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Host Plants Distribution and Overwintering of Cotton Mealybug (*Phenacoccus Solenopsis*; Hemiptera: Pseudococcidae)

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ABSTRACT

Phenacoccus solenopsis Tinsley (Hemiptera: Sternorrhyncha: Pseudococcidae) has been noted as a sap sucking pest on cultivated cotton *Gosspium hirsutum* L. in Pakistan from 2005. Since 2005, this New World species has emerged as serious pest of cotton and other crops and weeds in Pakistan and neighbouring countries. The species is polyphagous and invasive, and can attack many other economic crops. The study found the host plant range and the over wintering of the pest in agroecological conditions Pakistan during surveys from 2005 to 2009. This information can be helpful in management of this pest. © 2010 Friends Science Publishers

Key Words: *Phenacoccus solenopsis;* Pakistan; Host plants; Polyphagous mealybug

INTRODUCTION

Phenacoccus. solenopsis Tinsley (Hemiptera: Sternorrhyncha: Coccoidea: Pseudococcidae) has been reported from 35 localities of various ecological zones of the globe (Ben-Dov *et al.*, 2009). It has a wide range of variation in morphological characters, biological adaptations and ecological adjustability (Hodgson *et al.*, 2008). *P. solenopsis* was initially reported as a pest of cotton in Texas, USA (Fuchs *et al*., 1991). In Pakistan, from the year 2005 onwards, it has been recorded as a serious pest of cultivated cotton *Gosspium hirsutum* (Abbas *et al.*, 2007; Muhammad, 2007; Hodgson *et al.*, 2008). It has also been reported as a serious pest in India (Nagrare *et al*., 2008) and a potential serious threat in China (Wang *et al*., 2009) and other cotton growing countries including Pakistan. It has emerged as a potential serious pest of cotton in Pakistan (Hodgson *et al*., 2008). So far, it has been reported from 183 plants in 52 families (Ben-Dov *et al.*, 2009). Between 2002 and 2008, the average agricultural growth rate was 4.1% annually, but the production of cotton declined for three successive growing seasons (2005-2006, 2006-2007 & 2007-2008), by -8.7%, -1.2% and -9%, respectively (Naqvi & Nausheen, 2008) In 2007-2008, excessive rain combined with even more widespread damage by cotton mealybug (CMB) caused cotton yield to fall below the preceding three-year average by nearly 20%.

These studies were undertaken in field conditions of cotton growing districts of Pakistan to determine the range of host plant species with relative percentage infestation and level of intensity. More over carry over and over wintering was also studied so that it may help in decision making for management of this serious pest.

MATERIALS AND METHODS

These studies were carried out from year 2005 to 2009. The pest cotton mealybug *P. solenopsis* was closely observed on all the alternative plants in some cotton growing districts of Punjab and Sindh. Unidentified host plants were taken to the botanist for authoritative identification followed by listing. More than one locality was studied for each host species, to show that the same findings were repeated more than once. If the pest was recorded on the same host from at least more than five different localities in each case with the host species harbouring all the stages of the pest along with the breeding female, it was included in host plant list. The serial number allotted to each host species in the list (Table I) has been used as the reference number of that host-plant species in subsequent analyses and graphs.

The data on percentage infestation was calculated as:

Percentage infestation = No of plants infested/No of plants observed *100.

The level of intensity was standardized in the

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following ways. The maximum population of the pest on fresh biomass of the host plant was recorded and it was afterwards standardized on 20 g biomass of that host plant. Standardization was necessary, because the host-plant species varied in size from tiny plants like hazardani *Euphorbia prostrate* to large shrubs like shoe flower like *Hibiscus rosa-sinensis*. The seasonal growth implicated taking observations on a growing weed having 3-5 leaves in January. However it could not be compared with the same weed in April, when it had increased in size by 10-15 times. In order to make the data comparable, values taken per small plant or per upper six inches of the plant or per twig, where ever there was cluster of maximum population, were converted to number of pest population per 20 g fresh biomass of the host plant. The following conversion formula was used:

Maximum population recorded per sample unit = X
Average fresh biomass weight (grams) of unit = Y
Conversion factor = X (20/Y).

