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COTTON RESPONSE TO FOLIAR APPLICATION OF SALICYLIC ACID UNDER THE ENVIRONMENTAL CONDITIONS OF UPPER EGYPT

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Abstract

The hypothesis that foliar application of the bioregulator salicylic acid(SA)could increase cotton productivity under the environmental conditions of Upper Egypt was tested at the Experimental Farm of Mallawi Agric. Res. Station, Minia governorate, during 2005 and 2006 seasons. Cotton plants of Giza 83 cultivar were sprayed with SA at the concentrations of 0,50,100 , 200 , 300 , 400 and 500 ppm at early flowering stage .

Results of this study showed that , in comparison with the control , the lower SA concentrations up to 200 ppm significantly increased leaves content of chlorophyll a and total chlorophyll, while all SA treatments increased leaves content of polyphenols and total phenols . However, leaves content of chlorophyll b or sugars was not significantly affected by SA application .

The application of 100-200 ppm SA significantly increased open bolls per plant and seed cotton yield per fad. in both seasons as well as boll weight only in 2005 season , but significantly decreased nonopen bolls per plant in both seasons . The same trends of these traits were obtained by 50 ppm only in 2005 season . The concentration of 300 ppm significantly increased number of open bolls per plant in 2006 season and significantly decreased number of nonopen bolls per plant in both seasons . The higher SA concentrations , 400 and 500 ppm, gave almost no significant effects on yield and its components. SA application had no significant effects on plant growth characters , earliness % , lint % , seed index and fiber quality in both seasons .

The highest seed cotton yield and the best responses in general were obtained by 200 ppm in 2005 season and 100 ppm is 2006 season . Therefore , it could be concluded from results of this study , that SA could be used at the concentration of 100 or 200 ppm to improve cotton productivity under the environmental conditions of Upper Egypt.

INTRODUCTION

Cotton plants grown under the environmental conditions of Upper Egypt not only are usually challenged by the ordinary biotic agents of insects and pathogens , but they also frequently experience some abiotic stresses such as high temperature and excess light intensity which along with low relative humidity may further increase leaf water loss and often impose water stress. Both biotic and abiotic stresses disturb plant metabolism and adversely affect plant growth and productivity (Foyer *et al* , 1997). Thus, development of methods to induce stress tolerance in plants is vital and receives considerable attention.

Eliminating damage under stressful conditions depends on the plant ability to perceive the stimulus, generate and transmit signal, and induce biochemical changes that adjust metabolism accordingly (Rao *et al*, 1997). Plants posses many unique receptors that perceive various environmental cues, and many pathways that transduce specific signals (information) within their cells which allows them to generate protective responses and minimize the damage caused by biotic or abiotic stresses , Phytohormones play a key roles in modulating such protective responses (Jenkins, 1999) . In practical, the manipulation of potential signaling molecules has proved as a possible strategy for improving plant tolerance to multiple stresses (Larkindale and Huang, 2005).Salicylic acid (SA),a common plant produced phenolic compound , has been recently recognized as an important signal molecule regulating many aspects of plant growth and development as well as modulating plant responses to a wide range of biotic and abiotic stresses (Raskin, 1992, and Senaratna *etal*,2000) .

In recent years, the plant signal metabolite SA has become a topic of intense research primary due to its crucial role in the induction of disease resistance .SA is best known as an inducer of plant resistance to pathogens (Raskin, 1992). More recently , however , the role of SA in enhancing multiple stress tolerance in plants has received a growing attention . SA is strongly implicated in cross-tolerance in plants , the phenomenon that allows plants to adopt to a range of different stresses after exposure to one specific stress (Foyer , *et al* 1997). Now , it is clear that exogenous application of SA may has a practical importance in providing plant protection against various biotic and abiotic stresses (Senaratna *et al,* 2000 , and El- Tayeb , 2005) .

Besides its roles in plant pathogensis and stress tolerance , SA has been shown to have a regulatory role on diverse aspects of plant growth and development .The literature documents many biochemical and physiological effects of SA or its derivatives including , increases in leaf chlorophyll , photosynthetic rate and dry matter accumulation (El-Tayeb , 2005) , flowering induction and stomatal function (Raskin , 1992) and antioxidant activities (Rao *et al* , 1997) . Exogenously applied SA or its related compounds to different crops was shown to improve yield and yield components (Zaghlool *et al ,* 2001)

In cotton , SA has been demonstrated to upregulate antioxidant enzyme activities (Gossett *et al,* 2000), increase open bolls number (Hampton and Oosterhuis ,

1990) , mediate hormonal changes and enhance leaves content of chlorophyll , fruit retention and yield (Shehata *et al*, 2000) .

