

Weed hosts of cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae)

S. Vennila^{1*}, Y.G. Prasad², M. Prabhakar², Meenu Agarwal¹, G. Sreedevi² and O.M. Bambawale¹

¹National Centre for Integrated Pest Management, New Delhi-110 112, India

²Central Research Institute for Dryland Agriculture, Hyderabad-500 059, India

*Corresponding Author email : svennila96@gmail.com

Publication Info

Paper received:
29 November 2011

Revised received:
10 July 2012

Accepted:
26 July 2012

Abstract

The exotic cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) invaded India during 2006, and caused widespread infestation across all nine cotton growing states. *P. solenopsis* also infested weeds that aided its faster spread and increased severity across cotton fields. Two year survey carried out to document host plants of *P. solenopsis* between 2008 and 2010 revealed 27, 83, 59 and 108 weeds belonging to 8, 18, 10 and 32 families serving as alternate hosts at North, Central, South and All India cotton growing zones, respectively. Plant species of four families viz., Asteraceae, Amaranthaceae, Malvaceae and Lamiaceae constituted almost 50% of the weed hosts. While 39 weed species supported *P. solenopsis* multiplication during the cotton season, 37 were hosts during off season. Higher number of weeds as off season hosts (17) outnumbering cotton season (13) at Central over other zones indicated the strong carryover of the pest aided by weeds between two cotton seasons. Six, two and seven weed hosts had the extreme severity of Grade 4 during cotton, off and cotton + off seasons, respectively. Higher number of weed hosts of *P. solenopsis* were located at roadside: South (12) > Central (8) > North (3) zones. Commonality of weed hosts was higher between C+S zones, while no weed host was common between N+S zones. Paper furnishes the wide range of weed hosts of *P. solenopsis*, discusses their significance, and formulated general and specific cultural management strategies for nationwide implementation to prevent its outbreaks.

Key words

Cotton mealybug, *Phenacoccus solenopsis*, Weed hosts, Severity, Spatial distribution

Introduction

Geographic range, abundance, severity and timing of attack of an invasive insect are directly dependent on its ability to feed and reproduce on wide range of host plants besides its adaptiveness to biotic and abiotic environmental resistant forces (Vennila *et al.*, 2011). *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) has been reported from 35 global locations of various ecological zones (Ben-Dov *et al.*, 2009). It has been recorded as an invasive and serious pest of cultivated cotton *Gossypium hirsutum* L. first at Gujarat (Jhala *et al.*, 2008) followed by its wide spread occurrence across nine cotton growing states of the country viz., Punjab, Haryana, Rajasthan, Gujarat, Madhya

Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu during 2008-09 crop season (Nagrare *et al.*, 2009). Reports of 183 host plants from 52 families at USA (Ben-Dov *et al.*, 2009) and 154 hosts including 64 weeds from 53 families in Pakistan (Arif *et al.*, 2009) are available. Out of a total record of 84 host plants across 28 families recorded at Central cotton growing zone of India up to 2009, 60 plant species from 22 families belonged to weeds (Vennila *et al.*, 2010). Although the immediate management of outbreak of an invaded pest often involves instant recommendation of insecticides, its effective suppression does not result without formulation of carefully evolved holistic strategy. Reliance on insecticides continuously rather pre-empt the possible and successful suppression or even eradication

of the invasive pest by natural environmental factors. Hence documentation of host range of *P. solenopsis* over space and time was undertaken to understand the source and time of pest spread that could lead to formulation of scientific and non insecticidal strategic wide area management practices.

