Egypt. J. Plant Prot. Res. Inst. (2020), 3 (2): 690 - 702

Egyptian Journal of Plant Protection Research Institute

www.ejppri.eg.net

Potency of some elicitors plant as new approach to control some insect pests infesting okra and their effect on associated predators and okra production compared with the convention insecticide under field condition

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ARTICLE INFO

Article History

Received: 2/4/2020

Accepted: 4/6/2020

Keywords

Okra, *Helicoverpa armigera* and *Earias insulana*, actacron , predators, elicitors plant and insecticides.

Abstract:

This study was carried out at El-Ryiad region, Kafr El-Sheikh Governorate under field conditions during two okra growing seasons, 2018 and 2019 for examining the effect of some elicitors plant (Salicylic acid and jasmonic acid) only and mixture with conventional chemical insecticide compared with conventional chemical insecticide, actacron against the American bollworms , *Helicoverpa armigera* (Hübner), the spiny bollworm *Earias insulana* (Boisduval)) (Lepidoptera: Noctuidae) and okra crop production. The obtained results showed the potentiality of the highest concentration of jasmonic acid mixture with actacron for controlling both *H. armigera* and *E. insulana* as a new approach. The grand reduction percentage of *H. armigera* and *E. insulana* were 97.75, 98.06 and 89.79, 87.54% respectively, in case of okra treated with at the highest concentration 300 ppm of jasmonic acid mixture with actacron (375 ml/ fed.) during at the two successive seasons 2018 and 2019. However, the lowest redaction percentage of *H. armigera* and *E. insulana* were 59.26, 61.08 and 55.87, 54.15% respectively, in case of okra treated with at the lowest concentration 100 ppm of salicylic acid during at the two successive seasons 2018 and 2019. Also, the highest concentration (300 ppm) of salicylic acid mixture with actacron (375 ml/ ffed.) showed moderately control to *H. armigera* and *E. insulana*, where the reduction percentages ranged from 78.34 -53.82 and 75.62-51.14 and for *E.insulana* the reduction percentages ranged between 73.27-48.39 and 71.64-46.67% at three examined rates during the two seasons 2018 and 2019, respectively) compared with other treatments. The highest concentration of jasmonic acid (300 ppm) was more concentration of predators than other treatments. The lowest of predators were found on okra plants in case treated with conventional insecticide. The treatment with highest (300 ppm) of jasmonic acid mixture actacron showed the positive effectives in okra yield.

Introduction

Okra, *Abelmoschus esulentus* (L.) , fruit vegetable crops that belongs to family Malvaceae, is widely grown all over tropical, sup tropical and warm temperature regions of the world (Saifullah and Rabbani, 2009). Okra (*Abelmoschus esculentus* L. Moench) is a popular summer vegetable crop in Egypt. The cultivated area in Egypt for okra was nearly 17 thousand feddan (one fed. = 4200m2) and produced about 97 thousand ton in 2012 cropping season (Anonymous, 2013). It is a rich source of some essential vitamins (vitamin C) and mineral salts such as calcium, magnesium, potassium and iron including water at varying proportion (Shippers, 2002). Okra plays an important role in the human diet by supplying fats, proteins, carbohydrates, minerals and vitamins. The composition of okra pods per 100 g edible portion (81% of the product as purchased, ends trimmed) is: water 88.6 g, energy 144.00 kJ (36 kcal), protein 2.10 g, carbohydrate 8.20 g, fats 0.20 g, fibers 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, β-carotene185.00 µg, riboflavin 0.08 mg, thiamin 0.04 mg, niacin 0.60 mg, ascorbic acid 47.00 mg. (Gopalan *et al*., 2007 and Varmudy, 2011).

