Seasonality and severity of Cotton mealybug, *Phenacoccus solenopsis* Tinsley on Vegetable crops

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ABSTRACT

Two year survey at fortnightly intervals revealed a total of 18 vegetable plant species from seven families serving as alternate hosts. Round melon (*Citrullus vulgaris*), Beet root (*Beta vulgaris*) and Mesta (*Hibiscus cannabinus*) were the exclusive hosts during cotton season in respect of North, Central and South zones. Vegetable crops common across all cotton growing zones that served as alternate hosts were Guar (*Cyamopsis tetragonoloba*) during cotton season, Sponge gourd (*Luffa aegyptiaca*), Water melon (*Citrullus lanatus*) and Okra (*Abelmoschus esculentus*) during off season, and Tomato (*Solanum lycopersicum*) throughout the year. Roselle (*Hibiscus sabdariffa*) exclusive to Central zone and Tomato common across all zones had extreme (G4) mealybug severity. Considering the seasonality and severity of *P. solenopsis* on the vegetable hosts across different cotton growing zones, specific and general strategies for suppression of *P. solenopsis* on cotton in particular and of the pest in general, respectively was formulated for recommendation as cultural management.

Key words: *Phenacoccus solenopsis*, Severity, Vegetable hosts.

During 2008-2009 crop seasons, all nine States of three Indian cotton growing zones having *P. solenopsis* was noticed (Nagrare *et al.*, 2009). The ability of *P. solenopsis* to spread widely and quickly across regions has been due to its broader range of host plants on which it can feed and reproduce. Reports of 183, 154, and 194 plant species from 52, 53 and 50 families have been made from USA, Pakistan and India, respectively (Vennila *et al.*, 2011). Host plants *P. solenopsis* belong to various categories of plants *viz.*, field crops, fruits, vegetables, ornamentals, spices, trees and weeds. Knowledge on the specific category of plants serving as hosts of *P. solenopsis* is essential for assessing their role in spread and severity of the pest across cropping systems besides to formulate management strategies. Present paper reports the documented vegetable crops as alternate hosts of *P. solenopsis* with their seasonality and severity across three cotton production systems of the country, and suggests the needful cultural management for the suppression of the pest.

Materials and Methods

Fortnightly surveys were carried out between July 2008 and June 2010 in three States of cotton production system *viz.*, Haryana of North zone, Maharashtra of Central zone and Tamil Nadu represent South zone, respectively. All zones had grown >90% of cotton cultivated with Bt hybrids. Vegetable crops grown in fields including home gardens and along field borders of cotton were examined for the presence of *P. solenopsis*. Severity of mealybugs was measured using 0-4 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

slight increase in temperature resulted in the increased mite population. However, the population of mites also showed non-significant negative correlation with minimum temperature (r = -0.0209), rainy days (r = -0.0694), morning R.H. (r = -0.2583) and afternoon R.H. (r = -0.0895) (Table 2). The findings of the present study are similar to the result of Gulati (2004) and Geroh *et al.* (2010) who reported that the mite (*Tetranychus* spp.) incidence was higher during the months of July and August.

Studies related to seasonal incidence of white fly indicated that there was negligible incidence from January to April 2012 and the white fly population was ranged from 0.35 to 3.93/ 3 leaves. The highest population of white fly recorded in the month of April which ranged from 2.57 – 3.93/ 3 leaves (Fig. I). It was interesting to note that the white fly population was higher from January to April and this coincided with lower R.H. and higher temperature, the results can be comparable with the findings of Bandyopadhay *et al.* (2005) who reported that minimum R.H. was found to have positive significant influence on the population of whitefly. Similar types of result were reported by Mondol and Kumar (2012). Spiders, coccinellids like *Cryptolaemus montruozier*, *Schymnus coccivora* and predatory mites (Fig 2) were noticed using all the months. The incidence of thrips, mites and whitefly revealed that the highest mean population of these pests was observed during summer months. The population of thrips and mite showed significant positive correlation with maximum temperature and significant negative correlation with R.H.

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(G4)–severe incidence of mealy bug on the whole plant. The number of plants for anyone vegetable host of *P. solenopsis* was minimum ten during each survey period. The identity of vegetable plant species examined during the survey for *P. solenopsis* infestation was confirmed through comparisons of local names with their scientific nomenclature available at *http://en.wikipedia.org*. Since the North, Central and South cotton zones belonged to different agro climatic regions, vegetable species exclusive to each zone, common between any two zones and ubiquitous among all three zones for their seasonality and severity of *P. solenopsis* were enumerated for evolving strategies for its cultural management.

