INCIDENCE AND MANAGEMENT OF SUCKING PESTS ON GERBERA UNDER PROTECTED CULTIVATION

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INCIDENCE AND MANAGEMENT OF SUCKING PESTS ON GERBERA UNDER PROTECTED CULTIVATION

by

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THESIS

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2020

DECLARATION

I, hereby declare that this thesis entitled "**INCIDENCE AND MANAGEMENT OF SUCKING PESTS ON GERBERA UNDERPROTECTED CULTIVATION"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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PALADUGU YASASVI

CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

LIST OF ABBREVATIONS AND SYMBOLS USED

a.i.	Active ingredient
et al.	And other co workers
@	At the rate of
cm	Centimetre
CD	Critical difference
cfu	Colony forming unit
CRD	Completely Randomized Block Design
DAS	Days after spraying
DAT	Days after treatment
EC	Emulsifiable Concentrate
FYM	Farm yard manure
Fig.	Figure
FS	Flowable concentrate
g	Gram
ha	Hectare
L	Litre
mL	Millilitre
mg	Milligram
NSKE	Neem Seed Kernel Extract
NS	Non significant
viz.	Namely
OD	Oil Dispersion
ppm	Parts per million
%	Per cent
ha^{-1}	Per hectare
sp.or spp.	Species (Singular and Plural)
SP	Soluble Powder
SL	Soluble Concentrate
SC	Suspension Concentrate
i.e.	That is
WASP	Web Agri Stat Package
WG	Wettable Granules
WP	Wettable Powder

Introduction

1. INTRODUCTION

Gerbera (*Gerbera jamesonii* H. Bolus), commonly known as African daisy, is a very popular decorative garden plant with commercial significance and ranks fifth in position is the most used cut flowers (Anisha, 2009). It covers an area of 1.15 thousand ha.with a production of 20.53 thousand metric tons (Indiastat, 2015-16). This cut flower is gaining momentum in commercial floriculture industry in Kerala (Irshana, 2016).The major gerbera producing states in India are Karnataka, Maharashtra, Tamil Nadu, West Bengal, Himachal Pradesh, Jammu and Kashmir and Gujarat. It occurs in wide range of colours including red, orange, yellow, cream-white, pink, brick red, salmon and various other intermediate shades.

The profitable cultivation of gerbera is affected by many factors and among them pest incidence is the major factor responsible for yield reduction in gerbera. Gerbera is infested by number of insect and non-insect pests including mites, nematodes, snails, mice etc. from seedling stage to harvest. The major pests reported from gerbera are whiteflies (*Bemisia tabaci* Gennadius), (*Trialeurodes vaporariorum* Westwood), onion thrips (*Thrips tabaci* Lindeman), western flower thrips (*Frankliniella occidentalis* Pergande), aphid (*Myzus persicae* Sulzer), american serpentine leaf miner (*Liriomyza trifolii* Bergess), two spotted red spider mite (*Tetranychus urticae* Koch), yellow mite (*Polyphagotarsonemus latus* Banks) and foliage feeder army worm (*Spodoptera litura* Fabricius) (Rani and Mohan, 1997). Mostly the leaves and flower parts are affected by these pests. Among these, sucking pests cause extensive damage to gerbera crop under polyhouse conditions. They reduce the quality and quantity of gerbera flowers which results in the decrease of economic value of flowers.

Host Plant Resistance (HPR) is one of the most cost-effective and safe methods among Integrated Pest Management. A resistant variety can provide a base to construct an integrated control system (Gallun *et al*., 1975) and may be most fruitful when used in combination with other methods of control. HPR is seen to be a sustainable approach to pest management and response of different gerbera varieties to sucking pests is essential. This was an attempt to identify the

response of different available genotypes of gerbera to sucking pests in order to determine susceptibility or resistance.

Application of *Lecanicilium lecanii* @0.30% liquid formulation followed by *L. lecanii* @0.30% wettable powder formulation recorded the highest mortality of mite, *T. urticae* in gerbera (Mote *et al*., 2003). Shah and Shukla (2014) tested the bioefficacy of different pesticides against *T. urticae* in gerbera under polyhouse and revealed that diafenthiuron 50 WP 0.055% was the most effective (68.79% reduction) and was on par with fenpyroximate 5 EC (0.0025%), buprofezin 25 EC (0.03%), abamectin 1.9 EC (0.0025%) and fenazaquin 10 EC (0.01%). The treatment dimethoate 30 EC (0.03%) was less effective in reducing mites under polyhouse conditions.

Information on pests infesting a crop is an essential prerequisite for developing a suitable pest management strategy particularly in the context of ever changing pest scenario. Since, very little information is available on the pests of gerbera from Kerala and sucking pests being the major problem in gerbera, the present study was proposed to investigate the pest infestation in gerbera and to formulate suitable management measures against sucking pests under protected conditions with the following objectives:

- Documentation of pests infesting gerbera in polyhouses
- Evaluation of varieties for field tolerance to sucking pests
- Management of sucking pests infesting gerbera

Review of Literature

2. REVIEW OFLITERATURE

The research work on pests of gerbera, evaluation of varieties for field tolerance to sucking pests and their management is so meagre. Hence the literature on pests, evaluation of varieties for field tolerance to sucking pests and their management in gerbera and other related crops are reviewed and presented under the following headings.

2.1 PESTS OF GERBERA AND OTHER RELATED CROPS

The major pests of gerbera are whitefly (*B. tabaci*), (*T. vaporariorum*), onion thrips (*T. tabaci*), western flower thrips (*F.occidentalis*) aphid (*M. persicae*), American serpentine leaf miner (*L. trifolii*), two spotted red spider mite (*T. urticae*), yellow mite (*P. latus*) and foliage feeder army worm (*S. litura*) (Rani and Mohan, 1997). Dnyaneshwar, 2003 reported serpentine leaf miner (*L. trifolii*), whitefly (*B. tabaci*), aphid (*M. Persicae*), thrips (*T. palmi*) and mite (*T. urticae*) as the major pests of gerbera. However, Bhosale (2007) reported that major sucking pests infesting gerbera are whitefly (*T.vaporarioum),* aphid (*M. persicae*), two spotted spider mite (*T. urticae*). Besides American serpentine leaf miner, *L. trifolii*, tomato fruit borer, *Helicoverpa armigera* and tobacco leaf eating caterpillar, *S. litura* are most destructive pests.

Hole (2007) described whitefly, *T. vaporariorum*, mite, *T. urticae*; thrips, *F.schultzei* as pests of rose also inaddition to aphid, *Macrosiphum rosae* (Linnaeus); mealy bug, *Planococcus citri* (Risso) and foliage feeders and bud borers, *H. armigera* and *S. litura*

Sood (2010) stated that in India, about twenty insect and mite species have been recorded to be associated with the gerbera, rose, carnation, chrysanthemum and many other ornamentals under protected environment. Some of the important pest groups are aphids (*M.persicae, Aphis gossypii*), caterpillars (*Spodoptera* sp., *H. armigera*), leafminer (*L. trifoli*), mites (*T. urticae* and *P. latus* Banks), thrips (*T. tabaci* and *Scritothrips dorsalis* Hood) and whiteflies (*T. vaporariorum* and *B.tabaci*).

Abraham (2012) reported that *L. trifolii* is the primary pest of greenhouse gerberas. Secondary pests including whiteflies (*T. vaporariorum* and *B.tabaci*), thrips (*F. occidentalis*), mite (*T. urticae*) and aphid (*M. persicae*). Among different insect pests and mites, greenhouse whitefly, *T. vaporariorum,* leaf miner, *L. trifolii*, aphid, *M. persicae* and two spotted spider mite, *T. urticae* cause extensive damage to gerbera crop under polyhouse conditions (Shah, 2014).

Pal and Sarkar (2009) conducted a survey in different ornamental plants and reported a number of aphid species *viz*., *M. persicae* on carnation, gerbera and anthurium; *Macrosiphoniella sanborni* on chrysanthemum; *A.gossypii* on China rose. Other sucking pests included *B. tabaci* on gerbera, leafhopper on gladiolus and scale insect (unspecified) on Anthurium. Among the thysanopteran pests *Taeniothrips simplex* was serious pest on gladiolus. Among non-insect pests, the red spider mite, *T. urticae* was very important causing havoc to gerbera, carnation and chrysanthemum.

Leaf miner *L. trifolii*, whitefly *T. vaporariorum,* aphid species *viz*., *A. gossypii* and *M.persicae*, lepidopterous species such as *Trichoplusia ni* (cabbage looper), *S.exigua* and two spotted spider mite, *T. urticae* have been recorded as major pests on marigold under greenhouse conditions (Heinz and Parrella, 1990).

2.2. SUSCEPTIBILITY OF VARIETIES TO SUCKING PESTS OF GERBERA AND OTHER RELATED CROPS

Prabhatchandra (2015) screened eight varieties of gerbera against aphid and reported that "Latara" (0.67 aphid index) and Alcatraz (0.76 aphid index) varieties found resistant to aphid. "Dakota" (1.01 aphid index) variety was considered as moderately resistant. Whereas, "Terrajuba" (aphid index 3.18) was found susceptible. Remaining varieties Faith (3.00) and Basic (2.81) were considered as moderately susceptible to the aphid infestation.

Reddy and Janakiram (2004) evaluated fifty two varietal collections of chrysanthemum against aphids under polyhouse conditions and revealed that ten collections, *viz*., Asha, Aparajitha, Anuradha, Chandi, F-52, Heritage, PC-31, Red stone, Rangoli, and Usha Kiran were found to be resistant (mean no. of aphids <5/apical shoot and <10 per cent affected leaves). Among the remaining ones, 21

collections were moderately resistant, 16 were susceptible and 5 were highly susceptible (>25 aphids/shoot and >50 per cent affected leaves).

Munib and Abass (2015) screened rose cultivars for their resistance against aphid (*M. rosae*) and revealed that Grand Gala and Nobless harboured maximum mean aphid (infestation index 1.33 and 1.10 respectively), whereas Golden Gate and Naranga exhibited moderate mean aphid infestation (0.88 and 0.99). The minimum mean aphid infestation index was (0.55) in Konifittii.

Hole and Salunkhe (2005) tested thirty cultivars of rose against mite, *T. urticae* under field conditions and reported that the cultivar Rajhans found to be the most promising with lowest population of mites (16.08 mites leaf^{-1}) whereas, cultivar Arjun was recorded as highly susceptible with the highest population (40.01 mites leaf^{-1}). Sudhirkumar (2008) screened 11 cultivars of rose under polyhouse condition against *T. urticae* and reported that the cultivars Spinx and Temptation were found moderately susceptible, while the cultivars Nobless, Confity, Gold strikes, Grand Gala, Milwa, Passion, Aqua and Biyanca recorded as susceptible and the cultivar First Red found highly susceptible. Similarly six varieties of rose were evaluated against *T. urticae* and revealed minimum mite population in Sakira (8.17mites leaf^{-1}) and recorded as less susceptible and Naranga found moderate susceptible with 9.92mites leaf^{-1}. Whereas, varieties Gold strike and Nobless (11.16 mites leaf^{-1}) recorded higher number of mites and they were on par with passion (11.17 mites leaf^{-1}).The variety First red recorded maximum mite population (12.87 leaf^{-1}) and was identified highly susceptible to *T. urticae* (Toke, 2010).

Kumar (2007) screened different varieties of rose against mites and thrips. The results indicated that varieties Skyline, Confittee and Tinike were resistant against mites. Conversely Versilla, Eternal and Ravel were found susceptible to mites. In view of thrips, varieties Versilla, Tinike, Skyline and Confittee were found resistant against *S.dorsalis* and varieties Eternal, Ravel and Samurai were highly susceptible to thrips. Khalid *et al*. (2015) tested different rose cultivars, Christan dair, Visky Mac, Love, Macadi, Surkha rose, Iceberg, Perfecta and Gold Medal against thrips, *F. tritici*. The results showed that greater thrips population were observed on Perfecta, Iceberg and Gold Medal. However, significantly lesser thrips observed on Love and Mecadi.

Ramireddy *et al*. (2004) screened twenty germplasm collections of chrysanthemum under polyhouse for their relative resistance or susceptibility to two spotted spider mite, *T.urticae* and bud borer, *H. armigera*. The mite incidence on leaves was the lowest (<l leaf^{-1}) in Angel Bell and the highest (>10 leaf^{-1}) in Collection No. 10. The population of mite on flowers was as high as 5.2/floret in Arka Ravi while flowers of two varieties *viz*., Frost Whisker and Heavenly Tech were free from mites. Six collections *viz.*, Arka Swarna, Angel Bell, Nilima, Chandrika, Snow Ball and Collection No.9 were less susceptible (<10% damage) to bud borer while three varieties *viz*., Collection No.10, Collection No.12 and Heavenly Tech were found to be highly susceptible (>50%). Baburao (2011) studied on reaction of varieties of chrysanthemum against *T. urticae* and found that varieties, IlHR-6 and Jaya were less susceptible with low mite incidence. While, varieties Silk brocade, Shyamal, CS-16, Ravi Kiran, Red gold and Yellow gold were moderately susceptible. Highest incidence of mites were recorded on Nilima and Flirt and were found as highly susceptible to *T. urticae.*

Shukla and Radadia (2015) screened six carnation varieties for their reaction to two spotted red spider mite, *T.urticae* under the polyhouse conditions. The results showed that the carnation variety Domingo found highly resistant to spider mite attack (4.17mites leaf^{-1}), while the variety Rubisco was highly susceptible (32.43mites leaf^{-1}). The varieties Famosa (10.48 mites leaf^{-1}) and Cherry Solar (11.48mites leaf^{-1}) were moderately resistant whereas Gaudina (6.94 mites leaf^{-1}) and Garuda (9.17 mites leaf^{-1}) were tolerant to mite attack.

In marigold, evaluation of different genotypes against several pests revealed that dwarf red Dharwad recorded the lowest incidence of jassids, thrips and *H.armigera* followed by Crimson red tall and Red tall marigold. While, French dwarf marigold recorded the highest incidence of all pests followed by Raichur yellow tall, African yellow tall and Dharwad yellow tall genotype (Sumbad, 1999).

Subhash (2009) screened varieties of *Hibiscus rosa-sinensis* and reported that the variety, Red Satine recorded the lowest number of mealybug, *Phenacoccus solenopsis* (8.5 plant^{-1}) whereas, the variety Hawaii white showed the highest population of (29.87 plant^{-1}).

2.3. MANAGEMENT OF PESTS IN GERBERA AND OTHER RELATED CROPS

2.3.1Efficacy of non chemical insecticides

Mote *et al*. (2003) revealed that application of *L. lecanii* @0.30% liquid formulation followed by *L. lecanii* @0.30% wettable powder formulation recorded the highest mortality of mite, *T. urticae* on gerbera.Similarly in rose, *L. lecanii* @ 0.3% liquid formulation was effective for managing mite, *T. urticae* (Satyanarayana, 2006).

