SUCKING PEST COMPLEX OF CHRYSANTHEMUM (*Dendranthema grandiflora* BORKH) AND THEIR MANAGEMENT

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CERTIFICATE

This is to certify that the thesis entitled "SUCKING PEST COMPLEX OF CHRYSANTHEMUM (*Dendranthema grandiflora* Borkh) AND THEIR MANAGEMENT" submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY** to the College of Agriculture, Shivamogga, University of Agricultural and Horticultural Sciences, Shivamogga is a bonafide record of research work carried out by **Miss SMITHA, O.R., ID. No. MA1TAF0155** (odiyanasmitha369@gmail.com) during the period of study in this university under my guidance and supervision and no part of this thesis has previously formed the basis for the award of any other degree, diploma, associateship, fellowship or any other similar titles.

Shivamogga
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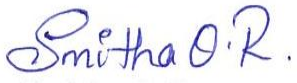

Smitha, O.R.

SUCKING PEST COMPLEX OF CHRYSANTHEMUM, *Dendranthema grandiflora* BORKH AND THEIR MANAGEMENT

SMITHA O.R.

ABSTRACT

Investigation on sucking pest complex of chrysanthemum, *Dendranthema grandiflora* Borkh and their management was carried out at Karnataka State Department of Horticulture (KSDH), Shivamogga, Karnataka during 2017-2018. During the study, two thrips species *viz*., *Haplothrips gowdeyi* Franklin and *Microcephalothrips abdomanalis* Crawford, two aphid species *viz., Macrosiphoniella sanbornii* Gillette and *Aphis gossypii* Glover and a whitefly species *Bemesia tabaci* Gennadius were found to infest chrysanthemum. During survey, maximum aphid population was recorded in Shivamogga district (9.57/3 leaves) during the first fortnight of January. The maximum mean number of whiteflies (5.25/3 leaves) was recorded during the first fortnight of September in Chitradurga district. The peak population of thrips was noticed during first fortnight of February in Chitradurga district (8.95 thrips/flower). Studies on the population dynamics of sucking pests revealed that the peak infestation of aphid was observed during second fortnight of January (42.59/3leaves), Both maximum and minimum temperature, relative humidity and rainfall were found to exert a significant negative influence on the aphid population. The peak thrips incidence (6.15 thrips/flower) was observed during first fortnight of February. The thrips incidence was positively correlated with both maximum temperature and minimum temperature but has negative correlation with maximum and minimum relative humidity and rainfall. The insecticidal treatments imidacloprid 17.8 SL, acetamiprid 20 SP and flonicamid 50 WDG were found to be effective in managing the sucking pests. However, all the insecticidal treatments under evaluation were significantly superior in recording lower population of sucking pests compared to untreated check.

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ಸೇವಂತಿಗೆ, *ಡೆಂಡ್ರಾಂಥೆಮ ಗ್ರ್ಯಾಂಫ್ಲೋರಾ* ಬೊರ್ಖ್ ಬೆಳೆಯಲ್ಲಿ ಬರುವ ರಸ ಹೀರುವ ಕೀಟಗಳ ಸಂಕೀರ್ಣತೆ ಮತ್ತು ಅವುಗಳ ನಿರ್ವಹಣೆ

(ಸ್ಮಿತಾ ಓ. ಆರ್.)

ಸಾರಾಂಶ

ಸೇವಂತಿಗೆ ಬೆಳೆಯಲ್ಲಿ ಬರುವ ರಸ ಹೀರುವ ಕೀಟಗಳ ಸಂಕೀರ್ಣತೆ ಮತ್ತು ಅವುಗಳ ನಿರ್ವಹಣೆಯನ್ನು ೨೦೧೭-೧೮ ರಲ್ಲಿ ಕರ್ನಾಟಕ ರಾಜ್ಯ ತೋಟಗಾರಿಕೆ ಇಲಾಖೆ, ಶಿವಮೊಗ್ಗದಲ್ಲಿ ಕೈಗೊಳ್ಳಲಾಯಿತು. ಒಟ್ಟಾರೆ ಎರಡು ಜಾತಿಯ ಥ್ರಿಪ್ಸ್ (*ಹ್ಯಾಪ್ಲೊಥ್ರಿಪ್ಸ್ ಗೌಡೇಯಿ ಫ್ರಾಂಕ್ಲಿನ್, ಮೈಕ್ರೋಸೆಫಾಲೊಥ್ರಿಪ್ಸ್ ಅಬ್ಡೋಮೆನಾಲಿಸ್*), ಎರಡು ಜಾತಿಯ ಸಸ್ಯಹೇನು (*ಮ್ಯಾಕ್ರೊಸಿಫೊನಿಯಲ್ಲಾ ಸ್ಯಾನ್ಬೊರ್ನಿ, ಅಫಿಸ್ ಗಾಸಿಪಿ*) ಹಾಗೂ, ಒಂದು ಜಾತಿಯ ಬಿಳಿನೊಣ (*ಬೆಮಿಸಿಯ ಟಬಾಸಿ*) ವರ್ಗಗಳನ್ನು ದಾಖಲಿಸಲಾಯಿತು. ರಸ ಹೀರುವ ಕೀಟಗಳ ಸಮೀಕ್ಷೆ ಸಮಯದಲ್ಲಿ ಅತೀ ಹೆಚ್ಚು ಸಸ್ಯಹೇನಿನ ತೀವ್ರತೆಯು (೯.೫೭/ ಮೂರು ಎಲೆಗಳಿಗೆ) ಜನವರಿ ತಿಂಗಳ ಮೊದಲನೆ ಪಾಕ್ಷಿಕದಲ್ಲಿ ಶಿವಮೊಗ್ಗ ಜಿಲ್ಲೆಯಲ್ಲಿ ಕಂಡುಬಂದಿದೆ, ಥ್ರಿಪ್ಸ್ ತೀವ್ರತೆಯು ಅಧಿಕವಾಗಿ ಫೆಬ್ರವರಿ ತಿಂಗಳ ಮೊದಲನೆ ಪಾಕ್ಷಿಕದಲ್ಲಿ (೮.೯೫ ಥ್ರಿಪ್ಸ್/ ಹೂವು) ಹಾಗೂ ಬಿಳಿನೊಣದ ತೀವ್ರತೆಯು ಅಧಿಕವಾಗಿ ಸೆಪ್ಟೆಂಬರ್ ತಿಂಗಳ ಮೊದಲನೆ ಪಾಕ್ಷಿಕದಲ್ಲಿ (೫.೨೫/ ಮೂರು ಎಲೆಗಳಿಗೆ) ಚಿತ್ರದುರ್ಗ ಜಿಲ್ಲೆಯಲ್ಲಿ ಕಂಡುಬಂದಿದೆ. ಸೇವಂತಿಗೆಯಲ್ಲಿ ಬರುವ ರಸ ಹೀರುವ ಕೀಟಗಳ ಸಂಖ್ಯಾಸ್ಥಿತಿಯ ಅಧ್ಯಯನದಲ್ಲಿ ಸಸ್ಯಹೇನಿನ ಸಂಖ್ಯೆ ಅತೀ ಹೆಚ್ಚಾಗಿ ಜನವರಿ ತಿಂಗಳಲ್ಲಿ(೪೨.೫೯/ಮೂರು ಎಲೆಗಳಿಗೆ) ಕಂಡುಬಂದಿದ್ದು ಗರಿಷ್ಠ ಮತ್ತು ಕನಿಷ್ಠ ತಾಪಮಾನಗಳೊಂದಿಗೆ ಗಮನಾರ್ಹ ಋಣಾತ್ಮಕ ಸಂಬಂಧವನ್ನು ಹೊಂದಿದೆ. ಥ್ರಿಪ್ಸ್ ಸಂಖ್ಯೆಯು ಅತೀ ಹೆಚ್ಚಾಗಿ ಫೆಬ್ರವರಿ ತಿಂಗಳಲ್ಲಿ ಕಂಡುಬಂದಿದ್ದು(೬.೧೫ ಥ್ರಿಪ್ಸ್/ ಹೂವು) ಗರಿಷ್ಠ ಮತ್ತು ಕನಿಷ್ಠ ತಾಪಮಾನಗಳೊಂದಿಗೆ ಧನಾತ್ಮಕ ಸಂಬಂಧವನ್ನು ಹೊಂದಿದೆ. ಸೇವಂತಿಗೆಯಲ್ಲಿ ಬರುವ ರಸ ಹೀರುವ ಕೀಟಗಳ ಹತೋಟಿಗೆ ಬಳಸಿದ ವಿವಿಧ ಕೀಟನಾಶಕಗಳ ಮೌಲ್ಯಮಾಪನದ ನಂತರ ಇಮಿಡಾಕ್ಲೋಪ್ರಿಡ್ ೧೭.೮ ಎಸ್ಎಲ್, ಅಸಿಟಾಮಿಪ್ರಿಡ್ ೨೦ ಎಸ್ಪಿ ಮತ್ತು ಫ್ಲೋನಿಕಾಮಿಡ್ ೫೦ ಡಬ್ಲ್ಯೂಡಿಜಿ ಕೀಟನಾಶಕವು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ಪೀಡೆಗಳನ್ನು ಹತೋಟಿಯಲ್ಲಿಟ್ಟಿರುತ್ತದೆ.

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INTRODUCTION

I INTRODUCTION

In India, floriculture is emerging as an important commercial enterprise. A lot of importance has been given to this sector due to its multiple uses *viz.*, satisfying the aesthetic needs of the people, creating more employment, ensuring higher rate of returns to rural people and facilitating to earn higher foreign exchange. More specifically, they are being used as raw materials in the manufacture of essence, perfumes, medicines and confectioneries for direct consumption by the society. Hence, many describe it as "Rosy Business Sector", "Blossoming Industry", "Thrust Area" etc.

Among the several floriculture crops, Chrysanthemum (*Dendranthema grandiflora* Borkh) is an important and commercially grown crop which is popularly called the "queen of the east". The word chrysanthemum is derived from two Greek word *chrysos* means gold and *anthemon* means flower. It belongs to the family Asteraceae and recognized as a potent flower crop in many countries and widely grown in open fields. It is a native of China and was under cultivation even before 500 BC. It is often described as the "autumn queen" as it blooms in November-December. Chrysanthemum is the national flower of Japan and it occupies second rank in the international cut flower trade next to rose. The year 1995-96 was celebrated as an international year of chrysanthemum.

Chrysanthemum ranks second to rose among top ten cut flowers in the world trade of flower crops preferred particularly for its range of shapes and size of flower, brilliant colour tones and long lasting flower life (Brahma, 2002). In India it has been recognized as one among the five commercially important flower crops (Janakiram *et al.*, 2006).

In India, chrysanthemum is grown for cut flowers, loose flowers, as potted plants and as border plants in the garden. In North India, various hues of red, yellow, white and purple coloured chrysanthemums are grown in abundance for decorating the landscape either in the ground or in pots. But in Southern India mostly the yellow coloured flowers are preferred and grown as loose flowers for trade. It is a photo sensitive crop, which requires long days for vegetative growth and short days for flowering. Growth and flowering of chrysanthemum is very much influenced by light and temperature. This phenomenon can be used for determining the planting time under different agroclimatic conditions for optimizing the yield of flowers.

Apart from the aesthetic value of chrysanthemum, it has several other uses such as the pyrethrum obtained from *Chrysanthemum cinerariaefolium* (Trev) is economically important as a natural source of insecticide. The flowers are

pulverized and the active components called pyrethrins which occur in the achenes are extracted and sold as an insecticide. Chrysanthemum plants have been shown to reduce indoor air pollution as given by NASA clean air study. Yellow or white chrysanthemum flowers of the species *C. morifolium* Ramat are boiled to make a tea in some parts of Asia, the resulting beverage is known simply as chrysanthemum tea.

The total area under chrysanthemum cultivation in India is 20090 hectare with the production of 188810 Metric Tons of loose flowers and 15.38 lakh cut flowers. The top ten states in floriculture are Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh, Himachal Pradesh, West Bengal, Maharashtra, Assam, Jammu and Kashmir and Telangana (NHB, 2015-16).

Karnataka stands second in terms of production next to Tamilnadu. The total area under production is 4429 hectare with the production and productivity being 54092 Metric Tons and 12.21 tons/ha, respectively (NHB, 2015-16).

Profitable production and quality of these flowers is affected by many insects and diseases causing economic loss to the growers. Diseases such as ascochyta ray blight, alternaria ray blight, bacterial leaf spot, powdery mildew, fusarium wilt and chlorotic mottle can be usually seen but the most important being damage caused by insect pests such as aphids, thrips, caterpillars, mites, whiteflies and leafminer. The productivity and marketability are decreasing considerably due to insect pest damage as pest scenario varies from place to place with the variation in the agro-climatic conditions of the locality.

Among these pests, chrysanthemum aphid, (*Macrosiphoniella sanborni* Gillette) causes direct damage through feeding on young shoot and leaves resulting in loss of vigour, stunted growth, yellowing and premature leaf fall and indirectly by sooty mold formation and transmission of chrysanthemum vein mottle virus and chrysanthemum virus B (Agrios, 1988).

Thrips species such as *Frankliniella schultzei* Trybom, *F. adadusta* Moulton, *F. aurea* Moulton, *F. helianthi* Moulton, *F. inutilis* Priesner, *F. minuta* Moulton, *F. celata* Priesner, *F. occidentalis* Priesner, *F. occidentalis* Priesner, *F. occidentalis* Pergande and *Thrips tabaci* Lindeman were found to damage flowers causing discoloured, withered and dried due to scorching and decreases the market value of the flowers (Daniel *et al.,* 2008). It also acts as a vector for Tospo viruses.

Chrysanthemum whitefly *(Bemesia tabaci* Gennadius) is another pest causing enormous economic loss mainly under green house condition. They suck the sap from undersurface of the leaf causing yellowing and mottling of the foliage followed by stunting, wilting and death if plants were heavily infested.

Chrysanthemum caterpillar (*Spodoptera litura* Fabricius), leaf folder (*Hedylepta indicate* Fabricius), bud borer (*Helicoverpa armigera* Hubner), hairy caterpillar (*Spilaretia oblique* Walker) were also found to damage chrysanthemum plants. Hence, it is imperative to know something about the pests which despoil and damage these plants and methods to combat the same (Butani, 1974). The use of good agricultural practices and integrated pest management strategies are being increasingly advocated in protected cultivation (Sabir *et al.*, 2010).

In this context, information on pest complex and succession in a specific agro-ecosystem is very much essential in devising pest management strategies which would not only economically feasible but also ecologically sound. However, such information on ornamental crops is scanty particularly from the state of Karnataka. In this context, studies regarding pest succession would help in planning management strategies as it clearly reveals the insect peak activity as well as insect free periods during crop growth period. Keeping in view, the importance of aphids and thrips in chrysanthemum production, and its management with new insecticides, the present study was undertaken with the following objectives:

Objectives of investigation

1. Survey on sucking pest complex of chrysanthemum
2. Population dynamics of sucking pest complex in chrysanthemum and
3. Efficacy of selected new insecticides against major sucking pests of chrysanthemum

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

The production of chrysanthemum is high but productivity and marketability are decreasing considerably due to insect-pest damage. In this context location specific studies regarding relative incidence of predominant insect pests is very much essential for devising economic and effective management practices. The literature on insect pests of chrysanthemum particularly in open field conditions is scanty and hence the related studies in other crops wherever relevant are presented in the brief review of literature below.

2.1 Survey on sucking pest complex of chrysanthemum

Ranganath *et al*. (2008) conducted survey to know the species composition of thrips occurring on grape foliage, inflorescence at Bijapur in Karnataka and Sangli in Maharashtra during January 2005 to January 2006. *Scirtothrips dorsalis* Hood constituted over 90 per cent of total thrips sampled from new flushes, inflorescence and berries in different stages during January, February, March and December 2005, respectively at Bijapur followed by *Thrips palmi* Karny (1.0- 4.3%).

Pal and Sarkar (2009) reported *Macrosiphoniella sanbornii* (Gillette) as the major sucking pest of chrysanthemum by conducting field survey in hilly regions of West Bengal.

Swamy *et al*. (2010) conducted roving survey to study the incidence of thrips on sunflower in five different sunflower growing districts of northern regions of Karnataka state, India *viz.,* Raichur, Koppal, Bellary, Bijapur and Gulbarga during August to January (2008-2009). The thrips species collected were identified as *T. palmi* Karny, *Bathrips melonicornis* (Shumsher), *Haplothrips gowdeyi* (Franklin), *Thrips hawaiiensis* (Morgan) and *Frankliniella schultzei* (Trybom). Among them, *T. Palmi* Karny was found to be predominant constituting major population.

Jyothirmai *et al*. (2011) conducted survey in different pulse growing region of Andhra Pradesh and recorded four species of virus transmitting thrips *viz., F. schultzei* Trybom, *Scirtothrips dorsalis* Hood, *Megalurothrips usitatus* (Bagnall) and *T. palmi* Karny.

