Indian Journal of Entomology, **81**(3): 000-000 (2019) DoI No.:

POPULATION DYNAMICS OF COTTON MEALYBUG, *PHENACOCCUS SOLENOPSIS* AND ITS NATURAL ENEMIES

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ABSTRACT

Studies revealed that, Brinjal (var. shyamala) planted on 31st July 2007 recorded highest (33.8 adults) cotton mealybugs, *Phenacoccus solenopsis* Tinsley, in March 2008 and lowest (0.93 adults) in November 2007, mealybugs found positively correlated with temperature. However, when planted on 14th July 2008 remained free from the mealybugs except scanty population noticed during January 2009. The other variety of Brinjal (var. Vikram) planted on14th July 2008 was found negatively correlated with rainfall (-0.21). The parasitoid, *Aenasius arizonensis* (Girault), was found negatively correlated with *P. solenopsis* (-0.21) and *Promuscidea unfasciativentris* Girault (-0.12). Highest (53.73 adults) population of *P. solenopsis* was observed during November followed by October (21.13 adults) and lowest observed in December (1.3 adults) on sorrel planted in 2007. Highest (91.7 adults) population of *P. solenopsis* was observed during July followed by June (54.5 adults) and lowest was seen in December (1.3 adults) on sorrel planted in 2008. Mealybug found positively correlated with temperature in sorrel planted 10.07.2007 and 15.04.2008 Highest number of *P. unfasciativentris* were recorded in October 2008 (116 adults) on sorrel and observed negatively correlated (-0.2) with mealybugs. Okra planted 26.06.2008, recorded highest (11.08 adults) population of *P. solenopsis* during October as compared to lowest (3.4 adults) in November. It was positively correlated with temperature. Highest population of *A. arizonensis* was observed during October (23 adults), and found positively correlated with temperature (0.68) and *P. unfasciativentris* (0.11) which was highest in highest in November (26 adults). China rose recorded highest (51.82 adults) population of *P. solenopsis* in July 2008, while lowest (0.06 adults) in October 2008. Mealybug was positively correlated with temperature (0.53), relative humidity (0.67) and rainfall (0.61). Mealybug, was again found positively correlated with parasitoid, *A. arizonensis* (0.70), hyper-parasitoid, *P. unfasciativentris* (0.97) and hyper-parasitoid, *Aprostocetus purpureus* Girault (0.73).

Key Words: *Phenacoccus solenopsis*, population dynamics, brinjal, China rose, sorrel, okra, parasitoids, hyperparasitoids

Solenopsis mealybug, *Phenacoccus solenopsis* Tinsley, has been the current topic of research for insect taxonomists and applied entomologists in India due to its invasiveness, rapid spread, morphological and biological variations and the need for establishing an effective control strategy (Vennila et al., 2010). *P. solenopsis* has been reported from 35 localities of various ecological zones across the globe (Ben Dov et al., 2009). Survey across 47 locations of the country between months of late 2007 and early 2008 established the predominance of *P. solenopsis* in India (Nagrare et al., 2009). Of late, increased build up of various mealybug species such as cotton mealybug, *P. solenopsis* and papaya mealybug, *Paracoccus marginatus* William and Granara De Willink in field and fruit crops is observed mainly due to certain abiotic changes in environment because of global warming. Cotton mealybug will certainly spread to sub-tropical and tropical parts of the world and might pose serious threats to agri-horticultural crops (Fand et al., 2013; Fand and Suroshe, 2015; Suroshe et al., 2013 and Suroshe et al., 2014). Lot has been said about mealybug withstanding rising temperatures and getting washed away after rains (Valuli and Kosol, 1983; Dhawan et al., 2009), but still there is scope for unraveling the role of weather factors on mealybug and its natural enemies, residing different crop ecosystems. So, the present studies were carried out to explore the reasons behind population fluctuation of *P. solenopsis* and its natural enemies in open field condition and to know round the year activity period of *P. solenopsis* and its natural enemies present in ecosystem of four crops viz., Brinjal (*Solanum melongena* L.), Sorrel (*Hibiscus sabdarifa* L.), Okra (*Abelmoschus esculentus* L.) and China rose (*Hibiscus rosa-sinensis* L.). Brinjal, Jamaican sorrel and Okra were studied being the important vegetable

crops grown in India through out the calendar year and ornamental crop, China rose, was considered being very important host, acting as source of inoculum to crops of economic importance.