Materials and Methods

Study was conducted over two years between July 2008 and June 2010 through fortnightly surveys in three representative States of Indian cotton growing zones viz., Haryana of North zone (N), Maharashtra of Central zone (C) and Tamil Nadu of South zone (S). The growing seasons and cropping systems of North, Central and South Zones are April-November, June-December and August-February, and cotton-wheat, cotton+ pigeonpea-fallow and cotton + pulse – maize, respectively. The cotton cultivation at North zone was completely under irrigation. Near to 65% of cotton grown in South and Central zones was rainfed. All zones had largely (>90%) cultivated Bt hybrids. Weed hosts of the cotton ecosystem harbouring *P. solenopsis* were located and severity of infestation was measured using zero to four scale viz., 0 – no mealybug; Grade 1(G1) – scattered appearance of few mealybugs on the plant; Grade 2(G2) – severe incidence of mealybug on any one branch of the plant; Grade 3(G3) – severe incidence of mealybug on more than one branch or half portion of the plant and Grade 4(G4) – severe incidence of mealy bug on the whole plant. The number of plants for anyone weed host of *P. solenopsis* during each survey period was ten. The weed plants were also collected and preserved as herbarium to confirm their botanical identity from College of Agriculture, PDKV, and Nagpur. The location of the weed hosts with *P. solenopsis* infestation in the fields of cotton ecosystem viz., within fields or field boundary or road side or near water channels was also noted during surveys. Number of weeds for their record as hosts of *P. solenopsis*, exclusive and common among cotton growing zones, their distribution across plant families, seasonality, severity and locations were made. General cultural and zone specific weed management recommendations for suppression of *P. solenopsis* were formulated based on diversity, seasonality, severity and spatial distribution of weeds as alternate hosts of *P. solenopsis*.

Results and Discussion

Spread of the exotic mealybug *P. solenopsis* can be limited with an understanding of temporal and spatial factors responsible for its carryover and perpetuation in agro ecosystems. The vast range of alternate host plants available seasonally or yearlong in the agro ecosystems offer sustenance to the invaded species. Since weeds are always associated with all cropping systems and regions, their role

as reservoir of mealybug *P. solenopsis* was analysed through the present study to evolve effective cultural management strategies. The North, Central and South cotton zones belonged to different agro climatic regions however with sequentially overlapping cotton growing seasons. Therefore, it has become essential to look for weed species exclusive to each zone, common between any two zones and ubiquitous among all three zones for their diversity, seasonality, severity and locations for evolving general and specific strategies for *P. solenopsis* management.

Diversity of weed hosts : A total of 108 weed species from 32 different plant families served as hosts of *P. solenopsis* in India which was higher than those recorded (65) from Pakistan by Arif et al. (2009). Host records of weeds indicated highest number of exclusive hosts at Central zone (36) followed by South (13) and North (11) zones belonging to 18, 10 and 8 families, respectively. While common hosts were minimal between N+C (2) and N+S (1) zones, the highest commonality was observed between C+S (32) zones. The two monocots viz., *Cyperus rotundus* and *Cynodon dactylon* were the only common hosts of *P. solenopsis* between N+C zones other than cotton. *Portulaca grandiflora* was common host between N+S zones. Thirteen weed species from 8 families were common across all the three zones indicating the extent of regional similarity of weed species across cotton growing zones (Table 1). The irrigated tract of North zone, and rainfed regions among C+S zones are the reasons for the observed differences in the commonality of weed hosts of *P. solenopsis*.

Distribution of all documented weed hosts of the three zones indicated single to 14 species belonging to a family of plant kingdom. Highest number of weed hosts of *P. solenopsis* belonged to Asteraceae (14) > Malvaceae (12) > Amaranthaceae (11) > Lamiaceae (9) > Euphorbiaceae (7) > Poaceae (6) (Fig.1). Fifteen families had single weed

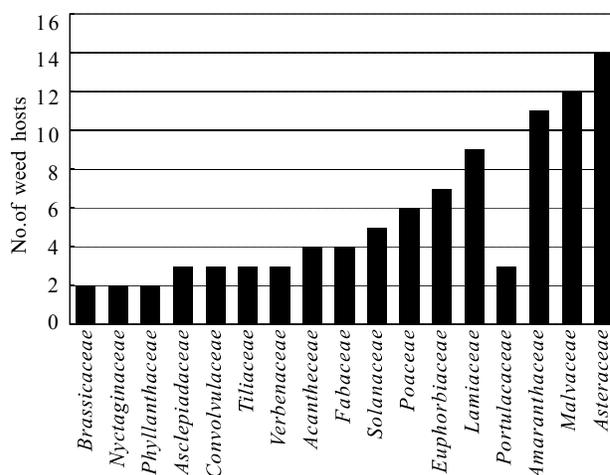


Fig. 1 : Families of weed host plants of *P. solenopsis*

species as hosts for *P. solenopsis*. Dicot weeds served as preferential hosts for *P. solenopsis* over monocots. There has been higher similarity of host families recorded in the present study with that of Arif *et al.* (2009).

