

**SURVEY OF INSECT PESTS AND NATURAL ENEMIES ASSOCIATED WITH
CHILLI IN VARIOUS DISTRICTS OF KYMORE PLATEAU & SATPURA HILLS
ZONE OF MADHYA PRADESH**

**Arthropod pests of chilli and associated natural enemies in Kymore Plateau and
Satpura Hill zone of Madhya Pradesh (India)**

Abstract

The ~~present investigations were carried out to~~ survey ~~was conducted in selected districts of insect pests and natural enemies associated with chilli crop in Kymore Plateau & and Satpura Hills zone of Madhya Pradesh (India) to assess the pest status of chilli during Rabi 2017-18 and 2018-19 growing rabi seasonseason. Observations were conducted~~ Crop ~~was monitored thrice~~ at vegetative, flowering, and fruiting stages ~~of the crop at each of thein~~ 4—four selected locations (pesticide-free fields) ~~of seven districts viz., Seoni,~~. The status of insect pests in each district of the zone is presented based on the mean of 4 locations. The outcome of the experiment revealed that four species of pest spectra included four insect pests and a mite species ~~i.e. namely, whiteflies~~ whitefly, *Bemisia tabaci* (Gennadius), thrips, *Scirtothrips dorsalis* Hood, ~~jassids~~ leafhoppers, *Amrasca biguttula biguttula* (Ishida), ~~and fruit-borers, Helicoverpa armigera Hubner, one and a mite species, of mites i.e. Polyphagotarsonemus latus (Banks);~~ and one species of predator, transverse ladybird beetle, ~~i.e. Coccinella transversalis Fabricius to be associated with various stages of chilli crop at districts Seoni, Jabalpur, Katni, Rewa, Satna, Panna, and Sidhi. The incidence of Leaf curl incidence-disease~~ was also observed. The pooled mean populations of *B. tabaci* in ~~districts~~ Seoni, Jabalpur, Katni, Rewa, Satna, Panna, and Sidhi ~~were was~~ 2.86, 2.45, 2.67, 2.79, 2.90, 2.86, and 2.70 individuals/ 10 cm twig, respectively at the flowering stage. ~~Peak mean-Mean~~ population of *S. dorsalis* was 1.65, 1.48 and 1.34 individuals/ 10 cm twig at flowering stage in ~~district~~ Jabalpur, Katni and Panna, while, in ~~district~~ Seoni, Rewa, Satna and Sidhi, ~~it peak mean population of S. dorsalis~~ was 1.37, 1.35, 1.34 and 1.48 individuals/ 10 cm twig, respectively at fruiting stage. ~~Peak mean-p~~ Population of *A. biguttula biguttula* was 3.14, 3.80, 3.49, 3.14, 3.18, 3.40, and 2.98 individuals/ 10 cm twig at fruiting stage. ~~Peak mean-populations of P. latus population was were recorded~~ 0.86, 1.01, 0.92, 0.99, 0.95, 1.13 and 0.96 ~~mites/~~ leaf at fruiting stage. ~~Peak mean-populations of H. armigera were population was~~ 1.13, 0.43, 0.53, 0.62, 1.28, 0.86 and 1.19 larvae/ plant at fruiting stage. ~~Peak mean-p~~ Populations of *C. transversalis* ~~were was~~ 1.80, 2.25, 2.32, 1.85, 1.88, 2.36, and 1.67 beetles/ plant at the fruiting stage. ~~Pooled data revealed that incidences~~

Comment [SM1]: Since the study included mite pest, the title insect pest is not appropriate. Mites does not belong to class insecta / insect group. Hence broader term arthropod may be used.

Formatted: Font: Italic

~~of the~~The leaf curl (% leaves infestation)~~incidence was~~ 27.28, 32.43, 33.33, 28.45, 36.03, 25.53, and 36.19 % at the fruiting stage in the mentioned districts of the zone.

Key words: Chilli, Survey, whiteflies, thrips, jassids, mites, fruit borer, Ladybird beetle.

Introduction

Chilli (*Capsicum annuum* L.), belonging to the family Solanaceae, is one of the important spice cum vegetable crops of India and is widely cultivated throughout warm temperate, tropical, and subtropical countries.

India is ~~not only~~ the largest producer ~~but also the largest and~~ consumer of chilli, a commercial spice crop, in the world. ~~and it is considered as one of the commercial spice crops.~~ It is widely used as a spice universally, named as “wonder spice” (Pawar et al., 2011)^[22].

It is grown throughout the year as a cash crop and pods are used in the fresh green stage, eaten raw in a salad or as a cooked vegetable. The red ripe dried stage is known for its pleasant aromatic flavor, pungency, and high coloring substance. Nutritionally, it is a rich source of vitamin—A, B, C, oleoresin, and red pigment. *Capsaicin*, an alkaloid responsible for the pungency in chillies, has medicinal properties and it prevents heart attack by dilating the blood vessels (Gill, 1989)^[10].

Capsicum is derived from the Greek word "Kapsimo" meaning "to bite". Genus *Capsicum* is divided into three sections by Hunziker - Monotypic *Tubocapsicum*, *Pseudoacnistus*, and *Capsicum*. All the species in the genus have n=12 except *C. ciliatum* and *C. scolnikianum* which have n=13. Genus *Capsicum* includes 22 wild species, three varieties, five domesticated species, and their wild relatives. In general domesticated species have larger but fewer fruits than their wild counterparts, though seed per plant is about the same (Anonymous, 2009)^[11].