MATERIALS AND METHODS

Population dynamics studies of Solenopsis mealybug, *P. solenopsis* along with its natural enemies, were carried out on four crops *viz.,* Brinjal, Sorrel, Okra and China rose in Division of Entomology, IARI, New Delhi.

Two season data was recorded from brinjal planted in *Kharif* 2007 and 2008. Brinjal cultivars *viz*., Shyamala (long fruit) and Vikram (round fruit) were transplanted on 31.7.2007 and 14.7.2008, respectively Var. Shyamala, did not attract *P. solenopsis* population considerably in 2007, hence was again transplanted in 2008 along with var. Vikram in anticipation of round fruit var. will attract more mealybugs. Three branches (top, middle and lower) per plant were observed for *P. solenopsis* and its natural enemies; total of five plants were selected weekly for observation. Observations were recorded from September 2007 to May 2008 for 2007 planted and September 2008 to May 2009 for 2008 planted brinjal. Two varieties of brinjal were selected to check the susceptibility of long fruit versus round fruit brinjal.

Two season data was recorded from Sorrel planted in kharif 2007 and summer 2008. The observations for the presence of mealybug and its natural enemies were recorded from top 5 cm of main stem/plant from randomly selected 5 plants of sorrel at weekly interval starting from September to December (2007) and June to December (2008) for *Kharif* and summer crops, respectively.

Observations were taken from September to December 2008 on okra crop (variety Rohini) planted on 26.06.2008 Twenty plants were selected weekly at random and 3 pods (top, middle and lower)/plant were observed for the presence of mealybug and its natural enemies.

China rose planted along the hedge rows around the Entomology Division of IARI were selected at random. At weekly intervals, top 10 cm of main stem/plant of twenty two plants was observed for the presence of mealybug and its natural enemies. Observations were noted from June 2008 to May 2009.

Observations, for mealybug were taken as stated above. Predators/plant were observed and noted down in field itself. Regarding the parasitoids, mummies, of *P. solenopsis*/plant were collected with camel hair brush and forceps, then brought to the laboratory, counted and kept individually in the numbered homeopathic vials for emergence of parasitoids. Observations on number and type of parasitoids emerged were made. Means for population/plant were tabulated; correlation coefficients were calculated for mealybug, natural enemies and weather parameters (average of minimum and maximum temperature, average of minimum and maximum relative humidity and rainfall/month) through 'MS-Excel-2010' for final interpretation of population dynamics data.

RESULTS AND DISCUSSION

Brinjal: Results (2007) are depicted in Fig. 1. Highest (33.8 adults) population of *P. solenopsis* was recorded during March 2008 and lowest (0.93 adults) in November. Month of December, January and February did not host mealybug, *P. solenopsis*. It was found positively correlated with temperature (0.20), negatively correlated with relative humidity (-0.41) and rainfall (-0.15). Natural enemies, *Coccinella septempunctata* L. (0.47) and *Cheilomenes sexmaculata* (F.) (0.17) were found positively correlated with mealybug. Other predators *Brumoides suturalis* (F.) (-0.1) and *Adonia variegata* (Goeze) (-0.1) were found negatively correlated with mealybug. Results (2008) are depicted in Fig. 1. *P. solenopsis* was not recorded during this period except in January 2009 (1 adult). December, January and February did not host mealybug, *P. solenopsis*. Among natural enemies, only *C. septempunctata*, was noticed and found negatively correlated (-0.18) with mealybug. Results of var. Vikram planted in 2008 are depicted in Fig. 2. Maximum (3 adults) population of *P. solenopsis* was observed in November and rest of the months except February (0.5 adults) did not observed mealybug. Mealybug was found positively correlated with temperature (0.22), positively correlated with relative humidity (0.09) and negatively correlated with rainfall (-0.21). Parasitoid, *Aenasius arizonensis* (Girault), was found negatively correlated with *P. solenopsis* (-0.21) and *Promuscidea unfasciativentris* Girault (-0.12). However, *P. solenopsis* and *P. unfasciativentris* were positively correlated (0.97). Predators, *C. septempunctata* (-0.15) and *C. sexmaculata* (-0.03) were negatively correlated with mealybug.