The maximum CMB population per 20 g of fresh biomass for each host-plant species was compared statistically using Minitab 15 statistical software. The data for different years, different months of observation and different districts visited were summarized with descriptive statistics to facilitate viewing the results.

For enlisting the host plant species, in some cases, where infestation could not be confirmed in the field, the host plants were taken to the laboratory. The host-pest relationship was confirmed by rearing the crawler of an adult female cotton mealybug on cut pieces of the subject host plant in the laboratory using a small transparent plastic glass petri dish of 5.5 cm diameter having a relatively tight lid. The favourite portion of the host plant under study was placed in a Petri dish daily, or on alternate days, under laboratory conditions at 25±2°C and RH 65±5% and the mortality or establishment was observed daily. Three replicates were made for each host-plant species. If the pest completed its life cycle and produced a crawler sac again on the host plant, it was recognized as a host of the pest mealybug. If the crawlers died or failed to mature or breed it was declared a non-host plant.

RESULTS AND DISCUSSION

The results of this study have been summarized in three tables. Table I shows the list of host plant species in alphabetical order of families. List of host plant species in order of percentage infestation and ranking of intensity of infestation on host plants and given in Tables II. Similarly the carryover of the pest on the above mentioned host plant throughout the season conducted during the observation of the pest in the field from 2005-2008 is summarized in Table III.

Until 2005, no alternate hosts of cotton mealybug were known, because the identity of the pest was uncertain and the problem was new. In the present study, a total of 55 host-plants in 18 families are reported (Hodgson *et al.*, 2008). The host-plants of cotton mealybug listed by ICAC Recorder (2008) included 22 plant species, 18 of which agree with the present study. Muhammad (2007) indicated that there were 300 host plants of the mealybug but this number has been quoted for *Maconellicoccus hirsutus*. Some host plants of cotton mealybug *P. solenopsis* were also mentioned by Muhammad (2007) but most of the plants listed were incompletely named. The diversity of host plants observed during the surveys reflected the preferences of the pest in natural conditions. Cotton (*G. hirsutum*) and shoe flower (*H. rosa-sinensis*) were the top two preferred host-plant species, when measured either in the laboratory by the number of developing eggs within a dissected adult female, or in the field by the cotton mealybug (CMB) infestation intensity and percentage CMB infestation on observed host plants. The results of these two studies support each other (Abbas, 2010, unpublished). The effect of tobacco (*Nicotiana tabacum*) on egg and crawler production was not observed, so it cannot be compared with cotton. The CMB survey results also support a generalization that the host plant-species found to be most heavily infested were most conducive to the pest. The percentage infestation and its intensity are important parameters for decision-making in pest management.

These findings are also in agreement with (Ben-Dov *et al*., 2009). The most comprehensive study of alternate hosts of cotton mealybug *P. solenopsis* was published recently by Arif *et al*. (2009). It documented 154 host-plant species including 20 economically important field crops, 64 weeds, 45 ornamental plants and 25 shrubs and trees, belonging to a total of 53 plant families. When analyzed critically, this list was similar to the list of 55 confirmed host plants determined in the present study and included all the plants listed in Table I. Arif *et al*. (2009) divided the hosts into four categories: Incidental, Low, Medium and High. Among the reported host plants reported in Arif *et al.* (2009), 72 species fell in category incidental, 58 in category low, 15 in category medium and 9 in category high. The present study only reported as hosts the members of categories medium and high and a few from category low. All the plants reported in category high by Arif *et al.* (2009) [i.e., *Xanthium strumarium* (Asteraceae); *Trianthema partulacastrum* (Aiozoaceae); *Abutilon indicum, A. mucatum, Gossypium hirsutum, Hibiscus mutabilis, H. rosa-sinensis* (Malvaceae) *Solanum melongena* and *Withania somnifera* (solenaceae)] are listed in Table I, except *A. muticum*, another species of the genus *Abutilon*. Similarly out of 15 host-plant species reported in category 'medium' by Arif *et al.* (2009), 66% are included in and a further 13.4% are additional species (Table I). In category high (Arif *et al.*, 2009) some of the plant species were different from hosts listed in Table I, however 60% of the host-plants reported as CMB hosts in present study were listed as CMB host by Arif *et al.* (2009). There are some differences in

