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Alternative Control Method for the Whitefly, *Bemisia tabaci* (Genn.) (Homoptera: Aleyrodidae) on Soybean Plants

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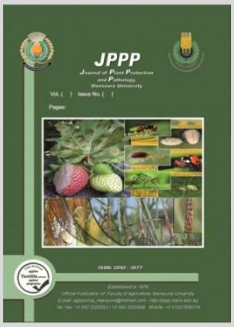

ABSTRACT

Soybean [*Glycine max* (L.) Merr.] is one of the most important crops cultivated all over the world. The cotton whitefly, *Bemisia tabaci* (Genn.) is an important piercing sucking insect pest attacking several crops. Using chemical insecticides in pest control causes several problems in the environment and agroecosystems so using non-chemical alternative applications are becoming more needed. The current work examined the effect of using salicylic acid (SA) and sodium meta silicate (SMS) at 2 mM concentration, as inducers, to enhance some biochemical contents and trichome density of soybean plants (Giza 111 and Giza 35 cv.) and their relationship with whitefly biology under laboratory conditions. For each variety, seven treatments were categorized including treated seeds, treated seeds + foliage spray and untreated seeds + foliage spray in addition to untreated check. The results showed that activities of catalase (CAT), polyphenol oxidase (PPO) and peroxidase (POX) increased significantly due to all treatments compared with control in both varieties. Treated seed + foliage spray with SMS induced significantly the highest increase in total protein; by 11.05% and 7.65% for Giza 111 and Giza 35, respectively. Based on biology of whitefly on the two soybean varieties, the results indicated that treated seed + foliage spray with SA and SMS were the most effective treatment against different developmental stages of whitefly from egg to adult. Using chemical inducers such as SA and SMS enhances the resistance of soybean plants and reduces whitefly development.

Keywords: Soybean, Whitefly Biology, Salicylic Acid, Sodium Meta Silicate, Induction of Resistance

INTRODUCTION

Soybean is one of the most important crops worldwide since, it is an important source of protein and oil (Dixit *et al.*, 2011). Damage caused by insect pests is one of the major limiting factors for soybean production (Steffey, 2015). Among sap feeding insect pests, the cotton whitefly *Bemisia tabaci* biotype B is one of the most serious crop pests worldwide (Oliveira *et al.*, 2013). This insect pest causes a great deal of damage to various plant species including soybean crops (Silva *et al.*, 2012). Whitefly causes both direct and indirect damage to plants (Oliveira *et al.*, 2013). Common treatment strategies for insect pests depend mainly on chemical control (David and Gardiner, 1959). The problem with this technique results in much damage. The most important problems are developing insecticide-resistant pest strains, killing nontarget organisms and elevation of secondary pests to a status of primary ones (Furk and Hines, 1993). Accordingly, alternative sources of application by using non-chemical methods for management of insect pests are becoming more targeted. Plants defend themselves against pathogens and herbivores using constitutive and induced resistance mechanisms (Thomma *et al.*, 1998; Vorwerk *et al.*, 2004). Both types of resistance have a unique defense mechanism involving various morphological and biochemical traits which have profound influence on the reproduction and survival of herbivores on a plant species. If the plants have the ability to develop new defense, this will reduce injury as a response to elicitor, which is known as induced resistance. Reactive oxygen species (ROS) is one of the first defense responses in plant cells. ROS inherently exist in plant cells at low concentrations and have a pivotal role in their functioning. Cell wall and membrane are the central locations for the synthesis of ROS in plants. The formation of ROS within the cell wall and their subsequent extracellular release seems to be intended, permitting their direct harmful effect on pest cells (Kulbat, 2016) and sometimes engaging in the infestation reduction (Santamaria *et al.*, 2018). In contrast, the high levels of ROS were found to be detrimental to plant cells as they cause degradation of cell components, resulting in disruption of their metabolic function and finally leading to cell death (Lu and Finkel, 2008). The application of plant activators results in the elicitation of a series of plant defense responses such as the induction of a range of enzymatic and non-enzymatic antioxidant compounds (Neerja *et al.*, 2013). The activation of ROS scavenging enzymes, including CAT, POX and PPO, is the most established channel in ameliorating the adverse effects of ROS synthesis during the plant-herbivore interactions (Jiang *et al.*, 1994; Mittler, 2002; Constabel and Barbehem, 2008). War *et al.*, (2012) reported that the integral part of mechanisms, used in agricultural pest management to control insect populations, is the induced response in plants. Also, Karban and Kuc (1999) concluded that induced responses in plants are controlled by several signaling pathways. Good knowledge of these pathways has led to the discovery of natural and synthetic compounds, which induce responses in plants similar to those caused by natural herbivory or pathogens known as elicitors. In this study, both SA and SMS were used as chemical inducers.