One of the important limiting factors in the cultivation of okra vegetable plants is insect pests. As high as 72 species of insects have been recorded on okra plant (Srinivas and Rajendran, 2003), among of them fruit borers like *Earias* spp. and *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) cause significant damage to crop to the tune of 91.60 % percent (Pareek and Bhargava, 2003). The fruit borers are alone reported to cause damage to the extent of 3.5 to 90 % percent to okra in different parts of the country (Mandal *et al.,* 2006). In general, the overall damage due to insect pests accounts to 48.97 % loss in fruit yields (Kanwar and Ameta, 2007). The caterpillar of the American bollworm *H. armigera* prefers the reproductive parts of the plant, including bands, flowers and fruits. Also, this insect attacks the ripped and pre ripped fruits, contaminating them fraises and exposing them to fungi and bacteria (Ahmed, 2000). Although several workers tested different chemicals against fruit borer, still the problem continues .Plants with aromatic qualities contain volatile oils that may interfere with host plant location, feeding, distribution and mating can decrease the pest abundance (Uvah and Coaked, 1984 and Lu *et al.,* 2007). Plants have developed an elegant defenses system against insect herbivore. The defense systems employed by plants against insects can be constitutive or induced. Constitutive resistance is present in plants all the time, whereas induced resistance occurs in response to various stimuli such as insect herbivory pathogen infection and/or elicitor application.(Wasternack, 2007; Chitra *et al.,* 2008 and Kawazu *et al.,* 2012). Induced resistance is very important as it makes plants phenotypically plastic, thereby making it freakish for the insect pests to feed on it (Scot *et al.,* 2010 and He *et al.,* 2011). Induced resistance can be direct or indirect. Direct induced resistance directly effects on the insect pest through antixenosis and/or antibiosis mechanisms (Sharma and Norris, 1991 and Sharma *et al.,* 2009) whereas indirect induced resistance is mediated through volatiles emitted by the plants in response to insect damage, which attract the natural enemies (parasitoids and predators) of the insect pests (Heng-Moss *et al.,* 2004 and Arimura *et al.,* 2008). Although many plant hormones act as elicitors of induced resistance, the most important and widely used phytohormones are jasmonic acid (JA) and salicylic acid (SA) (Kawazu *et al.,* 2012 and Zhao *et al.,* 2009). The use of these phytohormones in inducing plant resistance against insect pests has raised the possibility of their implications for insect

pest management. Exogenous application of JA results in the induction of plant responses that are almost like herbivore feeding. The JA-mediated octadecanoid pathway leads to the production of many defensive components, such as plant defensive proteins, oxidative enzymes, glandular trichomes, flavonoids, terpenoids, alkaloids, volatile compounds (Wasternack, 2007; Scott *et al.*,2010 and Arimura *et al.*, 2008). Systemic acquired resistance (SAR) is defined as the induced response to various biotic (feeding by insects or infections by pathogenic organisms) and abiotic or chemical elicitors (Such as salicylic acid and jasmonic acid), attributed to the synthesis of defensive phytochemicals (Kogan and Paxton, 1983). However, the research in the induced resistance against insect herbivore is limited (Karban and Kuc, 1999).

The present study hypothesized that salicylic acid (SA) and jasmonic acid (JA), as an inducer for plant resistance, can be used to activate the effectiveness of insecticides (Profenofos: Actacron) against the spiny bollworms *E. insulana*, and the American bollworms *H. armigera*. Therefore, this study aimed to reduce the amount of used insecticides (Actacron) by mixing them with SA and JA to control the spiny bollworms *E. insulana*, and the American bollworms *H. armigera*, and in relation to its associated predators as well as okra crop production under field conditions.

Materials and methods

1. Materials used:

Elicitor plants: Aqueous solutions of elicitors prepared from**:**

1.1. The salicylic acid: It were obtained from (Oxford Lab Chemicals unit No. 12,1st Neminath C7 H 603S), The salicylic acid (with a purity of 99.99%.) was dissolved in 1 ml of ethanol 95% before dispersed in one liter of tap water (Hussein *et al.*, 2014). Three concentration of salicylic acid (100, 200 and 300 ppm/4200 m^2) were used under field conditions.

1.2. The Jasmonic acid: Jasmonic acid preparation**:** Synthetic JA was dissolved in 1 ml of ethanol 95% and dispersed in an appropriate volume of water to achieve 5 mM JA solution (Thaler , 1999). The control solution consisted of only 1 ml of ethanol 95% / 1L. dissolved in water**.** Three concentration of jasmonic acid (100, 200 and 300 ppm/4200 m^2**)** were used under field conditions.

1.3. The tested insecticide: (Profenofos: Actacron) was used in this study by according to the recommended rate: 750 ml / fed. (750ml/200-liter of water). This insecticide is recommended for control of *H. armigera* and *E insulana* in vegetable crops.

1.4. Mixture of salicylic acid (SA) with half recommended rate actacron: at three concentrations SA100 ppm+ 375 ml/ fed. Actacron**, SA 200 ppm + 375 ml/ fed.** Actacron and SA 300 ppm + 375 ml/fed. Actacron were used under field conditions.

