J. of Plant Protection and Pathology, Mansoura Univ., Vol. 14 (2):67 -73, 2023

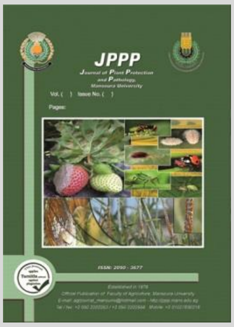
Journal of Plant Protection and Pathology

Journal homepage & Available online at: www.jppp.journals.ekb.eg

Seasonal Abundance of Cotton Mealybug, Phenacoccus *solenopsis* and Its Effect on Biochemical Defence of Okra Plants

Aneesa S. Sadek; Madeha E. H. El-Dewy* and Jehan B. A. El-Naggar

Plant Protection Research Institute, Agricultural Research Center, Giza, Egypt



ABSTRACT

Seasonal abundance of cotton mealybug was monitored on okra plants at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt during 2020 and 2021 cropping seasons. Biochemical changes have been monitored in infested okra plants by mealybug one, seven and fourteen days after feeding compared to healthy plants in the greenhouse. Additionally, the effectiveness of essential oils and insecticides were evaluated against this pest and its predators under field conditions. The population of cotton mealybug on okra started building up from June and reached its peak on August 14th and September 19th in 2020 season, while, it had two peaks on July 30th and August 28th in the second season. Biochemical changes showed an increase in carotenoids, meanwhile chlorophyll level exhibited significant decrease in okra plants seven and fourteen days after mealybug infestation, which led to a fall in the concentration of photosynthetic pigments. The level of catalase, peroxidase. superoxidase and malondialdehyde were much higher in infested than healthy plants, whereas carbohydrates and protein content decreased refereeing to plants damage. Profenofos provided an effective control against mealybug, which recorded rapid and long acting against this insect, although profenofos is advised for usage against high levels of mealybug. However, jojoba oil is an effective essential oil against low levels of mealybug infestation on okra plants, which was significantly the safest on predators. These findings might be used in integrated pest management programs (IPM) of cotton mealybug on okra and other plants.

Keywords: Seasonal abundance, mealybug, biochemical, insecticides.

INTRODUCTION

Okra, *Abelmoschus esculentus* (L.), a member of the Malvaceae family, is a vegetable crop grown in tropical and subtropical regions of the world that is significantly important (Nwangburuka *et al*., 2011). It is a plentiful source of vitamins and fiber-containing minerals (Moyin-Jesu, 2007). The presence of sucking pests considers one of the main factors limiting okra yield (Abdel Hamed *et al*., 2011; El-Fakharany, 2016; Zia and Haseeb, 2019). The cotton mealybug weakens, defoliates, and kills sensitive plants by feeding on all plant components, including the leaves, shoots, roots, and fruits of the host plants. Additionally, this mealybug excretes a lot of honeydew, which promotes the growth of sooty mould and impairs photosynthesis (Arif *et al*., 2012). In Egypt, the 1st record of *P. solenopis* was on the four economical crops; okra, *A. esculentus*; maize, *Zea mays* L., eggplant, *Solanum melongena* L. and malta jute (Meloukia), *Corchorus olitorius* L. at Sharkia Government (Nabil *et al*., 2015). Okra plants are one of the preferred hosts for mealybug (Nidheesh *et al*., 2020).

Phenacoccus solenopsis is predicted to become one of the most dangerous okra pests within the next few years because the agroecosytem is conducive to the growth of this pest, which has the ability to hide in cracks and crevices in the soil and corners of plants. Additionally, this pest has a waxy surface and can survive in a wide range of temperatures and relative humidity (Prasad *et al*., 2012; Hameed *et al.*, 2014). Is a waxy substance that covers the body's surface to shield it from pesticides and other natural killers.

Several treatments including plant extracts, essential oils, mineral oils, and biological control, have been demonstrated to be effective against infestations of cotton mealybug on various host (saeed *et al*., 2007; El-Zahi and Farag, 2017; Zia and Haseeb, 2019 ; Nidheesh *et al*., 2020). However, cotton mealybug outbreaks require the use of insecticides due to their rapid effect as compared to the biological control by predators and parasitoids (Joshi *et al*., 2010). The impact of cotton mealybug and other sucking insects on the physiology and defence system of the plants must be studied because it is generally known that active biosynthesis enzymes are involved in plant defence against pathogenic fungi, bacteria, and viruses (Walters, 2003), but it is still unclear how mealybug and other sucking insects affect plants.

Therefore, the present work was conducted to study the population abundance of cotton mealybug on okra plants and the direct effect of this pest on the defense system in okra plants. In addition, insecticides and essential oils have also been evaluated against this insect in the field.

MATERIALS AND METHODS

1. Population abundance of *Phenococcus solenopsis*:

To study the abundance of cotton mealybug, *P. solenopsis* population on okra plants (*Abelmoschus esculentus* L. var, White velvet), an experiment was conducted at the experimental farm of Sakha Agricultural

* **Corresponding author.**
E-mail address: madehadewy96@gmail.com
DOI: 10.21608/jppp.2023.186487.1132

Research Station, Kafr El-Sheikh Governorate, Egypt during okra cropping seasons of 2020 and 2021. An area, approximately 2000 m^2, was divided into four equal plots in a complete randomized block design. All agronomic practices were followed to raise the crop without receiving any insecticidal treatments. Inspection of the insect started 30 days after sowing and continued weekly till the end of crop season. In each inspection, 40 identically aged apical okra twigs were randomly selected from the experimental area (5 twigs from each corner and 5 from the center of each plot) to count adult females and nymphs of the cotton mealybug. Daily maximum and minimum temperatures and relative humidity were acquired from meteorological department at Sakha Agricultural Research Station.