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According to Rivas-San Vicente and Plasencia (2011), SA generates a ray of physiological and metabolic responses in plants, influencing ion uptake, translocation, and membrane permeability. It considers a main signaling agent in systemic acquired resistance which has a central function in the stimulation of plant tolerance to various abiotic and biotic stresses (Kamel *et al.,* 2016). Sodium meta silicate induces immune response in plants upon the attack of pathogens or insects which reinforces the plant defense system against pathogens or insects and this process is known as elicitation of plants (Bektas and Eulgem, 2015). Silicon plays a vital role in providing defense for crops of great economic importance against insect pest attack. Based on previous findings, silicon application led to induction of physical and metabolic defense mechanisms against damage resulting by herbivore attack (Reynolds *et al.*, 2009). Physical defense is ascribed to absorbed silicon build-up in the tissues of epidermis layer boosting hardness that reasons erosion to insect mandibles and hinders digestibility. Soluble silicon, involved in enhancing production of phenolics and defensive enzymes, acts as a biochemical defense mechanism against insect attack. Also, silicon can elicit both types of defense mechanisms by decreasing the potential of insect digestibility and enhanced synthesis and accumulation of peroxidases, chitinase, lignin and phenolics (Reynolds *et al.*, 2009). Therefore, the purpose of this study was to evaluate role of some chemicals as inducers in enhancing soybean resistance against whitefly, *Bemisia tabaci*.

MATERIALS AND METHODS

This study was conducted to examine the effect of salicylic acid (SA) and sodium meta silicate (SMS) as inducers of soybean resistance against the cotton whitefly, *Bemisia tabaci* under laboratory conditions. Two soybean varieties; Giza 111(whitefly susceptible) and Giza 35 (whitefly moderately resistant) (Abdalla *et al.,* 2015 and Eissa, 2018), were obtained from Food Legumes Research Section, Sakha Agricultural Research Station. Both of inducers; SA (C7H6O3; MW = 138.12) and SMS (Na2SiO3.9H2o; MW = 284.20) were produced by Oxford Lab Chem. Mumbai, India and applied at 2 mM concentration which are considered optimal for the normal growth of bean and widely used in several studies (Hodson and Evans, 1995; Gong *et al.,* 2005; Gunes *et al.*, 2007; Shen *et al.*, 2009; Locateli *et al.*, 2019). For each variety, seven treatments were applied as described in Table (1) with three replicates for each treatment.

Table 1. Treatments applied in laboratory and field

Treatment	Protocol
T1	Untreated control
T2	Seeds soaked for 4 h in SA (2mM)
T3	Seeds soaked for 4 h in SMS (2mM)
T4	Seeds soaked for 4 h in SA (2mM) + spraying plants with SA (2mM) one month after sowing
T5	Seeds soaked for 4 h in SMS (2mM) + spraying plants with SMS (2mM) one month after sowing
T6	Spraying plants with SA (2mM) one month after sowing
T7	Spraying plants with SMS (2mM) one month after sowing

1. Effect of SA and SMS treatments as inducers on some biochemical contents of soybean plants

The effects of SA and SMS on the activity of certain antioxidant enzymes: catalase (CAT), peroxidase (POX), and polyphenol oxidase (PPO) as well as total protein content were determined after 10 days of foliar spray with the above-mentioned treatments. Three leaflets were collected randomly from the middle level of the plant from each plot, and kept into ice box. Then, they were transferred to laboratory, (ERAP lab Faculty of Agriculture, Kafr El-Sheikh University). These samples were stored at -20 ^{o}c in a liquid nitrogen for subsequent processing. The leaflet samples were mixed together and chopped to 3 g weights from which 1g was collected as a sample.

Homogenate preparation

The homogenate was used for the determination of the oxidant enzymes and total protein content, which was prepared as the steps adopted by War *et al*., (2011)

Determination of catalase activity

The procedure described by Aebi, (1984) was used for determining catalase activity.

Determination of peroxidase activity

The method of Hammerschmidt *et al.,* (1982) was used to assay the activity of guaiacol – dependent peroxide.

