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BIOLOGY AND HOST PREFERENCE OF THE COTTON MEALYBUG, *PHENACOCCUS SOLENOPSIS* TINSLEY (HEMIPTERA: PSEUDOCOCCIDAE) ON DIFFERENT HOST PLANTS

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Abstract

The biology of the cotton mealybugs *Phenacoccus solenopsis* on eight different host plants have been determined under laboratory conditions 27±1°C and R.H. 65%. Duration of different developmental stages, total life cycle, total egg production and other biological parameters were investigated. In the present study, it is aimed to correlate the insect behavior with the chemical constituents of its host plant. For this purpose, the tested host plants with varying degrees of infestation with the cotton mealybugs were chemically analyzed for their volatile chemicals content using Gas Chromatography-Mass spectrometry (GC-MS) apparatus. Three main classes comprise the identified compounds and these are acetogenins, terpenoids and alkaloids. Data analysis clearly indicated that heavy infestation of some host plants seems to be correlated to the synergistic effects among the components of an odor blend emanating from the plants. By this insect relies chiefly on olfactory information resulting from the interaction between odor components which determine at least in part the host preference.

Keywords: *Phenacoccus solenopsis*, Biology, Host preference, Plant volatiles, Gas Chromatography-Mass spectrometry

Introduction

The cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) recorded for the first time in Egypt in 2010 (Abd-Rabou *et al.,* 2010). Recently, Shehata and Moussa (2018) recorded 22 host plants belonging to 13 families in Sharkia Governorate. So, this pest is polyphagous in nature with wide host adaptability in different climatic conditions around globe and hence they establish and spread readily on other crops of economic importance. The cotton mealybug has a wide range of host plants ranging from herbaceous weeds to woody plants. *P. solenopsis* has been recorded as pest of 154 host-plant species out of which 20 field crops, 64 weeds, 45 ornamental plants and 25 shrubs and trees, belonging to a total of 53 plant families (Arif *et al.,* 2009). Whereas Ben-Dov *et al.* (2009) recorded from 174 host plants belonging to 55 families. The insect infestation caused high reduction in the yield of cotton ranging from 30-60% as documented by Fand and Suroshe (2015) in India and Pakistan during 2005-2009.

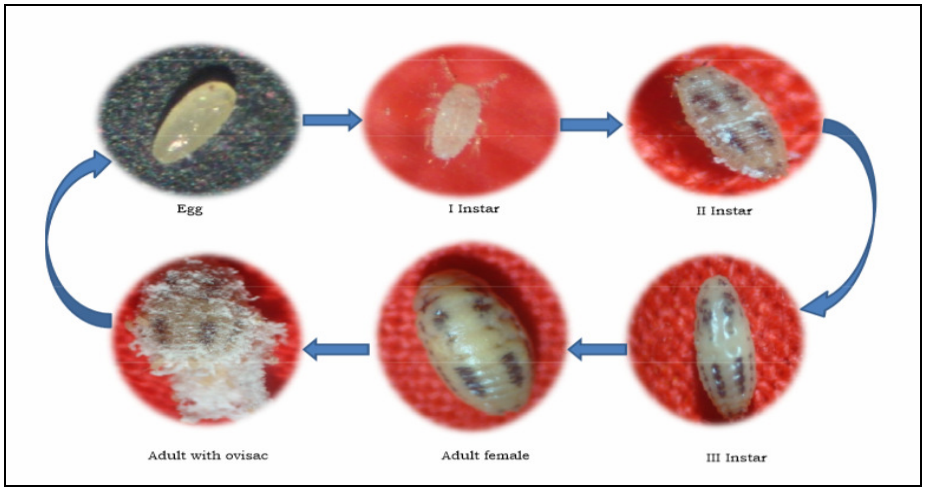

Plate 1 : Different stages of *P. solenopsis*.

The mealybug is a soft body insect which reproduces mostly parthenogenetically. The female lays eggs in ovisacs containing 150-600 eggs. Hatching takes place in few hours into nymphs (crawlers) which last for 15-20 days and finally growing into adults in 25-30 days under optimum conditions. It can produce hundreds of nymphs in one generation with the capacity to lay up to 6000 eggs per generation. *P. solenopsis* is known for its high reproduction capacity producing 812 offspring per female parthenogenetically with 95% female progeny on the cotton plants with several annual generations (Vennila *et al.,* 2010).

So far there are no comprehensive studies on the role of host plants and its chemical components on the development and distribution of this pest. Therefore, it was found advisable to evaluate the effect of different host plants on the biological aspects and to identify the chemical volatiles for each host plant that may play a role in the dispersion and distribution of this pest.

Material and Methods

Specimens of *P. solenopsis* were collected during field survey of different cultivations in Sharkia governorate,

Egypt. The laboratory culture was maintained under laboratory conditions (27 ± 1°C, RH 65%, 12:12 h. light/dark) using potato sprouts and okra fruits for feeding according to Shehata (2017).

For biological studies, the insect was reared on different host plants to evaluate their palatability and their effects on the biological aspects of this pest under laboratory conditions. Eight host plants belonging to five different families were tested. Selection of these host plants was based on the variation of the infestation rate, where the infestation rate was high on okra, eggplant and purslane while it was moderate on ivy and cotton but mild on pepper and cowpea (Shehata and Moussa 2018). During this study, the cotton mealybug *P. solenopsis* was recorded on potato plants in the field and the infestation rate appeared to be moderate (12.7±4.1 mealybugs on plant). So, all aforementioned plants were listed in table 1 and chemically analyzed for their volatile chemical constituents.

Table 1 : List of the tested host plants

N	Tested host plants	Scientific name	Family	Infestation rate in the field
1	Cotton	*Gossypium barbadense*	Malvaceae	Moderate
2	Okra	*Abelmoschus esculentus*		Severe
3	Potato	*Solanum lycopersicum*	Solanaceae	Moderate
4	Eggplant	*Solanum melongena*		Severe
5	Pepper	*Capsicum annuum*		Mild
6	Purslane	*Portulaca oleracea*	Portulacaceae	Severe
7	Ivy	*Convolvulus arvensis*	Convolvulaceae	Moderate
8	Cowpea	*Vigna unguiculata*	Fabaceae	mild

***For biological studies*,** a transparent plastic jar was cleaned, lined with sawdust and provided with washed and air dried young leaves of the tested host plant and then fifty individuals of the 1st nymphal instar were isolated from the laboratory colony and introduced into the jar for rearing the nymphs to complete the first generation development on each host plant separately and till the appearance of new insect offsprings (ovi-sacs) of the next generation (Bertin *et al.* 2013; Pacheco da Silva *et al.* 2017). These ovi-sacs were used to initiate this study.

Thereafter, three ovi-sacs were removed carefully with soft camel hair brush and left into new three plastic jars (single ovi-sac/jar/replicate) the number of eggs was not similar in all removed ovi-sacs. The jars were provided with fresh leaves of each host plant separately. Leaves of the selected host plants were changed every two days to provide fresh food to the newly hatched nymphs. In order to avoid damage to mouthparts, the nymphs were transferred with a paint brush only when they were moving, but when they were settled, the old leaf disk was cut around the nymph and placed on the fresh leaf. The nymphs were examined daily under a stereomicroscope and ecdysis was confirmed by the presence of exuviae near or at the end of the nymph body.

The development duration was calculated by recording the days that lasted to complete the successful molting process to the next instar until emerging adult males and/or females. After adult emergence, twenty females were reared in plastic cups provided with fresh leaves and each three females were confined with one male. Females were checked daily for signs of oviposition. When ovi-sac production started, the number of eggs in the wax was counted. The removed ovi-sacs were transferred to new Petri dishes until eggs hatching to calculate the hatchability. Adult longevity was recorded as the duration between adult emergence and death. Mealybugs were considered dead if they did not move after being touched with a fine-tip brush according to Pacheco da Silva *et al.* (2017). Statistical analysis was conducted using SPSS Program to evaluate the significant differences among the tested host plants.

