OPEN ACCESS
Freely Available Online

JOURNAL OF AGRONOMY RESEARCH
ISSN NO: 2639-3166

Research Article

DOI: 10.14302/issn.2639-3166.jar-18-2576

Laboratory Studies on the Host Preference of Cotton Mealybug '*Phenacoccus solenopsis*' Tinsely (Hemiptera: Pseudococcidae) in Khartoum State, Sudan

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Abstract

Cotton mealybug (*Phenacoccus solenopsis*) is a serious devastating pest which goes on a wide array of plant families. The pest spread all over the world from cool to dry hot regions. The main objective of this study was to investigate the food preference and behavior of P. solenopsis Tinseley (*Hemiptera: Pseudococcidae*) towards selected host plants in Khartoum State, Sudan, where a multi-choice experiment under laboratory conditions was adopted. Eight plant species were screened for attractiveness and food preference to Cotton mealybug. Where the proportions of the 1st, 2nd and 3rd nymphal instars and the adult females were recorded at 2, 8 and 24 hours after release, and compared with Chinese rose (*Rosa chinensis*) the control. The result revealed that the proportions of the 1st, 2nd and 3rd nymphal instars and adult females were maximum on plants of family Malvaceae, particularly the Okra (*Hibiscus esculentus*) followed by Cotton (*Gossypium sp*.) and Hambouk (*Abutilon pannosum*) as compared with the control. However, in contrast, the proportions were very low on unpalatable plants like Zaleya (Locally known as Raba) (*Zaleya pentandra*) and Eggplant (*Solanum melongena L*.). However, in contrast, the proportions were very low on unpalatable plants like Zaleya (Locally known as Raba) (Zaleya pentandra) and Eggplant (*Solanum melongena L.).* In conclusion, the most favorable host plants of the Cotton mealybug belonging to the family Malvaceae, while the families of Solanaceae [Egg plant (*Solanum melongena L*.)] and Aizoaceae (Raba) were found to be the least preferred host plants.

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Citation: Nawal Ahmed Mohamed, Awad KhalafAlla Taha, Abubaker Haroun Mohamed Adam (2019) Laboratory Studies on the Host Preference of Cotton Mealybug 'Phenacoccussolenopsis' Tinsely (Hemiptera: Pseudococcidae) in Khartoum State, Sudan. journal of agronomy research - 1(3):35-43. https://doi.org/10.14302/issn.2639-3166.jar-18-2576

Keywords: Gossypium, Chinese rose, nymphal, instar, Preference

Received: Dec 31, 2018 **Accepted:** Jan 26, 2019 **Published:** Feb 02, 2019

Editor: Berken Cimen, Cukurova University, Turkey.

Introduction

The mealybug which was not well known to many courtiers since, today it became very dangerous pest. It originated in Central America, and spread to more than 11 countries in South America, Asia, Africa and Australia [1]

It is reported that a number of mealybug species cause damages to over 202 plant species belonging to 55 families across the globe [2], [3], [4]. They parasitize on a wide range of host plants; causing significant damages to numerous plants including field crops (Cotton, Sesame, Sunflower), vegetables (Okra, Tomato, Eggplant), ornamentals, weeds, bushes, and in particular the plants which belong to the families of Malvaceae, Solanaceae, Asteraceae, Euphorbiaceae, Amaranthaceae and Cucurbitaceae [5], [6], [7].

Studies revealed that the pest attacks weeds throughout the year, and migrate to other crops through natural carriers (wind, water, bird and human being). It spread between continents through international trade [8]. One of the researcher reported that high population of mealybugs can cause serious losses to a wide range of crop plants through fruit, flower/leaf drop, fruit/flower deformation and development of discolored welts on the rind of the fruit, flower etc. He also added that in the last 30 years, outbreaks of mealybugs caused alarming damage to crops in the United States of America (USA), New Zealand and France [9].

Ibrahim, et. al., (2015) are the first to identified *P. solenopsis* as a new insect pest attacking tomato plants in Egypt [10]. In Queensland, the pest was first identified in 2009, and considered as minor pest, but it became a major pest and widely spread to affect the cotton crop [11] .