Seasonality of weed hosts : Number of exclusive weed hosts during off season was higher than cotton season at Central and North zones. They were equal in number (13) at Central and South zones during cotton season. The number of exclusive hosts of *P. solenopsis* present during cotton + off seasons was three and six in respect of North and Central zones. All the exclusive hosts of South zone occurring only during the cotton season enhance the possibility of effective spread on cotton. On the contrary, no exclusive host of *P. solenopsis* during off or cotton+off seasons indicated the importance of common hosts necessary for carry over and sustenance of the pest at South zone. No weed species was common for seasonality between N+S zones which could be attributed to the contrasting bio geographical features of zones. The seasonality of the common hosts indicated the dominance of off season hosts at C+S zones (Table 2). *Digera muricata* (Amaranthaceae), *Xanthium strumarium* (Asteraceae) and *Solanum virginianum* (Solanaceae) during cotton season, and *Lawsonia inermis* (Lythraceae), *Convolvulus arvensis* (Convolvulaceae) and *Datura metel* (Solanaceae) during off season, and *Physalis minima* (Solanaceae), *Parthenium hysterophorus* (Asteraceae) and *Abutilon indicum* (Malvaceae) throughout the year were the common weed hosts across all three zones. While *Portulaca grandiflora* occurred during cotton season at North zone the seasonality was year round at South zone. Indications of more number of host plants harbouring *P. solenopsis* during March and April months, and most of the common host species between off and cotton growing seasons in Pakistan reported by Abbas *et al.* (2010b) support the present observations from the India.

Severity of *P. solenopsis* on weed hosts : All scales of *P. solenopsis* severity between G1 and G4 were noticed for exclusive weed hosts in all three zones. Number of weed hosts with G1 severity was considerable among exclusive and common hosts indicating their role towards carryover of the insect rather than being suitable for perpetuation. Arif *et al.* (2009) also reported large number of incidental hosts of *P. solenopsis* that could be equated to G1 hosts of the present study. The highest number of weed hosts of G1 and G4 severity at Central zone implied the possible vast and fast spread of the species, respectively. The North zone specific weeds that had the highest severity (G4) were *Helianthus spp.* (Asteraceae) and *Sida cordifolia* (Malvaceae). Out of ten G4 weed hosts of Central zone three (*Lactuca runcinata*, *Acmella uliginosa* and *Pentanema indicum*) and two (*Abelmoschus ficulneus* and

Azanza lampas) belonged to Asteraceae and Malvaceae, respectively. *Portulaca quadrifida* (Portulacaceae), *Phyllanthus niruri* (Euphorbiaceae), *Boerhavia diffusa* (Nyctaginaceae), *Asteracantha longifolia* (Acantheceae) and *Triumfetta rhomboidea* (Tiliaceae) had also served as G4 hosts at Central zone. *Sida acuta* (Malvaceae) was the only weed host of South zone that had G4 severity (Table 3). Out of 13 common weed hosts 8 had similar severity, and two weed hosts *Parthenium hysterophorus* (Asteraceae) and *Trianthema portulacastrum* (Aizoaceae) had shown G4 severity of *P. solenopsis* across all the cotton zones (N+C+S).