2. Determination of biochemical components of okra plants after artificial infestation with cotton mealybug in the greenhouse:

Okra plants infestation with cotton mealybug in the greenhouse:

In 2021 cropping season, okra plants (*Abelmoschus esculentus* L. var, White velvet) were grown in a greenhouse at Sakha Agricultural Research Station and divided into two equal groups (each group contains 10 plants, i.e. replicates), each group was 40 days-old. All agricultural practices were done. Ten cotton mealybug adults were transferred onto each plant using a bristle bruch in the first group, while the second group plants were insect – free. The plants were kept apart from each other by cloth barricades to prevent plant contamination and to avoid cotton mealybug movement.

Sampling preparation:

One, seven and fourteen days after infestation by cotton mealybug, fresh okra leaves (newly matured) were randomly collected from each replicate from each group. The individuals of cotton mealybug were removed from leaves before chemical analysis.

Determination of photosynthetic pigments:

To determine leaf photosynthetic pigments (chlorophyll a, b and carotenoids), fresh okra leaf samples (0.5 gm) were homogenized with acetone (90% v/v), then filtered and the concentration was expressed as mg/g fresh weight. Leaf photosynthetic pigment concentrations were assessed according to Lichtenthaler and Buschmann (2001) and the optical density of the pigment solution was measured using spectrophotometry.

Determination of malondialdehyde content (MDA):

Fresh okra leaf samples (1 gm) were mixed with 1 ml of 10% trichloroacetic acid (TCA) and 1 ml of 0.67% thiobarbituric (TBA) and heated in a boiling water bath for 15 min. MDA was measured spectophotometrically by absorbance at 535 nm and expressed as n mol of MDA per gram fresh leaf samples (Madhava Rao and Sresty, 2000)

Antioxidant enzymes, total carbohydrates and protein content assays:

The freshly collected okra leaves (1 gm) were homogenized in liquid N_2 with 0.05 M. EDTA and 1 PVP at 4 °C, the extracts were centrifuged at 4 °C 15000 xg (Lowry *et al*., 1951). The resulting supernatant was used for determination of antioxidant enzymes (Catalase, peroxidase and superoxidase) and nonenzymatic components (total carbohydrates and protein content).

Catalase activity was measured according to Aebi (1984), the methods of Polle *et al*. (1994) was used for determination of peroxidase activity. Superoxide activity was determined as described by Zhou *et al* (2007), protein content was measured according to A.O.A.C. (1990), and total carbohydrates was determined by phenol-sulphuric acid method described by Dubois *et al*. (1956) and calculated as percentage. Determination of photosynthetic pigments, enzymes activity, protein content and total carbohydrates were assessed in the laboratory of Pesticides Chemistry and Toxicology Department, Faculty of Agriculture, Damanhour University.

3. Toxicity of some compounds against cotton mealybug, *P. solenopsis* and its predators:

Tested compounds:

The commercial formulations of acetamiprid (Acetabond 70% WG, Jiangxi Heyi Chemical Co., Lts, China, at rate 175 mg al/L); thiamethoxam 20+ chlorantaniliprole 20% (Folium Flex 40% WG, Syngenta (Agro Egypt), at rate 80 mg a.i/L); profenofos (Cord 72% EC, Al-Helb for pesticides and chemicals, at rate 2717 mg ai/L); lambda-cyhalothrin (Sembrator 10% SC., Agrochina dgroup, at rate 25 mg ai/L); jasmine, *Jasminum grandiflorum* L. and jojoba, *Simmondsia chinensis* L. (essential oil are formed as EC produced by Egyptian Natural oil Co.). Based on the Egyptian Ministry of Agriculture's guidelines for each insecticide to control sucking insects in the field, the recommended concentrations were utilized.

Field experiments layout:

During the 2020 and 2021 okra growing seasons, the trials were carried out at the Sakha Agricultural Research Station farm in the Kafr EL-Sheikh Governorate. Okra plants (*Abelmoschus esculentus* L. var, White velvet) were planted throughout a 1000 m^2 area in both seasons, which was divided into 42 m^2 plots. The area was divided into 28 plots (six insecticides plus control with four replicates), under a randomized complete design, and the aforementioned insecticidal applications were tested in this area in September 2020 and 2021 during the okra season. All agricultural practices were carried out throughout the entire season without any insecticide treatments before control is applied. A Knapsack sprayer was used to apply the tested compounds at the appropriate rates; the spray solution's ultimate volume was 200 L/Feddan.

Sampling of *P. solenopsis* and its associated predators:

Ten okra plants were randomly selected from each replicate to examine the effectiveness of the tested compounds against *P. solenopsis*. These plants were then labeled and further investigated to count the cotton mealybug population. All mealybug stage was counted on the terminal portion (20 cm) of selected okra plants' tops of selected okra plants. When there were enough mealybug populations in okra plants, tested compounds were put in the place. Records of observations were made just before spray and 3,7,10 and 14 days after spray. In addition, the effect of the tested compounds against associated predators; *Chrysopela carnea* and *Coccinella* spp. presence on ten okra plants were chosen randomly from each plot. Also, data were recorded at the same time followed with cotton mealybug according to the method described by Scale Insect Department, Plant Protection Research

Institute, Agricultural Research Center. Henderson and Tilton equation (1955) was used to compute the reduction percentages of insects and predators.