Mealybugs are known to proliferate if subject

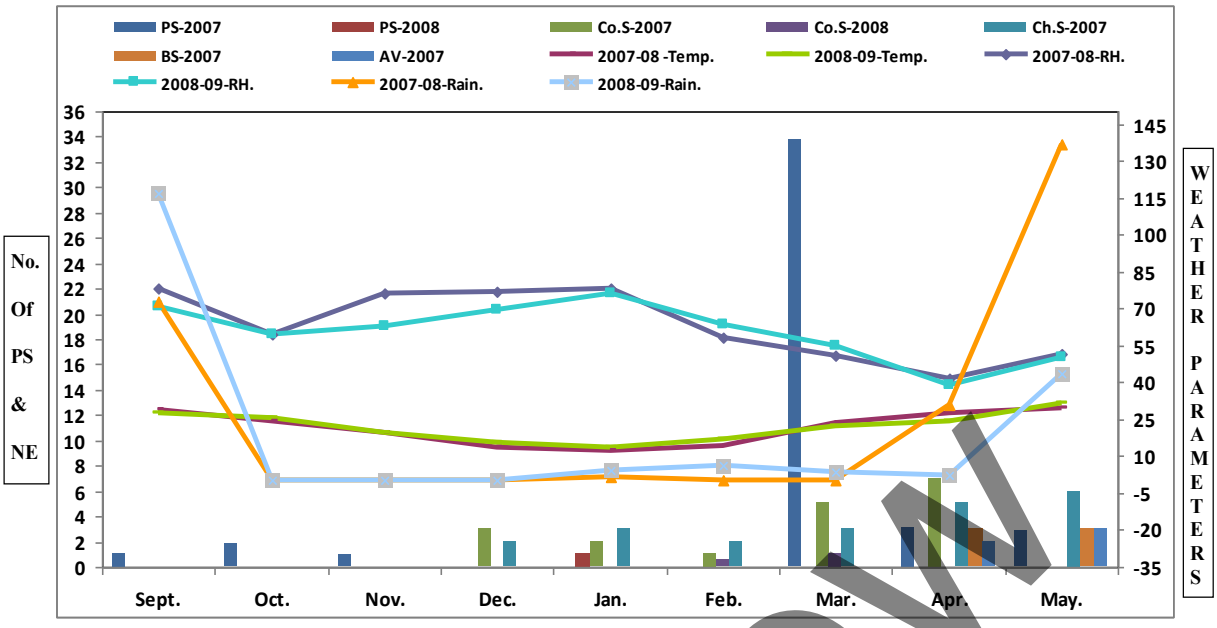

Fig. 1. Population dynamics of P. solenopsis and its natural enemies on brinjal var. Shyamala (2007 and 2008)

PS=*P. solenopsis*; Co.S=*Coccinella septempunctata*; Ch.S=*Cheilomenes sexmaculata*; BS=*Brumoides suturalis*; AV=*Adonia variegata*