In the light of the above findings the present study was performed to investigate if foliar application of SA can increase cotton productivity by enhancing its tolerance to the naturally occurring environmental stresses associated with Upper Egypt conditions .

MATERIALS AND METHODS

The physiological response of cotton cultivar Giza 83 to foliar application of the bioregulator salicylic acid (SA) was investigated in field trails at Mallawi Agric. Res. Station, Minia Governorate, Upper Egypt, in 2005 and 2006 seasons. A randomized complete block design was used. The experimental unit was 13 m^2 in area , including 5 ridges , 4 m long and 65 cm apart . Sowing date was during the last week of March in both seasons . SA was applied at early flowering stage at the concentrations of 0, 50,100, 200, 300, 400 and 500 ppm . Standard agricultural practices for cotton cultivation were followed throughout the growing seasons .

Table 1. Averages of some climatic factors at Minia region in 2005 and 2006 seasons .

Month and days	2005					2006				
	Field temperature (°C)		Relative humidity (%)		Evaporation (mm/24 h)	Field temperature (°C)		Relative humidity (%)		Evaporation (mm/24h)
	max.	main	min.	main		max.	main	min.	main	
May	43.2	28.1	24	68	11.1	46.0	31.1	31	54	11.3
June 1-10	44.9	31.0	26	51	13.3	46.9	31.8	28	53	12.8
June 11-20	46.7	32.3	23	46	12.7	44.2	32.0	28	56	11.2
June 21-30	45.2	31.8	26	54	13.0	47.7	34.0	28	51	15.0
July 1-10	46.7	32.8	27	58	10.8	47.5	33.0	26	58	11.8
July 11-20	45.1	32.7	32	65	11.6	46.9	32.7	26	59	11.5
July 21-31	49.2	34.3	29	57	10.5	50.6	35.7	27	58	10.2
August 1-10	48.5	34.6	30	64	10.2	45.7	32.1	32	64	10.3
August11-20	45.2	32.6	32	70	10.1	47.4	32.7	29	65	8.9
August 21-31	43.7	31.5	30	67	11.4	47.8	33.8	30	66	9.6
September	40.8	28.4	27	62	8.9	41.0	30.4	29	65	9.9

Source : Mallawi Meterological Station .

In 2006 seasons , samples of the fourth leaves from the plant apex were collected 15 days after SA application to determine : leaves content of chlorophyll (Arnon , 1949) , reducing sugars (A.O.A.C. , 1965) , total soluble sugars (Cerning , 1975) , polyphenols (A.O.A.C., 1965) and total phenols (Simons and Ross , 1971) .

At harvest, 6 representative plants from the central row of each plot were chosen to estimate, plant height, number of main stem nodes, numbers of fruiting branches , open bolls and unopen bolls per plant . Earliness % was calculated as (1 st pick yield ÷ total yield) x 100 . Seed cotton yield in kgs per plot was transformed to kentars per faddan. Samples of seed cotton yield were taken from each plot to estimate lint %, seed index and fiber quality : fiber fineness (Micronaire reading) and fiber strength (Pressley index) .

Data collected were subjected to statistical analysis outlined by Gomez and Gomez (1984) using the least significant difference (LSD) in treatments comparison .

RESULTS AND DISCUSSION

SA effects on leaves chemical constituents :

It is obvious from Table (2) that SA application significantly influenced leaves content of chlorophyll and phenols but had insignificant effects on leaves content of sugars as compared with the control . The lower concentrations of SA up to 200 ppm only increased leaves content of chlorophyll a and total chlorophlls, while all SA concentrations increased leaves content of polyphenols and total phenols .

SA effects on plant growth parameters :

Data illustrated in Tables (3 and 4) clearly show that various SA treatments exerted no significant effects on plant growth characters , plant height , number of main stem nodes or number of fruiting branches per plant in comparison with the control in the two studied seasons .