4. Statistical analysis:

Using the SPSS (2000) 16.0 program for Windows (Illonois, USA), partial correlation and regression coefficient between the each of climatic parameters and predator population, and cotton mealybug population were determined. One-way analysis of variance (ANOVA) was used to test whether there was a significant difference between insecticide treatment or not? In case of significant, means separated using Duncan's multiple range test (Duncan, 1955) at 0.05 probability. The *t* test was used to determine the differences in enzyme activity in the okra leaves between both infested and healthy (insect-free) plants.

RESULTS AND DISCUSSION

Population density of cotton mealybug, *P. Solenopsis* on okra plants:

Figure (1) shows that the mean populations of *P. solenopsis*. It began in low numbers on June 18 (11 insects per 10 twigs), increased steadily, and peaked on August 14 (310 insects per 10 twigs) in 2020. Following that, the population changed, and on September 19, a large quantity (580 insects/ 10 twigs) was recorded.

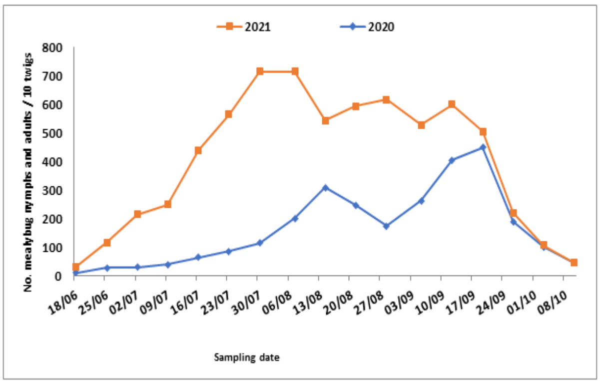


Figure (1): Population fluctuation of *Phenacoccus solenopsis* on okra plants in 2020 and 2021 seasons at Sakha Agricultural Research Station Farm.

. In 2021 okra cropping season, the first infestation of *P. solenopsis* was observed in June with a mean of 20 insects/10 twigs. The highest population density was noticed on July 30th (600 insects/ 10 twigs) and again recorded another peak on August 28th with a mean of 442 insects/ 10 twigs. Then, the population decreased gradually till the end of the season. These findings concur with those made by Nabil and Hegab (2019) and El-Fakharany (2020), who discovered that *P. solenopsis* infestations had two peaks, the first of which was observed in August and the second of which was noted in September on okra plants. Additionally, Zia and Haseeb (2019) demonstrated that the population of cotton mealybug on okra plants peaked in the third and fourth weeks of August after beginning to increase in May.

Correlations among cotton mealybug population, weather factors and predators:

Temperature, relative humidity, and associated predators were correlated with the mean weekly population of cotton mealybug. Data in Table (1) revealed that in 2020 season, each of maximum temperature, minimum temperature, relative humidity and predators had non-significant positive correlations with mealybug populations. The okra planting season of 2021 showed the same tendency, but only the mealybug population was inversely associated with the maximum temperature (r= -0.01). Our findings disagreed with Babu and Meghwal (2014) who found that *P. solenopsis* was positively correlated with maximum and lowest temperature, moreover, Nabil and Hegab (2019) and El-Fakharany (2020) obtained significant positive correlations between maximum temperature and lowest temperature with cotton mealybug populations, while it had insignificant correlations with relative humidity.

The maximum and minimum temperatures, relative humidity, and predators were all involved in the shift in *P. solenopsis* populations by 34.0 and 63.3% over the 2020 and 2021 seasons, respectively. This effect of all the different components was stated as the explained variance (EV %). The results of the correlation and regression analyses unambiguously indicate that weather factors and related predators together have a major impact on the development and dynamics of *P. solenopsis* populations.

Table 1. Correlation(r) and regression (b) coefficients between some weather factors, predators and mean populations of *Phenacoccus* /10 okra twigs at Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate

Season	Maximum temperature(°C)		Minimum temperature(°C)		Relative humidity %		Predators		EV
	R	b	r	b	r	b	R	B	%
2020	0.339	14.784	0.034	5.874	0.102	4.865	0.150	4.118	34.0%
2021	-0.010	-1.329	0.375	12.760	0.259	7.830	0.187	2.237	63.3%

2. Biochemical changes in okra plants after infestation with cotton mealybug:

Photosynthetic pigments, some nonenzymatic components and antioxidant enzymes as parameters related to the performance of biochemical changes were detected in okra leaves after mealybug feeding compared to healthy plants.

Photosynthetic pigments:

Chlorophyll a, b and carotenoids, as parameters related to the performance of cotton mealybug on photosynthesis pigments have been estimated. Chlorophyll a plays an important role in the process of photosynthesis and acts as a photoreceptor, which acts as a transitional factor in the transformation of absorbed solar energy and synthesis of organic substances in plants. Data in Table (2) indicates that chlorophyll a, b and carotenoid contents slightly increased one day after mealybug feeding comparing to the values recorded with healthy plants (non-infested). After that, chlorophyll a and b contents showed a significant decrease in okra plants seven and fourteen days after mealybug infestation. However, the pest induced a significant increase in carotenoid content seven and fourteen days after infestation. This infestation reflects a negative effect of mealybug infestation on photosynthetic process. The present findings revealed a positive correlation between photosynthetic potential and chlorophyll content. Puteh *et al.* (2013) found that high levels of photosynthetic pigments might improve light absorbance and increase the maximum yield of photosystem. According to our findings, mealybug feeding had a great impact in the removal of assimilates and the rate of photosynthetic activity in okra plants. The same results were obtained by Heng-Moss *et al*. (2003) and Farouk *et al*. (2021) who reported that piercing sucking pests feed on photosynthetic mesophyll cells in the lower epidermis of leaves and, as a result, the mesophyll cells disintegrated. This is a response to the pest infestation, which declines the concentrations of photosynthetic pigments