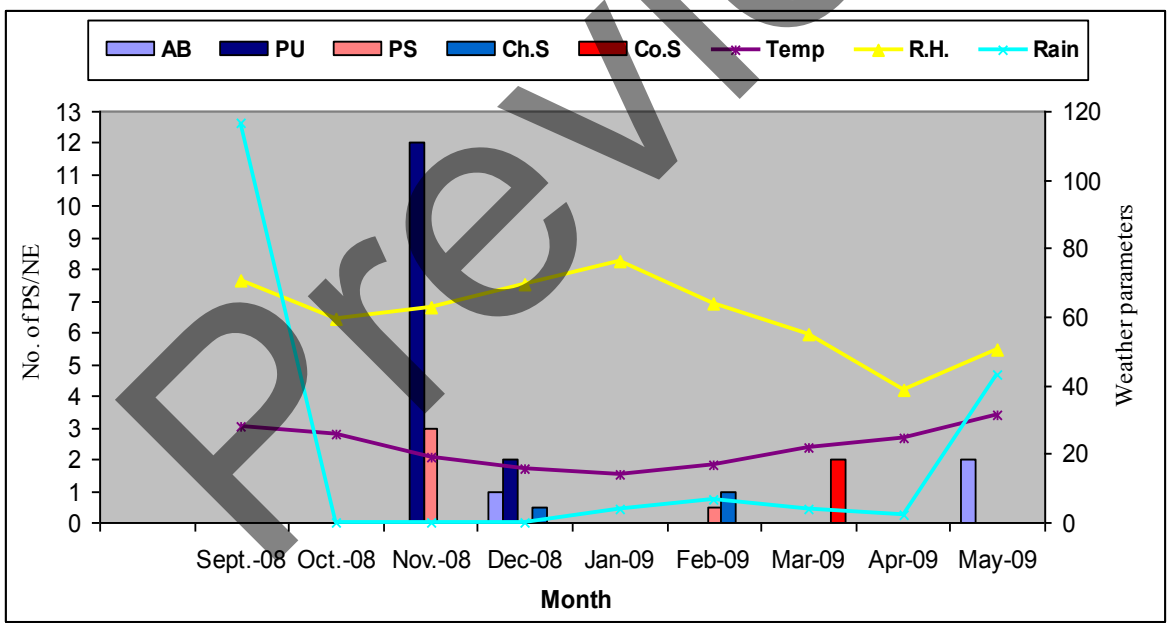

Fig. 2. Population dynamics of *P. solenopsis* and its natural enemies on brinjal var. Vikram (2008)

AB=*Aenasius arizonensis*, PU=*Promuscidea unfasciativentris*, PS=*P. solenopsis*, Ch.S=*Cheilomenes sexmaculata*, Co.S=*Coccinella septempunctata*

to increasing temperature; present findings showed positive correlation of mealybug population on var. Shyamala (2007) with temperature and results are in conformity with Dhawan et al. (2009). However, mealybug was found negatively correlated with both relative humidity (RH) and rainfall. It supported mealybugs getting washed off due to rains and it is well supported by Valuli and Kosol (1983) who reported reduction in mealybug population in rainy season and by. Jayakumar et al. (2009) also reported positive correlation of mealybug and RH, which is not proved in present findings. Besides, results indicate that mealybugs could not proliferate in winter and as soon as winter subsides it started build up from spring

onwards. Mealybug population was at minimum during 2008 on var. Shyamala, might be due to high rainfall in august 2008 (299.1 mm). Predator, *C. septempunctata* was negatively correlated with mealybug, which could not be explained as population of mealybug was at very minimum and found feeding on aphids in absence of mealybugs.

Mealybugs on var. Vikram (2008) were again found positive and rainfall negatively correlated. It inferred that heavy rainfall of 2008 and probably brinjal not a favoured host kept population of mealybugs at minimum. Mealybug were found negatively correlated with parasitoid, *A. arizonensis*, hyper-parasitoid, *P. unfasciativentris* and two predators which might be due to minimum population of *P. solenopsis* and in it absence predators were feeding on aphids.