Tillekaratne *et al.* (2011) conducted survey on thrips to know their distribution, host plant relationships and its damage on 1,000 plant species comprising crops, ornamental plants, weeds, shrubs and trees from 22 study sites. It was found that *Megalurothrips usitatus* (Bagnall), *T. palmi* Karny and *Haplothrips gowdeyi* Franklin were widely distributed. The grass infesting *Haplothrips spp., Microcephalothrips abdominalis* (Crawford), *M. usitatus* (Bagnall) and *S. dorsalis*

Hood had large number of host records. Their study showed the presence of 24 species of thrips belonging to 20 genera.

Akhtar and Azim (2013) conducted a preliminary taxonomic survey on thrips of Kashmir region. The thrips species collected belonged to suborder, Terebrantia and families Aeolothripidae, Thripidae and Phlaeothripidae.

Charan (2014) conducted survey on sucking pest complex of chrysanthemum in Telangana state and reported that leafminer, *Liriomyza trifolii* Burgess and aphids *Macrosiphoniella sanbornii* (Gillette) were found to affect the plants in the vegetative stage. Three species of thrips were observed during the reproductive stage of which *Frankliniella occidentalis* (Pergande) was the predominant species followed by *Frankliniella schultzei* (Trybom) and *Thrips palmi* Karny in the ratio of 63:28:9.

Tyagi and Kumar (2016) prepared a checklist of Thysanoptera from India with its distribution. Out of 739 species in 259 genera listed, India has 309 species in 116 genera of suborder Terebrantia and 430 species in 143 genera belonged to the suborder, Tubulifera.

2.2 Population dynamics of sucking pest complex in chrysanthemum

Several insects like leaf miners, aphids, thrips, whitefly and caterpillars have been found to affect chrysanthemum leaves and flowers**.**

Oetting *et al.* (1977) reported that aphid incidence and damage could be observed throughout the year on chrysanthemum but generally they were more numerous and damage would be severe during cooler months.

Kulat *et al*. (2000) conducted studies on seasonal monitoring of safflower aphids, *U. carthami* and revealed that though the population occurs throughout the crop growth period, it attained a peak during the second week of January with decline in temperature, and population declined thereafter with gradual rise in temperature. It was also observed that in high relative humidity levels, the population of aphids per plant was usually high, whereas under high population pressure the rainfall could not influence population decline.

Sumbad (2000) studied the seasonal incidence of pests of marigold and revealed that the peak appearance of the thrips was observed between January- May and was positively correlative with the maximum and minimum temperature during the study period.

Bade and Khadam (2001) reported first incidence of safflower aphid during the last week of November and continued until January. Cold temperature and

moderate relative humidity favoured the pest development. There was a significant and negative correlation between the aphid population per leaf of plant and minimum temperature.

Kamath and Hugar (2001) observed the mean maximum temperature of 28-30˚C and the minimum temperature of 13-16˚C and high relative humidity 83.4 per cent were the most conducive for safflower aphid multiplication. The mean maximum temperature coupled with relative humidity had significant negative correlation (r = -0.63) on aphid population. The mean minimum temperature alone had highly significant and positive correlation (r = 0.92 and 0.96, respectively) with aphids.

Jaskiewicz *et al*. (2001) reported that chrysanthemum aphid (*M. sanbornii*) acts as a vector for tomato aspermy cucumovirus (TAV) and chrysanthemum B carlavirus (CHVB).

Duraimurugan and Jagadish (2002) studied the seasonal incidence of *S. dorsalis* on local red rose during 1999-2000 and observed that incidence prevailed throughout the flowering period and reached its peak during first fortnight of April (42.81 thrips per flower). Thrips population was abundant during April and May and the incidence was significantly positively correlated with maximum temperature and sunshine hours but significantly negatively correlated with mean relative humidity and positively correlated with minimum temperature and negatively correlated with rain fall and wind velocity.

Cloyd (2003) observed the seasonal population dynamics of western flower thrips (*F. occidentalis*) by using blue coloured sticky traps on cut carnation in greenhouse condition. The study revealed that the highest thrips population was recorded from May to September and lowest thrips population was from November to March.

Gahukar (2003) observed that rose thrips, *S. dorsalis* Hood and *T. flavus* Schrank were high during January to March and were low during May to July.

Nagaraju *et al.* (2003) reported that the population of thrips and disease incidence on sunflower crop sown at different dates varied with different months and the disease was the highest in February.

Painkra *et al*. (2003) conducted field experiment to study the population dynamics of safflower aphid *U. carthami* and reported that the peak population was observed on 72 days old crop. Maximum and minimum temperature showed negative correlations with aphid population densities. The aphid population density

was negatively correlated with morning relative humidity, while evening relative humidity showed negative correlation.

Sadegian *et al.* (2003) determined biological characters and reproductive rates of chrysanthemum aphids on 2-4 leaved seedlings during august and September months of 1999-2000. The mean temperatures were 26.43˚C and 25.38 ^{0}C, respectively and relative humidity were 43.5, 28.6 per cent, respectively. Generation numbers, developmental time, daily fecundity, total fecundity and adult longevity in field conditions were found to be 15, 8.94, 2.71, 2.91 and 20.4, respectively.

Shivasharanayya and Nagaraju (2003) studied the correlation matrix on sunflower thrips count and weather parameters and virus disease incidence. They found that there was a positive correlation of mean number of thrips with maximum and minimum temperatures, bright sunshine hours and also with the disease incidence.

Duraimurugan and Jagadish (2004) evaluated seasonal incidence of *S.dorsalis* on rose from September 1999 to June 2000 and found thrips occurrence from February to May. The increase in temperature favored the multiplication of the pest. The population declined from June with the onset of rains. The study revealed that incidence was significantly positively correlated with maximum temperature and negatively correlated with rainfall and relative humidity.

Murphy and Broadbent (2004) described western flower thrips, *F. Occidentalis* (Pergande) (Thysanoptera; Thripidae), as a major pest of potted chrysanthemum (*D.grandiflora*) in Netherland.

Rajkumar *et al*. (2001) recorded four species of thrips infesting roses. The identified species of thrips were *F. schultzei* Trybom (80% in flowers), *S. dorsalis* Hood (80% in leaves), *Haplothrips ganglbaueri* Schmutz (15% in flowers) and *T. palmi* Karny (5% in flowers and 20% in leaves).

Mallapur *et al.* (2005) conducted studies to know the influence of meteorological parameters on the incidence of safflower aphid. The observations were recorded on aphid load and were correlated with corresponding values of various meteorological parameters. The aphid population was negatively correlated with maximum temperature, heavy rainfall and as the crop age advances. The average regression [r] value was 0.55 for six years.

Rhainds *et al*. (2007) reported that the relative intensity of damage caused by individual thrips decreased with increasing temperature, probably caused by thrips competition, reduced fecundity on depleted inflorescences.

Singh (2007) observed that minimum and maximum temperatures of 15 ˚C to 17 ˚C and 31 ˚C to 35 ˚C, respectively coupled with minimum and maximum RH of 21 to 30 and 69 to 81 per cent, respectively and rainfall of 31 mm during 5th standard week were more congenial for aphid population build up on safflower.

Nothangal *et al.* (2008) studied population dynamics of the polyphagous pest *F. occidentalis* (Pergande) on greenhouse grown chrysanthemum by using dynamic prediction model and reported that the thrips population growth was mainly dependent on temperature, population density and food availability.

Patil *et al.* (2008) revealed that the peak aphid population was observed at 83.4 per cent relative humidity. Lower relative humidity of 74.2 per cent and increase in temperature during first week of February set in a decline in aphid population. Mean maximum temperature coupled with relative humidity had significant negative correlation (r = - 0.63) on aphid population.

Shirisha and Singh (2008) found that the percentage infestation on safflower branches increased as the crop growth increased and there was a decline in the aphid population as the plant reached maturity.

Akashe *et al*. (2009) reported that the safflower aphid was more from December-January on prebranching stage of safflower crop, However, the maximum and minimum temperatures ranged between 30 ˚C to 35 ˚C and 14 ˚C to 17 ˚C, respectively were found most favourable for the rapid development of aphid on safflower.

Akashe *et al.* (2010) conducted field experiments to determine the effect of weather parameters on population dynamics of safflower aphid *U. compositae* revealed that low temperature and high humidity were conducive for the multiplication of this pest. Aphid population attained a peak of 147.5 aphids per 5 cm twig/plant in the 52nd SMW when the mean minimum and maximum temperatures, morning and evening relative humidity were 31.6 ˚C, 11.4 ˚C, 71 and 28 per cent respectively.

Nielsen *et al.* (2010) reported that two strains of western flower thrips *F. occidentalis* (Pergande) were repeatedly found in New Zealand. One strain was recorded in 1934 and it was most common in flowers of *Lupinus arboreus* Sims outdoors, the other strain was first recorded in New Zealand in 1992, and it was found mostly indoors on greenhouse crops.

Aliakbarpour and Salmah (2011) reported six thrips species on mango inflorescence *viz., T. hawaiiensis* (Morgan), *S. dorsalis* Hood, *F. schultzei* (Trybom),

M. usitatus Bagnall, *T. palmi* Karny and *Haplothrips* spp. from two localities of Penang Island, Malaysia. The thrips were found feeding on the petals, anthers, pollen and floral nectaries, resulting in the discolouration and malformation of panicles.

Pobozniak and Sobolewska (2011) conducted studies at Agriculture University in Cracow, Poland showed the presence of 16,058 adult thrips belonging to 22 Thysanoptera taxa from the flowers and inflorescences of 37 species of herbs. The polyphagous thrips species observed in flowers were: *T. fuscipennis* Haliday, *T. flavus* Schrank, *T. albopilosus* Uzel, *T. major* Uzel, *F. intonsa,* and *Aelothrips* spp. (predatory species). The flowers of *Salvia officinalis, Lavandula angustifolia, Nepeta cataria* and *Arnica Montana* were most infested with thrips.

Hazir and Ulusoy (2012) studied the occurrence and population fluctuation of thrips (Thysanoptera) and damage to nectaries in four orchards at two locations of Adana and Mersin in the east Mediterranean region of Turkey during 2005 and 2006. Direct sampling of nectarine flowers revealed presence of 12 thrips species with, western flower thrips, *F.occidentals* pergande. The most common and abundant species was followed by *T. tabaci* Lindeman and *T. major* Uzel.

Kikumura *et al.* (2012) observed eight thrips species belonging to genera *Frankliniella, Microphalothrips, Thrips* and S*cirtothrips* on chrysanthemum plants. Among them, *T. nigropilosus* was the predominant species irrespective of season, Island or cultivation environment, with its infestation frequency being 89 per cent of the fields in which thrips occurred.

Patil and Kamath (2012) reported that safflower aphid population was negatively correlated with maximum and minimum temperatures irrespective of dates of sowing.

Ali (2013) reported that the five aphid spp. on Rose were namely *Aphis fabae* Scopoli, *Aphis gossypii* (G.), *Macrosiphum rosae* (L.), *Myzus persicae* (Sulzer) and *Rhodobium porosum* (Sanderson). It was occurred that its populationon rose occured firstly in second week of January and the percentage of population reached maximum at June month.

Chau *et al.* (2013) observed that under greenhouse conditions rate of change in population density of *F.occidentalis* Pergande increased with fertilization level from 0 to 100 per cent of the standard fertilization level (375 ppm N) and thrips population was four times higher on plants fertilized with the standard level than on plants fertilized with zero per cent during first 4 weeks after inoculation.

Manner *et al*. (2013) reported that there was no difference in the total number of adults that emerged from growing media of high or low moisture content on any host plant. There were also no differences in the total number of thrips captured from chrysanthemum, gerbera and roses but about seven times the number of thrips were collected from flowering chrysanthemum compared with non flowering chrysanthemum.

Shakeel *et al*. (2014) reported that the population of aphid increased with decrease in temperature, lowest population was found on tomato (mean value 10) at temperature of 32.5°C and the highest population was recorded (mean value 16) at temperature of 27.5°C. Aphid dynamics were largely dependent on temperature and relative humidity, however aphid population was not significantly correlated with rainfall.

Gopal (2015) Studied species composition of chilli thrips during *Kharif* revealed that presence of *S. dorsalis* Hood, *F. schultzei* Trybom, *T. palmi* karny and *T. Hawaiiensis* Morgan belong to the family Thripidae of Terebrantia suborder and *H. verbasci* belongs to the Tubulifera suborder of phlaeothripidae family.

Ali (2017) reported that *A. gossypii* Glover was the most dominant species on chrysanthemum throughout the study period while *M. persicae* Sulzer is the least. Maximum abundance were found during spring (first week of March to the second week of April) while minimum abundance was found in the beginning of summer.

2.2. 1 Predators of chrysanthemum aphid and floral thrips:

Hirose (1991) and Hirose *et al.* (1993) reported that the most important predators observed in Hawaii were predatory thrips *F. vespiformis* and especially the minute pirate bug *Orius insidiosus* (Say) against *T. palmi* Karny.

Agostinelli *et al.* (1993) achieved good control of aphids in chrysanthemum by release of Cecidomyiid predator *Aphidoletes aphidimyza* and braconid parasitoid *Aphidius* spp. in summer and by release of *Chrysoperla carnea* in autumn when aphid numbers were high. Phytoseiid *Amblyseius cucumeris* and anthocorids *O. majuscules* were used to control *F. occidentalis* Pergande and *T. tabaci* Karny.

Numerous species of coccinellids are predators and major biological control agents of hemipterans such as aphids, mealybugs and scale insects, as well as thrips and mites in all parts of the world. The family of coccinellidae comprises some 5200 described species worldwide (Hawkeswood, 1987). Poorani (2002) has listed 400 species of coccinellids from Indian sub region, which includes the states of Uttar Pradesh and Uttarkhand.

Fransen *et al*. (1993) released *O. insidiosus* (Say) on chrysanthemum, rose and Saintpaulia for the control of *F. occidentalis* Pergande and it was noted that pest count was reduced on chrysanthemum and Saintpaulia but not on roses.

Behera *et al.* (1999) conducted a laboratory study to know the biology and feeding potential of *Coccinella septumpunctata* on *Macrosiphoniella sanbornii* (Gillette) at 27±2ºC and 70±5 per cent relative humidity. The egg larval, prepupal, pupal stages recorded were 2.41, 9.35, 0.73 and 3.53 days respectively and the adult longevity was 10-19 days in male and 26 to 35 days in female.

Bueno *et al.* (2003) achieved biological control of aphid and thrips population through the respective introduction of *Lysiphlebus testaceipes* (Cresson) and *O. insidiosus* (Say) in cut chrysanthemum crops in commercial greenhouses.

Silviera *et al.* (2004) evaluated the possibility of controlling the thrips by predator *O.insidiosus* (Say). Thrips infested potted chrysanthemums of cultivar White Reagan and Yellow Snowdon were exposed to *O.insidiosus* (Say). The number of thrips per plant increased from 2.0 to 7.0 after 6 weeks in control in absence of *O. insidiouss* (Say), while the thrips count per plant decreased from 2.0 to 0.2 in the presence of predator.

2.3 Efficacy of selected new insecticides against major sucking pests of chrysanthemum

Chung *et al.* (2000) reported that abamectin and imidacloprid were found to be effective against western flower thrips, *F. occidentalis* pergande in greenhouse egg plant.

Rathod (2003) evaluated the bioefficacy of acetamiprid 20 SP at different dosages against whiteflies and the results indicated that acetamiprid 20 SP @ 80 g a.i. per ha gave maximum protection to cotton against whiteflies.

Kendappa *et al.* (2004) evaluated certain new insecticides against the spiralling whitefly, *Aleurodicus dispersus* Rusell infesting cotton and found that buprofezin (Applaud 25 EC) 0.02 per cent and acetamiprid 0.01 per cent were the most effective in reducing nymphal population followed by acephate (0.1125%), triazophos (0.06%) and fenpropathrin (0.01%).

Reddy *et al.* (2005) reported that among seventeen insecticides tested against *Scirtothrips dorsalis* Hood, fipronil followed by thiamethoxam, acetamaprid and dimethoate were most effective, while carbaryl followed by phosolane and chlorpyrifos were the least effective.

Bhalala *et al.* (2006) studied the bioefficacy of thiomethoxam 25 WG, endosulfan and monocrotophos against sucking pest complex of okra under field conditions. They stated that the okra crop sprayed with thiomethoxam 25 WG at two higher doses (50 and 37.5 g a.i/ha) showed effective control of aphid, jassid, whitefly and mite population, the latter two remaining at par with monocrotophos, however, thiomethoxam (50ga.i/ha) yielded higher quantity of market fruit.

Hanumantharaya *et al.* (2007) through a field experiment at different locations (Annigeri, Solapur and Indore) in India showed that thiamethoxam and acetamiprid followed by imidacloprid were most effective (97% kill) and economic as against safflower aphids.

Nagaraj *et al.* (2007) reported that the thrips population and leaf curl index recorded were minimum in thiomethaxam 25WG (2.95 thrips / leaf and 1.66 damage), which was followed by imidacloprid (3.07 thrips / leaf and 1.46 damage), thiacloprid 21.7 SC (3.07 thrips / leaf and 1.55 damage) and clothianidin 50 WG (3.23 thrips / leaf and 1.52 damage). But comparatively more population of thrips and its damage was registered in acetamaprid 20 SP (3.95 thrips / leaf and 2.92 damage, which was on par with spinosad 45 SC (4.25 thrips / leaf and 3.01 LCI) and oxydemeton methyl 25 EC (4.20 thrips / leaf and 3.10 LCI).