Table 2. Photosynthetic pigments in okra leaves after artificial infestation with *Phenacoccus solenopsis* for 1, 7 and 14 days

Treatment	Chlorophyll a	Chlorophyll b	Carotenoids	Total
		After 1 day		
Control	2.017 ±0.05	1.368 ±0.21	0.368±0.034	3.753 ±0.38
Infested	2.114 ±0. 23	1.452 ±0. 18	0.424 ±0.026	3.990 ±0.31
p-valuep	**	**	*	*
		After 7 days		
Control	2.435±0.064	1.496±0.34	0.470±0.024	4.401±0.87
Infested	2.087±0.087	1.146±0.29	0.582±0.034	3.815±0.67
p-valuep	**	**	**	**
		After 14 days		
Control	2.508±0.035	1.541±0.22	0.505±0.041	4.554±0.59
Infested	2.117±0.049	1.372±0.36	0.782±0.078	4.271±0.44
p-valuep	**	**	**	**

**** Highly significant, p < 0 .01; * significant, p < 0 .05**

Non enzymatic components and antioxidant enzymes:

Catalase (CAT), peroxidase (POD) and superoxidase (SOD) were considered as antioxidant enzymes, as changes of their activity after infestation of the piercing sucking pests to plant tissues are caused by accumulation of reactive oxygen species (ROS) in plant tissues. SOD (superoxidase) constitutes the first line of defense against ROS (Alscher *et al*., 2002) by catalyzing the dismutation of superoxide radical to H_2O_2 and O_2, after that the two enzymes CAT and POD participate in the detoxification of H_2O_2 by converting it to H_2O and O_2 (Parween *et al*., 2012). The results in Table (3) cleared that catalase, peroxidase, superoxidase and MDA decreased in okra plants after one day due to mealybug attack but after seven and fourteen days, these enzymes and MDA significantly increased in their quantities compared to healthy plants. The increase in antioxidant enzymes activity and MDA are an indicator of plant injuries.

Non -enzymatic components (carbohydrates and protein content) significantly decreased in okra plants after one, seven and fourteen days due to assaulting mealybug in comparison with control. The findings in Table (3) indicate that the deposition of nutritive value of plants cells for mealybug feeding may have resulted from this response. The similar results were obtained by Kmeic *et al*.(2014) and Sempruch *et al*. (2014) who showed that *Phenacoccus longispinus* changed biochemical parameters (electrote outflow, malondialdehyde content (MDA) and antioxidant enzymes activity) reaching high values during the initial period of orchids infestation. Moreover, Goggin (2007) and Giordanengo *et al.* (2010) demonstrated that biochemical plant defense may be devised by components of aphis species and/ or wounding of epidermal, mesophyll and parenchyma cells during their probing behavior. On the other hand, Shafique *et al*. (2014) who observed that the quantity of physical barriers and biochemical defensive increased due to injuries of mealybug.

Table 3. Non-enzymatic components and antioxidant enzymes activity in okra leaves after artificial infestation with *Phenacoccus solenopsis* for 1, 7 and 14 days

Treatment	Non-enzymatic components			Antioxidant enzymes		
	Carbohydrates	Protein	MDA (nmol of MDA g fw^{-1})	Catalase (nmol H_2O_2 mg $protein^{-1}$ min^{-1}) 0) (CAT) (CAT)	Peroxidase (nmol ascorbate oxidized mg $protein^{-1}$ min^{-1})	Superoxides (nmol NO_2 mg $protein^{-1}$ min^{-1}).
				After 1 day		
Control	26.19±0.28	14.27±1.09	0.276±0.15	1.640±1.32	2.162±1.29	2.747±0.068
Infested	25.55±0.35	13.11±1.14	0.241±0.13	1.480±0.87	2.085±1.07	2.619±0.094
p-value	**	*	**	**	**	*
				After 7 days		
Control	39.23±0.55	18.76±0.68	0.371±0.13	1.510±0.12	2.156±.0114	3.191±0.073
Infested	27.96±0.41	11.27±0.98	0.391±0.15	1.720±0.119	2.662±.0152	3.786±0.094
p-value	**	**	**	**	**	**
				After 14 days		
Control	40.41±0.76	19.30±1.17	0.382±0.12	1.590±0.97	2.362±0.18	3.561±0.067
Infested	35.01±0.81	13.82±1.38	0.422±0.11	1.770±0.16	2.740±0.15	3.896±0.081
p-value	**	**	**	*	**	*