Recently, the Cotton mealybug has acquired the status of major insect pest in the world, and therefore, the entomologists are facing difficulties in managing this pest due to its polyphagous nature [1] [12]. It attacks weeds year around and migrate to other crops through natural carriers (wind, water, bird and human being). Moreover, it has the ability to increase rapidly and spread to cover vast areas in a relatively short period of time [13]. Furthermore, the pest is protected from insecticides and natural mortality factors by the presence of white powdery and waxy secretion [9]. Thus, it causes a significant damage to numerous crops including Cotton, Okra, Tomato, Eggplant, Sesame, Sunflower and Ornamental shrubs [7].

In Sudan, infestation with Cotton Mealybug was reported from different States in the country. A survey conducted in Gezira and Khartoum States in 2015 showed that at least 26 host plant species belonging to 16 plant families were identified as host plants [14]../

Materials & Methods

This study was conducted in the laboratory of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat during 2017.

A culture of Cotton mealybug, *(Phenacoccus solenopsis)* was prepared by collecting adult stage from infested vegetables, ornamental shrubs and weeds from different sites in Khartoum State. They were reared in plastic containers (15cm diameter by 7cm deep) under laboratory conditions maintained at temperature of 25 to 28°C and relative humidity (RH) 25-28 %. The females were reared from the newly emerged nymphs and adults of *P. solenopsis*.

In this study, three vegetables, two ornamentals, two weeds and one field crop were studied. Where a total of 8 common host plant species available in Khartoum State, namely the Okra (*Abelmoschus esculentus)*, Cotton (*Gosspium* sp), Egg plant (*Solanum melongena*), Tomato (*Lycopersicon esculentum*), Lantana (*Lantana camara*), Raba (*Zaleya pentandra*) and Hambouk (*Abutilon pannosum*), were collected.

The host plant species were evaluated against 1st, 2nd, and 3rd nymphal instar and adult female, where healthy twigs of each selected plant species with at least five tender leaves were collected, washed and dried to remove moisture from the surface of the leaves. In this study the Eickhoff, T.E., Baxendale (2005) [15] method was followed.

A Plastic dish (34 cm. diameter by 13 cm. deep) was used as a study arena. 2 cm. diameter holes were drilled in the outer circle of the dish (8 holes). The twigs were inserted in vials (2 cm. diameter by 9.3 cm. deep) containing fresh organic peat moss wetted with water. The vials were randomly inserted in the holes of the

dish. A counted number of Cotton mealybug (200 individual of each stage in a Petri-dish (15x2 cm.) were put in the centre of the dish and the whole dish was covered with muslin cloth following multi-choice experiment under laboratory conditions, at temperature of 25 -28°c and relative humidity27- 28%.

The food preference for the P. solenopsis among the tested plant species were compared with the Chinese rose (as a control), and proportion of mealybug was determined. The tested plant species were observed after 2 , 8 and 24 hours after release.

Data regarding feed preference of *P. solenopsis* among tested plant species in the laboratory were statistically analyzed by Software (Statistic 8 -Software, 2003) and subjected to analysis of variance (ANOVA) under completely randomized design (CRD). Means were also compared following the least significant difference test (LSD) at probability level of 1%.

Results & Discussion

This study revealed variation between the host plant species (cotton mealybug) (P. solenopsis) and attractiveness. However, the proportions of all nymphal instars varied significantly (P value = 0.01) with respect to plants species and observation intervals (Table: 1, 2, 3).

After two hours of release, the attraction of all the nymphal instar and adult of P. solenopsis revealed non-significant differences between the host plants as compared with the control (Chinese rose). The mean proportion of the first nymphal instar ranged from 1.3 to 25.3, on Raba and Hambouk respectively, where the attraction of the second nymphal instar, ranged from 0 to 9 on Egg plant and Hambouk, respectively. However, the third nymphal instar, displayed low levels of attraction on the tested plants with a range of 0 to 2 on Eggplant and Lantana, respectively. For the attraction of the adult of the P. solenopsis, low population of adult stage was recorded ranging from 3 to 0.67 on Egg plant and Cotton, respectively (Table 1).