Chilli is grown over an area of 2020.91 thousand hectares in the world, with a production of 3762.13 thousand tonnes and 1.86 tonnes per hectare in 2013. Major chilli growing countries are India, Myanmar, Bangladesh, Pakistan, Thailand, Vietnam, Romania, China, Nigeria, and Mexico, etc. India is the world leader in chilli production followed by China, Thailand, and Pakistan (Anonymous, 2013)^[2].

In India green chilli occupied an area of 366 thousand hectares with an annual production of 3737 thousand metric tonnes. Dried chili occupied an area of 739 thousand

Formatted: Font: Italic

Formatted: Font: Italic

Formatted: Font: Italic

Formatted: Font: Italic

Comment [SM2]: Author has cited 9 year old production data. Current year production data may be included.

hectares with an annual production of 2172 thousand metric tonnes in 2018-19 (Anonymous, 2019)^[5]. The productivity of dried chilli was reported to be 2.84 tonnes/hectare in 2017-18 (Anonymous, 2018a)^[3].

In Madhya Pradesh, the area under green chilli crop was 41.29 thousand hectares with an annual production of 669.16 thousand metric tonnes and dried chilli crop was 90.98 thousand hectares with an annual production of 244.55 thousand metric tonnes. The productivity of dried chilli was reported to be 2.69 tonnes/hectare in 2017-18 (Anonymous, 2018b)^[4].

The most important chilli growing states in India were Karnataka, Madhya Pradesh, Bihar, Andhra Pradesh, and Maharashtra in 2017-18. Major chilli producing districts of Madhya Pradesh were Chhindwara, Khandwa, Jhabua, Rewa, Vidisha, Damoh, Khargone, and Agar Malwa in 2016-17 (Anonymous, 2018b)^[4].

Many factors are responsible for the low production and productivity of chilli crops that includes biotic factors like the incidence of insect pests and diseases.

About 51 insect and 2 mites species, belonging to 27 families and 9 orders were found infesting chilli (Reddy and Puttaswamy, 1983)^[25]. Among these, thrips, *Scirtothrips dorsalis* Hood; whitefly, *Bemisia tabaci* Gennadius; aphid, *Aphis gossypii* Glover; jassid, *Amrasca biguttula biguttula* and mite, *Polyphagotarsonemus latus* Banks are major sucking pests causing 60 to 75 percent yield loss in green chilli (Patel and Gupta, 1998)^[21]. Nearly 35 species of insect pests were reported on chilli which ~~includes-included~~ thrips, aphid, whitefly, fruit borer, cutworm, plant bug, mite, and other minor pests (Sorensen, 2005)^[28]. Among all the sucking pests attacking chilli crop; the thrips, *Scirtothrips dorsalis* Hood and whitefly, *Bemisia tabaci* Gennadius were reported as dominant pests (Berke and Sheih, 2000)^[7]. The estimated losses due to sucking pests were up to 30 to 50 percent (Varadharajan, 1994)^[30]. The yield losses ~~range-ranging~~ from 50-90 percent due to insect pests in chilli ~~was reported~~ (Nelson and Natrajan, 1994)^[17].

Mites have become a major problem in chilli cultivation. It appears in the nursery itself and spreads to the main field during November. Leaves damaged by *Polyphagotarsonemus latus* (Banks) curl downward and the flowers become distorted and fail to open normally. In most attacked hosts the internodes are greatly shortened and fruit drop may occur under severe infestations (Pena and Bullock, 1994)^[23].

In addition to insect pests, the crop also suffers due to the incidence of diseases. Leaf curl is one of the important diseases leading to yield reduction in chilli. ~~Chilli-leaf-curl~~

~~complex is caused by Geminivirus transmitted by whitefly, *Bemisia tabaci*, and also by thrips, *Scirtothrips dorsalis*, and *Polyphagotarsonemus latus* (Venkatesh et al., 1998)^[34].~~

Chilli leaf curl locally known as "Murda" is a most destructive disease of chilli in India. ~~Leaf curl of chilli~~Causal agent of the disease, is caused by tobacco leaf curl virus (*Ruga tabaci*), ~~which~~ is transmitted by vector *B. tabaci*. The ~~diseases caused by virus belonged to the~~ genus Begomovirus ~~in of~~ the family Geminiviridae, ~~are easily recognized by their distinctive~~ The symptoms included with upward curling, puckering, and reduced size of leaves. Severely affected plants are stunted and produce no fruits. The symptoms are ~~broad of~~ three types: vein yellowing, yellow mosaic, and leaf curl (Zehra et al., 2017)^[34]. In the last two decades, *Begomoviruses*, largely leaf curl viruses have emerged as a major threat to vegetable crops, including chilli and causing up to 90% yield loss in India (Suresh et al., 2013)^[29]. Chilli leaf curl virus was first reported in India in 1954, which was later reported at infrequent intervals. However, after 2005 the virus complex has been emerging rapidly across India and the subcontinent (Kenyon et al., 2014)^[12]. Chilli leaf curl virus is mainly transmitted by whitefly and grafting (Senanayke et al., 2012)^[27]. The leaf curl complex is also reported to be transmitted by whitefly (*B. tabaci*), thrips (*S. dorsalis*) and a mite (*P. latus*) (Venkatesh et al., 1998)^[31]. whitefly, *Bemisia tabaci*, and also by thrips, *Scirtothrips dorsalis*, and *Polyphagotarsonemus latus* (Venkatesh et al., 1998)^[34].

Formatted: Font: Italic

Formatted: Superscript

The incidence of chilli leaf curl disease in major chilli growing regions of Madhya Pradesh was severe (88-100%) (Kumar et al., 2016)^[13].