Mahajan (2003) studied the bioefficacy of *Verticillium lecanii* against sucking pests attacking gerbera in polyhouse. The results revealed that at 14 days after treatment, *V. lecanii* 0.3 % recorded 95.45, 93.44, 91.67 and 82.40 per cent mortality of whitefly, aphid, thrips and red spider mite, respectively. Pillai and Visalakshy (2017) conducted an experiment in polyhouse to study the potency of entomopathogenic fungi for the management of whiteflies on gerbera. The study showed that *Beauveria bassiana* (70.81 and 85.65 % mortality over control) and *L. lecanii* (69.54 and 84.90 % mortality over control) were effective in two trails.

Manju *et al*. (2016) stated that among the biorationals evaluated against the carnation mites, the highest percent protection was provided by *L. lecanii* @2 g L^{-1} (90.90 %) followed by NSKE @5% (85.90 %) and garlic chilli kerosene extract @ 0.5% + cow urine @ 5% (77. 50 %). *Paecilomyces lilacinus* @ 2 gL^{-1} was the least effective treatment.

Raghavendra and Chinniah (2018) conducted field experiments against two spotted spider mite *T. urticae* on jasmine and rose. The study revealed that tulsi leaf extract @ 10% or neem oil @ 3% or nochi leaf extract @ 5% followed by *B. bassiana* @ 1×10^8 cfu g^{-1} or *L. lecanii* @ 1×10^8 cfu g^{-1} followed by bifenazate 240 SC @ 0.75 mL L^{-1} or spiromesifen 240 SC @ 0.75 mL L^{-1} as foliar application at fortnight interval proved to be effective**.**

Raghavendra *et al*. (2018) studied the bio-efficacy of mycoacaricides against two spotted spider mites, *T. urticae* on Jasmine at Vadipatti and Alanganallur blocks of Madurai district of Tamil Nadu. It was found that among the mycoacaricides evaluated, *B. bassiana* @ 1×10^8 cfu g^{-1} and *L.lecanii* @ 1×10^8 cfu g^{-1} recorded the highest reduction of eggs (59.99 and 58.61% at Vadipatti

block; 57.20 and 55.78 % at Alanganallur block) and mites (63.39 and 61.98% at Vadipatti block; 59.44 and 58.51% at Alanganallur block).

Hall (1976) found that the chrysanthemum aphid, *M. sanbornii* when treated with the spore suspension of *L. lecanii* at 2.33 x 10^5spores mL^{-1} caused 50 per cent mortality. Vehrs and Parrella (1991) evaluated *V. lecanii* against *A. gossypii* and *M. persicae* infesting greenhouse ornamentals including the chrysanthemum. Treatment of *V. lecanii* on chrysanthemums with 6.2 x 10^6, 6.2 x 10^5 or 6.2 x 10^4spores mL^{-1} resulted in decline of aphid population. Charan (2014) evaluated azadirachtin @ 5mL, karanj oil @ 2mL L^{-1}, *Verticillium* alone @ 5g L^{-1}, *Verticillium* followed by azadirachtin, *Verticillium* followed by karanj oil and imidacloprid @0.4mL L^{-1}against chrysanthemum aphid. Effective reduction in population of aphid over untreated control was observed in plots treated with imidaclopid 17.8% SL treatment @ 0.4 mL L^{-1}(92.31%). It was found that spraying of *Verticillium* @ 5g L^{-1}followed by azadiractin @ 5mL L^{-1}(68.54%) and *Verticillium* @ 5g L^{-1}followed by karanj oil @ 2 mL L^{-1}(67.34%) were significantly more effective than two consecutive sprays of *Verticillium* @ 5g L^{-1}(64.66%).

Bopache *et al*. (2018) studied the efficacy of biopesticides against safflower aphid, *U. compositae*. The results showed that the infestation of aphid, *Uroleucon compositae* was effectively checked due to *Metarhizium anisopliae* spray of 1x10^8 cfu/mL and was found to be the best treatment which was at par with *V. lecanii* (1x10^8cfu/mL) @ 2.5 ha^{-1}. Next best treatment was Neem Seed Kernel Extract @ 5% and Hingenbet Fruit Extract @5% which was followed by Karanj oil.

Cuthbertson *et al*. (2005) revealed the efficacy of *Lecanicillium* sp. to *B. tabaci* on plants like chrysanthemum, verbena, and poinsettia when treated with 10^7spores mL^{-1} caused more than 90 per cent mortality of the pest on all the host plants, seven days after treatment. Amjad *et al*. (2012) studied the effect of *L. lecanii* on two spotted spider mite, *T. urticae* and reported that spore loads at 10^6, 10^7 and 10^8 were pathogenic to eggs and adult females of mites.

Helyer (1992) found that integrated control of *A. gossypii*, *M. sanborni* and thrips on chrysanthemum by using *V. lecanii* at higher humid conditions at fortnight intervals. Kumar *et al.* (2010) reported that combined formulation consisting of methanolic extract of neem (*A. indica*) and karanj (*Pongamia pinnata* Pierre) was very effective against *Tetranychus* sp. and *M. sanbornii* on chrysanthemum.

Premalatha and Rajangam (2011) tested the efficacy of yellow sticky traps and yellow charts coated with castor oil to manage the whitefly, *T. vaporariorum* effectively in gerbera. The number of whitefly adults attracted towards yellow sticky trap was compared with conventional method *i.e*., tieing of yellow charts coated with castor oil. The results revealed that irrespective of the varieties, yellow chart coated with castor oil caught whiteflies more than the yellow sticky trap.

2.3.2 Efficacy of chemical insecticides

Shah and Shukla (2014) tested the bioefficacy of different pesticides against *T. urticae* in gerbera under polyhouse and revealed that diafenthiuron 50 WP 0.055% was the most effective (68.79% reduction) and was on par with fenpyroximate 5 EC (0.0025%), buprofezin 25 EC (0.03%), abamectin 1.9 EC (0.0025%) and fenazaquin 10 EC (0.01%). The treatment dimethoate 30 EC (0.03%) was less effective in reducing mites under polyhouse conditions. According to Pal and Karmakar (2017), application of sulphur @ 1600g ai ha^{-1}, spiromesifen @ 500 g ai ha^{-1}, fenazaquin @ 100 g ai ha^{-1}, diafenthiuron @ 800g ai ha^{-1} and dicofol @277.5 g ai ha^{-1} was most effective against mites while ethion was the least effective to mite species in gerbera.

Another study conducted by Reddy *et al*. (2014) in chrysanthemum showed the bioefficacy of acaricides against *T. urticae.* They concluded that during first season chlorfenapyr 10 SC @ 1.5mL L^{-1}, abamectin 1.9 EC @ 0.8 mL L^{-1}, hexythiazox 5.45 EC @ 0.8 mL L^{-1}, spiromesifen 240 SC @ 0.8 mL L^{-1}, fenpyroximate 5 EC @ 1 mL L^{-1}, bifenazate 50 WP @ 0.3 mL L^{-1}, showed 100 per cent mortality of *T. urticae* on 5, 7 and 15 days after treatment.

Cloyd and Sadof (2000) studied the efficacy of spinosad and acephate against western flower thrips on *G. jamesonii*. Three rates of spinosad 50, 100 and 200 mg (1ppm) and acephate 600 mg L^{-1} were used and found that both spinosad and acephate controlled thrips. Broughton and Herron (2009) found that acetamiprid and thiamethoxam were effective against larvae and adults of western

flower thrips in lettuce. The lowest aphid index (0.91) was recorded in gerbera plots treated with flonicamid 50 WP @ 0.05% and it was on par with imidacloprid 17.8 SL @ 0.0053% (1.26) and thiamethoxam 25 WG @ 0.01% (1.38). The descending order of effectiveness of remaining treatments was thiacloprid 48 SC @ 0.024% (1.56), acetamiprid 20 SP @ 0.006% (1.66), acephate 75 SP @ 0.75% (1.75) and dimethoate 30 EC @ 0.03% (1.85) (Patel, 2015).

Bhosale (2007) studied the potency of different insecticides against aphid (*M. persicae*) and whitefly (*T. vaporariorum*) in gerbera and revealed that imidacloprid (0.01%) proved to be the best with 87.82 and 94.80 per cent efficacy respectively followed by acetamiprid (0.005%) with per cent efficacy of 85.79 and 89.34 per cent, respectively. He also revealed that abamectin (0.005%) was found to be effective recording 91.59 per cent efficacy followed by clofentezine (0.006%) with 88.64 per cent efficacy against spotted spider mite (*T. urticae*).

Apte (2001) revealed the average efficacy of imidacloprid (0.01%) and acephate (0.075%) was 91.92 per cent and 90.25 per cent, respectively against *B.tabaci* on gerbera. Shalini *et al*. (2019) reported that, diafenthiuron 50 SC, fipronil 5 SC and thiamethoxam 25 WG were found to be superior in reducing the mean whitefly (*B. tabaci*) adults and nymphal population after first and second foliar spray on gerbera under protected condition. They were followed by imidacloprid 17.8 SL, acetamiprid 20 SP, dimethoate 30 EC and cyantraniliprole 10 OD in lowering the whitefly population. In another study, thiamethoxam 25EC (100%) was the most effective followed by imidacloprid 200SL (0.008%), methyl-o-demeton 25EC (0.030%), carbosulfan 250EC (0.003%), neem oil 5% (0.050%), novaluron 10EC (0.100%) and bifenthrin 10EC (0.050%) against *T. tabaci* in marigold (Ganai *et al*., 2018).

Ludlam and French (1973) stated that treatment dicofol (0.01 %) and formetanate (0.05%) were found effective against mites (0.1 and 0.23 mites 5 leaves^{-1} at 15 DAS) on chrysanthemum. Bhusal (2011) concluded that milbemectin (0.0004 %) was most effective in reducing *T. urticae* population and it was followed by abamectin (0.0025 %), whereas dimethoate (0.03 %) found moderately effective against the mite in chrysanthemum.

Akashe *et al*. (2009) tested the efficacy of newer insecticides for the control of safflower aphid, *U. compositae* and reported that thiamethoxam 25 WG (0.005 %) and acetamiprid 20 SP (0.004 %) effectively control the aphid population. Gore *et al*. (2010) conducted an experiment against safflower aphid (*U. compositae*) on safflower cv. Parbhani Kusum (PBNS 12) by using the treatments thiamethoxam 25WG (0.005%), imidacloprid 17.8 SL (0.0045%), acetamiprid 20 SP (0.004%),fipronil 5 SC (0.01%), acephate 75 SP (0.03%), diafenthiuron 50 WP (0.06%) and dimethoate 30 EC (0.03%) and found the lowest incidence of aphids/5 cm shoot length was recorded for thiamethoxam (2.40, 0.83, 7.93 and 25.26 respectively) at 1, 3, 7 and 14 days after spraying. Pawar and Bharpoda (2013) reported that imidacloprid 70 WG (0.015%), acetamiprid 20 SP (0.01%) and thiamethoxam 25 WG (0.0125%) proved effective in suppressing aphid, *U. compositae* in safflower.

Sathyan *et al*. (2007) evaluated the bio-efficacy of new molecules against thrips, *S. dorsalis* on rose. Significantly lowest thrips population per three buds was recorded in fipronil 5 SC @ 0.15%, imidacloprid 17.8 SL @ 0.02%, tolfenpyrad 15 EC @ 0.1% and diafenthiuron 50WP @ 0.12%. The insecticides dimethoate 30 EC @ 0.15%, acetamiprid 20 SP @ 0.02% and thiacloprid 21.7 SC @ 0.1% were also proven to be efficient in managing thrips population of rose as compared to thiamethoxam 25 WG @ 0.02%, chlorpyriphos 20 EC @ 0.25% and chlorfenapyr 10 SC @ 0.1%. Rani and Reddy (2001) evaluated 12 insecticides against *S. dorsalis* on rose in polyhouse, out of which acephate (15 g L^{-1}) was found consistently superior, ethofenprox (1g L^{-1}) was found to be the second best treatment followed by imidacloprid (0.4 mL L^{-1}) till 10th day. Efficacy of monocrotophos (2 mL L^{-1}), oxydemeton methyl (2 mL L^{-1}) and dimethoate (1.7 mL L^{-1}) was noticed after 10 and 14 days of treatment.

Among the different insecticides evaluated for their efficacy against thrips and mites in rose, fipronil (0.01%) was found to be very effective and its efficacy lasted up to 9 days after spray followed by monocrotophos (0.06%), acephate (0.075%), profenofos (00.1%), imidacloprid (0.01%) and acetamiprid (0.002%) (Rajkumar, 2001). Three sprayings of imidacloprid (0.01 %), buprofezin (0.1 %), fipronil (0.02 %) and abamectin (0.005 %) were found more effective against aphids, whiteflies, thrips and mites in rose, respectively under polyhouse condition

(Abhyankar, 2003).

Shashidhar (2019) tested insecticides against flower thrips, *Rhipiphorothrips cruentatus* in rose. The results showed that minimum thrips density was found in thiamethoxam 25WG treated plants *i.e.*, 3.19 per flower with maximum per cent reduction over control *i.e.*, 77.39 and it was found superior over other treatments. The density of thrips in imidacloprid 30.5 SC was found on par with acetamiprid 20SP with the population of 4.23 per flower. Chlorfenapyr 10EC was found to be least effective in reducing thrips population (8.48 flower^{-1}).

Pattanaik (2016) studied the bio-efficacy of insecticides against major pests of marigold. The results showed that, thiamethoxam @ 0.5 g L^{-1} as the best chemical in reducing the serpentine leaf miner, infestation in terms of number of live mines per plant with 87.43 per cent reduction over control at 15 DAS along with bifenthrin @1mL L^{-1} (81.24%) and tolfenpyrad @ 2mL L^{-1} (75.05%) and they were statistically on par. Spiromesifen @ 1mlL^{-1} alone and propargite50%+ bifenthrin 5% @ 2.5mL L^{-1} found superiority over the pesticides evaluated up to 15DAS in suppressing the spider mite population (0.67 and 1.33 leaf^{-1}) which was to the tune of 92.27 and 84.66 per cent respectively over control (8.67 leaf^{-1}).

Fluvalinate (0.012% and 0.006%) was the most effective acaricide against *T. urticae* on rose followed by fenpropathrin (0.015%), wettable sulphur (0.02%) and dicofol (0.05%) (Pokharkar *et al*., 1986). Toke (2010) revealed that abamectin (0.0025 %) was the most effective pesticide in per cent reduction of *T. urticae* on rose. It was followed by Propargite (0.05 %). Whereas dimethoate 0.03 per cent found moderately effective against thepest.

Singh *et al*. (2006) evaluated the efficacy of dicofol 0.04%, imidacloprid 0.04%, propargite 0.1%, oxydemeton methyl 0.05% and dimethoate 0.06% against eggs and active stages of *T. urticae* on rose in glasshouse. They found effectiveness of the insecticides which was in the order of propargite 0.1%, dicofol 0.04%, dimethoate 0.06% and oxydemeton methy l0.05%.