Sorrel: Results of sorrel planted in 2007 are depicted in Fig. 3 and 4. Highest (53.73 adults) population of *P. solenopsis* was observed during November followed by October (21.13 adults) and lowest in December (1.3 adults). Mealybug was positively correlated with temperature (0.08) and negatively correlated with both relative humidity (-0.04) and rainfall (-0.26). Natural enemies were not observed when planted in 2007; when planted in 2008 (Fig. 3 and 4) highest (91.7 adults) population of *P. solenopsis* was observed during July followed by June (54.5) and lowest (1.3 adults) in December. Mealybug was found positively correlated

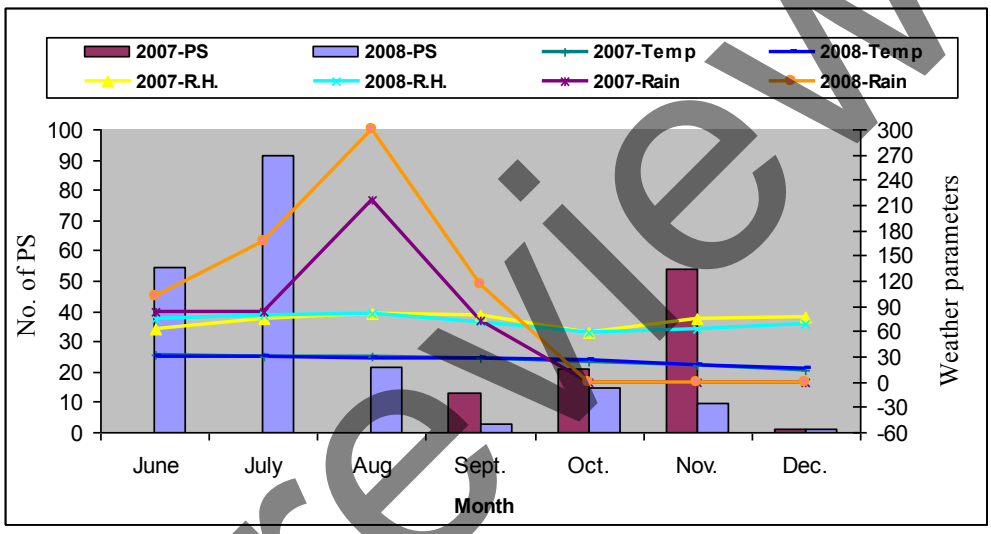

Fig. 3. Population dynamics of *P. Solenopsis* on Sorrel (2007, 2008)

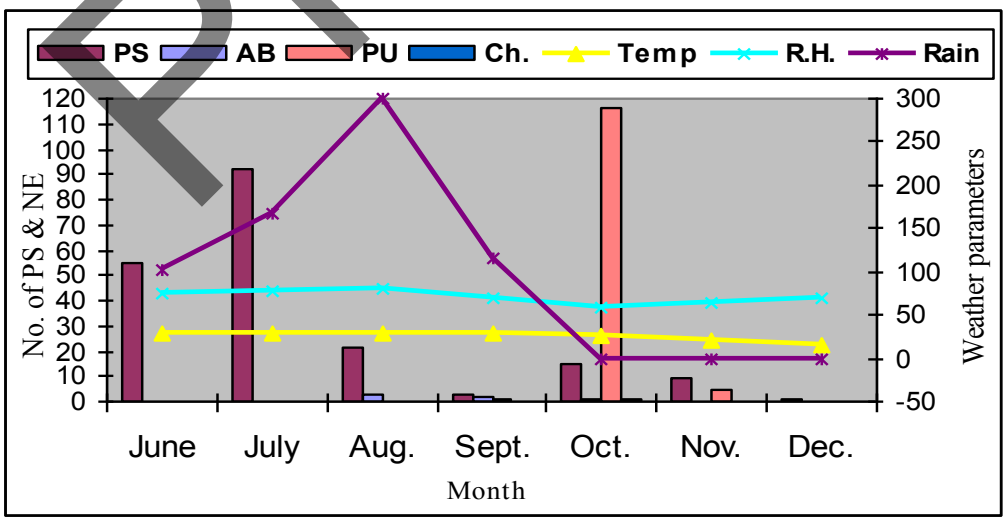

Fig. 4. Population dynamics of *P. solenopsis* and its natural enemies on Sorrel (2008)