**** Highly significant, p < 0 .01; * significant, p < 0 .05**

3. Activity of the tested compounds against cotton mealybug and associated predators:

The information in Table (4) demonstrates that before the tested chemicals were applied, there were not the same numbers of mealybugs per five okra plants. In actuality, this is a widespread issue that affects all crops afflicted by this insect in unfavorable environmental conditions, as well as randomly chosen plants (Hanchinal *et al*., 2009). These compounds significantly reduced mealybug populations in comparison with control in 2020 and 2021 season. In initial kill (after 3 days from application), profenofos was the fastest killer (88.85, 91.61% reduction) in 2020 and 2021 seasons, respectively, followed by acetamiprid and thiamethoxam + chlorantraniliprole without significant differences. Based on the general mean of reduction through the experiment which extended to fourteen days, profenofos again proved to be the most potent on *P. solenopsis* recording 95.19 and 96.64% reduction, followed by acetamiprid (80.64 and 84.4%) and thiamethoxam + chlorantraniliprole (78.85

and 89.18%) in 2020 and 2021 seasons, respectively, with insignificant differences. In terms of the impact of jasmine and jojoba oils on cotton mealybug populations, statistical analysis revealed that jojoba oil was only moderately effective (62.61 and 65.64% reduction in two seasons, respectively) while jasmine oil had the least impact (19.68 and 35.23%) in both seasons. These results are consistent with those found by Abd El-Rahman (2003), Salem *et al*. (2003) and Soltan (2020) who showed that jojoba oil formulation was a potent against some herbivorous insects as *Liriomyza trifolii* (Burgess), *Bemisia tabaci* Gennadius and *Empoasca decipiens* Paoli. Furthermore, Hexaflumuron was the most successful in eliminating *P. solenopsis* and *Tetranychus urticae* (Kouch) infestation, whereas moringa and jojoba oils were the least effective in both seasons, according to Farage and Abd El-Rahman (2021). According to previous results, profenofos provided greater control of mealybug infestation in field conditions than the other ones, thus, profenofos proved to be the most rapid and long acting. Acetamiprid and thiamethoxam + chlorantraniliprole occupied the second order in effect against cotton mealybug while jasmine oil exhibited the least impact against cotton mealybug.

Our results are in conformation with the findings of Saeed *et al*. (2007); Aheer *et al*. (2009) and Ahmad *et al*. (2011) who found that profenofos, methomyl, chlorpyrifos were the best in controlling cotton mealybug. Additionally, El-Fakharany (2020) and Nidheech *et al*. (2020) found that neonicotinoids such acetamiprid, thiamethoxam, and dinotefuran were the most successful at reducing cotton mealybug in comparison to other insecticides.

Table 4. Efficacy of tested compounds in lowering *Phenacoccus solenopsis* population on okra plants throughout the 2020 and 2021 growing seasons at Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate

Compound	Conc. (mg ai./L)	Mean No. pre-Spray/ 5 plants	Initial kill (3days)	Residual effect after indicated days			Mean number
				7	10	14	
2020 season							
Jasmine oil	1500	609.00	32.00 c	22.00	16.00	8.71	19.68 e
Jojoba oil	1500	505.00	53.27 b	65.00	57.40	74.78	62.61 c
Acetamiprid	175	805.00	54.80 b	84.10	88.21	96.00	80.64 c
Thiamethoxam + chlorantraniliprole	80	514.00	51.80 b	67.57	96.73	99.30	78.85 b
Profenofos	2717	915.00	88.85 a	93.17	99.34	99.41	95.19 a
Lambda-cyhalothrin	25	550.00	26.50 c	49.36	67.30	42.94	46.53 d
Control	-	592.00	442.00	237.00	293.00	110.00	-
2021 season							
Jasmine oil	1500	533.00	40.00 cd	47.0	33.90	20.00	35.23 e
Jojoba oil	1500	610.00	45.98 c	61.99	69.99	84.70	65.64 c
Acetamiprid	175	733.00	65.24 b	86.85	88.54	96.95	84.4 b
Thiamethoxam + chlorantraniliprole	80	461.00	65.79 b	94.68	97.09	99.19	89.18 ab
Profenofos	2717	785.00	91.61 a	96.36	98.59	100.00	96.64 a
Lambda-cyhalothrin	25	494.00	34.97 d	64.06	49.30	62.24	52.64 d
Control	-	500.00	600.00	856.00	285.00	134.00	

In a column, means followed by different letters show significant differences according to Duncan's test at *P*< 0.05

Table 5. Efficacy of tested compounds in lowering *a*ssociated predators populations on okra plants throughout the 2020 and 2021 growing seasons at Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate

Compound	Conc. (mg ai./L)	Mean No. pre-Spray/ 5 plants	Initial kill (3day) 9 (3days)	Residual effect after indicated days			Mean number
				7	10	14	
2020 season							
Jasmine oil	1500	16.00	30.93 c	20.30	10.00	24.31	21.39 e
Jojoba oil	1500	15.00	2.00 d	6.00	20.00	17.93	11.48 f
Acetamiprid	175	20.00	57.05 b	55.69	58.35	37.55	52.16 b
Thiamethoxam + chlorantraniliprole	80	23.33	86.30 a	61.43	71.03	90.34	77.28 a
Profenofos	2717	18.00	26.09 c	32.00	62.99	45.84	41.73 c
Lambda-cyhalothrin	25	15.00	59 .00b	20.00	13.92	35.01	31.98 d
Control	-	20.00	19.00	15.00	16.00	16.00	-
2021 season							
Jasmine oil	1500	15.00	36.47 c	29.52	36.40	30.00	33.1 d
Jojoba oil	1500	18.00	4.2 0d	7.50	31.30	25.00	20.52 e
Acetamiprid	175	25.00	69.47 b	45.00	73.25	68.13	63.96 b
Thiamethoxam + chlorantraniliprole	80	32.00	88.59 a	61.50	91.62	93.75	83.87 a
Profenofos	2717	19.00	46.21 c	58.32	71.95	52.63	57.28 b
Lambda-cyhalothrin	25	14.00	68.71 b	30.86	47.36	42.86	47.44 c
Control	-	16.00	22.00	18.00	24.00	16.00	-