Table I: List of host plant species in alphabetical order of families

S. No.	Plant family	Latin name	Vernacular Name	English name
1	Aizoaceae	*Trianthema portulacastrum* L.	Itsit	Horse purslane
2	Amaranthaceae	*Achyranthes aspera* L.	Puth kanda	Prickly chafflower
3	Amaranthaceae	*Amaranthus spinosus* L.	Chulai	Spiny amaranth
4	Amaranthaceae	*Amaranthus paniculatus* L.	Billi booti	Scarlet
5	Amaranthaceae	*Amaranthus viridis* L.	Jangli chulai	Pigweed
6	Amaranthaceae	*Digera muricata* Mart.	Tandla	Digera
7	Asteraceae	*Carthamus oxyacantha* M. Bieb.	Pohli	Wild safflower
8	Asteraceae	*Cirsium arvense* (L.) Scop.	Leh	Canadian thistle
9	Asteraceae	*Conyza ambigua* DC.	Lusan booti	Fleabane
10	Asteraceae	*Conyza bonariensis* (L.) Cronquist	Lusan booti	Hairy fleabane
11	Asteraceae	*Eclipta prostrate* (L.) L.	Daryai booti	
12	Asteraceae	*Helianthus annuus* L.	Suraj mukhi	Sunflower
13	Asteraceae	*Launea nudicaulis* Hook. f.	Peeli dodhak	
14	Asteraceae	*Parthenium hysterophorus* L.	Gajar booti	
15	Asteraceae	*Xanthium strumarium* L.	Muhabbat Booti	Cocklebur
16	Boraginaceae	*Heliotropium europeaum* L.	Namkeen Booti	
17	Boraginaceae	*Heliotropium indicum* L.	Oont chra	Wild heliotrope
18	Brassicaceae	*Coronopus didimus* L. Sm.	Jangli haloon	Swine cress
19	Brassicaceae	*Lepidium sativum* L.	Haloon	
20	Cannabinaceae	*Cannabis sativa* L.	Bhang	
21	Chenopodiaceae	*Atriplex crassifolia* C.A. Mey.	Lani	
22	Chenopodiaceae	*Chenopodium album* L.	Bathu	Lambs quarters
23	Chenopodiaceae	*Chenopodium morale* L.	Krund	Fathen
24	Convulvulaceae	*Convolvulus arvensis* L.	Lehli	Field bindweed
25	Cucurbitaceae	*Cucumis melo* L.	Kharboza	Musk melon
26	Cucurbitaceae	*Cucumis sativus* L.	Khera	Cucurbits
27	Cucurbitaceae	*Cucurbita moschata* Duchesne	Kaddu	Pumpkin
28	Euphorbiaceae	*Euphorbia prostrate* Ait.	Hazardani	
29	Euphorbiaceae	*Euphorbia granulate* Forssk.	Hazardani Dodhak	Trailing spurge
30	Euphorbiaceae	*Euphorbia hirta* L.	Lal dhodhak	Red garden spurge
31	Fabaceae	*Medicago alba* E.H.L. Krause	Do	Honey clover
32	Fabaceae	*Medicago polymorpha* L.	Maina	Black clover
33	Fabaceae	*Melilotus indicus* (L.) All.	Seinji	Indian clover
34	Fumariaceae	*Fumaria indica* Pugsley	Shahtra	
35	Malvaceae	*Abutilon indicum* (L.) Sweet	Kangi booti	
36	Malvaceae	*Gossypium hirsutum* L.	Kapah	Cotton
37	Malvaceae	*Abelmoschus esculentus* (L.) Moensch	Bhindi	Lady's finger
38	Malvaceae	*Hibiscus mutabilis* L.	-	Cotton rose
39	Malvaceae	*Hibiscus rosa-sinensis* L.	Gudhal	Shoe flower
40	Nyctaginaceae	*Boerhavia diffusa* L.	Jangli itsit	
41	Nyctaginaceae	*Bougainvillea spectabilis* Willd.	Boganbilla	Bougainvillea
42	Portulacaceae	*Portulaca oleracea* L.	Kulfa, lunak	Common purslane
43	Portulaceae	*Portulaca grandiflora* Hook.	Gule dupehri	
44	Solanaceae	*Capsicum annuum* L.	Mirch	Chillies
45	Solanaceae	*Datura alba* Rumph. Ex Nees	Dhatura	
46	Solanaceae	*Lycopersicon esculentum* Mill.	Tamater	Tomato
47	Solanaceae	*Nicotiana tabacum* L.	Tamakho	Tobacco
48	Solanaceae	*Solanum melongena* L.	Bengun	Brinjal
49	Solanaceae	*Solanum nigrum* L.	Mako	Black nightshade
50	Solanaceae	*Solanum tuberosum* L.	Aaloo	Potato
51	Solanaceae	*Withania somnifera* (L.) Dunal	Aksun	
52	Verbenaceae	*Clerodendron inerme* Gaertn.	Gardenia	
53	Verbenaceae	*Duranta repens* L.	Duranta	
54	Verbenaceae	*Lantana camara* L.	Lantana	
55	Zygophyllaceae	*Tribulus terrestris* L.	Bhakra	Puncture clover

