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Studies on Biological Parameters of an Invasive Mealy Bug, *Phenacoccus solenopsis* Tinsely (Pseudococcidae: Hemiptera) on Different Host Plants Under Laboratory Conditions

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Abstract: Biological parameters of *Phenacoccus solenopsis* were evaluated under laboratory conditions at Integrated Pest Management laboratory (25 ± 2°C and 65± 5%) by using commonly available plant species in the agro-climate of Faisalabad, (Punjab, Pakistan). The plant species affected the growth and development of *P. solenopsis*. *Conyza bonariensis* and *Digera arvensis* induced nympahl mortality and exerted antagonistic effects on crawler population and nymphal duration, whereas *Gossypium hirsutum*, *Hibiscus rosa-sinensis*, *Trianthema portulacastrum*, *Parthenium hysterophorus* and *Solamum melongena* exerted positive and synergistic effect on oviposition of pest. Maximum densities of crawlers per ovisac of *P. solenopsis* were recorded on *T. portulacastrum*, followed by *H. rosa-sinensis*, *S. melongena* and *P. hysterophorus*. It is concluded that *G. hirsutum*, *H. rosa-sinensis*, *T. portulacastrum*, *P. hysterophorus* and *S. melongena* served as favorite host plants for *P. solenopsis*, whereas *D. arvensis* and *C. bonariensis* as resistant source among the tested host plants.

Key words: Cotton Mealybug · Development · Invasive Pest · Food Preference

INTRODUCTION

A number of mealy bug species have been reported attacking vegetables, fruit trees and field crops all over the world [1]. Nature of damage of them is phloem-feeder because they suck cell sap. In this way they damage the economic crop directly by sucking cell sap and indirectly by excreting honey dews resultantly inhibiting photosynthetic activity of plant through physical contamination with their honey dews. Out of variety of mealy bug species, *Phenacoccus solenopsis* Tinsely, is now geographically wide spread all over the world and causing severe yield loss to different crops. The losses in yield of cotton crop due to mealy bug had been assessed from 58-73% [2], damage was also recorded up to 90% [3]. Heavy infestation of *P. solenopsis* result in defoliated condition and plants look like sprayed with defoliator [4]. In Pakistan, mealy bug devastated 60728.74 hectares of cotton only in Pakistan [5] and nearly 809.7 hectares in India [6]. In Pakistan, it appeared almost in 11 out of 18 cotton growing districts of Punjab including Faisalabad, Rahim Yar Khan, Bahawalpur, Lodhran, Multan, Muzaffergarh, Rajanpur, Dera Ghazi Khan, Layyah, Vehari and Khanewal and covered an area of near of about 15000 sq. kms [7].

Recently, *P. solenopsis* has acquired the status of a major insect pest in most of the cotton growing states of the world [8]. Now entomologists are facing difficulty in making decision for the management of *P. solenopsis*, because it is polyphagous in nature. Reportedly, it infests more than 154 plant species in 53 families. Level of infestation of *P. solenopsis* varied among different plant species [9].

Food plant sources have ability to exert antibiotic effects on biological activity of herbivorous insect pest. Researchers studied the biology of the mealy bug, *P. solenopsis* on cotton in India [10] whereas on *H. rosa-sinensis* in Nigeria [11] but work regarding the biological parameters of *P. solenopsis* in Pakistan is still lacking. It was therefore imperative to study the biological parameters of *P. solenopsis* on commonly available host plants in Punjab, Pakistan.

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MATERIALS AND METHODS

Tested Plant Material: A total of 25 host plant species viz., Lantana (*Lantana camara*) Verbenaceae, Krund (*Chinopodium morale*) Chenopodiaceae, chinese rose (*Hibiscus rosa-sinensis*) Malvaceae, Lehli (*Convolvulus arvensis*) Convulvulaceae, peeli dhodak (*Launea nudicaulis*) Euphorbiaceae, Aksun (*Withania somnifera*) Solanaceae, Janglihaloon (*Coronopus didimus*) Brassicaceae, Hazardani (*Euphorbia prostrate*) Euphorbiaceae, Loosen booti (*Conyza bonariensis*) Asteraceae, Brinjal (*Solamum melongena*) Solanaceae, Okra (*Abelmoschus esculentus*) Malvaceae, Leh (*Cirsium arvense*) Asteraceae, Bathu (*Chenopodium album*) Chenopodiaceae, Cotton (*Gossypium hirsutum*) Malvaceae, Chilli (*Capsicum frutescens*) Solanaceae, Cholai (*Amaranthus spinosus*) Amaranthaceae, Gardenia (*Clerodendron inerme*), Itsit (*Trianthema portulacastrum*) Aizoaceae, Qulfa (*Portulaca oleracea*) Portulacaceae, Bakhra (*Tribulus terrestris*) Zygophyllaceae, Tandla (*Digera arvensis*) Amaranthaceae, Daryaibooti (*Eclipta prostrate*) Asteraceae, Parthenium (*Parthenium hysterophorus*) Asteraceae, Puthkanda (*Achyranthes aspera*) Amaranthaceae and Sunflower (*Helianthus annuus*) Asteraceae were used in the present studies.