In a column, means followed by different letters show significant differences according to Duncan's test at *P*< 0.05

Side effect of tested compounds on associated predators:

At the experimental farm of Sakha Agricultural Research Station, *Chrysoperla carnea* and *Coccinella* spp. were the most prevalent predators on okra plants in the seasons of 2020 and 2021. According to data in Table (5), all tested compounds reduced depression in the two aforementioned predators by 11.48 to 77.28% in 2020 and by 20.52 to 83.87% in 2021. Jojoba and jasmine oils significantly proved to be the safest to the associated predators compared to other tested compounds during the experimental period recording 11.48 and 21.39% reduction in 2020 and 20.52 and 33.1% reduction in 2021 with significant differences from other compounds. On the other hand, thiamethoxam + chlorantraniliprole was harmful to predators recording 77.28 and 83.87% reduction in both seasons, meanwhile, acetamiprid, profenofos and lambada-cyhalothrin were moderately harmful to tested predators with significant differences between them.

In addition, El-Fakharany et al. (2016) and Sadek and El-Dewy (2019) demonstrated that acetamiprid, garlic oil, and eucalyptus oils were harmless to the predators. These findings are similar to those of Cloyd and Bathke (2011) who discovered that neonicotinoid insecticides applied as foliar, drench, or granular had an indirect impact on predators populations because there were fewer prey available for.

CONCLUSION

From the current results, it could be concluded that okra plants infested with cotton mealybug, *Phenacoccus solenopsis* exhibited increases in their biochemical contents of carotenoids, catalase, peroxidase, superoxidase and MDA. On the other hand, infested okra plants had less chlorophyll, carbohydrates and protein content, which mean injuries in plant tissues due to cotton mealybug attacks. In addition, jasmine and jojoba oils were the safest against the considered predators *Chrysoperla carnea* and *Coccinella* spp. as compared to the tested insecticides, despite both oils were less effective against the insect pest.

Accordingly, it could be recommended to use jojoba oil in case of low mealybug infestations, but in case of outbreaks, there is a necessity to use profenofos, acetamiprid and thiamethoxam + chlorantraniliprole.

ACKNOWLEDGEMENT

The authors thank Dr. El Sayed. A. Abo-Marzoka, Crop Physiology Dep., Field Crops Res. Inst., ARC ,Giza, Egypt for funding the current work.

REFERENCES

A.O. A. C. (1990). Official Method of Analysis, 10th Ed., Association of Official Analysis Chemists, Inc. USA.

Abdel Hamed, N.A.; H.S.Shaalon; S.A.Yasin and A.M.Abou-Zaid(2011). Effect of some abiotic factors on the population fluctuation of some pests infesting okra plants, with the using of some compounds in their controlling. J. Plant Prot. and Pathology, Mansoura Univ., 2(4):407-419.

Abd El-Rahman,S.F.(2003). Damage assessment of certain insects attacking faba bean in the field and store, M. Sc. Thesis, Fac. of Agric., Cairo University.

Aebi, H. (1984). Catalase in vitro. Methods in enzymology, 105: 121-126.

Aheer, G. M.; R. Ahmad and A. Ali (2009). Efficacy of different insecticides against mealybug, *Phenacoccus solenopsis* Ferris. J. Agric. Res., 47: 47-52.

Ahmad, F.; W. Akram; A. Sajjad and A. U. Imran (2011). Management practices against cotton mealybug, *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae). Int. J. Agric. and Biol., 13(4): 547-552.

Alscher, R. G., N. Erturk and L. S. Heath (2002). Role of superoxide dismutases (SODs) in controlling oxidative stress in plants. Journal of Experimental Botany, 53(372): 1331-1341.

Arif, M. I.; M. Rafiq; S. Wazir; N. Mehmood and A. Ghaffar (2012). Studies on cotton mealybug, *Phenacoccus solenopsis* (Pseudococcidae: Homoptera), and its natural enemies in Punjab, Pakistan. Int J. Agric. Biology, 14(4): 557-562.

Babu,S.R. and M. L. Meghwal (2014). Population dynamics and monitoring of sucking pests and bollworms on *BT* cotton in humid zone of Southern Rajasthan. The Bioscan, 9(2): 629-632.

Dubois, K. A.; J. K. Gilles; R.P.A. Ramilton and F. Smith (1956). Colorimetric method for determination sugars and related substances. Anal. Chem., 28: 350-356.

Duncan, D. B. (1955). Multiple range and multiple F tests. Biometrics, 11(1): 1-42.

El-Fakharany, S. K. M. (2016). Population density and effect of some toxic compounds on *Aphis gossypii* Glover and their preadators, parasitoids and major elements in okra plants. Egypt. Acad. J. Biol. Sci., 8(2):82-94.

El-Fakharany, S. K. M. (2020). Cotton mealybug *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae) population density in eggplant and okra plantations and effect of some insecticides. Egypt J. Plant Prot. Res. Inst., 3(1), 377-388.

El-Zahi, E. S. and A. A. Farag (2017). Population dynamic of *Phenacoccus solenopsis* Tinsley on cotton plants and its susceptibility to some insecticides in relation to the exposure method. Alex. Sci.Exch. J., 38(2): 231-237.

Farag, A.A. and H.A. Abd El-Rahman (2021). Impact of some plant oils and hexaflumuron against *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae) and *Tetranychus urticae* (Acari: Tetranychidae) on cotton plants. Egypt J. Plant Prot. Res. Inst., 4(4): 612-622.