Patil *et al.* (2009) evaluated the efficacy of fipronil 5% SC @ 800 g/ha, fipronil 40% + imidacloprid 200 SL @ 200 ml/ha, acetamiprid 20SP @ 100 g/ha and triazophos 40 EC @ 1500 ml/ha (standard checks) against sucking pests of cotton, at ARS, Dharwad. All the insecticides were found to give effective control of leafhoppers, aphids and thrips. Fipronil 5% SC @ 800 g/ha registered least number of thrips (8.47/3 leaves. Fipronil 40% + imidacloprid 40% -80 WG and was next best and imidacloprid 200 SL. Significantly highest seed cotton yield of 27.23 q/ha (2007) and 27.50 q/ha (2008) was harvested with higher dosage of fipronil 5% SC @ 800 g/ha.

Gore *et al.* (2010) observed that at 1, 3, 7, and 14 days after spraying, the lowest incidence of aphids per 5 cm shoot length was recorded for thiamethoxam (0.005%). The highest seed yield (15.55 q/ha) was also registered for thiamethoxam. All the insecticides *i.e.* imidacloprid (0.0045%), acetamiprid (0.004%), fipronil (0.01%), acephate (0.03%), diafenthiuron (0.06%) and dimethoate(0.03%) significantly increased the yield over the untreated control.

Rathod *et al*. (2010) conducted an experiment at oilseeds research unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *rabi* season of 2005-06, 2006-07 and 2007-08 to work out the effectiveness of botanicals and certain chemical pesticides against whitefly and thrips on sunflower. Imidacloprid 200 SL

@ 0.5 ml/ l was found most effective in minimizing thrips population followed by monocrotophos @ 0.05% and azadiractin 1500 ppm @ 2 ml/l.

Shirale (2010) conducted the field trial to evaluate the efficacy of insecticides against safflower aphids in the rabi season of 2007 at the Research Farm of Department of Agricultural Entomology, Marathwada Agricultural University, Parbhani. Lowest aphid population (0.83) was recorded in thiamethoxam followed by acetamiprid (1.30) and imidacloprid (1.73) which were on par with each other.

Sunitha and Jagginavar (2010) conducted studies on the management of thrips in grape with nine treatments comprised of four doses of confidor 200 per cent SL (0.3, 0.4, 0.8 and 1.6ml/lit), acetamaprid 20 per cent SP @ 0.3gm, thiamethoxam 25 per cent WG @ 0.3 gm, dimethoate 30EC (standard check) @ 1.7 ml/lit. All the four concentrations of Imidacloprid 200 per cent SL were found at par with each other in reducing the thrips population at 1, 3 and 7 days after spraying and were at par with other two neonicotinoid molecules. All the three neonicotinoid molecules were significantly superior over standard check.

Yasa *et al. (*2010) studied the bioefficacy of neonicotinoid group insecticides *viz.,* imidacloprid, acetamiprid, and thiamethoxam as foliar spray on groundnut sucking pests against conventional pesticide, monocrotophos. Neonicotinoids, showed higher efficacy in reducing thrips and jassid populations with increased pod yield in groundnut compared to conventional monocrotophos.

Anon (2011) reported that two round of sprays of thiamethoxam @ 125g, acetamiprid @ 100 g, imidacloprid @ 200 ml, clothianidin @ 50 g, [chlorpyriphos 50% + cypermethrin 5%] @ 1000 ml and [endosulfan 35%+cypermethrin 5%] @ 1000 ml per ha kept aphid population below 6 per plant and recorded higher yield compared to other insecticides evaluated as per report of Directorate of Oilseeds Research, Hyderabad.

Shivanna *et al*. (2011) conducted a field experiment at ZARS, College of Agriculture, Shivmogga during 2008-09 against sucking pests of cotton. Dimethoate and Imidacloprid were most effective against aphid and dimethoate alone was most effective on leafhopper, whitefly and thrips at three days after spraying which were found to be superior over other treatments followed by imidacloprid, acetamiprid, triazophos, fenpropathrin, eco neem and spinosad. The similar trend was also observed even at seven days after spray.

Basavaraj *et al*. (2012) found that two sprays of thiamethoxam 25 per cent WG and clothianidin 50 per cent WDG at 45-55 and 60-65 days after sowing found to be effective against safflower aphid by recording maximum decline in aphid population and highest yield of 1025.1 and 945.3 kg ha^{-1}, respectively.

Reddy and Latha (2012) studied the bio-efficacy of new molecules and botanicals against chrysanthemum aphid, *Macrosiphoniella sanbarni* (Gillette) and reported that acetamiprid was more effective compared to imidacloprid and thiamethoxam.

Sabir *et al*. (2012) conducted an experiment to study the efficacy of individual and integrated treatments for the management of key insect pests of chrysanthemum in Centre for Protected Cultivation Technology (CPCT), IARI, New Delhi for two seasons during 2009 to 2010. Combined treatment of phosphamidon and cypermethrin was most effective against key pests, *viz*. aphid and caterpillar. In chrysanthemum aphid control, the effectiveness of the treatment of agricultural spray oil and azadirachtin decreased immediately after two days of spraying, whereas combined treatment of both showed very effective result.

Hossain (2013) reported that in moong bean imidacloprid was significantly superior in reducing the infestation of thrips on flowers.

Rouhani *et al.* (2013) studied the toxicity of new insecticides against pomegranate aphid at Department of Plant Protection, Rafsanjan, Iran. Under laboratory condition the result revealed that imidacloprid 1 µl/ml showed higher mortality followed by thiacloprid 1 µl/ml, flonicamid 0.1 mg/ml and thiamethoxam 0.35 mg/ml.

Kadam *et al.* (2014) conducted field experiment during *Kharif* 2013 to evaluate the bio-efficacy of neonicotenoids against sucking pests of Bt cotton. The results revealed that significantly lowest population of sucking pests per three leaves were recorded when treated with nitenpyram 10 WSG @ 100 g a.i./ha, dinotefuran 20 SG @ 50 g a.i./ha and clothianidin 50 WDG @ 20 g a.i./ha compared to acetamiprid 20 SP @ 20 g a.i./ha, imidacloprid 17.8 SL, thiamethoxam 25 WS @ 25 g a.i./ha and thiacloprid 21.7 per cent SC @ 30 ga.i./ha.

Karar *et al.* (2014) studied the efficacy of eight insecticides against cotton whitefly at entomological research station, Multan and reported that imidacloprid 200 SL and acetamiprid 20 SP showed similar mortality of 76 and 75 per cent 72 hours after spray.

Devi *et al*. (2015) studied the relative toxicity of imidacloprid, acetamiprid, thiamethoxam, diflubenzuron and two horticulture mineral oils *viz.,* SERVO and ESSO against the second instar nymphs of the greenhouse whitefly, *Trialeurodes vaporariorum* Westwood and revealed that imidacloprid was found to be the most toxic insecticide followed by acetamiprid, thiamethoxam and diflubenzuron.

Gaurkhede *et al*. (2015) studied the bio efficacy of new molecules against sucking pests of Bt cotton at Dr. Panjabrao Deshmukh Krishi Vidyapeth, Akola. flonicamid 50 WG 0.02 per cent was effevtive in reducing aphid population followed by dinotefuran 20 SG 0.008, imidacloprid 30.5 SC 0.005 per cent, fipronil 5 SC 0.015 per cent, acetamiprid 20 SP 0.004 per cent. Fipronil 5 SC 0.015 was found effective in reducing thrips followed by imidacloprid 30.5 SC 0.005 per cent, dinotefuran 20 SG 0.008 per cent, acetamiprid 20 SP 0.004 per cent, flonicamid 50 WG 0.02 per cent and dinotefuran 20 SG 0.006 per cent.

Mahalakshmi *et al.* (2015) studied the field efficacy of different new insecticide molecules against whitefly of urdbean at RARS, Lam, Guntur, Andhra Pradesh for two consecutive seasons i.e. during Rabi 2010-11 and 2011-12. Among the four neonicotinoid molecules, acetamiprid 20 SP @ 0.2 g/ltwas found promising against whiteflies. Triazophos 40 EC @ 1.25 ml/lt was found on par with the neonicotiniods such as imidacloprid 200 SL @ 0.3 ml/lt, thiamethoxam 25 WG @ 0.2 g/lt and thiacloprid 21.7 SC @ 1.25 ml/lt.

Chandi *et al. (*2016) evaluated flonicamid 50WG @ 50, 75 and 100 g a.i. ha-1 against sucking insect pests and predatory complex on Bt cotton during 2007, 2008 and 2009. Based on pooled analysis of three years, Per cent reduction of aphid was higher in flonicamid @ 75 g a.i. ha-1 after 3, 7 and 10 days of spray as compared to all other treatments.

Sharma *et al.* (2016) studied the efficacy of new molecules of insecticides for the control of sucking pests in moongbean, *Vigna radiate* (L.). Among the insecticides, thiamethoxam was found more effective followed by imidacloprid and acitamiprid against jassid. However, imidacloprid significantly showed better effect to control the thrips population. Whitefly population significantly decreased by the application of thiamethoxam followed by imidacloprid and acetamiprid.

Choudhary *et al*. (2017) conducted an experiment to know bioefficacy of newer insecticides against aphid, *Aphis craccivora* Koch on cowpea at Agronomy farm, of S.K.N. College of agriculture, Jobner, Rajasthan during *Kharif,* 2016. The insecticides *viz.*, imidacloprid, thiamethoxam and dimethoate were found effective against the pests whereas, azadiracthin and malathion were found least effective.

Dara (2017) studied the field efficacy of various chemical insecticides and the entomopathogenic fungus *Beauveria bassiana* against *F. occidentalis* Pergande in lettuce at Santa Maria area of California. Spinetoram, methomyl, tolfenpyrad, and the combination of tolfenpyrad and methomyl caused a significant reduction in *F.occidentalis* Pergande but acetamiprid could not limit population build up.

Liburd *et al.* (2017) evaluated seven insecticides against flower thrips on farms in Florida and Georgia and in the laboratory. Assail 70WP (Acetamiprid) and Spintor 2SC (Spinosad) were the most promising insecticides in reducing thrips numbers in the field as well as in laboratory experiments. Spintor 2 SC killed all the thrips in laboratory arenas within 4 hours of application and showed low toxicity towards *O. insidiosus* (Say). All of the compounds tested performed including the conventional pesticide malathion.

Magsi *et al.* (2017) evaluated the effectiveness of different synthetic insecticides against *B. tabaci* (Gennadius) on tomato crop and found that Confidor 200 ml/acre brought the highest reduction (93.24%) in whitefly population within 72 hrs of post treatment interval followed by agrovista 100 g/acre (89.86%) ,Transform 30g/acre (87.50%) and Polo 200 ml/acre (86.79%) .

Jha *et al.* (2017) conducted field trial to know the relative efficacy of different insecticides against whitefly, *B. tabaci* (Gennadius) on tomato under field condition at Vegetable Research Farm of Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar and found efficacy was maximum in imidacloprid followed by profenophos 40% + cypermethrin 4 per cent and it was minimum in tobacco decoction.

MATERIAL AND METHODS

III MATERIAL AND METHODS

The present investigation on "Sucking pest complex of chrysanthemum (*Dendranthema grandiflora* Borkh) and their management" was carried out at Karnataka State Department of Horticulture (KSDH), Shivamogga, Karnataka during 2017-2018. The materials used and techniques employed in conducting experiments are elucidated below.

3.1 Survey on sucking pest complex of chrysanthemum

3.1.1 Experimental sites

Survey was conducted to record different sucking pests on chrysanthemum during 2017-2018 in open field conditions. The survey was undertaken at fortnightly intervals in open fields in two districts *viz.*, Shivamogga and Chitradurga. In Shivamogga survey was conducted at Holehonnuru, Hadonahalli and campus of University of Agricultural and Horticultural Sciences, Shivamogga. In Chitradurga four taluka were selected *viz.,* Chitradurga, Hiriyur, Holalkere and Challakere. In each taluk two villages were selected which include Doddasiddavvanahalli, TN kote, Aimangala, Hemadala, Nellikatte, Tekalavatti, Gopanahalli and Marikunte respectively (Plate 1).

3.1.2 Sampling methodology

In each field, 10 plants were selected randomly and average number of aphids present on randomly selected top, middle and bottom leaves of a plant were recorded and mean aphid population per two leaves was calculated by following the procedure given by Trumble (1982) and Singh *et al.* (1989). The whitefly count was taken from the top three leaves and the average population per three leaves was calculated.

Ten plants were selected and from each plant, five flowers were selected and tapped over a white paper and number of thrips dropped from the flower was counted using 10x magnifying lens. Likewise observations for ten randomly selected plants was recorded and mean number of thrips per flower was calculated by following the procedure given by Barbuceanu and Oromulu (2011).

3.2 Population dynamics of sucking pest complex in chrysanthemum

3.2.1 Land preparation

The experimental site was located at organic unit of Karnataka State Department of Horticulture (KSDH), Shivamogga, Karnataka (Plate 2). It falls under

Southern Transitional Zone with an average rainfall of 1800 mm. Experimental site is situated at 13º North latitude and 75º East longitude.

3.2.2 Cultivation aspects

3.2.2.1 Preparatory cultivation

The experimental field was thoroughly ploughed thrice with the help of tractor drawn cultivator, and then it was levelled after removal of stubbles, trash and weeds.

3.2.2.2 Fertiliser application

Well decomposed FYM @ 25 t/ha was incorporated during last ploughing. Recommended dose of nitrogen @ 125 kg/ha in the form of urea was applied in two split doses once at the time of planting and second dose one month after transplanting. Phosphorus and potassium was applied @ 100 kg/ha each in the form of single super phosphate and murate of potash basaly.

3.2.2.3 Seedling selection

Seedlings of chrysanthemum (variety marigold) were brought from Indian Institute of Horticultural Research (IIHR), Bangalore.

3.2.2.4 Transplanting

Thirty days old healthy seedlings with 2-3 fresh leaves were planted on 10th August 2017 in 4m × 3m plot and irrigation was given immediately after transplanting. Subsequent, irrigations were given as and when required.

3.2.2.5 Cultural operations

Throughout the experimental period uniform cultural operations were carried out. Hand weeding was done at 20 days after transplanting, subsequent weedings in the plots were carried out at regular intervals depending on the weed population to keep the plots clean and free from weeds. A total of four weedings were done during the crop period. One spray of mancozeb @ 2.5 g / lit and two sprays of chlorothalonil @ 2 ml / lit were given to control root rot and black spot diseases in chrysanthemum, respectively.

3.2.3 Sampling methodology

Incidence of sucking insect pests at different phenological stages was recorded at fortnightly intervals. Ten plants were randomly selected and tagged in the experimental plot. Aphids were counted on top, middle and bottom leaves of ten

Plate 1: General view of chrysanthemum field surveyed

Plate 2: General field view of experimental plot

selected plants at fortnightly intervals throughout the crop period and mean number of aphids per two leaves was calculated.

Ten plants were selected for samoling and from each plant five flowers were selected and tapped over a white paper and number of thrips dropped from the flower was counted using 10x magnifying lens, likewise observations for ten randomly selected plants was recorded and mean number of thrips per flower was calculated.

Mean fortnightly meteorological data on temperature, relative humidity, rainfall and sun shine hours was recorded from meteorology department, University of Agricultural and Horticultural sciences, Shivmogga, Karnataka (India) was correlated with insect incidence data recorded in the experimental plot at Karnataka State Department of Horticulture (KSDH), Shivamogga, Karnataka.

3.2.4 Species identification

3.2.4.1 Aphids

The aphids collected from field were preserved in vials containing 70 per cent alcohol and was later identified by Dr. Sunil joshi, Scientist, Division of insect systematics, NBAII, Bengaluru.

3.2.4.2 Thrips

Thrips collected were sent to Dr. Kaomud Tyagi, Scientist, Zoological Survey of India, Kolkata and identified.

3.2.5 Preparation of preservative media

Collection and preservation was made in AGA solution, which consists of ten parts of 60 per cent ethyl alcohol, one part of Glycerine and one part of Acetic acid (Thrips wiki, 2013). This mixture helps to distend the body of most thrips and keeps the body parts supple and relaxed.

3.2.6 Preparation of permanent slides

The detailed procedure followed for specimen processing and slide preparation is as follows, permanent slides were prepared using 10 per cent NaOH, distilled water, 50 per cent, 70 per cent, 90 per cent and 100 per cent grades of ethyl alcohol, terpineol and Canada balsam. The prepared slides were preserved in slide boxes after labelling.

1. The specimens of thrips stored in AGA mixture were removed and given a slight cut at the membranous region of abdomen between any of the middle segments using a fine micro pin to remove the inner body contents.

2. These specimens were transferred to 10 per cent NaOH solution using a fine camel hair brush for one hour in case of light coloured specimens and for 2 to 4 hours in case of dark specimens or until their ommatidia became transparent.