SA effects on yield and its components :

Results shown in Tables (3 and 4) reveal that, in comparison with the control , the application of SA at the concentrations of 50-200 ppm significantly increased number of open bolls per plant , boll weight and seed cotton yield in 2005 season . In 2006 season , the application of 100-200 ppm significantly increased number of open bolls per plant and seed cotton yield per . faddan compared with the control . The concentration of 300 ppm significantly increased number of open bolls per plant in 2006 season only. Number of nonopen bolls per plant was significantly decreased by all SA concentrations except 400 and 500 ppm in 2005 season and 50 and 400 ppm in 2006 season . The application of 400 or 500 ppm had almost no significant effects on yield and yield components in both seasons The application of SA exerted no significant effects on earliness % , lint % , and seed index in both seasons and boll weight in 2006 season .

SA effects on fiber quality :

Data presented in Tables (3 and 4) show that SA application exerted no significant effects on fiber fineness (Micronaire reading) or fiber strength (Pressely index) as compared with the control in both seasons .

Climatic conditions of Upper Egypt are characterized by a frequent waves of high temperature, a relatively low air moisture (Table 1) , and high light intensity, which all together could potentiate water stress . Cotton grown in Upper Egypt is subjected to experience such stresses, during its fruiting stage of growth in particular . Fruiting of cotton is very sensitive to heat stress . Also, high irradiance may induce photoinhibition and photooxidation which adversely affect photosynthesis and fruit retention in cotton . Besides, immature bolls are prone to disease attacks in Minia , Assuit and Sohag regions (Galal , 2001) . Both biotic and abiotic stresses disrupt normal plant metabolism and physiology via generating oxidative damage (Foyer *et al,* 1997) . One of the approaches taken to develop stress tolerance in plants is the use of growth regulators involved in defense signaling cascades (Senaratna *et al,* 2000). A considerable body of evidence has accumulated from various plant systems showing that SA , a recently identified as signal transducer molecule , can protect plants from oxidative damage caused by diverse stresses including , pathogen infection (Raskin , 1992) and several abiotic stresses (Senaratna *et al* , 2000 and Zhao and Zou , 2002) .

Results of the present study reveal that foliar SA application had no significant effects on plant growth parameters, but it exhibited some positive effects on leaf chemical composition and plant fruiting and yield . SA at lower concentrations (50-200 ppm) significantly increased leaves content of chlorophyll a and total chlorophyll , while all SA concentrations increased polyphenols and total phenols . leaf sugars content were not significantly affected by SA application . Previous studies showed that SA or its derivatives increased leaves contents of phenols (Zaghlool *et al* , 2001) and chlorophyll (El- Tayeb , 2005) . In This concern , SA was found by Shehata *et al* (2000) to mediate changes in hormonal status in favour of senescence retarding endogenous hormones (IAA , GA_3 and cytokinins) and to reduce auxin – transport out of cotton bolls , which though to delay chlorophyll degradation in the subtending leaf .

Obtained results also show that SA at rates 50 - 200 ppm generally increased open bolls number, boll weight and seed cotton yield (Kentar / fad.) and reduced nonopen bolls number. Enhanced seed cotton yield could be owing to increasing open bolls and boll weight. Increased open bolls may be a result of reducing unopen bolls which may imply that SA reduced pathogen – damaged bolls.Considerable percentage of pathogen – damaged bolls (7.3 -8.8%) was found in cotton grown in Minia region (Galal , 2001) .SA is an essential component of plant resistance to pathogens . Systemic acquired resistance and hypersensitive response are a common trigger for the accumulation of SA in plants. SA–mediated signal transduction is crucial for the induction of a range of defense genes that include pathogensis– related (PR) proteins. Similarly , PR proteins increase also in plants exposed to abiotic stress which implies some signaling cross – talk between biotic and abiotic stresses. Such similarity of the injury mechanism between pathogen attack and abiotic stress, as both involve oxidative damage , suggests that SA which is known to induce resistance to diseases can also confer tolerance to abiotic stresses in plants (Senaratna *et al* , 2000) . Therefore, SA induces cross - tolerance in plants , that is the induction of tolerance to specific environmental stress involving oxidative stress also increases the tolerance to one or more other stresses including biotic stress (Foyer *et al* , 1997) .

One of the proposed modes of action of SA is the inhibition of catalase , a major H_2O_2 scavenging enzymes , thereby increasing cellular concentration of H_2O_2 which acts as a second messenger and activates stress related genes . H_2O_2 is directly involved in crosslinking cell wall proteins and increasing lignification, known components of defense arsenal . Under such situation , cells are prone to oxidative damage by SA –elevated H_2O_2 , therefore , SA increases the level of alternate antioxidant system as a defensive mean to protect cells during SA–mediated oxidative stress (Srivastava and Dwivedi , 1997) . SA has been shown to influence many enzymatic and non – enzymatic antioxidants that have a protective role against oxidative damage caused by diverse stresses, it increases activities of many enzymes such as glutathione reductase and peroxidase, ascorbate peroxidase, and superoxide dismutase (Rao *et al* , 1997) . SA also enhances the amounts and redex state of ascorbate and glulatione (Srivastava and Dwivedi , 1997).

