Annotated Bibliography on Cotton Mealybug *Phenacoccus solenopsis* Tinsley

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Contribution under NAIP/COMP 4/DSS C 2046

Research into Decision Support System for
Insect Pests of Major Cotton Based Cropping Systems

National Centre for Integrated Pest Management
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Cover page photos : *Phenacoccus solenopsis on*
Top : *Parthenium hysterophorus*
Middle[1] : *Hibiscus sabdariffa*
Middle[2] : *Gossypium hirsutum*
Bottom : *Abelmoschus esculentus*

Year of publication : 2012

Published by : **Dr. O.M. Bambawale**
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LBS Building, Pusa Campus, New Delhi - 110 012
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Citation : Vennila S, Agarwal M, Jeyakumar P, Tanwar RK, Prasad YG and Prabhakar M. 2012. Annotated bibliography on cotton mealybug *Phenacoccus solenopsis* Tinsley. National Centre for Integrated Pest Management, New Delhi, pp 104.

Printed at : M/s Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase-I, New Delhi 110 028

Foreword

The invasion and wide spread infestation of the polyphagous mealybug *Phenacoccus solenopsis* Tinsley emerged as a potential threat to the commercial crop of cotton across all cotton growing zones of India. Mealybugs were never a menace on field crops but *P. solenopsis* assumed significance on cotton between 2007 and 2008 seasons in Northern states, in particular and across the country, in general. The wider and quicker spread of the *P. solenopsis* across varied cropping systems and differing agro climatic conditions of the country required holistic approach to understand the host range over space and time respectively, besides their natural regulating factors. Immediate and intensive research undertaken to understand the biology, host range and natural control of the species besides evaluation of insecticides against the pest for their efficacy led to formulation of management strategies for different agro-ecologies in India. Since then research reports on *P. solenopsis* either on new host plants or in new areas, are regularly being published.

Simultaneous efforts by researchers bringing forth information on mealybugs such as host range, life history, availability of natural enemies, and approaches adopted including awareness campaigns on its management yielded effective management of the pest. Information on mealybugs has been published as research papers, folders, leaflets, posters and videos. Literature on *P. solenopsis* has been added regularly and keeping track of them itself is an art of scientific research.

The present manual provides comprehensive assemblage of information through an updated literature on the *P. solenopsis* and would serve as a ready reckoner for use by students and researchers involved in study of mealybug. An annotated bibliography would prove useful for global researchers of plant protection providing first hand documented information. Regular updation beyond this point of time would also prove useful.

Fascination obtained through study of publications on *P. solenopsis* made in quick succession leading to the present compilation is appreciable as it would serve as one stop reference manual on the species.

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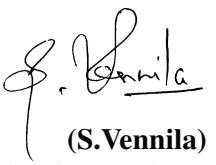
Preface

Involvement in research on *Phenacoccus solenopsis* towards understanding its potential as pest of cotton through multi pronged approaches involving taxonomy, biology and ecology leading to development of possible ecofriendly and non-insecticidal management approaches created continuous followup of literature accessible through various resources.

The ability of *P. solenopsis* to adapt to varied hosts and the strategic features of its biology were the compelling factors for continued interest with the insect even after four years of its established invasion. While India has realized the natural and fortuitous biological control of *P. solenopsis* in addition to development of curative measures, reports of invasion into many other countries keep growing. With gratefulness to all the abstracting web based search services, this compilation has been done only with the expectations of enriching researchers for quick access of not only the references on the pest but also the abstracts possessing summary findings in a nutshell.



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Introduction

Bibliography of 217 references has been published to provide annotated information of selected publications on mealybug *Phenacoccus solenopsis* Tinsley in retrospective support of the abstracts. References covering the identification, biology, ecology, and control of *P. solenopsis* are listed. Entries have been arranged alphabetically according to the surnames of first authors considering that the format would be useful and better for reference. Technical information from journal articles, government documents and proceedings from conferences, symposiums, research reports and on-line searches conducted through Consortium for e-Resources in Agriculture (CeRA), AGRICOLA and CAB abstracts have been made use of while compiling the document.

1. Abbas G, Arif MJ and Saeed S. 2005. Systematic status of new species of genus *Phenacoccus* Cockerel (Pseudococcidae), a serious pest of cotton *Gossypium hirsutum* L. in Pakistan. *Pakistan Entomologist,* **27**: 83-84.

   Phenacoccus gossypiphilous is considered to be a *Nomen nudum*, which is a synonym of *Phenacoccus solenopsis* Tinsley and the pest has achieved a status of serious threat in Pakistan.

2. Abbas G, Arif MJ, Ashfaq M, Aslam M and Saeed S. 2010a. The impact of some environmental factors on the fecundity of *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae): A serious pest of cotton and other crops. *Pakistan Journal of Agricultural Sciences,* **47**(4): 321-325. Available online: pakjas.com.pk/upload/55841.doc

   Phenacoccus solenopsis Tinsley (Hemiptera: Sternorrhyncha: Pseudococcidae) was first recorded on cultivated cotton from Texas, USA in 1991. Since 2005, this New World species has emerged as serious pest of cotton in Pakistan and India, and is now a serious threat to cotton in China and other cotton-growing countries worldwide. The species is polyphagous and invasive, and can attack many other economic crops. So far, it has been reported from 173 species in 54 plant families, and from 26 countries in different ecological zones. The study found that host plant species and meteorological conditions had significant effects, whereas locality had no significant effect on the fecundity of the mealybug.

3. Abbas G, Arif MJ, Ashfaq M, Aslam M and Saeed S. 2010b. Host plants, distribution and overwintering of cotton mealybug (*Phenacoccus solenopsis*; Hemiptera: Pseudococcidae). *International Journal of Agriculture and Biology,* **12**: 421-425.

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 overwintering of the pest in agroecological conditions of Pakistan during surveys from 2005 to 2009. This information can be helpful in management of this pest.

4. Abbas G, Arif MJ, Saeed S and Kava H. 2007. Increasing menace of a new mealybug, *Phenacoccus gossypiphilous*, to the economic crops of Southern Asia. Proceedings of the XI International Symposium on Scale Insect Studies, Oeiras, Portugal, 24–27th Sept. 2007. pp 30.

   From the year 2005, *Phenacoccus solenopsis* has been recorded as a serious pest of cultivated cotton *Gosspium hirsutum* L in Pakistan.

5. Abbas G, Arif MJ, Saeed S and Karar H. 2009. A new invasive species of genus *Phenacoccus* Cockerell attacking cotton in Pakistan. *International Journal of Agriculture and Biology,* **11**(1): 54-58.

   The name *Phenacoccus gossypiphilous* (Abbas *et al*., 2005) is considered to be a *Nomen nudum*. The same species has also been collected in India, Thailand, Taiwan and in New Caledonia and is morphologically extremely similar to many specimens considered to be *P. solenopsis* Tinsley from the Neotropics. We authors feel that the differences are sufficient to justify that Asian species are different from *P. solenopsis*. The adult female of *P. gossypiphilous* is therefore described and a holotype and paratypes are designated. Keys are provided to separate (a) the new species from similar species of *Phenacoccus* currently known from Asia. In addition, few details regarding the biology of *P. gossypiphilous* on cotton in Pakistan are included. This species is considered to be an important invasive species.

6. Abd-Rabou S, Germain JF and Malausa T. 2010. *Phenacoccus parvus* Morrison and *P. solenopsis* Tinsley, two new scale insects in Egypt (Hemiptera, Pseudococcidae). [French] *Phenacoccus parvus* Morrison et *P. solenopsis* Tinsley, deux Cochenilles nouvelles pour l'Egypte (Hemiptera, Pseudococcidae). *Bulletin de la Societe Entomologique de France*, **115**(4): 509-510.

   Two new species of Pseudococcidae belonging to the genus *Phenacoccus* are recorded for the first time in Egypt: *Phenacoccus parvus* and *P. solenopsis*. An

identification key is proposed to distinguish between the five *Phenacoccus* species known to occur in Egypt.

7. Admin. 2010. Exotic mealybug species – a major new pest in cotton. Published: February 12, 2010. http://thebeatsheet.com.au/mealybugs/exotic mealybug species a major new pest in cotton/. (Accessed on 25th May 2010).

   Biosecurity Queensland has confirmed an outbreak of an exotic species of mealybug currently affecting cotton properties in Emerald is also present in cotton crops in the Burdekin region. The exotic species of mealybug is commonly known as the Solenopsis mealybug (*Phenacoccus solenopsis*).

8. Afzal M, Rehman SU and Siddiqui T. 2009. Appearance and management of a new devastating pest of cotton, *Phenacoccus solenopsis* Tinsley, in Pakistan. Beltwide Cotton Conferences, San Antonio, Texas, January 5-8.

   In Pakistan, the cotton mealybug was the most difficult pest to control in 2007 around major cotton areas of the country, and it has brought a significant challenge to the crop protection industry. Bayer Crop Science was the first to identify this pest, as *Phenacoccus solenopsis* Tinsley in the country. Among the key reasons for the fast spread and difficulty in control of the bug lies in its high productivity, cottony pouches protecting eggs and crawlers, and adults protected with a hydrophobic waxy layer which serves as a difficult barrier to insecticides. A number of beneficial insects are known as natural enemies of mealybug. Such beneficials are generally ignored or get killed with the application of harmful organophosphate insecticides. The bugs are disseminated to far distances with the help of its light weight crawlers sticking to insect visitors, birds, cattle, farmers and mechanical implements entering the infested fields. Although commonly known as a pest of cotton, it has as many as 149 host plants which range from vegetables, orchards, ornamentals, as well as weeds. A number of insecticides from the existing chemistries and those from Bayer's future pipeline were evaluated during 2006 – 2008. Potential products were also looked for their compatibility with different adjuvants. Confidor 200 SL (imidacloprid) when applied with the external adjuvant UltraTM (Alkylether sulfate sodium salt 27%) or MERO (Rapsoelmethylester 81%) provided enhanced performance. Mixture of imidacloprid with spirotetramat in a ratio of 3:1, as Movento Plus 480 SC, provided excellent control with the addition of external adjuvants (UltraTM or MERO). Application on early stage (low infestation) was significantly better as compared to that of late (high) infestation. High performance of Confidor 200 SL and Movento

Plus 480 SC is attributed to the synergistic effect with adjuvants, UltraTM and MERO, enabling increased penetration of the active ingredients into the waxy cuticle of mealy bugs and plants. Use of these two external adjuvants with Confidor 200 SL and Movento Plus 480SC are highly recommended. Our seed treatment trials on cotton lead us to believe that there were no negative effects of seed treatment with the premix of spirotetramat + imidacloprid in the ratio of 1:3 at the tested dose rates. Bio-efficacy and residual control was significantly better when compared with the market standard. Our trials also lead us to conclude the premix of spirotetramat + imidacloprid in the ratio of 1:3 as a reliable seed treatment solution for the management of mealybugs. Because of the toxicity and residue issues associated, organophosphates are not recommended for vegetables where *P. solenopsis* breeds during the off cotton season. Thus, the use of softer chemistries, such as imdicloprid and its mixture with spirotetramat (with UltraTM or MERO) should be made in order to break the life cycle of these nasty pests on vegetables and other crops, besides cotton. Combinations have been widely used in Pakistan to counter possibilities of resistance development v/s use of single products. Movento Plus 480 SC can be a good solution to manage anticipated resistance, as the two active ingredients belong to different chemistries and have different mode of action. Use of seed treatment is highly recommended to eliminate early infestation of this pest in cotton.

9. Aggarwal N, Jindal V and Singh V. 2009. Evaluation of some insecticides against mealybug, *Phenacoccus solenopsis* Tinsley (Hemi: Pseudococcidae) on cotton. *Pestology*, **33**(6): 29-33.

   Profenophos, chlorpyriphos and carbaryl were evaluated for their efficacy against *P. solenopsis* and reported that profenophos 50 EC at 1250 ml /ha was effective against *P. solenopsis* on cotton.

10. Aheer Ghulam Mustafa, Shah Zafarullah and Saeed Muhammad. 2009. Seasonal history and biology of cotton mealybug, *Phenacoccus solenopsis* Tinsley. *Journal of Agricultural Research,* **47**(4): 423-431.

    Twenty two host plants were studied for the prevalence of cotton mealybug (CMB), *Phenacoccus solenopsis* Tinsley (a new pest of cotton crop in Pakistan) from December 2006 to November 2007 in the area around Faisalabad city. Maximum prevalence of CMB was observed on China rose (*Hibiscus chinensis*) followed by okra (*Abelmoschus esculentus*) *i.e.* 8.11 and 1.35 percent (high pest population with dried leaves/shoot/plant), 13.51 and 1.35 percent (presence of insect), respectively. CMB remained present throughout study period on China rose. Biology

of CMB was studied on China rose (the most preferred host) in laboratories of Entomological Research Institute, AARI, Faisalabad (Pakistan) during 2007. Freshly emerged 50 nymphs of CMB were kept in rearing cells, separately under laboratory conditions (25 ± 2ºC with RH 70 ± 5%). There were three nymphal stages in case of female and two in male CMB. The pupal stage in female was absent. Reproduction was bi-sexual and ovo-viviparous. Adult male lived for 2 to 3 days and female 45 to 85 days.

11. Ahmad Farhan, Akram Waseem, Sajjad Asif and Imran AU. 2011. Management practices against cotton mealybug, *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae). *International Journal of Agriculture and Biology*, **13**(4): 547-552.

    The influence of different management practices (insecticide, plant extract, homeo chemical & biological control) on the mealybug (*Phenacoccus solenopsis*) infestation was studied to evaluate their potential as a management strategy. Five treatments *viz.* chemical control (Profenofos 50 EC), plant product (Neemosal 0.5% EC), homeo-chemical (Fierce), biological control agent (*Chrysoperla carnea*) and a control plot were tested in three replicates. Profenofos showed the best control against cotton mealybug population. Neemosal and Fierce did not notably lower the mealybug population while *C. carnea* failed to produce any result. It is suggested that neem based insecticide (Neemosal) and homeo chemical (Fierce) can be applied during initial or low mealybug infestation, however chemical control (profenofos) should remain as the last option during heavy infestations.

12. Akintola AJ and Ande AT. 2008. First Record of *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on *Hibiscus rosa-sinensis* in Nigeria. *Agricultural Journal* (Medwell Journals, Pakistan), **3**(1): 1-3.

    A survey of mealybugs found in the southern guinea savanna of Nigeria was conducted and *P. solenopsis* was found on *Hibiscus rosa-sinensis* plant where the adult aggregated on the stem of the plant. Specimen of this was sent to Systematic Entomology Laboratory in the U.S and was identified by Douglas Miller. The adult recovered were females and the mouth part is the opisthorhynchous type with a long straight aseptate stylet. The organism was host specific and stationary. The tip of the abdomen was protruded with long setae. Various body appendages were measured and the life cycle studies conducted. Comparison between this mealybug and other related species was done and documented for the first time in Nigeria.

13. Akintola AJ and Ande AT. 2009. Pest status and ecology of five mealy bugs (Family: Pseudococcidae) in the Southern Guinea Savanna of Nigeria. *Journal of Entomological Research*, **33**(1): 9-13.

Five morphologically different types of mealy bugs (identified by Dug Miller, USDA): *Icerya aegyptiaca* Doughlas, *Rastrococcus* sp., *Rastrococcus invadens* Williams, *Phenacoccus madeirensis* Green and *Phenacoccus solenopsis* Tinsley were recoded on different host plants and at various locations within southern Guinea 'savanna zone'. *Rastrococcus* sp., *P. madeirensis* and *P. solenopsis* were restricted around Makurdi, where their presence was particularly pronounced (>70%) on their respective host plants. The incidence of the mealy bugs, particularly *I. aegyptiaca*, and *R. invadens*, was readily noticeable in all the sites visited. *Rastrococcus* sp., *P. madeirensis* and *P. solenopsis* had restricted occurrence within the zone. Whereas the mealy bugs infested the leaves of their respective host plants, especially the adaxial surface, *P. solenopsis* frequented the stem of *H. rosa- sinensis*. *Icerya aegyptiaca*, was a polyphagous individual recorded on eight different fruit and ornamental plants. *Rastrococcus* sp., *P. madeirensis* and *P. solenopsis* were monophagous, occurring only on *Acalypha* spp. and *H. rosa-sinensis*, respectively. Although *R. invadens* frequented *M. indica* plants, it was also found on *F. thonningii*.

14. Amutha M, Dharajothi B, Surulivelu T and Gopalakrishnan N. 2009. Natural Parasitism on Mealybugs, *Phenacoccus solenopsis* (Tinsley) and *Paracoccus marginatus* (Williams and Granara de Willink). *CICR Newsletter* January –March**, 25**(1): 5.

The parasitoid *Aenasius* sp. (Hymenoptera: Encyrtidae), a solitary endoparasitoid was recorded on mealybug collected from cotton and weed hosts *viz., Parthenium hysterophorus, Abutilon indicum, Phyllanthus niruri, Tridax procumbense, Commelina bengalensis, Convolvulus arvensis* and *Cleome viscosa*. In cotton, 10-45% parasitism by *Aenasius* sp was recorded. Among the alternate hosts, maximum percentage of parasitism was recorded on *A. indicum* (5-65%), followed by *P. hysterophorus* (5-30%).

15. Anonymous.1978. A mealybug (*Phenacoccus solenopsis*) - Florida. *Cooperative Plant Pest Report*, **3**(44-47): 622.

P. solenopsis reported for first time from Florida on ragweed.

16. Anonymous. 2008. Tackling mealybug menace in cotton: a new challenge. *NCIPM Newsletter,* **14**(1): 1-2. Available on http://www.ncipm.org.in/mealybugs/NewsletterJanJun2008.pdf

The main species of the mealybug reported from all the nine cotton growing States is *Phenacoccus solenopsis*. In Punjab the losses caused by the mealybug were estimated to be Rs. 159 crores to cotton growers during Kharif season 2007.

17. Anonymous. 2009. Mealybug species attacking Bt cotton is exotic? *Crop Care*, **35**(1):81. available on line at http://www.indianexpress.com/news/mealybug-species-the-bt-cotton-killer-is-exotic-experts/490540/0

In 2004, there was a sudden invasion on Bt cotton in Gujarat of mealybug, which spread to almost entire country and even in neighbouring Pakistan in the next two years. Such was its havoc that in 2007, the total damage to cotton in North India was estimated to be around Rs 2.5 crore. Infestation also increased pest control input costs by about Rs 10,000 per acre. Group of scientists at the Central Institute for Cotton Research (CICR) conducted a thorough molecular study of the deadly pest and concluded in December 2008 that the mealybug species was an exotic (alien) pest that was originally noticed in America.

18. Arif MJ, Abbas G and Saeed S. 2007. Cotton in danger. (In English). Dawn, the Internet Edition (http://DAWN.com), March 24th, 2007. 4 pp. 1-4. [ArifAbSa2007]

Phenacoccus gossypiphilous Nomen nudum is a synonym of *Phenacoccus solenopsis*.

19. Arif MI, Wazir S, Rafiq M, Ghaffar A and Mahmood R. 2011. Incidence of *Aenasius bambawalei* Hayat on mealybug *Phenacoccus solenopsis* Tinsley and its hyperparasite, *Promuscidea unfasciativentris* Girault at Multan. Paper presented in 5th ICAC International Cotton Advisory Committee held at Lahore, Pakistan on February 23-25, 2011. Available at: http://www.icac.org/tis/regional_networks/asian_network/meeting_5/documents/papers /PapArifMI-et_al.pdf

Random field samples of mealybug (*Phenacoccus solenopsis*) infestations were taken from cotton, brinjal, okra, China-rose and *Abutilon* etc. Both *Aenasius bambawalei* and *Promuscidea unfasciativentris* adults emerged in the laboratory from mummified mealybugs. Incidence of *A. bambawalei* was high on winter collections of mealybug from cotton (48%) and *Abutilon* (35%) in December and summer collections from China-rose (71% in July). *Promuscidea unfasciativentris* did not parasitize mealybug in the laboratory when mealybugs were offered to both the species in one container, however, its adults emerged from mummies of *A. bambawalei* indicating the tendency of *P. unfasciativentris* to act as

hyperparasite. High population of *P. unfasciativentris* in later half of cotton season (26.7% in October) may significantly reduce the performance of *A. bambawalei*.

20. Arif MJ, Gogi MD, Abid AM, Imran M, Shahid MR, Husain S and Arshad M. 2011. Predatory potential of some native coccinellid predators against *Phenacoccus solenopsis*, Tinsely (Pseudococcidae: Hemiptera). *Pakistan Entomologist*, **33**(2): 97-103.

Predatory potential of *Menochilus sexmaculatus, Coccinella septempunctata, Brumus suturalis, Hippodemia convergens* and their four instars against first instar nymphs of cotton mealybug, *Phenacoccus solenopsis* was investigated under laboratory conditions. The results showed significant variation in the predatory potential, in term of total, per-day and percent consumption of four predatory coccinellid species and their instars. The four evaluated predatory species of coccinellids caused more than 80% consumption and contributed significant and prominent role in the consumption of first instar nymphs of cotton mealybug; however, *C. septempunctata* and *B. suturalis*, registering total consumption of 538 and 536 nymphs/life and percent consumption of 95 and 92 %, respectively, was found better predator as compared to other two species. All the life stages of four predatory coccinellid species performed well registering more than 80% consumption of first instar nymphs of cotton mealybug, except fourth instar grubs (77.9% consumption); however, adult stage was found more effective predatory stage as maximum and highly significant predation (percent consumption) was registered by this stage (96.7%). Second, third and first instar grubs of all evaluated predatory coccinellid beetles showed 87.6, 86.1 and 81% consumption, respectively. In conclusion, all the predaceous life stage (four instars and adults) of *M. sexmaculatus, C. septempunctata, B. suturalis, H. convergens,* especially *C. septempunctata, B. suturalis,* were found potential predaceous stages/ predator for first instar nymphs of cotton mealybug and hence, should be evaluated in the fields for their potential effectiveness when used alone or in combination with other IPM tactics.

21. Arif MJ, Muhammad Rafiq and Abdul Ghaffar. 2009. Host plants of cotton mealybug (*Phenacoccus solenopsis*): a new menace to cotton agroecosystem of Punjab, Pakistan. *International Journal of Agriculture and Biology*, **11**(2): 163-167.

A new mealybug (*Phenacoccus solenopsis* Tinsley) appeared recently and has attained the status of a serious pest on a wide range of host plants. It was recorded from 154 plant species including field crops, vegetables, ornamentals, weeds, bushes and trees. Most of these belong to the families Malvaceae, Solanaceae, Asteraceae,

Euphorbiaceae, Amaranthaceae and Cucurbitaceae. Economical damage was observed on cotton, brinjal, okra, tomato, sesame, sunflower and China rose with plant death in severe conditions.

22. Arve S, Patel KG and Chavan S. 2012. *Phenacoccus solenopsis*: The White Menace to Global Agriculture: Population dynamics, Biology and Chemical control of mealybug, *Phenacoccus solenopsis* Tinsley on *Hibiscus rosa-sinensis*. LAP LAMBERT Academic Publishing, pp. 156.

    Mealybugs (Hemiptera: Pseudococcidae) are important plant pests worldwide. About 5000 species of mealybug have been recorded from 246 families of plants throughout the world. Among these, 56 species have been reported from 15 genera of family Malvaceae, including hibiscus, cotton and many other plants of economic importance. The mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) has a wide geographical distribution with its origin in Central America followed by reports of the Caribbean and Ecuador, Argentina, Brazil and Pakistan. It 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. The species *P. solenopsis* described as cotton mealybug due to its large scale occurrence on cotton attained damaging population simultaneously across many fields. In spite of its occurrence the information was scanty; therefore the present study on *P. solenopsis* was carried out so, the information generated may be used to formulate the management strategy of the pest.

23. Arve SS, Patel KG, Chavan SM and Vidhate PK. 2011. Investigation on population dynamics of hibiscus mealybug, *Phenacoccus solenopsis* Tinsley in relation to biotic factors under south Gujarat condition. *Journal of Biopesticides*, **4**(2): 211-213.

    Studies on population dynamics of hibiscus mealybug, *Phenacoccus solenopsis* Tinsley in relation to biotic factors were carried on randomly selected hibiscus plants at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) during 2007-08. Under field condition the observation recorded at fortnightly interval showed that the population of *P. solenopsis* on hibiscus was observed throughout the year with its peak activity from first fortnight of October to first fortnight of December. The highest population of mealybug per plant was found in first fortnight of November (93.68), exhibited the peak activity of mealybug population. During the course of investigation, the nymph and adult females were

found to be preyed by two predators *Spalgis epius* (Westwood) and *Scymnus coccivora* (Aiyar). The populations of both predators were directly related to the population of host, *P. solenopsis* and showed significant positive relationship with mealybug population.

24. Arve SS, Patel KG, Chavan SM, Vidhate PK. 2011. Varietal screening of *Hibiscus rosa-sinensis* under South Gujarat condition against mealybug, *Phenacoccus solenopsis*. *Insect Environment*, **17**(1): 36-37.

Screening of Hibiscus verieties against mealybug for their relative susceptibility was conducted at University area, Navsari Agricultural University, Navsari during 2007-08. To assess the damage caused by mealybug, observations were recorded by the number of nymphs and adult female mealy bugs, *P. solenopsis* on twigs of three places *viz.*, top, middle and bottom of five randomly selected plants of each cultivar of H. D. Maity, Hawaii white, Red satin, Agnes and snow flake at fortnightly intervals. The solenopsis mealybug population varied from 8 to 25 mealybug per plant. However, variety Red satin recorded the lowest mealybug. *P. solenopsis* population (8.5 mealybugs per plant) whereas, the highest population was found on Hawaii white with 29.87 mealybugs per plant. Among different varieties of Hibiscus, Red satin recorded the lowest mealybug population on par with H.D. Maity, followed by Agnes, Snow flake and Hawaii white.

25. Arve SS, Patel KG, Chavan SM, Vidhate PK. 2011. Nature of damage of mealybug, *Phenacoccus solenopsis* Tinsley on hibiscus. *Insect Environment*, **17**(1): 36.

It was observed that leaves, stems, flower buds and in large number on twig was infested by nymphs and female adults. The female laid eggs in group within cottony ovisac which remained posterior to the adult female. Whereas the entire surface of twig and stem was covered with overlapped adults female and nymphs. On hatching, the crawlers moved on to tender parts in search of food and chose a succulent spot, where they puncture the epidermis by inserting their stylets into host tissue and started sucking the cell sap. In severe infestation, they were found on all the aerial parts of tree such as leaves, tender branches, stem and flower. Due to continuous sucking of cell sap, the leaves turned pale yellow and began to dry and show symptom of wilting, young shoots started by curling and twisting and finally showed a bushy appearance with shortening of stem internodes leading to stunted plant growth. As the infestation progressed buds failed to open into in addition to this, both the nymphs and adult females excreted honeydew on which the black sooty mould developed, affecting the photosynthetic activity of plant.

26. Ashfaq M, Noor AR and Mansoor S. 2010. DNA-based characterization of an invasive mealybug (Hemiptera: Pseudococcidae) species damaging cotton in Pakistan. *Applied Entomology and Zoology*, Tokyo **45**(3): 395-404

    Mealybug (Hemiptera: Pseudococcidae) has emerged as a new cotton pest in Pakistan in recent years. We used DNA nucleotide sequences and PCR-RFLP, respectively, as tools for mealybug characterization and species composition. Partial nucleotide sequences of nuclear (elongation factor-1a , ribosomal DNA subunits 18S and 28S) and mitochondrial (COI) genes were used for species characterization, and the combined ITS1-5.8S-ITS2 sequences of rDNA were used for PCR-RFLP analyses. Homology searches of the nuclear genes indicated that the mealybug species damaging cotton in Pakistan belonged to the genus *Phenacoccus*. Further, the barcoding sequence of COI showed a significant nucleotide similarity with *Phenacoccus solenopsis*. PCR-RFLP analysis with three different endonucleases did not show restriction site differences among mealybug individuals collected from various host plants and geographical locations. This is the first DNA-based characterization of cotton mealybug from Pakistan and the findings will help in decision making while considering a biological control program.

27. Ashfaq Muhammad, Shah GS, Noor AR, Ansari SP and Mansoor Shahid. 2010. Report of a parasitic wasp (Hymenoptera: Encyrtidae) parasitizing cotton mealybug (Hemiptera: Pseudococcidae) in Pakistan and use of PCR for estimating parasitism levels. *Biocontrol Science and Technology,* **20**(6): 625-630.

    A parasitic wasp, *Aenasius bambawalei*, was studied for its biological parameters and parasitism levels in the cotton mealybug (*Phenacoccus solenopsis*). Biological parameters including parasitism efficiency, time to pupation, time to eclosion and adult sex ratio were studied under lab conditions. Parasitism levels in field collected mealybug were determined using PCR. Results showed an increase in parasitism over the study period, with higher parasitism levels in 2009 compared to the preceding 2 years.

28. Bambawale OM. 2008. *Phenacoccus solenopsis*, the main mealybug species on cotton in India does not appear to be “invasive”. Available online: http://www.ncipm.org.in/Mealybugs/Non-invasivePhenococcus_solenopsis.pdf.

    The occurrence of *P. solenopsis* a decade ago from non cotton growing areas of Uttar Pradesh, Madhya Pradesh and Karnataka states of India was reported and described it as a non-invasive pest.

29. Banu JG, Surulivelu T, Balamurugan M, Amutha M and Gopalakrishnan N. 2009. Natural occurrence of entomopathogenic fungi in mealybug, *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Psuedococcidae) in India. In proceedings of National symposium on Bt-cotton: Opportunities and Prospectus, CICR, Nagpur, November 17-19, pp150.

Mealy bugs (Hemiptera: Psuedococcidae) are small sap sucking insects and some species can cause severe economic damage to wide range of crops. Earlier, mealy bugs were considered to be non pests or as major pest in sporadic instances, but now they have become a major threat to cotton production in almost all cotton growing states of India. This exotic pest introduced accidentally created havoc not only on cotton but also on other crops, thereby threatening sustainable agricultural production in India. Several approaches for their control are presently under investigation including microbial agents. In order to get information on the role of naturally occurring pathogens in the regulation of mealy bug population, survey was carried out under farmer's field condition during 2007 and 2008. In infested cotton fields, dead mealy bug, *Phenococcus solenopsis* were collected and brought to the laboratory for the isolation of entomopathogens. These surveys resulted in the recovery and isolation of the following fungi from mealy bug. *Aspergillus clavatus A. oryzae, A. terreus, Verticillium* sp. and *Lecanicillium lecanii* (Zimm.) Zare and Gams. Among them *L. lecanii* was found to be highly pathogenic to *P. solenopsis* under laboratory condition. At an initial inoculum of 1 x 10^4 conidia/ml, lethal time (LT 50) was 3.77 and 2.51 days for nymphs and adults respectively. This is the first report on the natural occurrence of entomopathogenic fungi from mealy bug.

30. Ben - Dev Y. 2004. Scale Net, *Phenacoccus solenopsis*, Available from: http:// 198.77169.79/catalogs/pseudoco/Phenacoccussolenopsis.htm.

Phenacoccus solenopsis (solenopsis mealybug) was described originally from the U.S.in 1898 and it remained known only in the U.S., where it is widespread, until 1992 when, it spread to Central America, the Caribbean and Ecuador.

31. Bharathi Mohindru, Jindal Vikas and Dhawan AK. 2009. Record of parasitoid on mealybug *Phenacoccus solenopsis* in tomato. *Indian Journal of Ecology*, **36**(1): 101-102.

At Krishi Vigyan Kendra, Nurmahal, Punjab, India, tomato cultivars Punjab Upma and L 1001 were infested by mealy bugs (*P. solenopsis*). The mealy bug colonies were parasitized by an *Aenasius* species. Infestation of tomato and parasitism on

mealybug were initially recorded Punjab Upma on the 27th meteorological week and on L 1001 the following week. Parasitism of mealybugs on Punjab Upma and L 1001 reached 14.55-30.02 and 12.25-21.2%, respectively. Parasitism on Punjab Upma was greatest on the 28th standard week, whereas parasitism on L 1001 was most pronounced on the 30th standard week.

32. Bhatt NA. 2010. Mealybug [*Phenacoccus solenopsis* Tinsley (Homoptera: Pseudococcidae)] – a serious pest of tobacco in Gujarat. *Insect Environment*, **16**(2): 90-91.

In India, tobacco is mainly cultivated in Andhra Pradesh, Karnataka, Gujarat, Bihar, West Bengal and Tamilnadu. Among these, bidi tobacco (*Nicotiana tabacum* L.) and chewing tobacco (*Nicotiana rustica* L.) are largely cultivated in Gujarat. Tobacco being a long duration crop passes through various biotic stresses like insect pests causing quantitative and qualitative damage. Recently, Tobacco has been also found to be attacked by mealybug, *Phenacoccus solenopsis* Tinsley; a major species occurring on cotton in middle Gujarat. It has short to medium sized waxy filaments around the body; two dark stripes on either sides of middle ridge and absence of long tail. This species produces an egg mass or ovisac. *P. solenopsis* being a polyphagous pest, feeds on a number of field crops and weeds. It harbours throughout the year on weeds host and spread after preferred host crop appear in field. Under severe infestation, this pest was first noticed on parasitic weed of tobacco, Broomrape (*Orobanche ceranua* Loef). Another weed appeared on irrigation channels locally known as Bala. (*Sida acuta* Burm.f) was also found to be attacked by this pest.