3. The specimens were transferred to distilled water for half an hour in order to wash off the traces of NaOH.

4. Later the specimens were transferred to different concentrations of ethyl alcohol each for five minutes sequentially.

   50 per cent Ethyl alcohol

   70 per cent Ethyl alcohol

   90 per cent Ethyl alcohol

   100 per cent Ethyl alcohol

5. Then they were transferred to a 1:1 mixture of Ethyl alcohol and Terpineol for 30 minutes.

6. The specimens which were ready to be mounted were transferred to Terpineol for 2 to 5 minutes just before mounting them onto glass slides using Canada balsam. The legs, antennae and wings were spread properly and were covered carefully with cover slips without the interference of any air bubbles.

7. The slides were kept for curing in an oven at about 45^{o}C for atleast 2-4 weeks before they were used for further study.

8. The slides were labelled systematically with the right hand label indicating host plant, locality and date of collection along with the collector's name. The left hand side was labelled with the sex, genus and species name of thrips after identification.

3.3 Efficacy of selected new insecticides against major sucking pests of chrysanthemum

3.3.1 Experimental site

An experiment was conducted to evaluate the efficacy of selected new insecticides against major sucking pests of chrysanthemum during *Kharif* 2017-18 at farmers field, Holehonnuru, Shivamogga, Karnataka.

One month old nursery grown cuttings were transplanted to the 2x2 m plots in a manner to accommodate 36 plants in each plot with eight treatments and three replications. All the recommended package of practices was followed except plant protection measures. The treatments along with dosages are given in Table 1.

3.3.2 Sampling procedure

Ten plants were selected and tagged after first sighting of pest. The pretreatment aphid count were recorded on the tagged plants one day prior to spray and post treatment counts were recorded at 1, 3, 5, 7 and 14 days after spraying. The 14^{th} day aphid count of first spray is taken as precount for second spray. The reduction in pest population after each spray was determined.

First spraying was done on 8^{th} January 2018 when the pest incidence was noticed and second spraying was taken up at 15 days after first spray *i.e.*, 23^{rd} January 2018. The spraying was done with knapsack sprayer. The plants in each treatment were covered with respective spray fluid thoroughly.

Aphids were counted on top, middle and bottom leaves of ten selected plants at fortnightly intervals throughout the crop period and mean number of aphid per two leaves was calculated. The whitefly count was taken from the top three leaves and the average population per three leaves was calculated.

Ten plants were selected and from each plant five flowers were selected and tapped over a white paper and number of thrips dropped from the flower was counted using 10 x magnifying lens, likewise observations for ten randomly selected plants was recorded and mean number of thrips per flower was calculated.

3.3.3 Economic analysis

3.3.3.1 Cost of cultivation

The cost of cultivation was worked out considering the material inputs like manures, fertilizers, insecticides and the labour input for all the operations. Treatment wise cost of cultivation was worked out. The prevailing cost of input materials and labour cost were considered for computing the cost of cultivation which is expressed in Rs/ha.

3.3.3.2 Gross return

The price of chrysanthemum flower prevailing in the market at the time of harvest was used for the calculation of gross return (Rs/ha).

Gross return = Marketable yield (ton. /ha) × Market price (Rs. /ha)

3.3.3.3 Net return

Net return (Rs/ha) was calculated by subtracting the cost of cultivation (Rs /ha) from the gross return (Rs/ha).

Net return = Gross return – Total cost of cultivation

3.3.3.4 Benefit cost ratio

B: C ratio was calculated by dividing the gross returns (Rs/ha) by cost of cultivation (Rs/ha).

$$\text{B:C ratio} = \frac{\text{Gross returns}}{\text{Total cost of cultivation}}$$

3.3.3.5 Statistical analysis

The statistical analysis of the data obtained from post management trail was done using analysis of variance (ANOVA) using Web Agri Stat Package (WASP-2) developed by Indian Council of Agricultural Research, Research Complex, Goa. After analysis, data was accommodated in the table as per the needs of objectives for interpretation of results. The interpretation of data was done by using the critical difference value calculated at 0.05 probability level. The level of significance was expressed at P = 0.05.

Correlation studies were made to find out the relationship between the weather parameters and seasonal incidences of thrips and aphids. Regression analysis was made to know the effect of abiotic factors on thrips and aphids density.

Table 1. Insecticides evaluated for their efficacy against major sucking pests of chrysanthemum

Treatments	Chemical	Trade Name	Dosage (g or ml/l)
T1	Imidacloprid 17.8 SL	Confidor	0.50 ml
T2	Flonicamid 50 WDG	Ulala	2.00 ml
T3	Azadirachtin 1 EC	Neemoil	1.00 ml
T4	Diafenthiuron 50 WP	Pegasus	1.00 g
T5	Clothianidin 50 WDG	Dantotsu	0.10 g
T6	Acetamiprid 20 SP	Pride	0.30 g
T7	Monocrotophos 36SL (standard check)	Monocil	2.00 ml
T8	untreated control	-	-

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The results of present investigation on survey, population dynamics of sucking pest complex of chrysanthemum and their management during 2017-18 are presented in this chapter under the following headings.

4.1 Survey on incidence of sucking pest complex of chrysanthemum

The survey was conducted to record different sucking pests on chrysanthemum during 2017-2018 in open field conditions. The survey was undertaken at fortnightly intervals in open fields in two districts *viz.*, Shivamogga and Chitradurga. In Shivamogga survey was conducted at Holehonnuru, Hadonahalli and campus of University of Agriculture and Horticultural Sciences whereas, in Chitradurga four taluk were selected *viz.,* Chitradurga, Hiriyur, Holalkere and Challakere. In each taluk two villages were selected such as Doddasiddavvanahalli, TN kote, Aimangala, Hemadala, Nellikatte, Tekalavatti, Gopanahalli and Marikunte respectively. Average values of each taluk have been presented in the Table 2.

4.1.1 September first fortnight

4.1.1a Aphids

During September first fortnight out of two districts surveyed, maximum mean number of aphid population was recorded in Chitradurga district (5.62 aphids / 3 leaves) followed by Shivamogga with 4.69 aphids per 3 leaves. In Chitradurga district the highest population was recorded in Challakere with 6.25 aphids per 3 leaves followed by Holalkere with 6.20 aphids per 3 leaves, Hiriyur (6.08 aphids / 3 leaves), Chitradurga (3.96 aphids / 3 leaves).

4.1.1b Whitefly

The mean maximum whitefly population recorded in Chitradurga was 4.48 whiteflies per 3 leaves followed by Shivamogga (1.88 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Hiriyur with 5.25 whiteflies per 3 leaves followed by Holalkere with 4.69 whiteflies per 3 leaves, Chitradurga (4.41 whiteflies / 3 leaves), Challakere (3.56 whiteflies / 3 leaves).

4.1.1c Thrips

During September first fortnight, thrips incidence was not recorded in both the districts.

Table 2. Survey on sucking pest complex of chrysanthemum

Period of observation	District	Taluka	Mean no. of Aphids/3 leaves	Mean no. of whitefly / 3Leaves	Mean no. of Thrips/flower
Sep 1st fortnight	Shivamogga	Shivamogga	4.69	1.88	0.00
	Chitradurga	Chitradurga	3.96	4.41	0.00
		Hiriyur	6.08	5.25	0.00
		Challakere	6.25	3.56	0.00
		Holalkere	6.20	4.69	0.00
		Mean	**5.62**	**4.48**	**0.00**
Sep 2nd fortnight	Shivamogga	Shivamogga	5.33	2.25	0.00
	Chitradurga	Chitradurga	6.78	2.05	0.00
		Hiriyur	7.13	2.17	0.00
		Challakere	6.60	2.91	0.00
		Holalkere	8.12	3.12	0.00
		Mean	**7.16**	**2.56**	**0.00**
Oct 1st fortnight	Shivamogga	Shivamogga	4.05	3.36	0.00
	Chitradurga	Chitradurga	2.69	3.43	0.00
		Hiriyur	4.56	2.45	0.00
		Challakere	5.96	3.45	0.00
		Holalkere	7.90	3.95	0.00
		Mean	**5.28**	**3.32**	**0.00**

Contd….

Oct 2nd fortnight	Shivamogga	Shivamogga	6.45	3.59	1.42
	Chitradurga	Chitradurga	6.56	2.94	1.99
		Hiriyur	7.62	2.90	0.79
		Challakere	9.20	3.19	3.57
		Holalkere	7.55	3.50	2.25
		Mean	**7.73**	**3.13**	**2.15**
Nov 1st fortnight	Shivamogga	Shivamogga	6.08	2.92	2.01
	Chitradurga	Chitradurga	5.09	2.18	2.99
		Hiriyur	5.96	1.62	2.84
		Challakere	4.92	1.45	2.93
		Holalkere	6.36	1.46	2.23
		Mean	**5.58**	**1.68**	**2.75**
Nov 2nd fortnight	Shivamogga	Shivamogga	6.08	3.13	2.41
	Chitradurga	Chitradurga	4.38	2.22	2.93
		Hiriyur	5.18	4.40	2.83
		Challakere	4.77	3.60	2.87
		Holalkere	5.17	2.56	2.03
		Mean	**4.87**	**3.19**	**2.66**

Contd……

Dec 1st fortnight	Shivamogga	Shivamogga	6.85	3.92	3.23
	Chitradurga	Chitradurga	8.14	0.83	2.73
		Hiriyur	6.30	1.02	4.34
		Challalkere	4.99	1.52	3.50
		Holalkere	3.82	3.95	3.04
		Mean	**5.81**	**1.83**	**3.40**
Dec 2nd fortnight	Shivamogga	Shivamogga	6.12	2.08	4.11
	Chitradurga	Chitradurga	5.61	1.88	4.88
		Hiriyur	4.95	1.45	4.28
		Challakere	7.40	2.08	2.98
		Holalkere	4.02	2.94	4.87
		Mean	**5.49**	**2.09**	**4.25**
Jan 1st fortnight	Shivamogga	Shivamogga	9.57	3.00	5.87
	Chitradurga	Chitradurga	9.27	1.94	5.04
		Hiriyur	8.22	1.78	3.75
		Challakere	7.59	3.74	4.83
		Holalkere	7.53	1.78	4.27
		Mean	**8.15**	**2.31**	**4.47**

Contd…..

Jan 2nd fortnight	Shivamogga	Shivamogga	8.17	1.81	3.63
	Chitradurga	Chitradurga	7.95	1.28	5.74
		Hiriyur	6.48	1.34	5.99
		Challakere	5.87	3.94	4.63
		Holalkere	8.99	2.22	6.65
		Mean	**7.32**	**2.19**	**5.75**
Feb 1st fortnight	Shivamogga	Shivamogga	6.68	1.19	4.29
	Chitradurga	Chitradurga	8.45	1.44	6.28
		Hiriyur	6.84	1.92	7.89
		Challakere	4.26	2.73	6.50
		Holalkere	7.65	1.78	8.95
		Mean	**6.80**	**1.97**	**7.40**
Feb 2nd fortnight	Shivamogga	Shivamogga	3.12	2.32	7.26
	Chitradurga	Chitradurga	4.90	1.44	5.58
		Hiriyur	7.62	2.14	8.94
		Challakere	5.73	1.64	3.76
		Holalkere	5.25	2.63	4.68
		Mean	**5.88**	**1.96**	**5.74**
Mar 1st fortnight	Shivamogga	Shivamogga	5.71	1.79	2.98
	Chitradurga	Chitradurga	6.95	0.83	2.60
		Hiriyur	5.68	0.77	2.25
		Challakere	7.88	0.42	3.75
		Holalkere	6.68	0.17	4.37
		Mean	**6.80**	**0.55**	**3.24**

Contd……

Mar 2nd fortnight	Shivamogga	Shivamogga	5.29	0.48	4.01
	Chitradurga	Chitradurga	5.27	0.39	3.00
		Hiriyur	6.19	0.37	3.06
		Challakere	1.45	0.08	2.95
		Holalkere	3.90	0.00	3.80
		Mean	**4.20**	**0.21**	**3.20**
Apr 1st fortnight	Shivamogga	Shivamogga	2.33	0.00	3.77
	Chitradurga	Chitradurga	4.76	0.32	3.65
		Hiriyur	2.21	0.24	2.35
		Challakere	4.37	0.32	4.40
		Holalkere	2.20	0.39	4.50
		Mean	**3.38**	**0.32**	**3.73**
Apr 2nd fortnight	Shivamogga	Shivamogga	1.97	0.18	4.93
	Chitradurga	Chitradurga	3.30	0.30	2.10
		Hiriyur	1.35	0.22	5.15
		Challakere	3.65	0.05	3.85
		Holalkere	1.25	0.00	3.65
		Mean	**2.39**	**0.14**	**3.69**

4.1.2 September second fortnight

4.1.2a Aphids

The maximum aphid population was recorded in Chitradurga with 7.16 aphids per 3 leaves followed by Shivamogga (5.33 aphids / 3 leaves). In Chitradurga district the highest population was recorded in Holalkere with 8.12 aphids per 3 leaves followed by Hiriyur with 7.13 aphids per 3 leaves, Chitradurga (6.78 aphids / 3 leaves), Challakere (6.60 aphids / 3 leaves).

4.1.2b Whitefly

The maximum whitefly population was recorded in Chitradurga with 2.56 whiteflies per 3 leaves followed by Shivamogga (2.25 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Holalkere with 3.12 whiteflies per 3 leaves followed by Challakere with 2.91 whiteflies per 3 leaves, Hiriyur (2.17 whiteflies / 3 leaves), Chitradurga (2.05 whiteflies / 3 leaves).

4.1.2c Thrips

During September second fortnight, thrips incidence was not recorded in both the districts.

4.1.3 October first fortnight

4.1.3a Aphids

During October first fortnight maximum aphid population was recorded in Chitradurga with 5.28 aphids per 3 leaves followed by Shivamogga (4.05 aphids / 3 leaves). In Chitradurga district the highest population was recorded in Holalkere with 7.90 aphids per 3 leaves followed by Challakere with 5.96 aphids per 3 leaves, Hiriyur (4.56 aphids / 3 leaves), Chitradurga (2.69 aphids / 3 leaves).

4.1.2b Whitefly

The maximum whitefly population was recorded in Shivamogga with 3.36 whiteflies per 3 leaves followed by Chitradurga (3.32 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Holalkere with 3.95 whiteflies per 3 leaves followed by Challakere with 3.45 whiteflies per 3 leaves, Chitradurga (3.43 whiteflies / 3 leaves), Hiriyur (2.45 whiteflies / 3 leaves).

4.1.3c Thrips

During October first fortnight, thrips incidence was not recorded in both the districts.

4.1.4 October second fortnight

4.1.4a Aphids

During this week more number of aphids was observed in Chitradurga with 7.73 aphids per 3 leaves followed by Shivamogga (6.45 aphids / 3 leaves). In Chitradurga district the highest population was recorded in Challakere with 9.32 aphids per 3 leaves followed by Hiriyur with 7.62 aphids per 3 leaves, Holalkere (7.55 aphids / 3 leaves), Chitradurga (6.56 aphids / 3 leaves).

4.1.2b Whitefly

The maximum whitefly population was recorded in Shivamogga with 3.59 whiteflies per 3 leaves followed by Chitradurga (3.13 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Holalkere with 3.50 whiteflies per 3 leaves followed by Challakere with 3.19 whiteflies per 3 leaves, Chitradurga (2.94 whiteflies / 3 leaves), Hiriyur (2.90 whiteflies / 3 leaves).

4.1.4c Thrips

During October second fortnight first thrips infestation was observed and was highest in Chitradurga district with 2.15 thrips per flower followed by Shivamogga district with 1.42 thrips per flower. In Chitradurga district the highest population was recorded in Challakere with 3.57 thrips per flower followed by Chitradurga (1.99 thrips/flower), Hiriyur (0.79 thrips/flower).

4.1.5 November first fortnight

4.1.5a Aphids

During November first fortnight maximum aphid population was recorded in Shivamogga with 6.08 aphids per 3 leaves followed by Chitradurga (5.58 aphids / 3 leaves). In Chitradurga district the highest population was recorded in Holalkere with 6.36 aphids per 3 leaves followed by Hiriyur with 5.96 aphids per 3 leaves, Chitradurga (5.09 aphids/3leaves), Challakere (4.92 aphids / 3 leaves).

4.1.5b Whitefly

The maximum whitefly population was recorded in Shivamogga with 3.59 whiteflies per 3 leaves followed by Chitradurga (3.13 whiteflies/3 leaves). In Chitradurga district the highest population was recorded in Holalkere with 3.50 whiteflies per 3 leaves followed by Challakere with 3.19 whiteflies per 3 leaves, Chitradurga (2.94 whiteflies / 3 leaves), Hiriyur (2.90 whiteflies / 3 leaves).

4.1.5c Thrips

During November first fortnight highest thrips population was observed in Chitradurga district with 2.75 thrips per flower followed by Shivamogga district with 2.01 thrips per flower. In Chitradurga district the highest population was recorded in Chitradurga taluka with 2.99 thrips per flower followed by Challakere (2.93 thrips / flower), Hiriyur (2.84 thrips / flower), Holalkere (2.23 thrips / flower).