Determination of polyphenol oxidase activity

Polyphenol oxidase activity was estimated by the method of Mayer and Harel, (1979).

Determination of total protein content

Total protein was determined according to method of Koller, (1984).

The activity of all estimated enzymes was expressed as specific activity. Specific activity means activity /mg total protein.

2. Effect of SA and SMS treatments as inducers on leaf trichomes density and chlorophyll measurement of soybean varieties

To determine density of leaf trichome, three leaflets from the middle portion of the plants per treatment were selected 10 days after foliar spray (Baldin *et al*., 2017). The average number of trichomes per 25 mm^2 on the lower surface of leaflets and those on the middle region of the leaf blade were counted under microscope (Robards, 1978).

For measurement of chlorophyll, a portable chlorophyll meter (SPAD-502, Minolta Camera Co., Japan) was used to measure leaf greenness of soybean plants 10 days after foliar application. Measurements were taken on the middle trifoliate of each leaf.

3. Effect of SA and SMS treatments as inducers on some biological aspects of whitefly, *Bemisia tabaci* (Genn.) on soybean plants

Stock-rearing of *Bemisia tabaci* biotype B

The insects used in the experiment were originally collected from soybean plants grown at private farm at Qalin district, Kafr El-Sheikh Governorate and were identified as B biotype at Identification Unit, Plant Protection Research Institute. The collected insects were reared on soybean plants under laboratory conditions (30 ± 2 ºC; 70 ± 10% R. H. and a photoperiod of 14:10 h L: D) for two generations before starting the experiment. Soybean seed were soaked in the solutions of SA and SMS for 4 h and foliar spray also was applied later on with the same solution. The seeds of each treatment were grown individually in plastic pots (12 cm diameter) and used in the experiment at the 4–6 leaf stage. These pots for each treatment were placed into cages (60 × 60 × 60 cm).

Development and survival of whitefly

Each variety was sown as a single plant in 12 cm diameter pots, which contained soil and organic matter. The plants were kept free from insect infestations up to 40 days old (10 days after foliar sprays). Three soybean leaflets / plant (one leaf per plant level) were confined into small fabric cages. Fifty whitefly adults (48- hour old) were introduced into each cage, and left for 24 hours for egg laying. Then the insect adults were excluded, and only 30 eggs were kept per leaflet. When the whiteflies approached to exit, the leaflets were put back into the cages to keep the emerging adults inside. Daily observations were conducted in order to monitor the incubation period, the duration of nymph's survival and the time it takes for the egg to mature into an adult. For the purpose of measuring longevity, five newly emerged individuals from each leaflet were put into cages.

4. Statistical analysis

Comparisons among diverse treatments were done based on Duncan's test. Analysis of variance and correlations were executed using SPSS (Version 19.0 Chicago, USA). Data visualization was done using Microsoft Excel 2010 software. The 95% confidence level was used to express significant differences.

RESULTS AND DISCUSSION

Results

1. Effects of SA and SMS treatments as inducers on some biochemical contents of soybean plants

Results in Table (2) showed that (CAT), (PPO) and (POX) activities increased significantly due to all treatments compared with control in two soybean varieties. In Giza 111 variety, the highest increase of the three above mentioned enzyme activities was recorded in T2, T6 and T5 treatments by 43.22%, 11.11% and 41.58%, respectively, but the highest increase of the three enzyme activities for Giza 35 variety was recorded in T5 treatment by 49.78%, 6.82% and 45.29%, respectively.

Table 2. Activities of catalyze, polyphenol oxidase and peroxidase enzymes in soybean Giza 111 and Giza 35 varieties treated with salicylic acid (SA) and sodium meta silicate (SMS)