1.5. Mixture of jasmonic acid (JA) with half recommended rate actacron**: at three concentrations JA 100 ppm+ 375 ml/ fed.** Actacron **, JA 200 ppm + 375 ml/ fed.** Actcrone and JA 300 ppm + 375 ml/ fed. Actacron were used under field conditions.

Percentages fruit infestation = Number of damaged fruits /total number of fruits × 100.

2. Experimental :

The experiment was carried out during two okra growing seasons; 2018 and 2019 on the *E. insulana* and American bollworm *H. armigera* at El-Raid region, Kafr El-Sheikh Governorate, Egypt. An area of one feddan was prepared (15 treatments × 4 replicate) and divided into 60 plots (each plot about 70 m^2) in a randomized complete block design. The seeds of okra (Ladies fingers Mansoura Red Varity) were sowed at rate 2 seeds of hole on two sides of each row with widths of 100 cm spacing and 30 cm between plants during the two seasons, of

2018 and 2019 on April 10th**.** Horticultural practices were performed according to the recommendations of the Ministry of Agriculture and Land Reclamation of Egypt, but without any pesticides application. Weekly samples of *E. insulana*, *H. armigera* larval were taken randomly beginning from May 25th up to September 25th. Each sample consisted of 25 fruits from five plants randomly chosen (five fruits/ plant) and it was repeated four times. Application of salicylic acid, jasmonic acid at three concentration (100, 200 300 pm) only, salicylic acid, jasmonic acid at three concentration (100, 200 300 pm) mixture with conventional chemical insecticide compared with conventional chemical insecticide were implemented at economic threshold of fruit damage due to *E. insulana* and *H. armigera* (*i.e.* 5% fruit damage) by using high volume knapsack sprayer with the required concentration of salicylic acid, jasmonic acid, salicylic acid, jasmonic acid at three concentration (100, 200 300 pm) mixed with conventional chemical insecticide and conventional chemical insecticide as well as water (control) ethanol were applied on the okra plants four times at 15 days interval during the period from June 15th up to August 15th . Subsequent spray was given based the levels of infestation during both seasons of experiments, 2018 and 2019.The numbers of larvae and reduction percentages of *E insulana* and *H. armigera* were recorded from five plants randomly chosen (five fruits/plant) repeated four times per treatment -wise before spray as well as 7 and 14 days after each sprays. Observations on fruits damage due to *E. insulana*, *H. armigera* were recorded at each picking by counting the healthy and damaged fruits from net plot area on number as well as weights and percent fruit damage was worked out by using the following formula. The yield of marketable okra fruits from each treatment was recorded at each picking separately.

3.Abundance of associated predators:

The insect predators *Coccinella* sp. (Coleoptera, Coccinellidae) (eggs, larvae and adults), *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) (eggs and larvae), *Paederus alfieri* Koch. (Coleoptera: Staphylinidae) (adults), *Scymnus* spp. (Coleoptera: Coccinellidae) (larvae and adults), spiders (spiderlings and adults) were recorded and counted by the aid of lens from five plant/replicate, randomly selected per treatment by four replication-wise before spray as well as 7 and 14 days after each sprays. Each sample repeated four times beginning from May 25th up to September 25th.

4. Statistical analysis:

Data were subjected to the analysis of variance and differences among means were compared according to Duncan's Multiple Range Test **(Duncan, 1955)**. Percentage of reduction was calculated according to **Henderson and Tilton (1955)**.

Results and discussion

1. Effect of elicitors plant alone, mixture with actacron compared with actacron insecticide on *Helicoverpa armigera* larvae infesting okra plants during 2018 and 2019 seasons:

Data presented in Table (1) show the reduction percentage resulted from six treatments namely; salicylic acid (SA) + actacron (three rates), jasmonic acid (JA) + actacron (three rates also), salicylic acid (SA), jasmonic acid (JA), ethanol and chemical insecticide, actacron (recommended rate) during two growing of seasons 2018 and 201**9.**

The efficacy of the applied treatments against *H. armigera* larvae infesting okra plants under field conditions with respect to the larval mortality are presented in Table (1) during two experimental seasons 2018 and 2019. All the tested treatments were effective against the *H. armigera* larvae infesting okra plants under field conditions relative to the control treatment. The highest reduction percentage in the *H. armigera* larvae was

occurred on okra plants treated with the high rate (300 ppm) of jasmonic acid mixed with chemical insecticide (at the rate 375 ml/ fed.), followed by the high rate (300 ppm) of jasmonic acid with respect to the reduction in the larvae counts in treated plants. The general mean reduction percentages of the *H. armigera* larvae during two of the experimental during, 2018 and 2019 seasons are shown in Table (1). Results during the two seasons indicated that the high rate (300 ppm) of jasmonic acid mixed with chemical insecticide (at the rate 375 ml/ fed.), treatments were the most effective compared with other treatments, followed, by the high rate (300 ppm) of jasmonic acid mixture with actacron on the basis of reduction rates in the infestation by *H. armigera* larvae. The statistical analysis showed significant differences among all treatments.