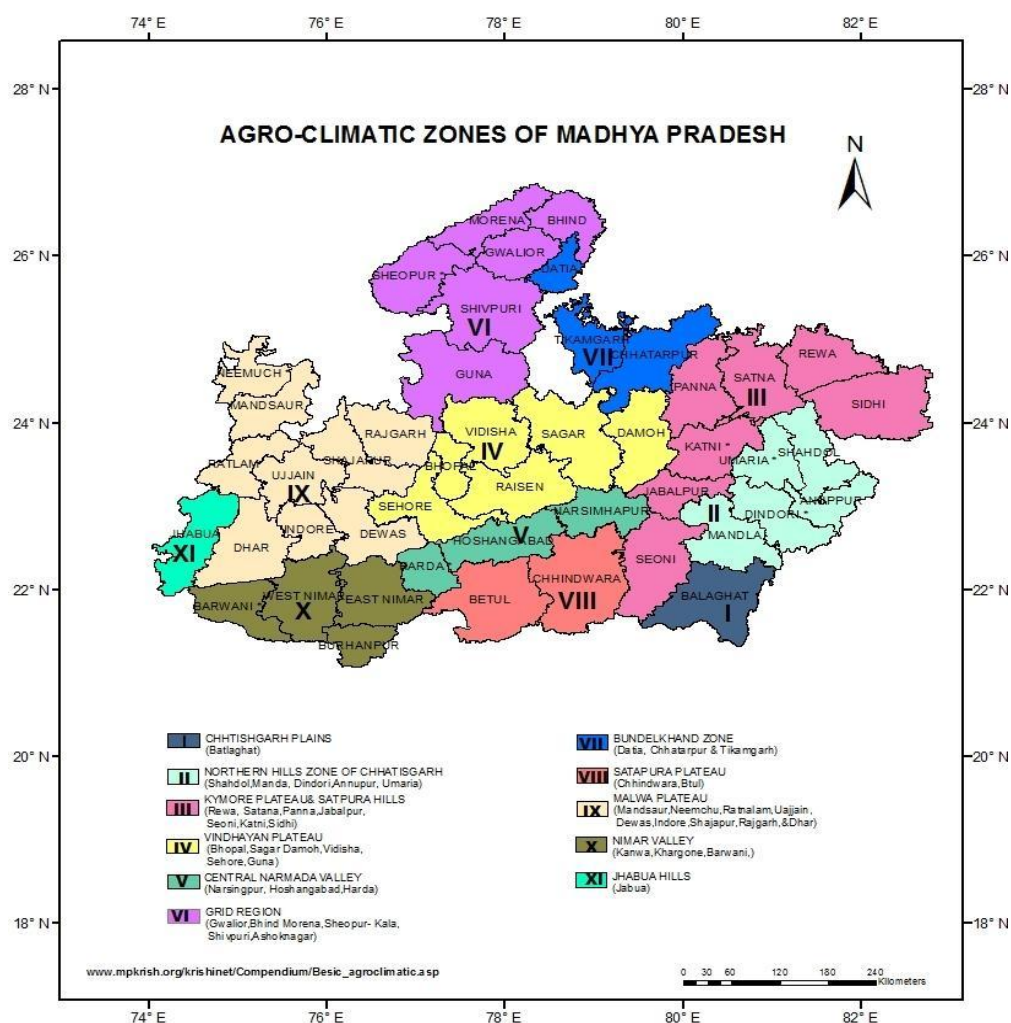
Any pest management program is successful only when due care is extended in augmenting and conserving the natural enemies. Present studies include the maintenance of district wise record on the activity of insect pests & natural enemies in chilli crop, in Kymore Plateau and Satpura hills zone of Madhya Pradesh.

Material and Methods

Survey to record the insect pests and natural enemies associated with chilli crop ~~in Kymore Plateau & Satpura Hills zone of Madhya Pradesh were was~~ conducted in Kymore Plateau and Satpura Hill zone of Madhya Pradesh (India) thrice at vegetative, flowering, and fruiting stages of the crop. Fifty samples were observed at each of the 4 selected locations (pesticide-free fields) in ~~districts~~ Seoni, Jabalpur, Katni, Rewa, Satna, Panna, and Sidhi districts. The population of major insect pests and natural enemies were recorded in each sample. The incidence of leaf curl disease was also observed in 50 sample plants at each location. The total number of leaves in each sample plant and the infected leaves were

counted to work out the infestation percentage. The status of insect pests in each district of the zone was presented based on the mean of 4 locations.

Details of pest sampling, sampling size, method of recording pest are required to be mentioned here. ...



* Map 1: Map indicating places of observations in Kymore Plateau & Satpura Hills zone of Madhya Pradesh

Comment [SM3]: This figure is not cited in the text body.

Results and Discussion

Whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae)

The pooled mean populations of *B. tabaci* in ~~districts~~ Seoni, Jabalpur, Katni, Rewa, Satna, Panna, and Sidhi ~~districts were was~~ 2.86, 2.45, 2.67, 2.79, 2.90, 2.86, and 2.70 individuals/ 10 cm twig, respectively at the flowering stage (Table 1 & Fig. 1).

Similar to present findings Meena et al. (2013)^[15] reported that the whiteflies (*B. tabaci* Genn.) appeared on chilli crop soon after transplanting. Whitefly attained their peak in the first week of September during 2006-07 (6.9 whiteflies/ 3 leaves/plant) and during 2007-08 (6.7 whiteflies/ 3 leaves/ plant), respectively.

Thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae)

Peak mean population of *S. dorsalis* was 1.65, 1.48 and 1.34 individuals/ 10 cm twig at flowering stage in district Jabalpur, Katni and Panna, while, in district Seoni, Rewa, Satna and Sidhi peak mean population of *S. dorsalis* was 1.37, 1.35, 1.34 and 1.48 individuals/ 10 cm twig, respectively at fruiting stage (Table 1 & Fig. 2).