Manju *et al*. (2015) studied on the efficacy of new chemicals against thrips and mites in carnation under naturally ventilated polyhouse. Among the chemicals evaluated, sequential spray of chlorfenapyr 10 SC @ 2 mL L^{-1}- fipronil 5 SC @ 1 mL L^{-1} was found to be the best treatment against thrips followed by chlorfenapyr

10 SC @ 2 mL L^{-1} - thiamethoxam 25 WG @ 0.2 g/L and diafenthiuron 25 WP @ 0.75 g/L - diafenthiuron 25 WP @ 0.75 g/L sprays.

Hara (1986) reported that cyromazine 75 WP l5.0 g a.i./100 liters and abamectin 0.15 EC 0.6 g a.i/100 liters were the most efficacious insecticides against *L. trifolli* on potted and cut chrysanthemum. Abamectin (Vertimec) 1.9 EC @ 10.64 g a.i ha^{-1} was effective against mite *T. urticae* on jasmine which recorded higher flower yield as compared to other treatments under field condition (Rajkumar, 2003).

Materials and Methods

3. MATERIALS AND METHODS

The studies on the documentation of sucking pests on gerbera under protected cultivation were conducted at polyhouses of Thiruvananthapuram (College of Agriculture, Vellayani, 8^0 25'N latitude, 76^0 59'E longitude), Thrissur (College of Horticulture, Vellanikkara, 10^0 32'N latitude, 76^0 16'E longitude) and Wayanad (Regional Agricultural Research Station, Ambalavayal, 11^0 36'N latitude, 76^0 12'E longitude) districts of Kerala. The studies on the evaluation of varieties for field tolerance to sucking pests and management of sucking pests infesting gerbera were carried out in polyhouse at the Department of Fruit science, College of Agriculture, Vellayani, Thiruvananthapuram. The materials used and the methods adopted are detailed here under.

3.1 DOCUMENTATION OF PESTS INFESTING GERBERA

Documentation of pests infesting gerbera was done in Thiruvananthapuram, Thrissur and Wayanad districts representing South, Central and Northern zones of Kerala (Plate 1). All pests and natural enemies found were recorded. The unidentified pests and natural enemies collected from different polyhouses were sent to respective taxonomists and identified.

Table 1.Details of pests and natural enemies collected from gerbera sent for identification

Sl.No.	Specimen	Place of collection	Identified by
1	Thrips	Thiruvananthapuram Wayanad	Mrs. Rachana R.R. Scientist,NBAIR, Bangalore, Karnataka
2	Scales, aphids and mealybugs	Thrissur, Wayanad and Thiruvananthapuram	Dr. Sunil Joshi, Principal scientist and Head, Division of Germplasm Collectionand Characterisation, NBAIR, Bangalore, Karnataka

3	Mites	Thiruvananthapuram	Dr.Haseena Bhaskar Professor, College of Horticulture, KAU, Vellanikara
4	Spiders	Thrissur, Thiruvananthapuram and Wayanad	Dr. Sudhikumar Professor, Calicut University, Kochi

a) Thiruvananthapuram (Vellayani)

b) Thrissur (Vellanikkara)

c) Wayanad (Ambalavayal)

Plate 1. Polyhouses of Kerala visited for the documentation of pests of gerbera

3.1.1 Extent of infestation

The details of extent of pest infestation on leaves and flowers of gerbera under polyhouses were calculated by using the following formulae.

$$\text{Leaf infestation (\%)} = \frac{\text{Number of leaves with insects} \times 100}{\text{Total number of leaves}}$$

$$\text{Flower infestation (\%)} = \frac{\text{Number of flowers with insects} \times 100}{\text{Total number of flowers}}$$

Leaf or flower with insects was treated as infested leaf or flower

3.2 EVALUATION OF GERBERA VARIETIES FOR FIELD TOLERANCE TO SUCKING PESTS

The experiment was carried out in the polyhouse of Department of Fruit Science, College of Agriculture, Vellayani,Thiruvananthapuram during June 2019-February 2020 to study the field tolerance of different varieties of gerbera.

3.2.1 Planting material

Tissue culture plantlets of gerbera varieties *viz*., Cappablanca, Aquamelone, Beaudine, Esmara and Sona were collected from Kattakada for the experiment (Plate 2). The field view is presented in plate 3.

Design : CRD

Treatments : 5

Replications : 4

No.of plants per replication: 4

Cappablanca

Aquamelone

Beaudine

Esmara

Sona

Plate 2. Gerbera varieties selected for study

3.2.2 Preparation of potting mixture

The experiment was carried out in polybags and laid out in completely randomized design. Red loam soil, sandy soil and farm yard manure were mixed in 1:1:1 ratio. The polybags were filled with prepared potting mixture leaving some head space and systematically arranged. In order to protect plants from fungal infection, carbendazim @1mL L^{-1} was sprayed at 15 days interval after planting. Manuring was done as per the recommendation (Anaswara, 2018).

3.2.3 Assessment of pest population in gerbera

Three leaves were randomly selected from top, middle and bottom portions of each plant and the mean number were counted and recorded (Thamilarasi, 2014).

3.2.4 Pest infestation

The infestation of pests in leaves, flower buds and flowers under polyhouse conditions was recorded on weekly basis as described in 3.1.1.

3.3. MANAGEMENT OF SUCKING PESTS INFESTING GERBERA

The experiment was carried out in the polyhouse of Department of Fruit Science, College of Agriculture, Vellayani, Thiruvananthapuram during June, 2019 -February, 2020 for managing the sucking pests of gerbera by evaluating different treatments.

Variety: Susceptible variety selected from the previous study

Design : CRD

Treatments:6

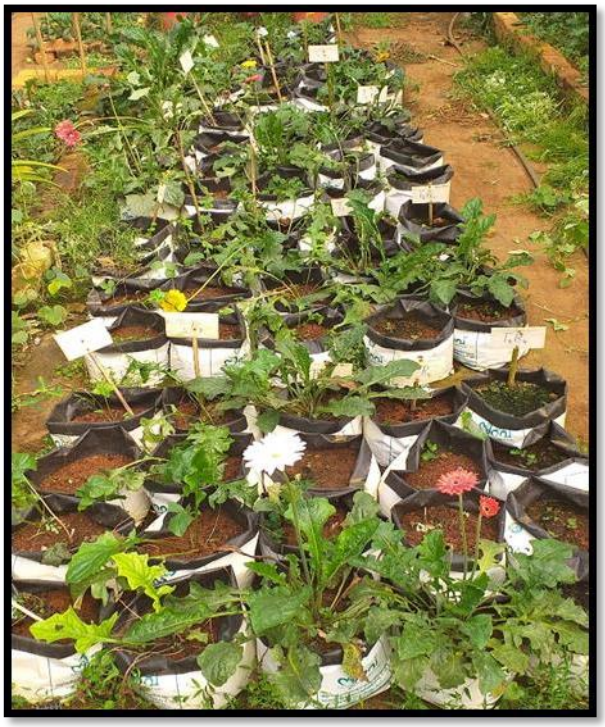
Replications: 4

No. of plants per replication:4

The treatments were applied at the initiation of flowering stage when the pest infestation was at 10-15 per cent.

a. Five days after planting

b. One month after planting



c. Five months after planting

Plate 3. Field view of the screening trial of gerbera varieties for field tolerance to sucking pests.

Table 2.Details of treatments against the sucking pests infesting gerbera

Sl. No.	Treatments	Trade name	Dosage (g ai ha^{-1})	Field dose (g or mL L^{-1})
1	Talc based formulation *Lecanicillium lecanii* NBAIR Vl 8	KAU product	-	20.00
2	Fish jaggery 0.5%	Abtech fish amino	-	5.00
3	Fipronil 40%+Imidacloprid 40%WG	ImFi	175+175	0.40
4	Thiamethoxam 25%WG	Actara	50	0.20
5	Spiromesifen 22.9%SC	Oberon	96	1.00

3.3.1. Assessment of population of pests in gerbera

The treatments were screened against two pests *viz.*, thrips and mites since these two pests were present in experimental plants during the study period.

Population of thrips and mites were assessed as described in 3.2.3.

The population of thrips and mites in leaves were taken before treatment and at 1,3,5,7 and 15 days after treatment. The population of thrips in flowers and flower buds were taken before treatment and at 1, 3, 5 and 7 days after treatment.

3.3.2. Pest infestation

Infestation of thrips and mites in leaves per plant was recorded before and at 15 days after treatment. The infestation of thrips in flower buds and flowers per plant was recorded before and at 15 days after treatment. The percentage infestation was calculated as described in 3.1.1.

3.3.3. Size of the flower

The size of the flower was measured by measuring diameter of flower using scale and expressed in cm. The measurement was taken before and at 1, 3, 5 and 7 days after treatment.

3.4 STATISTICAL ANALYSIS

The data collected from the each experiment were subjected to statistical analysis using WASP software (Panse and Sukhatme, 1967).Suitable transformations were applied and significant results were equated on the basis of critical difference.

Results

4. RESULTS

4.1 DOCUMENTATION OF PESTS INFESTING GERBERA

Pests of gerbera were documented from the polyhouses of Thiruvananthapuram, Thrissur and Wayanad districts of Kerala and the results are presented in Table 3 and 4.

Table 3. Pests and natural enemies of gerbera documented from the polyhouses of Kerala

Sl. No	Common name	Scientific name with taxonomic position	Parts of plant from where pest collected	Place of collection
1	Thrips*	*Scirtothrips dorsalis* Hood, Family: Thripidae, Order: Thysanoptera	Leaves	Thiruvananthapuram, Wayanad
		Haplothrips sp. Family: Phlaeothripidae, Order: Thysanoptera	Flower buds and flowers	
2	Scales*	*Icerya* sp. Family: Monophlebidae, Order: Hemiptera	Leaves	Thrissur
3	Aphids*	*Macrosiphum euphorbia* Thomas, Family: Aphididae, Order: Hemiptera	Leaves	Wayanad
4	Mites	*Tetranychus* sp., Family: Tetranychidae, Order: Acarina	leaves	Thiruvananthapuram
5	Mealybugs*	*Planococcus citri* Risso, Family: Pseudococcidae, Order: Hemiptera	Leaves, flowerbuds and flowers	Thiruvananthapuram

6	Spiders*	a) *Plexippus paykulli* (male) Audouin, Family: Salticidae, Order: Araneae. b) *Theridion* sp., Family: Theridiidae, Order: Araneae	Leaves	Thrissur
		a)*Oxyopes birmanicus* Thorell, Family: Oxyopidae, Order: Araneae b) *Ptocassius* sp., Family: Salticidae, Order: Araneae	Leaves	Thiruvananthapuram
		Plexippus paykulli (female) Audouin, Family: Salticidae, Order: Araneae	Leaves	Wayanad

*Newly recorded pests/natural enemies

The pests newly identified from gerbera were aphid, *Macrosiphum euphorbia* (Thomas), scales, *Icerya* sp., mealybugs, *Planococcus citri* (Risso) and thrips, *Scirtothrips dorsalis* (Hood) and *Haplothrips* sp. Natural enemies *viz.*, spiders recorded and identified were *Plexippus paykulli* (Audouin), *Theridion* sp., *Oxyopes birmanicus* (Thorell) and *Ptocassius* sp. Other sucking pest documented was mites, *Tetranychus* sp. (Plate 4,5,6,7, and 8).

Thrips, *S. dorsalis* and *Haplothrips* sp. were most predominant species found infesting gerbera in Wayanad and Thiruvananthapuram districts where survey was conducted.

In Wayanad district, *S.dorsalis* infestation on leaves varied from 25 to 63.63 per cent (Table 4). Whereas, *Haplothrips* sp. infestation in flowers varied from 63.15 to 100 per cent. *S. dorsalis* infestation in leaf varied from 22.22 to 62.50 per cent in Thiruvananthapuram. *Haplothrips* sp. infestation in flowers varied from 57.14 to 100 per cent. Curling and crinkling of leaves was the symptom of infestation of *S. dorsalis* and brownish discolouration in flowers was the symptom due to *Haplothrips* sp. infestation.

Aphids, *M. euphorbia* found infesting gerbera in Wayanad district where survey was conducted. Infestation on leaves ranged from 0 to 33.33 per cent. Both nymphs and adults were found sucking on the leaves of gerbera.

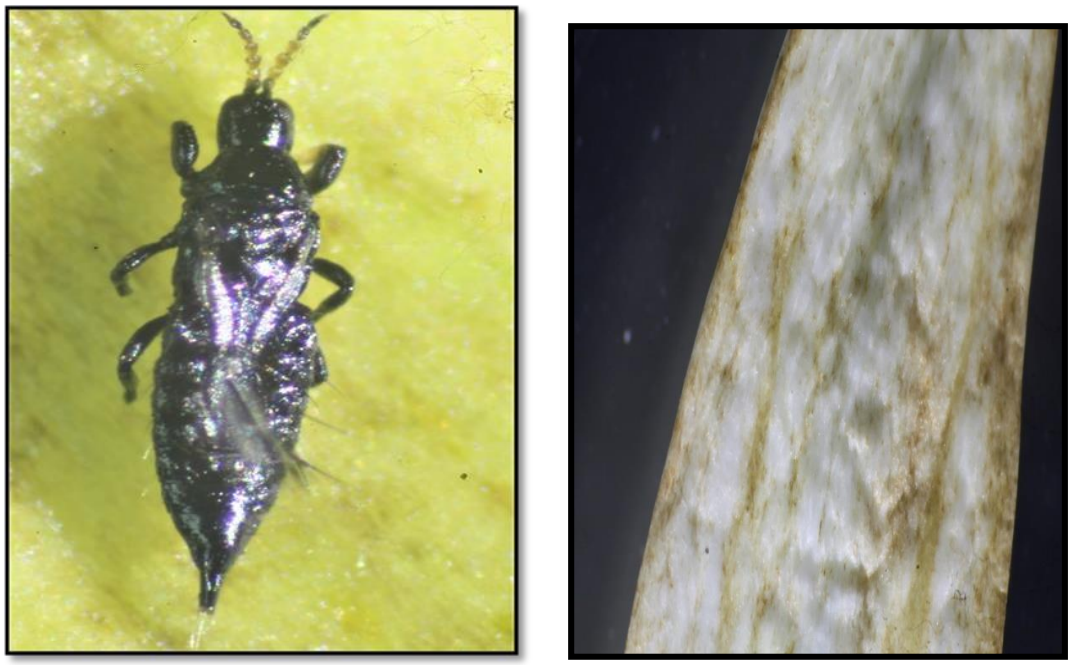
Scales, *Icerya* sp. found infesting gerbera in Thrissur district where survey was conducted. Scales infestation varied from 28.57 to 44.44 per cent. Brownish raised dome like structures were noticed on leaves due to scales infestation.