33. Bhatt NA, Jayani DB and Patel AD. 2009. Mealybug *Phenacoccus solenopsis* Tinsley an emerging pest of bidi tobacco in Gujarat. Proceedings of National Symposium IPM strategies to combat emerging pests in the current scenario of climate change, January 28-30, 2009, College of Horticulture and Forestry Central Agricultural University, Pasighat, Arunachal Pradesh, pp. 38.

Tobacco has been also found to be attacked by mealybug, *Phenacoccus solenopsis*.Tinsley; a major species occurring on cotton in middle Gujarat. An experiment was carried out at Tobacco Research Farm AAU Anand during 2007 on selected and tagged from each plot. The number of mealybugs was recorded before and 3,7,14 days after insecticide application. All insecticidal treatments have significantly reduced the population (49.15% to 89.41%) over control. Amongst the treatments methomyl 0.8% (6.1/leaf) was found significantly superior and at par with profenophos 0.1% (6.7/leaf) and carbaryl 10.2% (6.8/leaf), Profenophos (0.1%),

Trizophos (0.01%), Methomyl (0.08%), Methyl-O-dematone (0.05%), Phenthoate (0.1%). Phosphamidon (0.05%), Chlorpyridon (0.05%), Acephate (0.0075%) and Imidaclopride (0.005%).

34. Bhosle BB, Bhede BV, Patange NR and Patait DD. 2009. Mealybug (*Phenacoccus solenopsis*)- a new threat to cotton production in Marathwada region of Maharashtra. Proceedings of National Symposium IPM strategies to combat emerging pests in the current scenario of climate change, January 28-30, 2009, College of Horticulture and Forestry Central Agricultural University, Pasighat, Arunachal Pradesh, pp. 37.

    Mealybug (*Phenacoccus solenopsis* Tinsley) on cotton had emerged as a new threat to cotton production in India. A roving survey was carried out in major cotton districts (Parbhani, Nanded, Hingoli, Jalna and Aurangabad) of Marathwada region of Maharashtra during 2007-08 crop seasons to observe the severity of the infestation. The results revealed that the mean number of mealybug/2.5 cm apical shoot ranged from 8.88 to 20.41%. In Parbhani district, the number was highest (20.41%). The percentage of infested plants was highest in Parbhani (52.08%) and lowest in Hingoli district (11.41%). The infested leaves ranged from 11.37 to 49.95%.The severity of infested bolls ranged from 10.10 to 35.77%. The highest grade of infested plants was recorded in Parbhani (2.74), followed by Jalna (2.39), Aurangabad (2.03), Nanded (1.86) and Hingoli (1.12). Survey revealed that the incidence was severe all over in Marathwada and it may prove as a major biotic constraint in ensuring years.

35. Bhosle BB, Sharma OP, More DG, Bhede BV and Bambawale OM. 2009. Management of mealybugs (*Phenacoccus solenopsis*) in rainfed cotton (*Gossypium hirsutum*). *Indian Journal of Agricultural Sciences*, **79**(3): 199-202.

    A study was conducted during rainy (kharif) season of 2008 on the incidence of mealybugs rainfed cotton growing areas of Marathwada region in different transgenic cotton hybrids, especially the *Phenacoccus solenopsis*. Severity of incidence was maximum in Parbhani with 40.95% leaf infestations and 35.77% of green boll damage. Lowest incidence was recorded in Hingoli district with 11.37% leaf infestations and 10.10% of green boll damage. Since farmers were using a number of pesticides, field evaluation was carried out at the field of Sategaon Talak. Palam Dist. Parbhani. Out of 12 insecticides tried as curative spray at 2, 7 and 14 days after economic threshold level indicated that acephate 70 SP, followed by profenophos 50 EC and diclorvos 76 EC was effective in management of mealybug. The yield of seed cotton was significantly highest in acephate 70 SP (2.22 tonnes/ha) except profenophos 50 EC (2.22 tonnes/ha) which were at par with each other.

36. Bisane KD, Khande DM and Aherkar SK. 2010. Occurrence of mealybugs in Vidarbha region of Maharashtra**.** *Indian Journal of Entomology,* **3**: 202-204

Survey was conducted to identify the dominant species of mealybugs in Vidarbha region of Maharashtra during Kharif 2008. The observations revealed that *Phenacoccus solenopsis* Tinsley was a predominant species in Yavatmal, Chandrapur and Akola districts on cotton. The same species was also observed on sesamum in Chandrapur and on brinjal in Bhandara district of Vidarbha. Infestation was up to 14.6 mealy bugs/5 cm twig on cotton, while on sesamum it was 3.8 mealy bugs/5 cm twig and 9 mealy bugs/5 cm twig on brinjal. Same species was also harboring on *Bt* cotton in Akola. On soybean in Chandrapur, Washim and Yavatmal district of Vidarbha region, *Nipaecoccus viridis* Newstead was dominant and 8.8 mealybugs/5 cm twig was observed. *Formicoccus robustus* Ezzat and McConnell was recorded on mango trees in Wardha district, on which 5.2 mealybugs/5 cm twig were observed.

37. Bodlah I, Ahmad M, Nasir MF and Maeem M. 2010. Record of *Aenasius bambawalei* Hayat, 2009 (Hymenoptera Encyrtidae), a parasitoid of *Phenacoccus solenopsis* (Sternorrhyncha Pseudococcidae) from Punjab, Pakistan. *Pakistan Journal of Zoology*, **42**: 533-536.

The cotton mealybug *Phenacoccus solenopsis* Tinsley parasitoid, *Aenasius bambawalei* Hayat has been recorded for the first time from mummified mealybugs collected in the field on various weeds and cotton crop from different districts of Punjab province of Pakistan. The redescription of the species is provided with its four host plants and distribution in the Punjab province of Pakistan. The parasitoid is illustrated using micrographs and line drawings. In addition, this paper also presents brief information on its biological characteristics.

38. Brar JS, Singh S, Aulakh GS, Pandher S and Singh G. 2009. Status of mealybug *Phenacoccus solenopsis* Tinsley at Faridkot, Punjab and its management. Proceedings of National Symposium IPM strategies to combat emerging pests in the current scenario of climate change, January 28-30, 2009, College of Horticulture and Forestry Central Agricultural University, Pasighat, Arunachal Pradesh, pp. 34.

Studies were conducted in twenty villages (Tehna, Chahal, Chaina, Kiriwali, Chack Kalyan, Fiddekalan, Baja Khana, Sirewala, Fiddekhurd, Dhimanwali, Khuwarwala, Wanderjathana, Machaki Malsinghwala, Jalalaniana, Warradherakha, Khara, Arayanwala Kalan, Bhurjamasta, Sadhuwala, Doad) of Faridkot district of Punjab

state during the cotton season (2008) at PAU, Regional station, Faridkot. Intensive surveys were carried out to educate the farmers about the effective management of the mealybug. The percent infested plants and the intensity was calculated. The important management practices were eradication of the weed such as congress grass, Lantana, *Trianthema monogyna*, *Calotropis gigantean, Bathu* and common grass, burial of the infested weed in the soil and not to dispose it in the water source such as canal, regular monitoring of the field, spot treatment of the infested plants with recommended insecticides in rotation, washing of the implements to avoid dispersal. The intensity of the infested plants remained between 0.73 and 1.44. It was observed that besides all these practices adopted the rains also had great impact on the population which was initially high and lowered with the initiation of the rains.

39. Charleston K and Murray D. 2010. Exotic mealybug species – a major new pest in cotton. Queensland Government. The Beat sheet. Accessed online on 30 September 2010 at http://thebeatsheet.com.au/mealybugs/exotic-mealybug-species-a-major-new-pest-in-cotton/

    Biosecurity Queensland has confirmed an outbreak of an exotic species of mealybug currently affecting cotton properties in Emerald is also present in cotton crops in the Burdekin region. The exotic species of mealy bug is commonly known as the Solenopsis mealybug (*Phenacoccus solenopsis*).

40. Chen Hua-Yan, Cao Run-Xin and Xu Zai-Fu. 2010. First record of *Aenasius bambawalei* Hayat (Hymenoptera: Encyrtidae), a parasitoid of the mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) from China. *Journal of Environmental Entomology,* **32**(2): 280-282.

    Aenasius bambawalei Hayat, 2009, a parasitoid of the mealybug, *Phenacoccus solenopsis* Tinsley, was newly reported from Guangdong and Hainan Provinces, China, with its description and illustration in this paper.

41. Chu Dong, Liu GuoXia, Fu HaiBin and Xu Wei. 2009. Phylogenetic analysis of mt CO I reveal the cryptic lineages in *Phenacoccus solenopsis* complex (Hemiptera: Pseudococcidae). *Acta Entomologica Sinica,* **52**(11): 1261-1265.

    The mealybug species, *Phenacoccus solenopsis* Tinsley has caused severe economic losses during the last two decades in many countries. Recently this alien invasive species has been introduced in China and threatened the agricultural production. The rapid and accurate identification of the species has been the basis

of the scientific research and management of the alien invasive species (IAS). In this study, the mitochondrial cytochrome oxidase subunit I (mt CO I) of the *P. solenopsis* materials collected from Sanya City and Lingshui County, Hainan Province were sequenced and compared with the known sequences of the species from Florida of the USA. We unexpectedly found that there were two divergent clades in the mealybug species*, P. solenopsis*, based on the phylogenetic tree. The genetic distance between the collections from China and those from the USA was approximately 3%. This was the first report on the molecular identification of *P. solenopsis* in China based on the mt CO I marker. These data suggest that *P. solenopsis* might be a species complex which includes at least two cryptic lineages or sibling species. The newly collected *P. solenopsis* materials from Sanya and Lingshui are of a cryptic lineage or species in the complex. The data also suggest the source of Sanya and Lingshui populations of *P. solenopsis* in the present study might not come from Florida of the USA. The discovery of the cryptic lineages in *P. solenopsis* complex is helpful for its accurate identification and the future research in its invasion ecology.

42. Culik MP and Gullan PJ. 2005. A new pest of tomato and other records of mealybugs (Hemiptera: Pseudococcidae) from Espirito Santo, Brazil. (Summary In Portuguese). *Zootaxa,* **964**: 1-8

Three mealybug (Hemiptera: Pseudococcidae) plant pest species: *Dysmicoccus boninsis* (Kuwana), *Phenacoccus solenopsis* Tinsley, and *Pseudococcus viburni* (Signoret), are recorded for the first time in the state of Espírito Santo, Brazil. This is the first record of *Phenacoccus solenopsis* in Brazil, where it was found infesting tomato plants. The species *Antonina graminis* (Maskell), a common pest of Bermuda grass, and *Dysmicoccus brevipes* (Cockerell), a major pest of pineapple, also were encountered.

43. David PMM, Rajkumar K, Razak TA, Nelson SJ, Nainar P, Baskaran RKM and Rajavel DS. 2010. Efficacy of castor oil-based soft soaps against cotton mealybug, *Phenacoccus solenopsis* Tinsley on brinjal. *Karnataka Journal of Agricultural Sciences*, **23**(1): 169-170.

Greenhouse and field experiments were conducted during 2007-09 in Killikulam, Tamil Nadu, India, to study the efficacy of castor-oil-based soft soaps, fish oil soap (2.5%), imidacloprid 17.8 SL (50 g a.i./ha), spinosad 45 SC (90 g a.i./ha) and avermectin 1.9 EC (5 g a.i./ha) against *P. solenopsis* on aubergine (cv. KKM 1). The soft soaps were prepared by treating potassium hydroxide with castor oil before

adding plant extracts and naturally occurring preservatives. Five soft soap variants (soaps 1, 2, 3, 4 and 5) were evaluated at 2.0% each. In the greenhouse, soft soaps 3 and 5 were as effective as fish oil soap, spinosad and imidacloprid, while soft soap 1 was on a par with soft soaps 4 and 5. Soft soaps 5 and 3 reduced the mealybug incidence by 74.30-77.14% (88.6% reduction following imidacloprid and spinosad application). The number of mealy bug increased from 1.0 per 2-node shoot at 3 days after treatment (DAT) to 1.4 per 2-node shoot at 7 DAT, indicating that the effects of soft soaps and the other treatments lasted for a short period. In the field, soft soap 4 was as effective as imidacloprid and fish oil soap (0.9-1.3 per 2-node shoot). Mealy bug populations recorded for the other soft soap variants were on a par with those observed in the control (1.4-2.1 per 2-node shoot). Soft soap 4 and imidacloprid reduced the number of *P. solenopsis* by up to 50.0%.

44. David PMM, Elanchezhyan K, Rajkumar K, Razak TA, Nelson SJ and Suresh S. 2009. A simple petriplate bracket cage and host plants to culture cotton mealybug, *Phenacoccus solenopsis* (Tinsley) and its predator, *Harmonia octomaculata* (Fab.). *Karnataka Journal of Agricultural Sciences,* **22**(3): 676-677.

An aphidophagous coccinellid *Harmonia octomaculata* to feed on *Phenacoccus solenopsis* on sunflower and tried to culture them in screenhouse conditions by screening different host plants to maintain *Phenacoccus solenopsis* and by confining *H. octomaculata* on mealybug-infested plants in simple cages. Different host plants of *Phenacoccus solenopsis* were screened, and among them *Portulaca oleracea* was found suitable for easy propagation and rapid establishment of mealybug before designing a simple cage to mass culture *Phenacoccus solenopsis* and its predator *H. octomaculata* using plastic tea cups. Petri plates, A4-sized transparent OHP sheets and triangular clips were used for preparing simple Petri plate bracket cage. The results revealed that *Portulaca oleracea* was highly suitable for *Phenacoccus solenopsis* culturing under screen house conditions. It was easy to propagate with stem cuttings which rooted quickly. Planting of fresh unrooted cuttings through the Petri plate holes in the lower bracket allowed the mealybugs to feed without the plants losing turgidity. Mere placing of mealybug-infested cuttings into the cage without planting was also able to sustain mealybug feeding. Between the two colours of *Portulaca oleracea* (pink and white), those with pink flowers supported more mealybugs than those with white flowers. Those plants with spindle-shaped elongate leaves bearing variably coloured flowers were also supported mealybugs. *H. octomaculata* was found to develop inside the Petri plate bracketed cage by

feeding on *Phenacoccus solenopsis* infesting *Portulaca oleracea* in tea cups. Adult beetles laid clusters of eggs usually on the under surface of leaves, on the sides of OHP cylinder, or on the inner surface of the top Petri plate bracket.

45. Deosarkar DB, Zanwar PR and Shelke LT. 2011. Clothianidin: a promising new molecule for the management of sucking pests of transgenic cotton. In World Cotton Research Conference-5 held at Mumbai from 7-11 Nov. 2011.

Cotton is an industrial crop of the world and India accounts of 24% of the total area under cultivation. After introduction of Bollgard technology, sucking pests *viz.*, aphids, *Aphis gossypii (Glover),* jassids, *Amrasca devastans (Distant),* thrips, *Thrips tabaci (L.),* whiteflies, *Bemesia tabaci* (Genn.) and an emerging pest mealybug, *Phenacoccus solenopsis* Tinsley, affect the crop during early growth stages and causing phenomenal losses. Hence studies were conducted to evaluate the bio efficacy of clothianidin 50% Water Dispersible Granules belonging to neo nicotinoids group, introduced by Sumitomo Chemicals India, Pvt. Ltd., Mumbai during 2008-09 and 2009-10 at Cotton Research Station, Nanded (Maharashtra) India, against sucking pests of cotton at different rainfed conditions. The experiment was configured to Randomised Block Design with seven treatments replicated thrice in a homogenous block with respect to fertility status. The seeds of popular transgenic cotton hybrid Bunny Bt were sown with a spacing of 90 x 60 cm in plot measuring 5.4 x 6.0 m for each treatment. The treatments were applied after 25 to 30 days after sowing by soil drenching (Root zone) through Knapsack sprayer by removing nozzle for clothianidin 50% WDG treated treatments and foliar application with Knapsack sprayer for Chlorpyrifos 20% EC and Thiodicarb 75% WP treatments using 500 liters of spray volume per hectare. The results of two season field trials indicated that applications of clothianidin 50% WDG @ 100 and 125 g a.i. /ha twice rendered very good protection of crop against mealy bugs and other sucking pests with no adverse effect on coccinelids and chrysopids. The infestation of mealybugs declined gradually from grade II to I and finally disappeared in the treatments clothianidin 50% WDG @ 150,125and 100 g a.i. /ha. During both the years, the population of aphids, jassids, thrips and whiteflies were significantly reduced in the treatments clothianidin 50% WDG @ 150,125 and 100 g a.i. /ha. These treatments recorded higher seed cotton yield, which were at par with each other during both the years.

46. Desai HR, Patel CJ, Maisuria IM and Kumar V. 2011. Evaluation of different insecticides for the control of mealybug, *Phenacoccus solenopsis* Tinsley

in cotton. Abstract in World Cotton Research Conference-5 held at Mumbai from 7-11 Nov. 2011.

Paradigm shift in pest scenario has been more common in the recent times in the rapidly changing cropping systems and environment with the dominance of Bt cotton across India. An introduced species of mealybug, *Phenacoccus solenopsis* Tinsley was not known earlier and has emerged as major pest and caused havoc in all nine cotton growing states of the country causing heavy losses up to 40 to 50% of affected fields during 2006-07 in Gujarat state. Being an introduced /exotic pest, the knowledge among the farmers and researchers was lacking. A field study was conducted for three successive years (2007-09) to evaluate the various insecticides for mealybug management in cotton while being safe to native predators. Eleven insecticides along with control were evaluated on BG Bt hybrid by recording per cent infested plant, mealybug grade, predator population, seed cotton yield and economics. Highest cost benefit ratio was obtained in the treatment of Monocrotophos 36 WSC (1:13.05) followed by Imidacloprid 70 WG (1:13.03), Acetamiprid 20 SP (1:8.93), Acetamiprid 20 SP + Chlorpyriphos 20 EC (1:8.56), Methyl Parathion 50 EC (1:7.68) and Clothianidin 50 WDG (1:7.07). But considering the efficacy of these products against mealybug, then safety to predator, yield and economics, Imidacloprid 70 WG, Acetamiprid 20 SP and /or Acetamiprid 20 SP + Chlorpyriphos 20 EC at 15 days interval starting from initiation of pest damage was found most effective.

47. Deshmukh AJ, Vennila S, Pinjarkar DB, Ghodki BS and Kranthi KR. 2009. Host range of mealybugs *Phenococcus solenopsis* Tinsley in cotton +pigeon pea cropping system of central India. In Proceedings of the National Symposium on "Bt cotton: opportunities and prospects" held at Central Institute for Cotton Research, Nagpur during November 17-19, pp. 150.

Mealy bugs, *Phenacoccus solenopsis* Tinsley was the dominant species over large areas of all the three cotton growing regions widely cultivating Bt hybrids across cropping systems in India. Although the infestation levels of mealybugs in the cotton + pigeon pea – fallow system of Central Indian rainfed cotton were trace and disjunctive and was not alarming in majority of fields of cotton growers during 2008-09, the survey for host range under the rainfed cotton production system revealed a total record of 91 host plants spread across 24 families. *P. solenopsis* was found multiplying on 30 host plants during the cotton growing season and 61 plants exclusively during off season. Ten and 27 host plants had the highest severity of Grade 4 during cotton and off seasons, respectively. Plant species from three families

viz., Compositae, Leguminaceae and Malvaceae constituted 50% of the host plants of *P. solenopsis*. The rank of families with at least two plant species of plant kingdom supporting *P. solenopsis* build up is of the order: Compositae (10) > Leguminaceae and Malvaceae (eight each) > Amaranthaceae, Euphorbiaceae and Solanaceae (four each) > Graminae(3) > Convolvulaceae and Labiatae (two each). Off season hosts were higher than the growing season indicating the strong carry over between cotton seasons. While many host plants of *P. solenopsis* could delay the outbreaks on any one crop plants the numerous and widespread host plants would facilitate spatial spread of the insect. Since the occurrence of *P. solenopsis* is on large number of weed hosts over agriculturally important crop plants, cultural management practices such as field sanitation and weed removal with contained disposal during crop and off seasons play a significant role in preventing spread of *P. solenopsis*. Thus, the host plant diversity for *P. solenopsis* can be a boon and bane in rainfed Bt cotton production system.

48. Dhaliwal GS, Vikas Jindal and Dhawan AK. 2010. Insect pest problems and crop losses: changing trends. *Indian Journal of Ecology*, **37**(1): 1-7.

Insect pest problems in agriculture have shown a considerable shift during first decade of twenty-first century due to ecosystem and technological changes. While there has been an overall decline in the severity of *Helicoverpa armigera* (Hubner), the incidence of several other insect pests like mealy bugs, particularly *Phenacoccus solenopsis* Tinsley on cotton; sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner on sugarcane; and tobacco caterpillar, *Spodoptera litura* (Fabricius), on several crops, has shown an increasing trend. The diamondback moth, *Plutella xylostella* (Linnaeus), has consistently remained the most destructive pest of cruciferous vegetables. The global losses due to insect pests have declined from 13.6 per cent in post-green revolution era to 10.8 per cent towards the beginning of this century. In India, the crop losses have declined from 23.3 per cent in post-green revolution era to 17.5 per cent at present. In terms of monetary value, the Indian agriculture currently suffers an annual loss of about Rs 8,63,884 million due to insect pests.

49. Dharajyoti B, Surulivelu T and Gopalkrishnan N. 2008. Status of mealybug on cotton in various parts of India. In *Proceedings of the National Consultation on Mealybug Management.* Central Institute for Cotton Research, 28-29 January 2008, Nagpur, India. pp. 8-10.

Mealybug infestation reported from all the nine cotton growing states of India *viz.,* Punjab, Haryana, Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Tamil Nadu, Andhra Pradesh and Karantaka.

50. Dhawan AK and Saini S. 2009. First Record of *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on cotton in Punjab. *Journal of Insect Science* (Ludhiana), **22** (3): 309-310.

The solenopsis mealybug, *Phenacoccus solenopsis* Tinsley, a pest of ornamental and fruit trees, appeared on cotton crop in some pockets of Ferozepur (Abohar), Muktsar (Malout) and Bathinda (Sangat) districts of Punjab, India during 2006. This is a first record of mealybug *P. solenopsis* infesting cotton crop in Punjab.

51. Dhawan AK, Kamaldeep Singh and Ravinder Singh. 2009. Evaluation of different chemicals for the management of mealybug, *Phenacoccus solenopsis* Tinsley on Bt cotton. *Journal of Cotton Research and Development*, **23**(2): 289-294.

To assess the effectiveness of new combination, spirotetramate (12%)+imidacloprid (36%)-480 SC @ 500, 625 and 700 ml/ha vis-a-vis spirotetramate 150 OD, imidacloprid 200 SL, thiodicarb 75 WP and profenophos 50 EC @ 600, 900, 625 and 1250 ml/ha against the mealybug, *Phenacoccus solenopsis* Tinsley, the experiments were conducted on Bt cotton during 2007 and 2008 crop seasons at farmer's field. An untreated field was kept as check. Data were recorded on mealybug incidence on per cent reduction basis. The results indicated that spirotetramate (12%)+imidacloprid (36%)-480 SC @ 625 ml/ha was the best treatment in comparison to its other doses as it resulted in significant reduction in mealybug population yet remained at par with the standard checks. The seed cotton yield in spirotetramate (12%)+imidacloprid (36%)-480 SC @ 625 ml/ha was at par with thiodicarb and profenophos. Spirotetramate (12%)+imidacloprid (36%)-480 SC @ 625 ml/ha proved better than the spirotetramate and imidacloprid, when tested alone for the management of mealybug in cotton.

52. Dhawan AK, Kamaldeep Singh, Anand Aneja and Sarika Saini. 2009. Distribution of mealybug, *Phenacoccus solenopsis* Tinsley in cotton with relation to weather factors in South-Western districts of Punjab. *Journal of Entomological Research*, **33**(1): 59-63.

The incidence of mealybug, *P. solenopsis* was recorded from the South-western districts of Punjab *i.e*. Mansa, Bathinda, Muktsar, Faridkot and Ferozepur. The highest field infestation recorded was mostly in the 30th meteorological week with 14.9, 31.5

and 26.9 per cent in Bathinda, Muktsar and Ferozepur districts, respectively. In Faridkot, the highest field infestation of 10.2 per cent was recorded in 34th meteorological week. There was positive correlation among the per cent field infestation, number of infested rows by mealybug and temperature, whereas negative correlation was observed with relative humidity and rainfall. All the meteorological parameters influenced the incidence of mealybug on cotton in all the districts studied in Faridkot district where r-value is 0.71 in per cent infestation by mealybug and 0.76 in rows infested by mealybug.

53. Dhawan AK, Kamaldeep Singh, Sarika Saini, Anand Aneja and Jasbir Singh. 2011. Parasitizing potential of parasitoid (*Aenasius bambawalei*) on mealybug (*Phenacoccus solenopsis*) in cotton (*Gossypium* spp.) and weed plants. *Indian Journal of Agricultural Sciences*, **81**(1): 97-99.

The present study had been planned to study the extent of mealybug parasitization by *A. bambawalei* in cotton and other alternate hosts. Data were collected from five cotton growing districts of Punjab, *viz*., Mansa, Ferozepur, Bathinda, Faridkot and Barnala during September 2009. In addition to this, the population of *P. solenopsis* on its alternate hosts, *i.e* congress weed, kangi buti, and pilli buti, were also examined. The overall percentage parasitized mealybugs varied from 40.69 to 43.53% with no significant differences among each other. The highest (43.53%) parasitization of mealybugs by *A. bambawalei* was observed in kangi buti weed and lowest (40.69%) in cotton. On the basis of host plants, the parasitism by *A. bambawalei* on cotton was 25.78 to 55.87%, 30.76 to 57.12% on kangi buti, 21.81 to 53.40% on congress grass and 27.45 to 52.11% on pilli butti. It was concluded from the above study that *A. bambawalei* can cause high natural parasitization of mealybug on cotton as well as on other hosts of *P. solenopsis.*

54. Dhawan AK and Saini Sarika. 2009. Study on biology of mealybug, *Phenacoccus solenopsis* Tinsley on cotton in Punjab. Proceedings of National Symposium IPM strategies to combat emerging pests in the current scenario of climate change, January 28-30, 2009, College of Horticulture and Forestry Central Agricultural University, Pasighat, Arunachal Pradesh, pp. 35.

Biology of cotton mealybug*, Phenacoccus solenopsis* Tinsley was studied on cotton. The pest was observed to be viviparous with three nymphal instars preceding the adult stage. In case of male, after second instar cocoon is formed. Lifecycle ranged from 27-38 days including adult longevity in warmer conditions. The lifecycle of

male varies from 16-23 days. The fecundity varies from 270-340 young ones/female. Weather conditions like temperature, minimum RH and rainfall showed positive effect on the insect biology and their incidence in field.

55. Dhawan AK, Saini Sarika and Singh Kamaldeep. 2008. Evaluation of novel and conventional insecticides for management of mealybug, *Phenacoccus solenopsis* Tinsley in Punjab. *Pesticide Research Journal*, **20**(2): 214-216.

On the basis of LC_{50} values of insecticides and taking that of profenophos as unity, the order of toxicity of insecticides was same for the both one day old nymph/ crawler and adult female. The order of toxicity was spirotetramate > clothianidin > profenophos > thiodicarb > quinalphos > buprofezin > acephate with their relative toxicity values being 5.05, 2.93, 1.00, 0.84, 0.82, 0.29, 0.25 micro gm L^{-1} for one day old nymph/crawlers and 5.29, 2.41, 1.00, 0.96, 0.73, 0.35, 0.19 micro gm L^{-1} for the adult female, respectively. The new molecule, spirotetramate was found to be most toxic to one-day-old nymphs and adult female particularly among the conventional insecticides. Profenophos and thiodicarb proved to be the best insecticides for mealybug control. Acephate was found to be least toxic against both nymph and adult of mealybug.

56. Dhawan AK, Saini Sarika and Singh Kamaldeep. 2010a Seasonal occurrence of cotton mealybug *Phenacoccus solenopsis* Tinsley on different hosts in Punjab. *Indian Journal of Ecology*, **37**(1): 105-109.

A survey of a major cotton growing district in Punjab, India, was conducted from 2007 to 2008, to record the incidence of cotton mealybug (*Phenacoccus solenopsis*) on different host plants. Data on the incidence of cotton mealybug (CMB) were recorded from 22 host plant randomly selected in and around the field area at 15-day intervals. Depending on the host plant, symptoms such as twisted and dried leaves and shoots, white fluffy mass on stems, distorted or bushy shoots, presence of honeydew, black sooty mould and small deformed fruits, among others, were recorded. Grading was done based on the pest incidence on the plant, *i.e*. presence of mealybug (first grade), presence of mealybugs on central shoot of the plant (second grade), presence of mealy bugs on stems, leaves and reproductive parts of the plant (third grade) and appearance of honey dew and stunted growth, with almost all hosts with mealy bug showing white appearance (fourth grade). The incidence percentage of mealybug on each host plant was calculated. *P. solenopsis* was recorded on 22 plant species from 10 families comprising 7 field and vegetable

crops, 3 ornamentals and 12 weeds. Plants from the Malvaceae, Solanaceae, Asteraceae, Amaranthaceae, Verbenaceae and Zygophyllaceae families were generally found as preferred hosts of CMB. Plants from the Malvaceae family recorded the highest pest incidence, followed by Compositae and Solanaceae. China rose (*Hibiscus syriacus*) and congress grass (*Parthenium hysterophorus*) were the most preferred hosts.

57. Dhawan AK, Saini Sarika and Singh Kamaldeep. 2010b. Morphological comparisons among different geographical populations of cotton mealybug, *Phenacoccus solenopsis* Tinsley in Punjab. *Indian Journal of Ecology*, **37**(2): 193-198.

The present investigation was carried out to study the morphological comparisons among different geographical populations of cotton mealybug *Phenacoccus solenopsis* Tinsley from three districts of Punjab infesting cotton crop during 2007-08 crop season. The body length and width for egg, all instars, prepupa and pupa of male, adult female and male of *P. solenopsis*, length of prothoracic, mesothoracic and metathoracic legs and antennae length and number of segments were taken by using ocular and stage micrometer with the help of Olympus stereo microscope SZX16. All measurements are taken at the zoom magnification of 11.5X for all instars except adult male (at 5X). Based on our present understanding of the morphology of all the instars of mealybug, there were no significant variations in the various stages among Ludhiana, Bathinda and Muktsar population of *P. solenopsis*.

58. Dhawan AK, Saini Sarika, Singh Kamaldeep and Aneja Anand. 2009. Persistence and residual toxicity of some insecticides against *Phenacoccus solenopsis* on cotton (*Gossypium* spp). *Indian Journal of Agricultural Sciences*, **79**(3): 203-206.

The persistence and residual toxicity of profenophos, thiodicarb, buprofezin, quinalphos, chlorantraniliprole, spirotetremate, acephate, carbaryl and chlorpyriphos at recommended concentrations in field on cotton (*Gossypium* spp) against first instar and adult female of mealybug *Phenacoccus solenopsis* Tinsley. The mortality data for the crawlers were taken up to 24 hr, whereas for the adult females, the mortality data were recorded up to 72 hr within different exposure periods of 1, 3, 7, 10 and 14 days after application of the insecticides. Based on the index of persistence toxicity, the order of effectiveness for the crawlers of *P. solenopsis* were profenophos (637.1) > thiodicarb (587.9) > buprofezin (492.3) > quinalphos (407.9) > chlorantraniliprole (380.0) > spirotetramate (371.6) > acephate (345.7) > carbaryl

(314.6) > chlorpyriphos (273.4). Similarly, for the adult female this order of effectiveness was profenophos (572.9) > buprofezin (483.1) > thiodicarb (430.0) > quinalphos (379.9) > chlorantraniliprole (371.6) > spirotetramate (361.3) > acephate (296.7) > carbaryl (260.0) > chlorpyriphos (252.3).

59. Dhawan AK, Saini Sarika, Singh Kamaldeep and Mohindru Bharathi. 2008. Toxicity of some new insecticides against *Phenacoccus solenopsis* (Tinsley) [Hemiptera: Pseudococcidae] on cotton. *Journal of Insect Science* (Ludhiana), **21**(1): 103-105.

Bioassay studies were conducted to evaluate the relative efficacy of insecticides against mealybug, *P. solenopsis*, collected from the cotton fields of Bathinda district, Punjab, India. On the basis of the LC50 values of the insecticides, the order of toxicity for these insecticides was: emamectin benzoate > chlorantraniliprole > pyridalyl > nuvaluron > quinalphos > thiodicarb > flubendiamide > acephate > chlorpyrifos > endosulfan. Among the new molecules tested, chlorantraniliprole was the most toxic to *P. solenopsis*.

60. Dhawan AK, Singh K, Saini S, Mohindru B, Kaur A, Singh G and Singh S. 2007. Incidence and damage potential of mealybug, *Phenacoccus solenopsis* Tinsley on cotton in Punjab. *Indian Journal of Ecology*, **34:** 110-116.