Laboratory Experiment

Mealy Bug Cultures:

Mealy bugs were reared in Integrated Pest Management Laboratory at the University of Agriculture Faisalabad. The mealy bugs were collected from a nearby cotton field during summer and from Chinese rose during winter (also kept as control for comparison). However mealy bug culture was maintained on Chinese rose (*Hibiscuos rosasinensiss* L.), in glass cages kept at a temperature of 25 ± 2°C and relative humidity 65± 5%.

Experimental Procedure: The experiment was conducted in the Integrated Pest Management Laboratory, University of Agriculture, Faisalabad during 2008-09. Adult ovisacked females of cotton mealy bug were collected from the culture (Integrated Pest Management Laboratory, Department of Agri. Entomology) at a temperature of 25 ± 2°C and relative humidity 65± 5% for investigating development on different plant species.

Observation taken consisted of:

- Nymphs/Crawlers per ovisac
- Nymphal duration
- Crawler/nymphal mortality
- Pre-oviposition and oviposition period
- Total life span

In order to study crawler duration, one ovisacked female of cotton mealy bug was confined in Petri dish along with moist filter paper and leaves of selected plants. When the first instar crawlers emerged from the ovisacked female; female was removed from the petridish, time taken by first instar to change into second instar stage was calculated and the exuviae of developing crawlers were removed on daily basis in order to maintain cleanliness. Mealy bug‘s food was also changed on daily basis.

The pre-oviposition period was considered as the time between the emergence of female to ovisac production, whereas oviposition period as overall female’s egg laying period.

Mortality of all nymphal instars was observed by dividing alive nymphs to total (20) nymphs multiplied by 100.

Statistical Analysis: The data was analyzed statistically using Statistica package 5.5, to find out the significance of results among the tested plant species and means were compared by DMR test at 5% probability.

RESULTS

Crawlers per Ovisac of *P. solenopsis*: Number of crawlers per ovisac of *P. solenopsis* among the tested plant species ranged from 49-101 (Table 1). However, maximum crawlers per ovisac of cotton mealybug were recorded on itsit (101), followed by Chinese rose (99.33), brinjal (98.66) and parthenium (98.33), where as minimum number of crawlers per ovisac of cotton mealybug were recorded on loosen booti (49) and jangli haloon (53).

Nymphal Duration of *P. solenopsis*: All the tested host plants significantly affected the nymphal duration of 1st, 2nd and 3rd instars of cotton mealy bug (Table 1). Nymphal duration of first instar, second instar and third instar ranged from 3-6, 3.67-6.33 and 4.00-7.67days, respectively. Three plant species named Loosen booti (7.66 days), Tandla (6.66 days) and jangli haloon (6 days) prolonged nymphal duration as compared with brinjal where 1st instar of *P. solenopsis* completed nymphal duration within (3.00 days). Nymphal duration of second instar of cotton mealybug was maximum (7.33 days) on Leh, followed by Jangli haloon (6.66 days), Tandla (6.66 days) and Loosen booti (6.33 days) as compared with Chinese rose having minimum duration of

Table 1: (Means ± S.E) first, second, third instar durations and Total life span (days) of *P. solenopsis* on tested host plants