nomenclature between the studies, mainly in generic combinations and some family names, which may reflect different opinions of the botanists or literature sources of different ages.

In category incidental only few of the plants reported (for example, *Salvadora oleoides* Decsn.) were observed as casually harbouring the pest in the present study, but these did not fulfil the definition of the host applied in this study. As indicated by Arif *et al.* (2009), these were incidental hosts. It has been observed in the field that cotton mealybug can be carried by visiting birds and rodents to nearby trees like jangli kikir *Acacia leucophloea*, phulai *A. modesta*, siris *Albizzia lebbek*, (Mimosaceae); mango *Mangifera indica* (Anacardiaceae); symbol *Salmalia malabarica* (Bombacaceae); shisham *Dalbargia sisso* (Fabaceae); date palm *Phoenix dactylifera* (Palmae) etc., where it can survive for a few days. Although these plants play a role as a temporary lodge for the mealybug but these plants do not

Table II: The host plants of cotton mealybug listed in order of percentage infestation level observed during survey of CMB on various host plants, 2005-2008

Host No.	Vernacular name	Latin name	%age infestation			Intensity level		
			n	Mean±SD	rank	n	Mean±SD	rank
39	Gudhal	*Hibiscus rosa-sinensis*	14	96.4±7.5	1.	14	105.7±62	3
47	Tamakho	*Nicotiana tabacum*	5	44.8±35	2.	5	141.6±116.1	1
51	Aksun	*Withania somnifera*	5	41.3±42.1	3.	5	73.6±116.2	4
41	Boganbilla	*Bougainvillea spectabilis*	5	40.2±37	4.	5	8.0±9.3	28
54	Lantana	*Lantana camara*	7	38.0±39.3	5.	7	23.4±21.3	11
53	Duranta	*Duranta repens*	6	35.3±34.1	6.	6	17.7±13.4	12
36	Kapah	*Gossypium hirsutum*	25	29.3±33.5	7.	24	114.5±107.1	2
42	Gule dupehri	*Portulaca grandiflora*	10	23.3±26.9	8.	10	16.2±18.1	14
37	Bhindi	*Abelmoschus esculentus*	10	18.9±23.2	9.	10	41.5±44.3	5
15	Muhabbat booti	*Xanthium strumarium*	7	17.9±18.9	10.	7	34.7±28.5	7
48	Bengun	*Solanum melongena*	7	16.1±20.1	11.	7	31.0±24.8	8
28	Hazardani Dodhak	*Euphorbia prostrate*	16	14.9±28	12.	16	4.1±3.4	47
52	Gardenia	*Clerodendron inerme*	9	14.3±15.1	13.	9	11.9±11.7	19
49	Mako	*Solanum nigrum*	11	13.7±15.6	14.	11	9.9±9.0	22
38	Bhindi phool	*Hibiscus mutabilis*	10	13.3±18	15.	9	11.8±9.8	20
34	Shahtra	*Fumaria indica*	7	13.1±16	16.	7	3.1±2.3	51