Raizada (1965)^[24] observed that thrips were present throughout the year in Delhi, with the peak during spring and early summer, which confirm present findings. On the onset of rains during July – September the incidence was low, but the activity resumed in October causing severe damage. The author also observed considerable variation in the abundance of *S. dorsalis* in different years. In Andhra Pradesh, the *S. dorsalis* incidence was serious on chilli during October, February – March in Bihar, August to November in Delhi, Mysore, and Madhya Pradesh, and throughout the year in Tamil Nadu and Maharashtra.

Ningappa (1972)^[18] observed that the *S. dorsalis* was active throughout the year. The population reached its peak during October and thereafter gradually declined from November onwards reaching the lowest level in May. The difference in peak activity periods of *S. dorsalis* is evident in different states and locations.

Lee and Wen (1982)^[14] reported that though the incidence of thrips was found throughout the year, a higher population was recorded during the dry season.

Patel and Khatri (1982)^[20] noted *S. dorsalis* (Hood) in the epidemic form on chillies at Jabalpur, Madhya Pradesh, due to drought conditions in 1979.

Similar to present findings Narvaria (2003)^[16] studied the incidence of different insect pests on chilli at different stages of crop i.e., vegetative, flowering, fruiting, and maturity stages. Pest recorded were aphids, *Aphis craccivora* (Koch), thrips, *Scirtothrips dorsalis* (Hood), mites, *P. latus* (Banks), gall midge, *Asphondylia capsacin* (Barnes) on chilli crop. Aphids and thrips were present throughout the flowering and fruiting stages of the crop.

Comment [SM4]: Author repeatedly mentioned the word "peak mean population" in the results. Whether its peak population or mean of samples ?

Similar to present findings Meena et al. (2013)^[15] reported that the thrips (*S. dorsalis* Hood) appeared on chilli crop soon after transplanting. The peak population of thrips (14.5 and 14.7 /3 leaves /plant) was recorded in the first week of October.

Jassid/Leafhoppers, *Amrasca biguttula biguttula* (Ishida) (Hemiptera: Cicadellidae)

Peak mean population of *A. biguttula biguttula* were 3.14, 3.80, 3.49, 3.14, 3.18, 3.40 and 2.98 individuals/ 10 cm twig at fruiting stage (Table 1 & Fig. 3).

Broad mite, *Polyphagotarsonemus latus* (Acari: Tarsonemidae)

Peak mean populations of *P. latus* were recorded 0.86, 1.01, 0.92, 0.99, 0.95, 1.13 and 0.96 mites/ leaf at fruiting stage (Table 1 & Fig. 4).

Similar to present findings Meena et al. (2013)^[15] reported that the mites (*P. latus* Banks) appeared on chilli crop soon after transplanting. Mites population reached its peak in the second week of September (9.2 and 9.0 mites/ 3 leaves/ plant) during both the years.

Fruit borer, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae)

Peak mean populations of *H. armigera* were 1.13, 0.43, 0.53, 0.62, 1.28, 0.86 and 1.19 larvae/ plant at fruiting stage (Table 1 & Fig. 5).

Transverse ladybird beetle, *Coccinella transversalis* Fabricius (Coleoptera: Coccinellidae)

Peak mean populations of *C. transversalis* were 1.80, 2.25, 2.32, 1.85, 1.88, 2.36 and 1.67 beetles/ plant at fruiting stage (Table 2 & Fig. 6).

Leaf curl (% leaves infestation) on chilli

Pooled data revealed that incidences of the leaf curl (% leaves infestation) were 27.28, 32.43, 33.33, 28.45, 36.03, 25.53, and 36.19 % at the fruiting stage in the mentioned districts of the zone (Table 2 & Fig. 7).

Venzon et al. (2006)^[32] noted at Brazil the main pests of chillies, which included mites (*Polyphagotarsonemus latus* and *Tetranychus* spp.), aphids, thrips, *Bemisia tabaci*, the gelechiid *Gnorimoschema barsaniella*, *Neosilba* sp., and the noctuid *Agrotis ipsilon*.

Ghulam et al. (2014)^[9] reported a total of 7 species i.e. aphid, jassid, thrips, whitefly, mealy bugs, termites, and fruit borers at different growth stages.

Pandey (2014)^[19] reported 2 major groups of insect pests in chilli. The first recorded on the vegetative stage included aphids, *Aphis gossypii* (Glover) (Hemiptera: Aphididae) and thrips, *Scirtothrips dorsalis* (Hood) (Thysanoptera: Thripidae) that remained on the crop up to maturity. The second major group was of Lepidopteron borer i.e. chilli fruit borer, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) observed during the reproductive stage to maturity of the crop, similar major pests were observed in the present experiment.

Comment [SM5]: The references of Pandey (2014); Harne (2014), etc. were explained in too details as like thesis results Author should cite the relevant references and relevant results ... weekly incidence citation is irrelevant to the present study.

Seasonal incidence of insect pests on chilli crop revealed chilli thrips, *S. dorsalis* during 11th SW and was available up to 21st SW. The mean thrips population increasing from 11th SW with an average (0.08 thrips/ 6 leaves) and reached its peak (0.47 thrips /6 leaves) during 12th SW. After 20th SW there was a gradual decline in the mean thrips population and was observed up to 21st SW with an average population of 2.50 thrips /6 leaves. The infestation of the fruit borer, *H. armigera* started in the 12th SW with an average of 0.38 larva/plant. The gradual increasing trend in the population of the fruit borer was observed and reached its peak at 21st SW with an average of 2.17 larvae/plant. In the present experiment also the population of *H. armigera* remained below 2 larvae/plant.