Table(1): Effect of elicitor plants and actacron insecticide on the reduction percentages in *Helicoverpia armigera* larvae at El-Raid region, Kafr El-Sheikh Governorate, during two seasons of 2018 and 2019.

Treatment	Conce-Nitration	1st Spray	2nd Spray	3rd spray	4th spray	Average
Reduction percentages in *Helicoverpia armigera* larvae during 2018 season						
Jasmonic acid (JA)+ actacron	**300 + 375**	93.75 b	98.50 a	99.75 a	98.99 a	97.75 a
	200 + 375	79.00 d	88.45 b	96.57 a	97.85 a	90.47 b
	100 + 375	74.57 e	78.36 c	83.10 c	86.99 c	80.76 d
Salicylic acid (SA)+ actacron	**300 + 375**	78.90 d	82.35 c	88.00 c	91.67 b	85.23 c
	200 + 375	70.33 e	75.92 d	81.66 d	86.80 c	78.68 d
	100+ 375	62.55 f	69.00 e	75.63 e	81.22 d	72.10 e
Jasmonic acid (JA)	**300 ppm**	87.67c	96.96 a	98.00 a	98.78 a	95.35 a
	200 ppm	75.96 d	81.89 c	93.00 b	96.78 a	86.91 c
	100 ppm	62.99 f	70.85 e	80.22 d	85.75 c	75.95 e
Salicylic acid (SA)	**300 ppm**	70.25 e	77.00 c	86.36 c	90.15 b	80.94 d
	200 ppm	60.25 f	66.58 e	72.63 e	80.97 d	70.11 f
	100 ppm	46.00 g	56.22 f	60.25 f	70.55 f	58.26 g
Actacron	**750ml./fed.**	97.26 a	91.50 a	87.35 b	81.75 d	89.46 b
Ethanol	**1ml/1L.water**	-	-	-	-	-
Reduction percentages in *Helicoverpia armigera* larvae during 2019 season						
Jasmonic acid (JA)+ actacron	**300 + 375**	94.75 b	99.00 a	99.50 a	99.00 a	98.06 a
	200 + 375	81.50 d	89.99 b	95.50 a	99.99 a	91.75 b
	100 + 375	76.98 e	81.63 c	85.13 c	88.25 c	83.00 d
Salicylic acid (SA)+ actacron	**300 + 375**	79.99 d	83.78 c	89.95 c	93.65 b	86.84 c
	200 + 375	74.37 e	78.11 d	83.56 d	88.00 c	81.01 d
	100 + 375	68.36 f	70.90 e	77.33 e	83.75 d	75.09 e
Jasmonic acid (JA))	**300**	89.99 c	98.98 a	99.88 a	99.13 a	97.00 a
	200	78.15 d	83.26 c	95.10 b	98.99 a	88.88 c
	100	68.23 f	75.90 e	82.92 d	87.50 c	78.64 e
Salicylic acid (SA)	**300**	71.57 e	78.99 c	88.94 c	93.25 b	83.19 d
	200	62.77 f	68.93 e	75.10 e	82.99 d	72.45 f
	100	47.10 g	57.35 f	61.99 f	73.87 f	60.08 g
Actacron	**750/fed.**	98.86 a	93.92 a	89.99 b	84.65 d	91.86 b
Ethanol	**1ml/ 1L.water**	-	-	-	-	-

Means followed by a common letter are not significantly different at the 5% level by DMRT

2. Effect of some elicitors plants and conventional insecticide on the reduction percentages in *Earias insulana* larvae during two seasons of 2018 and 2019:

All plants treated with significant reduction in the toxicants showed numbers of larvae infesting okra plants compared to okra untreated plants during both 2018 and 2019 of experiments (Table, 2). The highest reduction percentages in the *E. insulana* larvae were 89.79, 87.54 and 86.27, 84.52 %, during the two seasons of 2018 and 2019 respectively in case of treating the okra pants with the highest concentrations of 300 ppm of jasmonic acid mixed with actacron and actacron (at the rate 375 ml/ fed); respectively followed by 84.57and 83.07 %, reduction in the pest infesting okra plants treated with the highest concentrations of 300 ppm of jasmonic acid in 2018 and 2019 experiments. Okra plants treated with ate the highest rate (300 ppm) of jasmonic acid mixed with conventional insecticide and the highest concentrations of 300 ppm of jasmonic acid were significantly higher than the other treatments. However, as shown in Table (2). The lowest reduction percentage of *E. insulana* larvae 55.87 and 54.15 %, was recorded during experiments, of 2018 and 2019 seasons, respectively followed by the okra plants were treated by the lowest concentration of salicylic acid (100 ppm).

Table (2): Effect of some elicitors plants and conventional insecticide on the reduction percentages in *Earias insulana* larvae at El-Raid region, Kafr El-Sheikh Governorate, during two seasons of 2018 and 2019.

Treatment	Conce ntration	1st Spray	2nd spray	3rd spray	4th spray	Average
Reduction percentages in *Earias insulana* larvae during 2018 season						
Jasmonic acid (JA)+ actacron	**300 + 375**	76.25 b	87.91 a	95.99 a	99.00 a	89.79 a
	200 + 375	70.33 c	78.63 b	88.23 b	95.99 a	83.30 a
	100 + 375	60.33 d	66.99 d	72.90 c	81.54 c	70.44 e
Salicylic acid (SA)+ actacron	**300 + 375**	70.0 c	75.76 b	82.99 b	90.75 b	79.88 b
	200 + 375	66.00 c	71.75 c	77.10 c	83.95 c	74.70 c
	100 + 375	56.15 d	62.36 d	70.00 c	76.80 c	66.33 d
Jasmonic acid (JA)	**300 ppm**	69.23 c	80.63 b	92.15 a	96.25 a	84.57 a
	200 ppm	57.52 d	64.00 d	72.85 c	80.47 c	68.71 d
	100 ppm	50.96 e	56.25 e	63.50 d	71.90 d	60.65 e
Salicylic acid (SA)	**300 ppm**	66.25 c	73.45 c	79.36 b	91.90 b	77.74 c
	200 ppm	53.75 d	63.34 d	70.25 c	81.97 c	67.33 d
	100 ppm	45.00 f	51.23 f	60.50 d	66.75 e	55.87 f
Actacron	**750/fedd.**	93.00 a	88.19 a	85.35 b	78.55 c	86.27 a
Ethanol	**1ml/1L.water**	-	-	-	-	-
Reduction percentages in *Earias insulana* larvae during 2019 season						
Jasmonic acid (JA)+ actacron	**300 + 375**	74.25 b	85.91 a	94.99 a	99.00 a	87.54 a
	200 + 375	66.33 c	75.63 b	85.23 b	94.99 a	80.55 a
	100 + 375	61.33 d	66.99 d	72.90 c	80.54 c	68.44 e
Salicylic acid (SA)+ actacron	**300 + 375**	66.0 c	74.76 b	80.99 b	90.75 b	78.13 b
	200 + 375	60.00 c	70.75 c	76.10 c	81.95 c	72.20 c
	100 + 375	51.15 d	60.36 d	70.00 c	76.80 c	64.58 d
Jasmonic acid (JA))	**300 ppm**	66.23 c	79.63 b	90.15 a	96.25	83.07 a
	200 ppm	53.52 d	62.00 d	71.85 c	80.47 c	66.96 d
	100 ppm	47.96 e	53.25 e	63.50 d	71.90 d	59.15 e
Salicylic acid (SA)	**300 ppm**	60.25 c	71.45 c	75.36 b	91.90 b	74.74 c
	200 ppm	50.75 d	56.34 d	77.25 c	81.97 c	64.08 d
	100 ppm	41.00 f	48.23 f	60.50 d	66.75 e	54.15 f
Actacron	**750/fed.**	93.00 a	88.19 a	81.35 b	75.55 c	84.52 a
Ethanol	**1ml/1L.water**	-	-	-	-	-

Means followed by a common letter are not significantly different at the 5% level by DMRT

3. Effects of some elicitors plant and actacron insecticide on marketable fruit yield crop of okra plants:

The effects of treatments on marketable fruit yield for both years are shown in Table (3). All treatments significantly increased the marketable fruit yield compared with untreated okra plants in both years**.** The highest percentage of the marketable fruit yield of okra was obtained from plants treated by the highest concentration (300 ppm) of jasmonic acid mixed with conventional insecticide; followed, by okra plants treated with jasmonic acid and conventional insecticide as compared with the other treatments. Conversely, the lowest percentage of marketable fruit yield was recorded for the untreated okra plants.