Farouk, S.; A. B. Almutairi; Y. O. Alharbi and W. I. Al-Bassam (2021). Acaricidal efficacy of jasmine and lavender essential oil or mustard fixed oil against two-spotted spider mite and their impact on growth and yield of eggplants. Biology, 10(410):1-13.

Giordanengo, P.; L. Brunissen; C. Rusterucci; C. Vincent; A. van Bel; S. Dinant; C. Girousse; M. Faucher and J. L. Bonnemain (2010). Compatible plant-aphid interactions: how aphids manipulate plant responses. Comptes Rendus Biologies, 333(6-7): 516-523.

Goggin, F. L. (2007). Plant–aphid interactions: molecular and ecological perspectives. Current Opinion in Plant Biology, 10(4): 399-408.

Hameed, A.; M. S. Shahzad; A. Mehmood and S. Ahmad (2014). Forecasting and modeling of sucking insect complex of cotton under agro-ecosystem of Multan-Punjab, Pakistan. Pakistan J. Agric. Sci., 51(4):997-1003.

Hanchinal, S.G.; B.V. Patil; M. Bheemanna; A. C. Hosamani and Sharanabasappa (2009). Incidence of mealybug on cotton in Tungbbadra project area: In. Proc. Dr. Leslie C. Colemon Memorial Nation.Srymp. Plant Prot. Dec.,4-6 (2008) University of Agriculture Science,GKVK. Bangalore.

Henderson, C. F. and E. W. Tilton (1955). Tests with acaricides against the brown wheat mite. J. of Econ. Entomol., 48(2): 157-161.

Heng-Moss, T. M.; X. Ni; T. Macedo; J.P. Markwell;F.P. Baxendale; S. S. Quisenberry and V. Tolmay (2003). Comparison of chlorophyll and carotenoid concentrations among Russian wheat aphid (Homoptera: Aphididae)-infested wheat isolines. J. Econ. EntomoL, 96(2): 475-481.

Joshi, M. D.; P.G. Butani; V.N. Patel and P. Jeyakumar (2010). Cotton mealybug, *Phenacoccus solenopsis* Tinsley-a review. Agric. Rev., 31:113-119.

Kmiec, K.; I. Kot;K. Rubinowska; B. Lagowska; K.Golan and E. Gorska-Drabik(2014). Physiological reaction of *Phaleanopsi*s x hybridum 'Innocence'' on *Pseudococcus lonispsis*(Targoni Tozetti)feeding. Acta. Sci. Pol. Hortorum Cultus. 13: 85-96.

Lichtenthaler, H.K. and C. Buschmann (2001). Chlorophylls and carotenoids: measurement and characterization by UV-VIS spectroscopy. In Food Analytic Chemistry (CPFA); Wrolstad RE, Acree TE,An H,Decker EA, An,H., Decker, E.A., Penner, M.H.,Reid,D.S,,Schwartz,S.J.,Shoemaker,C.F., Sporns, P.,Eds.; John Wiley and Sons:New York,NY,USA,ppF4.3.1-F4.3.8.

Lowry, O.H.; N.J. Rosebrough; A.L. Farr and R.J. Randall (1951). Protein measurement with the folin phenol reagent. J Biol Chem.,193: 265-275.

Madhava Rao, K.V. and T.V.S. Sresty (2000). Antioxidative parameters in the seedlings of pigeonpea (*Cajanus cajan* L. Millspaugh) in response to Zn and Ni stresses. Plant Sci., 157:113–128.

Moyin-Jesu, E.I. (2007). Use of plant residues for improving soil fertility, pod nutrients, root growth and pod weight of okra, *Abelmoschus esculents* (L). Bioresour.Tech., 98: 2057-2064.

Nabil, H. A. and M. A. M. Hegab (2019). Impact of some weather factors on the population density of *Phenacoccus solenopsis* Tinsley and its natural enemies. Egypt Acad. J. of Biol. Sci., 12(2): 99-108.

Nabil, H. A.; A. S. H. Hassan and S.H.A. Ismail (2015). Registration of the cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Sternorrhyncha: Coccoidea: Pseudococcidae) for the first time on four economical crops in Egypt. Zagazig J. Agric. Res., 42(6), 1555-1560.

Nidheesh, T. D., A. H. Jayappa; A. N. Shylesha; N. Nagaraju and H. M. Jayadeva (2020). Screening of new insecticide molecules against cotton mealybug, *Phenacoccus solenopsis* Tinsley (Homoptera: Pseudococcidae). Int. J. Curr. Microbiol. App. Sci., 9(3): 2542-2550.

Nwangburuka, C. C.; O. B. Kehinde, D.K. Ojo; O.A. Denton and A. R. Popoola (2011). Morphological classification of genetic diversity in cultivated okra, *Abelmoschus esculentus* (L) Moench using principal component analysis (PCA) and single linkage cluster analysis (SLCA). African Journal of Biotechnology, 10(54):11165-11172.

Parween, T.; S. Jan and F. T. Mahmooduzzafar (2012). Evaluation of oxidative stress in *Vigna radiata* L. in response to chlorpyrifos. Int. J. of Environ. Sci. and Technol., 9: 605-612.

Polle, A.; T. Otter and F. Seifert (1994). Apoplastic peroxidases and lignification in needles of Norway spruce (*Piceaabies* L.). Plant Physiology, 106(1): 53-60.