Harne (2014)^[11] reported four species of insect pests and one natural enemy. Whitefly, *B. tabaci*, and thrips, *S. dorsalis* were first observed seven days after transplanting (SMW 45) and remained active up to the maturity stage of the crop. Whiteflies remained active throughout the crop season (SMW 45 to SMW 14) with two distinct population peaks, first during SMW (standard meteorological week) 49 (3.46 individuals/ sample) & second during SMW 12 (2.24 individual/sample). Thrips remained active throughout the crop season (SMW 45 to SMW 14) with two distinct population peaks, first during SMW 10 (3 individuals/ sample) and the second during SMW 12 (2.64 individual/sample). Fruit borer, *H. armigera* was first observed in the crop 119 days after transplanting (SMW 9) at maturity stage and remained active till harvest. The pest remained active from SMW 9 to 14 with two distinct population peaks, first during SMW 10 (1.1 individual/ sample) and the second during SMW 13 (0.82 individual/sample). A ladybird beetle, *Coccinella septumpunctata* was first observed in the crop 63 days after transplanting (SMW 1) at the reproductive stage and remained active up to the third week of March. It remained active all through the crop season (SMW 1 to SMW 14) with peak population during SMW 5 (3.5 individuals/ sample). Leaf curl incidence commenced from 3rd December to 23rd March during the crop period. The studies were conducted at Jabalpur and confirm the present trend of incidence of insect-pests.

Roopa and Kumar (2014)^[26] reported a total of 10 species of insects and mites on the crop at Bengaluru condition. They recorded species belonging to 8 different families in six different orders. The insect pests included *Scirtothrips dorsalis*, *Myzus persicae*, *Trialeurodes vaporariorum*, *Attractomorpha crenulata*, *Monolepta signata*, *Myllocerus discolor*, *Thysanoplusia ni*, *Spodoptera litura*, *Helicoverpa armigera* and one mite pest *Polyphagotarsonemus latus*. *S. dorsalis* and *H. armigera* were the predominant species.

Chintkuntlawar et al. (2015)^[8] conducted experiment at Jabalpur (M.P.) during the winter season of 2009-10. In chilli, six species of insect pests and two species of coccinellid

predator, and one braconid parasitoid of aphid were enumerated. Whitefly, thrips, aphids, jassids, *Helicoverpa armigera*, and *Spodoptera litura* appeared on the crop.

Similar to present findings Asma and Hanumantharaya (2015)^[6] surveyed chilli and recorded insect, mite pests and their natural enemies at selected talukas of Chikmagalur district (Mudigere, Chikmagalur, and Kadur), Karnataka, India. During the survey, they found peak incidence of thrips, *Scirtothrips dorsalis* Hood and mites, *Polyphagotarsonemus latus* Banks during May at Mudigere, Chikmagalur, and Kadur. The peak leaf curl incidence due to thrips and mites were noticed during April at Mudigere, during May at both, Chikmagalur and Kadur. The population of fruit borers (*Helicoverpa armigera* Hubner and *Spodoptera litura* Fabricius) and percent infestation due to fruit borers was noticed in May at Mudigere, Chikmagalur, and Kadur.

Yadav et al. (2017)^[33] observed insect pest succession on chilli crops. Four insect species viz., thrips (*Scirtothrips dorsalis*), aphid (*Aphis gossypii*), whitefly (*Bemisia tabaci*), fruit borer (*Helicoverpa armigera*), and mite (*Polyphagotarsonemus latus*) were noticed causing damage at various growth stages of the crop from vegetative to fruiting stages (February to June). The peak population of thrips (*Scirtothrips dorsalis* Hood), whiteflies (*Bemisia tabaci* Genn.), and fruit borer (*Helicoverpa armigera*) were observed on chilli crop from mid-April to mid-May with 45.86, 6.28, and 1.56 insects per plant, respectively. Their findings indicate the same activity periods as observed in the present survey.

References

1. Anonymous. 2009. Post-harvest profile of chilli. Government of India, Ministry of Agriculture, Department of Agriculture & Cooperation, Directorate of Marketing & Inspection, Branch Head Office, Nagpur, page 8, <https://agmarknet.gov.in/Others/preface-chhilli.pdf>.
2. Anonymous. 2013. <http://faostat.fao.org/site>
3. Anonymous. 2018a. Agriculture statistics at a glance 2018. Page.202.
4. Anonymous. 2018b. Horticulture statistics at a glance 2018. Page.210, 241, 194, 293 and 456.
5. Anonymous. 2019. [http://nhb.gov.in/statistics/State_Level/2018-19\(1st%20Adv\).pdf](http://nhb.gov.in/statistics/State_Level/2018-19(1st%20Adv).pdf). 1st advance estimates, 2018-19.
6. Asma A and Hanumantharaya L. 2015. Survey of insect and mite pests of chilli under the hill zone of Karnataka. Journal of Experimental Zoology 18(1): 293-297.
7. Berke T and Sheih SC. Chilli peppers in Asia. Capsicum and Egg Plant Newsletter. 2000.19:38-41.
8. Chintkuntlawar PS, Pawar UA, and Saxena AK. 2015. Insect pest complex of chilli, *Capsicum annum* L. and their natural enemies in Jabalpur. International Journal of Plant Protection 8(2): 270-278.