	Duration (days)			
Plant species	1st instar	2nd instar	3rd instar	Total life span
Lantana	3.66±0.57^{cd}	4.33±0.5^{bcd}	4.66±0.5^{cde}	61±4^{abcd}
Peelidhodak	5.33±0.57^{abcd}	5±0^{abcd}	6±1^{abcde}	47.33±4.0^{def}
Krund	4.33±0.57^{bcd}	5.33±0.5^{abcd}	6.66±0.5^{abcde}	49.33±3.51^{cdef}
Lehli	4.33±1.15^{bcd}	4.33±1.52^{bcd}	6±1^{abcde}	47.33±2.08^{def}
Parthenium	3.33±0.57^{d}	4.66±1.15^{abcd}	5.33±0.5^{bcd}	64.33±4.16^{abc}
Aksun	3.66±0.57^{cd}	5±1 ^{abcd}	5.66±0.5^{bcd}	54±3.60^{bcdef}
Cholai	4±0^{cd}	5.33±0.5^{abcd}	6.33±0.5^{abcde}	48±3^{def}
Janglihaloon	6±1abc	6.66±0.5^{ab}	8.33±2.08^{a}	42.66±3.51^{ef}
Itsit	4.33±1.15^{bcd}	5±1^{abcd}	4.33±0.5^{de}	66.33±3.0^{ab}
Bakhra	4.33±0.5^{bcd}	5.66±0.5^{abcd}	6.33±1.15^{abcde}	53±4.5^{bcdef}
Chinese rose	4±1^{cd}	3.66±0.5^{d}	4±0^{e}	58.33±4.5^{abcde}
Okra	3.66±0.57^{cd}	5±1^{abcd}	5.33±0.5^{bcd}	57.66±3.0^{abcde}
Leh	4±0^{cd}	7.33±0.5^{a}	8±1^{ab}	52±3.6^{bcdef}
Loosenbooti	7.66±0.57^{a}	6.33±0.5^{abc}	7.33±1.15^{abc}	41.66±3.5^{ef}
Chili	4±1^{cd}	4.66±0.5^{abcd}	6.33±1.15^{abcde}	51±2^{cdef}
Hazardani	4±1^{cd}	4.66±0.5^{abcd}	5.33±0.5^{bcde}	49.33±5.5^{cdef}
Brinjal	3±1^{d}	4.66±0.5^{abcd}	5.66±0.5^{bcd}	60.33±3.0^{abcde}
Puthkanda	5±1^{bcd}	5.33±0.5^{abcd}	6.66±0.5^{abcde}	46.66±1.52^{ef}
Bathu	4.33±1.52^{bcd}	5.33±0.5^{abcd}	7±0^{abcd}	52.66±4.5^{bcdef}
Sunflower	3.66±0.5^{cd}	4±1^{cd}	5.33±0.5^{bcd}	71±3^{a}
Tandla	6.66±0.5^{ab}	6.66±0.5^{ab}	7±1^{abcd}	35.66±5.03^{f}
Qulfa	3.66±0.5^{cd}	4.66±0.5^{abcd}	5.33±0.5^{bcde}	43.33±2.5^{ef}
Daryiboti	4.33±0.57^{bcd}	5.66±0.5^{abcd}	6±1^{abcde}	61.66±3.5^{abcd}
Gardenia	3.66±0.57^{cd}	4.66±1.5^{abcd}	6.33±0.5^{abcde}	60±3.6^{abcde}
Cotton	3.66±0.57^{cd}	5.33±0.5^{abcd}	4.33±0.5^{de}	71±4^{a}
F (p) plant species Df = 24	<0.05	<0.05	<0.05	<0.05

Means sharing similar letters did not differ significantly from each other.

Table 2: (Means ± S.E) Preoviposition, oviposition period of adult female and crawlers/ovisac of *P. solenopsis* on tested host plants

Plant species	Pre-oviposition	Oviposition	(crawlers/ ovisac)
Lantana	2.66±0.5 ^{bcd}	2.66±0.5^{de}	80.66±6.0^{abc}
Peelidhodak	4.66±0.5 ^{abcd}	4±1^{abcde}	74.3±10.1^{abcd}
Krund	4.66±1.5 ^{abcd}	5.33±0.5^{ab}	83.66±4.0^{abc}
Lehli	3.33±0.5 ^{abcd}	3.66±0.5^{abcde}	74±3.6^{abcd}
Parthenium	3±1 ^{bcd}	2.66±0.5^{cde}	98.33±8.5^{ab}
Aksun	3.33±0.5 ^{abcd}	2.66±0.5^{cde}	96.66±5.6^{ab}
Cholai	3.33±0.5 ^{abcd}	4.33±0.5^{abcde}	77±5.5^{abcd}
Janglihaloon	5.33±1.1 ^{ab}	5.66±0.5^{a}	53±9.1^{cd}
Itsit	2.66±0.5 ^{cd}	3.66±0.5^{abcde}	101±7^{a}
Bakhra	4.66±0.5 ^{abcd}	4±1^{abcde}	86±7^{abc}
Chinese rose	2.66±0.5 ^{cd}	2.33±0.5^{e}	99.33±3.2^{a}
Okra	3±1 ^{bcd}	3±0^{cde}	95.33±1.5^{ab}
Leh	4.33±0.5 ^{abcd}	5.33±0.5^{ab}	85.33±2.0^{abc}
Loosenbooti	5±1 ^{abc}	5±1^{abc}	49.33±4.5^{d}
Chili	3.33±0.5 ^{abcd}	3.33±0.5^{bcde}	85.66±3.0^{abc}
Hazardani	3.66±0.5 ^{abcd}	3.66±0.5^{abcde}	93.33±1.5^{ab}
Brinjal	3±1 ^{bcd}	2.66±0.5^{de}	98.66±1.1^{ab}
Puthkanda	4.66±0.5 ^{abcd}	4.33±0.5^{abcde}	73.33±4.7^{abcd}
Bathu	5.66±0.5 ^{a}	4.66±1.1^{abcd}	96±1^{ab}
Sunflower	3±1 ^{bcd}	3.33±0.5^{bcde}	96±1^{ab}
Tandla	5.66±0.5 ^{a}	5±1abc	61.33±7.5^{bcd}
Qulfa	2.66±0.5 ^{cd}	2.66±0.5^{de}	92.33±2.5^{ab}
Daryiboti	3.33±0.5 ^{abcd}	3.33±0.5^{bcde}	87±6.2^{abc}
Gardenia	3.33±0.5 ^{abcd}	4.33±0.5^{abcde}	93.66±4.1^{ab}
Cotton	2.33±0.5 ^{d}	3±0^{cde}	95.33±3.5^{ab}
F (p) plant species Df=24	<0.05	<0.05	<0.05