Prasad, Y. G.; M. Prabhakar; G. Sreedevi; G. R. Rao; and B. Venkateswarlu (2012). Effect of temperature on development, survival and reproduction of the mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on cotton. Crop protection, 39(9): 81-88.

Puteh, A. B.; A. A. Saragih; M.R. Ismail; M. Mojurul and A. Mondal (2013). Chlorophyll fluorescence parameters of cultivated (*Oryza sativa L*. ssp. indica) and weedy rice (*Oryza sativa* L. var. nivara) genotypes under water stress. Aust. J. Crop Sci., 7(9): 1277-1283.

Saeed, S.; M. Ahmad; M. Ahmad and Y.J. Kwon (2007). Insecticidal control of the mealybug *Phenacoccus gossypiphilous* (Hemiptera: Pseudococcidae), a new pest of cotton in Pakistan. Entomol. Res., 37: 76-80.

Salem, H. E. M.; R.E.M.Omar; A.G. EL-Sisi and A.M. Mokhtar (2003). Field and laboratory use of environmental safe chemicals against white-fly *Bemisia tabaci* (Gennandius) and leafhopper *Empoasca* discipiens(Paoli): Annals Agric. Sci. Moshtohor, 41(4): 1737-1741.

Sempruch, C.; K.Golan; E. Gorska-Drabik; K. Kmiec;I. Kot and B. Lagowska (2014). The effect of a mealybug infestation on the activity of amino acid decarboclases in orchid leaves. J. of Plant Interaction, 9(1): 825-831.

Shafique, S.; A. Ahmad; S. Shafique; T. Anjum; W.Akram and Z. Bashir (2014). Determination of molecular and biochemical changes in cotton plants mediated by mealybug. NJAS: Wageningen J. of Life Sci., 70-71: 39-45.

Soltan, E. (2020). Effect of jojoba and moringa essential oils and cascade on grasshopper in the field. Egypt J. Plant Prot. Res. Inst., 3(1): 486-492.

SPSS. (2000): SPSS for windows, release 11.User's guide. SPSS,Chicago.

Walters, D. R. (2003). Polyamines and plant disease. Phytochemistry, 64(1): 97-107.

Zhou Z. S.; S.Q. Huang; K. Guo; S.K. Mehta; P.C. Zhang and Z.M. Yang (2007). Metabolic adaptations to mercury-induced oxidative stress in roots of *Medicago sativa* L. J Inorg. Bioch., 101:1-9.

Zia, A. and M. Haseeb (2019). Seasonal incidence of cotton mealybug, *Phenacoccus solenopsis* (Tinsley) on okra, *Abelmoschus esculentus* (L.) and comparative efficacy of insecticides on the mortality. Journal of Entomology and Zoology Studies, 7(4): 421-425.

الوفرة الموسمية لبق القطن الدقيقى *Phenacoccus solenopsis* وتأثيرة على التغيرات البيوكيماوية فى نباتات البامية

أنيسة صابر صادق ، مديحة الصباحى حامدالديوى و جيهان بدوى أحمد النجار

معهد بحوث وقاية النباتات ـ مركز البحوث الزراعية ـ الجيزة ـ مصر

الملخص

درست الوفرة الموسمية لبق القطن الدقيقى على نباتات البامية بمحطة البحوث الزراعية بسخا بمحافظة كفر الشيخ لموسمى ٢٠٢٠-٢٠٢١، كما تمت دراسة بعض التغيرت البيوكيماوية فى نباتات البامية السليمة بعد إحداث عدوى صناعية ببق القطن داخل الصوبة و قد سجلت التغيرات بعد ١و٧و١٤ يوم من تاريخ العدوى فى النباتات المصابة والخالية من الإصابة كمقارنة. ودرس تأثير بعض من الزيوت النباتية و المبيدات الحشرية فى خفض تعداد بق القطن و مفترساته حقليا فى موسمى الدراسة. وقد أثبتت الدراسة أن الإصابة ببق القطن الدقيقى ظهرت مبكرا فى شهر يونيو فى ذروتين من الاصابة ١٤ أغسطس و١٩ سبتمبرفى موسم ٢٠٢٠ كما سجلت ذروتين فى ٣٠ يوليو و ٢٨ أغسطس فى الموسم الثانى. وأشارت نتائج التغيرات البيوكيماوية فى نباتات البامية المصابة ببق القطن الدقيقى حدوث زيادة معنوية فى محتوى نبات البامية من الكاروتينات وخفض معنوي فى محتوى الكلوروفيل والتى بدورها تؤدى إلى خفض فى تركيز Photosynthetic pigments وذلك بعد ٧و١٤ يوم من الإصابة ببق القطن مقارنة بالنباتات السليمة . و قد حدث زيادة في نشاط الإنزيمات المضادة للأكسدة (catalase, peroxidase and superoxidase) وكمية malondialdehyde وحدث إنخفاض فى كمية الكربوهيدات والبروتين هذا يعكس حدوث تلف فى الأنسجه النباتية بعد الإصابة ببق القطن مقارنة بالنباتات السليمة. وكان مبيد البروفينوفوس أكثر المبيدات المختبره فاعلية لتميزه بسرعة تأثيره وطول فترة فاعليتة لذلك يجب استخدامة فى المكافحة عند زيادة التعداد. ويمكن أستخدام زيت الجوجوبا فى حالة التعداد المنخفض لبق القطن ولتميزه بامانه على المفترسات. يمكن الاستفادة من النتائج السابقة في وضع برامج إدارة متكاملة لبق القطن الدقيقى على نباتات البامية و النباتات الأخرى.