Results and Discussion

Host records of vegetables exclusive to Central zone (4) were higher followed by North (2) and South (2) zones belonging to three, one and two families, respectively. While common hosts between North+South (2) and North+Central+South (8) zones were noted, no common hosts were observed at Central+South and North+Central zones (Table 1). Three families had single vegetable species as hosts for *P. solenopsis viz.*, Apiaceae, Basellaceae and Fabaceae. *Citrullus vulgaris, Beta vulgaris* and *Hibiscus cannabinus* were the exclusive hosts in respect of North, Central and South zones during cotton season, respectively. Ramu *et al.* (2013) also reported the occurrence of *P. solenopsis* on *H. cannabinus* in Southern state. *Cucumis melo* at North zone, *Dacus carota* at Central zone and *Basella alba* at South zone served as hosts during off seasons. Vegetables exclusive to Central zone occurring throughout the year (*Spinacea oleracea* & *Hibiscus sabdariffa*) enhanced the possibility of effective spread on cotton. *Luffa acutangula* was the only common host at N+S during cotton season. Vegetable hosts of *P. solenopsis* common across all cotton growing zones included *Cyamopsis tetragonoloba* during cotton season, *Luffa aegyptiaca, Citrullus lanatus* and *Abelmoschus esculentus* during off season and *Solanum lycopersicum*, throughout the year, respectively. Three of the common hosts among N+C+S *viz.*, bitter gourd, potato and brinjal showed evidence of seasonality differences, indicating the differential importance of same vegetable as a carryover host at different regions possibly modulated by the growing seasons of vegetables *vis a vis* different agro climatic conditions. Nagrare *et al.* (2012) reported 17 species of vegetables as host plants for *P. solenopsis* amongst a total of 166 across the cotton growing zones of India. Only the present study reports on the seasonality of *P. solenopsis* on vegetables as alternate hosts thus allowing formulation of timing of cultural strategies for preventing the spread of the pest spatially and temporally in a particular or across different regions.

All scales of *P. solenopsis* severity (G1 to G4) were noticed for the vegetable hosts common to all three zones. Number of vegetable hosts with G1 severity (7) was considerable among exclusive and common hosts indicating their role towards carryover of the insect rather than being suitable for perpetuation. The Central zone exclusive vegetable *H. sabdariffa* had the highest severity (G4) indicating the preference by the pest for feeding and multiplication. No North and South zone exclusive vegetable host had G4 severity. *S. lycopersicum* is a favourable host of *P. solenopsis* across all the cotton zones (N+C+S) with G4 severity (Table 2). Since *S. lycopersicum* is one of the common and all season vegetable species across rural and urban settings of the globe, and that the infestation by *P. solenopsis* was severe and continuous year round, periodical monitoring is needed from the perspective of preserving the plant species, and prevention of rapid spread of mealybug in the region. Kedar *et al.* (2011) from Hisar (Haryana) reported that *P. solenopsis* confined mostly to cotton crop were predated by coccinellids. Present study indicated okra to be a preferred host at North and Central zones only during the off season attributing to the types of host and preference of the mealybug under field conditions. However, the population pressure was also the factor to infest the other vegetable crops grown around the cotton field (Maurice & Kumar 2011). Thus, the availability of hosts at a given time, and the variation in preference by *P. solenopsis* played a crucial role in determining the pest severity.

Table 1. Vegetable crops as alternate hosts of *Phenacoccus solenopsis.*

Botanical name	English/ Local name	Occurrence of *P. solenopsis*					
		Seasonality			Severity		
		North	Central	South	North	Central	South
Daucus carota L.	Carrot, Gajar	–	Off season	–	–	Grade II	–
Basella alba L.	Malabar spinach, Creeping spinach, Kodi pasalai	–	-	Off season	–	–	Grade I
Beta vulgaris L.	Beetroot, Sugarbeet	–	Cotton season	–	–	Grade II	–
Spinacea oleracea L.	Spinach, Palak	–	Throughout the year	–	–	Grade II	–
Citrullus vulgaris Sch.	Round melon	Cotton season	–	–	Grade I	–	–
Cucumis melo L.	Muskmelon, Sugar melon	Off season	–	–	Grade I	–	–
Luffa aegyptiaca Mill.	Sponge gourd	Off season	Off season	Off season	Grade I	Grade I	Grade I
Citrullus lanatus (Thumb) Mansf.	Watermelon	Off season	Off season	Off season	Grade I	Grade II	Grade II
Memordica charantia L.	Bitter gourd	Cotton season	Off season	Off season	Grade I	Grade I	Grade I
Lagenaria siceraria L.	Bottle gourd, Kaippan chura	Cotton season	–	Off season	Grade I	-	Grade I
Luffa acutangula	Ridge gourd/ Ribbed gourd	Cotton season	–	Cotton season	Grade I	-	Grade II
Cyamopsis tetragonoloba (L.) Taub.	Guar / Cluster bean	Cotton season	Cotton season	Cotton season	Grade IV	Grade II	Grade II
Hibiscus sabdariffa L.	Roselle, Ambadi	–	Throughout the year	-	-	Grade IV	-
Abelmoschus esculentus L.	Okra, Bhindi, Ladies Finger	Off season	Off season	Off season	Grade IV	Grade IV	Grade II
Hibiscus cannabinus	Gongura/Mesta	–	–	Cotton season	-	-	Grade I
Solanum tuberosum L.	Potato	Throughout the year	Cotton season	Cotton season	Grade III	Grade IV	Grade IV
Solanum melongena L.	Brinjal, Egg plant	Throughout the year	Cotton season	Cotton season	Grade IV	Grade IV	Grade III
Solanum lycopersicum L.	Tomato	Through-out the year	Through-out the year	Through-out the year	Grade IV	Grade IV	Grade IV