Variety	Treatment	Control(T1)	Treated seed		Treated seed + spray		Untreated seed + spray	
			SA(T2)	SMS(T3)	SA(T4)	SMS(T5)	SA(T6)	SMS(T7)
Giza 111	Catalyze	6.79 ±0.16 c	9.72 ±0.44a	8.01±0.22 b	9.52 ±0.29a	9.17 ±0.01a	9.27± 0.14a	7.96±0.21 b
	% change		+ 43.22	+ 17.91	+ 40.21	+ 35.07	+ 36.50	+ 17.30
	Polyphenol oxidase	0.00100 ±5.8*10^{-5} c	0.00101 ±5.8*10^{-6} c	0.00104 ±1.7*10^{-5} abc	0.00111 ±1*10^{-5} a	0.00109 ±2.9*10^{-5} ab	0.00111 ± 1.7*10^{-5} a	0.00103 ± 1.2*10^{-5} bc
	% change		+ 0.50	+ 3.63	+ 10.58	+ 9.00	+ 11.11	+ 3.09
	Peroxidase	0.0455 ± 0.0003g	0.0503 ±0.0002 f	0.0528 ±0.0003 d	0.0583 ± 0.0001b	0.0645 ± 0.0002a	0.0515 ± 0.0002e	0.0536 ±0.0002 c
	% change		+ 10.38	+ 16.09	+ 28.84	+ 41.58	+ 13.15	+ 17.75
	Total protein	1.9 ±0.06 b	1.99±0.007 b	1.93±0.017 b	2.08±0.012 a	2.11±0.006 a	1.98 ±0.006b	1.94±0.023 b
	% change		+4.74	+1.58	+ 9.47	+ 11.05	+ 4.21	+ 2.11
Giza 35	Catalyze	6.58 ±0.02 d	9.68±0.04 a	8.44±0.035 c	9.74± 0.023a	9.86± 0.029a	9.20 ±0.035b	8.77± 0.035c
	% change		+ 47.00	+ 28.27	+ 47.96	+ 49.78	+ 39.81	+ 33.23
	Polyphenol oxidase	0.00102 ± 5.8*10^{-6} a	0.00105 ±2.3*10^{-5} a	0.00106 ± 2.3*10^{-5} a	0.00105 ± 5.8*10^{-6} a	0.00109 ± 1.7*10^{-5} a	0.00106 ±5.8*10^{-6} a	0.00106 ±3.5*10^{-5} a
	% change		+ 2.90	+ 3.42	+ 2.67	+ 6.82	+ 3.94	+ 3.42
	Peroxidase	0.0199 ±0.00 d	0.0245 ±0.0001 bc	0.0256 ±0.0001 b	0.0281 ±5.8*10^{-6} a	0.0289 ± 5.8*10^{-6} a	0.0240 ±0.0001 c	0.0245 ± 0.0002bc
	% change		+ 23.13	+ 28.80	+ 41.20	+ 45.29	+ 20.56	+ 23.24
	Total protein	1.96 ±0.017 b	2.0±0.06 b	1.99±0.006 b	2.1±0.06 a	2.11±0.006 a	1.98±0.006 b	1.99±0.01 b
	% change		+2.04	+1.53	+7.14	+7.65	+1.02	+1.53

Mean means followed by the same letter in the same row are not significant different at 5% probability level according to D.M.R.T. (1955)

The Effect of treated soybean (Giza 111 and 35 varieties) with SA and SMS on change in total protein content is presented in Table (2). It was observed that treated seed + spray with SMS induced significantly the highest increase in total protein by 11.05% and 7.65% for Giza 111 and Giza 35, respectively, while the other treatments recorded moderate increase, ranging from 1.58 to 9.47% for Giza 111 variety as compared to control. On the other hand, for Giza 35 variety, untreated seed + spray with SA treatment caused the lowest increase in total protein (1.02%).

2. Effect of SA and SMS treatments as inducers on trichomes density and chlorophyll measurement of soybean varieties

Data presented in Table (3) shows trichome density on the lower surfaces of soybean leaflets. The highest mean numbers were recorded in T5 and T4 treatments in the two soybean varieties. In Giza 111 variety, T5 had the highest mean of trichome and represented by 154.33 ± 0.67 trichomes / 25 mm^2 followed by T4 treatment by 152.33 ± 1.45 trichomes / 25 mm^2 , but the control treatment had 133.67±0.67 trichomes / 25 mm^2. The lowest mean value was observed in T6 treatment by 138.33 ± 0.67 trichomes / 25 mm^2. Based on Giza 35 variety, T4 and T5 treatments had the highest (248.67 trichomes / 25 mm^2 each), while T6 had the lowest by 232.67 ± 3.71 trichomes / 25 mm^2. The number of the trichomes was significantly different between Giza 111 and Giza 35, with Giza 35 higher density of trichomes than Giza 111.

The color of plant leaves is one of the most important factors affecting attracting and repelling insects. Each insect has a suitable range of wavelengths to which it is attracted. Chlorophyll measurements were taken on the middle trifoliate of each leaf. Results in Table (3) indicated that T4 and T5 treatments were the highest in chlorophyll content in two soybean varieties compared with other treatments.