a) Aphid, *Macrosiphum euphorbia* Thomas

b) *Icerya* sp. and its damage symptom

Plate 4. Infestation of aphids and scales in gerbera

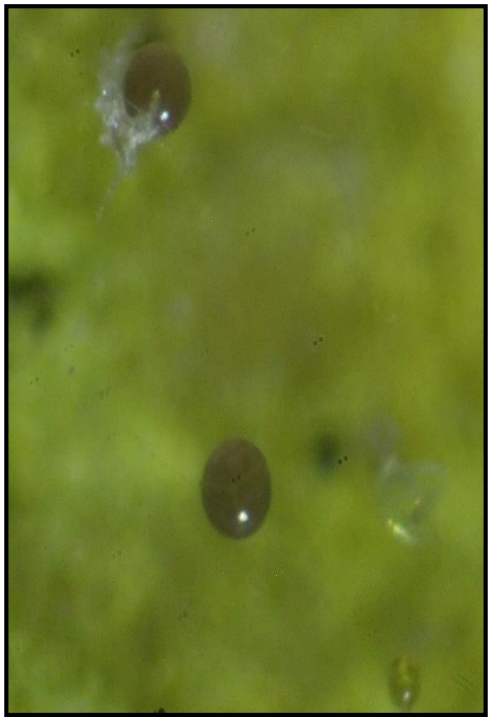
a) *Scirtothrips dorsalis* Hood b) Damage symptom



c) *Haplothrips* sp. d) Damage symptom

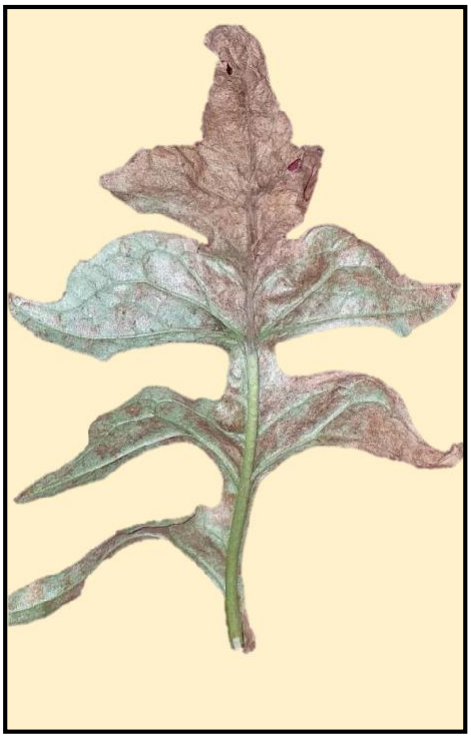
Plate 5. Infestation of thrips in gerbera

a) Adult



b) Egg

c) Webbing



d) Bronzing

Plate 6. Life stages and infestation of mites, *Tetranychus* sp. in gerbera

a) Microscopic view of *Planococcus citri* Risso

b) Damage by mealy bug in flowerbuds

Plate 7. Infestation of mealy bugs in gerbera

a) *Plexippus paykulli* (male)Audouin b) *Plexippus paykulli* (female)Audouin

c) *Ptocassius* sp. d) *Oxyopes birmanicus* Thorell

e) *Theridion* sp.

Plate 8. Spiders documented from gerbera

Table 4. Pest infestation in gerbera grown in the polyhouses of Kerala

Name of the pest	Variety of gerbera	Leaf infestation*(%)	Flower infestation*(%)
1.Thiruvananthapuram district			
i) *Scirtothrips dorsalis*	Beaudine	62.50	-
	Mammut	37.50	-
	Orinaco	30.00	-
	Ruble	22.22	-
ii) *Haplothrips* sp.	Beaudine	-	100.00
	Mammut	-	100.00
	Orinaco	-	66.66
	Ruble	-	57.14
2.Thrissur district			
Icerya sp.	Sona	28.57	-
	Ruble	2.85	-
	Orinaco	44.44	-
	Mammut	37.50	-
3. Wayanad district			
i) *Scirtothrips dorsalis*	Beaudine	28.57	-
	Palm beach	40.00	-
	Atletico	25.00	-
	Double date	63.63	-
ii)*Macrosiphum euphorbia*	Beaudine	24.00	-
	Palm beach	0.00	-
	Atletico	33.33	-
	Double date	27.27	-
iii) *Haplothrips* sp.	Beaudine	-	100.00
	Palm beach	-	100.00
	Atletico	-	63.15
	Double date	-	75.00

* Leaf or flower with insects was treated as infested leaf or flower

4.2 EVALUATION OF VARIETIES FOR FIELD TOLERANCE TO SUCKING PESTS IN GERBERA

Results on evaluation of varieties for field tolerance to sucking pests are presented in Table 5 to 7.

4.2.1 Population and extent of infestation of thrips, *S.dorsalis* in different varieties of gerbera

The results on the population and infestation of thrips, *S.dorsalis* on leaves of different varieties of gerbera are depicted in Table 5. Significantly lower population of thrips was recorded in the variety, Beaudine (26.85) which was on par with the population of thrips in Esmara (30.79) and Aquamelone (31.12). Higher population of thrips was recorded in Cappablanca (58.52) followed by Sona (50.62) and they were on par.

No significant difference was observed between varieties in terms of per cent infested leaves (23.55 to 34.24) (Plate 9).

4.2.2 Extent of infestation of thrips, *Haplothrips* sp. in different varieties of gerbera

The results on the infestation of thrips, *Haplothrips* sp. in flowerbuds and flowers of different varieties of gerbera are depicted in Table 6. No significant difference was observed between varieties in terms of per cent infested flower buds (20.20 to 41.14) and flowers (51.04 to 75.51) (Plate 10).

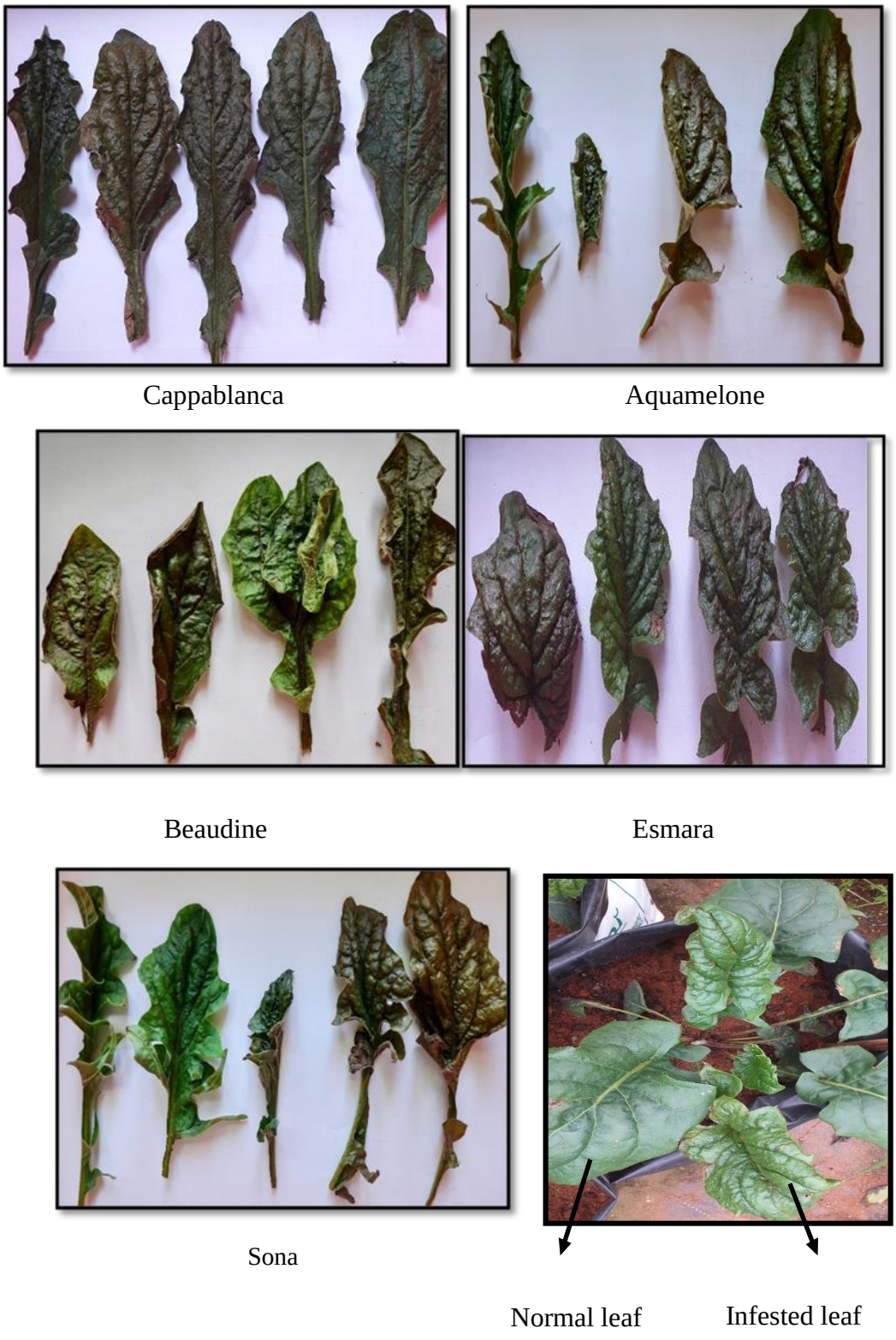


Plate 9. Leaf damage by *Scirtothrips dorsalis* in different gerbera varieties

Cappablanca

Aquamelone

Beaudine

Esmara

Sona

Plate 10. Flower damage by *Haplothrips* sp. in different gerbera varieties

Table 5. Population and infestation of thrips, *Scirtothrips dorsalis* in different varieties of gerbera under polyhouse condition

Varieties	Number of thrips plant^{-1*}	Infestation in leaves (%)**
Cappablanca	58.52 (7.64)^{a}	30.33(33.41)
Aquamelone	31.12 (5.57)^{bc}	29.31(32.77)
Beaudine	26.85 (5.18)^{c}	34.24(35.81)
Esmara	30.79 (5.54)^{bc}	33.31(35.25)
Sona	50.62 (7.11)^{ab}	23.55(29.03)
CD (0.05)	(1.58)	(NS)

*Figures in parentheses are √x+1 transformed values

**Figures in parentheses are arc sin transformed values

Table 6. Infestation of thrips, *Haplothrips* sp.in different varieties of gerbera under polyhouse condition

Varieties	Infestation in flowers (%)**	Infestation in flower buds (%)**
Cappablanca	67.18 (55.04)	20.20 (26.70)
Aquamelone	56.24 (48.58)	27.60 (31.69)
Beaudine	60.93 (51.31)	32.81 (34.94)
Esmara	51.04 (45.59)	40.62 (39.59)
Sona	75.51 (60.33)	41.14 (39.89)
CD (0.05)	(NS)	(NS)

**Figures in parentheses are arc sin transformed values

4.2.3 Population and extent of infestation of mealy bug, *P. citri* on different varieties of gerbera

The population and infestation of mealybugs on different varieties of gerbera are depicted in Table 7. The lower population of mealybugs was recorded in Beaudine (31.25) followed by Cappablanca (41.62), Esmara (42.62) and Aquamelone (48.50) and they were significantly on par. Sona recorded higher population of mealybugs (97.81) which was significantly different from others.

Lower infestation of mealy bug was recorded on leaves of Beaudine (30.03 %) followed by Cappablanca (30.59 %), Esmara (32.56 %) and Aquamelone (35.49 %) which were statistically on par. Sona recorded higher infestation of mealy bug (51.86 %) which was significantly different from others.

No significant difference was observed in infestation of mealy bug on flowers among different varieties (39.58 to 52.08).

Significantly lower per cent damage was observed in flowerbuds of Esmara (28.12) which was on par with Beaudine (32.81) and Sona (38.53).Cappablanca recorded higher per cent damage of mealy bugs in flowerbuds (62.50)followed by Aquamelone (49.99) and they were significantly on par.

Table 7. Population and infestation of mealybugs, *Planococcus citri* in different varieties of gerbera under polyhouse condition

Varieties	* Number of mealybugs plant^{-1}	Infestation on leaves (%)**	Infestation on flowers (%)**	Infestation on Flowerbuds (%)**
Cappablanca	41.62 (6.45)^{b}	30.59 (33.57)^{b}	39.58 (38.98)	62.50 (52.50)^{a}
Aquamelone	48.50 (6.96)^{b}	35.49 (36.56)^{b}	41.66 (40.19)	49.99 (45.02)^{ab}
Beaudine	31.25 (5.59)^{b}	30.03 (33.22)^{b}	52.08 (46.19)	32.81 (34.87)^{bc}
Esmara	42.62 (6.52)^{b}	32.56 (34.79)^{b}	47.91 (43.80)	28.12 (30.77)^{c}
Sona	97.81 (9.88)^{a}	51.86 (46.06)^{a}	49.99 (44.99)	38.53 (38.29)^{bc}
CD (0.05)	(1.55)	(9.05)	(NS)	(14.04)

*Figures in parentheses are √x+1 transformed values

**Figures in parentheses are arc sin transformed values

4.3. MANAGEMENT OF SUCKING PESTS INFESTING GERBERA

Results on management of sucking pests infesting gerbera are presented in Table 8-16.

4.3.1 Effect of treatments on infestation of mites, *Tetranychus* sp. in gerbera variety, Sona

4.3.1.1Population of mites, Tetranychus sp.

The population of mites in gerbera treated with different treatments were depicted in Table 8. No significant difference was observed in the population of mites in gerbera before and one day after treatment.

Significantly lower population of mites was recorded in spiromesifen 22.9%SC @ 1 mL L^{-1} treated plants (69.25) which was on par with the population of mites treated with fish jaggery 0.5% @ 5 mL L^{-1} (91.75) followed by fipronil 40%+imidacloprid 40% WG @ 0.40 g L^{-1} (101.00) and thiamethoxam 25%WG @ 0.20 g L^{-1} (126.50) treated plants after three days of treatment which were statistically on par. The plants treated with *L. lecanii* @20g L^{-1} recorded higher population of (146.50) after three days of treatment (Plate 11).

After five days of treatment, spiromesifen 22.9%SC @ 1 mL L^{-1} treated plants showed the lowest population of mites (12.75). Population of mites in fipronil 40%+imidacloprid 40%WG @ 0.40 g L^{-1} treated plants was (50.75) which was on par with fish jaggery 0.5% @ 5 mL L^{-1} (73.25) and thiamethoxam 25%WG @ 0.20 g L^{-1} (61.25) treated plants. Higher mite population was observed in *L. lecanii* @ 20g L^{-1} treated plants (103.50) which was significantly different from control.

