 100-seed weight.

For first picking percentage, there were significant differences between cultivars; however, SA application did not affect this important earliness criterion. Noreen *et al.* (2013) obtained first picking percentage values of 80% with SA application and 59% in the control application and reported that the difference between the SA and control applications was significant. These results do not agree with those of the present study. Kassem (2008) found that the rate of the first picking percentage was not affected by SA. Similar result obtained from this study.

The differences between the cultivars and the application × cultivar interaction were statistically significant in terms of the number of nodes. The highest number of nodes was obtained from the Fiona variety (17.79), while the lowest value was obtained from Stoneville 468 (15.31). In addition, considering the interaction, the highest number of nodes was obtained from the Fiona variety (18.62) during the squaring period SA application, while the lowest number of nodes was obtained from the Stoneville 468 variety (14.97) with SA application during the squaring period. Aziz *et al.* (2018) obtained 24.25 nodes from the control and 24.87 nodes from the SA application, but the difference was not significant. Similar results have also been reported by Kassem (2008).

For the height/node ratio (HNR), *Table 9* shows that the difference between the cultivars was significant. The highest height/node ratio (HNR) was obtained from the Stoneville 468 variety (3.92), followed by the May 455 variety (3.87), and these two varieties shared the same statistical group. The lowest HNR was obtained from the Fiona variety (3.13).

As shown in *Table 10*, no significant differences were observed between SA applications in terms of ginning percentage and fibre yield. The differences between cultivars were significant in terms of ginning percentage and fibre yield. The highest ginning percentage (46.45%) and the lowest fibre yield were obtained by the Fiona variety (1097.2 kg ha^{-1}).

The lowest ginning percentage was observed in Stoneville 468, and the highest fibre yield was obtained in the May 455 and Stoneville 468 cotton varieties, which shared the same statistical group.

Aziz *et al.* (2018) revealed that ginning efficiency was 40.31% in the control and 38.06% in the SA application, and they reported that the difference between the applications was not significant. Different results were obtained by Borzouiyi et al. (2021), who reported that ginning efficiency increased with SA application.

These findings are similar to those of Kassem (2008), Aziz *et al.* (2018) and Heidari *et al.* (2022), who showed no significant differences between SA applications and the control in terms of fibre yield. However, these results are contradictory to those of Borzouyi *et al.* (2021) and Razavi (2021), who reported that SA application had a significant effect on fibre yield.

Physiological Parameters

Differences between SA applications and cultivars were not significant for SPAD and NDVI values. *Table 11* shows that the general average of the SPAD value was 44.98, and the general average of the NDVI value was 0.64.

Sarwar *et al.* (2018) reported that SA had no significant effect on the chlorophyll content value in cotton Heidari *et al.* (2022) obtained significant differences between SA applications in terms of chlorophyll content; they observed a chlorophyll content value of 47.5 in the control and 50.2 in the SA application (150 ppm). Omar *et al.* (2018) reported that SA increased the chlorophyll content in cotton.

Table 11 shows that the average NDVI values varied between 0.63 and 0.65, depending on the applications, and the overall average of the experiment was 0.64. SA applications did not cause a significant difference in NDVI values. NDVI values of the varieties varied between 0.63 and 0.65, but the differences between the varieties were not significant. In the NDVI values, the lowest value was obtained from the Fiona variety with 0.63, while the highest value was obtained from the Stoneville 468 variety with 0.65.

The application × variety interaction was not significant for NDVI values, indicating that the NDVI values of the varieties did not change with SA application.

Fibre Quality Traits

The differences between SA applications in terms of fibre quality parameters were not statistically significant. There were significant differences between varieties in terms of fibre length, fibre elongation, fibre uniformity ratio, fibre reflectance, fibre yellowness value and short fibre index; the differences between varieties were not significant for fibre fineness or fibre strength properties.

As shown in *Table 12*, *Table 13*, *Table 14* and *Table 15*, the highest values in terms of fibre length and fibre reflectance were obtained from the Fiona variety, with a statistically significant difference. In addition, the highest fibre elongation, fibre uniformity and fibre yellowness value and lowest short fibre index were obtained in Stoneville 468.

El-Beltagi *et al.* (2017) revealed that SA application did not have a significant effect on fibre micronaire and that the micronaire value ranged between 4.13 and 4.17 mic. in the SA application group and the control group.