Table (3): Effects of some elicitors plant and actacron insecticide on marketable fruit yield crop of okra plants during 2018 and 2019 experiments at El-Raid region, Kafr El-Sheikh Governorate.

Treatment	concentration (ppm)/ fed.	2018	2019
		Percentage	Percentage
Jasmonic acid (JA)+ actacron	300 ppm + 375 mL	96.00 a	97.00 a
	200 ppm +375 mL	85.00 c	87.00 c
	100 ppm +375 mL	70.00 d	71.00 d
Salicylic acid (SA)+ actacron	300 ppm+ 375 mL	91.00 b	89.00 b
	200 ppm + 375 mL	79.00 c	77.00 c
	100 ppm+ 375 ml	63.00 e	65.00 e
Jasmonic acid (JA))	300 ppm	87.00 b	89.00 b
	200 ppm	80.00 c	82.00 c
	100 ppm	60.00 e	61.00 e
Salicylic acid (SA)	300 ppm	79.00 b	80.00 b
	200 ppm	72.00 d	73.00 d
	100 ppm	51.00 f	53.00 f
Actacron	60ml/fed.	90.00 b	91.00 b
Ethanol	1ml/1L.water	20.25 g	21.00 g
Control	-	20.00 g	21.00 g

Means followed by a common letter are not significantly different at the 5% level by DMRT.

This study aims to screen the response of okra plants to some elicitors plant salicylic acid, jasmonic acid only and mixture with conventional insecticide compared with the conventional insecticide open field conditions in order to minimize using pesticide and its side effect in the consumer health. In the current study, the highest concentration of jasmonic acid mixed with conventional insecticide and the conventional insecticide actacron showed the highest reduction in the number of larvae of *H. armigera* and *E.insulana*; also jasmonic acid kept the participated number of predators associated with *H. armigera* and *E.insulana* compared on the plants treated with the other two. Reduction percentages in *H. armigera* and *E.insulana* were obtained when okra plants treated with the highest concentration of jasmonic acid mixed with conventional insecticide compared to control. Plant response to the highest concentration of

jasmonic acid mixed with conventional insecticide showed significantly effects compared to the other treatments as well as the untreated control. The highest reduction in *H. armigera* and *E.insulana* population larvae was noticed on okra plants treated with the highest concentration of jasmonic acid mixed with conventional insecticide. These results agree with those obtained by Ali (2008). reported that the infestation levels with spiny bollworm were decreased when cotton was sprayed with combination of the insecticides used with salicylic acid compared with cotton treated with salicylic acid only and untreated cotton. These results are agreement with those reported by Peng *et al.* (2004), Younis and Ibrahim (2012), Al-Kazafy (2013), Zidan *et al*. (2012) and Albeltagy *et al*. (2013). Resistance induced in many plant species is known to influence the fitness and performance of insect pests (Mithöfer and Boland, 2012). However, the induced resistance by elicitors did not produce any phytotoxicity or negative effect on natural enemies (Bruce, 2014). Thaler (1999) reported that foliar JA application on tomato plants increased levels of polyphenol oxidase an oxidative enzyme implicated in resistance against several insect herbivores. responsible for producing certain secondary metabolites which decrease the survival of herbivores (Thaler *et al.*, 2001). This was also evidenced in *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae), feeding on induced foliage (Stout and Duffey, 1996). The high rate of pupal mortality of cotton bollworm (*H. armigera*) was correlated with high concentration of SA under laboratory conditions (Sivamani *et al*., 1992). Farouk and Osman (2011) reported that foliar application of salicylic acid (SA) or methyl jasmonate (MeJA) on common bean plants before or after two spotted spider mite infestation proved to be effective in reducing infestations. The post-ingestive interaction between insect pests and plant toxins plays a significant role in determining the resistance/susceptibility of plant tissues to insects. Induced resistance is an important component in this respect because it leads to the production of various toxic secondary metabolites and other compounds, which affect insect physiology, and growth and development. The negative effects of induced resistance on insect pests are attributed to the lower nutritional value of plant tissues and the toxicity of allelochemicals, proteins and protease inhibitors (Bhonwong *et al*., 2009 and Barbehenn *et al.*, 2010). SA induces resistance against sap sucking insects and pathogens (Zhao *et al.*, 2009).The results showed that silica nanoparticles and actcrone insecticide were the most effective treatment against *H. armigera* and *E.insulana* larvae infesting okra plants. The tested insecticide showed highly efficacy against *H. armigera* and the results agree with the findings of Wollweber and Tietjen (1999) as well as FERA (2009), they reported that neonictonoid insecticides are effective against larval infestation of *H. armigera* on tomato plants.