Seasonality of weed hosts with extreme severity (G4) : Only two exclusive weed hosts viz., *Helianthus debilis* (Asteraceae) and *Sida cordifolia* (Malvaceae) of North zone found through cotton and off seasons had extreme severity. Weed hosts numbering five (*Asteracantha longifolia*, *Azanza lampas*, *Lactuca runcinata*, *Triumfetta rhomboidea* and *Portulaca quadrifida*) and four (*Acmella uliginosa*, *Phyllanthus niruri*, *Abelmoschus ficulneus* and *Boerhavia diffusa*) had G4 severity during cotton and cotton+off seasons, respectively. *Pentanema indicum* (Asteraceae) was the only off season Central zone host with G4 severity. *Sida acuta* alone had G4 severity at South zone during cotton season. *Euphorbia hirta* was the only G4 common host at C+S zones. *Parthenium hysterophorus* prevalent at all zones (N+S+C) had served as year round alternate host to *P. solenopsis* (Table 4).

Spatial distribution of weed hosts of *P. solenopsis* : The weed hosts of *P. solenopsis* were grouped according to their presence exclusive to a location and common among two, three or more locations. Roadside located weeds dominated as hosts of *P. solenopsis* at all zones individually and among common hosts. *Raphanus raphanistrum* (Brassicaceae) and *Hyptis suaveolens* (Lamiaceae) were the exclusive hosts in respect of North and South zones found within fields of cotton. On the other hand, higher numbers of exclusive hosts at Central zone were located within cotton fields and in diverse combination of locations (eg. field borders + roadside, within fields + field borders, field border + roadside and so on). Twelve out of 13 exclusive hosts of South zone were located along roadside implies their significant role of roadside weeds in determining spatial spread. The common hosts of C+S zones were distributed across 10 of the 12 locations documented. Two common weed hosts viz., *Cyperus rotundus* (Cyperaceae) and *Cynodon dactylon* (Poaceae) at N+C zone located at field (F) + border (B) + roadside (R). Since canal irrigation is common at North zone weed hosts found along water channels(w) (*Rumex retroflexus* (Amaranthaceae) and *Brassica sp* (Brassicaceae)) also served as alternate hosts to *P. solenopsis* (Table 5). Distribution of weeds that serve

Table 1 : Profile of weed hosts of *P. solenopsis*

Particulars	Number of weed species							All India
	Exclusive			Common				
	North	Central	South	N+C	N+S	C+S	N+C+S	
Total records	11	36	13	2	1	32	13	108
Number of families	8	18	10	2	1	18	8	32

Table 2 : Seasonality of weed hosts of *P. solenopsis*

Season	Weed hosts (nos.)						All India
	Exclusive			Common			
	North	Central	South	N+C	C+S	N+C+S	
Cotton season	3	13	13	1	6	3	39
Off season	5	17	-	-	12	3	37
Cotton +off seasons	3	6	-	-	2	3	13

Table 3 : Severity of weed hosts of *P. solenopsis*

Severity*	Weed hosts (nos.)					
	Exclusive			Common		
	North	Central	South	N+C	C+S	N+C+S
G1	3	17	4	2	8	3
G2	3	6	5	-	7	2
G3	3	3	1	-	2	1
G4	2	10	1	-	3	2

(* : G1: About 1-10 mealybugs scattered over the plant; G2: One branch infested heavily with mealybugs ; G3: Two or more branches infested heavily with mealybugs, up to 50% plant affected and G4: Complete plant affected with mealybugs)

Table 4 : Seasonality versus extreme severity (G4)

Details of hosts	Weed hosts (nos.)					
	Exclusive			Common		
	North	Central	South	C+S	N+C+S	All India
Cotton season	-	5	1	-	-	6
Off season	-	1	-	1	-	2
Cotton +off seasons	2	4	-	-	1	7

Table 5 : Spatial distribution of weed hosts of *P. solenopsis*

Location*	Exclusive weed hosts			Common weed hosts		
	North	Central	South	N+C	C+S	N+C+S
B		2			1	1
BR		5			1	
BRW		1			1	
F	1	4	1		1	
FB		5			2	1
FBR	2	4		2	3	1
FR		7			4	
FRW	1					
R	3	8	12		8	3
RW	1				1	
FBRW	1				3	
W	2					