For estimation and identification of the host plant volatiles, samples of host plants that showed degrees of infestation rate ranging from mild to severe were used. The leaves in all tested plants appeared to be more susceptible to infestation except okra plant where the fruits were highly susceptible and also on cotton plant the tonsils were more susceptible than leaves.

***Extraction of the plant volatiles*,** to discuss the potential activity of various volatile chemicals and their constituents towards the target insect attraction, the fresh plant parts (250 gm) were subjected to hydro-distillation for eight hours in a Clevenger-type apparatus to extract their essential oils which were then dried over anhydrous sodium sulfate and then stored in dark test tubes under refrigeration (4 ºC) until use.

Analysis of the plant volatiles, Gas Chromatography-Mass Spectroscopy (GC-MS) analysis of the plant extract for their volatile fractions was performed in the Central Laboratory at the National Research Centre, Egypt on a varian GC interfaced to Finnigan SSQ 7000 Mass Selective Detector (MSD) with ICIS V2.0 data system for MS identification of the GC components. The column used was DB-5 (J & W Scientific, Folosm, CA) cross–linked fused silica capillary column (30m long, 0.25 mm internal diameter) coated with poly-dimethyl-siloxane (0.5µm film thickness). The oven temperature was programmed from 50 ºC for 3 minutes at isothermal, then heating by 7 ºC /mint. to 250 4 ºC and isothermally for 10 mint., at 250 ºC. Injector temperature was 200 ºC and the volume injected was 0.5 µl. The mass spectrometer had a delay of 3 mints. to avoid the solvent peak and then scanned from m/z 50 to m/z 300. Ionization energy was set at 70 ev. The obtained chemical constituents of volatiles for each host plant were detected and classified based on molecular weight by Dalton (Da) and chemical formula (Elhosieny *et al.* 2018).

Results

Biological studies on the tested host plants

Data on the effectiveness of different host plants on development, biological parameters and reproduction of the cotton mealybug *P. solenopsis* are shown in table 2.

The cotton mealybug has a high reproduction rate and females are capable of producing many ovi-sacs. The incubation period ranged from 3.44±1.1 to 5.56±0.2 hrs. and the hatching percentage of the incubated ovi-sacs ranged from 80.83±2.3 to 95.07±1.5 %. So, the host plants showed no obvious effects on incubation periods and hatching percentages at start of the experiment.

Effects of the tested host plants on some biological aspects of the pest recorded with observations on the developmental durations of the 1st nymphal instar that originally hatched from the incubated ovi-sacs. The 1st nymphal instar is very small in size, soft creamy in colour without waxy protective coating on the dorsal side. This instar is very active up to 24 hrs. after hatching searching for a food source. Once a feeding site is selected, the nymphs became inactive and less mobile after settling on the feeding site to suck the plant sap. The 1st nymphal instar duration was shortest on leaves of okra, purslane and eggplant being 4.58±0.4, 4.9±0.3 and 4.92±0.8 days, respectively. While it was longest on leaves of cowpea and pepper being 7.62±0.6 and 8.12±1.3 days, respectively.

The 2nd instar nymphs emerged after the first molting which was indicated by presence of the exuvium of the instar at/or near the posterior end of the abdomen. The nymphs sticked to parts of host plants and then appeared to be very slow in motion with a significant increase in size. Two black strips on the thorax and on abdomen and light white waxy filaments on the dorsal side one day after first molting were observed. The duration of 2nd instar showed no differences when reared on all tested host plants. It was shortest on purslane (5.63±0.4days) while it was lasted more than 7 days (7.26±1.5 days) when reared on leaves of pepper.

The 3rd nymphal instar is the last instar and appeared as oblong in shape with light green in color after moulting immediately. Two black strips were observed on the thorax and abdomen with increase in size compared with the previous instars. The duration was short on okra, eggplant, purslane and cotton leaves (5.04±0.3, 5.66±0.9, 5.94±1.3 and 5.96±0.4 days, respectively) compared to other host plants. While, the longest duration was recorded in individuals reared on leaves of pepper 8.3±0.8 days.

All tested host plants significantly influenced the total nymphal duration. The accumulative duration of nymphal stage was longer for individuals reared on leaves of cowpea and pepper being 22.68±1.8 and 23.66±2.7, respectively recording highly significant differences compared with the other tested host plants. On the other hand, the shortest total nymphal durations were recorded after rearing on leaves of the other host plants and ranged from 15.26±1.2 to 19.12±2.1 days, with no significant differences between the effect of okra, eggplant, purslane and cotton on the accumulative durations of the nymphal stage development.

The nymphs molted three times for females but four times for the males where the males had an additional instar identified as pre-male stage (pupa cocoon).

For male, the pre-male pupae were observed on all host plants but the highest percentage of pupation was recorded to be 26.6±11.6% in colonies previously reared during nymphal stage on pepper leaves. While, the lowest percentage of pupation was 14.04±5.5% in colonies that previously reared during nymphal stage on eggplant leaves, but significantly there was no differences when compared with effects of ivy, okra, potato, purslane and cotton on pupation %. On the other hand, the pupae lasted 7.72±1.5 and 7.98±1.8 days on both cowpea and pepper, respectively, to complete the development of the pupae till male emergence with recording of highly significant effects compared with the other host plants, where the shortest duration of pupal development were shortened on the other host plants. The adult males of cotton mealy bug are winged with blackish brown color with four abdominal filaments. All tested host plants showed an obvious effects on both number of emerged males and percentage of emergence as well as the males longevity. The highest percentage of emerged males was 94.19±5.5% in colonies reared on leaves of okra and then it was declined to 47.42±19.2% in colonies reared on leaves of potato. The tested host plants had significant effects on the longevity of males; the males lived on okra, cotton, purslane more than 4 days to lived longer than on the other hosts. The longevity of males significantly decreased in individuals developed on leaves of pepper and cowpea being 1.92±0.3 and 2.16±0.6 days.

Females are wingless, wide and oblong in shape and dark brown in color immediately after the last moult and then light white waxy filaments appeared after few hours of molting. The waxy secretions increased within two days to coat the body with two black spots/strips on the dorsal side of body.

Data presented in table (2) reported that the females had a wider range of emergence than males. The tested host plants had strong influence on overall percentages of females, pre-oviposition, post- oviposition, longevity of females and egg production with hatchability as well as developmental duration of *P. solenopsis* generation.

The percentages of the emerged females were highest in colonies previously reared during nymphal stage on leaves of okra (80.18±6.7%). While, the lowest percentage of females was 36.14±10.1 and 41.32±12.1 % in colonies reared on both pepper and cowpea leaves, respectively. Also, the pre-oviposition period was significantly influenced by the host plants and recorded to be shorter in females reared on leaves of okra (3.69±0.6 days), purslane (3.92±1.8 days), eggplant (4.08±0.9 days) and then cotton (4.62±1.6 days) without significant differences between them. While it was recorded to be more than 5 days (5.08±1.7, 5.23±1.6, 5.4±1.6 and 5.54±0.4 days) for females reared on leaves of lvy, pepper, cowpea and potato, respectively. On the other hand, the post-oviposition period has the same trend where it was shorter in females previously reared on leaves of okra and purslane being 2.69±0.7 and 2.92±0.6 days while; the longest post-oviposition period was 5.1±0.7 and 4.96 days after rearing on both cowpea and pepper, respectively.

Longevity of females was significantly affected by host plants. The longest female longevity was 23.76±4.5 days after rearing on okra leaves, with no significant differences when compared with the effects of eggplant, purslane and cotton where the female longevity were 22.23±3.6, 21.92±2.7

and 20.85±5.4 days, respectively and then decreased to 18.92±2.5 and 17.15±2.4 days after rearing on potato and ivy leaves, respectively. The shortest female longevity was recorded after rearing on cowpea and pepper leaves (15.62±2.1 and 13.77±2.6 days, respectively) with high significant differences compared with the other host plants.