PS=*P. solenopsis*, AB=*Aenasius arizonensis*, PU=*Promuscidea unfasciativentris*, Ch.=*Chieloneurus*

with all three weather parameters *viz.,* temperature (0.61), relative humidity (0.52) and rainfall (0.38). With respect to parasitoid, *A. arizonensis*, was highest (3 adults) in August, followed by September (2 adults) and lowest in October (1 adults). It was found negatively correlated (-0.34) with mealybug, whereas positively correlated with temperature (0.39), relative humidity (0.33) and rainfall (0.67). It was partially non-correlated with hyperparasitoid, *P. unfasciativentris* (0.08). Highest (116 adults) number of *P. unfasciativentris* were recorded in October, followed by November (5 adults), lowest in September (1 adults) and other months did not record it. It was observed negatively correlated (-0.2) with mealybug, *P. solenopsis* and partially non-correlated with temperature (0.02). The other hyperparasitoid observed was *Cheiloneurus* sp. (1) in October.

Again mealybugs on Sorrel (2007) were positively correlated with temperature and negative with RH and rainfall, it is in agreement with Valuli and Kosol, (1983) and Dhawan et al. (2009) which is already discussed as above. All three parameters (Temp., RH and Rainfall) were found positively correlated with mealybug. Findings related to the RH and mealybugs on sorrel (2008) are in agreement with Jeyakumar et al. (2009) who also reported negative correlation of RH with mealybug intensity on cotton. Sorrel, which is also a malvaceae crop like cotton might be supporting mealybug buildup because of nutritional changes in crop due to low ralative humidity. *A. arizonensis* and *P. unfasciativentris* was negatively correlated with mealybug which is understandable for Host:Pest association and positively with temperature which is well supported by Hanchinal et al. (2010).

Okra: Results of Okra planted in 2008 are depicted in Fig. 5. Highest (11.08 adults) population of *P. solenopsis* was recorded during the October followed by September (5.05 adults), lowest during November (3.4 adults) and did not record any in December. It was found positively correlated with temperature (0.75), negatively correlated with relative humidity (-0.72), not correlated with rainfall (0.02) and positively correlated with *A. arizonensis*. Highest (23 adults) population of *A. arizonensis* was observed during October followed by November (13 adults) lowest in September (11 adults) and no record in December. It was found positively correlated with temperature (0.68), negatively correlated with relative humidity (-0.82), not correlated with rainfall (-0.05) and positively correlated with *P. unfasciativentris* (0.11). Hyper-parasitoid, *P. unfasciativentris*, was highest (26 adults) in November, lowest (1 adults) during September and October (1 adults) while December did not report it. Hyper-parasitoid, *Chartocerus walkeri* Hayat was found non-correlated (-0.07) with mealybug and positively correlated with its primary host *A. arizonensis*. Other parasitoids observed in less numbers were *Prochiloneurus albifuniculus* (Hayat, Alam & Agarwal), and an unknown encyrtid.