4.1.6 November second fortnight

4.1.6a Aphids

During November second fortnight maximum aphid population was recorded in Shivamogga with 6.08 aphids per 3 leaves followed by Chitradurga (4.87 aphids / 3 leaves). In Chitradurga district the highest population was recorded in Hiriyur with 5.18 aphids per 3leaves followed by Holalkere with 5.17 aphids per 3 leaves, Challakere 4.77 aphids per 3 leaves, Chitradurga (4.38 aphids / 3 leaves).

4.1.6b Whitefly

The maximum whitefly population was recorded in Chitradurga with 3.19 whiteflies per 3 leaves followed by Shivamogga (3.13 whiteflies/3 leaves). In Chitradurga district the highest population was recorded in Hiriyur with 4.40 whiteflies per 3 leaves followed by Challakere with 3.60 whiteflies per 3 leaves, Holalkere (2.56 whiteflies / 3 leaves), Chitradurga (2.22 whiteflies / 3 leaves).

4.1.6c Thrips

The maximum thrips population was recorded in Chitradurga district with 2.756thrips per flower followed by Shivamogga district with 2.41 thrips per flower. In Chitradurga district the highest population was recorded in Chitradurga taluk with 2.93 thrips per flower followed by Challakere with 2.87 thrips per flower, Hiriyur (2.83 thrips / flower), Holalkere (2.03 thrips / flower).

4.1. 7 December first fortnight

4.1.7a Aphids

During December first fortnight maximum aphid population was recorded in Shivamogga with 6.85 aphids per 3 leaves followed by Chitradurga (5.81 aphids /3 leaves). In Chitradurga district the highest population was recorded in Chitradurga taluk with 8.14 aphids per 3leaves followed by Hiriyur with 6.30 aphids per 3 leaves, Challakere (4.99 aphids / 3 leaves), Holalkere (3.82 aphids / 3 leaves).

4.1.7b Whitefly

The maximum whitefly population was recorded in Shivamogga with 3.92 whiteflies per 3 leaves followed by Chitradurga (1.83 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Holalkere with 3.95 whiteflies per 3 leaves followed by Challakere with 1.52 whiteflies per 3 leaves, Hiriyur (1.02 whiteflies / 3 leaves), Chitradurga (0.83 whiteflies / 3 leaves).

4.1.7c Thrips

The maximum thrips population was recorded in Chitradurga district with 3.40 thrips per flower followed by Shivamogga district with 3.23 thrips per flower. In Chitradurga district the highest population was recorded in Hiriyur with 4.34 thrips per flower followed by Challakere with 3.50 thrips per flower, Holalkere (3.04 thrips / flower), Chitradurga (2.73 thrips / flower).

4.1.8 December second fortnight

4.1.8a Aphids

During December second fortnight maximum aphid population was recorded in Shivamogga with 6.12 aphids per 3 leaves followed by Chitradurga (5.49 aphids / 3 leaves). In Chitradurga district the highest population was recorded in Challakere with 7.40 aphids per leaves followed by Chitradurga with 5.61 aphids per 3 leaves, Hiriyur (4.95 aphids / 3 leaves), Holalkere (4.02 aphids / 3 leaves).

4.1.8b Whitefly

The maximum whitefly population was recorded in Chitradurga with 2.09 whiteflies per 3 leaves followed by Shivamogga (1.83 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Holalkere with

2.94 whiteflies per 3 leaves followed by Challakere with 2.08 whiteflies per 3 leaves, Chitradurga (1.88 whiteflies / 3 leaves), Hiriyur (1.45 whiteflies / 3 leaves).

4.1.8c Thrips

The maximum thrips population was recorded in Chitradurga district with 4.25 thrips per flower followed by Shivamogga district with 4.11 thrips per flower. In Chitradurga district the highest population was recorded in Chitradurga taluk with 4.88 thrips per flower followed by Holalkere (4.97 thrips / flower), Hiriyur (4.28 thrips / flower), Challakere (2.98 thrips / flower).

4.1.9 January first fortnight

4.1.9a Aphids

The maximum aphid population was recorded in Shivamogga with 9.57 aphids per 3 leaves followed by Chitradurga (8.15 aphids/3leaves). In Chitradurga district the highest population was recorded in Chitradurga taluk with 9.27 aphids per 3 leaves followed by Hiriyur with 8.22 aphids per 3 leaves, Challakere (7.59 aphids / 3 leaves), Holalkere (7.53 aphids / 3 leaves).

4.1.9b Whitefly

The maximum whitefly population was recorded in Shivamogga with 3.00 whiteflies per 3 leaves followed by Chitradurga (2.31 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Challakere with 3.74 whiteflies per 3 leaves followed by Chitradurga with 1.94 whiteflies per 3 leaves whereas, Hiriyur (1.78 whiteflies / 3 leaves) and Holalkere (1.78 whiteflies / 3 leaves) has almost same level of infestation.

4.1.9c Thrips

The maximum thrips population was recorded in Shivamogga district with 5.87 thrips per flower followed by Chitradurga district with 4.47 thrips per flower. In Chitradurga district the highest population was recorded in Chitradurga taluk with 5.04 thrips per flower followed by Challakere (4.83 thrips/flower), Holalkere (4.27 thrips / flower), Hiriyur (3.75 thrips / flower).

4.1.10 January second fortnight

4.1.10a Aphids

During January second fortnight maximum aphid population was recorded in Shivamogga with 8.17 aphids per 3 leaves followed by Chitradurga (7.32 aphids / 3 leaves). In Chitradurga district the highest population was recorded

in Holalkere with 8.99 aphids per 3 leaves followed by Chitradurga with 7.95 aphids per 3 leaves, Hiriyur (6.48 aphids / 3 leaves), Challakere (5.87 aphids / 3 leaves).

4.1.10b Whitefly

The maximum whitefly population was recorded in Chitradurga with 2.19 whiteflies per 3 leaves followed by Shivamogga (1.81 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Challakere with 3.94 whiteflies per 3 leaves followed by Holalkere with 2.22 whiteflies per 3 leaves, Hiriyur (1.34 whiteflies/3 leaves), Chitradurga (1.28 whiteflies / 3 leaves).

4.1.10c Thrips

The maximum thrips population was recorded in Chitradurga district with 5.75 thrips per flower followed by Shivamogga district with 3.63 thrips per flower. In Chitradurga district the highest population was recorded in Chitradurga taluk with 5.74 thrips per flower followed by Holalkere (6.65 thrips / flower), Hiriyur (5.99 thrips / flower), Challakere (4.63 thrips / flower).

4.1.11 February first fortnight

4.1.11a Aphids

The maximum aphid population was recorded in Chitradurga with 6.80 aphids per 3 leaves followed by Shivamogga (6.68 aphids / 3 leaves). In Chitradurga district the highest population was recorded in Chitradurga taluk with 8.45 aphids per 3 leaves followed by Holalkere with 7.65 aphids per 3 leaves, Hiriyur (6.84 aphids / 3 leaves), Challakere (7.53 aphids / 3 leaves).

4.1.11b Whitefly

The maximum whitefly population was recorded in Chitradurga with 1.97 whiteflies per 3 leaves followed by Shivamogga (1.19 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Challakere with 2.73 whiteflies per 3 leaves followed by Hiriyur (1.92 whiteflies / 3 leaves), Chitradurga with 1.44 whiteflies per 3 leaves, Holalkere (1.78 whiteflies / 3 leaves).

4.1.11c Thrips

The maximum thrips population was recorded in Chitradurga district with 7.40 thrips per flower followed by Shivamogga district with 4.29 thrips per flower. In Chitradurga district the highest population was recorded Holalkere with 8.95 thrips per flower followed by Hiriyur (7.89 thrips / flower), Challakere (6.50 thrips / flower), Chitradurga (6.28 thrips / flower).

4.1.12 February second fortnight

4.1.12 a Aphids

During February second fortnight maximum aphid population was recorded in Chitradurga with 5.88 aphids per 3 leaves followed by Shivamogga (3.12 aphids / 3 leaves). In Chitradurga district the highest population was recorded in Hiriyur with 7.62 aphids per 3 leaves followed by Challakere with 5.73 aphids per 3 leaves, Holalkere (5.25 aphids / 3 leaves), Chitradurga (4.90 aphids / 3 leaves).

4.1.12 b Whitefly

The maximum whitefly population was recorded in Shivamogga with 2.32 whiteflies per 3 leaves followed by Chitradurga (1.96 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Holalkere with 2.63 whiteflies per 3 leaves followed by Hiriyur with 2.14 whiteflies per 3 leaves, Challakere (1.64 whiteflies / 3 leaves), Chitradurga (1.44 whiteflies / 3 leaves).

4.1.12 c Thrips

The maximum thrips population was recorded in Shivamogga district with 7.26 thrips per flower followed by Chitradurga district with 5.74 thrips per flower. In Chitradurga district the highest population was recorded Hiriyur taluk with 8.94 thrips per flower followed by Chitradurga (5.58 thrips/flower), Holalkere (4.68 thrips / flower), Challakere (3.76 thrips / flower).

4.1.13 March first fortnight

4.1.13 a Aphids

The maximum aphid population was recorded in Chitradurga with 6.80 aphids per 3 leaves followed by Shivamogga (5.71 aphids / 3 leaves). In Chitradurga district the highest population was recorded in Challakere taluk with 8.45 aphids per 3 leaves followed by Chitradurga with 6.95 aphids per 3 leaves, Holalkere (6.68 aphids / 3 leaves), Hiriyur (5.68 aphids / 3 leaves).

4.1.13b Whitefly

The maximum whitefly population was recorded in Shivamogga with 1.79 whiteflies per 3 leaves followed by Chitradurga (0.55 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Chitradurga taluk with 0.83 whiteflies per 3 leaves followed by Hiriyur (1.77 whiteflies / 3 leaves), Challakere with 0.42 whiteflies / 3 leaves, Holalkere (0.17 whiteflies / 3 leaves).

4.1.13c Thrips

The maximum thrips population was recorded in Chitradurga district with 3.24 thrips per flower followed by Shivamogga district with 2.98 thrips per flower. In Chitradurga district the highest population was recorded Holalkere with 4.37 thrips per flower followed by Challakere (3.75 thrips / flower), Chitradurga (2.60 thrips / flower), Hiriyur (2.25 thrips / flower).

4.1.14 March second fortnight

4.1.14a Aphids

During March second fortnight maximum aphid population was recorded in Shivamogga with 5.29 aphids per 3 leaves followed by Chitradurga (4.20 aphids / 3 leaves). In Chitradurga district the highest population was recorded in Hiriyur taluk with 6.19 aphids per 3 leaves followed by Chitradurga with 5.27 aphids per 3 leaves, Holalkere (3.90 aphids / 3 leaves), Challakere (1.45 aphids / 3 leaves).

4.1.14b Whitefly

The maximum whitefly population was recorded in Shivamogga with 0.48 whiteflies per 3 leaves followed by Chitradurga (1.21 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Chitradurga taluk with 0.39 whiteflies per 3 leaves followed by Hiriyur with 0.37 whiteflies per 3 leaves, Challakere (0.8 whiteflies / 3 leaves) and in Holalkere infestation was not recorded.

4.1.14c Thrips

The maximum thrips population was recorded in Shivamogga district with 4.01 thrips per flower followed by Chitradurga district with 3.20 thrips per flower. In Chitradurga district the highest population was recorded Holalkere with 3.80 thrips per flower followed by Hiriyur (3.06 thrips / flower), Challakere (2.95 thrips /f lower), Chitradurga (3.00 thrips / flower).

4.1.15 April first fortnight

4.1.15 a Aphids

The maximum aphid population was recorded in Chitradurga with 3.38 aphids per 3 leaves followed by Shivamogga (2.33 aphids/3leaves). In Chitradurga district the highest population was recorded in Chitradurga taluk with 4.76 aphids per 3 leaves followed by Challakere with 4.37 aphids per 3 leaves, Hiriyur (2.21 aphids / 3 leaves), Holalkere (2.20 aphids / 3 leaves).

4.1.15 b Whitefly

The maximum whitefly population was recorded in Chitradurga with 0.32 whiteflies per 3 leaves followed by Shivamogga where no infestation was recorded. In Chitradurga district the highest population was recorded in Holalkere taluk with 0.39 whiteflies per 3 leaves followed by Challakere and Chitradurga has same level of infestation with 0.32 whiteflies per 3 leaves, Hiriyur (0.24 whiteflies / 3 leaves).

4.1.15 c Thrips

The maximum thrips population was recorded in Shivamogga district with 3.77 thrips per flower followed by Chitradurga district with 3.73 thrips per flower. In Chitradurga district the highest population was recorded Holalkere with 4.50 thrips per flower followed by Challakere (4.40 thrips / flower), Chitradurga (3.65 thrips /f lower), Hiriyur (2.35 thrips / flower).

4.1.16 April second fortnight

4.1.16a Aphids

During April second fortnight maximum aphid population was recorded in Chitradurga with 2.39 aphids per 3 leaves followed by Shivamogga (1.97 aphids /3leaves). In Chitradurga district the highest population was recorded in Challakere taluk with 3.65 aphids per 3 leaves followed by Chitradurga with 3.30 aphids per 3 leaves, Hiriyur (1.35aphids / 3 leaves), Holalkere(1.25 aphids / 3 leaves).

4.1.16b Whitefly

The maximum whitefly population was recorded in Shivamogga with 0.18 whiteflies per 3 leaves followed by Chitradurga (0.14 whiteflies / 3 leaves). In Chitradurga district the highest population was recorded in Chitradurga taluk with 0.30 whiteflies per 3 leaves followed by Hiriyur with 0.22 whiteflies per 3 leaves, Challakere (0.5 whiteflies / 3 leaves), and in Holalkere infestation was not recorded.

4.1.16c Thrips

The maximum thrips population was recorded in Shivamogga district with 4.93 thrips per flower followed by Chitradurga district with 3.69 thrips per flower. In Chitradurga district the highest population was recorded in Hiriyur with 5.15 thrips per flower followed by Challakere (3.85 thrips / flower), Holalkere (3.65 thrips /flower), Chitradurga (2.10 thrips / flower).

A lady bird beetle was found predating on the aphids. It was identified as *Cheilomenes sexmaculata*. The common predator of flower thrips and aphids, *Orius insidiosus* (Say) (minute pirate bug) was also recorded during survey.

4.2 Population dynamics of sucking pest complex of chrysanthemum

The study on population dynamics of sucking pest complex in chrysanthemum was carried out at KSDH, Shivamoga on chrysanthemum variety marigold (Plate 2).

4.2.1 Thrips

The thrips population was first recorded during second fortnight of November three months after transplanting and the infestation was continued till the end of the cropping period. The thrips species collected was identified such as *Haplothrips gowdeyi* and *Microcephalothrips abdomanalis* by Dr. Kaomud Tyagi.

The peak thrips incidence (6.15 thrips / flower) was observed during first fortnight of February (Table 3). The meteorological parameters which prevailed during the experimental period were correlated with thrips population to understand the relationship between meteorological parameters and thrips incidence during the period of study.

The thrips incidence was positively correlated with both maximum and minimum temperature. The maximum temperature ranged between 29.7 to 36.8 ˚C during the study period. The peak thrips population (6.15 thrips / plants) was found when maximum temperature was 32.9 ºC. The correlation between maximum temperature and thrips incidence indicated a positive significant relationship (r = 0.848**). The minimum temperature varied from 15.7 to 23 ºC (Table 4) and highest population was found at the temperature of 16.6˚c. The correlation found between minimum temperature and thrips incidence was positive (r = 0.23) (Table 4).

Table 3. Population dynamics of sucking pests of chrysanthemum during 2017-18

Period of observation	Average number of thrips/flower	Average number of aphids/2leaves
August 1st fortnight	0.00	0.00
August 2nd fortnight	0.00	6.74
September 1st fortnight	0.00	3.52
September 2nd fortnight	0.00	22.00
October 1st fortnight	0.00	19.15
October 2nd fortnight	0.00	34.40
November 1st fortnight	0.00	19.56
November 2nd fortnight	2.11	10.50
December 1st fortnight	3.12	15.65
December 2nd fortnight	1.78	21.40
January 1st fortnight	1.87	30.24
January 2nd fortnight	3.54	42.59
February 1st fortnight	6.15	31.55
February 2nd fortnight	4.71	18.33
March 1stfortnight	5.14	12.01
March 2nd fortnight	5.38	4.90
April 1st fortnight	6.12	0.00
April 2nd fortnight	6.11	0.00

Table 4. Correlation and regression analysis between sucking pest complex and weather parameter of chrysanthemum

Variable	Correlation coefficient (r)						Co efficient of determination (r^2)	Regression equation
	Meteorological parameters							
	Max. Tem. (X_1) (^{0}C)	Min. Tem. (X_2) (^{0}C)	RH-1 (X_3) (%)	RH-2 (X_4) (%)	Rainfall (X_5) (mm)	Sunshine hours (X_6)		
Thrips	0.848**	0.23	-0.774**	-0.800*	-0.379	0.604**	**0.839**	$Y=-11.957+0.004X_1+0.568X_2+0.041X_3-0.121X_4+0.023X_5+0.438X_6+1.240$
Aphids	-0.273	-0.693**	-0.209	-0.248	-0.485*	0.418	**0.693**	$Y= 188.610-0.075X_1\ 5.454\ X_2 + 0.055\ X_3 + 0.575X_4-0.790X_5+0.744X_6+8.682$

* Correlation is significant at 0.05 level (2-tailed)

** Correlation is significant at 0.01 level (2-tailed)

The maximum relative humidity exerted a significantly negative correlation on thrips incidence. The maximum relative humidity was found to range from 60 to 70 per cent at the time of peak incidence and showed significantly negative correlation (r = -0.774**). The minimum relative humidity was ranged from 23.52 to 78.6 per cent and showed significantly negative correlation (r = - 0.800**) (Table 4).