Mealybug *Phenacoccus solenopsis* was initially noticed in Punjab and in 2007 it has spread throughout major cotton growing districts and reported 30-40% losses in cotton yield due to this pest in Punjab.

61. Dhawan AK. 2008. Historical perspective of varius species as cotton pests in India and rest of world and factor affecting occurrence and outbreak on cotton. In Proceedings of the National Consultation on Mealybug Management. Central Institute for Cotton Research, 28-29 January 2008, Nagpur, India. pp. 11-14

Severe economic damage to *G. hirsutum* was reported in 2007 in four major cotton-growing districts (Bathinda, Muktsar, Faridkot and Ferozepur) of Punjab, two districts (Hisar and Sirsa) of Haryana, and low to moderate damage in parts of Maharashtra, Tamil Nadu and Andhra Pradesh.

62. Dutt U. 2007a. Mealybug infestation in Punjab: Bt cotton falls flat. Accessed online 26 September 2010 at http://www.countercurrents.org/dutt210807.htm

The cotton belt of Punjab was seriously threatened by mealybugs *Phenacoccus solenopsis* Tinsley (Hemiptera : Psuedococcidae) covering larger areas and causing huge losses in 2007-2008. Mealybug had destroyed large portion of cotton crop this

year so much so that Director Agriculture himself expressed drop in production of cotton bales despite increased area under cotton cultivation.

63. Dutt U. 2007 b. Mealybug takes away glory of Bt cotton. Accessed online 26 September 2010 at http://www.ens-newswire.com/ens/aug2007/2007-08-24-insdutt.asp

As the mealybug is destroying the cotton crop in the Malwa region of Punjab, in desperation the farmers are intensively spraying the cotton with pesticides, which are toxic and costly. A major portion of the profit which the farmer hoped to reap from his cotton crop, has already gone into pockets of pesticide companies, making the farmer once again the ultimate loser. This year it became so widespread that in hundreds of villages in all pockets of the Cotton Belt, farmer after farmer ploughed their Bt cotton fields under to get rid of the mealybug.

64. Fand BB, Gautam RD and Suroshe Sachin S. 2012. Bio-intensive Management of mealybug *Phenacoccus solenopsis*: methods and approaches. LAP LAMBERT Academic Publishing. pp. 124.

This book presents the work that has immense application in pest-control and will greatly help in offering ecofriendly and economical solution for development of bio-intensive management programme for an invasive mealybug species *Phenacoccus solenopsis* that devastated Indian cotton economy. In this book, the research work involving the impact of development stage and density of prey/ host insect on the biocontrol potential of natural enemies is illustrated along with identification of key host/ prey stage that contributes considerably towards development and progeny fitness of the parasitoids and predators of the mealybug. The information contained in this book can best be exploited by biological control scientists and integrated pest management practitioners in laboratory mass production of good quality bioagents, a prerequisite for successful biological control of insect pests. We hope, this will serve as a base for future ecofriendly pest management strategies.

65. Fand BB, Gautam RD and Suroshe SS. 2010a. Comparative biology of four coccinellid predators of solenopsis mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae). *Journal of Biological Control*, **24**(1): 35-41.

The biology of four important species of coccinellid predators, *viz*., *Hyperaspis maindroni*, *Cryptolaemus montrouzieri*, *Nephus regularis* and *Scymnus coccivora* associated with solenopsis mealybug, *Phenacoccus solenopsis*, infesting

cotton and other crops of economic importance was studied in the laboratory @ 27±2°C and 65±5% RH. The overall developmental time (including adult longevity) of *C. montrouzieri* was found significantly longer (97.8±1.32 days) than the rest of the species which ranged between 58.6±2.38 and 72.40±2.11 days. Females generally had longer developmental durations than males, irrespective of the species. The females of *C. montrouzieri* laid an average of 510±9.73 eggs in their oviposition period of 62.2±3.14 and this was longer than the others. In all the species, female started egg laying in the 2nd week of their adult life and reached the peak between 3rd and 6th weeks.

66. Fand BB, Gautam RD and Suroshe SS. 2010b.Effect of developmental stage and density of *Phenacoccus solenopsis* Tinsley (hemiptera: Pseudococcidae) on the predatory performance of four coccinellid predators. *Journal of Biological Control,* **24** (2): 110-115.

The predatory performance of four coccinellid predators, *viz., Hyperaspis maindroni, Cryptolaemus montrouzieri, Nephus regularis* and *Scymnus coccivora*, was studied on *Phenacoccus solenopsis* under laboratory conditions at 27 ± 2°C and 65 ± 5% RH. The grubs of all the four predators preferred to prey upon second instar mealybugs followed by third instars and adults when given the choice and fourth instar grubs were the most voracious. The overall predation by the grubs of *C. montrouzieri* (170.40 mealybugs) was significantly higher than that of the rest of the species. The rate of predation was dependent on developmental period and per day consumption of grubs of all the stages decreased with increase in size of the mealybug. Mean number of *P. solenopsis* individuals consumed and number of eggs laid per day by the females of all the predators increased gradually with prey density from lower to higher densities, but at a decreased rate.

67. Fand BB, Gautam RD and Suroshe SS. 2011. Suitability of various stages of mealybug, *Phenacoccus solenopsis* (Homoptera: Pseudococcidae) for development and survival of the solitary endoparasitoid, *Aenasius bambawalei* (Hymenoptera: Encyrtidae). *Biocontrol Science and Technology*, **21**(1/2): 51-55.

Aenasius bambawalei has been recently reported as a solitary endoparasitoid of *Phenacoccus solenopsis* in India. Laboratory experiments were conducted comparing the parasitoid's preference for the three developmental stages of mealybug and its effect on parasitism, development, progeny fitness and sex ratio of

A. bambawalei. The studies revealed third instar mealybugs as the most preferred stage for development of the parasitoid.

68. Fand BB, Gautam RD, Chander Subhash and Suroshe SS. 2010. Life table analysis of the mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) under laboratory conditions. *Journal of Entomological Research*, **34**(1): 175-179.

Results on age specific cohort life table on *Phenacoccus solenopsis* Tinsley at 27 ± 2°C and 65 ± 5% RH revealed that, the maximum female fertility was 140.69 female nymphs/female/week during the 5th age interval (28–35 days). The gross reproductive rate (GRR) was 242.07 females/female/generation while the net reproductive rate (R_0) was 123.41 females/female/generation. Mean generation time (T), the intrinsic rate of natural increase (r_m) and finite rate of increase (lamda) were 28.34 days, 0.1699 females/female/day and 1.185 females/female/day, respectively. The mortality rate was relatively higher for the first instar crawlers, which declined sharply in subsequent instars. The life cycle duration was 27.25 ± 0.5 days at 27 ± 2°C and 65 ± 5% RH. The female produced on an average 351 ± 44.73 young ones in her ovipositional period of 11.75 ± 0.96 days.

69. Fuches TW, Stewart JW, Minzenmayer R and Rose M. 1991. First record of *Phenacoccus solenopsis* Tinsley in cultivated cotton in the United States. *Southwestern entomologist,* **16**: 215-221.

This paper documents the first known occurrence of *Phenacoccus solenopsis* infesting cotton plantings in the USA. During surveys in Texas, the mealybug was found to infest 29 other plant species in 13 families. Early chemical control efforts proved unsatisfactory. Autumn sampling in 1990 yielded 3 species of parasitic Hymenoptera attacking the mealybug.

70. Gautam RD, Gautam Sudhida, Suroshe SS and Saxena Usha. 2010. Simple technique based on taxonomic characters for distinguishing the cotton mealybugs (Pseudococcidae: Homoptera). *Journal of Entomological Research,* **34**(1): 79-84.

Adult males of *P. solenopsis, P. solani* and *M. hirsutus* possessed black, brown and pink coloration on their head, respectively. The long waxy anal filaments were observed in females of *P. solenopsis* followed with *P. solani* and *M. hirsutus*. Besides, a distorted black marking as “horse shoe shape” in *P. solenopsis* another prominent and almost regular black marking was present on the ventral side of abdomen of *P. solani*. These markings were invisible in *M. hirsutus*. Observations

revealed that neither *P. solani* nor *P. solenopsis* possessed true ovisac unlike in *M. hirsutus*. Smaller size of loose sac attached to the female of *P. solani* was observed some times while larger in case of *P. solenopsis*, which contained crawlers. Body fluid colour of *P. solenopsis*, *P. solani* and *M. hirsutus* was noted as yellowish green, brownish green and pink, respectively. Elliptical cocoon produced males with black colour head, elongated and pointed cocoons at anterior end gave rise males with brown head, and produced globular prominent white cocoon forms in *P. solenopsis, P. solani* and *M. hirsutus*, respectively. Important taxonomic characters *viz*; presence of flacid circulus, nine segmented antennae and translucent pores on hind femur and tibia in *P. solenopsis* while rod shaped circulus, eight antennal segments and translucent pores on hind tibia of *P. solani* were matched with the field characters of each species. No hind femur and tibial translucent pores were seen in *M. hirsutus* while nine antennal segments and a goggle shaped circulus was present. Interestingly, circulus was observed in 2nd and 3rd instars of both the sexes and adult females while absent in 1st instars as well as in 4th instar male (pupa) and adult males, irrespective of species.

71. Gautam RD, Suroshe SS, Gautam Sudhida, Saxena Usha, Fand BB and Gupta Trishla. 2009, Fortuitous biological control of exotic mealybug, *Phenacoccus solenopsis* - a boon for Indian growers, *Annals of Plant Protection Sciences,* **17**(2): 473-474.

The recent appearance of *Phenacoccus solani* followed by *Phenacoccus solenopsis* on cotton has been the dilemma due to variations in determining the identity of the polyphagous mealybug species. Observations revealed that cotton and *Parthenium* were the plants most affected by this accidental entry of natural enemy along with pest. During the period, only indigenous natural enemies were observed developing appetite. Subsequently, the pest was observed to be attacked by a new parasitoid exclusively on *P. solenopsis, i.e. Aenasius bambawalei.* Presently, the pest is no more seen except in a few pockets, which may be due to heavy parasitization by *A. bambawalei*. Very likely, the new species described recently is case of fortuitous biological control, entered along with the exotic mealybug and got established. With this, the mealybug population was drastically reduced too on a few crops such as cotton. This paper briefly explains fortuitous biological control and the likely series of events that led to its occurrence in India.

72. Gautam Sudhida, Singh AK and Gautam RD. 2009. Comparative life table analysis of chrysopids reared on *Phenacoccus solenopsis* Tinsley in laboratory. *Journal of Biological Control*, **23**(4): 393-402.

Life tables of two chrysopid predators, *viz*., *Chrysoperla* sp. (carnea-group) and *Mallada desjardinsi* (Navas) on the invasive mealybug, *Phenacoccus solenopsis* (also reported as *P. solani*), were prepared in the laboratory to determine the efficacy of the predators as biocontrol agents of the pest. The rate of mortality (qx) during 0-7 days age interval was higher in *Chrysoperla* sp. (carnea-group) (0.28) than in *M. desjardinsi* (0.22) while it was reverse during 70-77 days age interval when reared on *P. solenopsis*. In fact, qx was higher in *M. desjardinsi* (2.50) than in *Chrysoperla* sp. (carnea-group) (0.00). The rate of multiplication per day was 0.1159 and 0.1414 females/female for *Chrysoperla* sp. (carnea-group) and *M. desjardinsi* respectively. The intrinsic rate of increase (rm) was found to be 0.11 for both the predators. *Chrysoperla* sp. (carnea-group) population multiplied 62.80 times in a generation time of 35.72 days on the mealybug, whereas *M. desjardinsi* multiplied 67.12 times in a time period of 29.75 days. Life table assays help in estimating the total number of the natural enemies to be released in biological control programmes. This study would be of paramount importance in estimating the total number of the natural enemies to be released in biological control programmes against the mealybug, which is exotic.

73. Gautam Sudhida, Singh AK and Gautam RD. 2010. Olfactory responses of green lacewings, *Chrysoperla* sp. (carnea group) and *Mallada desjardinsi* on mealybug, *Phenacoccus solenopsis* (Homoptera: Pseudococcidae) fed on cotton. *Acta Entomologica Sinica*, **53**(5): 497-507.

Host-habitat location of the green lacewing predators, *Chrysoperla* sp. (carnea group) and *Mallada desjardinsi* (Navas) (Neuroptera: Chrysopidae) depends on the foraging decisions and behavioral responses towards the plant odors released at various phases. The response of mated adults and mealybug (*Phenacoccus solenopsis*) infesting cotton were studied to understand the tritrophic interactions. Results revealed that both male and female perceived the green leaf volatiles emanating from the cotton plant. All the stages of the plant were responsible for the orientation of the predator and the mealybug. Higher amounts of the saturated hydrocarbons in the infested cotton leaves revealed better responses of the chrysopid adults. The efficacy of the predators can be increased in the fields by releasing the predators at the infested and flowering phase of the plant. Efficient biological control depends on the ability of the natural to establish on the plant and devouring of the pest.

74. Germain JF, Vayssieres JF and Matile-Ferrero D. 2010. Preliminary inventory of scale ins.ects on mango trees in Benin. *Entomologia Hellenica,* **19**: 124-131.

A preliminary inventory of scale insects (Hemiptera: Coccoidea) developing on the mango tree is presented for Northern and Central Benin. The following species, *Gigantococcus euphorbiae, Gigantococcus nigroareolatus, Ceroplastes uapacae, Parasaissetia nigra, Saissetia privigna, Udinia catori, Ferrisia virgata, Paracoccus interceptus, Phenacoccus solenopsis, Rastrococcus invadens, Aonidiella orientalis* and *Lepidosaphes tapleyi*, were collected from 2005 to 2007 in mango orchards in the Sudanian area of Benin, on branches, leaves, and particularly on mango petioles and fruits. Nine of these species are recorded for the first time in Benin while *P. interceptus* is recorded in Africa for the first time. Only two, *R. invadens* and *A. orientalis*, of the 12 species are considered as mango pests.

75. Ghule SR, Barkhade UP, Moharil MP and Ugale TB. 2010. Role of detoxifying enzymes in host plant resistance to cotton mealybugs (*Phenococcus solenopsis* Tinsley). *Asian Journal of Bio Science*, **5**(2): 219-222. & *Crop Research* (Hisar), 2011, **42**(1/2/3): 307-312.

A laboratory investigation was conducted to find out role of detoxifying enzymes in defense mechanism of cotton cultivars against mealybugs in Insect Biotechnology Laboratory of Department of Agricultural Entomology, Dr. PDKV, Akola during 2008-09. Quantitative and qualitative studies undertaken for estimation of detoxifying enzymes like Glutathione S-transferases and esterases. GST activity was found higher in resistant variety, PKV Hy-2, followed by AKH-3614-10 (*Hirsutum* pigmented). The highest esterase activity was found to be present in Bunny-Bt (187.14 nM mg protein-1 min-1) than other cotton cultivars. PKV Hy-2 showed very lowest esterase activity (76.97 nM mg protein-1 min-1). Glutathione-s-transferase and esterase bands were not detected in the susceptible CAHH-231 (Pigmented hybrid) variety. Three GST isozymes were observed in AKA-8, whereas, CAHH-231 did not show any isozyme. The study will be helpful in understanding the biochemical basis of mealybug resistance in cotton. The outcome of the present investigation will act as stepping stone to develop mealybug resistant cotton variety.

76. Ghule SR, Barkhade UP, Moharil MP and Ugale TB. 2011. Role of oxidyzing enzymes in host plant resistance to cotton mealybugs (*Phenacoccus solenopsis*). *International Journal of Plant Protection*, **4**(1): 55-60. & Influence of oxidyzing

enzymes in host plant resistance to cotton mealybugs (*Phenococcus solenopsis* Tinsley). *Crop Research* (Hisar), **42**(1/2/3): 313-319.

A laboratory investigation was conducted to find out the role of oxidizing enzymes in defense mechanism of cotton cultivars against mealybugs in Insect Biotechnology Laboratory of Department of Agricultural Entomology, Dr. PDKV, Akola during 2008-09. Quantitative and qualitative studies were undertaken for estimation of oxidizing enzymes like superoxide dismutase, polyphenol oxidase, polyphenol peroxidase and catalase from different cotton cultivars. CAHH-231 (pigmented hybrid) recorded higher activity of polyphenol oxidase (0.95 unit mg protein-1 min-1) and polyphenol peroxidase (0.87 unit mg protein-1 min-1). Catalase activity was found higher in susceptible cultivars. PKV Rajat showed highest SOD activity 2.84 unit mg-1 followed by Bunny-Bt. Polyphenol oxidase, polyphenol peroxidase and catalase activity was found higher in Bunny-Bt and CAHH-231 (Pigmented hybrid) which are susceptible to the sucking pests. The study will be helpful in understanding the biochemical basis of mealybug resistance in cotton. The outcome of the present investigation will act as stepping stone to develop mealybug resistant cotton variety.

77. Ghule SR, Barkhade UP, Moharil MP and Ugale TB. 2011. Biochemical basis of resistance to cotton cultivars against mealybugs (*Phenococcus solenopsis* Tinsley). *Crop Research* (Hisar), **42**(1/2/3): 320-323.

The current work aims at studying the defense mechanism of cotton plant against mealybug (*Phenococcus solenopsis*). Changes in phenol, tannin and lipid activity were observed in both resistant and susceptible cotton cultivars in response to mealybug infestation. Highly susceptible cultivar had higher protein quantity than resistant and tolerant cultivars, whereas phenol tannin and lipid content were higher in resistant cultivars. Total soluble sugar content for resistant and tolerant cultivars remained at similar levels. Gel stained for protein identified differences in the protein bands of resistant, tolerant and susceptible cultivars.

78. Gogi MD, Ijaz N, Arif MJ, Zain-ul-Abidin, Arshad M, Bashir MH and Khan MA. 2011. Impact of synergism with combinations of silicon oil, clove oil and sulfuric acid on the toxicity of some insecticides against cotton mealybug, *Phenacoccus solenopsis* (Hemiptera:Pseudococcidae). *Pakistan Entomologist*, **33**(2): 137-141.

Cotton mealybug, *Phenacoccus solenopsis* is a severe threat to cotton crop in Pakistan and its control at ovisac as well as at adult female stage is very difficult

with insecticides because eggs/nymphs inside the fluffy ovisac and adult female due to its thick waxy body coating avoid the exposure to insecticides and survive successfully. The present research was carried out under laboratory conditions to investigate effect of silicon oil, clove oil and sulphuric acid in different ratios (1:1:1, 2:1:1, 3:1:1, 4:1:1 and 5:1:1) with synergistic impact on the toxicity of nicotinoids (nitinpyram and thiacloprid), IGR (pyriproxifen) and supracide (used as standard) or not. The results revealed that co-administration of all combinations of silicon oil, clove oil and sulphuric acid in different ratios caused two and three times increase in the toxicity of evaluated insecticides against adult female and ovisac stage of cotton mealybug, respectively. The mortality was observed very high (>90%) even at the five times less insecticide quantity (100 ml) than the highest insecticide quantity (500 ml) of the FRD solution. All the ratios among silicon oil, clove oil and sulfuric acid induced statistically similar impact on the toxicity of evaluated insecticides. The nicotinoids as well as IGR, which are considered soft and biorational as comparative to highly toxic supracide, caused 90-100% mortality in the both target stages of cotton mealybug and were found nonsignificantly different from supracide in toxicity when evaluated alone or in combination with wax dissolving agents (WDA). Results indicate that soft and bio-rational insecticides like nicotinoids (Nitinpyram and Thiacloprid), IGR (Pyriproxifen), in combination with 1:1:1 of silicon oil, clove oil and sulfuric acid, at 1:1/ of WDA as well as of FRD solution 100 should be evaluated under field conditions on cotton before final recommendation.

79. Gogi MD, Siraj Ahmed, Muhammad Ashfaq, Arif MJ, Adeel Mukhtar and Muhammad Nauman. 2010. The silicon accumulation in cotton plant at different concentrations and doses of sodium silicate and effect on honeydew secretion, longevity and mortality of 1st instar of mealybug (*Phenacoccus solenopsis*). *Pakistan Entomologist*, **32**(1): 29-36.

Effect of different concentrations and doses of sodium silicate on the silicon accumulation and honeydew secretion, longevity and mortality of 1st instar *Phenacoccus solenopsis* in cotton was evaluated under the laboratory conditions. Honeydew secretion was reduced to 2-14 times over control when 1st instar nymphs were fed on plants treated with different concentrations and doses combinations of sodium silicate. Approximately 10-61 times higher mortality and 1.3-3 times longer life of 1st instar nymph and 1.4-4 times higher silicon accumulation in plants was observed under different concentrations and doses combinations of sodium silicate. Silicon concentration in plants had highly significant and positive correlation with

longevity but highly significant and negative correlation with the honeydew secretion of 1st instar nymphs of cotton mealybug. The silicon concentration in plant explained 71.6% variation in the number of honeydew drops/life-span, 54.7% variation in the percentage mortality and 51.5% variation in the longevity of 1st instar nymphs. Sodium silicate 10-25% concentrations at the dose rate of 6-15 ml/pot or per 500g soil can be used as a source of silicon and re-evaluation under field trails, before floating sound recommendation for the farmer use in cotton against cotton mealybug.

80. Gordh, G. 1979. Family Encyrtidae. 890-967 In: (Krombein, K.V., Hurd, P.D., Jr., Smith, D.R. & Burks, B.D., Eds.,) Catolog of Hymenoptera in America North of Mexico. Smithsonian Institution Press, Washington, D.C. pp. 1198

Host species mentioned include *Abgrallaspis oxycoccus, A. howardi, Aclerda andropogonis, Acutaspis agavis, A. umbonifera, Anisococcus adenostomiae, A. crawii, Antonina graminis, Aonidiella aurantii, A. citrina, Aonidomytilus concolor, Aspidiotus corticalis, A. destructor, A. hederae, A. nerii, A. spinosus, Asterolecanium quercicola, A. variolosa, Aulacaspis rosae, Carulaspis juniperi, C. visci, Ceroplastes cirripediformis, C. floridensis, C. irregularis, Chaetococcus phragmitis, Chionaspis americana, C. furfura, C. heterophyllae, C. pinifoliae, C. salicisnigrae, Chrysomphalus aonidum, C. dictyospermi, Coccus hesperidum, C. pseudomagnoliarum, Dactylopius confusus, Diaspidiotus aesculi, D. ancylus, D. brittanicus, D. uvae, D. viticola, Diaspis boisduvali, D. bromeliae, D. echinocacti, Dynaspidiotus britannicus, Dysmicoccus brevipes, D. ryani, D. timberlakei, Eriococcus azaleae, E. carolinae, E. quercus, E. tinsleyi, Eriopeltis festucae, Eucalymnatus tessellatus, Ferrisia virgata, Furchadiaspis zamiae, Gossyparia spuria, Hemiberlesia lataniae, H. rapax, Howardia biclavis, Icerya purchasi, Kermes cockerelli, K. galliformis, K. nigropunctatus, K. pubescens, Kuwanaspis hikosani, Lecanodiaspis* sp., *Lecanium caryae, L. corni, L. coryli, L. fletcheri, L. nigrofasciatum, L. persicae, L. pruinosum, L. quercifex, Lepidosaphes beckii, L. gloveri, L. ulmi, Lopholeucaspis japonica, Melanaspis lilacina, M. obscura, M. tenebricosa, Nuculaspis californica, Odonaspis* sp., *Parasaissetia nigra, Parlatoria blanchardi, P. oleae, P. pergandii, Phenacoccus acericola, P. gossypii, P. minimus, P. solani, P. solenopsis, Physokermes insignicola, Pinnaspis aspidistrae, P. strachani, Plagiomerus diaspidis, Planococcus citri, P. kraunhiae, Pseudaonidia duplex, Pseudaulacaspis pentagona, Pseudococcus calciolariae, P. comstocki, P. longispinus, P. maritimus, P. solani, Pulvinaria acericola, P. amygdali,*

P. bigeloviae, P. floccifera, P. vitis, Puto ambiguus, P. yuccae, Quadraspidiotus diaspidis, Q. forbesi, Q. juglansregiae, Q. ostraeaformis, Q. perniciosus, Rhizaspidiotus dearnessi, Saissetia coffeae, S. hemisphaerica, S. oleae, Spilococcus atriplicis, S. eriogoni, S. gutierreziae, S. implicatus, S. pressus, S. prosopidis, S. sequoiae, Tachardia sp., *Tachardiella larreae, Targionia vitis, Toumeyella liriodendri, T. parvicornis, T. pinicola, T. turgida, Trionymus utahensis* and *Unaspis euonymi*.

81. Gosalwad SS, Bhosle BB, Wadnerkae DW and Khan FS. 2010. Feeding potential of *Cryptolaemus montrouzieri* Mulsant on *Maconellicoccus hirsutus* and *Phenacoccus solenopsis*. *Journal of Cotton Research and Development*, **24**(2): 256-258.

The experiment conducted at Laboratory of Insect Parasitology Research Scheme, Department of Agricultural Entomology, Marathwada Agricultural University, Parbhani during kharif 2008 on feeding potential of *Cryptolaemus montrouzieri* Mulsant on two species of mealybugs namely, *Maconellicoccus hirsutus* and *Phenococcus solenopsis* revealed that the predatory grub consumed on an average 752.60, 742.80 eggs and 242.00, 222.80 nymphs of *M. hirsutus* and *P. solenopsis*, respectively. Adult female consumed 4340.20 eggs+235.20 nymphs, and 4355.00 eggs and 241.20 nymphs of *P. solenopsis* and *M. hirsutus*, respectively. While male beetle devoured 3586.00 eggs+149.60 nymphs and 3519.20 eggs+148.00 nymphs of *M. hirsutus* and *P. solenopsis*, respectively.

82. Gosalwad SS, Bhosle BB, Wadnerkar DW, Ilyas M and Khan FS. 2009. Biology and feeding potentional of *Cryptolaemus montrouzieri* Mulsant (Coccinellidae: Coleoptera) on *Maconellicoccus hirsutus* and *Phenacoccus solenopsis*. *Journal of Plant Protection and Environment*, **6**(2): 73-77.

A study on biology of *Cryptolaemus montrouzieri* Mulsant on two species of mealybug indicated that the incubation period was 4.78 and 4.88 on *M. hirsutus* and *P. solenopsis* respectively. The duration of I, II, III and IV instar was 5.14, 3.88, 6.84, 8.04 and 5.52, 4.58, 7.42, 8.20 on *M. hirsutus* and *P. solenopsis* respectively. The prepupal and pupal duration of 2.80 and 2.96 and 8.08 and 8.28 days were recorded for the corresponding species of mealybugs. The preoviposition and oviposition period was 7.90, 67.10 and 9.00, 68.00 on *M. hirsutus* and *P. solenopsis* respectively. While adult longevity of female and male was 77.44, 72.38 and 80.49, 78.44 days respectively on *M. hirsutus* and *P. solenopsis*. Fecundity was 478.20 and 460.42 on *M. hirsutus* and *P. solenopsis* respectively. Predatory grub consumed

on an average 752,60 eggs with 242.00 nymphs of *M. hirsutus* and 742.80 eggs with 222.80 nymphs of *P. solenopsis*. Adult female consumed 4355.00 eggs+241.20 nmphs and 4340.20 eggs+235.20 nymphs of the above two mealybug species respectively. While male beetle devoured 3586.00 eggs+149.60 nymphs and 3519.20 eggs+148.00 nymphs of *M. hirsutus* and *P. solenopsis* respectively.

83. Granara de Willink MC. 2003. New records and host plants of *Phenacoccus* for Argentina (Hemiptera: Pseudococcidae). *Revista de la Sociedad Entomológica Argentina,* **62**(3/4): 80-82.

Phenacoccus madeirensis Green, *P. manihoti* Matile-Ferrero and *P. solenopsis* Tinsley, first records from Argentina and new host plants of *P. crassus* Granara de Willink, *P. parvus* Morrison and *P. similis* Granara de Willink are provided.

84. Greathead DJ. 1971. A review of biological control in the Ethiopian region. Technical Communication (Commonwealth Institute of Biological Control), **5**: 162 pp.

This book attempts to summarize information on all biological control using natural enemies to control pests in the Ethiopian biogeographical region, which includes Africa south of the Sahara, Madagascar and the smaller islands both in the western Indian Ocean and the southern Atlantic Ocean which are faunistically and politically associated with Africa rather than India or South America. Species mentioned include *Antonina graminis, Aonidiella aurantii, Aspidiotus destructor, Aterolecanium* sp., *Aulacaspis tegalensis, Carulaspis minima, Chrysomphalus dictyospermi, C. ficus, Coccus hesperidum, C. viridis, Dactylopius opuntiae, Dysmicoccus boninsis, Eucalymnatus tessellatus, Ferrisia virgata, Gascardia destructor, G. sinoiae, Icerya purchasi, I. seychellarum, Ischnaspis longirostris, Lepidosaphes becki, L. ficus, L. newsteadi, Orthezia insignis, Parasaissetia nigra, Parlatoria blanchardii, Phenacoccus gossypii, Ph. kenyae, Ph. solani, Ph. solenopsis, Pinnaspis buxi, Planococcoides njalensis, Planococcus citri, Pl. kenyae, Pl. lilacinus, Pl. longispinus, Pseudaulacaspis pentagona, Pseudococcus fragilis, Ps. obscurus, Quadraspidiotus perniciosus, Rastrococcus iceryoides, Saccharicoccus sacchari* and *Saissetia oleae*.

85. Halbert SE. 1999. Entomology Section. *Tri-ology* **38**(4). [http://www.doacs.state.fl.us/pi/enpp/99-jul-aug.htm#ent]

Scale species identified include *Aulacaspis yasumatsui*, cycad aulacaspis scale, *Cerococcus deklei* Kosztarab & Vest, grenade scale, *Chrysomphalus aonidum*

(Linnaeus), Florida red scale, *Kuwanaspis* sp., a scale, *Eriococcus droserae* (Miller, Liu & Howell), sundew eriococcin, *Paracoccus marginatus* Williams & Granara de Willink, papaya mealybug, *Phenacoccus solenopsis* Tinsley, a mealybug, *Philephedra tuberculosa* Nakahara & Gill, philephedra scale, *Pseudaulacaspis major* (Cockerell), lychee bark scale, and *Rhizoecus leucosomus* (Cockerell), a root mealybug.

86. Hanchinal SG, Patil BV, Basavanagoud K, Nagangoud A, Biradar DP and Janagoudar BS. 2011. Incidence of invasive mealybug (*Phenacoccus solenopsis* Tinsley) on cotton, *Karnataka Journal of Agricultural Sciences*, **24**(2): 143-145.

Mealybug incidence was assessed in the scale of zero to four grades as well as percent incidence. Survey revealed that infestation ranged between zero to 3.62 through out the cotton growing Northern districts. Mealybug infestation on cotton was high in Thungabhadra Project area (TBP) and Upper Krishna Project area (UKP) which comprises of Bellary, Raichur and Gulbarga districts. Mean mealybug grade was as high as 3.42, 3.15 and 3.34 in Raichur, Gulbarga and Bellary districts, respectively as compared to Dharwad, Haveri and Belguam districts during 2008-09. Similarly, 2009-10, *Phenacoccus solenopsis* was severe in some parts of Bellary and Raichur districts and the mean infestation grade ranged between zero to 2.78 and zero to 2.58, respectively. Field infestation varied from 8.33 to 36.30 per cent in different talukas of North Karnataka. At Dharwad and Hubli talukas, several cotton fields were infested moderately with the mealybug and the per cent infestation ranged from zero to 18.5. Infestation in Gokak and Bailhongal taluks of Belgaum district ranged from zero to 24.22 per cent with a mean of 12.56 to 10.64 per cent, respectively. During 2009-10 cropping season, mean per cent infestation of mealybug on cotton across North Karnataka ranged from lowest of 2.96 in Dharwad district to highest of 12.47 in Raichur district.

87. Hanchinal SG, Patil BV, Bheemanna M and Hosamani AC. 2009. Incidence of mealybug *Phenacoccus solenopsis* Tinsley and its natural enemies on cotton in Karnataka: In proceedings of National symposium on Bt-cotton: Opportunities and Prospectus, CICR, Nagpur, November 17-19, pp.150.

Survey was conducted during 2008-09 cropping season to assess the level of incidence of cotton mealybug, *Phenacoccus solenopsis* in Karnataka. Incidence was assessed on 0 to 4 scale range. Mealybug population was ranged between 1 to 4 in the Thungabhadra project area (TBP) and upper Krishna project area (UKP), which comprises majority of the irrigated cotton area in the districts of

Raichur, Bellary and Gulbarga. In other parts of Karnataka *i.e.* Haveri, Dharwad and Belgaum districts, incidence ranged between zero to 3 scale. Incidence was severe in some places at the end of the cropping season. Natural enemies were also recorded. Major parasitoids belonged to Hymenoptera in TBP and UKP area. Parasitoids such as *Aenasius bambawalei* Hayat *Homalotylus eytelweinii* (Ratzeburg) *Prochiloneurus pulchellus* Silvestri *Anagyrus dactylopii* (Howard) belongs to Encyrtidae family and *Promuscidea unfasciativentris* Girault belong to Aphelinidae family. Among these *Aenasius bambawalei* was the dominant species.