9. Ghulam AB, Mir A, Juma KB, Juma KT, Ghulam R, and Muhammad HT. 2014. Survey of insect pests and predators on chilli crop. Life Sciences International Journal 8(1-4): 3071-3074.
10. Gill HS. Improved technologies for chilli production. Indian Cocoa Arecanut and spices Journal. 1989; 12:118-119.
11. Harne A. Studies on insect-pests incidence on chilli, *Capsicum annum* L., and evaluation of insecticides for their management. M.Sc. Agriculture (Entomology), thesis submitted to JNKVV, Jabalpur, (M.P.). 2014; pp: 35, 39 & 25.
12. Kenyon L, Kumar S, Tsai WS, and Hughes JA. 2014. Virus diseases of peppers (*Capsicum* spp.) and their control. Advance Virus Research 90: 297.
13. Kumar R, Kumar V, Sreenu K, and Sairam RP. 2016. Epidemiology and diagnosis of chilli leaf curl virus in Central India, a major chilli growing region. Indian Phytopathology 69 (4S): 61-64.
14. Lee US and Wen HC. 1982. Seasonal occurrence and injury caused by thrips and their control. Plant Protection Bulletin, Taiwan 24: 179-182.
15. Meena RS, Ameta OP, and Meena BL. Population dynamics of sucking pests and their correlation with weather parameters in chilli, *Capsicum annum* L. crop. The Bioscan. 2013; 8(1): 177-180.
16. Narvaria BS. 2003. Evaluation of botanical products against pest complex of chilli, *Capsicum annum* L. M.Sc. (Agri) thesis, JNKVV, Jabalpur (M.P.).
17. Nelson SJ and Natarajan S. Economic threshold level of thrips in semi-dry chilli. South Indian Horticulture. 1994; 42(5):336-338.
18. Ningappa MS. 1972. Studies on the role of *Scirtothrips dorsalis* (Hood) (Thysanoptera: Thripidae) and *Polyphagotarsonemus latus* (Banks) (Acarina: Tarsonemidae) in causing leaf curl and their control. M.Sc (Agri) Thesis, University of Agricultural Sciences, Bangalore pp 64.
19. Pandey A. Study on insect pest complex of chilli and their management. M.Sc. Agriculture (Entomology), thesis submitted to JNKVV, Jabalpur, (M.P.). 2014; pp: 21-23.
20. Patel RK and Khatri AK. 1982. Note on the efficacy of insecticides against chilli thrips. JNKVV, Research Journal 16 (3): 274 – 275.
21. Patel VN and Gupta HCL. Estimation of losses and management of thrips infesting chillies. In National Seminar on "Entomology in 21st Century" Biodiversity, Sustainability, Environmental Safety, and Human Health. Rajasthan Agriculture University, Udaipur. 1998; pp 99.
22. Pawar SS, Bharude NV, Sonone SS, Deshmukh RS, Raut AK, Umekar AR. 2011. Chillies as food, spice, and medicine: A Perspective International Journal of Pharmacy and Biological Science 1(3): 311-318.
23. Pena JE and Bullock RC. Effects of the feeding of broad mite (Acari: Tarsonemidae) on vegetative plant growth. The Florida Entomologist. 1994; 77(1):180-184.
24. Raizada U. 1965. Life history of *Scirtothrips dorsalis* Hood with detailed external morphology of the immature stage. Bulletin of Entomology 6: 30-49.
25. Reddy DNR and Puttaswamy. Pest infesting chilli (*Capsicum annum* L.) in the nursery. Mysore Journal of Agriculture Science. 1983; 17(3):122-125.

26. Roopa M and Kumar ACT. 2014. Seasonal incidence of pests of capsicum in Bangalore conditions of Karnataka, India. *Global Journal of Biology, Agriculture & Health Sciences* 3(3): 203-207.
27. Senanayake DMJB, Varma A, and Mandal B. 2012. Virus-vector relationships, host range, detection, and sequence comparison of chilli leaf curl virus associated with an epidemic of leaf curl disease of chilli in Jodhpur, India. *Journal of Phytopathology* 160: 146-155.
28. Sorenson KA. Vegetable insect pest management. 2005; www.ces.ncsu.edu/depts/ent/notes.
29. Suresh LM, Malathi VG, and Shivanna. 2013. Molecular detection of begomoviruses associated with a new yellow leaf crumple disease of cucumber in Maharashtra, India. *Phytopathology* 66(3): 294-301.
30. Varadharajan S. Studies on host plant resistance and biology of chilli thrips, *Scirtothrips dorsalis* Hood. M.Sc. (Agri.) thesis submitted to Annamalai University, Annamalaiagar, Tamil Nadu (India). 1994; Vegetables/veg37.html-11k.
31. Venkatesh HM, Muniyappa V, Ravi KS, and Prasad K. 1998. Management of chilli leaf curl complex. *Proceedings of the First National Symposium on Integrated Pest Management (IPM) in Horticultural Crops.*, Bangalore, pp: 111-117.
32. Venzon M, de Oliveira CHCM, Rosado MdaC and Pallini Filho A. 2006. Pests associated with chilli crops and management strategies. *Informe. Agropecuario*. 27(235): 75-86.
33. Yadav LK, Deole S, Yadu YK, and Gauraha R. 2017. Rabi - summer chilli crop-the spectrum of major insect pests. *International Journal of Plant Protection* 10(1): 47-51.
34. Zehra SB, Asif A, Sharma A, Shakeela S, Azra L, Zaffar B, Mohit H, and Rathore JP. 2017. Chilli leaf curl virus an emerging threat to chilli in India. *International Journal of Pure and Applied Bioscience* 5 (5): 404-414.