4. Effect of some elicitors plant and conventional insecticide on the participated predators:

Data recorded in Table (4) indicated that okra plants treated by the highest concentration of jasmonic acid (300 ppm) had the highest population density of all participated predators during the two 2018 and 2019 seasons, except for *C. carnea* compared with the other treated plants. However, the lowest mean number of predators was noticed on okra treated with insecticide, followed by okra plants treated with the lowest concentration of salicylic acid (100 ppm) actacron (375 aml/ fed.). These rustles are agreed with resistance induced in many plant species is known to influence the fitness and performance of insect pests (Mithöfer and Boland, 2012). However, the induced resistance by elicitors did not produce any phytotoxicity or negative effect on natural enemies (Bruce, 2014).

Table(4): Effect of silica nanoparticles, peppermint extract and actacron insecticide on predators participated in okra plants during growing season of 2018 and 2019.

Treatment	Concentration ppm/ fed.	*Chrysoperla carnea*	*Coccinela* spp.	*Paederus alfierii*	*Scymnus* spp.	True spider
Mean number/ five okra plants during 2018 season						
Jasmonic acid	300 ppm	45.25 c	75.50 a	35.00 a	55.25 a	59.25 a
	200 ppm	38.50 d	61.50 b	25.50 c	41.00 b	49.00 b
	100 ppm	32.25 e	50.25 d	19.75 d	32.75 d	37.50 d
Salicylic acid	300 ppm	63.0 a	55.00 c	30.00 b	46.00 b	43.75 c
	200 ppm	54.75 b	43.25 e	23.50 c	30.25 d	33.25 d
	100 ppm	41.75 d	35.00 f	18.25 d	23.00f	25.50 e
Jasmonic acid + actacron	300 ppm + 375	40.25 d	66.00 b	30.75 b	45.00 b	35.25 d
	200 ppm + 375	33.00 e	55.25 c	20.75 d	36.50 c	27.00 e
	100ppm+375	27.25 f	44.50 e	11.75 e	20.75 f	18.75f
Salicylic acid+actacron	300ppm+375	53.50 b	48.25 d	24.25 c	37.00 c	32.00 d
	200ppm+375	45.25 c	35.50 f	20.75 d	25.00 e	26.75 e
	100ppm+375	25.00 f	27.00 g	12.00 e	20.75 f	19.50 f
Control	-	19.75 g	21.00 h	8.25 f	13.50 g	15.00 g
Ethanol	1m/ L.water	19.25 g	21.25 h	8.50 .f	13.25g	14.75 g
Actacron	750 ml	2.25 h	13.50 i	1.00 g	5.75 h	3.25 h
Mean number/ five okra plants during 2019 season						
Jasmonic acid	300 ppm	48.75 c	79.75 a	39.50 a	59.50a	56.50a
	200 ppm	42.00 d	63.60 b	27.00 c	45.75b	45.50b
	100 ppm	34.50 e	53.75 d	20.25 d	35.25d	35.00d
Salicylic acid	300 ppm	69.25 a	58.50 c	33.00 b	49.50b	44.25c
	200 ppm	58.50 b	47.75 e	24.50 c	32.75d	30.50d
	100 ppm	44.75 d	39.50 f	17.75 d	25.50f	22.00e
Jasmonic acid+ actacron	300ppm+375	44.75 d	73.75 b	32.50 e	42.50b	32.50d
	200ppm+375	38.50 e	60.75 c	23.25 c	47.25c	23.00e
	100ppm+375	31.75 f	46.00 e	14.50 d	18.75f	18.50f
Salicylic acid+actacron	300ppm+375	56.00 b	50.75 d	27.75	39.50c	29.50d
	200ppm+375	49.75 c	39.00 f	21.50 d	31.50e	24.75e
	100ppm+375	28.50 f	29.50 g	13.75 e	23.50f	18.50f
Control	-	21.25 g	22.50 h	9.50 f	15.75g	14.00g
Ethanol	1m/ L. water	21.00 g	22.25 h	9.25 f	15.50g	14.00g
Actacron	750	2.50 h	12.50 i	1.50	6.75h	3.25h

Means followed by a common letter are not significantly different at the 5% level by DMRT.