The rainfall ranged between zero and 268.8 mm during the study period after the incidence of thrips was observed on chrysanthemum plants. The correlation between rainfall and thrips incidence was found to be negatively non significant (r = - 0.379) (Table 4).

The number of sunshine hours ranged between 1.00 and 10.00 hours during the study period. The rise in sunshine hours increased the thrips population. The correlation between sunshine hours and thrips incidence was found to be positive (r = 0.418) (Table 4).

The weather parameters *viz.,* maximum and minimum temperature, relative humidity, rainfall and sunshine hours influenced the population of thrips to an extent of 0.83 per cent (Table 4)

4.2.2 Aphids

The aphid incidence was first observed during second fortnight of august which corresponding to the vegetative stage of the chrysanthemum plants with a population of 6.74 aphids per two leaves (Table 3) and continued till the end of the cropping period (Plate 3). The aphids infesting chrysanthemum plants were identified as *Macrosiphoniella sanbornii* (Gillette) and *Aphis gossypii* Glover by Sunil Joshi.

The peak infestation was observed during second fortnight of January with a population of 42.59 aphids per two leaves (Table 3). The meteorological parameters which prevailed during the experimental period were correlated with aphid population to understand the relationship between abiotic factors and aphid incidence.

Both the maximum temperature and minimum temperature were found to exert a significant negative influence on the population buildup of aphids (r = - 0.273 and r = - 0.693**) (Table 4) respectively. The aphid population reached a peak (42.59 aphids/2 leaves) when the maximum temperature was 31.9 ˚C and minimum temperature was 14.8 ºC and thereafter decreased with an increase in maximum and minimum temperature.

The aphid incidence was negatively correlated with maximum and minimum relative humidity (%) during the study period (r = - 0.209 and r = - 0.248) (Table 4). The maximum relative humidity ranged from 58.3 to 90.6 per cent. The peak aphid population (42.59 aphids / 2 leaves) (Table 3) was recorded when maximum relative humidity was 72.3 per cent. The minimum relative humidity ranged between 26.7 and 78.6 per cent during study period.

High rainfall (24.4mm) recorded during October drastically reduced aphid population. Later as rainfall decreased the aphid population which increased gradually and peak was observed during second fortnight of January. Rainfall has shown significantly negative correlation (r = - 0.485*) (Table 4) to aphid population buildup during study period.

The number of sunshine hours ranged between 1.00 and 10.00 hours during the period of study. The peak aphid population (42.59 aphids / 2 leaves) was recorded at 9.1 sunshine hours. The results indicated that with an increase in sunshine hours the aphid population increased. The aphid incidence showed positive correlation to sunshine hours (r = 0.418) (Table 4).

The weather parameters *viz.,* maximum and minimum temperature, relative humidity, rainfall and sunshine hours influenced the population of aphids to an extent of 0.69 per cent (Table 4).

4.3 Efficacy of selected new insecticides against major sucking pests of chrysanthemum

A field experiment was conducted to evaluate the efficacy of insecticides along with untreated control against important sucking pests of chrysanthemum during *Kharif* 2017-18 at farmers field, Holehonnuru village, near Shivamogga. The crop received a total of two sprays during the cropping period at an interval of fifteen days. The pre treatment count was recorded one day prior to spraying and the post treatment count at three, five, seven and fourteen days after each spray, and the efficacy of insecticidal treatment were determined in terms of per cent reduction in the insect population over the untreated control, cumulative reduction of each spray and combined effect of two spray was worked out and the results are presented here below.

4.3.1 Efficacy of different insecticides against chrysanthemum aphid (Macrosiphoniella sanborni) after first spray.

The population of aphids in pretreatment count in all treatments was uniform which ranged between 30.20 and 34.62 per two leaves as indicated by non significant differences (Table 5).

Plate 3: Chrysanthemum leaves infested by aphids (*M. sanborni*) and alate aphid

Table 5. Efficacy of different insecticides against chrysanthemum aphid (*Macrosiphoniella sanborni*) after first spray during 2017-2018.

Tr. No.	Treatments	Dose ml or g/l	Aphid population per 2 leaves#					Overall Mean aphid population per 2 leaves	Per cent reduction of aphids over untreated control
			I Spray						
			1 DBS	3DAS	5 DAS	7 DAS	14 DAS		
T_1	Imidacloprid 17.8 SL	0.50	32.30 (5.68)*	13.19 (3.68) ^{d}	11.24 (3.42) ^{e}	14.57 (3.88) ^{e}	20.96 (4.61) ^{d}	14.99	57.82
T_2	Flonicamid 50 WDG	2.00	30.20 (5.52)	17.29 (4.22) ^{bcd}	15.14 (3.95) ^{cde}	19.14 (4.43) ^{cde}	23.94 (4.89) ^{bcd}	18.87	46.90
T_3	Azadiractin 1 EC	1.00	32.50 (5.72)	24.08 (4.86) ^{b}	22.79 (4.79) ^{b}	26.64 (5.21) ^{b}	31.57 (5.64) ^{b}	26.27	26.08
T_4	Diafenthiuron 50 WP	1.00	32.78 (5.75)	21.45 (4.69) ^{bc}	20.11 (4.54) ^{bc}	24.45 (4.99) ^{bc}	29.24 (5.45) ^{bc}	23.81	33.00
T_5	Clothianidin 50 WDG	0.10	34.62 (5.91)	18.05 (4.31) ^{bcd}	17.28 (4.21) ^{bcd}	21.95 (4.67) ^{bcd}	25.15 (5.06) ^{bcd}	20.60	42.03
T_6	Acetamiprid 20 SP	0.30	32.62 (5.75)	15.24 (3.96) ^{cd}	12.79 (3.65) ^{de}	18.79 (4.36) ^{de}	22.34 (4.77) ^{cd}	17.29	51.35
T_7	Monocrotophos 36 SL	2.00	32.79 (5.76)	20.19 (4.55) ^{bc}	18.09 (4.26) ^{bcd}	23.25 (4.87) ^{bcd}	26.46 (5.19) ^{bcd}	21.99	38.12
T_8	Untreated control	–	30.32 (5.55)	31.52 (5.66) ^{a}	33.00 (5.79) ^{a}	36.33 (6.06) ^{a}	41.32 (6.46) ^{a}	35.54	-
SEm±			-	0.26	0.23	0.21	0.26		
CD@P=0.05			-	0.83	0.72	0.65	0.79		
CV %			10.09	10.27	9.48	8.04	8.53		

Observations: # - Mean number of aphids per two leaves per plant; *Figures in parentheses are √x + 0.5 transformed values; Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05); DBS-Day before spray; DAS-Days after spray

Three days after spray**:** The observation after three days after spraying showed that all the treatments were significantly different from the untreated control in reducing the aphid population whereas imidacloprid 17.8 SL recorded lowest aphid population of 13.19 per two leaves and was on par with acetamiprid 20 SP (15.24 aphids / two leaves), flonicamid 50 WDG (17.29 aphids/two leaves) and clothianidin 50 WDG (18.05 aphids / two leaves). The next best are monocrotophos 36SL (20.19 aphids / two leaves) and diafenthiuron 50WP (21.45 aphids / two leaves). The highest population was observed in azadirachtin 1 EC treated plots (24.08 aphids / two leaves).

4.3.1.1 Five days after spray

Similar trend was observed at five days after spray where imidacloprid 17.8 SL was the most effective and superior treatment with a minimum population of 11.24 aphids/two leaves followed by acetamiprid 20 SP (12.79 aphids / two leaves) and flonicamid 50 WDG (15.14 aphid / two leaves) which were on par with each other and azadirachtin 1 EC showed the highest aphid population of 22.79 aphids per two leaves.

4.3.1.2 Seven days of first insecticidal spray

Field efficacy was highest in plots treated with imidacloprid 17.8 SL with least aphid population of 14.57 aphids per two leaves, next better treatment was acetamiprid 20 SP (18.79 aphids / two leaves) followed by flonicamid 50 WDG (19.14 aphids / two leaves), azadirachtin 1 EC treated plots showed highest population of 26.64 aphids per two leaves.

4.3.1.3 Fourteen days after spray

Similar trend was observed on fourteenth day after spray with minimum aphid population in imidacloprid 17.8 SL and maximum population was recorded in azadirachtin 1 EC (31.57 aphids / two leaves). However all the insecticidal treatments were significantly superior over unteated control.

4.3.1.4 Cumulative efficacy

Data on overall efficacy of insecticides against aphids after first spray revealed that imidacloprid 17.8 SL was found to be significantly superior to other treatments by recording significantly lowest population of 14.99 aphids per 2 leaves with highest per cent reduction of 57.82 population over untreated control. This was followed by acetamiprid 20 SP with overall per cent reduction of 51.35. The least per cent population reduction was observed in azadirachtin treated plots. Imidacloprid 17.8 SL and acetamiprid 20 SP were on par with each other with respect to reducing the aphid population (Table 5). However, all the insecticidal

treatments under evaluation were significantly superior in recording lower population of aphids per 2 leaves compared to untreated check.

4.3.2 Efficacy of different insecticides against chrysanthemum aphid (Macrosiphoniella sanborni) after second spray

4.3.2.1 Three days after spray

At three days after insecticidal application, all the treatments were found significantly superior over untreated control. Imidacloprid 17.8 SL continued to be extremely good with a reduction of population from 20.96 to 7.08 aphids per two leaves followed by acetamiprid 20 SP with 8.65 aphids per two leaf, flonicamid 50 WDG (9.41 aphids / two leaves), clothianidin 50 WDG (10.66 aphids / two leaves), monocrotophos 36SL (12.01 aphids / two leaves), diafenthiuron 50WP (13.11 aphids / two leaves). The highest population was observed in azadirachtin treated plots (15.21 aphids / two leaves) as presented in Table 6.

4.3.2.2 Five days after spray

The results obtained at five days after second spray showed that imidacloprid 17.8 SL was most effective with 3.21 aphids per two leaves followed by acetamiprid 20 SP with 4.55 aphids per two leaves, which were on par with each other, azadirachtin (12.08 aphids / two leaves) was found to be least effective.

4.3.2.3 Seven days after spray

Same trend continued seven days after second spray with imidacloprid 17.8 SL recording 3.91 aphids per two leaves and was significantly superior to the remaining treatments. Acetamiprid was next effective treatment with 5.16 aphids per two leaves followed by flonicamid (6.05 aphids / two leaves). Azadirachtin treated plots showed highest aphid population as compared to other treatment.

4.3.2.4 Fourteen days after spray

Similar trend was observed on fourteenth day after spray with minimum aphid population in imidacloprid and maximum population was recorded in azadirachtin 1 EC (27.13 aphids / two leaves). However all the insecticidal treatments were significantly superior over unteated control.

Table 6. Efficacy of different insecticides against chrysanthemum aphid (*Macrosiphoniella sanborni*) after second spray during 2017-18

Tr. No.	Treatments	Dose ml or g/l	Aphid population per 2 leaves#					Mean aphid population per 2 leaves	Per cent reduction of aphids over untreated control
			II Spray						
			1 DBS	3DAS	5 DAS	7 DAS	14 DAS		
T_1	Imidacloprid 17.8 SL	0.50	20.96 (4.61)* ^{d}	7.08 (2.75) ^{e}	3.21 (1.92) ^{f}	3.91 (2.1) ^{e}	11.48 (3.45)^{e}	6.42	86.06
T_2	Flonicamid 50 WDG	2.00	23.94 (4.89) ^{bcd}	9.41 (3.14) ^{cde}	5.6 (2.47) ^{de}	6.05 (2.56) ^{de}	15.05 (3.92)^{de}	9.02	80.42
T_3	Azadiractin 1 EC	1.00	31.57 (5.64) ^{b}	15.21 (3.93) ^{b}	12.08 (3.54) ^{b}	13.33 (3.71) ^{b}	27.13 (5.25) ^{b}	16.93	63.25
T_4	Diafenthiuron 50 WP	1.00	29.24 (5.45) ^{bc}	13.11 (3.68) ^{bc}	10.09 (3.23) ^{bc}	11.33 (3.43)^{bc}	24.03 (4.94)^{bc}	14.64	68.22
T_5	Clothianidin 50 WDG	0.10	25.15 (5.06) ^{bcd}	10.66 (3.33) ^{bce}	7.5 (2.82)^{cd}	8.26 (2.96)^{cd}	18.49 (4.36) ^{cd}	11.22	75.64
T_6	Acetamiprid 20 SP	0.30	22.34 (4.77) ^{cd}	8.65 (3.02) ^{de}	4.55 (2.24) ^{ef}	5.16 (2.38)^{e}	13.49 (3.7) ^{de}	7.96	82.72
T_7	Monocrotophos 36 SL	2.00	26.46 (5.19) ^{bcd}	12.01 (3.53) ^{bcd}	9.12 (3.08) ^{bc}	9.6 (3.16) ^{c}	21.6 (4.69) ^{bc}	13.08	71.60
T_8	Untreated control	–	41.32 (6.46) ^{a}	42.4 (6.54) ^{a}	44.96 (6.74) ^{a}	45.63 (6.78) ^{a}	51.29 (7.2) ^{a}	46.07	-
SEm±			0.26	0.20	0.17	0.16	0.23		
CD@P=0.05			0.79	0.62	0.53	0.48	0.71		
CV %			8.53	9.41	9.23	8.03	8.60		

Observations: # - Mean number of aphids per two leaves per plant; *Figures in parentheses are √x + 0.5 transformed values; Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05); DBS-Day before spray; DAS-Days after spray

4.3.2.4 Cumulative efficacy of second spray

Data on overall efficacy of insecticides against aphids after second spray revealed that imidacloprid 17.8 SL was found to be significantly superior to other treatments by recording significantly lowest population of 6.42 aphids per 2 leaves with highest per cent reduction of 86.06 population over untreated control. This was followed by acetamiprid 20 SP with overall per cent reduction of 82.72. Insecticidal treatment azadiracthin 1 EC proved to be least effective by recording highest of 16.93 aphids per 2 leaves. However, all the insecticidal treatments under evaluation were significantly superior in recording lower population of aphids per 2 leaves compared to untreated check (Table 6).

4.3.3 Efficacy of different insecticides against chrysanthemum thrips after first spray

The thrips population was almost uniform in all treatments ranging from 6.83 to 8.25 thrips per flower as indicated by non-significant difference at one day before imposition of the treatment (Table 7).

4.3.3.1Three days after spray

At three days after spray, there was a significant difference in the thrips population among the treatments. All the treatments were superior when compared to untreated check. Significantly lower thrips population was recorded in flonicamid 50 WDG with 3.28 thrips per flower and imidacloprid 17.8SL with 3.76 thrips per flower which were on par with each other and followed by acetamiprid 20 SP (4.19 thrips / flower), clothianidin 50 WDG (5.13 thrips / flower), monocrotophos 36 SL (5.31 thrips flower), diafenthiuron 50 WP (5.44 thrips / flower). Further, azadirachtin 1 EC (5.85 thrips / flower) recorded lowest population.

4.3.3.2 Five days after spray

At five days after spray significant differences among the treatments was evident from the results obtained. Flonicamid 50 WDG continued to be extremely good result with 2.82 thrips per flower followed by imidacloprid 17.8 SL with 3.35 thrips per flower followed by acetamiprid 20 SP (3.89 thrips/flower), clothianidin 50 WDG (4.58 thrips / flower), monocrotophos 36SL (4.67 thrips / flower), diafenthiuron 50WP (5.1 thrips / flower). The highest population was observed in azadirachtin treated plot (5.5 thrips /flower).