Females laid the highest number of eggs with no significant differences being 386.69±30.8, 345.46±35.3, 331.7±36.2 and 309.62±27.3 eggs/female, after rearing on both okra, eggplant, purslane and cotton leaves, respectively. After rearing on potato and ivy, the deposited eggs were reduced with no significant differences to be 231.69±66.9 and 206.77±26.3 eggs/female, respectively. While, the lowest numbers of deposited eggs were 155.92±32.2 and 137.77±30.3 eggs/female in females reared on cowpea and pepper leaves, respectively with significant differences compared to those females reared on the other host plants. The hatchability percentages were variable being 94.51±11.6 % after rearing on okra leaves to be the highest and then reduced to 92.45±8.71 and 90.4±6.3% in females reared on eggplant and purslane, respectively. After rearing on cotton and potato, the hatchability percentages were 88.54±5.8 and 70.19±16%, respectively. In the case of ivy, cowpea and pepper leaves the hatchability percentages ranged from 57.77 to 52.77% to be the lowest values with highly significant difference compared with the effect of the other host plants.

P. solenopsis completed its life cycle on all tested host plant species but without obvious effects where the cumulative durations of the life cycle were similar. Negatively significant effects were recorded on the life cycle durations after rearing of this insect species on all tested host plants, where the longest duration of life cycle was recorded after rearing on okra leaves (39.02±5.8 days), and then declined to 38.8±11.3, 38.3±11.3, 38.2±5.4, 38.1±12.49, 38.04±7.8 days after rearing on leaves of eggplant, cowpea, cotton, purslane and potato, respectively. On the other hand, the cumulative duration was shortest after rearing this insect species on leaves of pepper and ivy being 37.43± 7.02 and 36.2± 9.1 days, respectively with no significant differences between all tested host plants.

The foregoing results indicate that the tested host plants provide the nutritional requirements for the insect development based on the obvious differences detected in the cumulative durations for development of the different stages. On okra, eggplant, purslane and cotton the nymphal stage was developed rapidly and lasted short time for adult molting compared with the other host plants, while the longevity of the females was higher and lasted long lifespan before death. On the other hand, ivy, potato, cowpea and pepper caused slowly effects on nymphs development where the nymphal stage lasted long time to complete the development for adult molting, while the longevity of the females was short and lasted short lifespan before death. So, all tested host plants significantly had no effects on the total life cycle and the number of generations. These observations resulted from recording of highly observed inverse relationship between the nymphal stage durations and females longevity on the tested host plants but this may be caused highly effects on the population density of this pest on the plant.

The total egg production showed variation on different host plants where the okra, eggplant and purslane gave the highest production, while pepper, cowpea and ivy gave the lowest production. The longevity of females was higher on okra, eggplant and purslane judged by the possible availability of nutritional requirements during the nymphal stage development. Also, in the male, its longevity increased to the maximum based on the nutritional requirements available during nymphal stage development. The maximum egg hatchability was attained on those females reared on okra, eggplant, purslane and cotton but it decreased on ivy, cowpea and pepper.

Table 2 : Development and reproduction of *Phenacoccus solenopsis* on different host plants under laboratory conditions.

Biological aspects		Means of biological parameters ± SD of the pest on the tested host plants								L.S.D*
		Ivy	Eggplant	Okra	Potato	Cowpea	Purslane	Cotton	Pepper	
Egg stage	No. of incubated eggs	292.8±29.5	312.2±19.2	258.8±43.2	219.8±26.2	278.6±22.**3**	265.2±36.0	272.0±33.9	197.2±23.4	
	Incubation periods / Hours	5.41±0.8	5.56±0.2	4.9±0.3	5.14±0.4	4.84±0.3	4.75±0.4	3.44±1.1	4.24±0.7	
	No. of hatched eggs (1^{st} nymphal instar)	275.6±28.3	296.8±18.5	240.2±42.8	203.2±27.0	245.4±29.9	230.4±40.1	250.8±34.8	159.4±22.8	
	% of hatching	94.13±2.1	95.07±1.5	92.81±3.7	92.45±4.2	88.08±4.**9**	86.88±5.9	92.21±14.9	80.83±2.3	
Nymphal stage	Duration of 1^{st} instar / day	6±0.5	4.92±0.8	4.58±0.4	6.08±1.1	7.62±0.6	4.9±0.3	5±0.8	8.12±1.3	
	Duration of 2^{nd} instar / day	6.28±1.1	5.98±1.7	5.64±0.9	6.2±0.8	6.98±1.7	5.36±0.4	6.36± 1.6	7.26±1.5	
	Duration of 3^{rd} instar / day	6.78±1.6	5.66±0.9	5.04±0.3	6.84±0.7	8.08±1.1	5.94±1.3	5.96± 0.4	8.3±0.8	
	Total duration of nymphal stage / day	19.06±1.4^{a}	16.56±1.4^{ab}	15.26±1.2^{b}	19.12± 2.1^{a}	22.68±1.8^{c}	16.2±1.8^{b}	17.32±1.5^{ab}	23.66±2.7^{c}	2.81
Male	No. of pre-male stage (pupae)	50.4±18.2	42.4±18.4	34.4±5.7	38.8±10.1	59.6±13.5	39.6±10.1	42.6±19.6	42.4±12.5	
	% of pupation	18.28±5.9^{ab}	14.04±5.5^{a}	14.32±3.5^{a}	19.1± 3.6^{abc}	24.29±6.3^{bc}	17.2±4.7^{ab}	16.98±5.9^{ab}	26.6±11.6^{c}	8.17
	Pupal duration / day	6.01±0.6^{a}	5.06±0.3^{ab}	4.26±0.3^{b}	5.42±0.5^{ab}	7.72±1.5^{c}	4.36±0.5^{b}	4.56±0.4^{ab}	7.98 ±1.8^{c}	1.63
	No. of emerged male	34.6±14.5	36.2±16.2	32.4±5.7	18.4±5.9	41.4±7.8	32.8±8.5	29.8±20.5	27.2±9.4	
	% of male emergence	68.65±8.4	85.38±8.8	94.19±5.5	47.42±19.2	69.46±3.3	82.83±12.4	69.95±16.6	64.15± 14.9	
	Longevity of male / day	3.14±0.4^{ac}	3.76±0.2^{ab}	4.36±0.2^{b}	3.28±0.7^{bc}	2.16±0.5^{cd}	4.02±0.3^{ab}	4.16±1.6^{ab}	1.92±0.3^{d}	1.21
Female	No. of moulted female	164.8±32.2	197±27.8	192.6±40.65	136±35.7	101.4±22.9	157.6±21.8	154.6±23.1	57.6±13.1	
	% of female moulting	59.8±11.2^{a}	66.37±4.4^{a}	80.18±6.7^{b}	66.93±10.2^{a}	41.32±12.1^{c}	68.4± 4.7^{ab}	61.64±8.5^{a}	36.14± 10.1^{c}	13.1
	Pre-Oviposition period / day	5.08±1.7^{ac}	4.08±0.9^{ab}	3.69±0.6^{b}	5.54±0.4^{c}	5.4±1.6^{c}	3.92±1.8^{b}	4.62±1.6^{bc}	5.23 ±1.6^{c}	1.12
	Longevity of female/day	17.15±2.4^{ad}	22.23±3.6^{b}	23.76±4.5^{b}	18.92±2.5^{ac}	15.62±2.1^{de}	21.92±2.7^{bc}	20.85±5.4^{bc}	13.77±2.6^{e}	3.08
	Post-Oviposition / day	3.85±0.9^{ac}	3.15±0.7^{ab}	2.69±0.7^{b}	3.39±0.9^{ab}	5.1±0.7^{d}	2.92±0.6^{ab}	3.46±1.1^{ab}	4.96 ±1.3^{cd}	1.1
	No. of ovisacs (Range)	3.25±1.1 (2-5)	4.08±0.9 (3-5)	4.33±1.1 (3-6)	3.58±1.0 (2-5)	2.92±0.8 (2-5)	4.17±0.6 (3-5)	4.0±0.7 (3-5)	2.62±0.6(2-4)	
	Egg deposition / female	206.77±26.3^{ad}	345.46±35.3^{b}	386.69±30.8^{b}	231.69±66.9^{ac}	155.92±32.2^{ad}	331.7±36.2^{b}	309.62±27.3^{bc}	137.77±30.3^{d}	88.5
	Hatchability	119.46±42.5	319.38±30.5	365.46±39.1	162.62±26.7	84.46±21.6	299.85±38.6	274.15±37.3	72.7 ±21.0	
	% of hatchability	57.77±14.5^{ac}	92.45±8.7^{b}	94.51±11.6^{b}	70.19±16.0^{c}	54.17±14.7^{a}	90.4±6.3^{b}	88.54±5.8^{b}	52.77±10.4^{a}	13.9
Total life cycle of insect females / days		36.2± 9.1^{a}	38.8± 11.3^{a}	39.02±5.8^{a}	38.04±7.8^{a}	38.3±11.3^{a}	38.1± 12.49^{a}	38.2± 5.4^{a}	37.43±7.02^{a}	4.86