*B-field borders, R-roadside, F-within fields, W-Water channels

Table 6 : Weeds to be monitored and controlled for management of *P. solenopsis*

Region	Name of weed	When (season)	Location (where)
All cotton growing zones	Congress grass, <i>Parthenium hysterophorus</i>	Throughout the year	Fields, field borders and roadside
	Indian mallow, <i>Abutilon indicum</i>		Within fields, field borders, roadside and irrigation channels
North and Central zones	Giant pigweed, <i>Trianthema portulacastrum</i>	Off season	Within fields and roadside
	Burdock datura, <i>Xanthium strumarium</i>	Cotton season	Within fields, field borders and roadside
	Common spurge, <i>Euphorbia hirta</i>	Off season	Within fields, field borders, roadside and irrigation channels
	Coat buttons, <i>Tridax procumbens</i>		Within fields, field borders and roadside
	Whiskered commelina, <i>Commelina benghalensis</i>	Roadside	
	Country mallow khareti, <i>Sida cordifolia</i>	Throughout the year	Roadside
	Gule dupehri, <i>Portulaca grandiflora</i>	Cotton season	Within fields and roadside
	Wild jute, <i>Corchorus trilocularis</i>	Throughout the year	Within fields, field borders and roadside
	Red hogweed, <i>Boerhavia diffusa</i>		Within fields
	Hazardani, <i>Phyllanthus niruri</i>		Within fields and field borders
Central zone	Marsh para, <i>Cress Acmeilla uliginosa</i>		
	Ran bhendi, <i>Abelmoschus ficulneus</i>		
	Jangli-bhendi, <i>Azadirachta indica</i>	Cotton season	Border and roadside
	Wild purslane, <i>Portulaca quadrifida</i>		
	Pathari, <i>Lactuca runcinata</i>		
	False amaranth, <i>Digera muricata</i>		
	Water spiny ball, <i>Asteracantha longifolia</i>		
	Burr bush, <i>Triumfetta rhomboidea</i>		
	Sonkadi, <i>Pentanema indicum</i>	Off season	Within fields and field borders
	Pala aku, <i>Euphorbia geniculata</i>		Within fields, field borders, roadside and water channels
	Mountain knot grass, <i>Aerva lanata</i>	Throughout the year	Within fields and roadside
	Jangali amla, <i>Phyllanthus amarus</i>		Within fields, field borders and roadside
	Chilaka paraka, <i>Sida acuta</i>	Cotton season	Roadside
	Pulicheru, <i>Phyllanthus reticulatus</i>		
	Wild poinsettia, <i>Euphorbia geniculata</i>		Within fields, field borders and roadside
Purslane, <i>Portulaca oleracea</i>		Field borders, roadside and water channels	

as mealybug hosts indicated the need for weed management primarily along roadside and within fields across all zones. In addition, weed hosts at field border and along water channels in respect of Central and South zones, are recommended towards suppression of *P. solenopsis*. Monga et al. (2009) reported the spread of *P. solenopsis* from border rows to inside of the cotton fields and the need for early detection and initiation of insecticide interventions.

The vast diversity of weed host species of *P. solenopsis* suggests the possibility of its subtle presence in the agroecosystems all the time. Although the vast host range of *P. solenopsis* poses risk in terms of quicker and large scale spread, equal opportunities exists to exploit them for management of the pest when their exact role is identified. Since the mode of dispersal is also wide and varied, pest status needs continuous monitoring. Abbas et al. (2010 a) reported 173 plant species across 54 families from 26 countries representing different ecological zones. Current records from India would alter the host dimension across the globe. Host range analysis clearly indicated the larger monoculture of cotton vis a vis *P. solenopsis* preference for malvaceous hosts as one reason for the increased incidence and severity on the crop. Weed hosts viz., *Portulaca grandiflora* and *Xanthium strumarium* have been among the top ten hosts infested by *P. solenopsis* in Pakistan (Abbas et al. 2010b) and all of them had extreme (G4) severity in India, indicating similarities of host range and developmental attributes of the pest within Asian continent. The features of polyphagy and high reproductive potential associated with *P. solenopsis* itself provide innate capacity to the insect be a pest of economic significance. The sequentially placed cotton growing regions and seasons of India vis a vis the vast range of weed hosts available seasonally or yearlong in the vicinity of agro ecosystems offer sustenance and aid the species to attain pest status on the preferred host of cotton. Therefore, management of weeds per se and the pest on weeds gain utmost significance. Based on the seasonality and spatial distribution of the diverse weed hosts of *P. solenopsis* and the pest severity on them management strategies have been formulated that could be adopted (1) across all cotton growing zones, (2) common between any two cotton growing zones and (3) specific to a cotton growing zone (Table 6).