Table 9 – Average values and statistical groupings of node number and height/node ratio

Treatment		Node Number				Height/Node Ratio			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
Control		16.82^{c}	15.65^{d}	18.12^{ab}	16.86	3.72	3.80	3.05	3.52
Squaring		15.30^{d}	14.97^{d}	18.62^{a}	16.30	4.13	3.88	3.09	3.70
Flowering		15.47^{d}	15.05^{d}	17.37^{bc}	15.96	3.86	4.09	3.10	3.68
Square + Flowering		16.60^{c}	15.57^{d}	17.05^{c}	16.40	3.78	3.93	3.28	3.66
Mean		16.05^{b}	15.31^{c}	17.79^{a}		3.87^{a}	3.92^{a}	3.13^{b}	
General Mean		16.38				3.64			
CV %		3.93				6.35			
LSD $_{(0.05)}$	T	NS				NS			
	V	0.47				0.16			
	T × V	0.94				NS			
P value	T	0.79				0.40			
	V	62.51**				58.81**			
	T × V	3.92**				1.45			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

Table 10 – Average values and statistical groupings of the ginning percentage and fibre cotton yield

Treatment		Ginning percentage (%)				Fiber yield (kg ha^{-1})			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
Control		45.42	45.02	46.80	45.75	1328.2	1211.1	1056.3	1198.5
Squaring		45.31	45.33	46.31	45.65	1343.2	1236.9	1123.8	1234.6
Flowering		45.87	45.31	46.18	45.79	1337.4	1415.8	1005.1	1252.8
Squaring + Flowering		45.37	44.50	46.50	45.45	1435.1	1238.5	1203.6	1292.4
Mean		45.49^{b}	45.04^{b}	46.45^{a}		1361.0^{a}	1275.6^{a}	1097.2^{b}	
General Mean		45.66				1244.6			
CV %		1.61				12.15			
LSD $_{(0.05)}$	T	NS				NS			
	V	0.53				110.3			
	T × V	NS				NS			
P value	T	0.23				0.24			
	V	15.10**				12.66**			
	T × V	0.81				1.24			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

Table 11 – Average values and statistical groupings for leaf chlorophyll content (SPAD value) and normalised vegetation difference index (NDVI value)

Treatment		SPAD				NDVI			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
control		45.32	44.70	44.37	44.80	0.66	0.62	0.60	0.63
Squaring		45.95	45.67	41.32	44.31	0.63	0.67	0.66	0.65
Flowering		45.15	45.50	46.07	45.57	0.61	0.67	0.60	0.63
Square + Flowering		45.55	44.92	45.27	45.25	0.65	0.63	0.66	0.65
Mean		45.49	45.20	44.26		0.64	0.65	0.63	
General Mean		44.98				0.64			
CV %		4.70				8.41			
LSD (0.05)	T	NS				NS			
	V	NS				NS			
	T × V	NS				NS			
P value	T	0.34				1.17			
	V	1.47				0.34			
	T × V	1.67				1.29			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

Table 12 – Average values and statistical groupings of the fibre micronaire (mic.) and fibre length

Treatment		Fiber Micronaire (mic.)				Fiber Length (mm)			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
Control		4.48	4.21	4.30	4.33	27.26	27.40	28.66	27.77
Squaring		4.31	4.35	4.35	4.34	27.24	26.46	28.54	27.41
Flowering		4.59	4.34	4.37	4.43	27.55	26.94	27.84	27.44
Square + Flowering		4.66	4.51	4.32	4.50	26.87	27.32	29.05	27.75
Mean		4.51	4.35	4.34		27.23^{b}	27.03^{b}	28.52^{a}	
General Mean		4.40				27.59			
CV %		5.09				2.75			
LSD (0.05)	T	NS				NS			
	V	NS				0.55			
	T × V	NS				NS			
P value	T	1.19				0.70			
	V	2.95				18.14**			
	T × V	0.75				1.40			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

Table 13 – Average values and statistical groupings of fibre strength and fibre elongation