More or less comparable results were obtained on seventh day after treatment. The lowest population of mite was observed in spiromesifen 22.9%SC @ 1 mL L^{-1} treated plants (3.25) which was significantly different from others. Fipronil 40%+Imidacloprid 40%WG @0.40 g L^{-1} treated plants showed (17.50) number of mites followed by thiamethoxam 25%WG @ 0.20 g L^{-1} (21.25) which were on par. The highest number of mite was observed in control plants (179.25) which were significantly different from other treatments. The population of mite

Table 8. Effect of different treatments on population of mites, *Tetranychus* sp. in gerbera

Treatments	Dosage (g or mL L^{-1})	* Number of mites per plant (DAT)					
		Precount	1	3	5	7	15
Lecanicillium lecanii 20g L^{-1}	20.00	168.25 (12.97)	166.75 (12.91)	146.50 $(12.10)^{ab}$	103.50 $(10.17)^{b}$	63.25 $(7.95)^{b}$	13 $(3.60)^{b}$
Fish jaggery 0.5%	5.00	161.25 (12.69)	158.50 (12.58)	91.75 $(9.57)^{bc}$	73.25 $(8.55)^{bc}$	48.00 $(6.92)^{bc}$	13.25 $(3.64)^{b}$
Fipronil 40%+Imidacloprid 40%WG (175+175g a.i ha $^{-1}$)	0.40	179.75 (13.40)	179.00 (13.37)	101.00 $(10.04)^{abc}$	50.75 $(7.12)^{c}$	17.5 $(4.18)^{d}$	14.25 $(3.77)^{b}$
Thiamethoxam 25%WG (50g a.i ha $^{-1}$)	0.20	179.00 (13.37)	177.75 (13.33)	126.50 $(11.24)^{abc}$	61.25 $(7.82)^{bc}$	21.25 $(4.60)^{cd}$	10.50 $(3.24)^{b}$
Spiromesifen 22.9%SC (96g a.i ha $^{-1}$)	1.00	195.25 (13.97)	191.50 (13.83)	69.25 $(8.32)^{c}$	12.75 $(3.57)^{d}$	3.25 $(1.80)^{e}$	0.75 $(0.86)^{c}$
Control	-	151.25 (12.29)	152.00 (12.32)	162.75 $(12.75)^{a}$	167.75 $(12.95)^{a}$	179.25 $(13.38)^{a}$	182.75 $(13.51)^{a}$
CD (0.05)		(NS)	(NS)	(2.99)	(2.75)	(2.59)	(0.99)

*Mean of 4 replications, DAT-Days after treatment, Figures in parentheses are √x+1 transformed values

Table 9. Effect of different treatments on leaf infestation (%) of mites, *Tetranychus* sp. in gerbera

Treatments	Dosage (g or mL L^{-1})	Infestation in leaves (%)*	
		Pre count	15 DAT
Lecanicillium lecanii 20g L^{-1}	20.00	80.20(63.57)	b 72.08(58.10)
Fish jaggery 0.5%	5.00	69.16(56.26)	b 66.25(54.48)
Fipronil 40%+Imidacloprid 40%WG (175+175g a.i ha^{-1})	0.40	78.27(62.21)	bc 46.42(42.94)
Thiamethoxam 25%WG (50g a.i ha^{-1})	0.20	87.86(69.60)	c 38.65 (37.66)
Spiromesifen 22.9%SC (96g a.i ha^{-1})	1.00	87.91(69.65)	d 12.77(20.93)
Control		85.71(67.78)	a 100.00(89.41)
CD (0.05)		(NS)	(19.77)

*Mean percent of 4 replications comprising 4 plants each, DAT-Days after treatment, Figures in parentheses are arc sin transformed values

a. Treated plants

b. Control plant

Plate 11.View of mite infestation in a) Treated plants and b) Control plants

observed in fish jaggery 0.5% @ 5 mL L^{-1} (48.00) and *L. lecanii* @ 20g L^{-1} (63.25) treated plants were statistically on par after seventh day of treatment.

The lowest population of mites was observed in spiromesifen 22.9%SC @ 1 mL L^{-1} treated plants after fifteenth day of treatment which was significantly different from other treatments. The mite population seen in thiamethoxam 25%WG @ 0.20 g L^{-1} (10.50), *L. lecanii* @ 20g L^{-1} (13.00), fish jaggery 0.5% @ 5mL L^{-1} (13.25) and fipronil 40%+imidacloprid 40%WG @ 0.40 g L^{-1} (14.25) were significantly on par.

4.3.1.2 Leaf infestation (%) by mites, Tetranychus sp.

The results on the per cent leaf infestation caused by mites in gerbera after the application of various treatments are depicted in Table 9.

No significant difference was observed in the per cent leaf infestation in gerbera before treatment.

After fifteen days of treatment, significantly lower leaf infestation was observed in spiromesifen 22.9 %SC @ 1 mL L^{-1} (12.77 %) treated plants. Infestation of leaves recorded in *L. lecanii* @ 20g L^{-1} (72.08 %), fish jaggery 0.5% @ 5 mL L^{-1} (66.25%) and fipronil 40%+imidacloprid 40% WG @ 0.40 g L^{-1} (46.42%) treated plants were significantly on par.Thiamethoxam 25% WG @ 0.20 g L^{-1} treated plants recorded 38.65 per cent infestation.

4.3.2 Effect of treatments on infestation of thrips, *S.dorsalis* in gerbera variety, Sona

4.3.2.1 Population of thrips, *S.dorsalis*

The results on the thrips population in gerbera after the application of different treatments are depicted in Table 10. No significant difference was observed in the population of thrips in gerbera before and one day after treatment.Lower population of thrips was recorded in fipronil 40%+imidacloprid 40%WG @0.40 g L^{-1} (10.25) treated plants which was on par with spiromesifen 22.9%SC @ 1 mL L^{-1} (11.56) and thiamethoxam 25%WG@ 0.20 g L^{-1} (12.00) and was significantly different from fish jaggery 0.5% @ 5 mL L^{-1} (15.25) and *L. lecanii* @ 20g L^{-1}(15.50) treated plants after three days of treatment.

Table 10. Effect of different treatments on population of thrips, *Scirtothrips dorsalis* in gerbera

Treatments	Dosage (g or mL L^{-1})	* Number of thrips per plant (DAT)					
		Precount	1	3	5	7	15
Lecanicillium lecanii 20g L^{-1}	20.00	19.00 (4.35)	18.25 (4.27)	15.50 $(3.93)^{b}$	8.75 $(2.95)^{bc}$	3.25 $(1.80)^{b}$	3.75 $(1.93)^{bc}$
Fish jaggery 0.5%	5.00	19.56 (4.42)	18.56 (4.30)	15.25 $(3.90)^{b}$	9.50 $(3.08)^{b}$	3.25 $(1.80)^{b}$	5.25 $(2.29)^{b}$
Fipronil 40%+Imidacloprid 40%WG (175+175g a.i ha^{-1})	0.40	20.25 (4.50)	18.75 (4.33)	10.25 $(3.20)^{c}$	0.50 $(0.70)^{e}$	(0) $(0.70)^{c}$	1.50 $(1.22)^{c}$
Thiamethoxam 25%WG (50g a.i ha^{-1})	0.20	20.18 (4.49)	19.18 (4.37)	12.00 $(3.46)^{bc}$	5.93 $(2.43)^{cd}$	1.00 $(1.14)^{c}$	2.00 $(1.41)^{bc}$
Spiromesifen 22.9%SC (96g a.i ha^{-1})	1.00	21.37 (4.62)	19.87 (4.45)	11.56 $(3.40)^{c}$	3.50 $(1.87)^{d}$	0.25 $(0.50)^{c}$	1.75 $(1.32)^{bc}$
Control		17.37 (4.16)	18.12 (4.25)	21.62 $(4.64)^{a}$	23.25 $(4.82)^{a}$	25.00 $(5.00)^{a}$	26.75 $(5.17)^{a}$
CD (0.05)		(NS)	(NS)	(0.49)	(0.57)	(0.62)	(0.95)

*Mean of 4 replications comprising 4 plants each, DAT-Days after treatment, Figures in parentheses are √x+1 transformed values

Table 11. Effect of different treatments on leaf infestation (%) of thrips, *Scirtothrips dorsalis* in gerbera

Treatments	Dosage (g or mL L^{-1})	Infestation in leaves (%)*	
		Pre count	15DAT
Lecanicillium lecanii 20g L^{-1}	20.00	63.34(52.73)	51.45 (45.83)[b]
Fish jaggery 0.5%	5.00	63.12(52.60)	44.72 (41.96)[b]
Fipronil 40%+Imidacloprid 40%WG (175+175g a.i ha^{-1})	0.40	69.93(57.14)	20.71 (26.91)[c]
Thiamethoxam 25%WG (50g a.i ha^{-1})	0.20	48.55 (44.16)	23.68 (29.11)[c]
Spiromesifen 22.9%SC (96g a.i ha^{-1})	1.00	53.95 (47.26)	18.68 (25.60)[c]
Control		61.51(51.65)	95.00 (77.07)[a]
CD (0.05)		(NS)	(10.56)

*Mean of 4 replications, DAT-Days after treatment, Figures in parentheses are arc sin transformed values

The lowest population of thrips was observed in fipronil 40%+imidacloprid 40%WG @ 0.40 g L^{-1} treated plants after five days of treatment which was significantly different from other treatments. Spiromesifen 22.9%SC @ 1 mL L^{-1} treated plants recorded 3.50 number of thrips followed by thiamethoxam 25%WG @ 0.20 g L^{-1} (5.93) which were on par and significantly different from *L. lecanii* @ 20g L^{-1} (8.75). Fish jaggery 0.5% @ 5 mL L^{-1} recorded higher population of thrips (9.50) which was significantly different from control (23.25).

No population of thrips was observed in fipronil 40%+imidacloprid 40%WG @0.40 g L^{-1} treated plants after seven days of treatment. The population of thrips found in spiromesifen 22.9% SC @ 1 mL L^{-1} (0.25) and in thiamethoxam 25%WG@ 0.20 g L^{-1} treated plants (1.00) were statistically on par. Population of thrips recorded in *L. lecanii* @ 20g $L^{-1}$and fish jaggery 0.5% @ 5 mL L^{-1} (3.25 each) treated plants were significantly similar.

After fifteen day of treatment, significantly lower population of thrips was observed in fipronil 40%+imidacloprid 40%WG @0.40 g L^{-1} treated plants (1.50) followed by spiromesifen 22.9%SC @ 1 mL L^{-1} (1.75), thiamethoxam 25%WG @ 0.20 g L^{-1} (2.00) and *L. lecanii* @ 20g L^{-1} (3.75) treated plants and they were significantly on par. Fish jaggery 0.5% @ 5 mL L^{-1} treated plants recorded higher population of (5.25).

4.3.2.2 Leaf infestation (%) by thrips, S.dorsalis

The results on the per cent leaf infestation by thrips in gerbera after the application of various treatments are depicted in Table 11.

No significant difference was observed in the per cent leaf infestation in gerbera before treatment.

After fifteen days of treatment, significantly lower leaf infestation was observed in spiromesifen 22.9%SC @ 1 mL L^{-1} (18.68 %) treated plants followed by fipronil 40%+imidacloprid 40%WG @0.40 g L^{-1} (20.71 %) and thiamethoxam 25%WG @ 0.20 g L^{-1} (23.68 %) treated plants. Significantly higher per cent leaf

infestation of thrips was observed in fish jaggery 0.5% @ 5 mL L^{-1} (44.72) and *L. lecanii* @ 20g L^{-1} (51.45) treated plants which were significantly on par.

Table 12. Effect of different treatments on population of thrips, *Haplothrips* sp. in flowerbuds of gerbera

Treatments	Dosage (g or mL L^{-1})	* Number of thrips per flowerbud (DAT)				
		Pre count	1	3	5	7
Lecanicillium lecanii 20g L^{-1}	20.00	4.00 (1.54)	4.00 (1.54)	3.50 (1.48)	1.25 (1.11)	0.50 (0.92)
Fish jaggery 0.5%	5.00	3.25 (1.44)	3.25 (1.44)	2.75 (1.37)	0.75 (0.99)	0.25 (0.83)
Fipronil 40%+Imidacloprid 40%WG (175+175g a.i ha^{-1})	0.40	3.50 (1.48)	3.00 (1.41)	0.25 (0.83)	0.00 (0.70)	0.00 (0.70)
Thiamethoxam 25%WG (50g a.i ha^{-1})	0.20	7.00 (2.25)	6.25 (2.15)	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)
Spiromesifen 22.9%SC (96g a.i ha^{-1})	1.00	9.25 (2.53)	9.00 (2.50)	0.25 (0.83)	0.00 (0.70)	0.00 (0.70)
Control	-	3.00 (1.41)	3.25 (1.44)	4.00 (1.54)	5.25 (1.69)	6.00 (1.76)
CD (0.05)		(NS)	(NS)	(NS)	(NS)	(NS)

*Mean of 4 replications comprising 4 plants each, DAT-Days after treatment, Figures in parentheses are $\sqrt{x+1}$ transformed values

Table 13. Effect of different treatments on flowerbuds infestation (%) due to thrips, *Haplothrips* sp. in gerbera

Treatments	Dosage (g or mL L^{-1})	Infestation in flower buds (%)*	
		Pre count	15DAT
Lecanicillium lecanii 20g L^{-1}	20.00	25.00(22.79)	0.00 (0.58)
Fish jaggery 0.5%	5.00	53.95 (47.26)	25.00 (22.79)
Fipronil 40%+Imidacloprid 40%WG (175+175g a.i ha^{-1})	0.40	75.00 (60.00)	50.00 (45.00)
Thiamethoxam 25%WG (50g a.i ha^{-1})	0.20	23.68(29.11)	12.50 (11.68)
Spiromesifen 22.9%SC (96g a.i ha^{-1})	1.00	50.00 (45.00)	0.00 (0.58)
Control		50.00 (45.00)	37.50 (33.89)
CD (0.05)		(NS)	(NS)

*Mean of 4 replications, DAT-Days after treatment, Figures in parentheses are arc sin transformed values

Table 14. Effect of different treatments on population of thrips, *Haplothrips* sp. in flowers of gerbera

Treatments	Dosage (g or mL L^{-1})	* Number of thrips per flower (DAT)				
		Precount	1	3	5	7
Lecanicillium lecanii 20g L^{-1}	20.00	6.00 (1.76)	5.75 (1.74)	4.50 (1.60)	1.50 (1.16)	0.00 (0.70)[b]
Fish jaggery 0.5%	5.00	15.25 (3.59)	15.00 (3.56)	11.75 (3.18)	2.75 (1.68)	0.25 (0.83)[b]
Fipronil 40%+Imidacloprid 40%WG (175+175g a.i ha $^{-1}$)	0.40	12.00 (3.22)	11.25 (3.12)	3.75 (1.93)	0.25 (0.83)	0.00 (0.70)[b]
Thiamethoxam 25%WG (50g a.i ha $^{-1}$)	0.20	9.75 (2.58)	9.50 (2.55)	3.50 (1.72)	0.00 (0.70)	0.00 (0.70)[b]
Spiromesifen 22.9%SC (96g a.i ha $^{-1}$)	1.00	5.25 (1.69)	5.00 (1.66)	2.00 (1.25)	0.00 (0.70)	0.00 (0.70)[b]
Control	-	9.75 (2.58)	10.25 (2.64)	10.50 (2.67)	11.25 (2.75)	11.75 (2.80)[a]
CD (0.05)		(NS)	(NS)	(NS)	(NS)	(1.47)

*Mean of 4 replications comprising 4 plants each, DAT-Days after treatment, Figures in parentheses are √x+1 transformed values

Table 15. Effect of different treatments on flowers infestation (%) due to thrips, *Haplothrips* sp. in gerbera

Treatments	Dosage (g or mL L^{-1})	Infestation in flowers (%)*	
		Precount	15DAT
Lecanicillium lecanii 20g L^{-1}	20.00	25.00 (22.79)	0.00(0.58)
Fish jaggery 0.5%	5.00	37.50 (33.89)	0.00 (0.58)
Fipronil 40%+Imidacloprid 40%WG (175+175g a.i ha $^{-1}$)	0.40	75.00 (60.00)	50.00 (45.00)
Thiamethoxam 25%WG (50g a.i ha $^{-1}$)	0.20	50.00 (45.00)	0.00 (0.58)
Spiromesifen 22.9%SC (96g a.i ha $^{-1}$)	1.00	25.00 (22.79)	0.00 (0.58)
Control		50.00 (45.00)	0.00 (0.58)
CD (0.05)		(NS)	(NS)

*Mean of 4 replications, DAT-Days after treatment, Figures in parentheses are arc sin transformed values

4.3.3. Effect of treatments on infestation of thrips, *Haplothrips* sp. in gerbera variety, Sona

4.3.3.1 Population of thrips, Haplothrips sp. *in flowerbuds*

The results on the population of thrips in flower buds of gerbera after the application of different treatments are depicted in Table 12. No significant difference was observed in the population of thrips in flower buds of gerbera before and after treatment.