At eight hours after release, there is a highly significant different between the two (Lantana, and Cotton) and Raba. The proportions of P. solenopsis ranged from 0 to 50 on Raba and Lantana respectively. Nevertheless, Lantana possessed high population proportion followed by Cotton 45. The proportions of the second instar settled on the different host species ranged from 0 to 16.33 on Raba and Lantana respectively with non- significant differences as compared with the control. The proportion of the third nymphal instar ranged from 0 to 11.33 on Raba and Okra, respectively with significant differences. However, non-significant differences between the attractiveness of all tested plants and the control were recorded; with proportions for the adult stage ranged from 0.33 to 5.67 on Raba and Cotton, respectively (Table 2).

The occurrence of the first instar after 24 hours of release ranged from 0.33 to 62.33 on Raba and Okra and high significant difference between Okra and Lantana, Eggplant and Raba was recorded. The proportions for the second instar on the different host species ranged from 0.33 to 38.67 on Raba and Okra, and non-significant differences between Okra, Cotton (31.33) and Hambouk (27.33) were recorded. Moreover, high significant difference was noticed in the proportions of the 3rd instar on Okra compared with other plants and the control ranged between 0.33 and 43.67. For the Adult stage, Okra showed significant difference compared with other host plants, and the range was 0 to 33 on Egg plant and Okra respectively (Table 3).

From fig. 4, it is clear that, the settlement of all stages (1st, 2nd, 3rd nymphal instar and adult females) of P. solenopsis increased with increasing time on the host plant species belonging to family Malvaceae (Table). These observations were supported by of one of the researcher (12) who stated that once the mealybug attached to the host, it inserts proboscis and starts feeding on the plant. It remains attached on the plant. Therefore its numbers increase arithmetically with the passage of time. Nevertheless, there is a clear consistent preference of all stages of P. solenopsis.

Generally, Okra appeared to be highly preferred over the selected host species compared with the control (Fig. 1, 2, 3 and 4), followed by Cotton and Hambouk, except the 3rd nymphal instar where Hambouk was preferred more than Cotton (Fig.3). This finding disagrees with the findings of other researcher [16] who studied host preference of

Table 1. The average number of instars and adult females of Cotton mealybug 2 hours post treatment and host plants- Khartoum-Sudan (2018)

Plant Species	Stages of cotton mealybug			
	1st nymphal instar	2nd nymphal instar	3rd nymphal instar	Female Adult
Hambouk	25.33 a	a 9	0.33a	1.67a
Lantana	19.33 a	a 8.67	a 2	1.33 a
Okra	18.33 a	a 5.33	1 a	a 2
Tomato	16.33a	a 5	a 1	1 a
Chinese rose	15a	a 2	a 1	0.67 a
Cotton	11.67a	a 5.67	1.33 a	0.67 a
Egg plant	11.67a	a 0	0 a	3 a
Raba	1.33a	a 1.33	0.67 a	1.67 a
CV	94.64	106.57	109.09	96.23
LSD	33.571	11.754	2.3848	3.4422
SE	11.494	4.0242	0.8165	1.1785

*Mean sharing similar letters did not differ significantly from each other at (1%) level of probability using LSD test

Table 2. The average number of instars and adult females of Cotton mealybug 8 hours post treatment, and host plants- Khartoum-Sudan (2018)

Plant Species	Stages of cotton mealybug			
	1st nymphal instar	2nd nymphal instar	3rd nymphal instar	Female Adult
Hambouk	30a b	6.67a	3.67ab	4.67a
Lantana	50a	16.33a	9.33ab	3.67a
Okra	36.67 ab	13.33a	11.33a	3a
Tomato	35.33 ab	14.33a	5ab	3.67a
Chinese rose	26 ab	10.33a	4ab	2a
Cotton	45 a	15.67a	7.33ab	5.67a
Egg plant	21.33 ab	5a	3ab	3a
Raba	0 b	0a	0b	0.33a
CV	53.69	74.76	74.79	69.37
LSD	39.105	18.201	9.7359	5.3768
SE	13.388	6.2316	3.3333	1.8409

*Mean sharing similar letters did not differ significantly from each other at (1%) level of probability using LSD test

Table 3. The average number of instars and adult females of Cotton mealybug 8 hours post treatment and host plants- Khartoum-Sudan (2018)