Estimation and identification of the chemical volatile constituents of host plants

Variation in the biochemical characteristics of host plants is an important factor explaining the insect distribution on these hosts. Not all plants is attacked by all insect species in its environment and nor an insect species devours indiscriminately all plants in its geographic range. Each insect species is associated with a group of host plants large or small in number which is designated as its food range.

In the present investigation, eight host plant of the tested insect belonging to five families in the same locality (Sharkia Governorate) were used. Selection of these host plants was based on variation in their infestation rates as recorded by Shehata and Moussa (2018). The volatile oils of the tested host plants were extracted using hydrodistillation Clevenger type apparatus. GC-MS was used to identify volatiles from plants that attract the soft scale even in varying degrees. Each constituent of any volatile oil could be qualitatively and quantitavely characterized.

Many compounds were detected in the GC-MS analysis of the tested host plants volatile oils. Three main classes comprise the identified compounds and these were acetogenins (fat derivatives), terpenoids, and alkaloids (Table 3). Analysis of the obtained data clearly indicate that in okra which is severely infested with the target insect, acetogenins represent 37.1% of the constituents which may be olfactory stimuli of the insect. The volatile chemicals belonging to acetogenins supposed to be released from okra plants were 16 compounds and the molecular weight of most of these compounds was low and ranged from 108 to 330 Da. The chemical diversity found in okra recorded the highest percentages in all classes of the identified volatiles which gave the superiority in cotton mealybugs attraction. Of the volatile constituents present in high amount in okra belonging to acetogenins (37.1%) was Hexadecanoic acid methyl ester (20.42%), Dodecanoic acid methyl ester (4.85%), Ethyl 9, 12, 15-Octadecatrienoate (2.64%), Octadecanoic acid methyl ester (2.03%). The molecular weight of these compounds was 270, 214, 306 and 298 Da, respectively.

In plants of ivy, eggplant, purslane and cotton; the percentage of volatile chemicals belonging to acetogenins represents 14.29, 7.45, 8.41 and 10.8%, respectively. While, small quantities were detected in cowpea, pepper and potato plants.

In the class of terpenoids, the highest percentage of total terpenoids (13.5%) were detected in okra plant, followed by eggplant (7.44%), ivy (5.12%), purslane (4.66%), pepper (3.93%), cowpea (3.31%), potato (1.49%) and cotton (1.22%). However, in the class of terpenoids, five groups were detected as mono-terpenes, sesqui-terpenes, di-terpenes, tri-terpenes and tetra-terpenes.

The mono-terpenes group was only detected in okra plant and they amount to 4.1% of the total chemical constituents of volatiles. Nine compounds were identified as mono-terpenes and the compound of α-Damascenone and 3-(2,6,6-Trimethyl-l-cyclohexen-l-yl)-2-propenal having molecular weight 190 and 178 Da, respectively, they seem to be more attractive to the insect compared with the other compounds with higher percentages 1.27 and 1.22 %, respectively. It also appears that no mono-terpenes were detected in all other tested host plants. This indicates that mono-terpenes seem to be potential olfactory stimuli judged by high infestation rate of the okra plants.

The second group was sesqui-terpenes and only detected in okra, ivy and pepper plants. The major constituents of volatiles in okra plant are 6.09% from Caryophyllene compounds (- Caryophyllene oxide and Trans-Caryophellene) which have molecular weight 220 and 204 Da, respectively, and seem to be more potent as olfactory stimuli. In ivy plant, sesqui-terpenes represent 4.25% including Isochiapin B (3.19%). Small quantities were detected in pepper (0.35%) but non were found in the other host plants.

In the group of di-terpenes, the eggplant, purslane and okra have the highest percentages of total di-terpenes volatiles. The eggplant showed the higher content of volatiles (6.42%) and the compound of Retinol was detected in higher percentage 4.68% and low molecular weight 286 Da. In purslane, the total percentage of volatiles belonging to di-terpenes was detected being 3.31% followed by okra 2.96 %. This is compared with low amount (1.3 % and 0.47%) in pepper and cowpea plants, respectively, but not detected in cotton, potato and ivy plants.

In the group of tri-terpenes, volatiles of this group was only detected in okra plant and the compound of squalene was only detected recording 0.35% which may indicate its potency in host plant selection.

The fourth group tetra-terpenes was identified in all tested host plants except okra. The compound of Phytofluene was detected in all host plants containing tetra-terpenes but with varying degrees ranged from 0.87% to 2.84%. Small quantities of total tetra-terpenes were detected in ivy, eggplant, cotton, purslane and potato being 0.87, 1.02, 1.22, 1.35 and 1.49%, respectively. While, the highest percentage of total tetra-terpenes was recorded in cowpea and pepper being 2.84% and 2.28%, respectively.

Based on the total percentages of terpenoids in the chemical volatiles of all tested host plants, the highest percentages of terpenoids volatile constituents were detected and identified in plants of okra, eggplant, ivy and purslane, being 13.5, 7.44, 5.12, 4.66 %, respectively. While in the other host plants the lowest percentages of terpenoids were 3.93, 3.31, 1.49 and 1.22% for cowpea, pepper, potato and cotton, respectively.

Alkaloids represented by two compounds, the first was detected only in okra plant and identified as 3,4-Dimethoxy-bezeneethnamine and representing 14.35%, while the second was detected in purslane only and identified as 6,7-Dimethoxy-3-(3,4-dimethoxyphenyl)-1-methyl-4-phenylisoquinoline and representing 4.46%. No other alkaloids were detected in other host plants.

So, it appears that acetogenins, terpenoids (mono-terpenes, sesqui-terpenes, di-terpenes, tri-terpenes) and alkaloids include the highest olfactory stimuli in okra plant which is the most heavily infested host plant with cotton mealybugs with absence of tetra-terpenes compounds in chemical volatiles of this plant. On the other hand, the compounds of mono-terpenes and tri-terpenes were also detected in okra plant only but absent in the other host plants.

These analyses also revealed that, the total percentage of the chemical volatile constituents in each host plant was

identified to be highest in okra (65.93%) and purslane (21.56%) and then reduced to 19.41%, 14.89%, 14.53% and 10.17% in ivy, eggplant, cotton and potato plants, respectively. While, it was identified to be the lowest in cowpea (7.96%) and pepper plants (6.82%). Identification and detection of the percentage of the chemical volatile constituents (low or high) is very critical factor to estimate the role of these volatiles as an attractive or repellent agent against this insect pest and explain the reason of difference in infestation rates and the population density of the insect on the tested host plants.

The chromatograms (GC-MS) were illustrated to investigate the variation between the tested hot plants. Three figures only were presented in our text as different models of heavily infested host (okra), moderately infested host (cotton) and mildly infested host (cowpea) to explain and investigate the peaks of variation between the chemical volatile constituents of the host plants.

Table 3 : Chemical constituents of the tested host plants volatile oils using Gas Chromatography-Mass Spectroscopy (GC-MS) analysis.