Table 7. Efficacy of different insecticides against chrysanthemum thrips after first spray during 2017-18

Tr. No.	Treatments	Dose ml or g/l	Thrips population per flower#					Mean thrips population per flower	Per cent reduction of thrips over untreated control
			I Spray						
			1 DBS	3DAS	5 DAS	7 DAS	14 DAS		
T_1	Imidacloprid 17.8 SL	0.50	7.79 (2.87)	3.76 (2.06) ^{cd}	3.35 (1.95) ^{de}	3.45 (1.98) ^{de}	5.45 (2.43) ^{cd}	4.00	54.49
T_2	Flonicamid 50 WDG	2.00	7.18 (2.76)	3.28 (1.94) ^{d}	2.82 (1.82) ^{e}	2.92 (1.85) ^{e}	4.82 (2.28) ^{d}	3.46	60.63
T_3	Azadiractin 1 EC	1.00	8.52 (3.00) ^{b}	5.85 (2.5) ^{b}	5.5 (2.44) ^{b}	5.68 (2.48) ^{b}	7.68 (2.86) ^{b}	6.17	29.80
T_4	Diafenthiuron 50 WP	1.00	7.46 (2.79)	5.44 (2.44) ^{bc}	5.1 (2.36) ^{bc}	5.28 (2.38) ^{bc}	7.35 (2.8) ^{bc}	5.79	34.12
T_5	Clothianidin 50 WDG	0.10	6.83 (2.71)	5.13 (2.35) ^{bcd}	4.58 (2.25) ^{bcd}	4.69 (2.27) ^{bcd}	6.49 (2.64) ^{bcd}	5.22	40.61
T_6	Acetamiprid 20 SP	0.30	7.81 (2.88)	4.19 (2.16) ^{bcd}	3.89 (2.09) ^{cde}	3.97 (2.11) ^{cde}	5.8 (2.5) ^{bcd}	4.46	49.26
T_7	Monocrotophos 36 SL	2.00	8.25 (2.95)	5.31 (2.38) ^{bc}	4.67 (2.27) ^{bcd}	4.76 (2.29) ^{bcd}	6.8 (2.7) ^{bc}	5.38	38.79
T_8	Untreated control	–	7.31 (2.78)	8.14 (2.94) ^{a}	8.23 (2.94) ^{a}	8.3 (2.95) ^{a}	10.5 (3.31) ^{a}	8.79	-
SEm±			-	0.13	0.1	0.1	0.13		
CD@P=0.05			-	0.41	0.32	0.33	0.40		
CV %			8.91	10.04	8.2	8.27	8.59		

Observations: # - Mean number of thrips per flower per plant; *Figures in parentheses are √x + 0.5 transformed values; Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05); DBS-Day before spray; DAS-Days after spray

4.3.3.3 Seven days after spray

Significantly lower thrips population was recorded in the treatment flonicamid 50 WDG (2.92 thrips/flower) and imidacloprid 17.8SL (3.45 thrips / flower) followed by acetamiprid 20 SP (3.97 thrips / flower), clothianidin 50 WDG (4.69 thrips /flower), monocrotophos 36SL (4.76 thrips / flower), diafenthiuron 50WP (5.28 thrips / flower). The highest population was observed in azadirachtin treated plots (5.68 thrips / flower).

4.3.3.4 Fourteen days after first spray

Highest thrips population was observed in control followed by azadirachtin and the lower thrips population was observed in plots sprayed with flonicamid 50 WDG and imidacloprid 17.8 SL.

4.3.3.5 Cumulative efficacy

Data on overall efficacy of insecticides against thrips after first spray revealed that flonicamid 50 WDG was found to be significantly superior to other treatments by recording significantly lowest population of 3.46 thrips per flower with highest per cent reduction of 60.63 populations over untreated control. This was followed by imidacloprid 17.8SL with overall per cent reduction of 54.49. Insecticidal treatment azadirachthin 1 EC proved to be least effective by recording highest of 6.17 thrips per flower. However, all the insecticidal treatments under evaluation were significantly superior in recording lower population of thrips per flower compared to untreated check (Table 7).

4.3.4 Efficacy of different insecticides against chrysanthemum thrips after second spray

4.3.4.1Three days after spray

The observation recorded on three days after treatment imposition revealed that, lowest population of thrips was recorded in flonicamid 50 WDG with 1.45 thrips per flower and per cent reduction over control was 86.3 followed by imidacloprid 17.8 SL (1.69 thrips/flower) which were on par with each other, acetamiprid 20 SP (2.11 thrips / flower), clothianidin 50 WDG (2.18 thrips / flower), monocrotophos 36 SL (2.31 thrips / flower), diafenthiuron 50 WP (2.4 thrips / flower), azadirachtin 1 EC (2.76 thrips / flower) and highest population was recorded in untreated check (Table 8).

Table 8. Efficacy of different insecticides against chrysanthemum thrips after second spray during 2017-18

Tr. No.	Treatments	Dose ml or g/l	Thrips population per flower#					Mean thrips population per flower	Per cent reduction of thrips over untreated control
			II Spray						
			1 DBS	3DAS	5 DAS	7 DAS	14 DAS		
T_1	Imidacloprid 17.8 SL	0.50	5.45 (2.43) *cd	1.69 (1.48) cd	0.72 (1.11) d	0.81 (1.14) d	2.71 (1.78) de	1.48	86.58
T_2	Flonicamid 50 WDG	2.00	4.82 (2.28) d	1.45 (1.4) d	0.56 (1.03) d	0.62 (1.06) d	2.48 (1.72) e	1.27	88.48
T_3	Azadiractin 1 EC	1.00	7.68 (2.86) b	2.76 (1.81) b	2.48 (1.73) b	2.56 (1.75) b	5.76 (2.5) b	3.39	69.26
T_4	Diafenthiuron 50 WP	1.00	7.35 (2.8) bc	2.40 (1.7) bc	2.23 (1.65) bc	2.4 (1.7) bc	5.07 (2.35) bc	3.02	72.62
T_5	Clothianidin 50 WDG	0.10	6.49 (2.64) bcd	2.18 (1.64) bcd	1.81 (1.52) bc	1.99 (1.58) bc	4.26 (2.17) bcd	2.56	76.79
T_6	Acetamiprid 20 SP	0.30	5.8 (2.5) bcd	2.11 (1.61) bcd	1.54 (1.43) c	1.65 (1.47) c	3.55 (2.00) cde	2.21	79.96
T_7	Monocrotophos 36 SL	2.00	6.8 (2.7) bc	2.31 (1.67) bcd	1.91 (1.55) bc	2.04 (1.59) bc	4.64 (2.26) bc	2.72	75.33
T_8	Untreated control	–	10.5 (3.31) a	10.63 (3.33) a	10.69 (3.33) a	10.8 (3.35) a	12.02 (3.54) a	11.03	-
SEm±			0.13	0.13	0.08	0.08	0.13		
CD@P=0.05			0.40	0.27	0.25	0.26	0.40		
CV %			8.59	8.55	8.63	8.57	9.94		

Observations: # - Mean number of thrips flower per plant; *Figures in parentheses are √x + 0.5 transformed values; Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05); DBS-Day before spray; DAS-Days after spray

4.3.4.2 Five days after spray

The population reduction after five days of spraying insecticides revealed that lower population was recorded in flonicamid 50 WDG with 0.56 thrips per flower followed by imidacloprid 17.8SL and highest in untreated check followed by azadirachtin with 2.48 thrips per flower.

4.3.4.3 Seven days after spray

Same trend continued during seven days after second spray with flonicamid recording 0.62 thrips per flower and was significantly superior to the remaining treatments. Imidacloprid 17.8SL was next effective treatment with 0.81 thrips per flower followed by acetamiprid 20 SP (1.65 thrips / flower), azadirachtin 1 EC treated plots showed highest thrips population of 2.56 thrips per flower.

4.3.4.3 Fourteen days after spray

Similar trend was observed on fourteenth day after spray with minimum thrips population in flonicamid 50 WDG and maximum population in untreated control followed by azadirachtin 1 EC.

4.3.4. 4 Cumulative efficacy of second spray

Data on overall efficacy of insecticides against thrips after second spray revealed that flonicamid 50 WDG was found to be significantly superior to other treatments by recording significantly lowest population of 1.27 thrips per flower with highest per cent reduction of 88.48 population over untreated control. This was followed by imidacloprid 17.8 SL with overall per cent reduction of 86.58. Insecticidal treatment azadirachthin 1 EC proved to be least effective by recording highest of 3.39 thrips per flower. However, all the insecticidal treatments under evaluation were significantly superior in recording lower population of thrips/flower compared to untreated check (Table 8).

4.3.5 Efficacy of different insecticides against chrysanthemum whitefly (Bemesia tabaci) after first spray

The data on pre-count and post count observations of average number of whitefly population are presented in the table .It could be seen from the data that pre-count in different treatment plots ranged from 6.87 to 5.73 per three leaves. These observations were statistically non-significant (Table 9).

Table 9: Efficacy of different insecticides against chrysanthemum whitefly (*Bemesia tabaci*) after first spray during 2017-18

Tr. No.	Treatments	Dose ml or g/l	Whitefly population per 3 leaves#					Mean whitefly population per 3 leaves	Per cent reduction of whitefly over untreated control
			I Spray						
			1 DBS	3DAS	5 DAS	7 DAS	14 DAS		
T_1	Imidacloprid 17.8 SL	0.50	6.02 (2.53)*	1.31 (1.34) ^{e}	0.86 (1.16) ^{e}	0.31 (0.9) ^{f}	3.21 (1.9) ^{d}	1.42	82.00
T_2	Flonicamid 50 WDG	2.00	6.34 (2.61)	2.81 (1.81) ^{cd}	1.9 (1.54) ^{d}	1.23 (1.32) ^{cde}	4.28 (2.18) ^{bcd}	2.55	67.68
T_3	Azadiractin 1 EC	1.00	5.73 (2.49)	4.22 (2.16) ^{b}	3.54 (2.01) ^{b}	2.24 (1.65) ^{b}	5.44 (2.43) ^{b}	3.86	51.07
T_4	Diafenthiuron 50 WP	1.00	5.8 (2.48)	1.92 (1.55) ^{de}	1.09 (1.26) ^{e}	0.75 (1.1) ^{ef}	3.72 (2.05) ^{cd}	1.87	76.29
T_5	Clothianidin 50 WDG	0.10	6.39 (2.62)	3.23 (1.93) ^{bc}	2.32 (1.65) ^{cd}	1.63 (1.45) ^{bcd}	4.76 (2.28) ^{bc}	2.98	62.23
T_6	Acetamiprid 20 SP	0.30	5.84 (2.52)	2.1 (1.61) ^{de}	1.5 (1.4) ^{de}	1.03 (1.24) ^{de}	4 (2.12) ^{bcd}	2.15	72.75
T_7	Monocrotophos 36 SL	2.00	6.87 (2.7)	3.76 (2.06) ^{bc}	2.92 (1.85) ^{bcd}	1.92 (1.55) ^{bc}	5.06 (2.35) ^{bc}	3.41	56.78
T_8	Untreated control	–	6.15 (2.57) ^{a}	6.93 (2.72) ^{a}	7.16 (2.77) ^{a}	7.37 (2.8) ^{a}	10.13 (3.26) ^{a}	7.89	-
SEm±				0.09	0.09	0.08	0.12		
CD@P=0.05				0.27	0.26	0.25	0.36		
CV %			9.26	8.15	8.84	9.62	8.74		

Observations: # - Mean number of whiteflies per three leaves per plant; *Figures in parentheses are √x + 0.5 transformed values; Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05); DBS-Day before spray; DAS-Days after spray

4.3.5.1 Three days after spray

The data recorded on third day after treatment revealed that whitefly population varied from 1.31 to 6.93 per three leaves in different treatments. All the treatments were significantly superior over control in reducing whitefly population. Imidacloprid 17.8 SL found to be significantly superior in reducing the whitefly population (1.31whiteflies / 3 leaves) followed by diafenthiuron 50WP (1.92 whiteflies / 3 leaves) which was on par with acetamiprid 20 SP (2.10 whiteflies / 3 leaves). The next best treatments were flonicamid 50WDG, clothianidin 50WDG and Monocrotophos 36SL with 2.81, 3.23, 3.76 whitefly per three leaves. Azadirachtin 1EC was found to be least effective and recorded 4.22 whiteflies per three leaves**.**

4.3.5.2 Five days after spray

The observation on fifth day after spraying revealed that, lowest whitefly population was recorded in imidacloprid 17.8 SL (0.86 whiteflies / 3 leaves) followed by diafenthiuron 50 WP (1.09 whiteflies / 3 leaves) and were on par with each other. The next best treatment was acetamiprid 20 SP with 1.5 whiteflies per three leaves. On the contrary highest population of whiteflies was recorded in untreated control (7.16 whiteflies / 3 leaves) as compared to other treatments.

4.3.5.3 Seven days after spray

Imidacloprid 17.8 SL (0.31 whiteflies / 3leaves) was found to superior to other treatments by recording 95.79 per cent reduction of whitefly followed by diafenthiuron 50 WP (0.75 whiteflies / 3 leaves). Maximum whitefly population was recorded in azadirachtin 1EC (2.24 whiteflies/three leaves) as compared to other treatments. Whereas untreated check found to be least effective by registering a highest population of whitefly (7.37 whiteflies / 3 leaves).

4.3.5.4 Fourteen days after spray

All the treatments were significantly superior over the control at 14 DAS, less population of whitefly was observed in imidacloprid 17.8 SL (3.21 whiteflies / 3 leaves). Highest population of whitefly was observed in azadirachtin 1EC (5.44 whiteflies / 3 leaves).

4.3.5.5 Cumulative efficacy of first spray

Data on overall efficacy of insecticides against whitefly after first spray revealed that imidacloprid 17.8 SL was found to be significantly superior to other treatments by recording significantly lowest population of 1.42 whiteflies per three

leaves with highest per cent reduction of 82.00 population over untreated control. This was followed by diafenthiuron 50 WP with overall per cent reduction of 76.29. Insecticidal treatment azadirachtin 1 EC proved to be least effective by recording highest of 3.86 whiteflies per three leaves. However, all the insecticidal treatments under evaluation were significantly superior in recording lower population of whiteflies /three leaves compared to untreated check (Table 9).

4.3.6 Efficacy of different insecticides against chrysanthemum whitefly (Bemesia tabaci) after second spray

The data pertaining to the efficacy of insecticides after second spray is presented in the Table 10.

4.3.6.1 Three days after spray

At 3 DAS population of whitefly population varied from 0.7 to 11.28 per three leaves. Imdidacloprid 17.8 SL was retained superiority in reduction of whitefly population *i.e.,* 0.7 per three leaves. Whereas, Diafenthiuron 50 WP, acetamiprid 20 SP and flonicamid 50 WDG recorded 0.89, 1.14, 1.26 per three leaves respectively. In untreated control whitefly population increased from 10.13 to 11.28 per three leaves.

4.3.6.2 Five days after spray

At 5 DAS imidacloprid 17.8 SL and diafenthiuron 50 WP remained on par with each other and significantly superior over other treatments in recording lowest whitefly population per three leaves (0.3 and 0.42, respectively). Azadirachtin 1 EC recorded highest whitefly population than the other treatments *i.e.,* 1.52 per three leaves.

4.3.6.3 Seven days after spray

The data recorded on seventh day after spraying showed the whitefly population ranged from 0.11 to 11.65 per three leaves. All the treatments were significantly superior over untreated control. The lowest incidence of 0.11 per three leaves was observed in plots treated with imidacloprid 17.8 SL and emerged as the significantly superior treatment. However, it was on par with diafenthiuron 50 WP and acetamiprid 20 SP indicating whitefly population of 0.25 and 0.31 per three leaves respectively.

Table 10: Efficacy of different insecticides against chrysanthemum whitefly (*Bemesia tabaci*) after second spray during 2017-18

Tr. No.	Treatments	Dose ml or g/l	Whitefly population per 3 leaves#					Mean whitefly population per 3 leaves	Per cent reduction of whitefly over control
			II Spray						
			1 DBS	3DAS	5 DAS	7 DAS	14 DAS		
T_1	Imidacloprid 17.8 SL	0.50	3.21 (1.90)* ^{d}	0.7 (1.09) ^{e}	0.3 (0.89) ^{d}	0.11 (0.78) ^{e}	3.02 (1.87) ^{e}	1.03	91.43
T_2	Flonicamid 50 WDG	2.00	4.28 (2.18) ^{bcd}	1.26 (1.32) ^{cde}	0.9 (1.18) ^{c}	0.52 (1.01) ^{cd}	3.95 (2.1) ^{bcd}	1.65	86.28
T_3	Azadiractin 1 EC	1.00	5.44 (2.43) ^{b}	2.35 (1.67) ^{b}	1.52 (1.4) ^{b}	1.3 (1.33) ^{b}	5.33 (2.39) ^{b}	2.62	78.22
T_4	Diafenthiuron 50 WP	1.00	3.72 (2.05) ^{cd}	0.89 (1.17) ^{de}	0.42 (0.96) ^{d}	0.25 (0.86) ^{de}	3.27 (1.94) ^{de}	1.20	90.02
T_5	Clothianidin 50 WDG	0.10	4.76 (2.28) ^{bc}	1.59 (1.45) ^{bcd}	1.04 (1.24) ^{bc}	0.87 (1.16) ^{bc}	4.69 (2.27) ^{bc}	2.04	83.04
T_6	Acetamiprid 20 SP	0.30	4 (2.12) ^{bcd}	1.14 (1.27) ^{de}	0.7 (1.1) ^{cd}	0.31 (0.9) ^{de}	3.75 (2.05) ^{cde}	1.47	87.78
T_7	Monocrotophos 36 SL	2.00	5.06 (2.35) ^{bc}	2.08 (1.6) ^{bc}	1.24 (1.3) ^{bc}	0.98 (1.2) ^{bcd}	5.05 (2.35) ^{bc}	2.33	80.63
T_8	Untreated control	–	10.13 (3.26) ^{a}	11.28 (3.43) ^{a}	11.38 (3.45) ^{a}	11.65 (3.48) ^{a}	13.82 (3.78) ^{a}	12.03	-
SEm±			0.12	0.10	0.07	0.06	0.11		
CD@P=0.05			0.36	0.31	0.21	0.20	0.33		
CV %			8.74	10.74	8.46	8.37	8.06		

Observations: # - Mean number of whiteflies per three leaves per plant; *Figures in parentheses are √x + 0.5 transformed values; Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05); DBS-Day before spray; DAS-Days after spray

4.3.6.4 Fourteen days after spray

It is evident from the data that whitefly population recorded at 14th DAS varied from 3.02 to 5.33 per three leaves and 13.82 in untreated control. The superiority of imidacloprid 17.8 SL was found persisted and found to be significantly superior over rest of the treatments. The treatment with azadirachtin 1EC was least effective in controlling the whitefly population *i.e*., 5.33 per three leaves.