4.3.3.2 Flowerbud infestation (%) by thrips, Haplothrips sp.

The results on the per cent flower bud infestation by thrips in gerbera after the application of various treatments are depicted in Table 13.

No significant difference was observed in the per cent flower bud infestation in gerbera before treatment and 15 days after treatment.

4.3.3.3 Population of thrips, Haplothrips sp. *in flowers*

The results on the population of thrips in flowers of gerbera after the application of different treatments are depicted in Table 14. No significant difference was observed in the population of thrips in gerbera flowers before and at 1, 3 and 5 days after treatment.

After seven days of treatment, no population of thrips was observed in spiromesifen 22.9%SC @ 1mL L^{-1}, *L. lecanii* @ 20g L^{-1}, fipronil 40%+ imidacloprid 40% WG @0.40 g L^{-1} and thiamethoxam 25%WG@ 0.20 g L^{-1} treated flowers. Fish jaggery 0.5% @ 5 mL L^{-1} recorded the lowest population of thrips (0.25) which was significantly different from control (11.75).

4.3.3.4 Flower infestation (%) by thrips, Haplothrips sp.

The results on the per cent flower infestation by thrips in gerbera after the application of various treatments are depicted in Table 15.

No significant difference was observed in the per cent flower infestation in gerbera before treatment and at 15 days after treatment.

4.3.4 Effect of treatments on size of the flower (cm) in gerbera variety, Sona

There is no variation in size of the flower due to pest infestation (Table 16).

Table 16. Effect of different treatments on size of the gerbera flower (cm).

Treatments	Dosage (g or mL L^{-1})	Diameter of flower in cm (DAT)				
		Precount	1	3	5	7
Lecanicillium lecanii 20g L^{-1}	20.00	6.20	6.20	6.20	6.30	6.30
Fish jaggery0.5%	5.00	6.30	6.40	6.60	6.70	6.80
Fipronil 40%+Imidacloprid 40%WG (175+175g a.i ha^{-1})	0.40	6.20	6.30	6.40	6.50	6.70
Thiamethoxam 25%WG (50g a.i ha^{-1})	0.20	5.90	5.90	5.90	5.90	5.90
Spiromesifen 22.9%SC (96g a.i ha^{-1})	1.00	6.40	6.40	6.40	6.50	6.50
Control	-	7.10	7.10	7.30	7.50	7.60
CD (0.05)		(NS)	(NS)	(NS)	(NS)	(NS)

DAT-Days after treatment

Discussion

5. DISCUSSION

Gerbera is especially known for their wide spectrum of colors and shapes, and the popularity of this flower has also increased worldwide. Protection of the crop is of major importance when growing gerbera plants. The pests attacking gerbera will reduce the quality and quantity of flowers which badly affect the aesthetic and economic value of flowers.

The results of the present experiment entitled "Incidence and management of sucking pests on gerbera under protected cultivation" are discussed below with the help of available evidences and relevant literature.

5.1 DOCUMENTATION OF PESTS INFESTING GERBERA

Documentation of pests infesting gerbera was done in Thiruvananthapuram, Thrissur and Wayanad districts of Kerala.

The present study could identify four pests from gerbera *viz.*, thrips, *S.dorsalis*, *Haplothrips* sp., scales, *Icerya* sp., and aphid, *M. euphorbia.*

The results are in agreement with the findings of Dnyaneshwar (2003) and he reported American serpentine leaf miner (*L.trifolii*), whitefly (*B.tabaci*), aphid (*M. persicae*), thrips (*T. palmi*) and mite (*T.urticae*) as the major pests, whereas Bhosale (2007) reported the major sucking pests infesting gerbera as whitefly (*T.vaporariorum),* aphid (*M. persicae*), two spotted spider mite (*T. urticae*). They also reported that American serpentine leaf miner (*L. trifolii*), tomato fruit borer (*H. armigera*) and tobacco leaf eating caterpillar (*S. litura*) are most destructive pests. Shah (2014) conducted a study and reported that whitefly, *T. vaporariorum,*leaf miner *L. trifolii,* aphid, *M. persicae* and two spotted spider mite, *T. urticae* cause extensive damage to gerbera crop under polyhouse conditions.

The present study could document only the sucking pests from both leaves and flowers, whereas various other studies reported different groupsof pests *viz.*, sucking pests, leaf feeders, foliage feeders etc. from gerbera plants.

The natural enemies identified were different species of spiders *viz*., *P. paykulli*, *Theridion* sp., *O.birmanicus* and *Ptocassius* sp.

Some of the research works related to the present study are reviewed. According to Sebastian *et al*. (2005), Araneidae, Lycosidae, Tetragnathidae and Salticidae are the widely distributed spider families in Kerala. The diversity of spiders is greater in undistributed natural environments than in distributed ecosystems (Umarani and Umamaheshwari, 2013).Ganai *et al*. (2017) found natural enemies, syrphid fly (*Syrphus* spp.), lady bird beetle (*Coccinella septumpunctata*), spider (*O. javanus*) and big eyed bug (*Geoceris* spp.) on marigold.

5.2 EVALUATION OF VARIETIES FOR FIELD TOLERANCE TO SUCKING PESTS IN GERBERA

The data presented in Table 5 and 6 is graphically depicted in Figure (1) revealed that none of the varieties of gerbera were found free from the infestation of thrips. Among the five varieties of gerbera, the lower population of thrips was recorded in the variety, Beaudine (26.85) which was on par with the population of thrips in Esmara (30.79) and Aquamelone (31.12). Higher population of thrips was recorded in Cappablanca (58.52) followed by Sona (50.62). The ascending order of varieties on the basis of thrips population is Beaudine (26.85), Esmara (30.79), Aquamelone (31.12), Sona (50.62) and Cappablanca (58.52). Based on the data obtained, in the present study, Beaudine and Esmara varieties of gerbera harbour less number of thrips compared to other varieties, while Cappablanca variety was more susceptible to thrips as compared to Sona variety.

No significant difference was observed between varieties in terms of per cent infested leaves, flower buds and flowers.

The data presented in Table 7 and graphically depicted in Figure (2, 3 and 4) revealed that none of the varieties of gerbera were found free from the infestation ofmealybugs. Among the different varieties, mealybugs population varied from 31.25 to 97.81.However, among the five varieties of gerbera, the lower population of mealybugs was recorded in Beaudine followed by Cappablanca, Esmara and Aquamelone and they were significantly on par. Sona recorded higher population

of mealybugs which was significantly different from others. The ascending order of varieties on the basis of mealybug population was Beaudine (31.25), Cappablanca (41.62), Esmara (42.62), Aquamelone (48.50) and Sona (97.81).

No significant difference was observed between varieties in terms of per cent infested flowers.

In view of flower buds damage, Esmara variety of gerbera found less infested by mealybugs. Beaudine and Sona varieties were considered as moderately resistant. While Cappablanca variety was found susceptible. Aquamelone variety was considered moderately susceptible from mealy bug infestation.

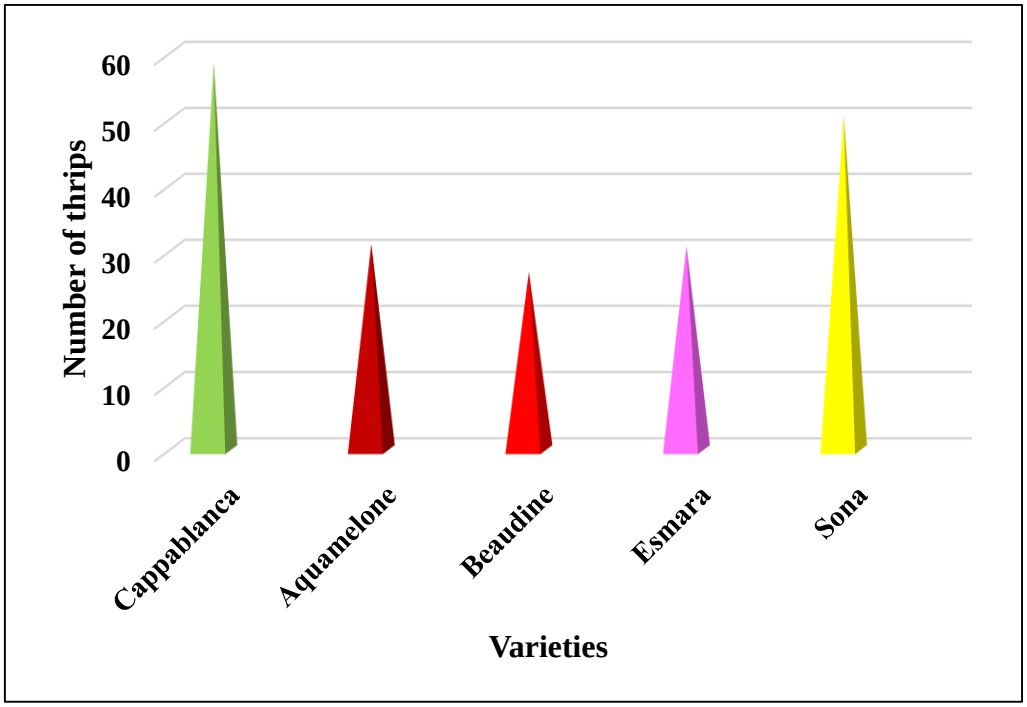


Figure 1. Population of thrips, *Scirtothrips dorsalis* in different varieties of gerbera

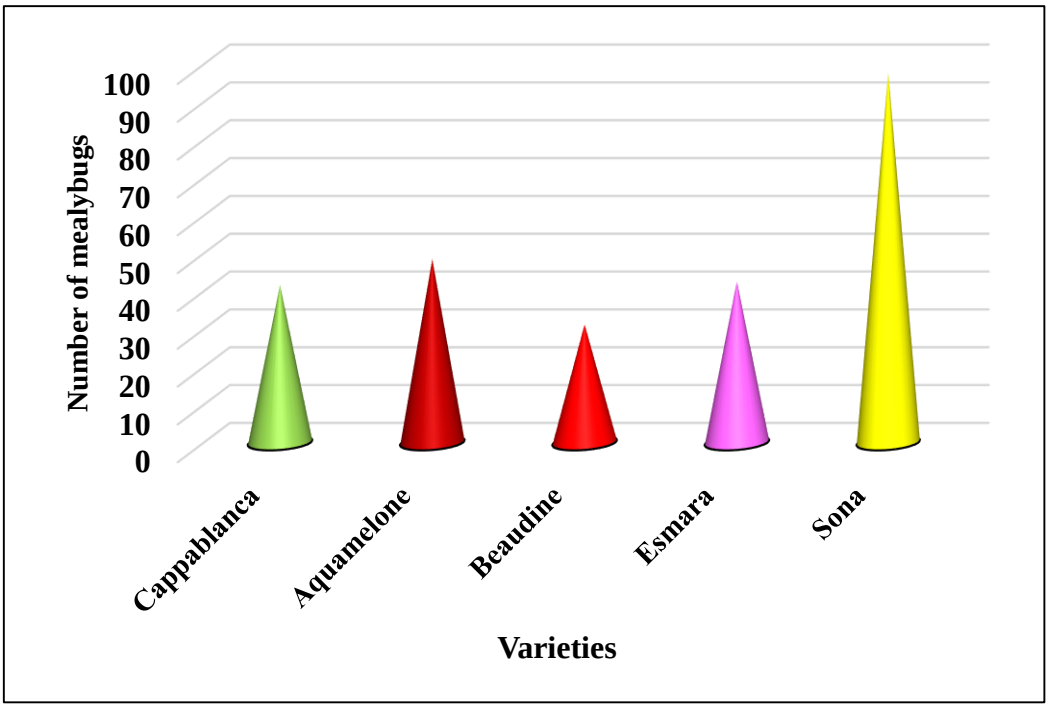


Figure 2. Population of mealy bug, *Planococcus citri* in different varieties of gerbera

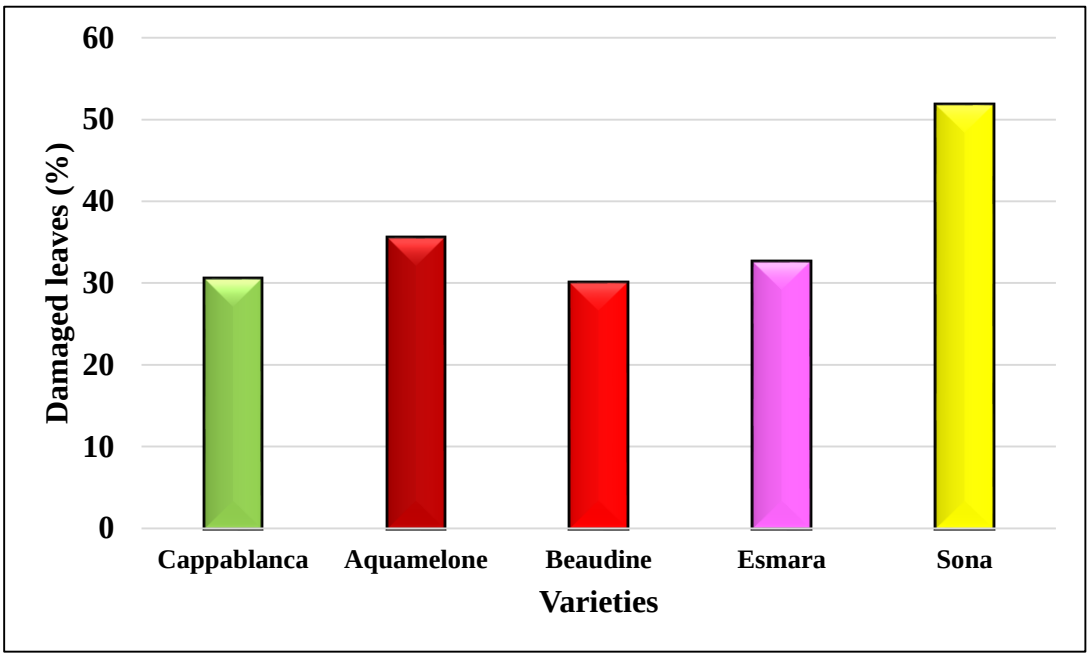


Figure 3. Extent of infestation of mealy bug, *Planococcus citri* in leaves of different varieties of gerbera