N.	**Chemical constituents names**	**Retention time / minute**	**Molecular weight**	**Molecular formula**	Percentage (%) of the chemical volatile constituents of the host plant							
					Okra	**Cowpea**	**Ivy**	**Eggplant**	**Cotton**	**Purslane**	**Potato**	**Pepper**
Acetogenins (Fat derivatives)												
1	1-Cyclopropyl-2,7-dodecadien-1-ol	7.87	222	$C_{15}H_{26}O$							1.49	
2	Nonanal	8.67	142	$C_9H_{18}O$			0.39					
3	9-(ethoxymethyl)- 2,15-Heptadecadiene	11.46	194	$C_{20}H_{38}O$								0.73
4	1,3-Trans-5-cis-octatriene	13.75	108	C_8H_{12}	0.13							
5	Stearaldehyde, dimethyl acetal	20.66	314	$C_{20}H_{42}O_2$		0.60						
6	7,10,13-Eicosatrienoic acid, methyl ester	21.49	320	$C_{21}H_{36}O_2$			1.47					
7	Arachidonic acid	22.35	304	$C_{20}H_{32}O_2$			4.60					
8	3-Isopropyltricyclo[4.3.1.1(2,5)]undec-3-en-10-ol	24.38	206	$C_{14}H_{22}O_2$	0.20							
9	Methyl-8,9,13-trihydroxy docosanoate	24.45	402	$C_{23}H_{46}O_5$			1.29		3.34		1.94	
10	Dodecanoic acid, methyl ester	25.03	214	$C_{13}H_{26}O_2$	4.85							
11	2,2,4,9,11,11-Hexamethyl-dodecane	28.27	254	$C_{18}H_{38}$					0.75			
12	1,4-dimethyl-2-octadecyl- Cyclohexane	31.38	364	$C_{26}H_{52}$		0.2		1.70				
13	18-Nonadecen-1-ol	31.62	312	$C_{20}H_{40}O_2$	1.13							
14	Z,Z-4,16-Octadecadien-1-ol acetate	31.74	308	$C_{20}H_{36}O_2$	0.42							
15	Z-3-Octadecen-1-ol acetate	31.93	310	$C_{20}H_{38}O$								
16	Z-8-Octadecen-1-ol acetate	31.98	310	$C_{20}H_{38}O_2$	1.15							
17	3,7,11,15-Tetramethyl-2-hexadecen-1-ol	32.64	296	$C_{20}H_{40}O$	0.83							
18	2-Oleoylglycerol	32.67	356	$C_{21}H_{40}O_4$								0.69
19	3-(Tetradecyl-18O-oxy)-1,2-propanediol	32.98	288	$C_{17}H_{36}O_3$			0.51					
20	Hexadecanoic acid, methyl ester	33.72	270	$C_{17}H_{34}O_2$	20.42							
21	Hexadecanoic acid, ethyl ester	35.02	284	$C_{18}H_{36}O_2$	1.78							
22	(9E,12E,15E)-octadeca-9,12,15-trienoate glycerol	35.33	366	$C_{22}H_{38}O_4$		0.71						
23	1-[2-(Hexadecyloxy)ethoxy]- octadecane	35.54	538	$C_{36}H_{74}O_2$					0.74			
24	Hexadecanoic acid	35.87	256	$C_{16}H_{32}O_2$	0.14							0.49
25	trans-(2-Docosenyl)succinic acid	36.61	424	$C_{26}H_{48}O_4$						3.57		
26	2-Octadecyloxy-1-cis-9-octadecenyloxy ethane	37.18	564	$C_{38}H_{76}O_2$			0.43					
27	Octadecanoic acid, methyl ester	37.50	298	$C_{19}H_{38}O_2$	2.03							
28	Octadecanoic acid, decyl ester	37.61	424	$C_{28}H_{56}O_2$					5.36			
29	(9Z,12Z,15Z)-octadeca-9,12,15-trienoate glycerol	37.74	366	$C_{22}H_{38}O_4$								
30	Oleic acid	37.78	282	$C_{18}H_{34}O_2$		0.57						
31	Ethyl linoleate	38.12	308	$C_{20}H_{36}O_2$	0.83							
32	Ethyl 9,12,15-octadecatrienoate	38.25	306	$C_{20}H_{34}O_2$	2.64							
33	Hexadecanoic acid, 2,3-dihydroxypropyl ester	38.69	330	$C_{19}H_{38}O_4$	0.16							
34	Docosane	40.40	310	$C_{22}H_{46}$	0.18		4.91	3.16				
35	(9Z)-9-Octadecenyl (9Z)-9-hexadecenoate	40.71	504	$C_{34}H_{64}O_2$		0.50			0.61			
36	Octadecanoic acid, eicosyl ester	40.72	564	$C_{38}H_{50}O_6$								0.98
37	Nonacosane	43.65	408	$C_{29}H_{60}$	0.21							
38	3-Octadecyloxy-1-O-octadecanoylpropanol	45.21	594	$C_{39}H_{78}O_3$		0.81	0.69					
39	1-Hexadecyl-2-stearoyl ethanediol	46.16	552	$C_{36}H_{72}O_3$		0.57						
40	Oleic acid, 3-(octadecyloxy)propyl ester	47.02	592	$C_{39}H_{72}O_3$		0.47						
41	Stearic acid, 3-(octadecyloxy)propyl ester	47.87	594	$C_{39}H_{78}O_3$				2.59		4.84	2.41	
Total					**37.1**	**4.43**	**14.29**	**7.45**	**10.8**	**8.41**	**5.84**	**2.89**
Terpenoids (Monoterpenes)												
42	2-Octen-1-ol, 3,7-dimethyl-, isobutyrate, (Z)-	11.64	226	$C_{14}H_{26}O_2$	0.18							
43	trans-Linalool oxide	12.96	170	$C_{10}H_{18}O_2$	0.44							
44	4-(3-Hydroxy-2,2,6-trimethyl-7-oxa-bicyclo[4.1.0]hept-1-yl)	13.61	224	$C_{13}H_{20}O_3$	0.15							
45	4,5,5-Trimethyl-tricyclo[2.2.1.0(2,6)]heptan-3-ol	15.03	152	$C_{10}H_{16}O$	0.20							
46	6,6-Dimethyl-bicyclo[3.1.1]hept-2-ene-2-carboxaldehyde	15.83	150	$C_{10}H_{14}O$	0.15							
47	α-Damascenone	21.38	190	$C_{13}H_{18}O$	1.27							
48	3-(2,6,6-Trimethyl-1-cyclohexen-1-yl)-2-propenal	21.88	178	$C_{12}H_{18}O$	1.22							
49	(5RS,6SR,7SR)-2,2,6,7-tetramethylbicyclo[4.3.0] non-9-ene-5,7-diol	22.21	210	$C_{13}H_{22}O_2$	0.30							
50	Geranyl isovalerate	28.61	238	$C_{15}H_{26}O_2$	0.19							
Total					**4.1**							