Table 3. Mean number ± SE of leaf trichome / 25 mm^2 and chlorophyll (leaf greenness) on two soybean varieties under different treatments

Treatment		Control (T1)	Treated seed		Treated seed + spray		Untreated seed + spray	
			SA (T2)	SMS (T3)	SA (T4)	SMS (T5)	SA (T6)	SMS (T7)
Trichome density	Giza 111	133.67±0.67 d	140.00±1.15 bc	142.00 ± 2.0 b	152.33 ± 1.45a	154.33 ± 0.67 a	138.33±0.67 c	139.67±0.67 bc
	Giza 35	202.33±2.4 d	239.00 ±1.7 bc	245.67± 2.3 ab	248.67 ± 2.6 a	248.67 ± 1.45 a	232.67±3.71 c	235.67 ±1.76 c
Chlorophyll	Giza 111	21.9 ±1.13e	29.0 ±1.0b	27.1 ±0.55bc	35.4 ±0.35a	33.8 ±0.40a	25.4 ±0.92cd	23.8 ±0.29de
	Giza 35	28.2 ±0.46c	37.2 ±0.99a	33.8 ±0.40b	38.6 ±0.23a	37.7 ±0.7a	28.9 ±0.63c	28.7 ±0.7c

Mean means followed by the same letter in the same row are not significant different at 5% probability level according to D.M.R.T. (1955)

3. Effect of SA and SMS treatments as inducers on some biological aspects of whitefly, *Bemisia tabaci* (Genn.) on soybean plants

Development of immature stages of whitefly

Development of immature stages of whitefly on soybean Giza 111 variety is shown in Table (4). The average incubation period did not vary between treatments; it ranged from 6.17 to 7.83 days compared with control (6.0 days). Regarding the nymphal stages of whitefly, there were significant differences in developmental periods of all instars between treatments, except the pupal stage period, which did not differ between treatments. The first nymphal instar was prolonged in the T4 treatment compared to the other treatments. Also, the durations of the second and third instars were the longest in T4 treatment. The average of the total development (egg – adult) of whitefly ranged from 21.33 to 28.33 days in the different treatments. T4 treatment produced the highest average, followed by T5 treatment. The percentage of total mortality was significant higher on T5 treatment (36.7%) followed by T3 treatment (35.6%) compared to control (23.3%).

In respect to Giza 35 variety the total period of *B. tabaci* immature was significantly longer on T4 and T5 treatments by 28.17 and 27.83 days, respectively, than on control (24.33 days). Also, the incubation period was significantly longer on T5 and T4 treatments (10.17 and 9.33 days respectively) than on control (7.83 days). There were non-significant differences between different treatments in the period of nymphal instars, except 2nd + 3th duration was significantly. The percentage of total mortality was higher on T5 treatment (41.1%) followed by T4 treatment (38.9%) than control (28.9%).

Table 4. Development of immature stages of whitefly on soybean Giza 111 and Giza 35 varieties that treated with SA and SMS