4.3.6.5 Cumulative efficacy of second spray

The overall mean whitefly population after spraying insecticides indicated that the superiority of imidacloprid 17.8 SL (1.03 / 3 leaves). The treatments with diafenthiuron 50 WP and acetamiprid 20 SP were found equally effective (1.20 and 1.47 /3 leaves) as compared to imidacloprid 17.8 SL.

Among the treatments, significantly highest per cent reduction of 91.43 was recorded in imidacloprid 17.8 SL followed by diafenthiuron 50 WP and acetamiprid 20 SP (90.02 and 87.78 %) respectively (Table 10).

4.3.7 Yield and cost economics

The effect of different insecticides on yield and cost economics is presented in the Table 11.

The data on chrysanthemum flower yield revealed that significantly higher chrysanthemum flower yield was recorded in imidacloprid 17.8 SL with 19.10 ton flowers per ha, followed by acetamiprid 20 SP (18.20 ton flowers/ha), flonicamid 50 WDG (15.80 ton flowers/ha), monocrotophos 36 SL (15.20 ton flowers / ha), clothianidin 50 WDG (14.30 ton flowers / ha), diafenthiuron 50 WP (14.10 ton flowers / ha), azadirachtin 1 EC (13.80 ton flowers / ha) and significantly lower chrysanthemum flower yield was recorded in untreated control 6.60 ton flowers per ha.

The higher cost benefit ratio of 1:2.0 was recorded in imidacloprid 17.8 SL followed by acetamiprid 20 SP (1:1.9), flonicamid 50 WDG (1:1.6), monocrotophos 36 SL (1:1.6), clothianidin 50 WDG (1:1.5), diafenthiuron 50 WP (1:1.4) and azadirachtin 1 EC (1:1.4). However, lower benefit cost ratio of 1:0.7 was recorded in untreated check (Table 11).

Table 11. Cost economics of different insecticides in the management of sucking pests of chrysanthemum during 2017-18

Tr.No	Treatments	Dosage gm/ml per l.	Yield flower/ha (ton)	Yield increment over control (%)	Cost of production (Rs/ha)	Total cost for protection (Rs/ha)	Total cost of production (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	C:B ratio
T1	Imidacloprid 17.8SL	0.50	19.10	52.03	469000	1800	470800	955000	484200	1:2.0
T2	Flonicamid 50WDG	2.00	15.80	43.60	469000	5750	474750	790000	315250	1:1.6
T3	Azadiractin 1EC	2.00	13.80	36.90	469000	2202	471202	690000	218798	1:1.4
T4	Diafenthiuron 50WP	1.00	14.10	38.01	469000	5200	474200	705000	230800	1:1.4
T5	Clothianidin50WDG	0.10	14.30	38.72	469000	2582	471582	715000	243418	1:1.5
T6	Acetamiprid 20SP	0.30	18.20	50.04	469000	1460	470460	910000	439540	1:1.9
T7	Monocrotophos36SL	2.00	15.20	41.75	469000	2280	471280	760000	288720	1:1.6
T8	Untreated control	_	6.60	-	469000	-	469000	430000	383100	1:0.7

Cost per flower= Rs.50/kg.

Cost of insecticides/L: T1: Imidacloprid 17.8SL (150ml)/ -Rs.300.00; T2: Flonicamid 50WDG (150gm) -1485.00/-; T3: Azadiractin 1EC (1000ml)-1402.00/-; T4: Diafenthiuron 50WP (25g) -110.00/-, T5: Clothianidin50WDG(6g) -107.00/-, T6 : Acetamiprid 20SP (100g): 220.00/-, T7: Monocrotophos36SL (100ml)–74.00/-, T8: control; Cost of labour: Rs. 200/day; Standard spray volume: 500 l/ha

DISCUSSION

V DISCUSSION

In order to know the seasonal incidence of sucking pest of chrysanthemum and to evaluate the efficacy of different insecticides against these pests, studies were conducted during 2017-18. The research findings of the studies presented in the previous chapter are discussed here under.

5.1 Survey on sucking pest complex of chrysanthemum

The survey was conducted to record different sucking pests on chrysanthemum during 2017-2018 in open field conditions. The survey was undertaken at fortnightly intervals in open fields in two districts *viz.*, Shivamogga and Chitradurga. In Shivamogga survey was conducted at Holehonnuru, Hadonahalli and campus of University of Agricultural and Horticultural sciences. In Chitradurga four taluk were selected viz., Chitradurga, Hiriyur, Holalkere and Challakere. In each taluk two villages were selected *viz.*, Doddasiddavvanahalli, TN kote, Aimangala, Hemadala, Nellikatte, Tekalavatti, Gopanahalli and Marikunte respectively

5.1.1 Aphids

Among two districts surveyed, the highest mean number of aphids per 3 leaves was recorded in Shivamogga district (9.57aphids/3 leaves), this may be due to decline in temperature during January. Lowest mean number of aphid population of 1.25 was observed during second fortnight of April in Holalkere taluk of Chitradurga district. The present findings are in agreement with Kulat *et al*. (2000) who conducted studies on seasonal monitoring of safflower aphids, *U. Carthami.* He revealed that though the population occurs throughout the crop growth period, it attained a peak during the second week of January.

5.1.2 Whitefly

The maximum mean number of whiteflies (5.25/3 leaves) was recorded during the first fortnight of September at Hiriyur taluk of Chitradurga district. The present finding was in contrary with the findings of Singh *et al*. (2013) who reported that the whitefly population on okra was maximum during the fourth week of September *i.e.* second fortnight. The difference may be due to varying weather conditions and soil type as well as difference in crops grown.

5.1.3 Thrips

The peak population of thrips was noticed during first fortnight of February (7.40/flower) in Chitradurga district and among different taluks, maximum mean population was recorded in holalkere taluk with 8.95 thrips per flower. The present

finding was in agreement with Sumbad (2000) who studied the seasonal incidence of pests of marigold. He revealed that the peak appearance of the thrips was observed between January-May and was positively correlated with the maximum and minimum temperature during the study period.

5.2 Population dynamics of sucking pest complex of chrysanthemum

Successful management of sucking pests depends upon understanding the seasonal fluctuation of the population and seasonal incidence in revealing the pest behaviour. This study was carried out during the year 2017-18 at Karnataka State Department of Horticulture (KSDH), Shivamogga, Karnataka.

5.2.1 Aphids

The aphid incidence commenced during second fortnight of August with a population of 6.74 aphids per two leaves and continued till the end of the cropping period. The peak infestation was observed during second fortnight of January with a population of 42.59 aphids per two leaves.

The aphid population reached a peak (42.59 aphids / 2 leaves) when the maximum temperature was 31.9˚C and minimum temperature was 14.8 ºC and thereafter decreased with an increase in maximum and minimum temperature. It was found that both the maximum temperature and minimum temperature were found to exert a significant negative influence on the population buildup of aphids (r = -0.273 and r = -0.693**) respectively.

The above result are in concurrence with the findings of Painkra *et al.* (2003), Patil and Kamat (2012) and Mallapur *et al*. (2005) who studied aphid population *vs.* weather relations in the safflower aphid (*Uroleucon carthami*), a related species occurring during the same time window as the chrysanthemum aphid and found a significant negative correlation of aphid population to maximum temperature and rainfall. Peak aphid population was observed at a mean maximum temperature of 28-32 ºC, mean minimum temperature of 13-16 ºC and a relative humidity of 83 per cent in safflower (Patil *et al*., 2008) which coincides with the present findings.

The aphid incidence was negatively correlated with maximum and minimum relative humidity (%) during the study period (r = - 0.209 and r = - 0.248).The peak aphid population (42.59 aphids/2 leaves) was recorded when maximum relative humidity was 72.3 per cent. These findings are in agreement with those of Mane *et al*. (2002) who found that the relative humidity was negatively correlated with aphid incidence in safflower.

High rainfall during October drastically reduced aphid population. Later as rainfall decreased the aphid population increased gradually and peak population was observed during second fortnight of January. Rainfall has shown significantly negative correlation (r = - 0.485*) to aphid buildup during study period. These were in close agreement with the report of Kakar and Sood (1989) who worked on rose aphid *Macrosiphoniella rosae* and reported that the rainfall has negative influence on aphid population.

5.1.2 Thrips

Flower thrips, *Frankliniella* spp. was found first during the reproductive period of plant growth and continued till the end of the cropping period. The peak thrips incidence (6.15thrips / flower) was observed during first fortnight of February.

The peak thrips population (6.1 thrips / flower) was found when maximum temperature was 32.9ºC. The correlation between maximum temperature and thrips incidence indicated a positive significant relationship (r = 0.848**). The minimum temperature varied from 15.7 ºC to 23 ºC and highest population was found during 16.6 ºC. The correlation found between minimum temperature and thrips incidence was positive (r = 0.23).

A related study on the influence of weather parameters on incidence of rose thrips *F. schultzei* Trybom has shown that maximum and minimum temperature had a positive significant correlation with the incidence of thrips (Rajkumar, 2001). The findings of the present study are in agreement with the above study. Similar studies in brinjal and mulberry have also corroborated the above statement that maximum and minimum temperature are positively correlated to thrips population build up (Su *et al.*, 1985 and Ghosh, *et al.*, 2000)

The maximum relative humidity was found to range from 60 to 70 per cent at the time of peak incidence and showed significantly negative correlation (r = -0.774**). The minimum relative humidity ranged from 23.52 to 78.6 per cent and showed significantly negative correlation (r = -0.800**). Rajkumar (2001) reported a negative significant correlation between minimum relative humidity and thrips incidence in rose which corroborates the findings of the present study.

5.3 Efficacy of selected new insecticides against major sucking pests of chrysanthemum

5.3.1 Aphid

In the present study imidacloprid 17.8 SL was found to be effective in reducing the aphid population followed by acetamiprid 20 SP. When the per cent

reduction over untreated control was calculated it was found that imidacloprid 17.8 SL could reduce the population to an extent of 57.82 and 86.06 per cent in first and second spray respectively.

These results are comparable with the work of Choudhary *et al*. (2017) who reported that imidacloprid, thiamethoxam and dimethoate were found effective against the cotton aphid whereas, the azadirachtin and malathion were found least effective against the pest. Reddy *et al*. (2012) reported that acetamiprid was effective against chrysanthemum aphid, *Macrosiphoniella sanbarni* (Koch). Shirale, (2010) reported that lowest aphid population (0.83) was recorded in thiamethoxam followed by acetamiprid (1.3) and imidacloprid (1.73) which were on par with each other.

5.3.2 Thrips

The cumulative result from both the sprays revealed that flonicamid (88.48 %) was found to be significantly superior to other treatments in reducing thrips population followed by imidacloprid (86.58 %). The per cent mortality of flonicamid in both sprays was 60.63 and 88.48, respectively.

The present findings are in agreement with the work of Abbas *et al. (*2016) who reported that Per cent reduction of thrips was higher in flonicamid 50 per cent WG as compared to all other treatments. Chung *et al.* (2000) reported that imidacloprid was found to be effective western flower thrips, *F. occidentalis* Pergande in greenhouse egg plant. Hossain (2013) reported that on mung bean imidacloprid showed significant performance in reducing thrips infestation on flowers.

5.3.3 Whitefly

The present study revealed that imidacloprid 17.8 SL was effective in reducing the whitefly population in both the sprays to an extent of 91.43 per cent over untreated control followed by diafenthiuron 50WP .The present findings are in agreement with Afzal *et al.* (2014) who found that imidacloprid was effective 72 h after application and was on par with diafenthiuron. Jha *et al.* (2017) also reported that imidacloprid was effective to an extent of 49 per cent which was similar to the findings of the present study.

Conclusion

The results of survey revealed that the highest aphid population was recorded in Shivamogga district during first fortnight of January followed by Chitradurga district and in Chitradurga district, the maximum aphid was observed in Chitradurga taluk.

The peak whitefly population was observed during first fortnight of September in Chitradurga district followed by Shivamogga district and peak thrips incidence was observed during first fortnight of February in Chitradurga district.

The population dynamics of sucking pests indicated that the maximum aphid population was observed during second fortnight of January, whereas maximum thrips population was recorded during first fortnight of February.

Among the insecticides tested against sucking pest complex of chrysanthemum imidacloprid 17.8 SL, acetamiprid 20 SP and flonicamid 50 WDG were found to be effective in managing the sucking pests *viz.,* thrips, aphids and whiteflies.

Future line of work

1. Development of suitable integrated pest management strategies against sucking pests
2. Utilization of natural enemies in the management of sucking pests

SUMMARY

VI SUMMARY

The investigations were carried out on survey, population dynamics of sucking pests in relation to weather parameters and evaluation of insecticides against sucking pests of chrysanthemum during 2017-2018. The salient findings of present investigation are summarized in this chapter.

During survey, the highest mean number of aphids per 3 leaves was recorded in Shivamogga district (9.57/3 leaves) during the first fortnight of January. Whereas, lowest mean number of aphid population of 1.25 was observed during second fortnight of April in Holalkere taluk of Chitradurga district.

The maximum mean number of whiteflies (5.25/3 leaves) was recorded during the first fortnight of September in Hiriyur taluk of Chitradurga district and whitefly incidence was not recorded from March second fortnight onwards in many taluks.

The peak population of thrips was noticed during first fortnight of February (7.40/flower) in Chitradurga district and among the different taluks, maximum mean population was recorded in Hololkere taluk with 8.95 thrips per flower.

Studies on the population dynamics of sucking pests revealed that the aphid incidence was first observed during second fortnight of August with a population of 6.74 aphids per two leaves and continued till the end of the cropping period. The peak infestation was observed during second fortnight of January with a population of 42.59 aphids per two leaves.It was found that both maximum and minimum temperature, relative humidity and rainfall were found to exert a significant negative influence on the population buildup of aphids whereas, the sunshine hours has positive correlation with aphid population.

The thrips population was first recorded during second fortnight of November three months after transplanting and the infestation continued till the end of the crop. The peak thrips incidence (6.15 thrips/flower) was observed during first fortnight of February. The thrips incidence was positively correlated with both maximum temperature and minimum temperature and also with sunshine hours but has negative correlation with maximum and minimum relative humidity and also rainfall.

The insecticidal treatments imidacloprid 17.8 SL, acetamiprid 20 SP and flonicamid 50 WDG were found to be effective in managing the sucking pests. However, all the insecticidal treatments under evaluation were significantly superior in recording lower population of sucking pests compared to untreated check.

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VII REFERENCES

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APPENDIX

VIII APPENDIX

Appendix I: Fortnightly mean meteorological data for maximum temperature, minimum temperature, rainfall and relative humidity from August 2017 to April 2018

Period of observation	Rainfall (mm)	Max Temperature (°C)	Min Temperature (°C)	Relative humidity I	Relative humidity II
Aug 1st fortnight	268.80	29.70	20.20	90.60	78.60
Aug 2nd fortnight	40.10	30.40	20.40	89.90	77.60
Sep 1st fortnight	147.60	30.50	20.30	89.90	73.70
Sept 2nd fortnight	9.80	30.40	19.90	90.50	69.30
Oct 1st fortnight	33.40	31.70	20.40	90.30	72.50
Oct 2nd fortnight	24.40	32.00	21.00	89.80	70.20
Nov 1st fortnight	00	31.90	16.50	90.10	71.90
Nov 2nd fortnight	9.50	31.40	18.90	91.20	71.30
Dec 1st fortnight	00	31.30	17.90	91.30	70.90
Dec 2nd fortnight	00	31.40	15.90	89.40	69.40
Jan 1st fortnight	00	32.20	15.70	76.50	46.20
Jan 2nd fortnight	00	31.90	14.80	72.30	34.00
Feb 1st fortnight	00	32.90	16.60	62.70	35.70
Feb 2nd fortnight	00	34.40	16.40	58.30	23.52
March 1st fortnight	00	35.90	18.50	67.20	26.70
March 2nd fortnight	7.60	36.10	21.30	73.80	42.70
April 1st fortnight	18.20	36.70	22.30	75.00	46.10
April 2nd fortnight	44.20	36.80	23.00	81.90	53.30