Terpenoids (Sesquiterpenes)											
51	2,6,10-Trimethyl-tetradecane	20.91	240	$C_{17}H_{36}$	0.11						
52	α-Copaene	21.18	204	$C_{15}H_{24}$	0.49						
53	trans-Caryophyllene	22.39	204	$C_{15}H_{24}$	1.91						
54	α-Humulene	23.33	204	$C_{15}H_{24}$	0.75						
55	3-Hydroxy-5,6-epoxy-β-ionone	24.06	222	$C_{14}H_{22}O_2$	0.72						
56	7-epi-cis-sesquisabinene hydrate	24.17	222	$C_{15}H_{26}O$			0.54				
57	Isochiapin B	24.80	346	$C_{19}H_{22}O_6$			3.19				
58	δ -Cadinene	24.84	204	$C_{15}H_{24}$	0.18						
59	(-)-Caryophyllene oxide	26.55	220	$C_{15}H_{24}O$	1.93						
60	E-9-Methyltrisporate C	32.01	320	$C_{19}H_{28}O_4$			0.52				
61	2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5-trienyl]cyclohex-1-en-1-carboxaldehyde	37.51	324	$C_{23}H_{32}O$							0.35
Total					**6.09**		**4.25**				**0.35**
Terpenoids (Diterpenes)											
62	Dimethyl 4a-formyl-7-hydroxy-1-methyl-8-methylenegibbane-1,10-dicarboxylate	21.41	390	$C_{22}H_{30}O_6$							0.70
63	Isohumulone	28.11	362	$C_{21}H_{30}O_5$				0.66			
64	3,8,12-Tri-O-acetoxy-7-desoxyingol-7-one	30.30	490	$C_{26}H_{34}O_9$						1.49	
65	Retinol	31.38	286	$C_{20}H_{30}O$				4.68			
66	3,7,11,15-Tetramethyl-2-hexadecen-1-ol	32.64	296	$C_{20}H_{40}O$	1.83						
67	Octanoic acid,1a,2,5,5a,6,9,10,10a-octahydro-5,5a-dihydroxy-4-(hydroxymethyl)-1,1,7,9-tetramethyl-11-oxo-1H-2,8a methanocyclopenta[a] cyclopropa[e]cyclodecen-6-yl ester,	33.24	474	$C_{28}H_{42}O_6$				0.58			
68	1H-Cyclopropa[3,4]benz[1,2-e]azulene-4a,5,7b,9,9a(1aH)-pentol,3-[(acetyloxy)methyl]-1b,4,5,7a,8,9-hexahydro-1,1,6,8-tetramethyl-,9,9a-diacetate	35.74	492	$C_{26}H_{36}O_9$						0.78	
69	8,8a-bis(acetyloxy)-2a-[(acetyloxy)methyl]-1,1a,1b,1c,2a,3,3a,6a,6b,7,8,8a-dodecahydro-3,3a,6b trihydroxy-1,1,5,7-tetramethyl-4H-Cyclopropa [5',6']benz[1',2':7,8]azuleno[5,6-b]oxiren-4-one	37.13	522	$C_{26}H_{34}O_{11}$		0.47					
70	1H-Cyclopropa[3,4]benz[1,2-e]azulene-5,7b,9,9a-tetrol, 1a,1b,4,4a,5,7a,8,9-octahydro-3-(hydroxymethyl)- 1,1,6,8-tetramethyl-,9,9a-diacetate,	37.10	434	$C_{24}H_{34}O_7$				0.50			
71	7aHCyclopenta[a]cyclopropa[f]cycloundecene-2,4,7,7a,10,11-hexol,1,1a,2,3,4,4a,5,6,7,10,11,11a-dodecahydro-1,1,3,6,9-pentamethyl-,2,4,7,10,11penta-acetate	37.95	580	$C_{30}H_{44}O_{11}$							0.60
72	3,7,11,15-tetramethyl-Hexadecanoic acid, methyl ester	41.00	326	$C_{21}H_{42}O_2$	1.13						
73	9a-(acetyloxy)-1a,1b,4,4a,5,7a,7b,8,9,9a-decahydro-4a,7b-dihydroxy-3-(hydroxymethyl)-1,1,6,8-tetramethyl-5-oxo-1H-cyclopropa[3,4]benz[1,2-e]azulen-9-yl ester, 2,4,6,8,10-Tetradecapentaenoic acid	44.34	606	$C_{36}H_{46}O_8$						1.04	
Total					**2.96**	**0.47**		**6.42**		**3.31**	**1.3**
Terpenoids (Triterpenes)											
74	Squalene	44.31	410	$C_{30}H_{50}$	0.35						
Total					**0.35**						
Terpenoids (Tetraterpens)											
75	Astaxanthin	47.94	596	$C_{40}H_{52}O_4$							0.59
76	Lycoxanthin	48.33	552	$C_{40}H_{56}O$					0.59	0.47	
77	Phytofluene	48.56	542	$C_{40}H_{62}$		2.84	0.87	1.02	0.63	0.61	0.90	2.28
Total						**2.84**	**0.87**	**1.02**	**1.22**	**1.35**	**1.49**	**2.28**
Total Percentage of all terpenoids					**13.5**	**3.31**	**5.12**	**7.44**	**1.22**	**4.66**	**1.49**	**3.93**
Alkaloids											
78	3,4-Dimethoxy-benzeneethanamine	18.74	181	$C_{10}H_{15}NO_2$	14.35						
79	6,7-Dimethoxy-3-(3,4-dimethoxyphenyl)-1-methyl-4-phenylisoquinoline	22.63	415	$C_{26}H_{25}NO_4$						4.46	
Total					**14.35**					**4.46**	
Miscellaneous											
80	5-Hydroxy-6,7,8-trimethoxy-2,3-dimethyl-4H-chromen-4-one	6.10	280	$C_{14}H_{16}O_6$							2.48	
81	3-(2,3-Dihydro-benzo[1,4]dioxin-6-yl)-3-(3,4-dimethoxy-phenyl)-propionic acid	16.39	344	$C_{19}H_{20}O_6$						4.03		
82	4-Methyl-7-methoxy-1,2-dihydronaphthalene	16.68	174	$C_{12}H_{14}O$	0.98						
83	14-α-Pregna	19.09	288	$C_{21}H_{36}$					2.51		
84	γ- Sitosterol	41.22	414	$C_{29}H_{50}O$		0.22					
Total					**0.98**	**0.22**			**2.51**	**4.03**	**2.48**	
Total percentage of the chemical volatile constituents in each host plant					**65.93**	**7.96**	**19.41**	**14.89**	**14.53**	**21.56**	**10.17**	**6.82**

Discussion

The cotton mealybug is a polyphagous species attacking a wide range of host plants with different odor composition; it has been recorded as a pest of 154 host plants belonging to 53 plant families (Arif *et al.,* 2009; Vennila *et al.,* 2013).

Life table is an important tool for the study of population dynamics by providing important birth-to-death information of insect individuals in the generation (Carey 1993). Various studies related to the biology of *P. solenopsis* have been conducted. In these studies, the effect of both temperatures (Hameed *et al.,* 2012; Kumar and Kontodimas 2012; Shehata 2017) and different host plant species on the biology of the cotton mealybugs were estimated (Abbas *et al.,* 2010; Arif *et al.,* 2012).The biological parameters or life table of *P. solenopsis* was strongly affected by different host plant species but there is no detailed information on the development and reproduction of the cotton mealybug on different host plant belonging to different families, which

have different rates of infestation under field conditions. So, we selected 8 different host plant species that were previously examined for detection of the infestation rate under field conditions.

Our laboratory results showed that, the tested host plant species significantly affect the development durations, survival, longevity, fecundity and life span of *P. solenopsis*. While, okra, eggplant and purslane were the most suitable host plant species for development and reproduction of this pest and caused highly significant reduction on development durations of nymphal stage, while the longevity of males and females, egg deposition and hatchability significantly were increased after rearing on these host plants compared with the other host plants. Due to these observations, no significant differences were recorded on the total life cycle between all tested host plants. These results agree with those of Awadalla *et al.* (2015) and El-Batran *et al.* (2016) they recorded effects of different host plants on development of immature and mature stages of citrus mealybugs and suggested that, quantity and quality of the nutritional requirements with chemical analysis of the plant (crude protein, lipids and total carbohydrates) are the main factors affecting insect development. In previous study the host plants of okra, eggplant and purslane were highly infested with different stages of this pest under field conditions (Shehata and Moussa, 2018). In polyphagous insect pests, variation of the biological parameters and disturbance in their life tables after rearing on different host plants resulted from imbalanced food nutrients for the growth and development of the pest. Dietary requirement and fitness of insect pest depends upon the chemical constituents of its host plant (Hartnett and Abrahamson 1979; Dhaliwal and Arora 2003; Shahid *et al.,* 2017). Therefore, variation of the host plant species as a food source and their chemical constituents affects the food selection behavior, survival and reproduction of polyphagous insect pest (Du *et al.,* 2004).