Stage		Giza 111							Giza 35						
		Control (T1)	Treated seed		Treated seed + spray		Untreated seed + spray		Control (T1)	Treated seed		Treated seed + spray		Untreated seed + spray	
			SA(T2)	SMS(T3)	SA(T4)	SMS(T5)	SA(T6)	SMS(T7)		SA(T2)	SMS(T3)	SA(T4)	SMS(T5)	SA(T6)	SMS(T7)
Egg	Incubation period (day)	6.00 d	6.17 cd	6.67 bcd	7.83 a	7.5 ab	6.17 cd	7.17 abc	7.83 d	8.67 c	8.50 cd	9.33 b	10.17 a	8.00 cd	8.50 cd
	Hatchability (%)	94.4 ab	93.3 ab	91.1 b	94.4 ab	94.4 ab	95.6 a	92.2 ab	92.2 a	88.9 bc	88.9 bc	88.9 bc	86.7 c	91.1 ab	90.0 ab
Nymphal stages	1st instar period (day)	3.17 c	3.50 c	3.67 c	5.67 a	5.00 ab	4.27 bc	3.67 c	1.67 ab	1.67 ab	1.17 b	1.83 a	1.50 ab	1.83 a	1.83 a
	Mortality (%)	5.9 c	8.3 abc	9.8 ab	9.4 abc	11.8 a	9.3 abc	6.0 bc	7.2 b	8.8 ab	10.0 ab	10.0 ab	11.5 a	9.8 ab	9.9 ab
	2nd +3rd instar period (day)	5.33 c	5.33 c	6.50 ab	7.17 a	5.67 bc	6.00 bc	6.50 ab	6.17 d	6.83 c	7.83 a	7.67 a	7.50 ab	6.17 d	7.17 bc
	Mortality (%)	7.5 c	10.4 bc	16.2 a	9.1 c	17.3 a	12.8 b	9.0 c	13.0 b	13.7 ab	15.3 ab	16.7 ab	17.4 a	14.9 ab	15.1 ab
	Pupa period (day)	6.83 ab	6.33 b	7.33 ab	7.67 a	7.50 ab	6.83 ab	7.67 a	8.67 a	9.33 a	8.67 a	9.33 a	8.67 a	8.83 a	8.50 a
	Mortality (%)	6.8 b	8.7 ab	6.5 b	8.6 ab	8.1 ab	5.9 b	11.3 a	4.5 a	7.9 a	8.2 a	8.3 a	7.0 a	7.9 a	8.1 a
Immature total period (day)		21.33 c	21.33 c	24.17 bc	28.33 a	25.67 ab	23.27 bc	25.00 ab	24.33 d	26.50 abc	26.17 bc	28.17 a	27.83 ab	24.83 cd	26.00 cd
Total mortality (%)		23.3 c	30.0 b	35.6 a	28.9 b	36.7 a	28.9 b	30.0 b	28.9 c	35.6 b	37.8 ab	38.9 ab	41.1 a	35.6 b	36.7 b

Mean means followed by the same letter in the same row are not significant different at 5% probability level according to D.M.R.T. (1955)

Adult stage and oviposition of *Bemisia tabaci* on soybean

Regard to Giza 111 variety, the obtained data in Table (5) show the lowest percentage of adult emergence was occurred on T5 treatment (63.3%) followed by T3 treatment (64.4%). Also, the lowest percentage of female was in T5 treatment (51.1 %). There were non-significant differences amongst all treatments in the pre-reproduction and reproduction periods, and longevity. The longest period of life span was occurred on T4 treatment (54.3 days) compared with control (51.3 days).

In respect to Giza 35 soybean variety, the lowest percentage of adult emergency occurred on T5 treatment (58.9%) followed by T4 treatment (61.1%). Judging by percentage of other parameter such as male, female, sex ratio, pre-reproductive, reproductive, post- reproductive, adult female longevity, total life span of female and generation time the statistical analysis showed no significant differences between treatments (Table5).

Table 5. Adult stage and oviposition of *Bemisia tabaci* on soybean Giza 111 and Giza 35 varieties

Parameter		Giza 111							Giza 35						
		Control (T1)	Treated seed		Treated seed + spray		Untreated seed + spray		Control (T1)	Treated seed		Treated seed + spray		Untreated seed + spray	
			SA(T2)	SMS(T3)	SA(T4)	SMS(T5)	SA(T6)	SMS(T7)		SA(T2)	SMS(T3)	SA(T4)	SMS(T5)	SA(T6)	SMS(T7)
% Emergence		76.7 a	70.0 b	64.4 c	71.1 b	63.3 c	71.1 b	70.0 b	71.1 a	64.4 b	62.2 bc	61.1 bc	58.9 c	64.4 b	63.3 b
% Female		65.2 a	57.1 ab	53.4 b	51.7 b	51.1 b	53.1 b	52.4 b	53.1 a	51.9 a	51.8 a	50.9 a	50.8 a	53.4 a	52.6 a
Sex ratio (female/male)		1.88 a	1.33 b	1.15 bc	1.07 c	1.04 c	1.13 bc	1.10 c	1.13 a	1.08 a	1.07 a	1.04 a	1.03 a	1.15 a	1.11 a
Pre-reproductive (day)		1.0 a	1.3 a	1.3 a	1.0 a	1.0 a	1.0 a	1.0 a	1.3 a	1.7 a	2.0 a	1.7 a	2.3 a	1.7 a	1.7 a
Reproductive (day)		9.3 a	8.6 a	9.0 a	9.2 a	9.3 a	8.3a	9.3 a	8.3 a	8.0 a	8.3 a	7.7 a	7.7 a	7.7 a	7.7 a
Post-reproductive(day)	Male	7.3 a	6.3ab	6.0 b	6.0 b	7.0 ab	6.7 ab	6.7 ab	7.0 a	7.0 a	5.7 b	5.7 b	5.7 b	6.7 ab	5.7 b
	Female	19.7 a	17.3 b	15.7 b	15.7 b	15.7 b	17.0 b	16.3 b	16.7 a	16.7 a	16.7 a	15.3 b	15.0 b	16.7 a	16.3 a
Adult female longevity (day)		30.0 a	27.3 b	26.0 b	26.0 b	26.0 b	26.3 b	26.6 b	26.3 ab	26.4 ab	27.0 a	24.7 d	25.0 cd	26.1 abc	25.7 bcd
Total life span of female (day)		51.3 ab	48.6 b	50.2 ab	54.3 a	51.7 ab	49.6 b	51.6 ab	50.63 b	52.9 ab	53.17 a	52.87 ab	52.83 ab	50.93 ab	51.7 ab
fecundity/female		57.7 a	49.0 b	47.7 c	48.8 b	46.5 d	49.8 b	49.3 b	52.29 a	50.4 ab	39.01 c	36.19 c	36.19 c	45.6 b	40.81 c
Daily mean fecundity		6.2 a	5.7 abc	5.3 bc	5.3 bc	5.0 c	6.0 ab	5.3 bc	6.3 a	6.3 a	4.7 b	4.7 b	4.7 b	6.0 a	5.3 b
Generation time (day)		22.33 d	22.63 cd	25.47bcd	29.33 a	26.67ab	24.27bcd	26abc	25.63d	28.2 abc	28.17 abc	29.87ab	30.13a	26.53cd	27.7 bcd