Treatment		Fiber strength g tex^{-1}				Fiber elongation (%)			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
Control		29.54	30.19	30.60	30.11	5.34	5.71	4.85	5.30
Squaring		30.52	28.52	29.90	29.65	5.40	5.56	4.95	5.31
Flowering		29.24	30.75	29.73	29.91	5.29	5.69	4.92	5.30
Square + Flowering		29.41	29.67	31.62	30.23	5.42	5.64	4.79	5.28
Mean		29.68	29.78	30.46		5.36[b]	5.65[a]	4.88[c]	
General Mean		29.97				5.30			
CV %		7.10				3.50			
LSD (0.05)	T	NS				NS			
	V	NS				0.12			
	T × V	NS				NS			
P value	T	0.12				0.04			
	V	0.64				70.47**			
	T × V	0.78				0.76			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

Table 14 – Average values and statistical groupings of fibre uniformity and reflectance degree

Treatment		Fibre uniformity (%)				Reflectance Degree (Rd)			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
Control		82.79	83.70	82.48	82.99	79.11	80.16	81.78	80.35
Squaring		82.47	82.71	82.22	82.47	79.23	79.15	82.25	80.21
Flowering		82.25	82.79	81.73	82.25	79.34	78.88	82.31	80.18
Square + Flowering		81.11	82.86	82.26	82.07	78.93	79.28	82.38	80.19
mean		82.15[b]	83.01[a]	82.17[b]		79.15[b]	79.37[b]	82.18[a]	
General Mean		82.45				80.23			
CV %		1.18				0.86			
LSD (0.05)	T	NS				NS			
	V	0.71				0.50			
	T × V	NS				NS			
P value	T	1.70				0.11			
	V	4.06*				94.77**			
	T × V	0.79				1.64			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

Table 15 – Average values and statistical groupings of the yellowness and short fibre index

Treatment		Yellowness (+b)				Short Fiber index (%)			
		May 455	STV 468	Fiona	Mean	May 455	STV 468	Fiona	Mean
Control		8.51	8.65	7.33	8.16	9.31	7.76	9.96	9.01
Squaring		8.31	8.89	7.58	8.26	10.45	9.59	10.74	10.26
Flowering		8.87	8.74	7.61	8.41	9.79	8.94	9.66	9.46
Square + Flowering		8.65	8.88	7.59	8.37	10.63	9.13	9.11	9.62
Mean		8.58^{b}	8.79^{a}	7.53^{c}		10.04^{a}	8.85^{b}	9.87^{a}	
General Mean		8.30				9.59			
CV %		2.62				13.97			
LSD (0.05)	T	NS				NS			
	V	0.15				0.98			
	T × V	NS				NS			
P value	T	2.55				2.00			
	V	154.76**				3.61*			
	T × V	2.09				0.70			

Different lowercase letters within a row indicate significant differences between values, according to LSD's test ($p \leq 0.05$). CV: Coefficient of Variation
*.** Significant at $p \leq 0.05$ and $p \leq 0.01$ respectively, NS - not significant; T - treatment; V - variety.

Sarwar *et al.* (2018) reported similar results. Noreen *et al.* (2015) applied SA and achieved a 9.52% improvement in fibre fineness. These findings were not similar to those of the present study.

There was no statistically significant difference in fibre length between SA applications. The varieties were statistically significant at the 1% probability level, and the application × variety interaction was not significant. In this study, significant differences were determined in terms of fibre length among the varieties. The highest fibre length was obtained by the Fiona variety (28.52 mm) in group a, followed by the May 455 (27.23 mm) and Stoneville 468 varieties (27.03 mm) in group b. Omar *et al.* (2018) and Sarwar *et al.* (2018) reported that fibre length was not affected by SA application. Similar results were obtained in the present study. Noreen *et al.* (2015) reported that the SA application (100 mg/L) provided a 3.78% improvement in fibre length, and these results are not similar to those of the present study.

As shown in *Table 13*, no significant differences were found in fibre strength between SA applications, but significant differences were observed between varieties in terms of fibre elongation. The highest fibre elongation rate was obtained for the Stoneville 468 (5.65) variety. El-Beltagi *et al.* (2017) and Sarwar *et al.* (2018) stated that the difference in fibre strength values between SA application and the control was insignificant. Noreen *et al.* (2015) found that SA application improved fibre strength by 4.76%. Omar *et al.* (2018) showed that SA increased the fibre strength value, which was not similar of the results of present study. Omar *et al.* (2018) observed an increase in the fibre elongation value with the application of organic components, such as ascorbic acid, ascobin and SA to the green parts, but they did not detect a significant difference in the first year of the study. The results of Omar *et al.* (2018) agree with those of the present study.