5. Effect of some elicitors' plant and actacron insecticide on okra yield:

Data illustrated in Table (5) present the okra yield as an average two seasons of 2018 and 2019 as affected by the tested insecticides and their different rate of treatments. Okra treated by the highest concentration of jasmonic acid (300 ppm) mixture with actacron (375 ml/fed.) pattern proved to be the best compound. This compound produced 249.25 and 255.00 K.g. / Kirat in 2018 and 2019 seasons, respectively. In 2018 and 2019 season experiments, data presented in Table (5) indicated that total

yield reduction of okra was influenced by different concentrations of elicitor treatments, other treatments compared to untreated okra plants (Table, 5). The highest total fruit yield (as weight and number) was obtained with foliar spray with the highest concentration (300 ppm) of jasmonic acid mixed with conventional insecticide, while plants sprayed with ethanol only and okra untreated (control) recorded the lowest values (Table, 5). The highest concentration of jasmonic acid mixed with conventional insecticide (300 ppm) gave 249.25and 255.00 Kg / Kirat which about 1495.5 and 1530.00 value L.E./ Kirat , respectively, during two seasons of 2018 and 2019 , while the control plant gave 66.25and 68.75 kg/ Kirat, respectively during two seasons of 2018 and 2019 (Table, 5).

Table (5): Effect of silica nanoparticles, peppermint extract and actacron insecticide on okra yield.

Treatment	Rate/fed.	2018 season			2019 season		
		Yield production (K. g./ Kirat)	Value L.E./ Kirat	Relative Price Benefit%	Yield production (K. g./ Kirat)	Value L.E./ Kirat	Relative Price Benefit%
Jasmonic acid+ actacron	300+375	249.25a	1495.5	376.06	255.00a	1530.0	370.91
	200+375	215.25b	1291.5	324.76	219.75b	1318.5	319.64
	100+375	180.50d	1083.0	272.33	185.00d	1110.0	269.09
Salicylic acid+ actacron	300+375	195.50c	1173.0	295.96	199.25c	1195.5	289.81
	200+375	155.25e	931.5	294.96	157.50e	945.0	229.09
	100+375	120.00f	720.0	181.05	124.75f	748.5	181.45
Jasmonic acid	300 ppm	200.75c	1204.5	302.88	210.25c	1261.5	305.82
	200 ppm	188.50c	1131.0	284.40	193.50c	1161.0	281.45
	100 ppm	156.25e	937.5	235.74	161.50e	969.0	234.90
Salicylic acid	300 ppm	170.25d	1021.5	256.86	177.00d	1062.0	257.45
	200 ppm	156.50e	939.0	236.12	160.75e	964.5	233.81
	100 ppm	123.75f	742.5	186.71	127.75f	766.5	185.81
Actacron	750 ml/ fed	212.25b	1273.5	320.23	216.00b	1296.0	314.18
Control		66.25g	397.68	-	68.75g	412.5	-
Ethenol	1ml/ L. Wat	66.25g	397.68	-	68.75g	412.5	-

Means followed by a common letter are not significantly different at the 5% level by DMRT.

The highest okra yield was occurred on okra treated by the highest concentration of jasmonic acid mixture with conventional insecticide, these results agree with some investigators. In most concentrations these elicitors significantly improved common bean plant growth i.e. had a positive effect on plant height, number of branches, shoot dry weight and leaf area per plant and bean yield (Farouk and Osman, 2011). Salicylic acid (SA) (o-hydroxybenzoic acid), is a plant phenolic, widely distributed throughout the plant kingdom. It is a hormone-like substance, which plays an important role in the regulation many aspects of plant growth and development (Raskin, 1992).

It is concluded that jasmonic acid mixed with actacron insecticide showed highly efficient compound in the reduction in the infestation of *E. insulana* and *H. armigera* compared to check and the other treated on okra plants. Salicylic acid mixed with actacron insecticide treatments showed moderate efficient in control this insect however, the highest total number of predators was found on okra plants treated with the highest concentration of jasmonic acid. Generally, additional studies showed be investigated to study the side effects of tested elicitors plant on parasitoids and environmental.

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