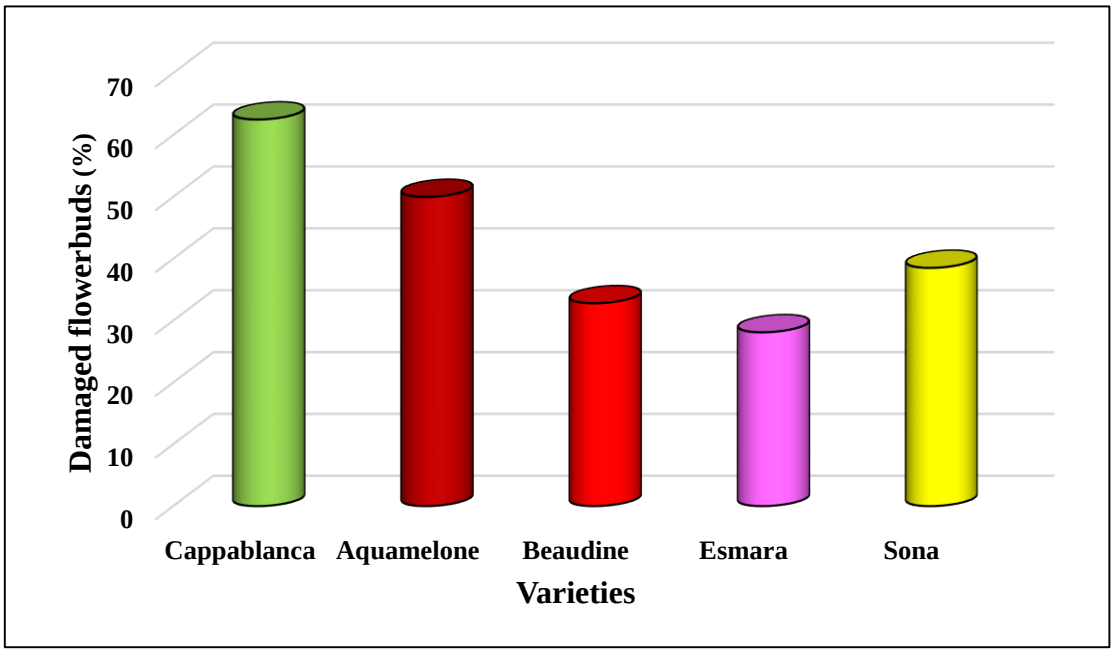


Figure 4. Extent of infestation of mealy bug, *Planococcus citri* in flower buds of different varieties of gerbera

The studies on evaluation of varieties for field tolerance to sucking pests in gerbera are so meagre**.** Prabhatchandra (2015) screened eight varieties of gerbera against aphid and reported that "Latara" recorded the lowest aphid index (0.67) which was at par with Alcatraz (0.76 aphid index) and "Dakota" (1.01 aphid index). Maximum aphid index (3.18) was recorded in "Terrajuba" followed by Faith (3.00) and Basic (2.81).

5.3 MANAGEMENT OF SUCKING PESTS INFESTING GERBERA

A preliminary evaluation was conducted to screen five treatments *viz*., *L.lecanii* @ 20g L^{-1}, fish jaggery 0.5% @ 5 mL L^{-1}, fipronil 40%+ imidacloprid 40%WG @ 0.40 g L^{-1}, thiamethoxam 25%WG 0.20 g L^{-1} and spiromesifen 22.9%SC @ 1 mL L^{-1} for their efficacy in controlling sucking pests infesting gerbera. The sucking pests encountered were two spotted spider mite, *T.urticae* and thrips, *S. dorsalis*.

Spiromesifen 22.9%SC @ 1 mL L^{-1} was proved to be the best treatment in reducing the population and infestation of mites in gerbera and it recorded 99.61 per cent reduction in mite population (Figure 5) and 12.77 per cent reduction in leaf infestation at fifteen days after treatment (Figure 6). Studies on the management of thrips, *S.dorsalis* showed that fipronil 40% + imidacloprid 40% WG @ 0.40 g L^{-1} was found to be the best treatment in reducing the population and infestation of thrips in gerbera. It recorded 100 per cent reduction of thrips population at 7 DAT (Figure 7) and 20.71 per cent reduction in infestation of leaves at fifteen days after treatment (Figure 8). The next best treatments were spiromesifen 22.9%SC @ 1 mL L^{-1} and thiamethoxam 25%WG@ 0.20 g L^{-1}which recorded 98.83% and 95.04% reduction of thrips population at 7DAT.

No population of thrips was observed in thiamethoxam 25%WG @ 0.20 g L^{-1} treated flowerbuds after three days of treatment (Table 12) and in flowers five days after treatment. Similarly no thrips could be detected in spiromesifen 22.9% SC @ 1 mL L^{-1} treated flowers after five days of treatment (Table 14).

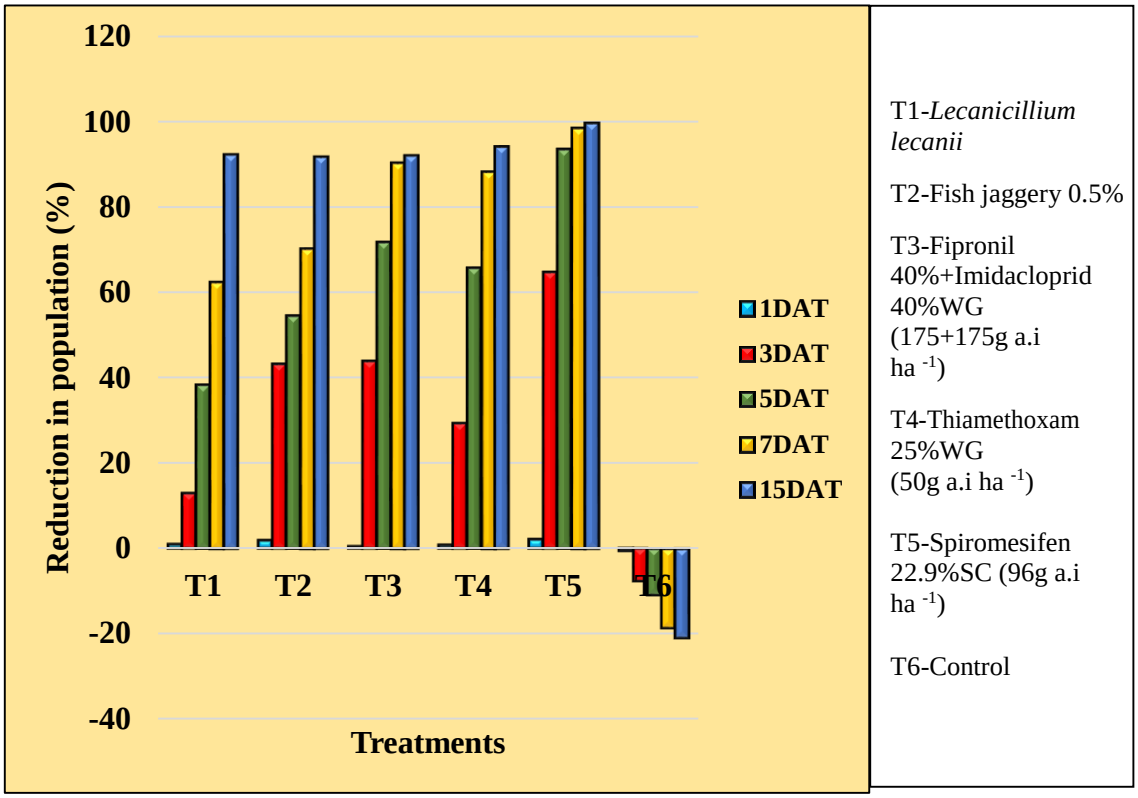


Figure 5. Reduction in the population (%) of mites after treatment

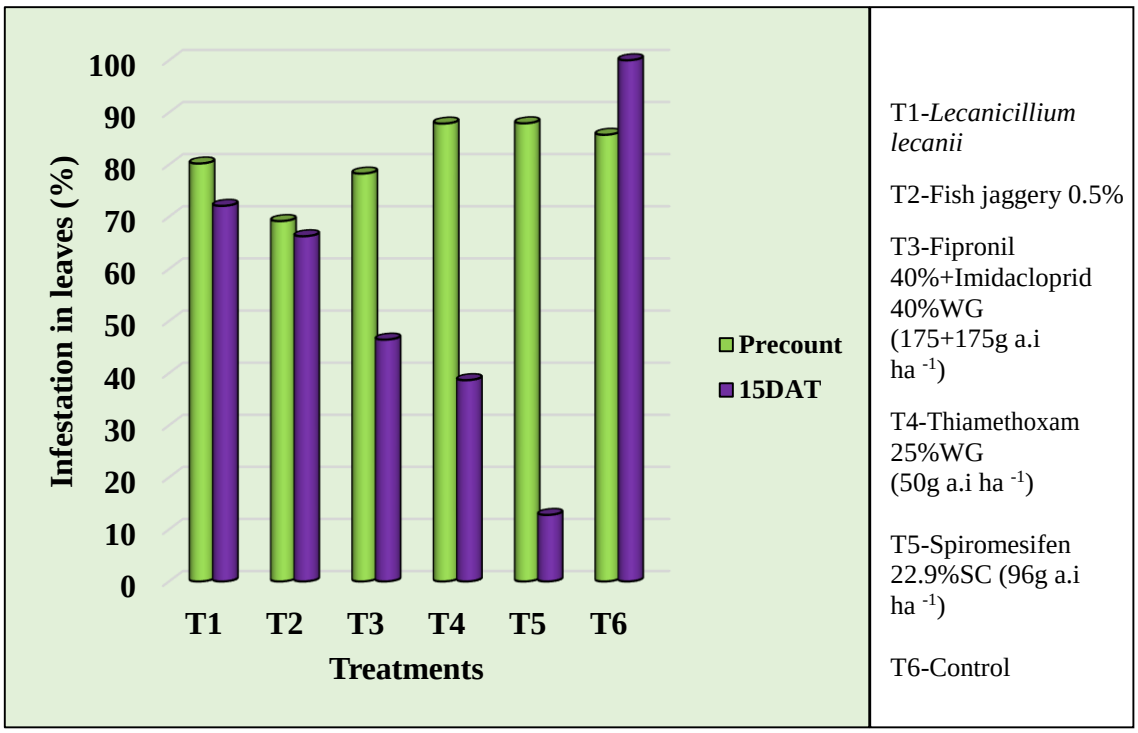


Figure 6: Reduction in leaf infestation (%) of mites after treatment

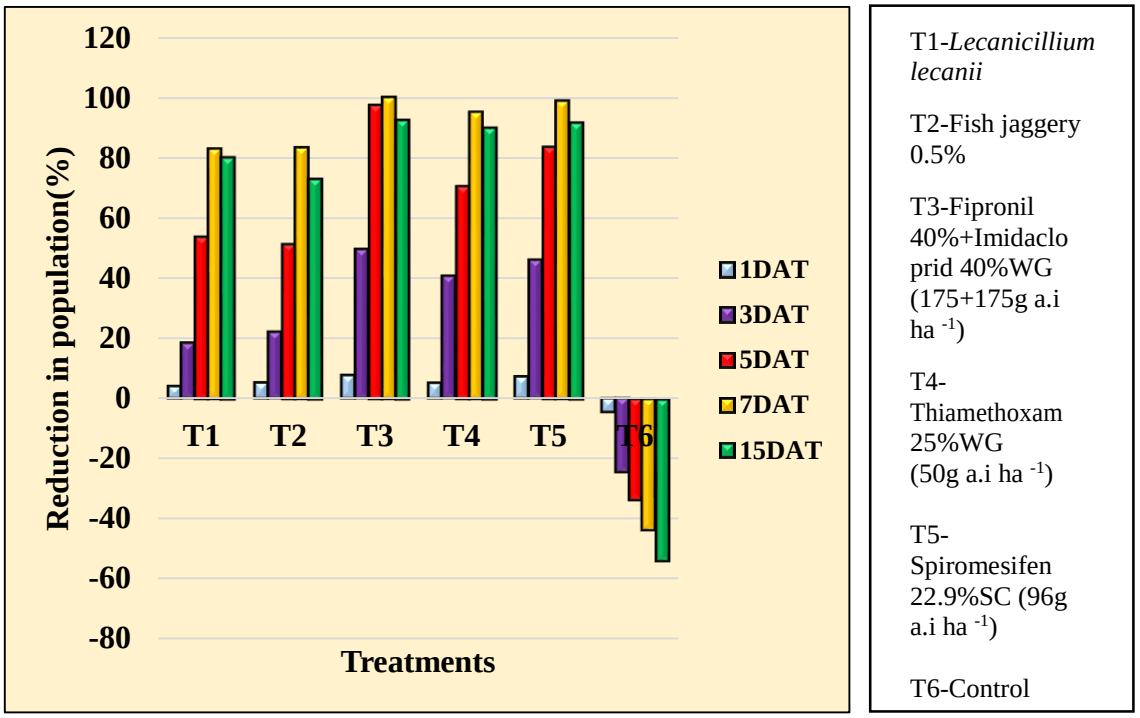


Figure 7. Reduction in the population (%) of thrips after treatment

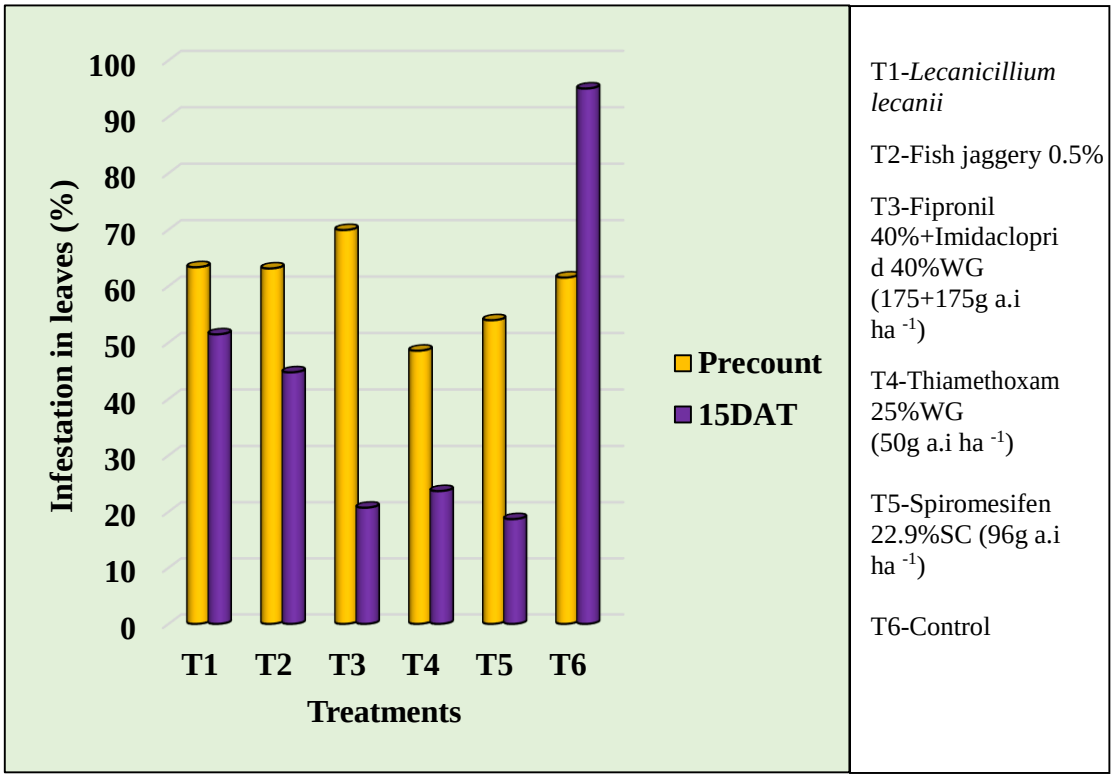


Figure 8: Reduction in leaf infestation (%) of thrips after treatment

Study conducted by Pal and Karmakar (2017) reported that application of spiromesifen @ 500 g a.i ha^{-1} was effective in the management of mites in gerbera along with fenazaquin @ 100 g a.i ha^{-1}, diafenthiuron @ 800g a.i ha^{-1} and dicofol @277.5 g a.i $ha^{-1}$was most effective against mites while ethion was the least effective to mite species in gerbera. This study is in agreement with present study.