88. Hanchinal SG, Patil BV, Bheemanna M and Hosamani AC. 2010. Population dynamics of mealybug, *Phenacoccus solenopsis* Tinsley and its natural enemies on Bt cotton. *Karnataka Journal of Agricultural Sciences*, **23**(1): 137-139.

A study was conducted during 2008-09 in Raichur, Karnataka, India to evaluate the population dynamics of the mealybug (*Phenacoccus solenopsis*) and its natural enemies (coccinellids, chrysoperla, spiders and parasitoids) in cotton. The correlation coefficients between weather parameters (maximum and minimum temperature, rainfall, number of rainy day, relative humidity) and the seasonal fluctuation in populations of mealybugs, predators and parasitoids were also estimated. Mealybug infestation started appearing in the month of September and gradually increased as crop growth advanced. The population was 0.50/10 cm apical shoot in the 38th meteorological week and progressively increased throughout the season. Population reached to 115.42/10 cm apical shoot in the 3rd week of January and thereafter increased suddenly to reach 180.42/10 cm apical shoot in the 7th meteorological week. Later on, infestation of mealybug declined gradually and reached to 146.64/10 cm apical shoot in the 14th meteorological week. In general, predator population was low during the cropping season. Maximum population of coccinellids, chrysoperla and spiders were 0.14, 0.13 and 0.16 per plant, respectively, during the season. Parasitoid cocoons ranged between 0.52 to 20.02%. The activity of parasitoids started during 44th meteorological week and later on increased gradually to reach peak during 7th to 9th meteorological weeks. Highest parasitoid (20.65%) was recorded during 7th meteorological week which coincides with the higher population of mealybug. Mealy bug population was significantly and positively correlated with maximum temperature (0.775) and negatively correlated with other parameters. Among predators, *Chrysoperla* significantly correlated with relative humidity (0.289) and others were non-significant. The mealybug parasitoid cocoons were positively correlated with maximum temperature (0.421) but negatively correlated with other meteorological parameters.

89. Hanchinal SG, Patil BV, Bheemanna M, Hosamani AC and Sharanabasappa. 2009. Incidence of Mealybug on cotton in Tungbhadra project area In: Proc. Dr. Leslie c. Colemon Memorial National Symposium of Plant protection Dec., 4-6, 2008, Univ. of Agric. Sci. GKVK, Bangalore.

Mealybug incidence was assessed in the scale of zero to four grades as well as percent incidence. Survey revealed that infestation ranged between zero to 3.62 through out the cotton growing Northern districts. Mealybug infestation on cotton was high in Thungabhadra Project area (TBP) and Upper Krishna Project area (UKP) which comprises of Bellary, Raichur and Gulbarga districts. Mean mealybug grade was as high as 3.42, 3.15 and 3.34 in Raichur, Gulbarga and Bellary districts, respectively as compared to Dharwad, Haveri and Belguam districts during 2008-09. Similarly, 2009-10, *Phenacoccus solenopsis* was severe in some parts of Bellary and Raichur districts and the mean infestation grade ranged between zero to 2.78 and zero to 2.58, respectively. Field infestation varied from 8.33 to 36.30 per cent in different talukas of North Karnataka. At Dharwad and Hubli talukas, several cotton fields were infested moderately with the mealybug and the per cent infestation ranged from zero to 18.5. Infestation in Gokak and Bailhongal taluks of Belgaum district ranged from zero to 24.22 per cent with a mean of 12.56 to 10.64 per cent, respectively. During 2009-10 cropping season, mean per cent infestation of mealybug on cotton across North Karnataka ranged from lowest of 2.96 in Dharwad district to highest of 12.47 in Raichur district.

90. Hanchinal SG. 2010. Bioecology and management of mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on Bt Cotton. Ph.D (Degree) Agricultural Entomology (Department) University of Agricultural Sciences, UAS, Dharwad (Institute).

Investigations were carried out on survey, seasonal fluctuation of mealybug, *Phenacoccus solenopsis* Tinsley and its natural enemies, crop loss assessment, estimation of EIL, biology of mealybug, biology of the predator *Cryptolaemus montrouzieri* Muls. and efficacy of insecticides including biological agents against mealybugs were undertaken during 2008-09 and 2009-10 at MARS, Raichur and Department of Entomology, College of Agriculture, Dharwad. Mealybug incidence was moderate to severe in Raichur, Bellary and Gulbarga districts while its incidence was low in Dharwad, Haveri and Belguam districts of North Karnataka on Bt cotton. The peak activity of the parasitoids was observed mainly from January to March in both the years. Mean per cent parasitoid emergence from mealybugs collected at

various places was highest in TBP and UKP areas as compared to other districts in both the years. There were more than 15 alternate host plants of *P. solenopsis* belonging to eight families found across the cotton growing districts of North Karnataka. Among them, *Abutilon indicum* L. (Malvaceae) and *Parthenium hysterophorus* L. (Asteraceae) were the major weed hosts. Steep increase in the mealybug population was observed from January and reached peak in March in both the years of study. Initially parasitoid population was low and peak activity started during first week of January which gradually increased up to 34.62 per cent and 34.64 per cent during the last week of March 2008-09 and 2009-10 seasons, respectively. Among different parasitoids, *Aenasius bambawalei* Hayat was the dominant species. Total life cycle of *P. solenopsis* female and male was 38.47 and 20.33 days, respectively. The total life cycle of *Cryptolaemus montrouzieri* was 28.82 and 24.71 days when reared on the mealybug nymphs and adult female, respectively. Crop loss estimation due to mealybug damage indicated that cotton plants did not survive at all the damage levels at 60 days after sowing in both the years. Cotton yield was severely affected due to different levels of mealybug damage at 90 days after sowing. Estimation of EIL due to mealybug damage on Bt cotton under irrigated ecosystem resulted in 20, 27, 44 and 51 mealybugs per plant at 60, 90, 120 and 150 days after sowing, respectively. Profenophos 50 EC @ 2000 ml/ha and buprofezin 25 SC @ 1500 ml/ha were effective in reducing the mealybug population on cotton. These two treatments recorded significantly maximum seed cotton yield with higher net returns in both the seasons of study.

91. Hayat M. 2009. Description of a new species of *Aenasius* Walker (Hymenoptera: Encyrtidae), parasitoid of the mealybug, *Phenacoccus solenopsis* Tinsley (Homoptera: Pseudococcidae) in India. *Biosystematica*, **3**: 21-26.

A new species of the encyrtid genus *Aenasius*, *A. bambawalei* is described. This parasitoid has been reared from *Phenacoccus solenopsis*, a mealybug that has invaded India and spread to all the cotton-growing areas in India.

92. Hodgson CJ, Abbas G, Arif MJ, Saeed S and Karar H. 2008. *Phenacoccus solenopsis* Tinsley (Sternorrhyncha: Coccoidea: Pseudococcidae), an invasive mealybug damaging cotton in Pakistan and India, with a discussion on seasonal morphological variation. *Zootaxa,* **1913**: 1-35.

Since at least 2005, a possibly introduced mealybug of the genus *Phenacoccus* has been causing serious damage to cotton (*Gossypium hirsutum*) over much of the Sindh and Punjab districts of Pakistan and in North-Western India. Some short papers

have been published locally giving details on the structure and biology of this species and suggesting the name *Phenacoccus gossypiphilous* Abbas, Arif & Saeed (2005) but without designating type specimens or depositories. This name is here considered a nomen nudum. A detailed morphological study has been unable to separate this species from many specimens of *Phenacoccus* from the Neotropics that are believed to be *Phenacoccus solenopsis* Tinsley. The material from the Indian subcontinent shows considerable morphological variation in the frequency of multilocular disc pores and oral collar tubular ducts on the ventral submargin of the abdomen; this appeared to be related to conditions under which this species was reared, with those cultured in a screen-house during the non-cotton-growing season being indistinguishable from *P. solenopsis* from the Neotropics. This paper re-describes the adult female of *P. solenopsis* Tinsley based on the type specimens from New Mexico, and designates a lectotype. The type material was compared with specimens considered to be *P. solenopsis* from elsewhere in the New World, and from West Africa and several areas in Asia, particularly Pakistan and India. Based of our present understanding of the morphology of adult female *P. solenopsis*, it is concluded that the species is rather variable, that this variability may be environmentally induced, and that the species currently causing widespread damage to cotton on the Indian subcontinent is referable to *P. solenopsis*. Adult male *P. solenopsis* from North America, Pakistan and India were also studied and again no significant differences were found. *solenopsis,* based on material from India and Pakistan. Keys are provided to (a) separate *P. solenopsis* from similar species of *Phenacoccus* currently known from Asia and (b) to identify all instars. The morphological differences between *P. solenopsis, P. solani Ferris* and *P. defectus* Ferris are reviewed and, based on the morphological variation found in the Asian material, it is considered that there is some support for the suggestion that these three species might be environmentally induced variants of a single species. A few details are given of the biology of *P. solenopsis* on cotton in Pakistan.

93. Huang Fang, Tjalling WF, Zhang PengJun, Zhang JinMing, Lu YaoBin and Lin JinTian. 2012. EPG waveform characteristics of solenopsis mealybug stylet penetration on cotton. *Entomologia Experimentalis et Applicata*. **143**(1): 47-54.

The solenopsis mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae), is a polyphagous insect known to cause severe damage to cotton (especially transgenic varieties) in South Asia, and currently poses a serious threat

in Asia and potentially elsewhere. Stylet penetration behavior of *P. solenopsis* on cotton was monitored using the electrical penetration graph (EPG) technique (DC system) and the EPG characteristics were compared with those previously published from *Phenacoccus manihoti* Matile-Ferrero and *Planococcus citri* (Risso). We identified and further characterized typical waveforms of A, B, C, and pd (together pathway), E1 and E2 (phloem), F (derailed stylet mechanics), and G (xylem). Five novel EPG aspects were distinguished in the EPG waveforms from *P. solenopsis*: (1) obvious B waveforms occurred following waveform A, (2) during waveform C, some aphid-like E1e waveforms were observed, (3) prolonged potential drops (pd) up to >1 h occurred with two continuously alternating sub-phases pd1 and pd2, (4) the pd1 waveform always occurred as the first waveform related to phloem sieve elements, preceding the other phloem waveforms (E), the labeling of which we changed to achieve a better comparison to the aphid E waveforms, and (5) waveform F, related to derailed stylet mechanics occurred but was not reported from other mealybugs so far. This is mainly a waveform morphology study to extend existing knowledge on mealybug EPGs to investigate mealybug-host plant interactions. Further experimental verification of waveform correlations with plant tissue positions of stylet tips and insect activities is still needed.

94. ICAC Recorder. 2008. Mealybug: a new threat to cotton production in Pakistan and India. A review article shared by International Cotton Advisory Committee (ICAC), Technical Information Section, June 2008, **25**:15-19.

Review article commented on the biology of *P. solenopsis* on cotton, on some of its important host plants, and on symptoms of damage caused by the pest.

95. Imran Bodlah, Munir Ahmad, Nasir MF and Muhammad Naeem. 2010. Record of *Aenasius bambawalei* Hayat, 2009 (Hymenoptera: Encyrtidae), a parasitoid of *Phenacoccus solenopsis* (Sternorrhyncha: Pseudococcidae) from Punjab, Pakistan. *Pakistan Journal of Zoology,* **42**(5): 533-536.

The cotton mealybug *Phenacoccus solenopsis* Tinsley parasitoid, *Aenasius bambawalei* Hayat has been recorded for the first time from mummified mealybugs collected in the field on various weeds and cotton crop from different districts of Punjab province of Pakistan. The redescription of the species is provided with its four host plants and distribution in the Punjab province of Pakistan. The parasitoid is illustrated using micrographs and line drawings. In addition, this paper also presents brief information on its biological characteristics.

96. Jagadish KS, Shadhanaikural A, Chandru R and Shadkashari YG. 2009. Biochemical and morphological changes due to mealybug, *Phenacoccus solenopsis* Tinsley (Homoptera: Psuedococcidae) infestation on sunflower (*Helianthus annuus* L.). *Insect Environment,* **15**(1): 28-30.

During 2008, the sunflower seed production plots of the parental line CMS 234 (Date of sowing : 19-05-08) at the Main Research Station, UAS, Hebbal, Bengaluru showed mealybug incidence on 21st June, 2008, for the first time. This is the first report of mealybug incidence on sunflower in Karnataka, identified as *Phenacoccus solenopsis* Tinsley (Homoptera: Psuedococcidae). On 12th August 2008, there was an increase in the population of the pest on the crop varying from 0.00 – 386.00 / plant (mean= 120.10/Plant). The infested leaves contained higher quantity of total soluble sugars (4.50%) and soluble protein (3.50%) compared to the healthy leaves. Total phenol content was higher in the healthy leaves (1.05%) compared to the infested leaves (0.65%). These preliminary findings indicated that total phenol could be one of the key biochemical factors imparting tolerance to mealybug in Sunflower.

97. Jagadish KS, Shankaramurthy M, Kalleshwaraswamy CM, Viraktamath CA and Shadakshari YG. 2009. Ecology of the mealybug, *Phenacoccus solenopsis* Tinsley (Hymenoptera: Pseudococcidae) infesting sunflower and its parasitization by *Aenasius* sp. (Hymenoptera: Encyrtidae). *Insect Environment*, **15**(1): 27-28.

During March-April, 2009, surveys were conducted for the mealybug, *P. solenopsis* infesting sunflower in and around the plots of the sunflower parental line CMS-335 at Main Research Station, Hebbal, Bengaluru. The survey revealed that in addition to sunflower, the mealybug was also found infesting *Parthenium hysterophorus*. Besides, sunflower and *Parthenium*, the mealybug was also found infesting other plants *viz*., mulberry, *Morus alba* and a weed *Blumea lacera* (\) belonging to Family Asteraceae. In addition to the tour species of ants, that had been reported earlier *viz.*, *Myrmicaria bunnea* saunders, *Solenopsis geminata* Fabricius, *Anoplolepis gracilipes* Smith and *Tapinoma monocephalum* fabricius (Jagadish *et al.,* 2008), another species of ant, *i.e.*, *Oecophylla smaragdina* Fabricius (Hymenoptera: Formicinae) was also observed attending to the mealybug. Besides it was also found transferring the mealybugs from Jack tree in vicinity of the sunflower crop. The mealy bug was found to be parasitized by the encyrtid wasp, *Aenasius* sp. (Hymenoptera: Encyrtidae). The extent of parasitisation ranged from 0.00.-60.00 per cent on *Parthenium* and it was negligible (<10.00%) on sunflower.

This is the first report of parasitization by *Aenasius* sp. on *P. solenopsis* infesting sunflower from Karnataka. The study reveals that *P. hysterophorus* has a major role to play, both in the survival and perpetuation of both *Aenasius* sp. and its host, *P. solenopsis* in sunflower ecosystem.

98. Jayanthi PDK, Sangeetha P and Abraham Verghese. 2010. Does food adaptation influence prey choice of a generalist predator, *Cryptolaemus montrouzieri* Mulsant? *Current Science,* **99**(11): 1520-1522.

A study was carried out to determine whether pre-conditioning of a generalist predator on a particular prey affects the way it forages when it encounters an altogether different prey. The laboratory cultures of *Cryptolaemus montrouzieri* (Cm) that were continuously maintained for 10 generations on pink hibiscus mealybug, *Maconellicoccus hirsutus* (Mh), were used. Three different sets (n=30) of Cm were exposed to 3 different preys, i.e. field-collected *Rastrococcus iceryoides* (Ri) on mango and *Phenacoccus solenopsis* (Ps) on congress weed (*Parthenium hysterophorus*), to study the changes in immediate prey preference, along with the regular prey (Mh) for comparison. In each set, 10 (pre-starved for 12 h) late second-instar grubs were kept individually in separate Petri plates and provided with a fixed number of respective second-instar mealybugs as prey. Observations on the number of mealybugs consumed were recorded every 12 h. The experiment was continued with the same grubs and terminated when 50% of them pupated. After emergence, again the respective adults were given the same food on which they were fed during their grub stage. Thus, the prey-preference studies were carried out through larval and adult stages (continuously for 47 days) with brief and rigorous starvation in between to study any change in their preference towards each species separately. Given the broad range of variability in the diet breadth of Cm, the present study indicated that recommending this predator in the field should always be considered with brief pre-conditioning towards the target prey prior to its release, as it may help in reversal of prey specificity. Further, situation-specific, species-specific prey preference of Cm has to be studied, since even conditioned response of reversal prey specificity could not last long as in the case of *Phenacoccus*.

99. Jeyakumar P, Tanwar RK, J Singh, S Singh and A Dhandapani. 2009. Impact of weather factors on cotton mealybug, *Phenacoccus solenopsis* Tinsley. Proceedings of National Symposium IPM strategies to combat emerging pests in the current scenario of climate change, January 28-30, 2009, College of Horticulture and Forestry Central Agricultural University, Pasighat, Arunachal Pradesh, pp. 39.

An intensive surveillance was carried out in 32 cotton- growing villages in Faridkot district of Punjab from June to September 2008.In each villages two fixed fields and two random fields were selected for weekly surveillance. In the selected fields 100 plants were selected at random for observations and which was expressed as per cent incidence. In the same fields 10 plants were selected at random, in which the mealybug grade was worked out using the scale of 0-4. The correlation analysis indicated that both maximum as well as minimum temperature is negatively correlated with incidence (%) and intensity (grade). Relative humidity (morning and evening) shows a positive correlation; correlation of morning RH with incidence was low (0.23 0.42) compared to that of evening RH (0.51 0.60). The same trend was observed with that of intensity. It appeared that high rainfall has washed away all the small crawlers. Moreover the high rainfall has favored the growth of entomopathogens, and it was confirmed by the samples collected from Bhatinda (Punjab) of October/ November, 2008. It is evident that enough humidity favours the multiplication, but the intense rainfall adversely affects the spread and reduces the intensity.

100. Jhala RC and Bharpoda TM. 2008. Occurrence in Gujarat and suggestions for action plan to combat the menace of mealybugs on cotton. Paper presented in workshop organized buy Department of Agriculture and Cooperation, Ministry of Agriculture, Krishi Bhavan, New Delhi, NCIPM, IARI Campus, New Delhi on 05.01.2008 & Proceedings of the National Consultation on mealybug Management CICR, 28-29 Jan. 2008, Nagpur, India.

Mealybug (*Phenacoccus solenopsis*) becomes serious pest on Bt variety in 2006-07 in Gujarat. Reduction in yields (50%) in Gujarat also reported during 2006 due to severe mealybug infestation.

101. Jhala RC, Bharpoda TM and Patel MG. 2008a. Occurrence of mealybugs, *Phenacoccus solenopsis* Tinsley and *Phenacoccus solani* Ferris (Hemiptera Pseudococcidae) on cotton in Gujarat, *Insect Environment,* **13**(4): 149-151.

During the survey in 2006-2007, mixed infestation of two species of mealybugs *viz., Phenacoccus solenopsis* Tinsley and *Phenacoccus solani* Ferris (Homoptera : Psuedococcidae) have been observed on cotton in central Gujarat. *P. solenopsis* was also found infesting weed plants [Congress grass, *Parthenium hysterophorus*; Cocklebur, *Xanthium strumarium*; Indian abutilon, *Abutilon indicum* (syn. *Sida indica*); wild bhendi, *Abelmoschus* (Hibiscus) *manihot*; Little ironweed (*Phulni, Fulakia* or *Sahdevi*) *Vernonia cinerea*; Prickly Chaff flower, *Achyranthes aspera*; Boken (*Seshmul*), *Comanilla* sp: Amaranthus (*Kanjira*), *Dygera arventhis*; and

Atrilel (*Pittapatra*), *Peristrophe bicalyculata*]; medicinal plants (Ashwagandha, *Withania somnifera*; Madhunaashini, *Gymnema sylvestre*; Chota halkusa, *Leucas aspera*; Mount Atlas daisy, *Anacyclus pyrethrum*; Black Nightshade, *Solanum nigrum*; Devil's claw, *Martynia annua*; Downy thorn apple, *Datura innoxia*; Phalsa, *Grewia asiatica* (Syn. *Grewia subinequalis*); Butterfly pea, *Clitorea fernatea* and Rasna, *Pluchea lanceolata*]; ornamental plants [Cosmos, *Cosmos bipinnatus*; Zinnia*, Zinia eleganus*; china rose (Jasund), *Hibiscus rosa-sinensis*; Indian jasmine, *lxora singaporensis*; plume flower, *justicia carnea*; Garden Crown Daisy, *Chrysanthemum coronarium*]; vegetable crops [okra, tomato, brinjal and chilli]; and field crops [wheat, sesamum, sunflower and tobacco].

102. Jhala RC, Bharpoda TM and Patel MG. 2008b. *Phenacoccus solenopsis* Tinsley (Hemiptera Pseudococcidae), the mealybug species recorded first time on cotton and its alternate host plants in Gujarat, India. *Uttar Pradesh Journal of Zoology*, **28**(3): 403-406

During the survey on insect pests in middle Gujarat, mixed infestation of three species of mealybugs, namely *Phenacoccus solenopsis*, *Phenacoccus solani* and *Ferrisia malvastra* have been observed infesting cotton cultivated in middle Gujarat. *Phenacoccus solenopsis* was the major while the other two were minor species occurring on cotton. Congress grass, *Parthenium hysterophorus*; Cocklebur, *Xanthium strumarium* and Indian abutilon, *Abutilon indicum* (syn. *Sida indica*) were the major alternate hosts of *P. solenopsis*. An outbreak of *Phenacoccus solenopsis* population was observed on cotton during October-December 2006. The possible reasons for spread and upsurge of mealybugs in cotton are also discussed.

103. Jhala RC, Patel MG and Bharpoda TM. 2010. Evaluation of insecticides for the management of mealybug, *Phenacoccus solenopsis* Tinsley in cotton. *Karnataka Journal of Agricultural Sciences*, **23**(1): 101-102.

A field experiment was conducted during 2007-08 and 2008-09 in a farmer's field of Bt cotton in Karajan, Vadodara district, Gujarat, India, to evaluate the efficacy of various insecticides against *P. solenopsis*. The treatments were: 0.2% carbaryl 50 WP, 0.1% profenofos, 0.1% triazophos 40 EC, 0.04% chlorpyrifos 20 EC, 0.08% methomyl 40 SP, 0.05% methyl-o-demeton [demephion] 25 EC, 0.1% phenthoate 50 EC and 0.05% phosphamidon 40 SL. At 3 days after spraying (DAS), carbaryl (75.36%), profenofos (74.86), triazophos (73.93%), methomyl (69.67%) and chlorpyrifos (67.93%) were the most effective in the reduction of pest population.

At 7 DAS, methomyl (95.17%), profenofos (94.57%), methyl-o-demeton (92.90%) and carbaryl (92.37%) resulted in the greatest reduction in pest incidence. At 15 DAS, the highest percent reduction over the control was obtained with profenofos (91.73%), carbaryl (91.24%), phosphamidon (90.49%), methyl-o-demeton (90.02) and triazophos (89.95%). Pooled data revealed that profenophos was the most effective (90.66% reduction in mealybug population) among the insecticides.

104. Jhala RC, Patel MG, Vaghela NM and Bharpoda TM. 2009. Field efficacy of buprofezin, a chitin inhibitor against cotton mealybugs, *Phenacoccus solenopsis* Tinsley. *Insect Environment*, **15**(3):135-137.

The efficacy of buprofezin (Applaud) 25% SC against *P. solenopsis* in comparison to chlorpyriphos and carbary1 was evaluated based on pest population and impact on seed cotton yield under field condition at farmers field located in Karjan taluka of Vadadara district during 2007-08 and 2008-09. Western India (Gujarat). There was an indication that effects on *P. solenopsis* were greater, the higher the rate of buprofezin applied. Buprofezin at all the 3 doses (250, 312.5 and 625 g a.i./ha) was significantly more effective than carbary1 1000 g a.i./ha and chlorpyriphos 400 g a.i /ha in controlling the population growth of *P. solenopsis* in cotton. There was more than 95 per cent reduction in mealy bug population over control after spray application of buprofezin at all 3 doses. Buprofezin was more effective at two higher doses (312.5 and 625 g a.i./ha) as compared to its lowest dose (250 g a.i./ha). Thus *P. solenopsis* can be effectively control by spray application of buprofezin 25 SC even at lower dose (250 g a.i/ha) under field condition in cotton crop. The efficacy of buprofezin 25% SC against *P. solenopsis* was also reflected on seed cotton yield and it was dose dependent *i.e*., as dose increased, correspondingly the seed cotton yield increased.

105. Jhala RC, Solanki RF, Bharpoda TM and Patel MG. 2009. Occurrence of hymenopterous parasitoids, *Aenasius bambawalei* Hayat and *Promuscidea unfaciativentris* Girault on cotton mealybugs, *Phenacoccus solenopsis* Tinsley in Gujarat. *Insect Environment*, **14**(4): 164-165.

During the survey hymenopterus parasitoids, *Aenasius bambawalei* and *Promuscidea unfaciativentris* observed first time on *P. solenopsis* in cotton fields of Baroda district during August-September, 2008.

106. Joshi MD, Butani PG, Patel VN and Jeyakumar P. 2010. Cotton mealybug, *Phenacoccus solenopsis* Tinsley - a review. *Agricultural Reviews*, **31**(2): 113-119.

Mealybug, *Phenacoccus solenopsis* Tinsley is a serious pest of cotton limiting the production and quality of fibre and lint. It is a polyphagous pest and multiply on different hosts like field crops, horticultural, fruit, vegetable and ornamental plants. They suck a large amount of sap from leaves and stems depriving plants of essential nutrients showing the symptoms like retarded growth, late opening of bolls and total drying of the plant. The yield losses due to the pest are estimated upto 50 per cent. Mealybugs are cottony in appearance, small, oval, soft-bodied sucking insects covered with white mealy wax, which makes them difficult to eradicate. An individual mealybug survived for 25–38 days. Effective control of the pest can be achieved through an integrated pest management approach. Field sanitation, uprooting of infested plants, dusting of methyl parathion 2 per cent or spraying of profenophos 50 EC or chlorpyriphos 25 EC or quinalphos 25 EC help to reduce the pest population. *Aenasius bambawalei* Hayat, *Anagyrus kamali* Mani, *Cryptolaemus montrouzieri* (Mulsant), *Chrysoperla carnea* (Stephens), *Verticillium lecanii* (Zimmermann) and *Beauveria bassiana* (Vuillemin) are the effective biological control agents in managing the infestation of the pest.

107. Kamariya NM and Patel VN. 2011. Biology of mealybug, *Phenacoccus solenopsis* (Tinsley) on cotton. *Journal of Cotton Research and Development*, **25**(1): 115-118.

The biology of mealy bug, *Phenacoccus solenopsis* (Tinsley) was studied on cotton under laboratory conditions at Junagadh Agricultural University, Junagadh at average temperature of 23.6°C with a relative humidity of 59.2 per cent during June 2008. The average numbers of eggs laid by a female were 427.68±86.69 and these were minute, oval in shape and light yellow or whitish yellow in colour. The average incubation period was 6.62±1.71 days. There were three nymphal instars preceding the adult stage. The average durations of first, second and third instar nymphs were 4.82±1.12, 5.64±1.14 and 6.42±1.14 days, respectively with total nymphal duration of 16.88±2.11 days. The active movement of newly hetched crawlers (nymphs) was noticed. The first and second instar nymphs were pale yellow in colour and oblong shaped. Two longer caudal white filaments were present on tip of abdomen. No mealy scale presented on the body. A pair of red eye and filiform antenna was seen on head. Three pair of reddish legs were present on thorax. During third instar white waxy substance covered dorsal body surface. The adult female was oblong in shape, light to dark yellow in appearance and was wingless. Several pairs of short white waxy filaments were also seen around the body (peripheral) with a longest

pair at the posterior end. The pre oviposition, oviposition and post oviposition periods were recorded as 4.32±0.80, 8.00±0.82 and 2.72±0.79 days, respectively. The female adult survived for 15.52±1.42 days and the entire life span was 31.13±3.19 days. A pair of dark spots on thorax and three pairs on abdomen forming two longitudinal stripes were noticed.

108. Kamariya NM and Patel VN. 2011. Efficacy of various insecticides against mealybug, *Phenacoccus solenopsis* (Tinsley) infesting cotton. *Journal of Cotton Research and Development*, **25**(1): 119-121.

Nine insecticides namely buprofezin (0.025%), chlorpyriphos (0.05%), dimethoate (0.03%), fenobucarb (0.1%), malathion (0.1%), methyl parathion (0.05%), profenophos (0.1%), quinalphos (0.05%), and triazophos (0.06%) were evaluated for their efficacy against mealybug, *Phenacoccus solenopsis* infesting cotton at Junagadh during 2008-2009. Two applications of all the insecticides were given when sufficient population of the pest developed on the crop at boll development stage and the mortality of mealybug caused by each insecticide was recorded at 3 and 7 days after their application. The data revealed that two applications at 20 days interval with methyl parathion was most effective and economical against mealybug which caused 98 to 99.9 per cent mortality of the pest. The treatment resulted in highest yield (1028 kg/ha) and net return (Rs.9279/ha) with C:B ratio of 6.8. The treatments of profenophos and dimethoate were found next effective (89% and 78% mortality of the pest).

109. Kaur Harmeet and Virk JS. 2011. Feeding potential of *Cryptolaemus montrouzieri* against the mealybug *Phenacoccus solenopsis*. *Phytoparasitica.* DOI 10.1007/ s12600-011-0211-3.

Phenacoccus solenopsis Tinsley (Hemiptera: Pseudococcidae) is an exotic species native to the USA, damaging cotton and other plant families. The feeding potential of different development stages of *Cryptolaemus montrouzieri* Mulsant, a biological control agent against mealybugs, was investigated on different development stages of *P. solenopsis*. Fourth instar grubs and adults of *C. montrouzieri* were the most voracious feeders on different instars of mealybug. The number of 1st instar nymphs of mealybug consumed by 1st, 2nd, 3rd and 4th instar larvae and adult beetles of *C. montrouzieri* was 15.56, 41.01, 125.38, 162.69 and 1613.81, respectively. The respective numbers of 2nd and 3rd instar nymphs of mealybug consumed were 11.15 and 1.80, 26.35 and 6.36, 73.66 and 13.32, 76.04 and 21.16, 787.95 and 114.66. The corresponding figures for adult female mealybugs

were 0.94, 3.23, 8.47, 12.71 and 73.40, respectively. The results indicate that *C. montrouzieri* has the potential to be exploited as a biocontrol agent in North India; inoculative releases of 4th instar larvae and adults may provide instant control of *P. solenopsis*. Field experiments should be conducted to determine the efficiency of the ladybird on this mealybug.

110. Kaur Harmeet, Virk JS and Kaur Rabinder. 2010. Biology of Australian ladybird beetle, *Cryptolaemus montrouzieri* Mulsant on *Phenacoccus solenopsis* Tinsley *Journal of Biological Control*, **24**(2): 123-125.

The biological parameters of *Cryptolaemus montrouzieri* on *Phenacoccus solenopsis* were studied under laboratory conditions at 17–27°C and 58–82% RH. The mean incubation period and total larval periods were 4.36 and 17.33 days (2.78, 4.64, 6.13 and 3.79 days for 1st, 2nd, 3rd and 4th instar grubs, respectively). The pre-pupal, pupal and total development period recorded were 2.38, 8.69 and 32.75 days, respectively. Pre-oviposition, oviposition and post-oviposition periods were 7.23, 46.75 and 7.80 days, respectively. Males lived longer than females (68.30 and 61.78 days, respectively) and life cycle duration were 100.29 and 93.77 days, respectively. The mean fecundity was 98.15 (eggs/female) and sex ratio (male: female) was 1: 1.36. The per cent hatchability and adult emergence observed were 79.00 and 88.50, respectively.

111. Kedar S, Saini RK and Ram Pala. 2011. Record of coccinellid predators associated with solenopsis mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) from Haryana. *Journal of Entomological Research*, **35**(3): 245-246.

Surveys on coccinellid predators associated with solenopsis mealybug, *Phenacoccus solenopsis* Tinsley, infesting cotton and other host plants in and around Hisar, Haryana revealed that six species of coccinellids i.e. *Scymnus coccivora* Ayyar, *Nephus regularis* Sicard, *Brumoides suturalis* Fabricius, *Hippodamia variegata* Goeze, *Cheilomenes sexmaculata* Fabricius and *Coccinella septempunctata* L. were associated with *P. solenopsis*.

112. Kedar S, Saini RK and Ram Pala. 2011. Survival of solenopsis mealybug, *Phenacoccus solenopsis* Tinsley, in cotton ecosystem. In World Cotton Research Conference-5 held at Mumbai from 7-11 Nov. 2011.

Studies on survival of solenopsis mealybug, *Phenacoccus solenopsis Tinsley*, a serious pest of cotton in India, were conducted on cotton during 2009-10 at the

Research Farm of Department of Entomology, CCS Haryana Agricultural University, Hisar (Haryana). Between caged and exposed (uncaged) cotton plants, survival of the *Phenacoccus solenopsis* (when the first instar crawlers were released on them) was considerably higher in caged condition, indicating significant role of biotic factors and rains in mealybug population regulation. Under exposed condition, there was 32.6, 42.2, 6.6 and 15.8% reduction in the released mealybug population during July, August, September and October, respectively due to parasitization by *Aenasius bambawalei* Hayat.