Means sharing similar letters did not differ significantly from each other.

Table 3: (Means ± S.E) mortality of first, second, third instar of *P. solenopsis* on tested host plants

	Mortality		
Plant species	1st instar	2nd instar	3rd instar
Lantana	11.6±5.7^{ef}	10±5^{def}	8.33±5.7^{bcd}
Peelidhodak	46.66±7.6^{abcde}	28.3±2.8^{abcde}	16.66±2.8^{abcd}
Krund	58.33±5.7^{abc}	36.6±2.8^{abcd}	23.33±2.8^{abcd}
Lehli	20±5^{def}	13.3±2.8^{bcdef}	13.33±2.8^{abcd}
Parthenium	8.33±2.8^{f}	6.6±2.8^{f}	6.66±2.8^{cd}
Aksun	21.66±2.8^{cdef}	15±5^{bcdef}	11.66±2.8^{abcd}
Cholai	31.66±2.8^{bcdef}	25±0^{abcde}	20±0^{abcd}
Janglihaloon	58.33±2.8^{abc}	35±5^{abcde}	25±0^{abcd}
Itsit	16.66±2.8^{def}	13.3±2.8^{cdef}	11.66±2.8^{abcd}
Bakhra	33.33±12.5^{bcdef}	23.3±7.6^{abcde}	18.33±7.6a^{bcd}
Chinese rose	8.33±2.8^{f}	8.3±2.8^{ef}	5±5^{d}
Okra	18.33±10.4^{def}	15±8.6^{bcdef}	13.33±5.7^{abcd}
Leh	58.33±15.2^{abc}	35±5^{abcde}	25±0^{abcd}
Loosenbooti	73.33±7.6^{a}	46.6±10.4^{a}	26.66±5.7^{abc}
Chili	26.66±7.6^{bcdef}	21.6±7.6^{abcde}	16.66±2.8^{abcd}
Hazardani	23.33±7.6^{cdef}	18.3±7.6^{bcdef}	13.33±5.7^{abcd}
Brinjal	18.33±10.4^{def}	15±5^{bcdef}	11.66±2.8^{abcd}
Puthkanda	63.33±7.6^{ab}	41.6±5.7^{abc}	28.33±2.6^{ab}
Bathu	51.66±10.4^{abcd}	35±5^{abcde}	25±5^{abcd}
Sunflower	10±5^{ef}	8.333±2.8^{ef}	8.33±2.8^{bcd}
Tandla	75±5^{a}	45±5^{ab}	31.66±2.8^{a}
Qulfa	23.33±2.8^{cdef}	18.333±2.8^{bcdef}	13.33±2.8^{abcd}
Daryiboti	23.33±2.8^{cdef}	20±5^{abcde}	15±5^{abcd}
Gardenia	35±5^{bcdef}	25±0^{abcde}	15±0^{abcd}
Cotton	11.66±7.3^{ef}	10±5^{def}	5±0^{d}
F (p) plant species Df=24	<0.05	<0.05	<0.05

Means sharing similar letters did not differ significantly from each other.

(3.67 days). Similarly nymphal duration of third instar of cotton mealybug was prolonged to 7.66 days when fed on Jangli haloon and Leh plant as compared with Chinese rose with minimum duration of (4.00 days), followed by cotton (4.33 days).