Similarly, Reddy *et al*. (2014) tested the bioefficacy of spiromesifen with other acaricides against *T. urticae* on chrysanthemum in polyhouse and results showed that during first season chlorfenapyr 10 SC @ 1.5mL L^{-1}, abamectin 1.9 EC @ 0.8 mL L^{-1}, hexythiazox 5.45 EC @ 0.8 mL L^{-1}, spiromesifen 240 SC @ 0.8 mL L^{-1}, fenpyroximate 5 EC @ 1 mL L^{-1}, bifenazate 50 WP @ 0.3 mL L^{-1}, showed 100 per cent mortality of *T. urticae* on 5, 7 and 15 days after treatment. Pattanaik (2016) studied the bio-efficacy of insecticides against major pests of marigold. The results showed that, Spiromesifen @1mL/l alone and (Propargite 50% + Bifenthrin 5%) @ 2.5mL/l established their superiority over the pesticides evaluated up to 15DAS in suppressing the spider mite population (0.67 and 1.33/leaf) which was to the tune of (92.27%) and (84.66%) respectively over control (8.67/leaf). All these results are in agreement with the findings of present study.

Contradictory to the present study, Lakhabhai (2017) revealed that spiromesifen 0.0025 % were found moderately effective in controlling mites in rose. Abamectin 0.0025 % was significantly effective for the management of mite and it was on par with fenazaquin 0.01 % and propargite 0.05 %.

Spiromesifen is a novel insecticide or acaricide belonging to the new chemical class of spirocyclic phenyl-substituted tetronic acids, and it is especially active against tetranychid spider mite species and whiteflies (Bielza *et al*., 2009). It acts on lipid synthesis by inhibiting acetyl CoA carboxylase and causes a significant decrease in total lipids (Bouabida *et al*., 2017). Because of its high selectivity, good residual activity, minimal risk to pollinators and predatory mites combined with a novel mode of action make spiromesifen as an excellent new toolformany Integrated Pest Management programs (Kodandaram *et al*., 2016; Singh *et al*., 2016). It works by preventing the treated mite from maintaining proper water balance and results in dessication, drying and death of mite.

In Kerala, Varghese and Mathew (2013) reported that spiromesifen was the safest insecticide against predatory mite, coccinellid beetles, spiders and neutral insects and the results were in line with present findings. Viswanathan (2019) reported that spiromesifen 22.9 % SC was found as the safest insecticide towards spiders as it maintained its higher number even after 15 days of spraying and it is relatively similar to the population of spiders seen in untreated control.

The results of the present study revealed that fipronil 40% + imidacloprid 40% WG @ 175 + 175 g ai ha^{-1} was found to be the best treatment in reducing the population and infestation of thrips in gerbera. The research works related to the efficacy of fipronil 40% + imidacloprid 40% WG @ 0.40 g L^{-1} against thrips in gerbera are so scanty. However, several research works on efficacy of insecticide mixture against pests of cotton, chilli and okra are available. The present findings are in line with Patil *et al*. (2009) and they reported that fipronil 40% + imidacloprid 40% 80 WG @ 100 ml ha^{-1} was the best treatment in controlling aphids, thrips and whiteflies in cotton. This finding is in agreement with present study.

Fipronil 40% + imidacloprid 40% WG is a new combination insecticide recommended by CIBRC and it has a label claim for sugarcane white grub, *Holotrichia consanguinea* (CIB & RC, 2020).

Chundawat (2011) reported that among different treatments, two sprays of Fipronil 40% + Imidacloprid 40% 80 WG @ 100g ha^{-1}at 15 days interval were found most effective over all the treatments in terms of mean reduction in the population of sucking insect pests of okra.

In agreement with present study, Viswanathan (2019) reported that less incidence of whiteflies in fipronil 40% + imidacloprid 40% WG @ 175 + 175 gha^{-1} (0.43per leaf) treated chilli plants on seventh day after spraying in Kerala followed by beta cyfluthrin 8.91% + imidacloprid 19.81 % OD @ 15.75 + 36.75 g a.i ha^{-1} (0.60 per leaf) and thiamethoxam 25 % WG @ 50 g a.i ha^{-1} (2.23 per

leaf). No population of thrips was observed in chilli plants treated with fipronil 40% + imidacloprid 40% WG @ 175 + 175 g a.i ha^{-1} on tenth day after spraying followed by betacyfluthrin 8.91% + imidacloprid 19.81 % OD @ 15.75 + 36.75 g a.i ha^{-1}(1.30 perleaf).

Blockage of the GABA-gated chloride channels by fipronil reduces neuronal inhibition and leads to hyper-excitation of the central nervous system, convulsions and death. Glutamate-gated GABA chloride channels appear to be a critical target for fipronil, since these channels are only found in invertebrates, possibly explains the high selectivity of fipronil for invertebrate pests (Zhao *et al*., 2005). Imidacloprid is a systemic, chloro-nicotnyl insecticide used for the control of sucking insects such as aphids, turf insects, whiteflies, fleas, termites, soil insects and some beetles. It works by interfering with the transmission of stimuli in the insect nervous system causing irreversible blockage of acetylcholine receptors. These receptors are rendered incapable of receiving acetylcholine molecule and an accumulation of acetylcholine occurs, resulting in the insect's paralysis and eventual death (Giraddi *et al*., 2017). Thus the insecticide mixture fipronil + imidacloprid became the best treatment for the thrips in gerbera.

The dissipation studies of spiromesifen in chilli conducted by Varghese (2011) in Kerala revealed that the residues dissipated within five days and the half-life was 2.62 days. The dissipation studies of insecticide mixtures in chilli conducted by Viswanathan (2019) in Kerala revealed that fipronil 40% + imidacloprid 40% WG in which each single insecticide was dissipated to below LOQ within 1 and 3 days after spraying respectively. The above studies showed the safety of spiromesifen and fipronil 40% + imidacloprid 40% WG for spraying in gerbera by keeping sufficient waiting period.

The present work is a maiden attempt to study the pests of gerbera and their management in Kerala. The study could document four pests and four spiders as natural enemies from gerbera. The variety of gerbera *viz.*, Sona was harbouring more number of pests.The studies on management of pests of gerbera revealed the application of spiromesifen 22.9%SC @ 1 mL L^{-1} effectively manage the *Tetranychus* sp. and fipronil 40% + imidacloprid 40%

WG @ 0.40 g L^{-1} followed by spiromesifen 22.9%SC @ 1 mL L^{-1} and thiamethoxam 25%WG@ 0.20 g L^{-1} were found to be effective in managing *S.dorsalis* in gerbera. The results could be concluded that the application of spiromesifen 22.9%SC @ 96g a.i ha^{-1} could effectively manage mite, *Tetranychus* sp. and thrips, *S.dorsalis* in gerbera.

Summary

6. SUMMARY

Gerbera commonly known as African Daisy is an important flower grown throughout the world under wide range of climatic conditions. Gerbera cultivation in polyhouse is highly susceptible to several pests and diseases especially sucking pests as major biotic stress. These pests reduce the quality and quantity of gerbera flowers which results in the decrease of economic value of flowers. The present investigation entitled "Incidence and management of sucking pests on gerbera under protected cultivation" was undertaken in polyhouses of Kerala with an objective to document sucking pests on gerbera under protected cultivation, to evaluate thegerbera varieties for field tolerance to sucking pests and their management. The findings of these studies are summarized here under.

- Documentation of pests infesting gerbera in polyhouses of Thiruvananthapuram, Thrissur and Wayanad districts revealed new record of sucking pests *viz.*, aphid, *Macrosiphum euphorbia* (Thomas), scales, *Icerya* sp., and mealybugs, *Planococcus citri* (Risso) and thrips, *Scirtothrips dorsalis* and *Haplothrips* sp. Natural enemies recorded and identified were spiders *viz., Plexippus paykulli* (Audouin), *Theridion* sp., *Oxyopes birmanicus* (Thorell) and *Ptocassius* sp.Other sucking pest documented was mites, *Tetranychus* sp.

- Studies on evaluation of varieties for field tolerance to sucking pests revealed that among the five varieties of gerbera, the lower population of thrips, *S. dorsalis* was recorded in the leaves of variety, Beaudine (26.85) which was on par with the population of thrips in Esmara (30.79) and Aquamelone (31.12). Higher population of thrips was recorded in Cappablanca (58.52) followed by Sona (50.62) and they were on par.

- In respect of mealybugs, the lower population of mealybugs was recorded in Beaudine (31.25) followed by Cappablanca (41.62), Esmara (42.62) and Aquamelone (48.50) and they were significantly on par. Sona recorded higher population of mealybugs (97.81) which was

significantly different from others.

- Lower infestation of mealy bug was recorded in leaves of Beaudine (30.03 %) followed by Cappablanca (30.59 %), Esmara (32.56 %) and Aquamelone (35.49 %) which were statistically on par. Sona recorded higher infestation of mealy bug (51.86 %) which was significantly different from others.
- Significantly lower per cent damage was observed in flowerbuds of Esmara (28.12) which was on par with Beaudine (32.81) and Sona (38.53).Cappablanca recorded higher per cent damage of mealy bugs in flowerbuds (62.50) followed by Aquamelone (49.99) and they were significantly on par.
- Studies on management of sucking pests infesting gerbera revealed that spiromesifen 22.9%SC @ 1 mL L^{-1} was the best treatment in reducing the population and leaf infestation of mites in gerbera. Among the different treatments, it recorded 99.61 per cent reduction of population and 12.77per cent reduction in leaf infestation of mites at fifteen days after treatment.
- The lowest incidence of thrips was recorded in fipronil 40% + imidacloprid 40% WG @ 175+175g a.i ha^{-1} treated plants (100%) at 7DAT and 20.71per cent reduction in leaf infestation at 15DAT. The next best treatment was spiromesifen 22.9%SC @ 96g a.i ha^{-1} and thiamethoxam 25%WG @ 50g a.i ha^{-1} and which recorded 98.83 per cent and 95.04 per cent reduction of thrips population at 7DAT.
- The study could concluded that the Beaudine variety of gerbera harbor less number of thrips and mealybugs, while Cappablanca variety found susceptible to thrips and Sona variety susceptible to thrips and mealy bugs. The studies on management of pests of gerbera revealed that the application of spiromesifen 22.9%SC @ 96g a.i ha^{-1} could effectively manage mite, *Tetranychus* sp. and thrips, *S.dorsalis* in gerbera.

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INCIDENCE AND MANAGEMENT OF SUCKING PESTS ON GERBERA UNDER PROTECTED CULTIVATION

by

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ABSTRACT

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ABSTRACT

A study on "Incidence and management of sucking pests on gerbera under protected cultivation" was undertaken in polyhouses of Thiruvananthapuram, Thrissur and Wayanad districts during June 2019 - February 2020. The objectives were to evaluate the response of different gerbera varieties to sucking pests and to evolve effective method for its management.

Documentation of pests infesting gerbera in polyhouses of Thiruvananthapuram, Thrissur and Wayanad districts revealed new record of sucking pests *viz.*, aphid, *Macrosiphum euphorbia* (Thomas), scales, *Icerya* sp., mealybugs, *Planococcus citri* (Risso) and thrips, (*Scirtothrips dorsalis* and *Haplothrips* sp.). Natural enemies *viz.,* spiders recorded and identified were *Plexippus paykulli* (Audouin), *Theridion* sp., *Oxyopes birmanicus* (Thorell) and *Ptocassius* sp. Other sucking pest documented was mites, *Tetranychus* sp.

Experiment was carried out in CRD to evaluate varieties for field tolerance to sucking pests. Among the five varieties of gerbera, Beaudine (26.85) and Esmara (30.79) harbour less number of thrips compared to other varieties, while Cappablanca (58.52) variety was more susceptible to thrips compared to Sona (50.62) variety. In case of mealybugs, the lower population of mealybugs was recorded in Beaudine (31.25) followed by Cappablanca (41.62), Esmara (42.62) and Aquamelone (48.50) and they were significantly on par. Sona recorded higher population of mealybugs (97.81) which was significantly different from others and hence Sona has selected for further study.

Experiment was carried out in CRD to evaluate the efficacy of five treatments *viz*., spiromesifen 22.9%SC @ 1 mL L^{-1}, *L. lecanii*@ 20g L^{-1}, fish jaggery 0.5% @ 5 mL L^{-1}, fipronil 40%+ imidacloprid 40%WG @ 175+175g a.i ha^{-1} and thiamethoxam 25%WG @ 50g a.i ha^{-1} against sucking pests infesting gerbera. The results revealed that spiromesifen 22.9%SC @ 96g a.i ha^{-1} was the best treatment in reducing the population (99.61 %) and leaf infestation (12.77%) of mites in gerbera after 15 days of treatment.

The lowest incidence of thrips was recorded in fipronil 40% + imidacloprid 40% WG @ 175+175g a.i ha $^{-1}$ treated plants (100%) at 7DAT and reduced 20.71per cent reduction in leaf infestation at 15DAT. The next best treatment was spiromesifen 22.9%SC @ 96g a.i ha^{-1} and thiamethoxam 25%WG @ 50g a.i ha^{-1} which recorded 98.83 per cent and 95.04 per cent reduction of thrips population at 7DAT.

The study could concluded that the Beaudine variety of gerbera harbour less number of thrips and mealy bugs, while Cappablanca variety found susceptible to thrips and Sona variety was susceptible to thrips and mealy bugs. The studies on management of pests of gerbera revealed that the application of spiromesifen 22.9%SC @ 96g a.i ha^{-1} could effectively manage mite, *Tetranychus* sp. and thrips, *S.dorsalis* in gerbera.