- Not found

Considering the seasonality and severity of *P. solenopsis* on the diverse vegetable hosts across different cotton growing zones, strategies for suppression of the pest have been formulated for recommendation (Table 3) wherein monitoring for *P. solenopsis* on specific vegetable crops in a particular or across zones should be the first step. Cultural management of *P. solenopsis* implies need

Table 2. Seasonality and severity of *Phenacoccus solenopsis* on vegetable hosts.

Particulars	Vegetable hosts* (Nos)				
	Exclusive			Common	
	North (N)	Central (C)	South (S)	North, and South (N+S)	North, Central and South (N+C+S)
Seasonality					
Cotton season	Round melon	Beetroot	Mesta	Ridge gourd	Guar
Off season	Muskmelon	Carrot	Malabar spinach	–	Okra, Sponge gourd, Watermelon
Throughout the year	–	Roselle, Spinach	–	–	Tomato
Severity					
Grade 1	Muskmelon, Round melon	–	Malabar spinach, Mesta	Bottle gourd	Sponge gourd, Bitter gourd
Grade 2	–	Carrot, Beetroot, Spinach	–	–	–
Grade 4	–	Roselle	–	–	Tomato

* Refer Table 1 for scientific name; – Not found

Table 3. Vegetable crops to be monitored for management of *Phenacoccus solenopsis*.

Region	Vegetable crop	Season
North zone	Guar (*Cyamopsis tetragonoloba*)	Cotton season
Central zone	Ambadi (*Hibiscus sabdariffa*)	Throughout year
All cotton growing zones	Tomato (*Solanum lycopersicum*)	Throughout year
	Potato (*Solanum tuberosum*)	Cotton season
	Brinjal (*Solanum melongena*)	
North and Central zones	Okra (*Abelmoschus esculentus*)	Off season

for monitoring of vegetables *viz;* Guar (*C. tetragonoloba),* Ambadi (*H. sabdariffa),* Tomato *(S. lycopersicum),* Potato (*S. tuberosum),* Brinjal (*S. melongena)* and okra (*A. esculentus*) that are the alternate hosts, and maintenance of field sanitation by removal and proper disposal of infested plants. Removal should be by pruning of affected parts if the infestation severity is Grade 3 or less, and by uprooting of the completely infested plants. Das and Mayuri (2010) also reported mealy bug infestations on various vegetables crops in Jorhat Assam. Care also had to be exercised to bury or burn *P. solenopsis* infested plants such that complete destruction of pest stages occured. Practice of burial for host plants with severity of grade one and two, and burning for plants with extreme severity (G4) is advocated. Approach of cultural management targeting vegetables that served as alternate hosts during off and cotton seasons for *P. solenopsis* in the production systems of cotton would prevent the buildup of the pest on cotton.

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Table 2. Level of adoption of IPM.

Questions	Adoption %	
	IPM farmers	NON IPM
Deep summer ploughing	100	90
Burning of farm refuge/stubble	60	20
Selection of variety	80	40
Seed treatment	100	30
Intercropping & mixed cropping	90	40
Trap cropping	100	60
Neem oil	90	0
Pheromone Traps	100	0
Application of *Ha*NPV	100	0
Bird perches	70	0

were recorded in the Thimmapuram village during 2011-2012 (Table 2).