Table 1: Status of insect pests ~~on-of~~ chilli ~~crop at-in~~ different districts during Rabi season (2017-18 and 2018-19) in Kymore Plateau & Satpura Hills zone of Madhya Pradesh

Districts & crop stages		Mean population /sample*														
		<i>B. tabaci</i>			<i>S. dorsalis</i>			<i>A. biguttula biguttula</i>			<i>P. latus</i>			<i>H. armigera</i>		
		2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Seoni	Vegetative	1.19	1.28	1.23	1.05	1.27	1.16	1.36	1.34	1.35	0.00	0.00	0.00	0.00	0.00	0.00
	Flowering	2.84	2.88	2.86	1.24	1.43	1.33	1.63	1.51	1.57	0.84	0.62	0.73	0.00	0.00	0.00
	Fruiting	1.29	1.24	1.26	1.35	1.39	1.37	3.24	3.04	3.14	0.98	0.75	0.86	1.07	1.20	1.13
Jabalpur	Vegetative	1.18	1.11	1.14	1.13	0.93	1.03	0.38	0.39	0.38	0.00	0.00	0.00	0.00	0.00	0.00
	Flowering	2.63	2.27	2.45	1.75	1.55	1.65	1.41	1.43	1.42	0.45	0.51	0.48	0.00	0.00	0.00
	Fruiting	1.02	1.17	1.09	1.45	1.25	1.35	3.78	3.82	3.80	1.01	1.02	1.01	0.45	0.40	0.43
Katni	Vegetative	1.17	0.97	1.07	1.03	1.13	1.08	0.49	0.55	0.52	0.00	0.00	0.00	0.00	0.00	0.00
	Flowering	2.62	2.72	2.67	1.44	1.52	1.48	1.18	1.23	1.20	0.46	0.47	0.47	0.00	0.00	0.00
	Fruiting	1.16	1.03	1.09	1.38	1.34	1.36	3.56	3.41	3.49	0.99	0.86	0.92	0.54	0.52	0.53
Rewa	Vegetative	1.17	1.02	1.10	1.18	1.13	1.16	1.20	0.55	0.87	0.00	0.00	0.00	0.00	0.00	0.00
	Flowering	2.77	2.81	2.79	1.31	1.20	1.26	1.39	1.33	1.36	0.51	0.54	0.52	0.00	0.00	0.00
	Fruiting	1.19	1.09	1.14	1.31	1.38	1.35	3.12	3.17	3.14	0.96	1.02	0.99	0.58	0.66	0.62
Satna	Vegetative	1.22	1.15	1.18	1.15	1.15	1.15	1.34	1.28	1.31	0.00	0.00	0.00	0.00	0.00	0.00
	Flowering	2.88	2.93	2.90	1.34	1.25	1.29	1.46	1.47	1.47	0.52	0.63	0.57	0.00	0.00	0.00
	Fruiting	1.32	1.24	1.28	1.35	1.34	1.34	3.18	3.19	3.18	0.85	1.06	0.95	1.18	1.38	1.28
Panna	Vegetative	1.12	1.18	1.15	1.01	1.11	1.06	0.46	0.52	0.49	0.00	0.00	0.00	0.00	0.00	0.00
	Flowering	2.82	2.91	2.86	1.37	1.31	1.34	1.20	1.13	1.16	0.30	0.41	0.35	0.00	0.00	0.00
	Fruiting	1.21	1.41	1.31	1.39	1.15	1.27	3.44	3.36	3.40	1.16	1.10	1.13	0.90	0.83	0.86
Sidhi	Vegetative	1.02	0.97	0.99	1.02	1.28	1.15	1.28	1.26	1.27	0.00	0.00	0.00	0.00	0.00	0.00
	Flowering	2.74	2.66	2.70	1.24	1.31	1.28	1.49	1.47	1.48	0.72	0.87	0.79	0.00	0.00	0.00
	Fruiting	1.21	1.34	1.27	1.44	1.53	1.48	3.23	2.73	2.98	0.97	0.83	0.90	1.05	1.32	1.19

*Mean of 4 locations

Comment [SM6]: Instead of writing population per sample, it may be expressed in exact units like insects / twig or insects/ 10 cm twig etc .

Table 2: Status of natural enemies and leaf curl incidence during *Rabi* season (2017-18 and 2018-19) in Kymore Plateau & Satpura Hills zone of Madhya Pradesh

Districts / Crop stages Stages of crop		Mean population /sample^{1*}					
		<i>Coccinella transversalis</i>			Leaf curl (% leaves infestation)		
		2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Seoni	Vegetative	0.00	0.00	0.00	7.95	10.64	9.29
	Flowering	0.00	0.66	0.33	17.79	21.09	19.44
	Fruiting	1.74	1.87	1.80	26.33	28.23	27.28
Jabalpur	Vegetative	0.00	0.00	0.00	14.44	12.08	13.26
	Flowering	0.00	0.43	0.22	24.26	25.70	24.98
	Fruiting	2.31	2.20	2.25	33.60	31.26	32.43
Katni	Vegetative	0.00	0.00	0.00	16.08	15.84	15.96
	Flowering	0.00	0.40	0.20	25.25	26.03	25.64
	Fruiting	2.30	2.35	2.32	34.13	32.53	33.33
Rewa	Vegetative	0.00	0.00	0.00	8.84	11.89	10.37
	Flowering	0.00	0.49	0.24	17.16	21.19	19.17
	Fruiting	1.66	2.04	1.85	26.06	30.84	28.45
Satna	Vegetative	0.00	0.00	0.00	11.59	14.18	12.88
	Flowering	0.00	0.65	0.32	31.02	32.12	31.57
	Fruiting	1.83	1.94	1.88	36.18	35.87	36.03
Panna	Vegetative	0.00	0.00	0.00	10.70	13.30	12.00
	Flowering	0.00	0.51	0.25	19.87	22.90	21.38
	Fruiting	2.34	2.39	2.36	23.02	28.03	25.53
Sidhi	Vegetative	0.00	0.00	0.00	15.59	22.20	18.90
	Flowering	0.00	0.76	0.38	23.28	24.53	23.90
	Fruiting	1.68	1.67	1.67	34.15	38.23	36.19