Plant Species	Stages of cotton mealybug			
	1st nymphal instar	2nd nymphal instar	3rd nymphal instar	Female Adult
Hambouk	38.33abc	27.33abc	28ab	8.33b
Lantana	15.67bc	5 cd	2.67c	3b
Okra	62.33a	38.67a	43.67a	33a
Tomato	26.67abc	12.67bcd	11.67bc	2.67b
Chinese rose	26abc	10 bcd	5.67c	2b
Cotton	55ab	31.33ab	16bc	10.33b
Egg plant	10c	4.67cd	1.33c	0b
Raba	0.33c	0.33d	0.33c	1.33b
CV	60.29	60.37	56.44	86.51
LSD	42.133	23.397	18.396	15.646
SE	14.418	8.0104	6.2981	5.3567

*Mean sharing similar letters did not differ significantly from each other at (1%) level of probability using LSD test

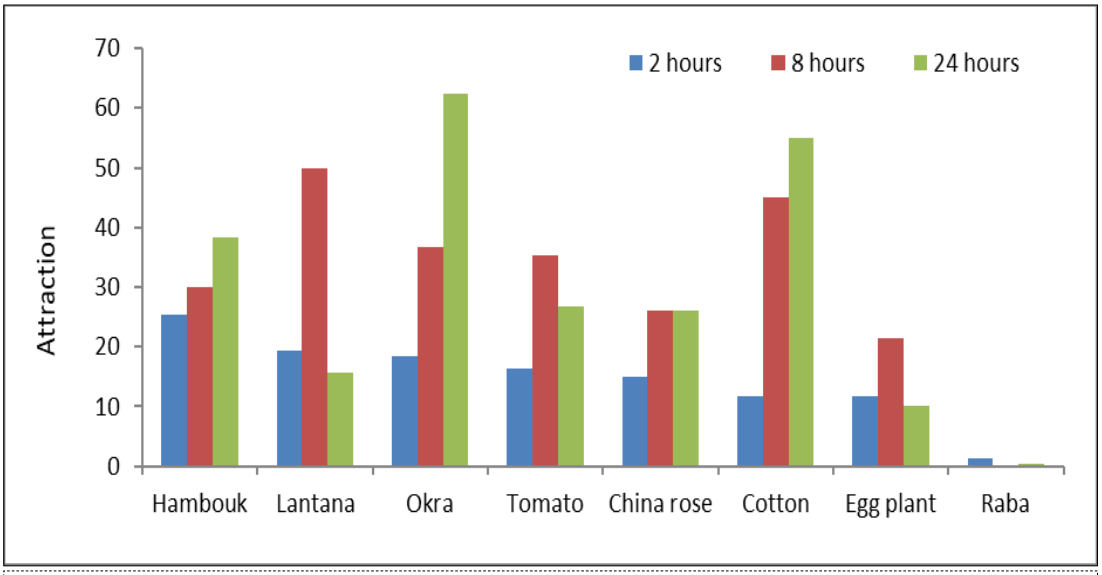

Figure 1. Attraction of the 1st nymphal instars of cotton mealybug to selected plant species, compared with Chinese rose (control), at different interval time after release - Khartoum-Sudan (2018).