113. Kharbade SB, Navale PA, Mehetre SS and Chandele AG. 2009. Evaluation of bio-pesticide against mealybugs, *Phenacoccus solenopsis* (Tinsley) on Cotton: In proceedings of National symposium on Bt-cotton: opportunities and prospectus, CICR, Nagpur, November 17-19, pp. 89.

A field experiment was conducted to study the efficacy of biopesticides against cotton mealy bug, *Phenacoccus solenopsis* at Cotton Improvement Project, MPKV, Rahuri during 2006-074 on cotton cultivar NHH-44 in a randomized block design with seven treatments. The biopesticides viz.; *Verticillum lecani*@2000 gm/ha, *Metarhizium anisopliae* @ 2000 gm/ha, *Beauveria bassiana* @ 2000 gm/ha, EM solution III @ 2000 ml/ha and Neem oil @ 2000 ml/ha. Three sprays of insecticides were given at an interval of 10-15 days. The observations on number of mealybugs/ 5 cm shoot tip length/plant were recorded on 1, 3, 5, 7 and 10 days after each spray. The treatment with *Metarhizium anisoplae* @ 2000 gm/ha was observed to be most effective by recording minimum of 87.46 mealybugs/ 5 cm shoot tip length/ plant resulting in to reduction of mealybugs over untreated control. This treatment was statistically on par with the treatments of Neem oil 2000 ml/ha and Dashparni @ 10 % in which average of 108.73 and 110. 33 mealybugs/ 5 cm shoot tip length/ plant, were noticed, respectively. This was followed by the treatments with EM solution III @ 2000 ml/ha, *Verticillum lecani* @ 2000 gm/ha and *Beauveria bassiana* @ 2000 gm/ha in which 118.00, 124.33 and 127.00 mealybugs/5 cm shoot tip length/ plant were observed, respectively. The higher seed cotton yield of 1521 kg/ha was obtained in a treatment with *M. anisopliae* @ 2000 gm/ha. The untreated control recorded maximum of 322.06 mealybugs/5 cm shoot tip length/plant with lower seed cotton yield of 913 kg/ha. Therefore, these biopesticidees can be incorporated in the development of ecofriendly Integrated Pest Management modules for cotton mealybug.

114. Kharbade SB, Chandele AG, Mehetre SS, Nawale PA and Dokhe SD. 2011. Record of mealybug *Phenacoccus solenopsis* Tinsley on cotton from Maharashtra, India. *Pestology*, **35**(9): 25-26.

The population of crawler varied from 400 to 600 per plant and damage by mealybug recorded 15 to 60 percent. This seems to be the first record of mealybug incidence on Bt and non Bt cotton in Maharashtra, India.

115. Khuhro SN, Kalroo AM and Mahmood R. 2011. Present status of mealybug *Phenacoccus solenopsis* (Tinsley) on cotton and other plants in Sindh (Pakistan), In World Cotton Research Conference-5 held at Mumbai from 7-11 Nov. 2011.

In Pakistan mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) was recorded first time in 2005 on cotton and other plants. The survey was carried out in different districts of Sindh to know the status of the mealybug on cotton and other plants. The pest was widely sprayed in the surveyed areas attacking a number of plants including cotton. Mean maximum population (mealy bug 2nd & 3rd instars and adults/shoot) was recorded in the districts Shaheed Benazirabad 46.93 followed by Ghotki district (38.88), Sukkur, (32.17), Naushahro Feroze (32.07), Khairpur (29.67), and Dadu district (14.69). Mealybug was recorded on 22 plants in Shaheed Benazirabad district. On unsprayed cotton (95%) mealybugs were found parasitized by *Aenasius bambawalei* Hayat, followed by (92%), on *Abutilon indicum* (91%), okra (87%), datura, (86%) , china rose (80%) on egg plant, and on tomato (77%) during 2010. However, mealybugs parasitized by *Aenasius bambawalei* very low in 2011 due to indiscriminate use of pesticides and appearance of hyper parasitoid. Different insecticides were also tested for controlling mealybug on cotton. Maximum mortality of the mealy bug recorded in plots treated with Movento 20 SC (95.2%), followed by Movento energy 480 SC (94.8%), Confidor 50 SC+ Ultra (93.3%), Profenofos 50 EC (92.69%), Confidor 70 WG (92.40%), Fyfanon 57 EC (91.1%), Bono 20 SC (89.60), and Malatox 57 EC (84.65%) up to one week of spray. The meteorological data revealed that mealybug was more common in the field at temperatures in the range of 30.5-39.5°C.

116. Khuhro SN, Kalroo AM and Mahmood R. 2011. Survey and Management of Cotton Mealybug *Phenacoccus solenopsis* (Tinsley) on cotton and other host plants in different districts of Sindh (Pakistan) in 2010. In World Cotton Research Conference-5 held at Mumbai from 7-11 Nov. 2011.

In Pakistan mealybug *Phenacoccus solenopsis* Tinsley, was recorded first time in 2005 on cotton and other plants. The mealybug infestation was recorded on both

Bt and non Bt varieties in different districts of Sindh. The survey carried out in different districts of Sindh and showed that mean maximum population of (38.88 mealybug /shoot) was recorded in October 2010 in Ghotki district, followed by (32.17) in Sukkur, (32.07) Shaheed Benazirabad, (29.67) in Khairpur and (14.69 /shoot) in Dadu district. Besides cotton mealy bug was recorded on 21 other host plants in Shaheed Benazirabad district. About 95% parasitism of *Aenasius bambawalei*, was noted on cotton, followed by Abutilon (92%), Okra (91%), Dhatoro (87%), China rose (86%), Brinjal (80%), and Tomato (77%). Different insecticides were also tested for controlling mealybug on cotton. Maximum mortality of the mealybug occurred in plots treated with Movento 20 SC (95.2%), followed by Movento energy 480 SC (94.8%), Confidor 50 SC+ Ultra (93.3%), Profenofos 50 EC (92.69%), Confidor 70 WG (92.40%), Fyfanon 57 EC (91.1%), Bono 20 SC (89.60), and Malatox 57 EC (84.65%) up to one week of spray. The meteorology data reveals that maximum mealybug population was recorded when the temperature was in the range of (30.5-39.5°C).

117. Kondo T, Ramos-Portilla AA and Vergara-Navarro EV**.** 2008. Updated list of mealybugs and putoids from Colombia (Hemiptera: Pseudococcidae and Putoidae) (In English; Summary In Spanish). *Boletin del Museo de Entomologia de la Universidad del Valle,* **9**(1): 29-53

Collecting localities, plant hosts and associated ants of 34 species of mealybugs and putoids (Hemiptera: Coccoidea: Pseudococcidae and Putoidae) in Colombia collected during 1995—2008 are provided. Brief notes on their biology, taxonomy, and distribution are given. Eleven species, *{Dysmicoccus} sp., {Ferrisia} sp., {Maconnellicoccus hirsutus} (Green), {Nipaecoccus} sp.1, {Nipaecoccus} sp.2, {Phenacoccus solani} Ferris, {P. solenopsis) Tinsley, {Planococcus halli} Ezzat & McConnell, {Prorhizoecus} sp., {Pseudococcus calceolariae} (Maskell) and {Rhizoecus mayanus}* (Hambleton) are newly recorded from Colombia. An updated list of 78 mealybugs species from Colombia is given.

118. Kranthi S, Kranthi KR, Kumar Rishi, Dharajothi Udikeri SS, Prasad GMV, Rao, Zanwar PR, Nagrare VN, Naik CB, Singh V, Ramamurthy VV and Monga D. 2011. Emerging and key insect pests on Bt cotton—their identification, taxonomy, genetic diversity and management. In World Cotton Research Conference-5 held at Mumbai from 7-11 Nov. 2011.

Technology Mission on Cotton in India has proved to be successful in the planning, implementation, execution and monitoring of research projects in a stipulated time

with a focused approach. Emerging and key insect pests on Bt cotton- their identification, genetic diversity and management is one of the projects that addressed the changing pest problems in different regions through strategic research. Mealybugs (*Phenacoccus solenopsis, Paracoccus marginatus*), mirids (*Creontiades biseratense, Campylomma livida, Hyalopeplus linefer*), flower bud maggots (*Dasineura gossypii*), safflower caterpillar (*Perigea capensis*), tea mosquito bug *(Helopeltis bryadi*) were emerging insect pests while leaf hoppers (*Empoasca devastans*), whiteflies (*Bemisia* sp), pink bollworm (*Pectinophora gossypiella*) and the armyworm (*Spodoptera* spp.) were the key pests on Bt cotton. Incidence and damage caused by these pests varied across regions and Bt genotypes being cultivated. Timely taxonomic identification of the mealybug, *P. solenopsis* and subsequent molecular study to suggest its narrow genetic diversity led to the development of meaningful management strategies to limit its spread. Studies on the mt COI region of the key pest *E. devastans* revealed that leaf hopper populations on cotton although morphologically and taxonomically similar were genetically distinct from leaf hoppers of South and Central India. Implications on pest management in light of this finding are presented. Flower bug maggots that were hitherto not reported on cotton were found to cause extensive damage in parts of Karnataka. The life cycle of *D. gossypii* was elucidated to identify vulnerable stages in its life cycle that can be exploited for pest management. Two botanical formulations Mealy Kill 50EC (against sucking pests) and Mealy Quit (against mealybugs) were identified, developed and validated in multilocation trials. Entomofungi were evaluated for their efficacy in sucking pest management.

119. Kumar H Kesava and Ganguly Sudershan. 2011. Bioefficacy of Indian strains of entomopathogenic nematodes against different homopterans under laboratory conditions. *Indian Journal of Nematology,* **41**(2): 197-200.

The virulence of four strains of entomopathogenic nematodes *Steinernemac thermophilum* (New Delhi strain), *S. meghalayensis* (Meghalaya strain), *S. riobrave* (Gujarat strain), *S. harryi* n. sp. (Tamil Nadu strain) were evaluated against third instar nymphs of solenopsis mealybug (*Phenacoccus solenopsis*), adult cotton aphid (*Aphis gossypii*) and second instar nymphs of cotton whitefly (*Bemisia tabaci*) in two doses (50 and 500 IJs/ml) in sand well and leaf disc assays under laboratory conditions. *S. thermophilum* caused significant mortality of mealybugs which was 83% within 72 h after inoculation at 50 IJ/ml and 100% within 48 h at 500 IJs/ml. *S. riobrave* and *S. harryi* n. sp. produced intermediate mortality of about

66% within 60 h at 500 IJs/ml. Against aphid, *S. thermophilum* caused 66 and 83' O mortality at 50 and 500 IJs/ml. respectively within 3 days post inoculation. None of the *Steinernema* spp. caused significant mortality of whitefly at 50 Ijs/ml; only the higher concentration produced mortality. At 5J0 IJs/ml *S. riobrave* caused maximum mortailty of about 66% within 72 h after inoculation. *S. meghalayensis* was the least effective strain as it caused only 33% mortality fo all tested insects at both low and high doses. Emergence was observed only in 16.6% of the mealybug cadavers infected with *S. thermophilum* and *S. harryi* n. sp, while no emergence was observed from whitefly and aphid cadavers.

120. Kumar Rishi, Jat SL, Pal Vijander and Chauhan Rahul. 2009. Biology of the mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Psuedococcidae) on cotton in India. *Entomon*, **34**(3): 189-192.

Phenacoccus solenopsis Tinsley (Hemiptera: Psuedococcidae) reported on cotton in India in 2007 is an exotic species originally described from USA in 1898. The oblong shaped, wingless female of *P. solenopsis* laid eggs in uniformly secreted ovisac covered under its body. The mean number of ovisacs per female was 2.9. The mealybug is a prolific breeder and produced a mean of 390.7 crawlers per female on cotton. The female has three nymphal instars whereas the male has two nymphal instars and a pupal stage (cocoon). The 1st and 2nd nymphal instars of male and female are indistinguishable. The 1st instar nymph (crawler) showed high motility and had no permanent feeding site. The mean total nymphal duration of male was 23 d and of female, 24.6 d. The mean longevity of male was 1.2 d and of female, 16.9 d. The population of *P. solenopsis* had a positive correlation with temperature.

121. Kumar Rishi, Kranthi KR, Monga D and Jat SL. 2009. Natural parasitization of *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on cotton by *Aenasius bambawlei* Hayat (Hymenoptera: Eneyrtidae). *Journal of Biological Control,* **23**(4): 457-460.

Studies were conducted during 2007 and 2008 over a considerable geographical area under cotton cultivation for finding potential natural enemies of *Phenacoccus solenopsis* Tinsley. In July 2008, large numbers of mummified *P. solenopsis* along with healthy mealybugs were observed on heavily infested cotton crop at Central Institute for Cotton Research, Regional Station, Sirsa (Haryana) due to parasitization by *Anasius bambawalei* Hayat, a potential bioagent of *P. solenopsis*. The parasitoid completed its life cycle on the mealybug leaving the mummified body along with the exit hole behind. The parasitization efficiency of the parasitoid from field collected

mealybugs was 57.2 per cent (range 46-64%) whereas under laboratory condition, it was 60.6 per cent (45-74%). As biological control is a supplement to chemical control, the adverse effect of commonly used insecticides on cotton on the efficiency of this parasitoid was studied and monocrotophos was recorded as the most deleterious (57.52% reduction in parasitization). Spinosad and spirotetramet were found to cause the least reduction in parasitisation.

122. Kumar Rishi, Kranthi KR, Swami D, Nitharwal M and Pal V. 2011. Insecticide induced resurgence of mealybug, *Phenacoccus solenopsis* Tinsley in cotton. In World Cotton Research Conference-5 held at Mumbai from 7-11 Nov. 2011.

The knowledge relating to risk associated with the insecticide as regards resurgence is of paramount importance, the influence of the commonly used insecticides alone and in combination was studied for their role in resurgence of mealybug population on cotton cultivar RCH 134 during 2008-09.The insecticides *i.e.* cypermethrin, monocrotophos, acephate, ethion, profenophos, spinosad, cypermethrin+ monocrotophos, cypermethrin + acephate, cypermethrin + ethion, cypermethrin + profenophos were applied 11 times at 10 day intervals in mealybug infested fields spreading throughout the cotton season at their recommended dosages. On the basis of two year cumulative data 14.53% resurgence in mealybug population was recorded due to Spinosad. No resurgence in mealybug population during the year 2008 after 1^{st} and II^{nd} spray was observed but 0 .69 to 11.24% resurgence was recorded after 3^{rd}, 4^{th}, 6^{th}, 7^{th}, 8^{th}, 9^{th}, 10^{th} and 11^{th} spray after 7^{th} day of each spray application. During the 2009, 4.53 to 43.53% resurgence in mealybug due to spinosad was recorded after 2^{nd}, 3^{rd}, 4^{th}, 5^{th}, 6^{th}, 7^{th}, 8^{th}, 9^{th}, 10^{th} and 11^{th} spray after 7^{th} day of each spray application. The studies conducted under polyhouse conditions also revealed 12.92% resurgence in mealybug population due to spinosad after 5 sprays at weekly intervals. Among the other insecticides applied, 10.89 to 21.92% resurgence due to cypermethrin during the 2009 was recorded after 5^{th}, 6^{th}, 7^{th}, 8^{th}, 9^{th}, 10^{th}, and 11^{th} spray after 7^{th} day of each spray application. 12.12 to 29.08% resurgence due to monocrotophos was recorded after 6^{th}, 7^{th}, 8^{th}, 9^{th} and 11^{th} spray after 7^{th} day of each spray application. As per record, though the infestation of mealybug was more during 2008, resurgence in mealybug population due to insecticides was more during 2009. The reason for the resurgence like biochemical changes in plant, changes in insect reproduction physiology or ecological changes could not be traced at this stage which has to be confirmed through more planned and systemic studies.

123. Kumar Rishi, Kumar Sanjay, Monga D and Dhiman SC. 2010. Off-season survival of mealybug and its impact on succeeding cotton crop. *Indian Journal of Entomology,* **72**(1): 57-59

Mealybug, *Phenacoccus solenopsis* Tinsley, a newly introduced pest has appeared on cotton in a devastating manner in North India. Though overwintering of mealybug was reported in stacks of infested cotton stalks, bark of trees near infested area, weed hosts that survived during winter of 2007-08 but it was maximum in stacks of infested cotton stalks. In the preceding cotton crop of 2008-09 near the source of previous infestation of 2007-08, the earliest initiation (April-May) and highest infestation (41%) was recorded around stacks of infested cotton stalks, though in general the infestation was less during 2008-09 as compared to 2007-08. The maximum distribution of mealybug was found to parallel the source of infestation (39-62%) reducing to the perpendicular side (6-31%). The manipulation in source of overwintering (off-season survival) population significantly affects the infestation.

124. Kumar Rishi, Monga D, Nitharwal M, Jat SL and Kumhar KC. 2011. Validation of eco friendly integrated pest management (EPM) packages in Bt cotton at farmer's participatory field. *Journal of Cotton Research and Development*, **25**(2): 243-247.

Integrated Pest Management (IPM) module developed for transgenic cotton was compared with Recommended Package of Practices (RPP) on Bt cotton (RCH 134) during 2008 and 2009 at farmer's field in Sirsa, district of Haryana. The incidence of leafhopper, (*Amrasca biguttula biguttula* Ishida), Thrip (*Thrip tabaci* Lindeman) as well as mealybug (*Phenacoccus solenopsis* Tinsley) was significantly low in IPM as compared to RPP, except of whitefly (*Bemisia tabaci*, Gennadius). The predator's population was more in IPM modules than RPP. The populations of spider (0.33 and 0.28/plant), lady bird beetle (*Coccinella septumpunctata* Linnaeus 0.18 and 0.12/plant) and lacewing (*Chrysoperla cornea*, Stephens 0.29 and 0.23/plant) in IPM and RPP, respectively were recorded frequently throughout the season. The damaged fruiting bodies, rosette flower, loculi damage, green boll damage were higher in RPP than IPM. On contrary, the number of good opened boll was more in IPM and bad opened bolls were more in RPP. Seed cotton yield was more in IPM (11.90 q/ha) as compared to RPP (11.47 q/ha) with Cost:Benefit ratio of 1:4.29 and 1:3.75 in IPM and RPP, respectively. The better

performance of Bt cotton was recorded in both IPM modules and RPP but reduced insecticides usage to the 38 per cent in IPM (4.0 sprays in IPM and 6.5 in RPP).

125. Kumar Rishi, Nitharwal Mukesh, Chauhan Rahul, Pal Vijender and Kranthi KR. 2012. Evaluation of ecofriendly control methods for management of mealybug, *Phenacoccus solenopsis* Tinsley in cotton. *Journal of Entomoloy,* **9**(1): 32-40.

Eco-friendly management of mealybug, *Phenacoccus solenopsis* Tinsley, was important to reduce reliance on insecticides and conservation of natural enemies. The study was conducted to evaluate a set of eco-friendly biopesticides, biorationals and insecticides against mealybug, *Phenacoccus solenopsis* Tinsley. The treatments were applied thrice in mealybug infested field at 15 days interval and the mortality data both for mealybug and generalist predators were recorded. Similarly the mortality data on 5 day old mealybug nymphs was also obtained under laboratory condition. The insecticides, acephate and chlorpyriphos proved effective in reducing the population of mealybug by 72.34 and 68.60%, respectively after 3 spray applications. The insecticides were found statistically superior over biopesticides and biorationals in reducing the mealybug population. The biopesticides and biorationals insecticides reduced 18.52 to 41.42% mealybug population after three spray applications under field condition. The biopesticides and biorationals are least toxic to generalist predators and can be integrated with insecticides for sustainable management of the mealybug.

126. Kumar Rishi, Pal Vijander, Jat MC, Monga D and Jat SL. 2009. Studies on mealybug, *Phenacoccus Solenopsis* Tinsley on transgenic cotton in North India. *Indian Journal of Entomology,* **71** (2): 125-129.

Fifty species of plants of taxonomic identity belonging to 20 families from field crops (4), fruits crops (5), ornamental crops (4), plantation crops (7), vegetable crops (9) and weed plants (21) were recorded as host of mealybug. The studies conducted during 2007 and 2008 on its population dynamics revealed that the pest appeared on cotton immediately after sowing from other weed hosts and remained active throughout the cotton season. The peak infestation of *P. solenopsis* was recorded in August-September on cotton during both years. A low (1–10) to medium (10–20 ants/plant) grade population of ants were recorded on cotton plants infested with mealybug. Seven predators and two parasitoids have been recorded feeding on mealybug. Out of 14 insecticides tested profenofos @ 1250 ml, monocrotophos @ 1250 ml, chlorpyriphos @ 3000 ml, quinalphos @ 2000 ml, acephate @ 2000 g,

thiodicarb @ 625 g and carbaryl WP @ 2500 g/ha were found effective as spot sprays.

127. Kumar S, Kular JS and Dhaliwal LK. 2011. Seasonal abundance of mealybug (*Phenacoccus solenopsis* Tinsley) on Bt cotton in Punjab, *Acta Phytopathologica et Entomologica Hungarica*, **46**(1): 115-127.

The average mealybug (*Phenacoccus solenopsis* Tinsley) population was maximum (2.69, 2.40 and 1.73 adults/plant) on *Parthenium hysterophorus* at wasteland, in or near field and weeds present near stacks at Muktsar. At Ferozepur, the mean mealybug population was 1.10 adults/plant on cotton. On the weeds, near or in the field, the maximum population (5.94 adult/plant) was recorded on *P. hysterophorus* followed by *Digeria arvensis* (3.74 adults/plant). The population was 2.69, 2.66 and 2.86 adults/plant on Sida acuta, *Abutilon theophrasti* and *Achryanthus aspera*, respectively. On wasteland weeds, similar trend was observed, i.e. maximum population was on *P. hysterophorus* (7.31 adults/plant), while minimum (3.00 adults/plant) on *S. acuta*, during 2008. Similar trend was followed in 2009 in Muktsar and Ferozepur but the population was lower than the previous year. Among the weeds, *P. hysterophorus* was the most preferred host for multiplication. During carry-over studies all the stages and ovisac was maximum, followed by detached leaves in Muktsar and in Ferozepur again on *P. hysterophorus*. In Ludhiana, the maximum population was observed on *Hibiscus* sp. followed by ratoon cotton crop.

128. Lanjar AG, Manmood R, Khuhro RD, Abro GH and HA Sahito. 2010. Biological and morphological studies of cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) development under laboratory environment. *Pakistan journal of Entomology*. **25**(2): 134-141

The biology of the cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) was studied in the laboratory of Entomology Section, Tandojam. Two sets of experiments were conducted in the summer (1st June, 2008 at 25.51 ± 2.05°C) and winter (15th November, 2008 at 16.83± 2.02°C) seasons. The insects were provided cotton green leaves and residual leaves in petridishes, respectively. There was great variation observed between sex (male/female) i.e. reproduction, fecundity, fertility, developmental period of immature stages longevity, survival and sex ratios. The variation was also observed between sexual and asexual reproduction. The egg developmental period during both the seasons were recorded as 1.90 days in summer and 2.90 days in winter. The oviposition (4.60±35.43) with 95.77%

fertility were recorded in summer season and (189.60± 23.20) with 86.76% fertility in winter season.

129. Larrain SP. 2002. Insect and mite pest incidence on sweet pepinos (*Solanum muricatum* Ait.) cultivated in the IV Region, Chile. *Agricultura Tecnica*, **62**(1): 15-26.

From October 1995 to March 1997, pests were studied on pepino (*S. muricatum*) plants grown in Chile. Six pepino plots were planted at 2-month intervals and the different pests that infested the crops were monitored. In addition, acaricides and insecticides were evaluated for the control of 2-spotted spider mites, *Tetranychus urticae*, and mealybugs, *Phenacoccus solenopsis*, respectively. The results showed 24 species of arthropods infesting pepino plants. Among them, the mites, particularly *T. urticae*, were abundant and reached levels of 350 mites per leaf, causing severe defoliation. Spraying the acaricides, cyhexatin and amitraz, effectively controlled the infestation. The pepino fly, *Rhagoletis nova*, provoked considerable losses during certain periods, but its greatest importance is that it is a quarantined pest and limits pepino exports to important markets. Other pests of economic significance to the crop, whose population levels must be monitored and controlled, are the moth *Symmetrischema tangolias*, the green peach aphid, *Myzus persicae* and the soil mealybug, *Phenacoccus solenopsis*. The mealybug was controlled by spraying with chlorpyrifos and carbofuran.

130. Lu Yongyue, Guan Xin and Zeng Ling. 2011. Effect of temperature on the development of the mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae). *Scientific Research and Essays*, **6**(31): 6459-6464.

An invasive mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) has attacked cotton (*Gossypium hirsutum L.)* seriously in Pakistan and India, and caused great loss in the production of cotton in recent years. This kind of pests can probably spread rapidly and would threaten cotton and other crops in many infested and non-infested countries. *P. solenopsis* has first been reported to severely damage Chinese hibiscus (*Hibiscus rosa-sinensis*) in Guangzhou, in December, 2008. In order to understand the effects of temperature on the development of *P. solenopsis*, the developmental threshold temperature (*Ct*) and effective accumulated temperature (*K*) were calculated for each developmental stage. A total of 30 *P. solenopsis* individuals were divided into 6 groups and reared at six constant temperatures (18, 21, 24, 27, 30, and 33°C). Total developmental duration ranged from 81.3 days at 18°C to 24.06 days at 30°C for female mealybug, and

from 44.21 days at 18°C to 12.95 days at 30°C for male mealybug. Degree-day values for each developmental stage for both male and female mealybugs were determined. Total degree-day values required for full development for female and males were 414.9 and 218 degree-days respectively. Estimated threshold temperatures for different life stages ranged from 12.8°C (pre-oviposition) to11.7°C (3 rd instar) for female mealybugs, and 16.5°C (prepupa) to 11.5°C (2 nd instar) for male mealybugs.

131. Lu Yong-Yue, Zeng Ling, Wang Lin, Xu Yi-Juan and Chen Ke-Wei1. 2008. Precaution of solenopsis mealybug *Phenacoccus solenopsis* Tinsley. *Journal of Environmental Entomology,* Issue **4**: 386-387

Solenopsis mealybug *Phenacoccus solenopsis* Tinsley is a dangerous pest to ornametnal plants, fruit trees, and crops, especially cotton in China, because it was introduced into Pakistan and India, and outbroken and caused serious damage to the cotton in Pakistan since 2005. A brief introduction including its distribution, hosts, harmfulness, biology and spread was given in this paper.

132. Mae-Wan Ho. 2010. Mealybug Plagues Bt Cotton in India and Pakistan. Available on-line at http://www.gmwatch.org/component/content/article/1-news-items/11870-mealy-bug-plagues-bt-cotton-in-india-and-pakistan?format=pdf

In the Malwa belt of rural Punjab, mile after mile of Bt cotton fields are under attack by the mealybug pest," a news feature reported in 2007. "Bathinda, Muktsar, Faridkot and Ferozepur, Punjab's four major cotton-growing districts, have been badly affected. The so-called "magic bullet" Bt cotton has turned into a bitter pill for farmers who were promised profits but who are now faced with huge losses." Scientists confirm the exotic origin of the mealybug plague. *P. solenopsis* was the predominant species that infested cotton throughout the country and caused significant economic damage.

133. Mahalakshmi V, Kalyanasundaram M, Karuppuchamy P and Kannan M. 2010. Biology and management of the cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae). *Entomon*, **35**(2): 73-79.

The biology and management of cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) were studied during 2008-09. *P. solenopsis* completed its development on potato sprouts quicker than on cotton plant. The total nymphal period, adult longevity, oviposition period and fecundity were more favourable on potato sprouts. Field studies showed that the insecticides, profenophos and methyl parathion were highly effective (>90% mortality) against the pest and gave

the highest yield of 14.89 and 14.56 q ha-1. Buprofezin and thiamethoxam were least effective and gave only 30.62-44.92% mortality, with yield of 11.56 and 11.33 q ha-1. Natural products like Fish Oil Rosin Soap (FORS), combination of FORS with neem oil, neem oil alone and entomopathogenic fungus, *Verticillium lecanii* (Zimmerman), also gave effective control of *P. solenopsis*. Mineral oil @3% gave 98.41% mortality but caused phytotoxicity to the plants. The highest benefit cost ratio of 2.44 and 2.43 was observed for profenophos and methyl parathion treatments with the net income of Rs. 23,703/- and Rs. 23,162/- per ha.

134. Mahmood R, Aslam MN, Solangi GS and Samad A. 2011. Historical perspective and achievements in biological management of cotton mealybug *Phenacoccus solenopsis* Tinsley in Pakistan. Paper presented in 5th ICAC International Cotton Advisory Committee held at Lahore, Pakistan on February 23-25, 2011. Available at: www.icac.org/tis/regional_networks/asian_network/.../MahmoodR.pdf

In India subcontinent the mealybug *Phenacoccus solenopsis* Tinsley, was first time reported from India in 2004 damaging cotton in Gujarat. In Pakistan it was recorded first time in 2005 on cotton and other plants from Vehari (Punjab) and Sanghar in Sindh. It has now spread almost throughout Pakistan except in the high hills. It has attacked not only cotton but also is damaging a number of vegetables and ornamental plants and is a potential threat to Pakistan cotton. It caused huge economic loss to cotton crop in 2007. In most of the cases pesticides were ineffective in controlling this insect. The pest status of mealybug on cotton and other crops demanded an appropriate control strategy. Studies were conducted on assessing the role of natural enemies in suppressing pest populations on cotton and other plants in pesticides free environment at Tando Jam (Sindh), Multan (Punjab) and Winder (Balochistan). To maximize biological control of the mealybug, techniques were developed for utilizing the plant refuses (mealy bug infested drying shoots and leaves) for onsite production of natural enemies of the mealybug. The predators and parasitoids produced at the site not only naturally dispersed but also could be manually collected and released at farmers' fields. With these interventions natural enemies populations increased and the mealybug numbers decreased. At pesticides free farms the biological interventions led to three times decrease of the mealybug compared with those at the insecticides treated farms. The endemic natural enemy complex recorded on the mealybug at bio-control farm comprised of nine coccinellids, a chrysopid, a ceccidomyiid, and two unidentified predatory bugs. An encyrtid *Aenasius bambawalei* (Hayat) that might have come with the mealybug was also recorded in 2008. *Cryptolaemus*

montrouzieri (Muls.) was imported from California, mass bred and released in the country. This was recovered repeatedly from Tando Jam (Sindh) and Winder (Balochistan). It was not recovered from any place in Punjab.

135. Mamoon-ur-Rashid M, Khattak MK, Abdullah K and Hussain S. 2011. Toxic and residual activities of selected insecticides and neem oil against cotton mealybug, *Phenacoccus solenopsis* Tinsley (Sternorrhyncha: Pseudococcidae) under laboratory and field conditions. *Pakistan Entomologist*, **33**(2): 151-155.

Laboratory and field studies were carried out during Kharif 2009-10 and 2010-11 to evaluate the efficacy of Commando (97% DF), Confidor (20% SL), Lannate (40% SP), Actara (25WG) at field recommended doses and neem oil at 1.5 and 2.0% concentrations against cotton mealybug, *Phenacoccus solenopsis* on cotton. Under laboratory environment Commando at recommended dose resulted into 95.2% mortality of the 2nd instar nymphs of *P. solenopsis* 72 hours after exposure period. Commando, under laboratory and field conditions, was found not only more toxic but also persisted longer in its efficacy than the rest of the trialed insecticides. Under field conditions, Commando caused 80.6% mortality of the mealybug that was significantly higher than that caused by Confidor (73.29%), Lannate (70.93%), Actara (74.36%) and neem oil @ 1.5% (43.48%) and 2.0% (52.97%) concentration. Neem oil at both concentrations was less toxic than the rest of the synthetic insecticides; however, it significantly reduced the population of mealybug and remained effective up to more than 72 hours at both concentrations.

136. Mane PN, Rathod PK and Deshmukh SN. 2011. Evaluation of insecticides for the management of mealybug, *Phenacoccus solenopsis* in Sunflower. *Indian Journal of Plant Protection*, **39**(2): 113-115.

Insecticides from different groups having contact and systemic action were evaluated against sunflower mealybug during 2007–08 to 2009–10. Dichlorvos 76% WSC having fumigant effect along with contact and stomach action @ 2 ml l^{-1} of water was found effective for the management of mealybug followed by methomyl 40 SP 400 gai ha^{-1} (1.00 g l^{-1}), a broad spectrum, quick knock down effect. Dichlorvos 76 WSC also showed maximum yield and incremental cost benefit ratio (1:7.60) followed by methomyl 40 SP.

137. Mark PC and Gullan PJ. 2005. A new pest of tomato and other records of mealybugs (Hemiptera: Pseudococcidae) from Espirito Santo, Brazil. *Zootaxa*, **964**: 1-8.

Three mealybug (Hemiptera: Pseudococcidae) plant pest species: *Dysmicoccus boninsis* (Kuwana), *Phenacoccus solenopsis* Tinsley, and *Pseudococcus viburni* (Signoret), are recorded for the first time in the state of Espírito Santo, Brazil. This is the first record of *Phenacoccus solenopsis* in Brazil, where it was found infesting tomato plants. The species *Antonina graminis* (Maskell), a common pest of Bermuda grass, and *Dysmicoccus brevipes* (Cockerell), a major pest of pineapple, also were encountered.