Table 14 shows that SA application was not significant for fibre uniformity, but there were significant differences between varieties in terms of fibre uniformity. The general average fibre uniformity was 82.45%. Among the cotton varieties, the highest fibre uniformity value was observed in Stoneville 468, while the lowest value was observed in May 455.

For fibre reflectance (Rd), there were non-significant differences between SA applications; however, significant differences were obtained between cotton varieties. The general average reflectance degree value was 80.23. Among the cotton varieties, the highest reflectance value was observed in Fiona and the lowest value was observed in May 455.

Table 15 shows that SA application did not affect fibre yellowness or short fibre index, but there were significant differences between varieties for both traits. The general average of the fibre yellowness value was 8.30, and the general average of the short fibre ratio was 9.59%.

In terms of yellowness, the best value was obtained by the Fiona cotton variety, while the best value for the short fibre index was obtained by Stoneville 468. A low short fibre ratio and low yellowness value are desirable features for the textile industry. The short fibre index is a feature associated with immature fibre content and negatively affects the stages of yarn production (Manandhar, 2013).

CONCLUSIONS

SA application did not have a significant effect in terms of the properties examined in this study. However, although there was no significant difference between the applications, the highest seed cotton yield (2845.2 kg ha^{-1}) was obtained with SA application (0.5 mM ×2) during the flower + squaring period, while the lowest seed cotton yield was obtained from the control application at 2621.4 kg ha^{-1}.

Although there were no significant differences between SA applications in this study, there was a slight increase in yield of 223.8 kg ha^{-1} compared to the control. SA applications may show different effects on each cotton variety, and the positive effects may increase using applications at different intervals.

When these data were examined, the yield and yield components in cotton were lower than expected. It is thought that cotton experienced stress caused by high summer temperatures in the development period of 2022, causing yield loss in the plant. The average temperature values in the year of the experiment were above the long-term average, negatively affecting the yield.

In this study, in which the effect of SA applied at different stages of plant development on 3 different cotton cultivars was examined, the interaction of SA and cultivar was important for some traits, and cultivar differences were important for the majority of the examined traits. Very important results have been obtained in terms of yield and quality characteristics in studies on SA.

As a result, the interaction between SA application and cultivar was significant for the number of days to first boll opening and the number of nodes, indicating that the applications may have different effects in different cultivars. However, long-term studies are needed to reach a definite conclusion.

The application of plant growth regulators and osmoprotectants together with SA is recommended at different intervals and at different cotton development stages (3–4 leaf stage, squaring and flowering period). A study carried out in this way can more clearly reveal the effect of SA on cotton.

Author Contributions: Conceptualization, RK, ÇK; methodology, RK; validation, ÇK; formal analysis, RK, ÇK; investigation, RK, ÇK; resources, ÇK; writing—review and editing, RK, ÇK; All authors have read and agreed to the published version of the manuscript.

Funding: This study, which was produced from the master's thesis of the first author, was supported by Siirt University Scientific Research Projects Coordinatorship (SİÜ-BAP) with the project number 2022-SİÜFEB-022.

Acknowledgments: We would like to thank Siirt University Scientific Research Projects Coordinatorship for their support of this study.

Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

Aamer, M.; Chattha, M.U.; Hassan, M.U.; Ahmed, H.A.I.; Haiying, T.; Rasheed, A.; Guoqin, H.; Shahzad, B. Regulation of Photosynthesis by

Salicylic Acid Under Optimal and Suboptimal Conditions, In *Managing Plant Stress Using Salicylic Acid: Physiological and Molecular Aspects*, 1st Edition, John Wiley & Sons, New Jersey, USA. 2022, pp. 258-269. https://doi.org/10.1002/9781119671107.ch14

Aziz, M.; Ashraf, M.; Javaid, M.M. Enhancement in cotton growth and yield using novel growth promoting substances under water limited conditions. *Pakistan Journal of Botany*. **2018**, 50, 1691-1701. https://doi.org/10.3390/ijms23042228

Bagautdinova, Z.Z.; Omelyanchuk, N.; Tyapkin, A.V.; Kovrizhnykh, V.V.; Lavrekha, V.V.; Zemlyanskaya, E.V. Salicylic acid in root growth and development. *International Journal of Molecular Sciences*. **2022**, 23, 2228. https://doi.org/10.3390/ijms23042228