The present investigation is an attempt to evaluate the relation between the infestation rate of various host plants with the cotton mealybug *P. solenopsis* and their chemical volatile constituents. Most plant odors are complex mixtures of essential oils and other volatile chemicals.

By the aid of GC-MS, the chemical constituents of volatile oils in the different plants have been qualitatively and quantitatively characterized and a total of 84 compounds were detected in the GC-MS analysis. These compounds fall into acetogenins, terpenoids and alkaloids in addition to some miscellaneous compounds.

The olfactory reception of host plant odors by the insect showed that some constituents seem to be attractive than others. Synergistic effects among compounds of an odor blend are likely to contribute to the attraction of insect to the plant (Visser, 1986).

The host plant selection in polyphagous insects is based on sequence of behavioral responses to an array of stimuli associated with host and non-host plants.

The target insect like other scale insects is equipped with some sensory receptors (Salama, 1971) enabling them to perceive these stimuli. These stimuli involved include in varying proportion visual, mechanical, gustatory and olfactory characteristics.

The chemical specificity of detection is based on specificity of interaction between odor components. This means that plant chemicals rather than nutritive substances determine at least in part the peculiar likes and dislikes of insects. No one attractant alone performs the service of guiding an insect to its proper host plant and that the desired end is achieved only by a complex of stimuli such as light, temperature and humidity (Dethier, 1947).

Investigation of the data obtained by Shehata and Moussa (2018) indicate that among the tested plants, some host plants were heavily infested (okra, eggplant and purslane), with moderately infested plants (ivy, cotton and potato) and mildly infested plants (cowpea and pepper) with the cotton mealybug. The volatile chemicals identified by GS-MS determine the mechanism of attraction and the olfactory reception of the insect pest to host plant odors, where some were more attractive than the others, but the attraction occurs by specific odors of some compounds or combinations of more than one component. In this case, the hatched crawlers react accordingly to this blend of odors and behave chiefly depending on the olfactory information. The chemical specificity of detection is based on speciality of interaction between odor components.

So, among the tested host plants, okra showed to be heavily infested in the field. Correlating this status with the essential and volatile components identified in this plant revealed that acetogenins, terpenoids and alkaloids almost exist in okra plant in higher amounts as compared with corresponding amounts in other plants. The molecular weight of most of these compounds was low which accelerate its volatility.

The volatile constituents in okra plant belonging to acetogenins represent 37% and seven of these compounds may be attractive while others were detected but may be negligible. While, the volatile constituents belonging to the terpenoids including mono-, sesqui-, di-, tri- and tetra-terpenes represent 13.5%. Among the terpenoids, the mono- and tri- terpenes were only detected in okra plants with no detection of tetra-terpenes compared to all other tested plants. On the other hand, in cowpea and pepper plants which were mildly infested in the field, the chemical analysis of their volatiles recorded high amounts of tetra-terpenes represent 2.84% and 2.28 %, of the volatile constituents, respectively, between all tested host plants with detection of low amounts of acetogenins, sesqui- and di-terpenes. No mono- , tri-terpenes and alkaloids were detected in both cowpea and pepper. This indicates that mono-, tri-terpenes and alkaloids are potential olfactory stimuli in okra plants and thus may be causing its severe infestation rate by this insect pest. While, high amount of tetra-terpenes may be causing repellent or unstimuli effects in mildly infested plants.

Again, eggplant which is also heavily infested and the volatile constituents belonging to acetogenins were 7.45%. No mono-, sesqui- and tri-terpenes were detected. While highly amount of di-terpenes (6.42%) and low amount of tetra-terpenes (1.02%) were detected. Alkaloids were not identified. This indicates that, acetogenins integrate mostly with mono-, sesqui-, di- and tri-terpenes and alkaloids to be olfactory stimuli in case of heavily infested okra plants. While in eggplant, acetogenins with high amounts of di-terpenes were bond to induce the olfactory stimuli. Also, in purslane the detected amounts of acetogenins were 8.41% of

the volatile constituents with di-terpenes (3.31%), and high amounts of alkaloids (4.46%) may be form a blend serving as olfactory stimuli. The total terpenoids of the volatile constituents in mildly infested plants represent 3.31% in cowpeas and 3.93% in pepper as compared to 13.5% in okra, 7.44 % in eggplant and 4.66% in purslane plants which were heavily infested plants. With regard to alkaloids, no volatile alkaloids were detected in cowpeas and pepper, while it was recorded only in okra plant (14.53%) and purslane (4.46%) which were highly infested with this pest in the field.

In the case of moderately infested plant (ivy, cotton and potato), the acetogenins represent 14.29% of volatile constituents of ivy plants. No volatiles of mono-, di- and tri-terpenes were detected, but sesqui-terpenes represent 4.25% with low traces of tetra-terpenes (0.87%) were detected. The total terpenoids amount was 5.12% as compared to 13.5% in okra plants. No alkaloids were detected in ivy plant. While, in cotton and potato plants, volatiles of acetogenins represent 10.8% and 5.84%, respectively, as compared to 37.1% in okra plants. No volatiles of mono-, sesqui-, di- and tri-terpenes were detected; the only detected terpenoids was tetra-terpenes and occurred in small amounts (1.22 % and 1.49%) of volatile constituents of cotton and potato plants, respectively so, the total terpenoids was low. No alkaloids were detected.

The total percentage of the chemical volatile constituents in each host plants based on accumulation of the percentage of each chemical component was detected to be 65.93%, 21.56% and 14.89% for okra, purslane and eggplant (heavily infested host plants), respectively, and 19.41%,14.53% and 10.17% for ivy, cotton and potato (moderately infested host plants), respectively. While in cowpea and pepper (mildly infested host plants) the total percentage of the chemical volatile constituents was 7.96% and 6.82%, respectively.

The foregoing analysis clearly indicates that synergistic effects among compounds of an odor blend or mixture are likely to contribute to the attraction of the insect to the plant. This odor blend include mainly the classes acetogenins, terpenoids and alkaloids, the percentage of constituents of each class together with low molecular weight of these constituents increase the insect attraction. A look at data presented in table (3) clearly revealed that okra plant is a heavily infested host plant in contrast to cowpea and pepper which are mildly infested. These findings almost agree with those reported by Arif *et al.* (2009) and Vennila *at al*. (2013) who reported that the favorable host families to the cotton mealybug *P. solenopsis* were mostly malvaceae, solanaceae and portulacaceae.

Conclusion

The host plant species significantly affect the development durations, survival, longevity, fecundity and reproductive rate of *P. solenopsis*. Based upon the obtained data for the life cycle parameters, the availability in the natural environment and for prolonged durability the okra, eggplant and purslane seems to be a potential host plants for mass-rearing purposes of *P. solenopsis* under laboratory, green houses and field conditions. The emitted chemical volatiles from the host plants act as an attractive agent of insect pests to select the preferred plants for completing the insect life cycle and then increase their population density. The Chemical volatiles belonging to acetogenins as fat derivatives were detected in low amounts in mildly infested host plants. Also, di- terpenes were detected in high amounts in heavily infested host plants. So, the percentage chemical volatiles belonging to acetogenins and di-terpenes have a positive relationship on the infestation rate and the population density of this insect pest. While, tetra-terpenes were detected in high amounts in mildly infested host plants recording an inverse relationship on both infestation rate and population density of this pest.