138. Moghaddam M and Bagheri AN. 2010. A new record of mealybug pest in the south of Iran, *Phenacoccus solenopsis* (Hemiptera: Coccoidea: Pseudococcidae). *Journal of Entomological Society of Iran,* **30**(1): 67-69.

Mealybug specimens collected on *Hibiscus rosa-sinensis* on 1 January 2009 in Bandar Abbas, *Hormozgan province*, were identified as *Phenacoccus solenopsis*. The adult females gather into mass on the stems of the host plant. This is thought to be the first report of this species in the south of Iran. Comparison of adult female specimens of *P. solenopsis* with Pakistani and Iranian material shows that they are similar in appearance; however there are a few differences in their microscopic characteristics. The main dissimilarity is that multilocular disc pores are present submarginally on segments I-VI in Iranian specimens.

139. Mohindru B, Jindal V and Dhawan AK. 2009. Record of parasitoid on mealybug *Phenacoccus solenopsis* in tomato. *India Journal of Ecology,* **36**(1): 101-102.

At Krishi Vigyan Kendra, Nurmahal, Punjab, India, tomato cultivars Punjab Upma and L 1001 were infested by mealybugs (*P. solenopsis*). The mealybug colonies were parasitized by an *Aenasius* species. Infestation of tomato and parasitism on mealybug were initially recorded Punjab Upma on the 27th meteorological week and on L 1001 the following week. Parasitism of mealybugs on Punjab Upma and L 1001 reached 14.55-30.02 and 12.25-21.2%, respectively. Parasitism on Punjab Upma was greatest on the 28th standard week, whereas parasitism on L 1001 was most pronounced on the 30th standard week.

140. Monga D, Kumar Rishi, Pal V and Jat MC. 2009. Mealybug a new pest of cotton crop in Haryana: a survey. *Journal of Insect Science*, **22**(1): 100-103.

The entomopathogen *i.e*., *V. lecanii*, *B. bassiana* and *M. anisopliae* are good for mealybug management and can be rotated or mixed with insecticides. *V. lecanii* has shown good compatibility with insecticides like acephate and imidacloprid.

141. Monga D, Kumhar KC and Kumar R. 2009. Integrated management of mealybug, *Phenacoccus solenopsis* Tinsley on cotton. Proceedings of the International Conference on Emerging Trends in Production, Processing and Utilization of Natural Fibres, April 16-19, Mumbai, India, pp: 132-137.

Infestation of the mealybug on cotton in North India has been reported.

142. Monga D, Kumhar KC and Kumar Rishi. 2010. Record of *Fusarium pallidoroseum* (Cooke) Sacc. on cotton mealybug, *Phenacoccus solenopsis* Tinsley, *Journal of Biological Control*, **24**(4): 366-368.

Cadavers of *Phenacoccus solenopsis* Tinsley were collected from locations in Haryana and Punjab during 2007-2010. The entomofungal pathogen, *Fusarium pallidoroseum* (Cooke) Sacc., was consistently isolated from all locations during three seasons. The recovery of the entomopathogen varied among locations and seasons. Koch's postulates were proved by reisolating the same fungus from infected mealybugs. In the laboratory, *F. pallidoroseum* caused 80-95% mortality of *P. solenopsis*.

143. Muhammad A. 2007. Mealybug: cotton crop's worst catastrophe' published by the Centre for Agro-informatics Research (CAIR) Pakistan in October 2007, Availbale at http://agroict.org/adss/mealybug.pdf accessed jul.2008, (Verified 27 May 2009).

Stated that the exotic mealybug, *P. solenopsis* had destroyed 0.2 million bales and 50 000 acres (out of the 8 million acres) of cotton area across Pakistan, especially in Punjab and Sindh provinces.

144. Muhammad Ashfaq, Noor AR and Shahid Mansoor. 2010. DNA-based characterization of an invasive mealybug (Hemiptera: Pseudococcidae) species damaging cotton in Pakistan. *Applied Entomology and Zoology*, **45**(3): 395-404.

A mealybug (Hemiptera: Pseudococcidae) has emerged as a new cotton pest in Pakistan in recent years. We used DNA nucleotide sequences and PCR-RFLP, respectively, as tools for mealybug characterization and species composition. Partial nucleotide sequences of nuclear (elongation factor-1 alpha, ribosomal DNA subunits 18S and 28S) and mitochondrial (COI) genes were used for species characterization, and the combined ITS1-5.8S-ITS2 sequences of rDNA were used for PCR-RFLP analyses. Homology searches of the nuclear genes indicated that the mealybug species damaging cotton in Pakistan belonged to the genus *Phenacoccus*. Further,

the barcoding sequence of COI showed a significant nucleotide similarity with *Phenacoccus solenopsis*. PCR-RFLP analysis with three different endonucleases did not show restriction site differences among mealybug individuals collected from various host plants and geographical locations. This is the first DNA-based characterization of cotton mealybug from Pakistan and the findings will help in decision making while considering a biological control program.

145. Muhammad Ashfaq, Shah GS, Noor AR, Ansari SP and Shahid Mansoor. 2010. Report of a parasitic wasp (Hymenoptera: Encyrtidae) parasitizing cotton mealybug (Hemiptera: Pseudococcidae) in Pakistan and use of PCR for estimating parasitism levels. *Biocontrol Science and Technology*, **20**(5/6): 625-630.

A parasitic wasp, *Aenasius bambawalei*, was studied for its biological paramenters and parasitism levels in the cotton mealybug (*Phenacoccus solenopsis*), biological parameters including parasitism efficiency, time to pupation, time to eclosion and adult sex ratio were studied under lab conditions. Parasitism levels in field collected mealybug were determined using PCR. Results showed an increase in parasitism over the study period, with higher parasitism levels in 2009 compared to the preceding 2years.

146. Muhammad Iqbal Arif, Muhammad Rafiq and Abdul Ghaffar. 2002. Host Plants of Cotton Mealybug (*Phenacoccus solenopsis*): A new menace to cotton agroecosystem of Punjab, Pakistan. *International Journal of Agriculture & Biology*, **11**(2): 163–167.

A new mealybug (*Phenococcus solenopsis*) Tinsley appeared recently and has attained the status of a serious pest on a wide range of host plants. It was recorded from 154 plant species including field crops, vegetables, ornamentals, weeds, bushes and trees. Most of these belong to the familes Malvaceae, Solanaceae, Asteraceae, Euphorbiaceae, Amaranthaceae and Cucurbitaceae. Economical damage was observed on cotton, brinjal, okra, tomato, seasame, sunflower and China rose with plant death in severe conditions.

147. Muhammad Sana-Ullah, Arif MJ, Gogi MD, Shahid MR, Adid AM, Ali Raza and Asif Ali. 2011. Influence of different plant genotypes on some biological parameters of cotton mealybug, *Phenacoccus solenopsis* and its predator, *Coccinella septempunctata* under laboratory conditions. *International Journal of Agriculture and Biology*, **13**(1): 125-129.

The response of different plant species on some biological parameters of cotton mealybug and of its predator *Coccinella septempunctata* was investigated. All the tested plant species affected the studied biological parameters of cotton mealybug and *C. septempunctata* significantly. Maximum mortality in 1st instar nymphs (70-90%) was induced by rose (Rosa indica), jatropha (*Jatropha curcus*), mango (*Mangifera indica*), ashok plant (*Saraca indica*), niazboo (*Ocimum basilicum*) and bouginvilla (*Bougainvillea* spp.); in 2nd instar nymphs (50 to 70%), by rose, jatropha, mango, niazboo and ficus sp., and in 3rd instar nymphs (40-50%) by ficus, rose, jatropha and bakain. The nymphal duration was prolonged by 20-23 days, when nymphs were fed on rose, jatropha, mango, ashok plant, niazboo, ficus and bakain, the same was shortened (16-17 days), when nymphs were fed on peeple, gardenia, shesham, Janem, vincarosa, cotton, shoeflower and silvery. The least fecundity in cotton mealybug was recorded for rose and jatropha (100-200 eggs/ovisac/female), while it was the maximum in case of shoeflower (>400 eggs/ovisac/female). Sterculia, niazboo, mango, ficus, rose, ashok, bakain, bouginvilla and jatropha caused maximum mortality (61-80%) in the adults of *C. septempunctata*. Life duration of *C. septempunctata* shortened (7-12 days) in case of sterculia, niazboo, mango, ficus sp., rose, ashok, bakain, and bouginvilla; whereas the same was prolonged the most (16-18 days) in case of lantana, itsit, shoeflower and cotton. Sterculia, niazboo and mango, ficus, rose, ashok and bakain badly affected the consumption of *C. septempunctata* (approximately 50-70% reduction in consumption). The consumption by *C. septempunctata* increased by 81-90% of the offered nymphs (10-20% reduction in consumption) in case of lantana, itsit, shoeflower and cotton as host plants of the prey insect. It was concluded that the host plants influenced the biology of insect pest and its predator. However, the biochemical factors influence the biology of both prey and its host need to be explored.

148. Muniappan R. 2011. Recent invasive hemipterans and their biological control in Asia. Paper presented at the 5th Meeting of the Asian Cotton Research & Development Network (Lahore, PK, 2011-02-23/25). http://www.icac.org/tis/regional_networks/asian_network/meeting_5/documents/papers/PapMuniappanR

The mealybugs that invaded old world tropics from the neotropics are the papaya mealybug *Paracoccus marginatus*, solenopsis mealybug *Phenacoccus solenopsis*, cassava mealybug *Phenacoccus manihoti*, Madeira mealybug *Phenacoccus madeirensis* and *Pseudococcus jackbeardsleyi*.

149. Muniappan R, Shepard BM, Watson GW, Carner GR, Rauf A, Sartiami D, Hidayat P, Afun JVK, Goergen G and Ziaur Rahman AKM. 2009. New records of invasive insects (Hemiptera: Sternorrhyncha) in Southeast Asia and West Africa. *Journal of Agricultural and Urban Entomology,* **26**(4): 167–174.

    Several sap-sucking insects (Hemiptera: Sternorrhyncha) of neotropical origin have been accidentally introduced to Southeast Asia and West Africa in recent years, including the mealybugs *Paracoccus marginatus* Williams & Granara de Willink, *Phenacoccus madeirensis* Green, *Phenacoccus manihoti* Matile-Ferrero, *Phenacoccus solenopsis* Tinsley, *Pseudococcus jackbeardsleyi* Gimpel & Miller, and the whitefly *Aleurodicus dugesii* Cockerell (Aleyrodidae). This paper documents new distribution records of introduced mealybugs and some other sap-sucking hemipteran insects (Coccidae and Diaspididae) in these regions and discusses progress in the biological control of some of these pests.

150. Nagrare VS, Kranthi S, Biradar VK, Zade NN, Sangode V, Kakde G, Shukla RM, Shivare D, Khadi BM and Kranthi KR. 2009. Widespread infestation of the exotic mealybug species, *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae), on cotton in India. *Bulletin of Entomological Research*, **99**(5):537-541.

    A survey was conducted in 47 locations in nine cotton-growing states of India to identify the composition of mealybug species occurring on cotton. Results of the taxonomic study showed that two mealybug species, the solenopsis mealybug, *Phenacoccus solenopsis* (Tinsley), and the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green) were found to infect cotton plants from all nine cotton growing states of the country. However, *P. solenopsis* was found to be the predominant mealybug species, comprising 95% of the samples examined *P. solenopsis,* which was hitherto not reported to occur in India, now appears to be widespread on cotton in almost all cotton-grwing states of the country. *P. solenopsis* is an exotic species originated from the USA and was reported to damage cotton and crops of 14 familes. This report discusses the implications of the introduction of this exotic polyphagous pest species and the necessary steps to mitigate its potential threat to agriculture in India.

151. Nagrare VS, Kranthi S, Rishi K, Dharajyoti B, Amutha M, Deshmukh AJ, Bisane KD, and Kranthi KR. 2011. “Compendium of cotton mealybugs”. CICR Publication 2011/1, Central Institute of Cotton Research, Nagpur, pp.42.

    Studies carried out on *P. solenopsis* and other cotton mealybugs facilitating the availability of basic comprehensive information for the researchers are compiled.

It would be useful in understanding pest behaviour and devising ecofriendly management strategies based on the situation to save the cotton and other important crops infested by mealybugs.

152. Nelson CR, Haws BA and Nelson DL. 1990. Mealybugs and related Homoptera of shadscale: possible agents in the dieoff problem in the intermountain west. General Technical Report - Intermountain Research Station, USDA Forest Service. INT-276, 152-165.

The results of a survey of the Homoptera associated with *Atriplex confertifolia* in Utah, Idaho, Nevada and Oregon are given. The coccid *Ceroplastes irregularis,* the diaspidid *Aonidomytilis incisus, Orthezia annae,* and the pseudococcids *Chorizococcus polyporus, Distichlicoccus salinus, Humococcus atriplicis, Phenacoccus solenopsis* and *Puto atriplicis* were found, with *C. polyporus, O. annae* and *Phenacoccus solenopsis* being widespread. Of the sites surveyed, 80% had plants infested by coccoids. Poor shrub health was only weakly correlated with either high incidence or numbers of coccoids. Small, young plants were less likely to harbour coccoids than large old plants. Healthy plants were more likely to be infested and to have larger populations of coccoids than unhealthy plants. This paper was presented at the Symposium on Cheatgrass Invasion, Shrub Die-Off and Other Aspects of Shrub Biology and Management held in Las Vegas, Nevada, on 5-7 April 1989.

153. Nikam ND, Patel BH and Korat DM. 2010. Biology of invasive mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on cotton. *Karnataka Journal of Agricultural Sciences*, **23**(4): 649-651.

Laboratory studies were conducted to determine the biology of *Phenacoccus solenopsis*, an invasive mealybug, to formulate a management strategy for the pest. To establish an initial culture of *P. solenopsis*, mealybug infested twigs were collected from cotton fields and reared in the laboratory. Pumpkin (*Cucurbita* sp.) fruits were used for rearing of the mealybugs. Newly hatched larvae were transferred on cotton leaves and observed daily until they attained the adult stage for further aspects of their biology. The ova laid by *P. solenopsis* were examined under the binoccular microscope for colour, shape and size determination. The freshly emerged nymphs were marked individually on cotton leaves and observed daily under the microscope to note the moulting process. Morphometry of different nymphal instars was also determined. Adult females that emerged after the last moult were observed for colour and shape and the longevity of males and females was assessed. Results

showed that the *P. solenopsis* females laid their ova in cottony ovisacs located at the posterior part of their abdomens. The ova were smooth translucent, light creamy yellow in colour and oblong in shape with tapering ends. *P. solenopsis* exhibited variation in males and females in the immature stages. The female nymphs moulted 3 times and 4 times for males. Freshly emerged first instar nymphs were oblong in shape, dorsally convex, light yellow in colour with 3 pairs of legs and a pair of 7 segmented filiform antennae. The eyes were bright red. Body colour of newly hatched nymphs changed to pale white within 2 days after hatching from ova. After the first moult, the second instar nymphs were oblong and yellow in colour. Nymphs of the males and females were distinguished from the third instar onwards. The male nymphs formed a white silken cocoon after their third moult, but no such phenomenon occurred in females. Male cocoons were cylindrical in shape and white in colour. Third instar nymphs of females were oblong in shape and yellow in colour. There were 2 pairs of black coloured spots with prominent glassy wax fibres on the dorsal surface of its body. Females had a pair of prominent red coloured compound eyes, a pair of 7 segmented filiform antennae and 3 pairs of well developed thoracic legs. Adult males were delicate, slender and elongated in shape. The colour of the head, thorax, antennae and legs was yellowish-brown, whereas the abdominal region was pale yellow. A pair of well developed metathoracic milky white wings and 3 pairs of well developed legs were observed. Female adults were oblong in shape and light to dark in colour, having 2 pairs of black spots/strips on the dorsal side of the body region. Females were apterous, soft bodied, well distinguished segmented and the body was covered with a white dusty secretion. It also possessed a pair of brownish, short, 6 segmented filiform antennae and 3 pairs of red coloured legs. Observations on preoviposition, oviposition, and post-oviposition periods revealed that it varied from 8 to 9, 16 to 18 and 9 to 10 days, with an average of 8.56± 0.61, 16.73±0.57 and 9.33±0.47 days, respectively. Total number of ova laid by a single female during its entire life period ranged from 400 to 700 with an average of 572±102 ova.

154. Nikam ND, Patel BH and Korat DM. 2010. Laboratory and field efficacy of selected insecticides against mealybug *Phenacoccus solenopsis* Tinsley infesting cotton *Journal of Agricultural Sciences,* **23** (5): 712-715.

Bioefficacy of some selected insecticides was evaluated against mealybug, *Phenacoccus solenopsis* Tinsley in laboratory as well as in field condition at B. A. College of Agriculture, Anand (Gujarat), India during the year 2006-07. Out

of nine different insecticides evaluated, profenophos (0.05 %), triazophos (0.04 %) and carbaryl (0.2 %) found to be most effective for *P. solenopsis* in both laboratory and field conditions. Spraying of profenophos could register significantly highest (2759 kg/ha) seed cotton yield followed by triazophos (2679 kg/ha) and carbaryl (2644 kg/ha). Incremental Cost Benefit Ratio (ICBR) was maximum (1: 21.70) from triazophos treatment followed by profenophos (1:18.64) and carbosulfan (1:18.29).

155. Patel HP, Patel AD and Bhatt NA. 2009. Record of coccinellids predating on mealybug, *Phenacoccus solenopsis* Tinsley (Homoptera: Pseudococcidae) in Gujarat. *Insect Environment*, **14**(4): 179.

Field survey for natural enemy complex of *P. marginatus* on existing flora is to be given top priority as had been done in the case cotton mealybug *P. solenopsis.*

156. Patel MG, Jhala RC, Vaghela NM and Chauhan NR. 2010. Bio-efficacy of buprofezin against mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) an invasive pest of cotton. *Karnataka Journal of Agricultural Sciences,* **23**(1): 14-18.

A field experiment was carried out during 2007-08 and 2008-09 on farmer's field comprising of Bt cotton *cv.* Vikram-5 following randomized block design with four replications and six treatments to evaluate the bioefficacy of buprofezin against mealybug in cotton. The efficacy of buprofezin against *P. solenopsis* on cotton was found to be dose dependent. Buprofezin at all the three doses was more effective followed by carbaryl and chlorpyriphos. There was more than 95 per cent reduction in mealybug population over control after 3 DAS in buprofezin at all the three doses. In case of carbaryl and chlorpyriphos the per cent reduction was less than70. Buprofezin was more effective at two higher doses (312.5 and 625 g a.i./ha) compared to its lowest dose (250 g a.i./ha). The efficacy of buprofezin against early and later instar nymphs of *P. solenopsis* under laboratory condition was also found to be dose dependent. It was more toxic to early instars than later instar nymphs. It was most effective against early as well as later instars nymphs at highest dose (625 g a.i./ha). At 2 lower doses (250 g a.i./ha and 312.5 g a.i./ha), its effectiveness was comparable to chlorpyriphos 400 g a.i./ha and Carbaryl 1000 g a.i./ha.

157. Pathania PC, Seni A, Katewa A and Dilawari VK. 2010. Incidence of mealybug, *Phenacoccus solenopsis* Tinsley (Pseudococcidae: Hemiptera) and extent of parasitism on cotton in Punjab and Rajasthan, *Journal of Insect Science* (Ludhiana), **23**(4): 395-398.

An attempt has been made to study the mealybug, *Phenacoccus solenopsis* Tinsley infestation in the cotton belt of north-western India in the states of Punjab and Rajasthan. The parasitization of Hymenopteran insects on mealybug has also been surveyed on 12 different host plants (including weeds and crops) from various localities.

158. Patil BV, Hanchinal S, Bheemanna M and Hosamani A. 2011. Influence of weather parameters on population of mealybug, *Phenacoccus solenopsis* and its natural enemies on Bt cotton. In World Cotton Research Conference-5 held at Mumbai from 7-11 Nov. 2011.

Seasonal incidence of mealybug, *Phenacoccus solenopsis* (Tinsley) on cotton was studied at main agricultural research station, UAS, Raichur during 2008-09 and 2009-10 cropping seasons. Mealybug incidence started in the month of September (40^{th} standard week) during both the seasons. Initially mealybug population was low and gradually increased as the crop stage advanced. Steep increase of mealybug population was observed after January and reached peak in the month of March. Population varied from 66.28 to 146.64 and 12.32 to 122.64 per 10 cm apical shoot during 2008-09 and 2009-10 seasons, respectively. In general predator population was low throughout the season in both the years. Hymenopteran parasitoids activity started in the month of October and it ranged between 0.52 to 22.12% during 2008-09 and 0.08 to 34.64% during 2009-10. Parasitoid cocoons were maximum in the month of March which recorded 22.12 and 34.64% during 2008-09 and 2009-10 seasons, respectively. Maximum temperature was positively correlated and significant where as other parameters were negatively correlated.

159. Pawar S, Desai H, Pingle S, Patel C and Kumar V. 2011. Assessment of avoidable loss of seed cotton yield due to the infestation of mealybug, *Phenacoccus solenopsis* Tinsley in south Gujarat. In World Cotton Research Conference-5 held at Mumbai from 7-11 Nov. 2011.

An introduced species of Mealybug, *Phenacoccus solenopsis* Tinsley which was hitherto not familiar destroyed cotton crops causing economic damage in the recent 3-4 years. Concern over severity and economic damage were expressed by different stake holders across cotton growing areas of Gujarat. Paired plot technique was employed to assess the crop loss (VICH 5 BG I Bt) in kharif (June- October) seasons of 2010-11 at Cotton farm, Main Cotton Research Station, Navsari Agricultural University, Surat. The crop loss in terms of seed cotton yield due to the infestation of mealybug, *Phenacoccus solenopsis* Tinsley was estimated to be

25.02% under South Gujarat Condition worth of Rs. 26350 /- per hectare (at an average seed cotton price of Rs. 5000 per quintal). Paired t-test was found significant for mealybug population and its damage in protected and unprotected plots whereas differences in other sucking pests and pink bollworm population at the later stage of the crop were non significant. The mean mealybug population across ten pairs varied from 1.74 to 1.94 per 5 cm top shoot area, average grade from 0.80 to 1.37% and per cent severity from 16.67 to 34.17 in protected plots as against 7.83 to 10.12 population per 5 cm top shoot area, average grade from 1.11 to 1.99 and per cent severity from 27.71 to 49.79 in unprotected plots. Further, natural parasitism of *Aenasius bambawalei* Hayat was observed to the tune of 8.63 to 9.99% in unprotected plots in the later stage of the crop.

160. Pinjarkar DB, Vennila S, Ramamurthy VV, Kranthi KR, Ghodki BS and Deshmukh AJ. 2009. Diversity and abundance of Hymenopteran parasitoids of mealybugs in rainfed cotton. In Proceedings of the National Symposium on "Bt Cotton: opportunities and prospects" held at Central Institute for Cotton Research, Nagpur during November 17-19, 2009. pp.127 -128.

Solenopsis mealybug *Phenacoccus solenopsis* Tinsley and pink hibiscus mealybug *Maconellicoccus hirsutus* (Green) occur on rainfed cotton dominated by Bt transgenic hybrids of Central India. A survey conducted on the occurrence of natural enemies of mealy bugs during 2007 and 2008 seasons on cotton led to records of higher diversity and abundance of hymenopterous parasitoids on *M. hirsutus* than *P. solenopsis*. A total of three and nine parasitoids were documented on *P. solenopsis* and *M. hirsutus*, respectively. While *Aenasius bambawalei* Hayat (Encyrtidae) was recorded only on *P. solenopsis*, two species *viz., Promuscidea unfasciativentris* Girault (Aphelinidae) and *Aprostocetus bangaloricus* Narendran (Eulophidae) were recorded on both *P. solenopsis* and *M. hirsutus*. *M. hirsutus* was additionally parasitized by five encyrtids *viz*., *Encyrtus aurantii* (Geoffroy), *Prochiloneurus pulchellus* Silvestri, *Anagyrus dactylopii* (Howard), *Anagyrus mirzai* Agarwal & Alam and *Homalotylus albiclavatus* (Agarwal) and one each of Signiphoridae (*Chartocerus kerrichi* (Agarwal)) and Pteromalidae (*Pachyneuron leucopiscida* Mani). Seasonal mean parasitization of *P. solenopsis* by *A. bambawalei* and *P. unfasciativentris* together was estimated to be 21 per cent with a maximum of 48 per cent during August. The control offered by these hymenopterans on *M. hirsutus* based on the abundance of adult emergence was of the order *E. aurantii* > *P. unfasciativentris* > *P. pulchellus* > *C. kerrichi*. Since parasitoids regulate the population of *P. solenopsis* and *M. hirsutus* effectively

under field conditions, strategies of mealybug management placing priority for natural control coupled with cultural control before the curative measure of spray of insecticides would go a long way in tackling mealy bugs in cotton fields.

161. Prasad YG, Prabhakar M, Sreedevi G and Thirupathi M. 2011. Spatio-temporal dynamics of the parasitoid, *Aenasius bambawalei* Hayat (Hymenoptera: Encyrtidae) on mealybug, *Phenacoccus solenopsis* Tinsley in cotton based cropping systems and associated weed flora. *Journal of Biological Control*, **25**(3): 198- 202

The mealybug, *Phenacoccus solenopsis* Tinsley, a polyphagous pest with a wide host range is of recent occurrence on Bt cotton in all the three major cotton growing zones in India. The first perceptible appearance of the pest on cotton in Warangal district of Andhra Pradesh was noticed in *Kharif* 2008. *P. solenopsis* was recorded on several plants other than cotton which include cultivated crops and weed hosts. The mealybug population is naturally regulated by *Aenasius bambawalei* Hayat (Hymenoptera: Encyrtidae). This paper reports the dynamics of this key parasitoid in a spatio-temporal perspective. Monitoring of the parasitoid on *P. solenopsis* occurring on weed hosts found on field bunds, crop fallows, barren lands, roadsides and village backyards indicated its activity on eight weed hosts late in the cotton growing season of 2009. During the year 2010, its activity started early in the season on few weed hosts while many more supported parasitization late in the season. Parasitoid activity was higher (11.3 to 15.3%) initially on the key hosts (*Corchorus olitorius* L., *Abutilon indicum* L., and *Sida acuta* Burm. F.) early in the season (August) which later shifted gradually to the main host (cotton) during the later part of the season. Cropping system and spatial perspective indicated that cotton fields adjacent to roadside and crop fallows supported higher parasitization during September (8.3 - 9.1%) and cotton fields adjacent to barren lands in December (13.3%). These findings have implications for the management of *P. solenopsis* mealybug on cotton from an agro eco-system perspective.

162. Prasad YG, Prabhakar M, Sreedevi G, Ramachandra Rao G and Venkateswarlu B. 2012. Effect of temperature on development, survival and reproduction of the mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on cotton, *Crop Protection,* 39: 81-88

The effect of temperature on life cycle of the solenopsis mealybug, *Phenacoccus solenopsis* Tinsley, on cotton (*Gossypium hirsutum* L.) was assessed under laboratory conditions at ten constant temperatures (18 to 40°C). The development

duration of female and male nymphal instars linearly decreased with the increase in temperature from 18 to 32°C. Cumulative developmental time of females ranged from 43.9 d (18°C) to 15.0 d (32°C). Survival of crawlers to adulthood was lowest (<53%) at 20 and 36°C and highest (80%) at 32°C. The solenopsis mealybug exhibited obligate sexual ovoviviparous reproduction and the pre-oviposition period in mated females showed a significant decreasing trend between 20°C (23.0 d) and 30°C (9.5 d). The oviposition period of 10.2 to 11.5 d at e" 25°C was nearly half the duration than at 20°C and the highest fecundity (245 eggs + crawlers) was observed at 30°C. Longevity of mated females was significantly prolonged at 20°C (46.0 d) compared to 30°C (21.4 d). Proportion of females was highest (97.5%) at 25°C. Males required higher degree-days (363.6) for their cumulative development compared to females (317.5). Lower temperature thresholds estimated from the linear model for cumulative female and male development were 11.7 and 10.1°C, respectively. The estimated optimum temperature thresholds for nymphal instars (32 to 33.4°C) from â type distribution function were closer to the observed maximum developmental rate compared to Lactin-2 model. The population trend index using survival, fecundity, and sex ratio of *P. solenopsis* with an initial population of 100 crawlers in the Morris-Watt life table model indicated a potential population increase of 170.3 and 97.6 times at 30 and 35°C, respectively, in the next generation. The usefulness of the information on the temperature-dependent life cycle of *P. solenopsis* in understanding its field abundance and distribution on cotton and implications for management is discussed.

163. Prishanthini M and Laxmi VM. 2009. The *Phenacoccus solenopsis*. Department of Zoology, Eastern University, Sri Lanka. Available online: http://www.dailynews.lk/2009/07/01/fea30.asp

Latest report on the invasiveness of *P. solenopsis* has been from the Eastern region of Sri Lanka on ornamentals, vegetable crops and weeds.

164. Rabinder Kaur, Ramandeep Kaur and Brar KS. 2008. Development and predation efficacy of *Chrysoperla carnea* (Stephens) on mealybug, *Phenacoccus solenopsis* (Tinsley) under laboratory conditions**.** *Journal of Insect Science* (Ludhiana)*,* **21**(1): 93-95.

An investigation on the development and predation efficacy of *Chrysoperla carnea* was carried out on the young crawlers of mealybugs, *P. solenopsis*, a new pest of cotton. It was compared with *Corcyra cephalonica* eggs as prey (standard).

The total larval period of *Chrysoperla carnea* was 8.25 days on *Corcyra cephalonica* eggs and 22.15 days on crawlers of *P. solenopsis*. The corresponding pupal periods were 6.95 and 7.05 days, respectively. The total development period (larval+pupal period) was significantly longer on cotton mealy bugs (28.90 days) compared to that on *Corcyra cephalonica* eggs (15.20 days). *Chrysoperla carnea* larvae consumed significantly higher number of crawlers of cotton mealybug (671.45) than *Corcyra cephalonica* eggs (211.70). The daily consumption of cotton mealy bugs and *Corcyra cephalonica* eggs by *Chrysoperla carnea* larvae was 30.79 and 25.92, respectively.

165. Ram Pala, Saini RK and Vijaya. 2009. Preliminary studies on field parasitization and biology of solenopsis mealybug parasitoid, *Aenasius bambawalei* Hay at (Encyrtidae: Hymenoptera). *Journal of Cotton Research and Development*, **23**(2): 313-315.

Preliminary studies on field parasitization and biology of *Aenasius bambawalei* Hayat (Encyrtidae: Hymenoptera), a solitary nymphal endoparasitoid of solenopsis mealybug, *Phenacoccus solenopsis* Tinsley (Pseudococcidae: Hemiptera), indicated that this parasitoid was very active against mealybug in Haryana, India. Surveys of cotton growing belt of the state showed 37.6% (13.3-53.4%) and 47.2% (5.2-90.4%) parasitization on cotton and other host plants in Hisar and Rohtak districts, respectively, during September, 2008. During April, 2009 the parasitoid activity further increased and the parasitoid spread upto Sirsa causing 72.3% (61.1-88.4%) parasitization in the cotton growing belt. The parasitoid took 12-14 days to complete its development in the host and caused transformation of parasitized mealybugs into reddish-brown mummies which could be easily identified on the plants. A female parasitized 38-163 mealybugs during its life of 11-35 days. The parasitoid had an excellent searching ability attacking mealybugs in colonies as well as those present solitarily on different host plants of mealybug. It was concluded from the studies that in view of heavy natural parasitization of mealybug by this parasitoid, it needed to be conserved and further exploited for biological control of this pest. A hyperparasitoid, *Promuscidea unfasciativentris* Girault (Hymenoptera: Aphelinidae) of *A. bambawalei* was also recorded.

166. Ram Pala and Saini RK. 2010. Biological control of solenopsis mealybug, *Phenacoccus solenopsis* Tinsley on cotton: a typical example of fortuitous biological control. *Journal of Biological Control,* **24**(2): 104-109

Observations on field incidence of solenopsis mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) attacking cotton and the predators and

parasitoids associated with it were recorded in the cotton growing belt of Haryana state by conducting monthly surveys during 2008 and 2009. To assess the impact of primary and secondary parasitoids on the population of the solenopsis mealybug, parameters like severity of pest incidence, abundance of predators and parasitoids and parasitism/hyperparasitism by various parasitoids were taken into consideration. One primary parasitoid, *Aenasius bambawalei* Hayat, and four hyperparasitoids were recovered. The most abundant and dominant hyperparasitoid was *Myiocnema comperei* Ashmead, while the other three were of lesser importance. Similarly, out of six predators recovered from mealybug colonies, *Brumoides suturalis* (Fabricius) and *Nephus regularis* Sicard were more abundant. During 2008, in the absence of the primary parasitoid, *A. bambawalei*, mealybug incidence was quite high on cotton. However, during 2009, as the activity of the primary parasitoid increased, the pest population reduced significantly and its incidence was confined to only 18% of the fields and 1.6% of the plants by August. During mid-season (July-August), *A. bambawalei* was attacked by several species of hyperparasitoids, particularly *M. comperei*, which caused considerable reduction in its population during August. This resulted in the resurgence of solenopsis mealybug, though on a lower scale, during September-October.