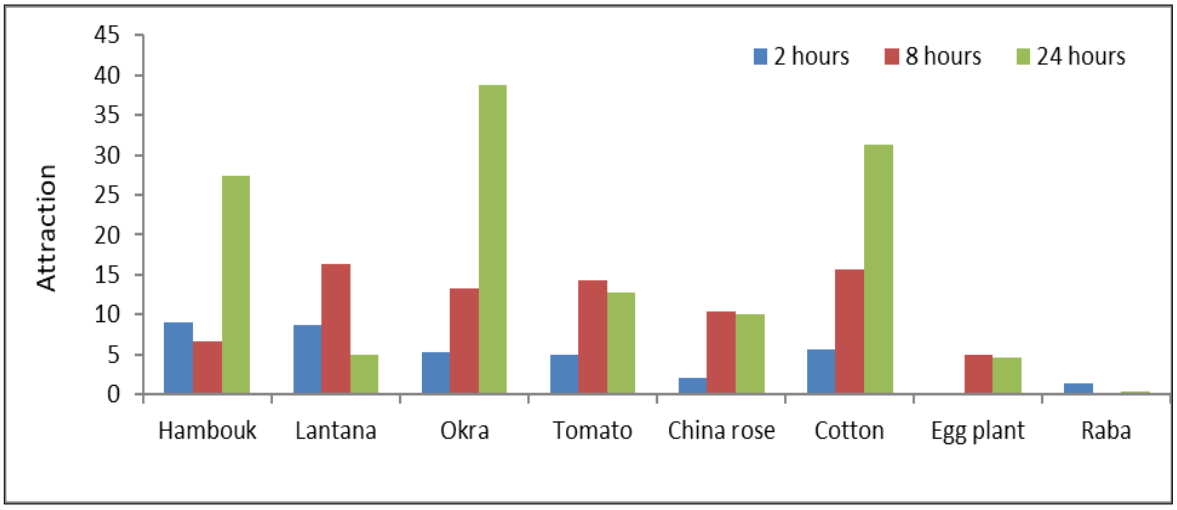

Figure 2. Attraction of the 2nd_ nymphal instar of cotton mealybug to selected plant species, compared with Chinese rose (control), at different interval time after release- Khartoum- Sudan (2018).

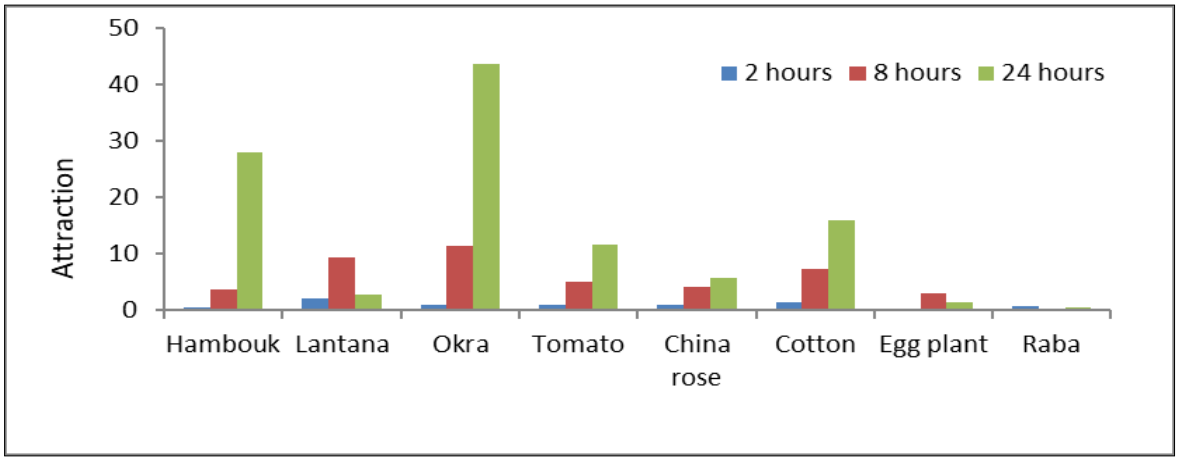

Figure 3. Attraction of the 3rd_nymphal instar of cotton mealybug among selected plant species as compared with Chinese rose (control) at different interval time after release- Khartoum- Sudan (2018).