*Mean of 4 locations

Comment [SM7]: Express in proper unit

District wise pooled population trend of individual insect pests at various stages of the crop during *Rabi* season 2017-18 and 2018-19

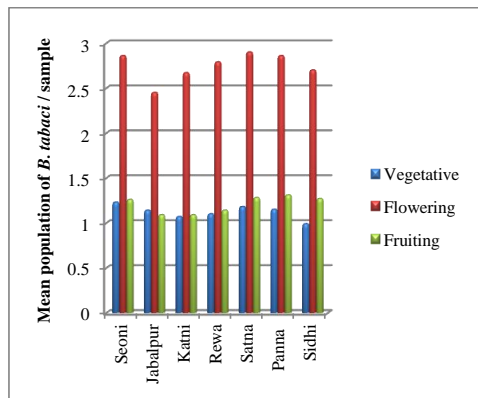


Fig. 1: Population trend of *B. tabaci* on chilli

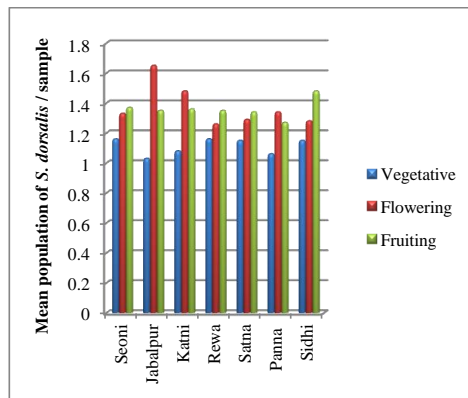


Fig. 2: Population trend of *S. dorsalis* on chilli

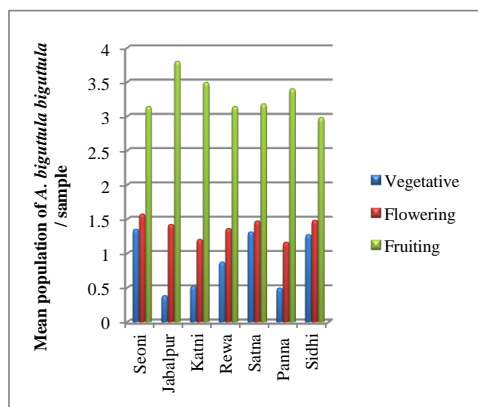


Fig. 3: Population trend of *A. biguttula biguttula* on chilli

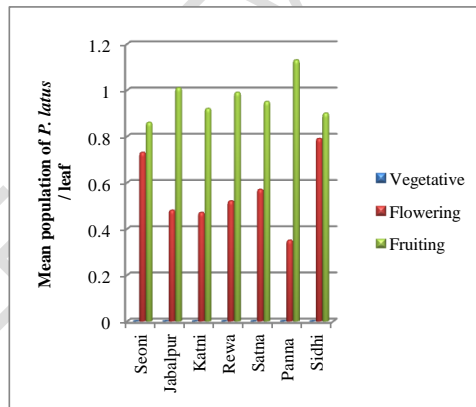


Fig. 4: Population trend of *P. latus* on chilli

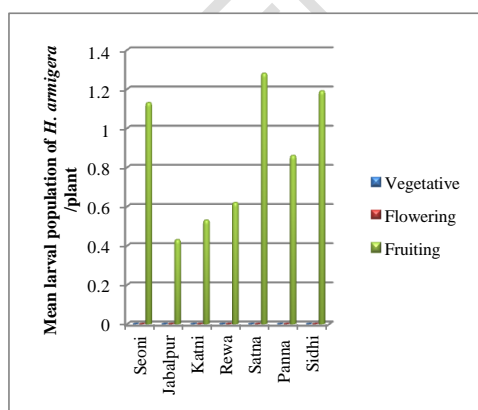


Fig. 5: Population trend of *H. armigera* on chilli

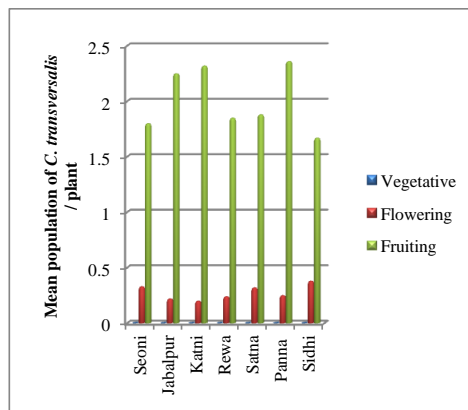


Fig. 6: Population trend of *C. transversalis* on chilli

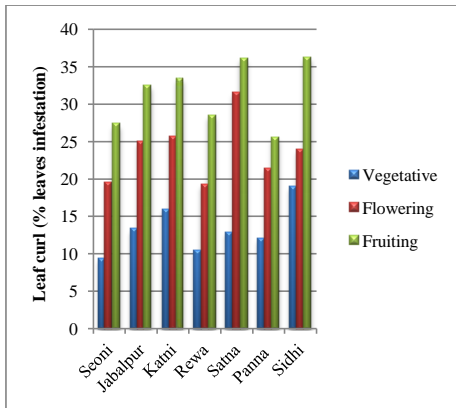


Fig. 7: Leaf curl incidence trend on chilli