167. Rani Archna, Jain Sapna and Gautam RD. 2012. Investigation of insecticidal activity of some alpha, beta-unsaturated carbonyl compounds and their synergistic combination with natural products against *Phenacoccus solenopsis* Tinsley. *Journal of Plant Protection Research*, **52**(1): 146-155.

In continuation of our previous work, the current study explores an environmentally benign approach for the control of *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) using a synergistic combination of alpha, beta -unsaturated carbonyl compounds (1a-1e; 2a-2i) and the natural products, neem oil (N1) and nicotinic acid (N2). Our approach also evaluates the insecticidal activity of 3-(5-chloro-1,3-diaryl-1H-pyrazol-4-yl)-1-arylprop-2-en-1-one(2j-2o) consisting of bioactive moieties, *viz.,* chalcone and pyrazole, in a single molecular structure. Compounds 2l and 2o exhibited maximum activity with 58% and 50% of mortality, respectively, under laboratory conditions. Among various test combinations, 2a-N2 showed maximum insecticidal activity, with 54% mortality, comparable to that of the most active newly synthesized compound, 2 l, followed by 1c-N1 and 2 g-N2 with 52% mortality. The compound 2a was also found to be non-toxic to potato tuber used as a plant substrate in the current investigation.

168. Sahito HA, Abro GH, Khuhro RD and Buriro AS. 2009. Varietal resistance of cotton crop against mealybug *Phenacoccus solenopsis* Tinsley. *Pakistan journal of Agriculture,* **25**(1): 34-38.

The studies on varietal resistance of cotton crop against mealybug were conducted at Experimental Field, Entomology Section, ARI, Tandojam from May to November 2007. Fifteen varieties of cotton crop *viz.,* Cris-134, Chandi, FH-901, CIM-473, CIM-499, Shahbaz, TH-57/96, NIAB-111, CIM-496, Haridost, Okra leaf, Sindh-1, NIAB-78, Bt and Okra desi were cultivated in a complete randomized block design with four replications. Results indicated that this was a new mealybug species in Pakistan known as *Phenacoccus solenopsis* Tinsley, which appeared on cotton crop two months after sowing and remained till harvest of the crop. Data indicated that there were two population peaks of the mealybug. The analysis of variance showed a highly significant ($P < 0.001$) difference in the population of mealybug on 15 varieties.

169. Sahito HA, Abro GH, Khuhro RD, Lanjar AG and Riaz. 2010. Biological and morphological studies of cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) development under laboratory environment. *Pakistan Journal of Entomology* Karachi, **25**(2): 131-141.

The biology of the cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) was studied in the laboratory of Entomology section, ARI, Tandojam. Two sets of experiments were conducted in the summer (1st June, 2008 at 25.51± 2.05°C) and winter (15th November, 2008 at 16.83 ± 2.02°C) seasons. The insects were provided cotton green leaves and residual leaves in petridishes, respectively. There was great variation observed between each sex (♂ ♀) *i.e.* reproduction, fecundity, fertility, developmental period of immature stages longevity, survival and sex ratios. The variation was also observed between sexual and asexual reproduction. The egg developmental period during both the seasons were recorded as 1.90 days in summer and 2.90 days in winter. The oviposition (4.60±35.43) with 95.77 % fertility were recorded in summer season and (189.60±23.20) with 86.76 % fertility in winter season. The development period for 1st, 2nd , 3rd instars and adult female were recorded as (5.64±0.22), (12.94±0.56), (4.34±0.37) and (22.17±0.57), respectively in summer and (8.48±0.24), (5.11±0.23), (6.24±0.51) and (51.08±0.42) in winter seasons. Similarly, development period for 1st instar, cocoon and adult male were recorded as (5.16±0.28), (8.20±0.83) and (2.55±0.22) days, respectively in summer and (7.76±0.21), (12.66±0.28) and (3.86±0.74) days in winter seasons.

Stadium time as (10.35±0.55), (6.97±0.41) and (6.63±0.43) hours were recorded after 1st, 2nd and 3rd instars in summer season and (20.49±1.39), (11.11±1.16) and (13.37±1.26) hours, respectively in winter seasons. The oviposition last for (25.73±10.41) in summer and (45.38±3.64) days in winter seasons whereas, the sex ratios (2.82♀:1♂) and (2.23♀:1♂) were recorded in summer and winter seasons, respectively. Mortality percentages 3.47, 12.48, 9.99, 7.82 and 2.35 were recorded in eggs, 1st, 2nd, 3rd and adult female, respectively in summer and 7.38, 20.93, 20.15, 26.18 and 7.23 in winter season. Similarly, mortality percentages during development of adult male in various life stages were recorded as 22.71, 17.59 and 17.59 in 1st instar, cocoon and adult stages in summer season and 7.73, 11.46 and 4.28, respectively in winter season. The survival (70.02%) for female and (83.14%) for male in summer season whereas, it was (67.07%) and (55.29%) for female and male, respectively in winter seasons. The female produced more eggs (460.10±35.34) sexually in summer and (189.60±23.20 eggs) in winter as well. However, in asexual reproduction (parthenogenesis) the female produced more eggs (416.54±21.57) when fed on cotton leaf than starved female (330.81±28.44) in summer season. In winter unstarved female produced more eggs (236.60±2.93) asexually than starved female (196.50±26.76). It is concluded that more fecundity, fertility and percent survival were observed in summer season. Adult and immature lived shorter life in summer than winter season. Maximum emergence of adult female was also recorded in summer season. The starved female produced the least number of eggs asexually.

170. Sahito HA, Abro GH, Mahmood R and Malik AQ. 2011. Survey of mealybug, *Phenacoccus solenopsis* (Tinsley) and effect of bio-ecological factors on its population in different ecological zones of Sindh. *Pakistan Journal of Agriculture Agricultural Engineering and Veterinary Sciences,* **27**(1): 51-65

The study on the effects of bioloigical factors on the population of mealybug was conducted in different locations of Khairpur (Mir's), Naushahro Feroze, Sanghar, Matiari, Hyderabad, Mirpurkhas, and Tando Allahyar districts throughout season at fortnightly intervals. Results indicated a new mealybug species *Phenacoccus solenopsis* Tinsely was identified from the British Natural History Museum through help of CABI (South Asia) which appeared on cotton two months after sowing and remained till harvest of the crop in all Farms. The pest infestation was more severe during 2007 compared with 2008 which may be due to increased parasitization of pest by a hymenopteran parasitoid, *Aenasius bambawalei* Hapat first time recorded in Pakistan during August, 2008 and population development and activity of predators.

There was a significant reduction in overall pest population during 2008 compared with 2007 which may be due to a significant overall increase in predator activity in cotton fields throughout study area in 2008. The highest and the lowest pest population 106.21±15.29 and 55.21±18.71 of mealybugs per twig per plant were recorded during 2007 at Mirpurkhas and Tando Allahyar, respectively. However, during 2008, the highest and the lowest population 58.30±12.42 and 18.34±5.32 of mealybugs per twig per plant were recorded from Naushehro Feroze and Tando Allahyar, respectively. The predators population recorded during 2007 was highest at Mirpurkhas 1.73±0.37 per plant and the lowest 0.19±0.08 predators per plant observed from Tando Allahyar. The higher predators activity was recorded during 2008 compared to 2007. The highest predators population was 11.96±2.83 per plant observed at Nashahro Feroze and the lowest 2.29±0.79 per plant found at Tando Allahyar. The predators such as *Coccinella spp., Chrysoperla sp.*, *Geocoris* sp., *Orius sp.* Spiders were found active feeding on mealybug population at all different varieties and farms during both seasons.

171. Sahito HA, Abro GH, Sayed TS, Lanjar AG, Mal B and Khajjak AS. 2011**.** Seasonal population abundance of cotton mealybug, *Phenacoccus Solenopsis* Tinsley (Hemiptera: Pseudococcidae) and its natural enemies on various hosts plants. *Pakistan Journal of Entomology Karachi*, **26**(1): 25-40.

The experiment on "Seasonal population abundance of cotton mealybug, *Phenacoccuss solenopsis* Tinsley (Hemiptera: Pseudococcidae) and its natural enemies on various hosts" was conducted at experimental field, Entomological Section, A.R.I, Tando jam in summer and winter seasons of 2007-08,. The summer hosts were: NIAB-78, okra, brinjal, China rose, abutilon and itsit, while winter hosts were: tomato, potato, chilies, sunflower, thorn apple and rough cocklebur. The data was compiled for two years that is 2007-8. Results indicated that *P. Solenopsis* appeared on all hosts of summer and winter as well. The analysis of variance showed significant ($P<0.05$) difference in the population of mealybug on the varieties. However, the overall means showed that the maximum population of mealybug (130.13±25.68) 10 cm. per twig/plant was recorded on China rose followed by abutilon (123.75±22.56), cotton (119.95±27.99), brinjal (57.01±14.03), okra (38.26±10.88), and itsit (35.09±9.58) in summer season. However, during winter / off season rough cocklebur (70.83±6.13) followed by thorn apple (69.24±5.92), sunflower (60.65±6.99), chilies (48.19±6.66), potato (34.30±4.47) and tomato (32.83±6.45). Whereas; predator population per plant observed on China rose (21.75±4.49), followed by abutilon (20.09±3.39), cotton (15.69±3.40), itsit (10.36±3.18), okra, (6.44±2.11) and brinjal

(6.26±1.75) in summer. However, in winter rough cocklebur (28.59±3.44) followed by thorn apple (27.36±3.10), sunflower (24.59±2.91), chilies (18.41±2.99), tomato (14.94±2.79) and potato (14.71±2.07) respectively. However, the 1st time mummies of *P. solenopsis* were found after 1st attack 2005 in the month of August-2008. Therefore, the parasitism percentage was continued on cotton with various host plants. Thus, the samples of mummies and adult parasitoid were sent to CABI, South Asia and identified as (hymenopteran encyrtid*)* parasitoid *Aenasius* sp. nov. nr. *longiscapus* compare through the help of MINFA project from the Natural History Museum in London, UK. Therefore, the *Aenasius bambawalei* parasitoid population observed on cotton (12.85 %) followed by China rose (8.57%), abutilon (6.79%), Brinjal (4.28%), okra, (1.36%), and itsit (1.08%) with (30.17°C) temperature and (72.10°C) relative humidity. Whereas on thorn apple (5.20%) followed sunflower (4.46%), rough cocklebur (2.24%), tomato (1.21%), chilies (0.91%) and potato (0.81%) with (18.81°C) temperature and (65.13%) relative humidity during 2008-09, respectively. The predators population observed in both years on all hosts however parasitoid population observed from August, 2008-09. The predators such as Coccinellids spp., *Chrysoperla* sp. spiders, *Geocoris* sp., *Orius* sp. and ants were found active when the mealybug populations were predominant on cotton and alternate hosts. More than 60 host plants are identified from ornamental, vegetables and weeds from different locations of Sindh.

172. Sahito HA, Lanjar AG, Nahiyoon AA, Kajjak AS, Memon SA and Bhugro Mal. 2011. Seasonal Occurrence of *Phenacoccus Solenopsis* Tinsley (Hemiptera: Pseudococcidae) and its natural enemies on different varieties of cotton crop. *Pakistan Journal of Entomology Karachi*, **26** (1): 17-24.

The studies on "Seasonal Occurrence of *Phenacoccus Solenopsis* Tinsley (Hemiptera: Pseudococcidae) and its Natural Enemies on Different Varieties of Cotton Crop" was conducted at Experimental Field, Entomology Section, A.R.I, Tandojam from May to November 2008. Fifteen varieties of cotton crop *viz.* Cris-134, Chandi, FH-901, CIM-473, CIM-499, Shahbaz, TH-57/96, NIAB-111, CIM-496, Hari dost, Okra leaf, Sindh-1, NIAB-78, Bt and Okra desi were cultivated in a Complete Randomized Block Design with 4 replications. The results of studies showed that mealybug appeared on all varieties of cotton crop. The occurrence of *Phenacoccus solenopsis* was recorded one month after sowing (8 June 2008) till harvesting (14 October) of the varieties. The analysis of variance showed highly significant ($P<0.001$) difference in the population of mealybug on the varieties. The peak populations were recorded on 8 June 2008, (8.80±2.73 on TH-57/96), 23

June (43.20±14.41 on NIAB-111), 7 July (57.00±20.49 on Cris-134), 21 July (20.40±5.13 on Bt.), 5 August (36.00±6.63 on Sindh-1) and 18 August (72.60±24.37 also on Sindh-1), 3 September (148.30±33.98 on F-H. 901), 17 September (141.10±30.50 on Chandi), 30 September (189.10±78.14 on NIAB-78) and 14 October (42.40±14.88 on Okra desi). However, the highest overall mean population (62.34±24.72) was recorded on variety NIAB-78 whereas, the lowest mean population (7.47±3.19) on Okra leaf, respectively. Whereas, the predators peak populations were recorded on 8 June 2008, (1.60±0.67 on CIM-496), 23-June (3.20±0.88 on NIAB-111), 7 July (5.20±2.08 on Sindh-1), 21 July (5.10±1.47 on Shahbaz), on 5 August (5.50±2.32 on Bt.), 18 August (6.80±1.63 on F-H.901), 3 September (12.20±4.16 on Okra desi), 17 September (16.60±5.31 on NIAB-78), 30 September (21.30±11.73 on NIAB-78) and 14 October (25.70±3.88 on NIAB-78). However, the highest overall mean population (8.44±2.30) was recorded on variety F-H. 901 whereas, the lowest mean population (3.02±1.18) on TH-57/96 were recorded, respectively. Whereas; the highest mummies population percentage was recorded on CIM-473 (67.55%) followed by Okra leaf (62.55%), Hari-Dost (59.09%), Shahbaz (57.96%), Cris-134 (56.52%), CIM-499 (56.36%), F-H. 901 (48.02%), NIAB-111 (47.38%), Bt. (45.70%), Chandi (45.07%), Okra-Desi (44.89%), NIAB-78 (44.18%), Sindh-1 (43.59%), TH-57/96 (37.59%) and CIM-496 (30.97%) during , 2008 respectively. In the field the predators were found active feeding on mealybug population on all varieties. The mummified (3rd) instar mealybugs were collected that were never observed before August-2008, indicating that parasitoids were present under unsprayed field condition. This hymenopteran encyrtid parasitoid was identified as *Aenasius* sp. *nov. nr. longiscapus* Compere through the help of MINFA project from the Natural History Museum in London, UK. Study is describes importance of immediate actions to control this vigorous pest through the help of biological control.

173. Sahito Hakim Ali, Abro Ghumlam Hussain, Syed Tajwer Sultana, Memon Shafique Ahmed, Mal1 Bhugro And Kaleri Sakhawat. 2011. Screening of pesticides against cotton mealybug *Phenacoccus solenopsis* Tinsley and its natural enemies on cotton crop. *International Research Journal of Biochemistry and Bioinformatics*, **1**(9): 232-236.

A field study was carried out to determine the efficacy of different insecticides against cotton mealybug, *Phenacoccus solenopsis* Tinsley and their toxicity against natural enemies of mealybug at Chaudhery Al-Rahmat Agriculture Farm near to

Experimental Field of Central of Agriculture and Biosciences International, South East and West Asia, Modal Farm Mirpur Khas, Sindh, during 2009 on cotton (cv. Bt. 207) variety. The treatments included four pesticides, *i.e*. neem oil (repellent), profenophos, imidacloprid (SL), imidacloprid (WP) compared with control. Before application of insecticides, the pre treatment observations were taken on mealybug and its natural enemies, while post- treatment observations on mealybug were taken after 24, 48, 72 hrs., 7th and 10th days, where as, the population of predators and parasitoid were recorded after 10th day of application of insecticides. The crop was sprayed five times at 15 days intervals. The results showed that all insecticides were found effective against mealybug. However, imidacloropid showed its effectiveness up to 7 day in most of the sprays. While, prophenophos was next to imidacloropid which retained its effectiveness upto 7 days after application. The activities of natural enemies (predators and parasitoids) were found maximum in control plot followed by neem oil, imidacloropid and prophenophos indicating that neem oil (repellent) was the least toxic against natural enemies followed by imidacloprid (WP).

174. Saini RK, Ram Pala, Sharma SS and Rohilla HR. 2009. Mealybug, *Phenacoccus solenopsis* Tinsley and its survival in cotton ecosystem in Haryana *In: Proc.Nation. Symp. on Bt-cotton: opportunities and prospectus*, Central Institute of Cotton Research, Nagpur, November 17-19, pp. 150.

Monthly surveys of the cotton growing belt of the state in 2007 and 2008 during the active crop season as well as off-season showed that the pest survived on more than 28 species of plants, including some crops like cotton, okra, egg plant, sesame, guar and guava, and some ornamental plants. The most preferred hosts included *Gossypium* spp., *Parthenium hysterophorus, Trianthema portulacastrum, Xanthium strumarium, Tribulus terrestris, Abutilon indicum, Conyza canadensis, Achyranthes aspara, Chenopodium spp., Hibiscus rosasinensis, Withania somnifera, etc. From July to December, the pest survived on cotton, T. partulacastrum, P. hysterophorus, T. terrestris, A. indicum, C. canadensis, Physalis minima, A. aspara, Chenopodium spp., Helianthus annus, Azadirachta indica, W. somnifera, Datura metel, Peristrophe peniculata* and several other unidentified host plants. In January – February, it passed wintered in/on stacks of cotton sticks, *C. canadensis, A. aspara, P. hysterophorus* and *A. indicum.*

175. Sangle PM, Korat DM, Pawar SR and Patel BH. 2011. Extent of parasitism by *Aenasius bambawalei* Hayat on cotton mealybug, *Phenacoccus solenopsis* Tinsley in laboratory. *Insect Environment*, **17**(3): 119.

Aenasius bambawalei Hayat (Hymenoptera: Encyrtidae) ia a solitary endoparasitoid of solenopsis mealybug. *solenopsis* Tinsley (Homoptera: Pseudococcidae) in cotton ecosystem in middle Gujarat (Jhala *et al.*. 2009). In laboratory, it was found that the extent of parasitism by *A. bambawalei* to *P. solenopsis* ranged from 30.00 to 63.33% with an average of 46.67±2.03%. Jhala *et al*., (2009) recorded 15.88 to 40.08% with an average of 27.19% parasitism by *A. bambawalei* as well as *Promuscidea unfasciativentris* on *P. solenopsis* in cotton. The results of present study also showed that the number of mealybugs parasitized per day ranged from 61 to 143 in its life period of 9 to 13 days.

176. Sankar C, Marimuthu R, Saravanan P, Jeyakumar P, Tanwar RK, Sathyakumar S, Bambawale OM, Ramamurthy VV and Barik Anupam. 2011. Predators and parasitoids of cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) in Perambalur district of Tamil Nadu. *Journal of Biological Control*, **25** (3): 242-245

Solenopsis mealybug, (*Phenacoccus solenopsis)* infests cotton at Perambalur district of Tamil Nadu. During the surveys carried out during 2008-10, coccinellids *Scymnus nubilus* Mulsant, *Hyperaspis maindroni* Sicard, green lacewing, spiders, *Aenasius bambawalei* Hayat, *Homalotylus eytelwenii* Ratzeburg (Encyrtidae) *Promuscidea unfasciativentris* Girault and *Coccophagus* sp. (Aphelinidae) were recorded. The per cent emergence of *S. nubilus* was highest (68%) during second week of February and lowest (6%) during last week of November. The highest percentage (18%) of *H. maindroni* was recorded during second week of February and lowest (2%) during third week of March. The highest parasitisation (76%) by *A. bambawalei* was recorded during last week of February whereas it was lowest (8%) during last week of December. Similarly, the highest parasitisation (28%) by *P. unfasciativentris* was recorded during third week of February whereas it was lowest (2%) during third week of March. But the percent parasitized mealybug by *Coccophagus* sp. was very lower than others. *A. bambawalei* and *P. unfasciativentris* were most common parasitoids on mealybug *P. solenopsis* in cotton.

177. Saroja DGM, 2009. Incidence of mealybug *Phenacoccus solenopsis* Tinsley and its parasitoids on cotton. Proceedings of National Symposium IPM strategies to combat emerging pests in the current scenario of climate change, January 28-30,

2009, College of Horticulture and Forestry Central Agricultural University, Pasighat, Arunachal Pradesh, pp. 42.

A total of 18 intensive cotton- cultivating villages in the Shayampet mandal covering 36 farmers during the four months periods from August to November 2008 were used. The incidence was recorded on 100 plants per acre sampled diagonally across the field. Samples along with host material were collected from each village kept in one liter plastic jars by closing the mouth of the jar with cotton (Kora) cloth and observed for the emergence of parasitoids. In 8 out of 18 villages surveyed, the percentage of plants infested during October last week was in the range of 21 and 61. There were no significant differences in the incidence between BT and non-Bt cotton cultivars. Natural parasitoids an *P. solenopsis* in the field were identified by the presence of reddish brown cocoons of *Aenasius* sp. (Hymenoptera:Encyrtidae), a solitary endoparasitoid percent parasitization by parasitoids was in the range of 8 to 26. Mealybug assumed pest status during the 2008 Kharif as the infestation was moderate to severe across 18 villages sampled in the Warangal district. The survey reports for the first time the extent of natural field parasitization in Andhra Pradesh. It hoped that the information on the natural regulation of the pest which is likely to keep it under check will lead reliance on pesticide application.

178. Satpathy S, Gotyal BS, Ramasubramanian T, Bhattacharyya SK and Laha SK. 2009. Mealybug infestation in jute and mesta crop - A case study: In National Symposium on Climate Change, Plant Protection and Food Security Interface, held at West Bengal, Kalyani from December 17-19, 2009, pp. 78.

Although this pest was reported to infest jute and mesta, not to that extent as it is in other crops. During 2009, summer season a survey was conducted in Bashirhat sub-division of North 24-Parganas to assess the extent and causes of mealybug outbreak. The plant infestation in jute (cv. JRO-524) was 60-80% with average intensity of 2-3 in 0-4 scale, while it was 60% and 4 respectively in case of mesta (cv. Local). Other crops badly damaged in the locality were sesamum and okra. The damage of such proportion in the early crop growth (40-65 days old) was unprecedented. An insight into the weather parameters persisting during the past 6 years indicated that compared to the previous years there was increase in the days from January to May. The warm and dry condition during the summer may be the pre-disposing factor for mealybug outbreak in jute and mesta. In addition to the earlier two reported species i.e. *Ferrsia virgata* Ckll and *Pseudococcus*

filamentosus var. corymbatus, it was identified as *Phenacoccus solenopsis Tinsley*.The farmers used wide array of insecticides (synthetic pyrethroids, organophosphates, phenyl pyrazoles and neonicotinoids) without any appreciable result. In the other hand repeated insecticide spray suppressed the natural enemy activity favouring the pest activity. In this context, the changing climatic factors may be the possible cause of outbreak of mealybug in the early crop of jute and mesta. The multiplication of the insect under favourable condition almost nullified the effect of insecticides. The ever increasing pestilence of mealybug on new crops and regions is a major concern. There is a need to analyse the exact cause of the sudden pest upsurge and devise basic and applied strategies to combat the pest in an economically sustainable manner.

179. Sharma OP, Bhosle BB, Deshpande GD, Bambawale OM, Jagtap GP, Bhede BV, More DG and Patange NR. 2008. Pest records on transgenic cotton in the Marathwada region. *Indian Journal of Plant Protection*, **36**(2): 186-191.

Cotton growing areas in Marathwada, Maharashtra, India, during 2006-07 and 2007-08 revealed that the incidence of bacterial blight (*Xanthomonas campestris* pv. *malvacearum*), grey mildew (*Ramularia areola*), Alternaria blight (*Alternaria macrospora*), root rot [*Rhizoctonia solani*], wilt, reddening, and mealybugs (*Phenacoccus solenopsis*) increased on transgenic cotton lines. Bacterial blight and grey mildew (*Ramularia areola* [*R. gossypii*]) caused significant yield losses. Grey mildew, which used to occur at the harvesting stage, was observed affecting young plants and plants at the vegetative stage. The incidence of bacterial blight, grey mildew and Alternaria blight was greater (33.5, 19.7 and 14.9%, respectively) on Bt cotton than on non-Bt cotton. Mealybug, which was the most prevalent pest in the region, caused significant yield losses. The greatest severity of mealybug-induced losses was observed in Parbhani (41.0% leaf infestation and 35.8% green boll damage), whereas the lowest incidence was recorded for Hingoli district (11.4% leaf infestation and 10.1% green boll damage). The mealybug was polyphagous, infesting weeds (especially *Parthenium, Xanthium strumarium* and wild okra), vegetables and ornamental crops growing in the cotton ecosystem.

180. Sharma SS. 2007. *Aenasius* sp. nov. effective parasitoid of mealybug (*Phenacoccus solenopsis*) on okra. *Haryana Journal of Horticultural Sciences*, **36**(3/4): 412.

During kharif 2008, okra was grown Hisar, Haryana, India. The presence of mealybug (*P. solenopsis*) was observed at 15-day intervals after germination until the end of the cropping season. In July, the pest initially appeared on this crop.

On 15 July, a total of 100 plants with the mealy bug were recorded. The total number of mealy bugs and mummified bugs (brown in colour) were monitored. Similar observations were recorded at 15-day intervals until the end of October. The mean parasitism rate was 41.8%. The parasitoid was identified to be a new species of *Aenasius*.

181. Sharma SS, and Kaushik HD. 2010. Effect of Spinosad (a bioinsecticide) and other insecticides against pest complex and natural enemies on eggplant (*Solanum melongena* L.). *Journal of Entomological Research*, **34**(1): 39-44.

Spinosad 45 SC alongwith six chemical insecticides *viz.*, emamectin benzoate 5 WSG, cypermethrin 10 EC quinalphos 25 EC, endosulfan 35 EC, lambda cyhalothrin 5 EC, chlorpyrifos 20 EC was evaluated against shoot and fruit borer (*Leucinodes orbonalis*), leafhopper (*Amrasca biguttula biguttula*), whitefly (*Bemisia tabaci*), lace bug (*Urentius hystericellus*), mealybug (*Phenacoccus solenopsis*) and hadda beetles (*Henosepilachna vigintioctopunctata* and *Epilachna dodecastigma*) and also against natural enemies (*Encarsia lutea, Chrysoperla carnea* and ladybird beetles) on eggplant (Cv., BR-112 and plant growth parameters). Spinosad @ 162.5 ml/h was most effective against shoot and fruit borer, affording the minimum damage on shoots, flower buds and fruits and getting the maximum fruit yield and highest cost-benefit ratio. This insecticide was not found effective against sucking pests and hadda beetles but was safe to natural enemies whereas the chemical insecticides proved toxic to them.

182. Sharma Sudhendu, Virk JS, Kaur Rabinder, Aggarwal Naveen and Mahal MS. 2010. Monitoring studies on natural parasitization of cotton mealybug, *Phenacoccus solenopsis* Tinsley, by parasitoid, *Aenasius bambawalei* Hayat in Punjab. *Indian Journal of Ecology*, **37**(2): 226-228.

Field surveys were conducted in 36 villages from the major cotton growing districts of Punjab (Bathinda, Faridkot, Ferozepur, Mansa and Muktsar), India, in 2009, to assess the impact of natural parasitism of the parasitoid, *Aenasius bambawalei*, on the regulation of mealybug (*Phenacoccus solenopsis*) populations on different hosts. During the survey, the mealybug parasitization was recorded from 10 randomly selected cotton plants at each location. The collected samples were observed under laboratory conditions for the emergence of parasitoids from the infested twigs. Similarly, the percent parasitization was also determined in different hosts other than cotton (*Parthenium hysterophorus, Xanthium strumarium,*

Abutilon theophrasti, Sida acuta and *Euphorbia hirta*). Results showed that the most effective natural enemy of the mealybug was *A. bambawalei.* Medium to heavy parasitization was observed in samples collected from different villages in all the districts. The maximum parasitization of mealybugs was observed in Ferozepur, followed by Bathinda, where it was observed in all the 10 locations surveyed, while the lowest parasitization was observed in Mansa. Among various host plants, *Abutilon theophrasti* was the most preferred host.

183. Shera PS, Dhawan AK and Anand Aneja. 2010. Potential impact of ladybird beetle, *Coccineila septumpunctata* L. on cotton mealybug, *Phenacoccus solenopsis* Tinsley and aphid, *Aphis gossypii* Glover. *Journal of Entomological Research*, **34**(2): 139-142.

Results revealed that aphids were slightly more preferred (53.8%) as compared to mealybugs (46.2%) when both were exposed together to adult of *Coccinella septumpunctata* in free choice test. In no choice test, when aphids and mealybugs were fed individually to *Coccinella septumpuctata*, the predation of mealybugs was 80 per cent after 24 hours; however it increased to 84.7 per cent after 96 hours. The overall mealybugs consumption varied from 24.0 ± 0.77 to 25.40 ± 0.98 per day. The mean number of aphids consumed the predator varied from 26.00 ± 0.81 to 28.00 ± 0.71 per day and the per cent predation was 88.7 per cent after 24 hours and it increased to 93.3 per cent after 96 hours.

184. Singh Anita, Kataria Ruchika and Kumar Dolly. 2012. Repellence property of traditional plant leaf extracts against *Aphis gossypii* Glover and *Phenacoccus solenopsis* Tinsley. *African Journal of Agricultural Research*, **7**(11): 1623-1628.

Aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae) and mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) are major polyphagous pests in Vadodara agricultural fields. To control these sap sucking insect pests; farmers are using broad spectrum insecticides which are toxic to non target insects. Therefore, the objective of this study is to control these pests by using biorational control methods. Hence, laboratory assays were carried out to evaluate the repellent property of leaf extracts of three indigenous native botanicals namely; *Azadirachta indica* A. Juss; *Eucalyptus globules* L. and *Ocimum basilicum* L. against aphids and mealybugs. The methanol extract of leaf was isolated by using soxhlet method. The leaf extracts were applied against aphids and mealybugs at dose levels of 1, 2, 4, 8 and 10%.

Observations were made at 12 and 24 h. After 24 h of release of aphids and mealybugs, the highest repellency was recorded in *A. indica* leaf extract which gives 99.0 and 97.0% followed by *E. globules* leaf extract giving 96.0 and 93.0%. While minimum repulsion was seen in *O. basilicum* leaf extract 91.0 and 88.0%, respectively. As the dose increases, the repellent effect also increased irrespective of the plant extracts. The use of such plant extracts can control the population of serious pests like aphids and mealybugs in an environmental friendly way.

185. Singh R and Dhawan AK. 2009. Evaluation of different insecticides against *Phenacoccus solenopsis* Tinsley on transgenic cotton. *Journal of Insect Science* (Ludhiana), **22**(1): 95-97.

Profenophos 50 EC, acephate 75 SP, thiodicarb 75 WP, chlorpyriphos 20 EC, quinalphos 25 EC and carbaryl 50 WP @ 500 ml, 800 g, 250 g, 2000 ml, 800 ml and 1000 g per acre were significantly effective against the pest.

186. Singh S, Pandher S, Brar JS, Kaur S and Bambawale OM. 2011. Area wide management of cotton mealybug *Phenacoccus solenopsis* (Tinsely) in Faridkot district of Punjab. In World Cotton Research Conference-5 held at Mumbai from 7-11 Nov. 2011.

An intensive area wide management strategy was carried out for three years in twenty cotton growing villages of Faridkot from 2008 to 2010.The mealybug *Phenacoccus solenopsis* (Tinsely) (Homoptera: *Pesudococcidae*) appeared as a serious threat to cotton in Northern India in the year 2007-08. In Punjab, it appeared on cotton in some pockets of Ferozepur, Muktsar and Bathinda districts during 2006 and spread to whole of Punjab causing 30-40% loss to cotton yield. During 2010, nine new villages were introduced in our studies replacing the previous nine as our survey reports revealed slightly higher incidence of mealybug in the new ones in 2009. Four cotton fields (two fixed and two random) at least one acre size were selected per village to collect data regarding mealy bug incidence and damage and to educate the farmers for the various pest management practices. The fixed fields were marked using GPS (global positioning system). Twenty five plants were selected randomly at weekly intervals to record the mealybug incidence using four scale grading (0-4) and to calculate the% infestation and intensity of infested plants. Intensive surveys were carried out to educate the farmers about the effective management of mealybug through on and off-farm trainings, village level meetings, radio talks, newspapers etc. The important management practices disseminated among the growers were eradication of the weed such as Congress grass

(*Parthenium hysterophorus*), Lantana, *Trianthema monogyna*, *Calotropis gigantea*, Bathu and common grass etc from the main field and around the field, burial of the infested weed in the soil and not to dispose it in water source such as canal etc, regular monitoring of the cotton field, spot treatment of the infested plants with recommended insecticides in rotation, washing of the implements between use in two fields to avoid dispersal of the mealybug. This programme had a great impact on the mealybug incidence as compared to the year of outbreak i.e 2007. The average percent incidence was 8.06, 8.17 and 4.97 in 2008, 09 and 2010, respectively which points to successful management of the pest in the progressive years of study. Intensity of the infested plants was 1.07, 0.85 and 0.57 in 2008, 09 and 2010, respectively. The programme resulted in successful management of the pest in the major cotton pockets of Faridkot.