Overall Life Span of *P. solenopsis*: All the tested host plants induced significant differences on the life span of cotton mealybug (Table 1). Overall life span of *P. solenopsis* ranged from 35.66-71.00 days, minimum life span was found on loosen booti on which life span of third instar was shortened to only 35.66 days as compared with sunflower and cotton with life span (71.00 days).

Pre-Ovipositional and Ovipositional Periods of *P. solenopsis*: Pre-ovipositional period of *P. solenopsis* among tested plant species ranged from 2.33-5.66 days, when fed on cotton and Tandla, whereas ovipositional period 2.33- 5.66 days on Chinese rose and Jangli haloon (Table 1).

Nymphal Mortality of *P. solenopsis*: All the tested host plants induced significant differences for mortality of first, second and third instar of cotton mealybug (Table 2). Mortality of first instar ranged from (8.33-75%), second instar (6.67-46.67%) and third instar (5.00-31.67%). However, maximum mortality of first instar crawlers of cotton mealybug occurred on Tandla (75%) and loosen booti (73.33%). Whereas minimum mortality was recorded on Chinese rose (8.33%), parthenium (8.33%), sunflower (10%), cotton (11.76%) and lantana (11.76%). Among the remaining tested host plants, mortality of first instar ranged from 16.67-63.33%, second instar ranged from 6.67-46.67% on loosen booti (46.67%) and on parthenium (6.67%) respectively, Similarly third instar's mortality ranged from (5.00%) on cotton to (31.67%) on Tandla. Whereas mortality of third instar crawlers ranged from 6.67-28.33% among the remaining tested host plant species.

DISCUSSION

The major hindrance in the management of cotton mealy bug is its polyphagous nature. *P. solenopsis* has been reported to feed on 154 species of plants [4], but with variable level of infestation that may be due to

difference in food quality among tested plant species. Feeding preference and biological activity of insect pest is influenced with the nutrition and quality of the required food source of pest. Various scientists confirmed that the food plants directly affect the demography, survival, fecundity and life expectancy of various insect pests [12].

Food source may have synergistic or antagonistic effect on herbivorous insect pest in the form of mortality, prolonged nymphal duration and reduced oviposition. Understanding of the life history of *P. solenopsis* is crucial to the integrated management. Based on the results of present studies regarding the response of different plant species on some biological parameters of cotton mealy bug it is interesting to note that *P. solenopsis* spent its maximum life period on preferable plants for attaining food and oviposition that resulted in increased life span and more number of crawlers per ovisac. The present findings are confirmatory to the findings of various researchers regarding effect of plant resistance on insect pest [13].

Nymphal mortality of *P. solenopsis* was maximum in Tandla and loosen booti that may be due to their antagonistic effect. The results of present studies are confirmatory to the findings of Sana-Ullah *et al*. [14]. In contrast *P. solenopsis* when fed on least preferred plants it altered its behavior in the form of reduced life span and early oviposition with reduced crawlers population per ovisac, however pest was forced to produce its offspring much earlier than its favorite plant species. Many researchers verified antagonistic behavior of plants to insect pests [12].

The present study revealed that maximum crawlers per ovisac of cotton mealybug were recorded on itsit, followed by Chinese rose, brinjal and parthenium. The results of present study are consistent to the findings of Sana-Ullah *et al*. [14] who reported that maximum fecundity was reported in Chinese rose (> 400 eggs/ ovisac/female). Minimum number of crawlers per ovisac of cotton mealybug was recorded on loosen booti and jangli haloon. The present studies are partially supported with the studies of Sana-Ullah *et al*. [14] who reported that least fecundity in cotton mealybug was recorded for rose and jatropha (100-200 eggs/ovisac/female). Vennila *et al*. [10] explained that females showed dynamic patterns of fecundity with the number of crawlers produced per female ranging between 128 and 812, with a mean of 344 ± 82. The present results also revealed that nymphal duration of third instar of mealy bug is longer as compared with other instars among tested plant species. The results are supported by Akintola and Ande [11] who found increasing developmental periods of 6, 8 and 10 days for the 1st, 2nd and 3rd instars respectively on Chinese rose in Nigeria.

It was concluded that the host plants influenced the biology of insect pest, however the biochemical factors that influence the biology of pest is needed to be explored.

CONCLUSION

Based on above results it was confirmed that food source of plant play an important role toward pest maturity and oviposition however cotton, Chinese rose, brinjal and parthenium favored the fecundity and life span of *P. solenopsis* but opposite for Tandla and Loosen booti that induced antagonistic effects in the form of nymphal mortality, nymphal duration and oviposition period of the pest.

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