24	Lehli	*Convolvulus arvensis*	15	11.2±16	17.	15	3.4±2.5	49
2	Puth kanda	*Achyranthes aspera*	8	10.9±5.2	18.	8	36.9±31.6	6
40	Jangli itsit	*Boerhavia diffusa*	5	8.9±12.7	19.	5	5.6±5.9	37
23	Krund	*Chenopodium morale*	12	8.7±16.7	20.	12	3.7±6.9	48
14	Gajar booti	*Parthenium hysterophorus*	8	8.2±6	21.	8	26.4±29.3	10
45	Dhatura	*Datura alba*	6	7.8±3.2	22.	6	17.5±14.7	13
35	Kangi booti	*Abutilon indicum*	7	7.6±3.3	23.	7	28.4±22.3	9
7	Pohli	*Carthamus oxyacantha*	8	7.5±6.6	24.	8	7.6±6.1	29
31	Jangli methi	*Medicago alba*	5	6.5±8.4	25.	5	2.4±2.1	53
46	Tamater	*Lycopersicon esculentum*	17	6.2±8.3	26.	17	15.1±21.8	15
33	Seinji	*Melilotus indicus*	11	5.9±8.1	27.	11	2.4±2.0	54
30	Laldhodhak	*Euphorbia hirta*	12	5.7±5.7	28.	12	8.5±10.9	30
50	Aaloo	*Solanum tuberosum*	6	5.0±5.7	29.	6	11.0±9.6	21
1	Itsit	*Trianthema portulacastrum*	15	4.9±5.8	30.	15	14.9±20.6	16
25	Kharboza	*Cucumis melo*	8	4.6±3.2	31.	8	9.0±7.6	25
11	Daryaibooti	*Eclipta prostrate*	8	4.0±2.5	32.	8	5.0±4.1	40
13	Peelidodhak	*Launea nudicaulis*	6	4.0±6.9	33.	12	8.5±10.9	30
19	Haloon	*Lepidium sativum*	5	4.0±2.5	34.	5	9.2±4.4	23
27	Kaddu	*Cucurbita moschata*	9	4.0±5.2	35.	9	4.3±4.2	45
4	Billi booti	*Amaranthus paniculatus*	7	3.9±4.0	36.	7	6.6±5.1	33
29	Hazardani	*Euphorbia granulate*	7	3.9±3.4	37.	7	6.9±8.1	32
43	Kulfa lunak	*Portulaca oleracea*	10	3.8±3.3	38.	10	5.0±4.9	42
44	Mirch	*Capsicum annuum*	5	3.8±2	49.	5	5.2±4.8	39
55	Bhakra	*Tribulus terrestris*	6	3.8±2.2	40.	6	9.2±7.5	24
18	Janglihaloon	*Coronopus didimus*	6	3.7±2.3	41.	6	8.5±5.7	26
8	Leh	*Cirsium arvense*	6	3.6±3.8	42.	6	2.7±2.3	52
9	Lusan booti	*Conyza ambigua*	7	3.6±4.1	43.	7	5.1±5.4	40
5	Jangli chulai	*Amaranthus viridis*	16	3.5±2.6	44.	8	4.8±3.7	43
32	Maina	*Medicago polymorpha*	5	3.3±2.5	45.	5	6.6±4.4	34
6	Tandla	*Digera muricata*	8	3.1±2.5	46.	8	12.4±9.8	18
21	Lani	*Atriplex crassifolia*	7	3.1±2.6	47.	7	5.7±4.6	36
26	Khera	*Cucumis sativus*	7	3.1±2.9	48.	7	7.1±4.9	31
22	Bathu	*Chenopodium album*	20	2.9±3.8	49.	20	1.8±1.7	55
17	Oont chra	*Heliotropium indicum*	6	2.7±4.8	50.	6	3.2±5.0	50
20	Bhang	*Cannabis sativa*	8	2.7±1.8	51.	8	13.6±10	17
10	Lusan booti	*Conyza bonariensis*	7	2.4±3.6	52.	7	6.3±5.3	35
12	Suraj mukhi	*Helianthus annuus*	9	2.2±3.3	53.	8	5.5±7.7	38
3	Chulai	*Amaranthus spinosus*	9	2.1±2.7	54.	9	4.3±4.9	44
6	Namkeen	*Heliotropium europeaum*	9	1.8±2	55.	8	4.1±5.4	46