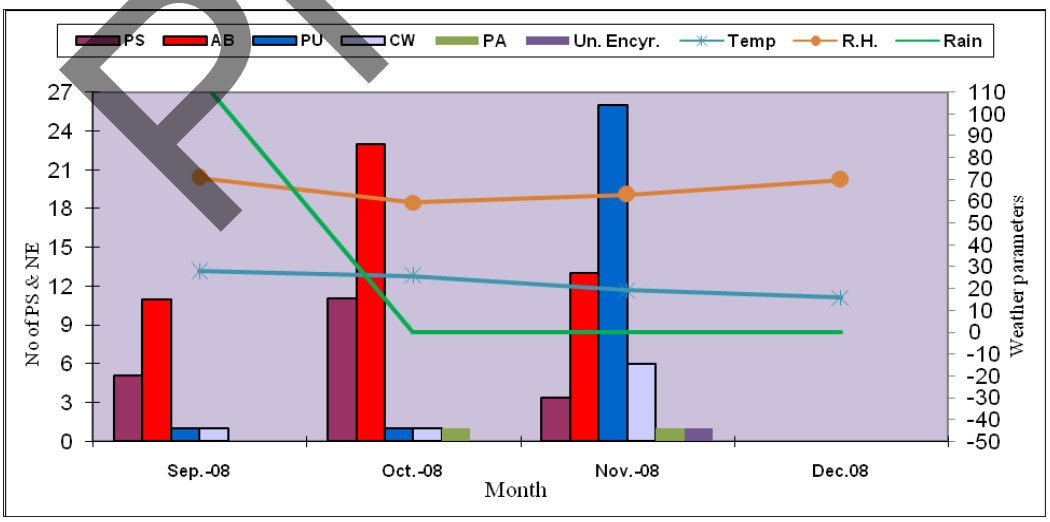

Fig. 5. Population dynamics of *P. Solenopsis* and its natural enemies on okra (2008)

PS=*P. solenopsis*, AB=*Aenasius arizonensis*, PU=*Promuscidea unfasciativentris*, CW=*Chartocerus walkeri*, PA=*Prochiloneurus albifuniculus*, Un. Encyr.=Unknown Encyrtid

Mealybug population remained at peak during October and started declining from the onset of winter. As reported earlier with other crops, mealybugs were positively correlated with temperature which is in agreement with Hanchinal et al., (2010), who reported on cotton, a malvaceae crop like okra. Mealybugs were positively correlated with its parasitoid, *A. arizonensis* and *A. arizonensis* was positively correlated with it parasitoid, *P. unfasciativentris*, an ideal situation in biological pest suppression; a phenomenon where as host population increases its natural enemy also increases and brings its hosts pest down to general equilibrium position (GEP).

China rose: Results for 2008-09 are depicted in Fig. 6. Highest (51.82 adults) population of *P. solenopsis* was observed during July followed by August (22.01 adults) and June (6.29 adults), while lowest (0.06 adults) in October. From November to May, mealybugs were not observed. Mealybug was positively correlated with temperature (0.53), relative humidity (0.67) and rainfall (0.61). Mealybug, was again found positively correlated with parasitoid, *A. arizonensis* (0.70), hyper-parasitoid, *P. unfasciativentris* (0.97) and hyper-parasitoid, *Aprostocerus purpureus* Girault (0.73). Highest (6 adults) numbers of *A. arizonensis* were observed in August followed by June (4 adults), July (4 adults) and lowest in October (2 adults). January to May 2009 did not see any *A. arizonensis*. It was found positively correlated with temperature (0.72), relative humidity (0.71), rainfall (0.80), *P. unfasciativentris* (0.46) and *A. purpureus* (0.82). Highest (124 adults) *P. unfasciativentris*, were seen in July followed by August (27 adults) and other months did not record it. It was seen positively correlated with temperature (0.43), relative humidity (0.53) and rainfall (0.45). Other hyper-parasitoids, recorded from July to October were *Chartocerus walkeri* Hayat (3 adults), *P. albifuniculus* (3 adults), and *Marietta leopardina* Motschulsky (3 adults).

Highest (51.81 adults) mealybugs of July were brought down in August (22.01 adults) because of heavy rains of August (299.1 mm). Mealybugs were positively correlated with temperature; it is well supported by Hanchinal et al. (2010) and Dhawan et al. (2009), but also reported negative correlation with RH and rainfall which is not reported in present findings. As in case of okra, mealybug were positively correlated with *A. arizonensis* and *P. unfasciativentris*, an ideal situation for restoring general equilibrium position of mealybugs and its natural enemies. *A. arizonensis* was positively correlated with temperature also reported by Hanchinal et al., (2010). *P. unfasciativentris* seen most active in July and August and not in other months, it is in agreement with Ram Pala and Saini (2010) and Gautam et al. (2009) who reported that during July-August *A. arizonensis* was attacked by hyper-parasitoids.