187. Singh Satnam, Sharma Rakesh, Kumar Rajinder, Gupta VK and Dilawari VK. 2012. Molecular typing of mealybug *Phenacoccus solenopsis* populations from different hosts and locations in Punjab, *India Journal of Environmental Biology*, **33**: 539-543.

True identity and existence of genetic variability in mealybug from different regions holds immense significance for adopting appropriate control measures along with predicting the development of any biotypes. Mealybug, *Phenacoccus solenopsis* adults were collected from four host plants i.e., *Gossypium hirsutum* – cotton (C), *Abelmoschus esculentus* – okra (O), *Pennisetum glaucum* – Napier Bajra (B) and a weed – *Parthenium hysterophorus* (P) in five cotton growing districts i.e., Abohar, Bathinda, Mansa, Muktsar and Faridkot of Punjab state. Variability among different populations was investigated through comparative analysis of four different RAPD markers. The genetic similarity dendrogram established that irrespective of the host plant and the collection site, 20 mealybug populations were distinguishable into two major clades that were related to each other by 68 %. Clade 1 included populations from Abohar district; it also included a single population each from Muktsar and Bathinda districts. The populations from all the other districts were grouped under Clade 2 with genetic similarity of 78 % Even under Clade 2, individual populations appeared to exist in location specific sub-clades. Thus, there is great possibility of development of biotypes which may differ in resistance to insecticides and host plant specificity.

188. Solangi GS and Mahmood R. 2011. Biology, host specificity and population trends of *Aenasius bambawalei* Hayat and its role in controlling mealybug *Phenacoccus*

solenopsis Tinsley at Tandojam Sindh. Paper presented in 5th ICAC International Cotton Advisory Committee held at Lahore, Pakistan on February 23-25, 2011.

Mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae), appeared first time in Pakistan in 2005 and is now one of the major pests on cotton crop. A very aggressive parasitoid *Aenasius bambawalei* Hayat (Hymenoptera: Encyrtidae) was recorded first time in Pakistan in 2008. It has strong searching ability and attacked mealybug in colonies and the scattered individuals on the plants. On pesticides free farms with augmentation and conservation of this parasitoid the mealybug was brought under complete control in cotton crop and other plants consistently from 2008 whereas the mealybug became serious in pesticides treated farms as the parasitoid could not build up its populations in this environment. On pesticides free farms the parasitism ranged between 79-93% whereas on pesticides treated farms parasitism did not exceed 8%. In laboratory females lived 10-37 days and parasitized 32-170 mealybugs. Development of the meal bug, from the day of parasitization to emergence of adults from mummies, was completed in 11-15 days. In progeny male and female ratio was 1:2. The parasitoid seems host specific as of the entire mealy bugs tested in laboratory it completed development in *P. solenopsis* only.

189. Suganthi A, Kalyanasundaram M and Mahalaksmi V. 2009. A butterfly predator on cotton mealy bugs. Online edition of India's National Newspaper 'The Hindu' Thursday, November 12, 2009. Available on-line at http://www.hindu.com/seta/2009/11/12/stories/2009111250181400.htm

Recently a survey was made in different cotton growing areas of Tamil Nadu for the presence of mealybug *Phenacoccus solenopsis*, a new pest that is spreading very fast. This mealybug was also found to attack other crops like tomato and sunflower. *S.epius* was found associated with cotton mealybugs and was collected from both Bt and non Bt cotton plants attacked by *P. solenopsis*. The larvae of this butterfly were also found on parthenium, crotons, hibiscus and tomato infested with *P. solenopsis*.

190. Suresh S and Kavitha PC. 2008. Seasonal incidence of economically important coccid pests in Tamil Nadu. 285-291 In: Branco, M., Franco, J.C. & Hodgson, C.J. (Editors), Proceedings of the XI International Symposium on Scale Insect Studies, Oeiras, Portugal, 24-27 September 2007. ISA Press, Lisbon, Portugal. pp. 322.

Scale insects (Coccoidea) are amongst the most destructive pests of horticultural crops in India. More than six hundred species have been recorded to-date.

A survey, conducted in 2006- 2007, found that five species *(Phenacoccus solenopsis* Tinsley, *Coccidohystrix insolita* (Green) and *Rastrococcus iceryoides* (Green) (Pseudococcidae), *Cerococcus indicus* (Maskell) (Cerococcidae) and *Saissetia coffeae* (Walker) (Coccidae)) were the most frequent scale insect pests on *Parthenium*, cotton, hibiscus and crotons in Coimbatore, Tamil Nadu. Our survey showed that the mealybugs were most abundant during May, the cerococcid population was present between October and February, while *S. coffeae* was present throughout the year but most abundant in February and March. Studies correlating the seasonal incidence of each species with weather factors found that, for mealybugs, abundance was negatively correlated with rainfall and evening relative humidity. Reasons for these correlations are discussed in this paper.

191. Suresh S and Kavitha PC. 2008. New records of Coccoidea in India. 155 In: Branco, M., Franco, J.C. and Hodgson, C.J.(Editors), Proceedings of the XI International Symposium on Scale Insect Studies, Oeiras, Portugal, 24-27 September 2007. ISA Press, Lisbon, Portugal.pp. 322.

Coccids are some of the most destructive pests in horticultural crops in India. More than six hundred species have been recorded. A survey conducted during 2005 to 2007, recorded four species for the first time in India, *viz*., {*Phenacoccus solani*} Ferris, {*P. solenopsis*} Tinsley, {*Ferrisia malvastra* (McDaniel) on cotton, and *Conchaspis angraeci* Cockerell on vanilla. Among them, the Solenopsis mealybug. {*P. solenopsis*} was the most destructive. Studies were undertaken on its host range, seasonal incidence, population dynamics, influences of weather factors, natural enemies and evaluation of insecticides. More than thirty plant species have been recorded as hosts. Cotton and parthenium were found to be the more preferred hosts. Peroxidase, polyphenol oxidase and chitinase levels varied in the infested leaves of cotton. Maximum temperature and sunshine hours had a positive influence, while relative humidity and rainfall had a negative influence on the population build up of mealybug. *Cryptolaemus montrouzieri*, {*Scymnus coccivora*} and {*Harmonia octomaculata*} were the predominant coccinellids responsible for population reduction. Among the insecticides tested, imidacloprid, profenophos, acephate, chorpyriphos and thiomethoxam were found to be effective in the laboratory but only moderately so in the field.

192. Suresh S, Jothimani R, Sivasubrmanian P, Karuppuchamy P, Samiyappan R and Jonathan EI. 2010. Invasive mealybugs of Tamil Nadu and their management. *Karnataka Journal of Agricultural Sciences*, **23**(1): 6-9.

Solenopsis mealybug, *Phenacoccus solenopsis* Tinsley and papaya mealybug, *Paracoccus marginatus* Willams and Granara de Willink were recorded for the first time in India and considered to be invasive pests. Studies were made on the biology, seasonal incidence; alternate host plants and integrated management practices were developed for the above pests and discussed in detail.

193. Suresh S. 2008. Cotton mealybug complex. in Proceedings of the National Consultation on Mealybug Management. Central Institute for cotton Research, 28-29 January, Nagpur, India. pp. 15-17.

A recent identification report revealed five mealybug species: *P. solenopsis, M. hirsutus,* the Solanum mealybug (*Phenacoccus solani* Ferris), the malvastrum mealybug (*Ferrisia malvastra* McDaniel) and the two tailed mealybug (*Ferrisia virgata* Cockerell), in samples received from cotton researchers across India.

194. Suresh S, Karuppuchamy P, David PMM and Jonathan EI. 2010. Invasive Mealybug Pests of Tamil Nadu, India. In Potential Invasive Pests Workshop held at Miami, Florida from October 10-14, pp.66.

Mealybugs are once minor pests of late assumed major pest status. *Ferrisia virgata, Maconellicoccus hirsutu*s, *Coccidohystrix insolita* and *Brevennia rehi* are the common mealybug pests in India. During 2004-05 there was a sudden outbreak of *Phenacoccus solenopsis* Tinsley in North India and subsequently spread to other parts of the country and it is considered to be the serious pest of vegetables and fruits for the past two years in Tamil Nadu, India. During July,2008 an invasive mealybug, *Paracoccus marginatus* Williams & Granara de Willink got introduced into Tamil Nadu, India and caused extensive damage to papaya, tapioca, mulberry, guava, Jatropha, Hibiscus, many fruits and vegetables, flower crops, and many weeds including Congress grass, *Parthenium hysterophorus* .This poster describes list of host plants, mode and extent of spread to other areas, seasonal incidence and conducive weather parameters which favour multiplication of the pest. Awareness campaign were organized to contain the pest and to prevent further spread by giving emphasis on correct identification, monitoring the pest, early diagnosis, destruction of affected plants, alternate hosts and possible management with special emphasis on conserving lepidopteran predator, *Spalgis epius* and other coccinellids like *Cryptolaemus montrouzieri, Harmonia octomaculata.* Use of plant products like neem oil, fish oil rosin soap and need based spot application of insecticides like dimethoate, buprofezin, chlorpyriphos and profenophos were also recommended for containing the pest. Cheap mass production technique for the multiplication of

H. octomaculata was standardized for the management of *P. solenopsis*. Large scale demonstrations in various places are in progress. Importation of parasitoids for *P. marginatus* was done and is being tested for their biosafety to other organisms.

195. Tanwar RK, Bhamare VK, Ramamurthy VV, Mohammad Hayat, Jeyakumar P, Singh A and Bambawale OM. 2008. Record of new parasitoids on mealybug, *Phenacoccus solenopsis*. *Indian Journal of Entomology*, **70**(4): 404-405.

A survey conducted in five Tehsils of Parbani district (Maharashtra), India, and in nearby areas in Delhi during July and August 2008 indicated the presence of cocoons of *Aenasius* sp. on mealybug (*Phenacoccus solenopsis*) infesting *Parthenium hysterophorus, Xanthium strumarium* and *Achyranthes aspera.* Parasitism on these weeds ranged from 20 to 70%. This parasitoid is a solitary endoparasitiod causing mealy bugs to swell and change their colour to brown. The parasitoid cocoons appeared brown in colour among the mealy bugs.

196. Tanwar RK, Jeyakumar P and Monga D. 2007. Mealybugs and their management, *Technical Bulletin 19,* National Centre for Integrated Pest Management, New Delhi, India.12pp. Available online: http://www.ncipm.org.in/MealybugPDFs/Bulletin-Mealybugs%20.

The pest became a threat to Bt cotton by 2006 and 2007 in Punjab, Haryana, Rajasthan, Gujarat and Maharashtra and caused significant losses in cotton production. The species was identified as *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae) which is a new species to cotton in India..3

197. Tanwar RK, Jeyakumar P and Singh Amar. 2008. Management of mealybugs in cotton. *Indian Farming*, **58**(5): 22-24

Mealy bugs are polyphagous, feeding on variety of plants belonging to Malvaceae, Solanaceae and Fabaceae. The waxy coating present on their body facilitates passive transport of the insect and also protects them from chemical. During the last few years mealybugs which were considered minor pests have acquired the status of major pests, especially in cotton. In India recently the cotton crop in Punjab, Rajasthan, Maharashtra and Gujarat is found to be seriously infested with mealybugs. It is, therefore, important to take up timely measure to avert any impending cotton losses.

198. Tanwar RK, Jeyakumar P, Singh Amar, Jafri AA and Bambawale OM. 2011. Survey for cotton mealybug, *Phenacoccus solenopsis* (Tinsley) and its natural enemies. *Journal of Environmental Biology*, **32**(3): 381-384.

Mealybug was considered to be a minor pest of cotton but it emerged as a major pest in 2006-2007 in North and Central zones. Extensive field surveys conducted in cotton fields during 2007-09 in Haryana, Rajasthan and Punjab in the North zone and Madhya Pradesh, Maharashtra and Gujarat in the Central zone indicated that *Phenacoccus solenopsis* was the only major species of mealybug recorded on cotton in North as well as Central zones except one location in Gujarat where *Ferrisia virgata* Cockerrel was also recorded. Infestation of mealybug at most of the places in North and Central zones ranged from mild (10-20%) to high (40-60%) during 2007 and 2008 but reduced to traces in 2009. Extensive field survey indicated that *Aenasius bambawalei* Hayat (Chalcidodea: Encyrtidae), an indigenous parasitoid, played a key role in reducing the insect pest infestation. The parasitoid was first recorded in Delhi in July 2008 and by 2009 it was found in most of the cotton growing districts of North and Central zones. Its natural parasitization on *P. solenopsis* could reach more than 90% at many locations. This is the most successful example of biological control of mealybug. Along with this parasitoid, another parasitoid, *Promuscidea unfasciativentris* Girault (Chalcidodea: Aphelinidae), was also recorded at most of the locations in smaller proportions.

199. Thomas Asha and Ramamurthy VV. 2008. On the problems in diagnostics of cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae). *Entomon*, **33**(4): 277-282.

Detailed studies on the mealybugs recently collected from different parts of India on cotton and other hosts revealed the abundance of *Phenacoccus solenopsis*. These studies also revealed that there had been confusions in the identification of this species due to synonymy, misidentifications and anomalies due to material preparation, terminology and interpretation of taxonomic characters, in particular, the multilocular disc pores and circulus. The present study, through analysis of populations from all over India and from illustrated diagnostics of the distinguishing characters at all taxonomic levels, updated the taxonomic conclusions on the multilocular disc pores in the abdominal segments.

200. Thomas Asha, Chaudhary Babita, Singh Jagmail and VV Ramamurthy. 2008. Preliminary observations on the non-target insect communities in Bt cotton. *Indian Journal of Entomology*, **70**(4): 400-402.

Nontarget insect communities in fields of Bt cotton (MRC-11) were studied in New Delhi, India, during 2007-08. Insects were sampled from 183 days after sowing (DAS) to 306 DAS. The most abundant arthropod pests were *Aphis gossypii,*

Amrasca biguttula biguttula, Phenacoccus solenopsis, Oxycarenus hyalinipennis and *Thrips tabaci*. Less abundant were mites (Phytoseiidae) and coccinellids (*Coccinella septempunctata* and *Brumoides suturalis*). The populations of *Aphis gossypii, O. hyalinipennis, T. tabaci* and *P. solenopsis* markedly varied between the fields of Bt cotton and non-Bt cotton (cv. Pusa 8-6). Aphids were dominant among the insects in terms of density. Populations of *Amrasca biguttula biguttula* and *B. tabaci* were highest towards the harvesting stage of non-Bt cotton. *P. solenopsis* were most abundant during the postharvest stage. Populations of mites and *O. hyalinipennis* were higher on not-Bt cotton than on Bt cotton at the postharvest stage.

201. Tinsley JD. 1898. An ants'-nest coccid from New Mexico. *Canadian Entomologist*, **30**: 47-48.

Phenacoccus solenopsis n. sp. is a native of the United States of America, was first collected in 1897 in New Mexico.

202. Tinsley JD.1898. Notes on Coccidae, with descriptions of new species. *Canadian Entomologist* 3**0**: 317-320.

Dactylopius kingii neo-mexicana n. var., *D. azaleae* n. sp.; descriptive notes on *Eriococcus tinsleyi* and *Phenacoccus solenopsis*. The cotton mealybug, *P. solenopsis* was reported originally on ornamental and fruit crops in the United States.

203. Trencheva K, Trenchev G, Tomov R and Wu SA. 2010. Non-indigenous scale insects on ornamental plants in Bulgaria and China: A survey. *Entomologia Hellenica* **19**:114-123

A preliminary list of non-indigenous scale insect species on ornamental plants in Bulgaria and China is presented. The sampling was done between April and November, 2009, in the framework of the project "Invasive scale insects on ornamental plants in Bulgaria and China". The insects were collected in nurseries, parks, gardens, botanical collections and greenhouses. Representatives from four families have been identified in Bulgaria, the most numerous of which are the Diaspididae (eight species), Coccidae (four species), Pseudococcidae (two species) and Margarodidae (one species). Three species of non-indigenous scale insects associated with ornamental plants viz., *Phenacoccus solani* Ferris, *Phenacoccus solenopsis* Tinsley*, and Pseudococcus philippinicus* Williams were collected in China, all belonging to the family Pseudococcidae. A list of alien scale insect species

on ornamental plants is given, including the sampling sites, host plants on which they were found, origin and first report in both countries.

204. Vennila S, Deshmukh AJ, Pinjarkar D, Agarwal M, Ramamurthy VV, Joshi S, Kranthi KR and Bambawale OM. 2010. Biology of mealybug, *Phenacoccus solenopsis* on cotton in Central India. *Journal of insect science,* **10**:119. Available online: insectscience.org/10.119.

Phenacoccus solenopsis Tinsley (Hemiptera: Pseudococcidae) 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. The biology of the mealybug *P. solenopsis* was studied on cotton under laboratory conditions between August and October of 2009 with mean temperature and relative humidity of 23.3-30.2^{0}C and 40.5-92.5% RH, respectively, in Central India. Neonate crawlers that emerged from a field population were collected and constituted the study population. The developmental period from immature crawler to adult stage was greater for males (18.7 ± 0.9 days) compared to females (13.2 ± 1.8 days), probably due to the additional molt to the pupal stage in males. Survival of second instars was lower (45.5%) than first and third instars (71.4%). Females showed dynamic patterns of fecundity with the number of crawlers produced per female ranging between 128 and 812, with a mean of 344 ± 82. The reproductive period lasted 30.2 ± 8.2 days. Parthenogenesis with ovoviviparity (96.5%) was dominant over the oviparous (3.5%) mode of reproduction. Adult females lived 42.4 ± 5.7 days. Males accounted for less than 5% of the population, and lived 1.5 ± 0.1 days. The life history parameters of *P. solenopsis* adult females are discussed relative to the appearance of symptoms on the cotton crop, and the importance of making management interventions during the effective reproductive period of the insect.

205. Vennila S, Prasad YG, Prabhakar M, Kumar Rishi, Nagrare V, Amutha M, Dharajyothi, Agarwal Meenu, Sreedevi G, Venkateswarlu B, Kranthi KR and Bambawale OM. 2011. "Spatio-temporal Distribution of Host Plants of Cotton Mealybug, *Phenacoccus solenopsis* Tinsley in India". Technical Bulletin 26, NCIPM, Pusa Campus, New Delhi. pp. 39.

Current compilation presents comprehensive analysis on the documented host plants of *Phenacoccus solenopsis* across cotton growing zones of India based on studies carried out between 2007 and 2010. Seventy one, 141, 124 and 194 species of plants belonging to 27, 45, 43 and 50 families served as hosts for *P. solenopsis* at North,

Central, and South and across all cotton growing zones, respectively. The diversity of hosts for *P. solenopsis* was greater at Central (72.6%) followed by South (63.9%) and North (36.6%) zones. Weed hosts constituted 38, 58.9 and 47.5 per cent in respect of North, Central and South zones. Out of the total 194 hosts of *P. solenopsis* documented across the country, 55.6% were weeds. Zone wise and all India level cultural management strategies have been given for effective management of *P. solenopsis*.

206. Vennila S, Ramamurthy, V.V. Deshmukh, A. Pinjarkar, D.B. Agarwal, M. Pagar, P.C. Prasad, Y.G. Prabhakar, M. Kranthi, K.R. and Bambawale, O.M. 2010. "A Treatise on Mealybugs of Central Indian Cotton Production System". Technical Bulletin No. 24, NCIPM, Pusa Campus, New Delhi, pp. 50.

The exclusive study was carried out on mealybugs in general and of *Phenacoccus solenopsis*, in particular at Central India. A total record of 84 host plants across 28 families with majority of them (60 across 22 families) belonging to weeds was recorded. Eighty four host plants belonged to eight categories of plant kingdom *viz.,* field crops, fruits, medicinal plants, ornamentals, plantations, spices, vegetables and weeds.

207. Verma Jeewa Ram, Bhati DS, Srivastav AK, Jasuja Seema, Sidhu BS and Singh Vichiter. 2011. Survey and surveillance of *Parthenium hysterophorus* as a major alternate host of cotton mealybug in Rajasthan. In World Cotton Research Conference-5 held at Mumbai from 7-11 Nov. 2011.

Parthenium hysterophorus L. is an obnoxious fast growing alien annual weed, most commonly known as a congress grass or carrot grass. It is a main source of nuisance and health hazard to human and animal, it has become one of the seven most dangerous weeds of the world due to its well known ability to destroy the major portion of nutrient, natural vegetation and create havoc in field. Survey was conducted during kharif season of the year of 2008 and 2009 in a district of Sriganganagar, Hanumangarh, Alwar, Ajmer, Nagour, Jodhpur and Pali districts of Rajasthan for alternate host of mealybug. Surveillance of mealybug infestation was found greater when *Parthenium* population was high in surveyed area of Rajasthan. Three species of mealybug were found in cotton surveyed area of Rajasthan. *Phenacoccus solani* is the most predominant in the state followed by *Maconellicoccus hirsutum* in and *Phenacoccus solenopsis*. Out of three species *P. solani* was found in greater intensity in the surveyed area of Rajasthan and its infestation was up to 91.46% followed by *M. hirsutum* 7.66% while

P. solenopsis was negligible. During the years 2008 and 2009 maximum mealy bug infestation in Bt cotton was 32.62% and 24.75% respectively. Thus in present study it is revealed that mealybug infestation was recorded higher in district Sriganganagar followed by Hanumangarh, Alwar, Ajmer, Nagour, and Jodhpur and in least in Pali district Pali. *Parthenium hysterophorus* acts as major mealybug host followed by *Achyranthes aspera*, *Aerva javanica*, *Datura stamonium*, *Hibiscus rosa-chinensis*, *Sesbania aculeate*, *Abutilon bidentatum, Cyperus rotandus*, *Citrus spp*.

208. Vinobaba, ML and Prishanthini M. 2009. A new invasive species of mealybug from the East. Department of Zoology, Eastern University, Vantharumoolai, Chenkalady, Sri Lanka .http://www.esn.ac.lk/Zoolgy mealy%20bug%20web% 20article.pdf

A new species of mealy bug an invasive species, locally called as cotton mealybug is identified as *Phenacoccus solenopsis* Tinsley (Pseudococcidae) and reported for the first time in Sri Lanka, during a research on mealybugs of home gardens, which was not reported previously on any crop from Sri Lanka.

209. Wang Li, Huang Li and Ying Zhong. 2010. Survey of diseases and insect pests damage in landscape plants and their control measures in Baise City. [Chinese] *Guangxi Agricultural Sciences*, **41**(7): 679-682.

The present study was conducted to investigate the kind and occurrence of plant diseases and insect pests and damages caused by them in landscape plants in main scenic spots, artery and residential areas of the Baise City using the combined method of general and special investigation. The results showed that the main diseases and insect pests of street trees in Baise City included leaf-hopper, *Gynaikothrips uzeli* zimm, psylla, bagworm moth, Pseudaulacaspis, camphor scale, *Chilades pandava*, sooty mold, anthracnose, leaf spot, leaf blight disease and parasitism on Cascuta chinesis. The main diseases and insect pests of hedge plants included *Phenacoccus solenopsis* tinsley, *Ceroplastes japonicus*, asian butterflybush rust, Murraya powdery mildew, rose blackspot, etc. The integrated control measures suggested include enhancing plant quarantines, rational distribution of plant varieties, physical, mechanical or chemical pesticide prevention, protection of natural enemies, etc.

210. Wang Yan Ping, Watson GW and Zhang RunZhi. 2010. The potential distribution of an invasive mealybug *Phenacoccus solenopsis* and its threat to cotton in Asia. *Agricultural and Forest Entomology*, **12**(4): 403-416

In recent years, an invasive mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) has attacked cotton (*Gossypium hirsutum* L.) in Pakistan and India, causing severe economic losses. This polyphagous pest was probably introduced accidentally from North America. Infestations have broken out suddenly and spread rapidly. Seasonal and annual population growth data of *P. solenopsis* from nine locations in its native range in the U.S.A., and the distribution of the mealybug worldwide, were analyzed using the CLIMEX model. This indicated that tropical regions worldwide were highly suitable for *P. solenopsis*. Its potential distribution was limited by cold in high latitudes and altitudes, and dryness in northern Africa, inland Australia and parts of the Middle East. CLIMEX was used to predict where *P. solenopsis* might establish, and to estimate the potential threat to cotton yield in Asia. The key limiting factors were low precipitation as well as minimum temperatures in northern areas. When irrigation was factored into the simulation, the potential distribution of *P. solenopsis* expanded dramatically, indicating that *P. solenopsis* presents a great economic threat to cotton in Asia and other parts of the world.

211. Wang YP, Wu SA and Zhang RZ. 2009. Pest risk analysis of a new invasive pest *Phenacoccus solenopsis*, to China. (in Chinese; Summary in English). *Chinese Bulletin of Entomology,* **46**(1):101-106.

P. solenopsis was found in numerous sites in Guangzhou city, Guangdong Province, China, on Hibiscus spp. on 16 December 2008. The genetic algorithm for rule-set prediction modelling system was used to predict the potential distribution of *P. solenopsis* in China. The pest could occur in most areas in 17 provinces (Hainan, Guangdong, Guangxi, Fujian, Taiwan, Zhejiang, Jiangxi, Hunan, Guizhou, Yunnan, Chongqing, Hubei, Anhui, Shanghai, Jiangsu, Shandong and Henan), and in some areas in 11 provinces (Xinjiang, Sichuan, Gansu, Ningxia, Shaanxi, Shanxi, Hebei, Beijing, Tianjin, Liaoning and Inner Mongolia). According to the international pest risk analysis method, *P. solenopsis* is a high-risk invasive species in China, with a risk value.

212. Wu SA and Zhang RZ. 2009. A new invasive pest, *Phenacoccus solenopsis* threatening seriously to cotton production. (In Chinese; Summary in English). *Chinese Bulletin of Entomology,* **46**(1): 159-162

A serious pest insect infesting *Hibiscus rosa-sinensis* L. was found in August, 2008 in Guangzhou, Guangdong Province. It was founded in many sites in Guangzhou on hibiscus trees on December 16, 2008. It was identified to a new invasive species,

Phenacoccus solenopsis Tinsley to China. The insect is an important invasive pest and seriously damaging cotton in India and Pakistan. It could be a potential disaster to world cotton including China. The paper presents its morphological identification characters, hosts, distribution, damage as well as some quarantine and control suggestions to prevent its outbreak in China.

213. Zaka SM, Saeed S, Bukhari SA and Baksh E. 2006. Mealybug, *Phenacoccus solenopsis* (Homoptera: Pseudococcidae): a novel pest of cotton in Pakistan. Proceedings of 34th Pakistan (SAARC) Countries Science conference, University of Veterinary and Animal Sciences, February 8-10, 2006. Lahore, Pakistan, pp. 32.

A number of mealybug species have been reported attacking vegetables, fruit trees, glasshouse- and field-crops around the fields were infested with mealybug and 20-90% plants were world and cause very substantial economic losses to these crops It was first found in Pakistan in 2005.

214. Zhang PengJun, Zhu XiaoYun, Huang Fang, Liu Yong, Zhang JinMing, Lu YaoBin and Ruan YongMing. 2011. Suppression of jasmonic acid-dependent defense in cotton plant by the mealybug *Phenacoccus solenopsis*. PLoS ONE, **6**(7): e22378. doi:10.1371/journal.pone.0022378.

The solenopsis mealybug, *Phenacoccus solenopsis*, has been recently recognized as an aggressively invasive pest in China, and is now becoming a serious threat to the cotton industry in the country. Thus, it is necessary to investigate the molecular mechanisms employed by cotton for defending against *P. solenopsis* before the pest populations reach epidemic levels. Here, we examined the effects of exogenous jasmonic acid (JA), salicylic acid (SA), and herbivory treatments on feeding behavior and on development of female *P. solenopsis*. Further, we compared the volatile emissions of cotton plants upon JA, SA, and herbivory treatments, as well as the time-related changes in gossypol production and defense-related genes. Female adult *P. solenopsis* were repelled by leaves from JA-treated plant, but were not repelled by leaves from SA-treated plants. In contrast, females were attracted by leaves from plants pre-infested by *P. solenopsis*. The diverse feeding responses by *P. solenopsis* were due to the difference in volatile emission of plants from different treatments. Furthermore, we show that JA-treated plants slowed *P. solenopsis* development, but plants pre-infested by *P. solenopsis* accelerated its development. We also show that *P. solenopsis* feeding inhibited the JA-regulated gossypol production, and prevented the induction of JA-related genes. We conclude that

P. solenopsis is able to prevent the activation of JA-dependent defenses associated with basal resistance to mealybugs.

215. Zhang Runzhi, Wang Yanping and Li Yalan. 2010. Discovery of a New Invasive Mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) in China. In Potential Invasive Pests Workshop held at Miami, Florida from October 10-14, pp.71.

The invasive mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae), has attacked severely to cotton (*Gossypium hirsutum* L.) in Pakistan and India. It expanded dramatically and presented a great economic threat to world cotton production. *P. solenopsis* was found from Guangzhou City (23°802 N, 113°172 E) on August 20, 2008 for the first time in China. Its host plant is *Hibiscus rosasinensis* L. According to the results of field investigation during 2008-2010, the insect was found within 8 provinces including Guangdong (Guangzhou, Panyu, Shaoguan, Zengcheng), Guangxi (Qinzhou), Hainan (Haikou, Sanya), Fujian (Sanming, Xiamen, Zhangzhou), Hunan (Changsha), Zhejiang (Hangzhou, Wuyi), Yunnan (Funing, Huaping, Jinghong, Yongren), Jiangxi (Zhanggong, Yongxiu) and Sichuan (Panzhihua). Although it was found in many provinces in South China, but the distribution areas were small with pot distribution pattern. So far, we have only found *P. solenopsis* attacked cotton in Jiangxi and Hunan where closing to main cotton production areas in China.Potential distribution analysis by CLIMEX modeling indicated that *P. solenopsis* presents a significant threat to cotton production in China and many Asian countries. The climate of many Chinese cotton-producing areas is suitable for its colonization and establishment.

216. Zhou Wan Lin YunBiao Xu FengXian Yan Tie Wang XiuHua Liang XianHe and Shi ZuHua. 2010. Investigation of distribution and damage of *Phenacoccus solenopsis* in Zhejiang Province. [Chinese]. *Chinese Bulletin of Entomology*, **47**(6): 1231-1235.

The results of a general investigation conducted in September-November 2009 on the new invasive insect, *Phenacoccus solenopsis* Tinsley, are reported. So far, *P. solenopsis* is found in Xiasha and Yuhang county of Hangzhou district, Wuyi county of Jinhua district, and Yunhe county of Lishui district. 29 species of crops, flowers and weeds belonging to 19 families are damaged by this pest, including *Zea mays, Ipomoea batatas, Cucurbita moschata, Lycium chinense, Portulaca grandiflora, Primula maximowiczii, Cirsium setosum* and *Comnyza canadensis.* Quarantine and control practices for this pest are suggested.

217. Zhu YiYong Huang Fang and Lu YaoBin. 2011. Bionomics of mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on cotton. *Acta Entomologica Sinica*, **54**(2): 246-252.

A serious invasive exotic mealybug pest, *Phenacoccus solenopsis* Tinsley, has been recently found in China, with a great potential threat to cotton production. In the laboratory, we studied the developmental duration, reproduction and morphology of the mealybug on cotton. The results showed that there are five stages (egg, 1st, 2nd and 3rd instar nymph and adult) in the life cycle of female, while in the male there are six stages (egg, 1st and 2nd instar nymph, pre-pupa, pupa and adult). The egg stage was short; the nymphal stage of the female lasted 15-20 days and the total life span of the female was about 47-59 days, while in the male the nymphal and pupal stage together lasted about 17-22 days and the total life span of the male was about 20-26 days. The longevity of the female was much longer than the male. *P. solenopsis* has strong fecundity with an egg laying amount per female adult ranging from 200 to 862 (average 458 eggs). Egg, elongate-oval in shape, orange in colour and slightly transparent. First instar nymph, yellowish green in colour, and moves very fast. Second instar nymph, the protuberances on marginal surface of body become visible, anal lobes protrudent; male and female can be differentiated by the dark spots on body surface in late-2nd instar stage. Third instar female nymph, similar to adult female, covered by a thin layer of white waxy powder, with dark dorsomedial bare spots on intersegmental areas of thorax and abdomen from 1st to 4th segment, these areas forming 1 pair of dark longitudinal lines on dorsum. Adult female, oval in shape, covered with a thick layer of white waxy powder; several pairs of dark spots present under the waxy powder on thorax and abdomen, with 18 pairs of lateral wax filaments, posterior 2-3 pairs longer. Male pupa covered in loose white silky cocoon. Adult male, small and blackish brown in colour; antennae long and thin; one pair of transparent fore wings with hind wings degenerated into poiser; and two pairs of abdominal filaments present at the terminal part of the body. The results of this study are the base for the further studies and sustainable control of this serious pest.

Acknowledgement

Sincere thanks are to Dr. V. Sridhar, Indian Institute of Horticultural Research, Bengaluru, for his assistance towards supply of abstracts from *"Insect Environment"*. We thankfully acknowledge the financial assistance of National Agricultural Innovation Project NAIP (NAIP/DSS/C2046) for publishing the work.