Farmers were randomly selected and interviewed as per the questionnaire. The response showed difference in knowledge levels between the farmers practicing IPM and non IPM farmers who got the information from NFSM project. The awareness levels differed among IPM farmers and non IPM farmers. Most of the conventional farmer's needs education about benefits of various IPM tools, which in long term can help them in establishing low input sustainable agricultural strategies. However, analysis of farmers of adopted villages clearly shows that, there was spread of IPM concept and awareness within the village.

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Fruit crops as alternate hosts of Cotton mealybug

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Cotton mealybug, *Phenacoccus solenopsis* Tinsley invaded India and Pakistan around 2005, and caused severe damage and yield reduction to cotton. The propensity of mealybugs to multiply in large numbers in shorter time along with their high dispersal ability makes their management difficult. A study was conducted between July 2008 and June 2010 through fortnightly surveys to document the host range of *P. solenopsis* in three representative States of Indian cotton growing zones *viz.*, Haryana of North zone, Maharashtra of Central zone and Tamil Nadu of South zone. Present study reports

Table 1. Seasonality and severity of *Phenacoccus solenopsis* on fruit crops.

Botanical name	Seasonality			Severity		
	North	Central	South	North	Central	South
Mangifera indica	–	Off season	Off season	–	Grade 1	Grade 1
Annona squamosa	–	Off season	Off season	–	Grade 3	Grade 3
Carica papaya	Throughout year	Throughout year	Throughout year	Grade 4	Grade 4	Grade 4
Psidium guajava	Off season	Off season	Off season	Grade 1	Grade 1	Grade 1
Punica granatum	Throughout year	Off season	Off season	Grade 2	Grade 1	Grade 1
Ziziphus mauritiana	Throughout year	Off season	Off season	Grade 2	Grade 1	Grade 1
Achras zapota	–	Throughout year	Throughout year	–	Grade 1	Grade 1
Vitis vinifera	Off season	–	–	Grade 2	–	–

– indicate absence of the *P. solenopsis* infestation

the fruit crops as alternate hosts of *P. solenopsis* observed across the cotton growing zones. Severity of mealybug infestation was noted on 0-4 rating scale *viz.*, 0 – no mealybug; Grade 1 (G1) – scattered appearance, Grade 2 (G2) – severe incidence of mealybug on any one branch Grade 3 (G3) – severe incidence of mealybug on more than one branch and Grade 4 (G4) – severe incidence of mealy bug on the whole plant.

The eight fruit crops constituted 4% of the 194 total host plants documented in India belonging to 50 families (Vennila *et al.,* 2011). Makadia *et al.* (2009) reported *Maconellicoccus hirsutus* was attacking custard apple in Junagadh area. Vijay and Suresh (2013) reported five fruit crops from North and South zones, respectively as hosts for *P. solenopsis*. While grapes was an exclusive host of *P. solenopsis* at North zone, four hosts *viz.*, papaya, guava, pomegranate and ber were common at North, Central and South zones. Two species of citrus from South zone add to the 8 fruit hosts making the total number of fruit hosts for *P. solenopsis* to be 10 in India. While the exclusive host of grapes in North zone had *P. solenopsis* infestation only during off season, papaya across all three zones and sapota at Central and South zones harboured throughout the year. Guava as an alternate host of *P. solenopsis* gains significance during off season. Mango and custard apple also served as carry over hosts during off season (Das & Baruah 2010) thus, played an important role in the spread of pest to cotton (Table 1).

P. solenopsis severity on the fruit crops ranged between G1 and G4, the highest severity being on papaya across all three zones indicating the spatial and temporal suitability of the crop. Among all the off season hosts, custard apple had higher severity (G3). Lowest severity (G1) on mango, guava, sapota, pomegranate and ber indicated the lesser preference by *P. solenopsis*. Since papaya is one of all season fruit species across the globe, and the infestation by *P. solenopsis* was severe and continuous year round, periodical monitoring is needed. Considering the importance of fruit crops as alternate hosts of *P. solenopsis* it becomes imperative to monitor especially papaya throughout the year across all zones. Care has to be taken to remove the affected parts if *P. solenopsis* infestation severity is Grade 3.

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Table 1. Population fluctuation and damage of *Bandicota bengalensis* in rice field (2009-10 & 2010-11).

Months	LBC/ha	Trap Index	Cut tillers (%)
January	18.67	1.12	1.8
February	15.67	1.57	1.9
March	16.33	2.67	2.1

From the observations, it was found that the % cut tillers were recorded maximum in the month of October (8.8%) followed by November (6.6%) and June (6.0%). The % cut tillers was recorded to be minimum in the month of January (1.8%) and February (1.9%). These findings were in agreement with Sasikala and Neelanarayanan (2008). It has been reported that *B bengalensis* breeds throughout the year with peak activity coinciding with the