The ability of SA to enhance antioxidant status was thought to be a mechanism by which SA protect plants from oxidative damage and induce multiple stress tolerance (Senaratna *et al* , 2000 , and Larkindale and Huang , 2005) . Zhao and Zou (2002) revealed that exogenous application of phenolic compounds could be a direct and simple means to induce plant tolerance to environmental stresses through enhancing antioxidant status .SA itself is a phenolic compound and it increased leaves phenols content in the present study and in other previous studies (Zaghlool *et al* , 2001) . Considering the above findings , it seems that the positive effects for SA on leaf chlorophyll and plant fruiting and yield obtained in this study were owing to its protective roles against pathogens and oxidative damage caused by various stresses associated with the climatic conditions of Upper Egypt , through improving the antioxidative activity .

It is obvious from results of this study that the higher SA concentrations had almost no marked effects on cotton productivity . This trend could be explained on the basis that deployment of defense responses is energetically costly , and cumulative unnecessary responses would be expensive in terms of resources expended in these responses , and hence potentially damaging (Jenkins , 1999) . In this connection , it was reported that while moderate doses of SA enhance the antioxidant status and induce stress resistance , higher concentrations activate hypersensitive cell death pathway and increase stress sensitivity (Larkindale and Huang , 2005) .

Summing up results of this study , it could be concluded that foliar application of 100 or 200 ppm SA exerted some improvement in leaves chemical composition and cotton fruiting and yield under the naturally occurring environmental conditions of Upper Egypt .

Table 2. Effect of foliar application of salicylic acid (SA) on some chemical constituents (mg / g dry weight) of cotton leaves in 2006 season .

SA Treatments	Chlorophyll			Sugars		Phenols	
	Chl.a	Chl.b	Total	Reducing	Total soluble	Poly	Total.
00 ppm (control)	4.38	1.69	6.07	5.11	8.81	6.72	9.37
50 ppm	4.68	1.85	6.53	4.95	7.98	7.48	11.17
100 ppm	4.76	1.90	6.66	4.88	8.16	7.87	12.20
200 ppm	4.70	1.83	6.53	5.36	8.41	7.58	11.77
300 ppm	4.52	1.75	6.27	5.11	8.67	8.20	11.96
400 ppm	4.45	1.71	6.16	5.28	8.92	8.37	12.91
500 ppm	4.25	1.76	6.02	5.30	8.78	7.94	11.67
L.S.D 5%	0.21	N.S.	0.32	N.S.	N.S.	0.43	0.60

Table 3. Effect of foliar application of salicylic acid (SA) on growth parameters, yield, yield components, and some fiber quality of cotton in 2005 seasons .

SA Treatments	Final plant height (cm)	No.of main stem nodes	No.of sympodia per plant	No.of open bolls per plant	No.of nonopen bolls/plant	Boll weight (gm)	Earliness %	Seed cotton yield (ken./fad.)	Lint %	Seed index (gm)	Fiber quality	
											Micronaire reading	Pressley index
00 ppm (control)	98.8	25.0	15.3	13.4	5.7	2.58	64.29	9.76	41.36	10.2	4.7	9.8
50 ppm	99.2	24.8	15.2	14.5	3.9	2.77	66.2	10.50	41.41	10.3	4.8	9.6
100 ppm	96.3	24.4	15.0	14.8	3.2	2.75	63.02	10.60	41.14	10.3	4.6	9.4
200 ppm	96.8	24.4	14.9	14.5	3.5	2.69	67.64	11.43	41.41	10.2	4.7	9.3
300 ppm	95.9	24.1	14.8	14.2	3.7	2.65	67.31	10.33	41.61	10.1	4.6	9.7
400 ppm	100.3	24.6	14.9	13.9	4.3	2.62	65.49	10.14	41.19	10.3	4.8	9.6
500 ppm	96.9	24.6	14.9	13.7	4.7	2.66	65.72	9.96	40.98	10.4	4.7	9.4
L.S.D 5%	N.S	N.S	N.S	1.1	1.6	0.11	N.S	0.61	N.S	N.S	N.S	N.S

Table 4. Effect of foliar application of salicylic acid (SA) on growth parameters, yield , yield components and some fiber quality of cotton in 2006 seasons .