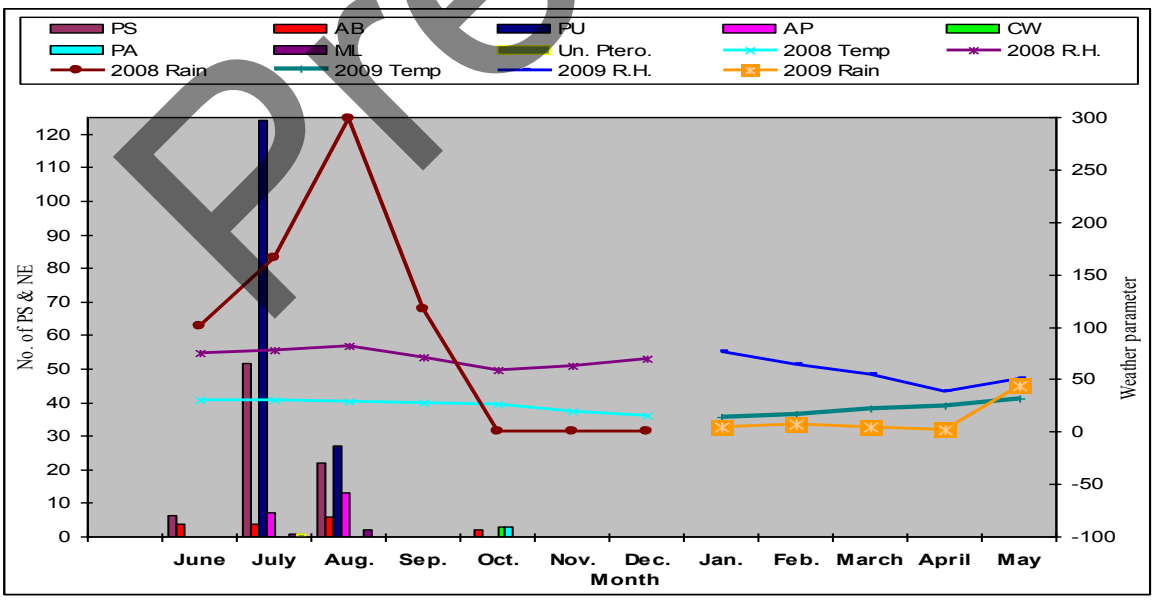

Fig. 6. Population dynamics of *P. Solenopsis* and its natural enemies on China rose (2008-2009)

PS=*P. solenopsis*, AB=*Aenasius arizonensis*, PU=*Promuscidea unfasciativentris*, *Aprostocetus purpureus*, CW=*Chartocerus walkeri*, PA=*Prochiloneurus albifuniculus*, ML=*Marietta leopardina*, Un. Ptero.=Unknown Pteromalid

Brinjal a favoured host of Solanum mealybug, *P. solani*, is not found a favored host of *P. solenopsis*. Crops belonging to Malvaceae family attracted considerable number of *P. solenopsis* and its parasitoids. Brinjal, Sorrel and China rose registered highest number of *P. unfasciativentris* than *A. arizonensis,* but in Okra, *A. arizonensis* over-numbered hyper-parasitoid, *P. unfasciativentris*. The situation in Okra is found to be most desirable for successful biological pest suppression. Unlike, in Brinjal and Sorrel, *A. arizonensis* and *P. unfasciativentris* were found restoring population of *P. solenopsis* at 'General Equilibrium Position' (GEP) in different crop ecosystems.

ACKNOWLEDGEMENTS

Authors express sincere gratitude to Head, Division of Entomology, and Director, ICAR-IARI, New Delhi for providing necessary facilities**.**

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(Manuscript Received: April, 2019; Revised: August, 2019;
Accepted: August, 2019; Online Published: August, 2019)