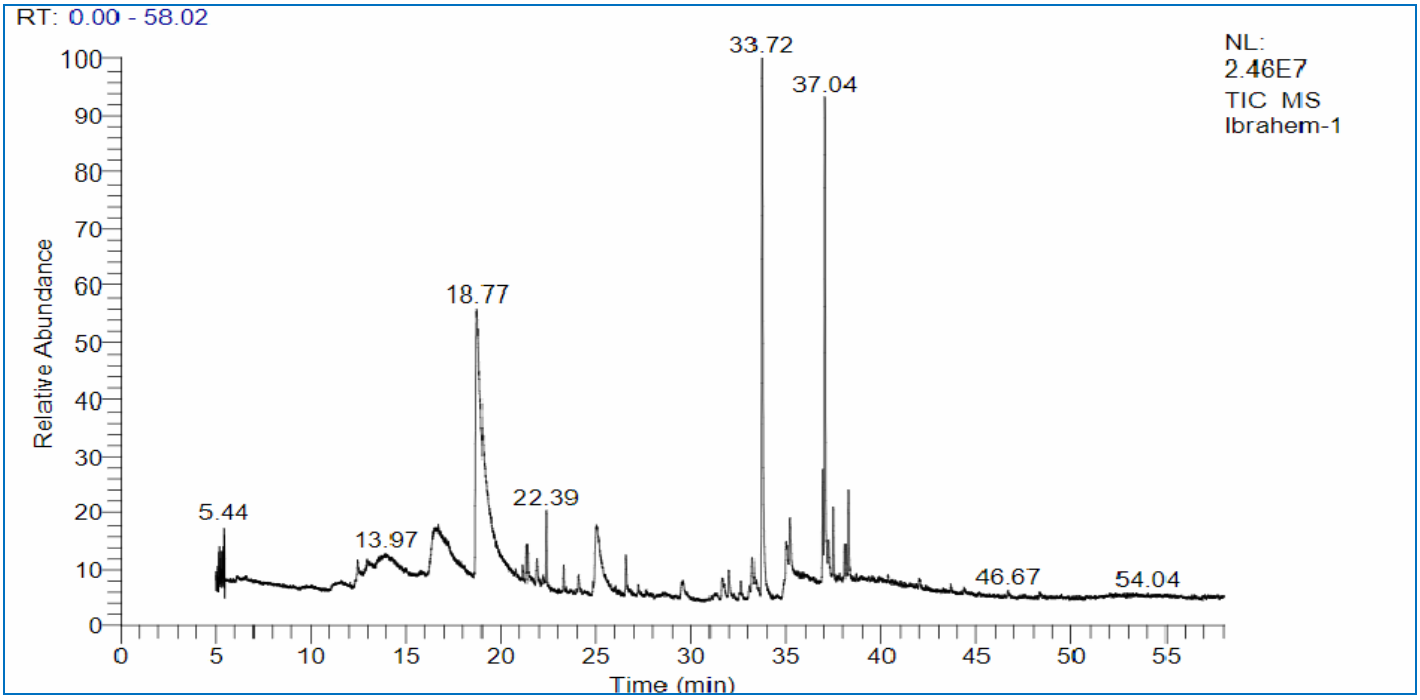

Fig. 1 : Chromatogram (GC-MS) of okra plant

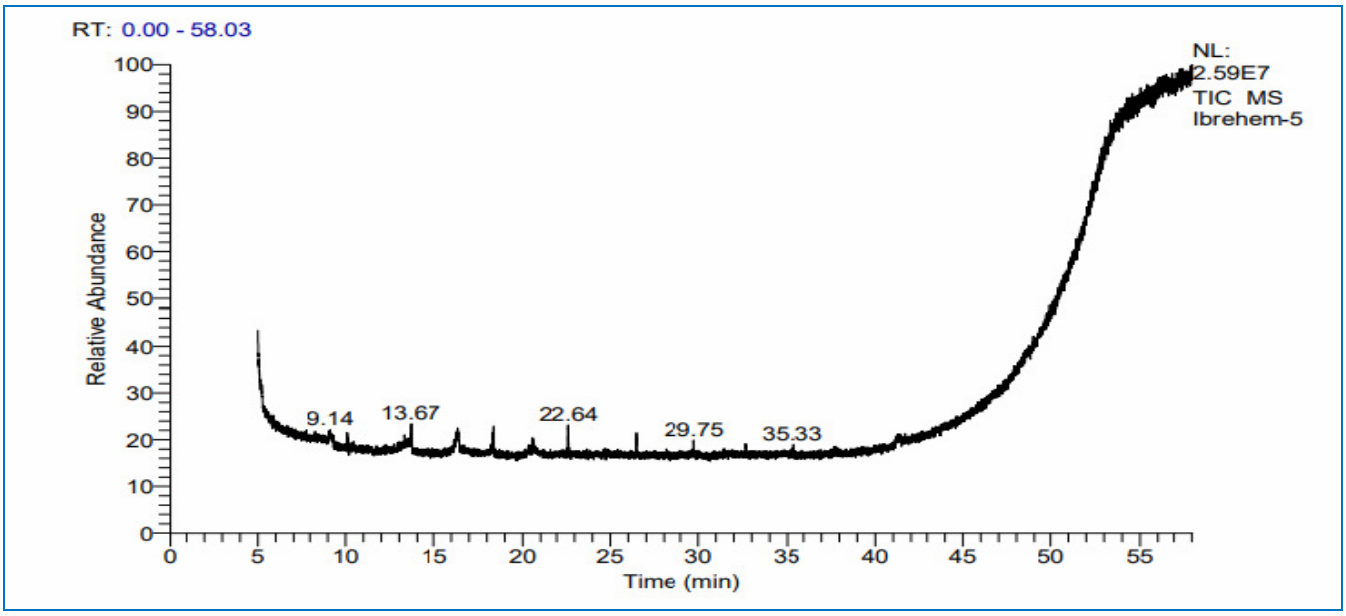

Fig. 2 : Chromatogram (GC-MS) of cotton plant

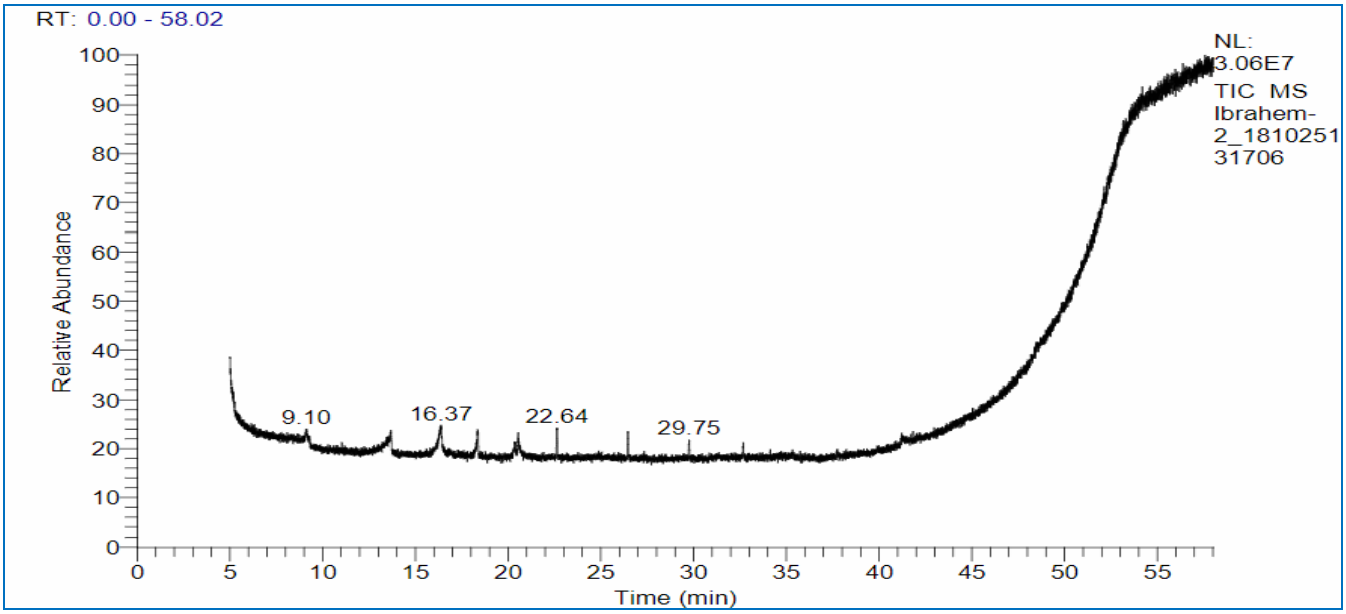

Fig. 3 : Chromatogram (GC-MS) of cowpea plant

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