Mean means followed by the same letter in the same row are not significant different at 5% probability level according to D.M.R.T. (1955)

Discussion

Catalase (CAT) is one of antioxidant enzymes which catalyzes hydrogen peroxide to oxygen and water. This provides protection against oxidatory injury to cell. The role of catalases in oxidative stress has been widely known (Aebi, 1984). Polyphenol oxidase (PPO) is a versatile oxidase that catalyzes the oxygen dependent oxidation of phenols to quinines which are highly reactive molecules which can react with amino acids and proteins and it is suggested playing a defense role against plant pathogen and pest interaction (Thipyapong and Steffens, 1997 and Cho and Ahn, 1999). Peroxidase (POX) participates in a wide range of physiological processes.These include hydrogen peroxide detoxification, cell elongation, cell wall construction, differentiation and plant response to stress. In general, their main function is to scavenge hydrogen peroxide and defense against stress (Sasaki *et al.*, 2004).

Results showed that (CAT), (PPO) and (POX) activities increased significantly in all treatments compared with control in the two soybean varieties. Treated seed + spray with SMS induced significantly the highest increase in total protein by 11.05% and 7.65% for Giza 111 and Giza 35 respectively. Our findings are in agreement with the results of Razmi *et al.*, (2017) who demonstrated that activities of superoxide dismutase, ascorbate peroxidase and concentration of hydrogen peroxide and total protein increased as a response to SA applications. These results are also in agreement with the findings of El-Shafey, (2017) who showed that foliar spray of salicylic and ascorbic acids and their combination, significantly increased peroxidase and polyphenol oxidase activities in leaves of soybean plants as compared with untreated plants (control). Also, Foyer *et al.*, (1997) reported that the activities of antioxidant enzymes such as CAT, and POX are generally stimulated and found to be related to enhanced tolerance in plants under stress conditions.

The number of trichome was significantly different between Giza 111 and Giza 35. Giza 35 leaves had more trichome than Giza 111. The color of plant leaves is one of the most important factors affecting attracting and repelling insects. Chlorophyll measurements indicated that T4 and T5 treatments were the highest of leaf greenness in two soybean varieties compared with other treatments. These results are also in line with the outcomes of El-Shafey, (2017) who showed that foliar spray of salicylic, or ascorbic acid, significantly increased chlorophyll content on soybean plants. Also, Faiz *et al.*, (2021) indicated that higher number of abaxial leaves trichome density has a negative effect on *Empoasca* sp. population, which is the opposite of the effect known given to *Bemisia tabaci*.