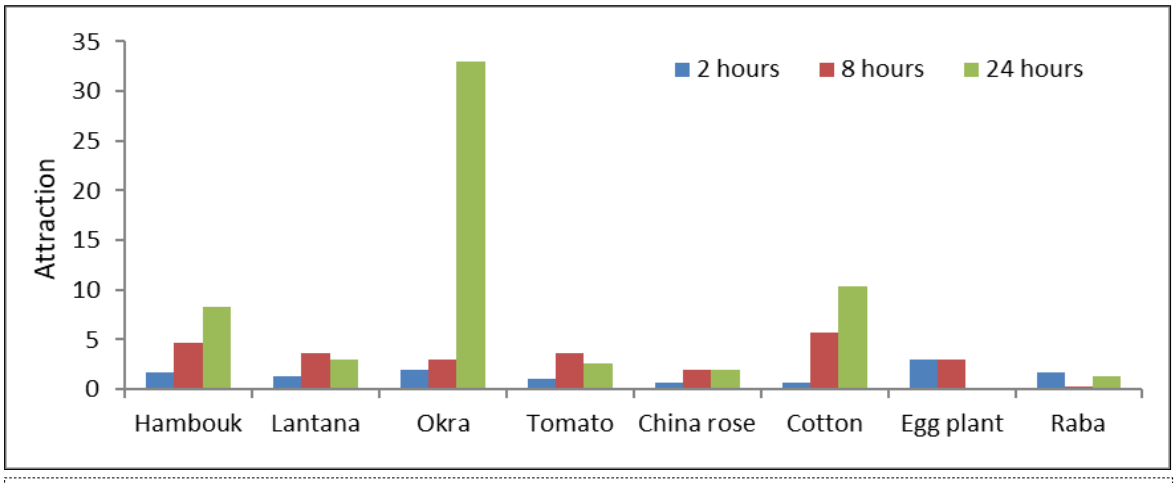

Figure 4. Attraction of adult females of cotton mealybug to selected plant species, compared with Chinese rose (control), at different interval time after release- Khartoum- Sudan (2018).

P. solenopsis using 25 plant species, and recorded that, the proportions of the 1st and 3rd instars were maximum on cotton. Other studies [17],[18], [5] [19] reported that, the most favorable host plants of the cotton mealybug are Cotton, Eggplant, Sunflower, Chinese rose and Lantana[19].

This study showed that the first instar of P. solenopsis moves quickly towards the vials containing the host plant species more than other stages, where the mean population of the first instar was high in all observation intervals as compared with other developmental stages (Table1, Fig.1). These results are confirmatory to the findings of one of the researchers [20] who studied host plant preference and mortality of P. solenopsis on different plant species.

However, although both Tomato and Egg plant are belonging to the same family (Solanaceae), but tomato is more preferred by the host than Egg plant, because the first plant is succulent.

The response of the pest to the various host species is significantly different. The more suitable and preferred the host, the more is the fecundity of the pest in the locality and the same environmental conditions [21]. It is reported that the insect selection and utilization of a host plant depends upon both biophysical and biochemical factors [19].

The dietary requirement and fitness of phytophagous insect pests depends upon the nutrient chemistry of the host plant reflected that the quality and quantity of the food affects the food selection behavior, survival and reproduction of phytophagous insect pests. Sucking insects, including mealybug, are commonly attracted towards succulent plants that enriched with chlorophyll [20].

The selection of host plant by the pest is often divided into 'host plant finding' and 'host plant acceptance, where the volatile chemicals guide phytophagous insects to their host plants [22]. The insects assess the plant with respect to its suitability as host species and also its nutritional suitability. However, the plant secondary compounds play a significant and dominant role in host plant selection by a behavioral response of the insects to these chemicals [23].

The preference of Phenacoccus solenopsis for the family Malvaceae is confirmed by the finding of one of the researcher [21] who study, under field conditions, the effect of host plant species, and season in three locations in Pakistan (Alipur, Multan, Faisalabad) on the fecundity of P.solenopsis , using 10 alternative host plants to determine its relative preference and suitability as feed. His results indicated that the host plant species belonging to the family Malvaceae (Cotton, Okra and China rose) has higher number of crawlers per female which varies significantly between different months according to the temperature and relative humidity. On contrast, locality has a non significant effect on fecundity.

Conclusion and Recommendation

All plant species which belong to the family Malvaceae such as Okra, cotton and Hambouk are the most favorable to Cotton mealybug. Plants species belonging to the families Verbenaceae (Lantana) and Solanaceae (Tomato) appeared to be an intermediate to attractiveness, while Egg plant (Solanaceae) and Raba (Aizoaceae) appeared to be the least preferred host plants at temperature of 25 to 28oC and relative humidity (RH) 25-28 %..

The study recommends further study on food preference and attitude of P. solenopsis under both; different climatic conditions in the laboratory and field to understand the magnitude of pest damage to economic crops so that to propose strategies for managing this serious pest.

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