Barros, T.C.; Prado, R.M.; Roque, C.G.; Arf, M.V.; Vilela, R.G. Silicon and salicylic acid in the physiology and yield of cotton. *Journal of Plant Nutrition*. **2019**, 42, 458-465. https://doi.org/10.1080/01904167.2019.1567765

Borzouyi, Z.; Armin, M.; Marvi, H. The effect of time and type of stress moderators on yield and yield components of cotton on conventional and double-cropping systems under saline conditions. *Journal of Cotton Research*. **2021**, 4, 1-15. https://doi.org/10.1186/s42397-021-00103-6

Dong, Y.J.; Wang, Z.L.; Zhang, J.W.; Liu, S.; He, Z.L.; He, M.R. Interaction effects of nitric oxide and salicylic acid in alleviating salt stress of *Gossypium hirsutum* L. *Journal of soil science and plant nutrition*. **2015**, 15 , 561-573. http://dx.doi.org/10.4067/S0718-95162015005000024

El-Beltagi, H.S.; Ahmed, S.H.; Namich, A.A.M.; Abdel-Sattar, R.R. Effect of salicylic acid and potassium citrate on cotton plant under salt stress. *Fresenius Environmental Bulletin*. **2017**, 26, 1091-1100.

Hara, M.; Furukawa, J.; Sato, A.; Mizoguchi, T.; Miura, K. Abiotic stress and role of salicylic acid in plants, In *Abiotic Stress Responses in Plants*. Ahmad, P.; Prasad, M. (eds), Springer, New York, USA, 2012, 235-251. https://doi.org/10.1007/978-1-4614-0634-1_13

Heidari, M.; Moradi, M.; Armin, M.; Amerian, M.R. Effects of foliar application of salicylic acid and calcium chloride on yield, yield components and some physiological parameters in cotton. *Sustainability in Food and Agriculture*. **2022**, 3, 28-32. http://doi.org/10.26480/sfna.01.2022.28.32

Heitholt, J.J.; Schmidt, J.H.; Mulrooney, J.E. Effect of foliar-applied salicylic acid on cotton flowering, boll retention, and yield. *Materials and Methods*. **2001**, 46, 105-109.

Hu, Y.; Zhi, L.; Li, P.; Hancock, J.T.; Hu, X. The role of Salicylic acid signal in plant growth, development and abiotic stress. *Phyton-International Journal of Experimental Botany*. **2022,** 91, 2591-2605. https://doi.org/10.32604/phyton.2022.023733

Hussain, N.; Yasmeen, A.; Afzal, M.A. Exogenously applied growth promoters modulate the antioxidant enzyme system to improve the cotton productivity under water stress conditions. *Italian Journal of Agronomy*. **2020**, 15, 165-171. https://doi.org/10.4081/ija.2020.1537

ICAC. International Cotton Advisory Committee (ICAC) https://www.icac.org/DataPortal/DataPortal?Year=2021/22%20proj (accessed on 2 December 2022).

Janda, T.; Gondor, O.K.; Yordanova, R.; Szalai, G.; Pál, M. Salicylic acid and photosynthesis: signalling and effects. *Acta Physiologiae Plantarum*. **2014**, 36, 2537-2546. https://doi.org/10.1007/s11738-014-1620-y

Johnson, J.R.; Saunders, J.R. Evaluation of chlorophyll meter for nitrogen management in cotton. *Annual Report*. 2002, 162-163.

Karademir, E.; Karademir, Ç.; Ekinci, R.; Sevilmiş, U. Determination of yield and fiber quality characteristics in advanced generation cotton (Gossypium hirsutum L.) lines (in *Turkish*). *Türkiye Tarımsal Araştırmalar Dergisi.* **2015**, 2, 100-107. https://doi.org/10.19159/tutad.60964

Kassem, M. Cotton response to foliar application of salicylic acid under the environmental conditions of upper Egypt. *Egyptian Journal of Agricultural Research.* **2008**, 86, 1477-1488. https://doi.org/10.21608/EJAR.2008.209987

Korndörfer, G.H.; Oliveira, L.A. Use of silicon in commercial crops, In *Silicon in Agriculture*, F.A. Rodrigues, New York, NY: Elsevier, 2010, 1, 1-25.