However, understanding the biology and life table parameters of any insect is essential for developing an integrated pest management strategy because these parameters provide the population growth rate of an insect in current and future generations (Frel *et al.*, 2003). Development of immature stages of whitefly on soybean Giza 111 variety presented that the averages for the total duration of egg-adult development of whitefly on different treatments ranged from 21.33 to 28.33 days. The percentage of total mortality was significant higher on T5 treatment (36.7%) followed by T3 treatment (35.6%) compared to control (23.3%). Regard to Giza 35 variety the percentage of total mortality was higher on T5 treatment (41.1%) followed by T4 treatment (38.9%) compared to control (28.9%). The current findings are in agreement with the outcomes of Correa *et al.*, (2005), who reported that foliar application of Si significantly deter the ovipositional preference (223.1 eggs) and increased the developmental duration (24.8 days) of *B. tabaci* on cucumber plants. Ferreira *et al.*, (2011) showed that silicon did not effect on whitefly oviposition preferences, but caused significant mortality in nymphs.

For Giza 111 variety, the period of longevity was insignificant between all treatments compared with control (30 days) while, the longer period of life span occurred on T4 treatment by 54.3 days compared with control (51.3 days). Based on Giza 35 soybean variety results revealed that the lowest percentage of adult emergency occurred on T5 treatment by 58.9% followed by T4 treatment (61.1%). Judging by percentage of other parameter the statistical analysis showed no significant differences between treatments. The current findings are in agreement with the outcomes of Dias *et al.*, (2014) who observed that wheat plants treated with silicon reduced fecundity, reproductive period, longevity, intrinsic rate of increase, and net reproductive rate of apterous the english grain aphid *Sitobion avenae* Fabricius (Hemiptera: Aphididae) was due to induction of antibiosis resistance in plants treated with silicon. Also, Atia and Alyousf, (2021) studied the effect of salicylic acid spraying with four concentrations 0, 0.5, 0.75 and 1 mM on three cultivars of tomato plants (Wijdan, Randy and Newton) and its effect on *B. tabaci* during 2019-2020 seasons. Results showed that all concentrations of salicylic acid inhibited the egg laying process of whiteflies also, reducing the number of nymphs. Regard to reducing adult stage of *B. tabaci* was no significant differences between three cultivars.

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طريقة بديلة لمكافحة الذبابة البيضاء *Bemisia tabaci* (Homoptera : Aleyrodidae) على نباتات فول الصويا

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الملخص

يعد فول الصويا أحد محاصيل إنتاج البروتين الهامه عالمياً. وتمثل الذبابة البيضاء أحد الأفات الحشرية الخطيرة التى تهاجم هذا المحصول. يتسبب استخدام المبيدات الكميائية فى إدارة الأفات فى إحداث الكثير من الضرر, لذا أصبحت طرق المكافحة الغير كميائية أكثر قبولاً. فى هذا البحث تمت دراسة تأثير إستخدام حامض السالسيليك وسليكات الصوديوم المائية بتركيز 2 ملى مولر كعوامل حث نباتية على المحتوى البيوكميائى والكثافة العددية للشعيرات على صنفى فول الصويا (جيزه 111 وجيزه 35) وعلاقة هذه المعاملات بدورة حياة الذبابة البيضاء تحت الظروف المعملية. لكل صنف تم تطبيق سبع معاملات مختلفة وتشمل معاملة البذور, معاملة البذور + رش النباتات و بذور غير معاملة + رش النباتات بالإضافة إلى الكنترول. أظهرت النتائج المتحصل عليها أن نشاط الكاتليز والبوليفينول أكسيديز والبروكسيديز زاد بشكل معنوى لجميع المعاملات مقارنة بالكنترول لكلا من الصنفين (جيزة 111 و جيزة 35). معاملة البذور + الرش أعطت أعلى زيادة معنوية فى محتوى البروتين الكلى بنسبة 11.05% و 7.65% لجيزة 111 وجيزة 35 على التوالى. بالنسبة لدورة حياة الذبابة البيضاء لكلا الصنفين, أشارت النتائج إلى أن معاملة البذور + الرش بكل من حامض السالسيليك وسليكات الصوديوم المائية كانت الأكثر فاعلية للمراحل المختلفة لتطور الذبابة البيضاء (من البيضة حتى الطور البالغ), كما أثرت على فترة النمو الكلية والنسبة المئوية للموت الكلى. نستخلص من هذة الدراسة أن استخدام المستحثات الكميائية مثل حامض السالسيليك وسليكات الصوديوم المائية يحسن مقاومة نباتات فول الصويا ويقلل من تطور الذبابة البيضاء.