n = number of observations

fall in the criteria of true 'host plants' as defined in this study.

The observations made by Arif *et al.* (2009) were correct, but as explained in the section on field observations in this study (Abbas, 2010 unpublished) cotton mealybug *P. solenopsis* has a remarkable ability to withstand starvation; a mature adult female was observed to survive up to 12 days of starvation in October (at a mean temperature of 27.8ºC & 50.6% Relative Humidity). A confusing observation was that when a mature adult female was near to death in winter it produced its crawler sac, which was sheltered under its moribund body through the un-favorable conditions, while

Table III: The summary of population intensity on various host plants, observed during field survey of cotton mealybug in Pakistan in different months from 2005-2008

Month	Host-plant species no.
Jan	47, 50
Feb	1, 3, 4, 5, 6, 10, 13, 19, 22, 32, 34, 40, 42, 43, 47, 50, 52, 53, 54, 55
Mar	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 33, 34, 35, 36, 37, 39, 40, 42, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54
Apr	2, 3, 4, 6, 7, 8, 9, 10,11, 12, 13, 15, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 36, 37, 38, 39, 40, 42, 43, 44, 45, 46, 48, 49, 50, 52, 53, 54, 55
May	1, 3, 4, 5, 7, 8, 9, 10, 12, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 32, 36, 37, 39, 44, 45, 46, 48, 49, 54
Jun	1, 2, 3, 4, 5, 6, 9, 10, 11, 8, 10,14, 20,21,22 24, 28, 30, 31, 32, 33, 36, 38, 39, 41, 42, 43, 48, 49, 53, 55
Jul	1, 2, 9, 13, 15, 23, 28, 31, 35, 36, 39, 43, 44, 49, 51, 52, 53, 55
Aug	1, 5,10, 14,15, 19, 20, 32, 36, 38, 39, 41, 43, 45, 49, 52, 55
Sep	1, 3, 7, 13, 14, 16, 17, 21, 22, 23, 27, 28, 29, 30, 36, 37, 38, 39, 40, 42, 46, 50, 52, 54
Oct	1, 2, 6, 7,10, 11, 13, 14, 15,16, 17, 21, 22, 23, 24, 28, 29, 30, 33, 35, 36, 37, 38, 39, 40, 41, 42, 43, 45, 46, 49, 52, 54
Nov	7, 11, 13, 17, 22, 23, 28, 29, 30, 36, 40
Dec	11, 17, 18, 21, 22, 23, 28, 29, 30, 35, 39, 45

For host-plant species names, see the S. No. in Table I

the development of the crawlers was prolonged by the low temperatures. When favorable conditions returned, the crawlers emerged from beneath the body of the dead female in search of favourable feeding sites. Future investigations and experiments are imperative to strengthen the status of these observations and their role in management of this pest.

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