SA Treatments	Final plant height (cm)	No.of main stem nodes	No.of sympodia per plant	No.of open bolls per plant	No.of nonopen bolls/plant	Boll weight (gm)	Earliness %	Seed cotton yield (ken./fad.)	Lint %	Seed index (gm)	Fiber quality	
											Micronaire reading	Pressley index
00 ppm (control)	133.4	29.5	19.6	18.3	6.8	2.52	55.79	11.75	39.61	11.0	4.8	9.4
50 ppm	131.8	29.1	19.6	18.5	6.2	2.55	56.42	12.18	39.14	11.3	4.7	9.6
100 ppm	135.4	30.0	20.5	19.6	4.9	2.61	55.12	12.40	39.70	11.3	4.8	9.6
200 ppm	132.5	29.4	20.1	19.4	5.2	2.60	53.89	12.34	39.86	11.2	4.9	9.1
300 ppm	136.5	30.5	20.6	19.8	4.8	2.66	52.96	11.46	39.91	11.5	4.8	9.7
400 ppm	134.4	29.6	20.0	18.4	5.6	2.59	53.27	11.96	40.13	10.9	5.0	9.1
500 ppm	136.6	30.2	20.6	18.1	5.4	2.65	51.63	12.07	39.85	11.1	4.9	9.4
L.S.D 5%	N.S	N.S	N.S	0.9	1.3	N.S	N.S	0.58	N.S	N.S	N.S	N.S

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استجابة القطن للمعاملة بحمض السلسيلك تحت الظروف البيئية للوجه القبلى

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أجريت هذه الدراسة بمحطة البحوث الزراعية بملوى بمحافظة المنيا خلال موسمى الزراعة ٢٠٠٥، ٢٠٠٦ بهدف دراسة تاثير الرش بحمص السلسيلك بتركيزات صفر، ٥٠، ١٠٠، ٢٠٠، ٣٠٠، ٤٠٠ و ٥٠٠ جزء فى المليون فى مرحله بداية التزهير على نمو وانتاجية صنف القطن جيزه ٨٣ تحت الظروف البيئية للوجه القبلى .

أظهرت نتائج الدراسة أن الرش بحمض السلسيلك بتركيزات منخفضة حتى ٢٠٠ جزء فى المليون أدى إلى زيادة معنوية فى محتوى الأوراق من كلورفيل أ والكلوروفيل الكلى فيما أظهرت كل معاملات حمض السلسيلك زيادة فى محتوى الأوراق من الفينولات العديدة والكلية بينما لم يؤثر الرش بحمض السلسيلك معنويا على محتوى الأوراق من كلوروفيل ب أو السكريات.

أظهرت المعاملة بحمض السلسيلك بتركيزات ١٠٠ حتى ٢٠٠ جزء فى المليون زيادة معنوية فى عدد اللوز المتفتح / نبات ومحصول القطن الزهر / فدان فى كلا الموسمين وكذلك وزن اللوزة فى موسم ٢٠٠٥ فقط ولكنها أدت إلى نقص معنوى فى عدد اللوز غير المتفتح / نبات فى كلا الموسمين . أظهرت المعاملة بتركيز ٥٠ جزء فى المليون نفس التأثيرات على تلك الصفات فى موسم ٢٠٠٥ فقط . أظهر التركيز ٣٠٠ جزء فى المليون زيادة معنوية فى عدد اللوز المتفتح فى موسم ٢٠٠٦ ونقص معنوى فى عدد اللوز غير المتفتح فى كلا الموسمين . لم يكن للرش بتركيز ٤٠٠ أو ٥٠٠ جزء فى المليون تأثير معنوى على المحصول ومكوناته . أعطى الرش بتركيز ١٠٠ أو ٢٠٠ جزء فى المليون أعلى محصول من القطن الزهر وكذلك أفضل النتائج بشكل عام . لم تظهر المعامله بحمض السلسيلك تأثير معنوى على صفات النمو ، % للتبكير % للشعر ، معامل البذرة أو صفتى جوده الشعر النعومة والمتانة فى كلا الموسمين .

يمكن أن نستخلص من هذه الدراسة أن الرش بحمض السلسيلك بتركيز ١٠٠ أو ٢٠٠ جزء فى المليون يمكن أن يستخدم فى تحسين إنتاجية القطن تحت الظروف البيئيه للوجه القبلى .