Manandhar, R. Impact of Cotton Fiber Maturity for Cotton Processing, Doctoral thesis, Texas Tech University Department of Plant and Soil Science, Texas, 1-350, 2013.

Melotto, M.; Underwood ,W.; Koczan, J.; Nomura, K.; He, S.Y. Plant stomata function in innate immunity against bacterial invasion. *Cell*. **2006**, 126, 969-980. https://doi.org/10.1016/j.cell.2006.06.054

Noreen, S.; Athar, H.U.R.; Ashraf, M. Interactive effects of watering regimes and exogenously applied osmoprotectants on earliness indices and leaf area index in cotton (*Gossypium hirsutum* L.) crop. *Pakistan Journal of Botany*. **2013**, 45, 1873-1881.

Noreen, S.; Zafar, Z.U.; Hussain, K.; Athar, H.U.R.; Ashraf, M. Assessment of economic benefits of foliarly applied osmoprotectants in alleviating the adverse effects of water stress on growth and yield of cotton (*Gossypium hirsutum* L.). *Pakistan Journal of Botany*. **2015**, 47, 2223-2230.

Omar, A.M.; El Menshawi, M.; El Okkiah, S.; El Sabagh, A. Foliar application of organic compounds stimulate cotton (*Gossypium barbadense* L.) to survive late sown condition. *Open Agriculture.* **2018**, 3, 684-697. https://doi.org/10.1515/opag-2018-0072

Razavi, S.E. Effect of salicylic acid on cotton yield and induced resistance against biological stress. *Journal of Crop Production*. **2021**, 14, 19-30. https://doi.org/10.22069/EJCP.2021.17581.2295

Sarwar, M.; Saleem, M.F.; Ullah, N.; Rizwan, M.; Ali, S.; Shahid, M.R.; Alamri, S.A.; Alyemeni, M.N.; Ahmad, P. Exogenously applied growth regulators protect the cotton crop from heat-induced injury by modulating plant defense mechanism. *Scientific reports*. **2018**, 8, 1-15. https://doi.org/10.1038/s41598-018-35420-5

Sharma, P. Salicylic acid: a novel plant growth regulator–role in physiological processes and abiotic stresses under changing environments. John Wiley & Sons, New Jersey, USA. 2013, 939-990. https://doi.org/10.1002/9783527675265.ch36

Sharma, A.; Bhardwaj, R.; Kumar, V.; Zheng, B.; Tripathi, D.K. Managing Plant Stress Using Salicylic Acid: Physiological and Molecular Aspects. John Wiley & Sons, 2022a.

Sharma, N.; Sharma, V.; Sharma, V.; Bhardwaj, R. Salicylic acid: A regulator of plant growth and development, Managing Plant Stress Using Salicylic Acid: Physiological and Molecular Aspects, John Wiley & Sons, Chapter 1, 2022b,1-15.

TUIK. Turkish Statistical Institute. Crop Production Statistics. https://data.tuik.gov.tr/Kategori/GetKategori?p=tarim-111 (accessed on 2 December 2022).

Uzunova, A.N.; Popova, L.P. Effect of salicylic acid on leaf anatomy and chloroplast ultrastructure of barley plants. *Photosynthetica*. **2000**, 38, 243-250. https://doi.org/10.1023/A:1007226116925

Vlot, A.C.; Dempsey, D.M.A.; Klessig, D.F. Salicylic acid, a multifaceted hormone to combat disease. *Annual Review of Phytopathology*. **2009**, 47, 177-206. https://doi.org/10.1146/annurev.phyto.050908.135202

WeatherSpark. Climate and Average Weather Year Round in Siirt. https://tr.weatherspark.com/y/101948/Siirt-T%C3%BCrkiye-Ortalama-Hava-Durumu-Y%C4%B1l-Boyunca. (accessed on 2 December 2022).

Zhang, Y.; Li, X. Salicylic acid: biosynthesis, perception, and contributions to plant immunity. *Current Opinion in Plant Biology*. **2019**, 50, 29-36. https://doi.org/10.1016/j.pbi.2019.02.004

Academic Editor: Dr. Isabela Maria Simion

Publisher Note: Regarding jurisdictional assertions in published maps and institutional affiliations ALSE maintain neutrality.