Current analysis of the significant ecological aspects of seasonality, severity and spatial distribution of *P. solenopsis* vis a vis host plants brought out clearly the

carry over hosts common and specific across cotton growing zones. Management of alternate hosts having moderate to high severity located along roadside, within fields and field borders would effectively suppress the pest. Continued practice of such recommendations has the potential to eradicate the pest from India, if practised simultaneously over cotton growing regions.

Acknowledgments

We sincerely acknowledge the technical assistance of all the project partners, and financial assistance of the World Bank funded National Agricultural Innovation Project (NAIP/DSS/C2046).

References

- Abbas, G., M.J. Arif, M. Ashfaq, M. Aslam and S. Saeed: The impact of some environmental factors on the fecundity of *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae): A serious pest of cotton and other crops. *Pak. J. Agril. Sci.*, **47**, 321-325 (2010a).
- Abbas, G., M.J. Arif, M. Ashfaq, M. Aslam and S. Saeed: Host plants, distribution and overwintering of cotton mealybug (*Phenacoccus solenopsis*; Hemiptera: Pseudococcidae). *Int. J. Agri. Biol.*, **12**, 421-425 (2010b).
- Arif, M.I., M. Rafiq and A. Ghaffar: Host plants of cotton mealybug (*Phenacoccus solenopsis*): A new menace to cotton agroecosystem of Punjab, Pakistan. *Int. J. Agri. Biol.*, **11**, 163-167 (2009).
- Ben-Dov, Y., D.R. Miller and G.A.P. Gibson: *Scale Net: A Searchable Information System on Scale Insects*. Available on-line at <http://www.sel.barc.usda.gov/scalenet.htm>. (2009).
- Jhala, R.C., T.M. Bharpoda and M.G. Patel: *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae), the mealybug species recorded first time on cotton and its alternate host plants in Gujarat, India. *Uttar Pradesh J. Zoology*, **28**, 403-406 (2008).
- Monga, D., Rishi Kumar, V. Pal and M.C. Jat: Mealybug a new pest of cotton crop in Haryana: A survey. *J. Insect Sci.*, **22**, 100-103 (2009).
- Nagrare, V.S., S. Kranthi, V.K. Biradar, N.N. Zade, V. Sangode, G. Kakde, R.M. Shukla, D. Shivare, B.M. Khadi and K.R. Kranthi: Widespread infestation of the exotic mealybug species, *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae), on cotton in India. *Bull. Entomolo. Res.*, **99**, 537-541 (2009).
- Vennila, S., V.V. Ramamurthy, A. Deshmukh, D.B. Pinjarkar, M. Agarwal, P.C. Pagar, Y.G. Prasad, M. Prabhakar, K.R. Kranthi and O.M. Bambawale: "A Treatise on Mealybugs of Central Indian Cotton Production System". Technical Bulletin No. 24, NCIPM, Pusa Campus, New Delhi, pp.39 (2010).
- Vennila, S., Y.G. Prasad, M. Prabhakar, Rishi Kumar, V. Nagrare, M. Amutha, Dharajyothi, Meenu Agarwal, G. Sreedevi, B. Venkateswarlu, K.R. Kranthi and O.M. Bambawale: "Spatio-temporal distribution of host plants of cotton mealybug, *Phenacoccus solenopsis* Tinsley in India". Technical Bulletin 26, NCIPM, Pusa Campus, New Delhi, pp.50 (2011).