"ENVIRONMENT FRIENDLY MANAGEMENT OF THRIPS AND FRUIT FLIES ON CUCUMBER"

By

Mr. Medshikar Rushikesh Ulhas
(Reg. No. 2020/152)

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA

in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL ENTOMOLOGY

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

POST GRADUATE INSTITUTE
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2023

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institution
for a Degree or
Diploma

Place : MPKV, Rahuri

Date : / /2023 **(R.U. Medshikar)**

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Maharashtra State, INDIA

CERTIFICATE

This is to certify that the thesis entitled, **"ENVIRONMENT FRIENDLY MANAGEMENT OF THRIPS AND FRUIT FLIES ON CUCUMBER"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY,** embodies the results of a piece of *bona fide* research work carried out by **Mr. MEDSHIKAR RUSHIKESH ULHAS,** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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Place : MPKV, Rahuri

Date : / /2023 (S.A. Ranpise)

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"There is only one religion in the world and that is Hard Work."

- Shah Rukh Khan

To reach a goal, you don't need to know all the answers in advance. But you must have clear idea of the goal you want to reach. Success is possible only after involvement of many minds and hands to beautiful it. Emotions can not be expressed in words because then emotions are transformed into mere formalities. Nevertheless, formalities have to be completed.

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Place : MPKV, Rahuri

Date : / /2023 (R.U. Medshikar)

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LIST OF ABBREVIATIONS AND SYMBOLS

%	:	Per cent
/	:	Per
@	:	At the rate of
+, -	:	Plus, minus
µ	:	micron
CD	:	Critical difference
cm	:	Centimere (s)
DAS	:	Days after spray
e.g.	:	Exempli gratia, For example
EC	:	Emulsifiyable concentrate
et al.	:	Etalia and others
etc.	:	Etcetera
FYM	:	Farm yard manure
g	:	Gram (s)
ha	:	Hectare (s)
hr	:	Hours (s)
i.e.	:	Idest, that is
kg	:	Kilograms (s)
L	:	Litre (s)
m	:	Meter
mg	:	Milligram (s)
ml	:	Mililiter (s)
mm	:	Milimeter (s)
N	:	North
No.	:	Number
ºC	:	Degree celcius
q/ha	:	Quintal/hectare
R.H.	:	Relative humidity
RBD	:	Randomized block design
SC	:	Suspension Concentrate
SE	:	Standard error
SMW	:	Standard Meteorological week
SP	:	Soluble Powder
Temp.	:	Temperature
viz.,	:	Videlicet (namely)
WP	:	Wettable Powder
Wt	:	Weight

ABSTRACT

ENVIRONMENT FRIENDLY MANAGEMENT OF THRIPS AND FRUIT FLIES OF CUCUMBER”

by

Mr. Medshikar Rushikesh Ulhas
A candidate for the degree
of
MASTER OF SCIENCE (AGRICULTURE)
in
AGRICULTURAL ENTOMOLOGY

Mahatma Phule Krishi Vidyapeeth, Rahuri - 413 722
2023

Research Guide	:	**Dr. S.T. Aghav**
Department	:	**Agricultural Entomology**

The present study entitled “Environment friendly management of thrips and fruit flies of cucumber” was carried out at PG Research Farm, Department of Agricultural Entomology, Mahatma Phule Krishi Vidyapeeth, Rahuri during summer 2022. The present investigation was carried out to study seasonal dynamics of thrips, *T. tabaci* and fruit flies, *B. cucurbitae* on cucumber and bioefficacy of different treatments against thrips, *T. tabaci* and fruit flies, *B. cucurbitae* on cucumber.

Studies on seasonal dynamics revealed that, thrips incidence started from 6^{th} meteorological week (0.34 thrips/plant) and lasted upto the harvesting of the crop i.e. 19^{th} standard meteorological week (1.3 thrips/plant). Thrips population ranged from 0.34 thrips/plant to 15.22 thrips/plant during the crop growth period. Highest population of thrips was found in last week of March i.e. 17^{th} standard meteorological week (15.22 thrips/plant). From the results it was revealed that, thrips incidence had significant positive correlation with maximum temperature (r = 0.636*) and minimum temperature (r = 0.649*). However, highly significant negative correlation was noticed between thrips incidence and morning relative humidity (r = -0.665**) as well as evening relative humidity (r = -0.700**). The correlation coefficient showed non-significant positive correlation between thrips incidence and bright sunshine hours (r = 0.070NS) whereas, non-significant negative correlation was noticed between thrips population and rainfall (r = -0.001NS).

Abstract contd… **Mr. R.U. Medshikar**

The fruit fly incidence started from 6th standard meteorological week (3 fruit flies/trap) and lasted upto the harvesting of the crop i.e. 19th standard meteorological week (5 fruit flies/trap). Fruit fly population ranged from 3 fruit flies/trap to 24 fruit flies/trap during the crop growth period. The population of fruit flies then gradually increased up to the 14th standard meteorological week i.e. first week of April (24 fruit flies/trap) which was found to be the highest trap catches during whole experimental trail. From the results it was noticed that, incidence of cucumber fruit fly had significant positive correlation with maximum temperature (r = 0.618*) and non-significant correlation with minimum temperature (r = 0.504NS). However, significant negative correlation was found between fruit fly incidence and morning relative humidity (r = -0.554*) whereas highly significant negative correlation was found between fruit fly incidence and evening relative humidity (r = -0.784**).

Fruit fly incidence had non-significant positive correlation with bright sunshine hours (r = 0.111NS) and non-significant negative correlation with the rainfall parameter (r = -0.094NS).

From the bioefficacy study it was found that, the treatment with chemical insecticide tolfenpyrad 15 EC @ 150 g a.i/ha and flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha were found to be most promising treatments against cucumber thrips and fruit fly, respectively with least average survival population of thrips (4.24 thrips/plant) and minimum mean per cent fruit damage of 3.96 per cent, respectively.

However, the treatment T7 (Mulching with polythene sheet of 25 µ size + Cue lure traps+ Azadirachtin 300 ppm) was found equally effective treatment in reducing thrips population (4.45 thrips/plant) and mean per cent fruit damage (5.00 %) caused by cucumber fruit fly as well. When compared with chemical insecticide treatment, the treatment T7 also gave highest marketable cucumber fruit yield of 331.33 q/ha over rest of the treatments.

Pages 1 to 64

1. INTRODUCTION

Vegetables and fruits are one of the most important source of nutrition for its enormous population. To date, with the increasing globalization and population, it has become a challenge for our country not only to feed its own population but also to export fruits and vegetables to various developed countries. This requires strict quality control and restrictive quarantine measures (Kapoor, 2005).

Vegetables play an important role in human diet as well as in economy of the farmers. They are rich source of vitamins (Vit-A, Vit-B and Vit-E), minerals, proteins, fibers etc. which is the most important part of the balanced diet of biological value. They are also a good source of dietary fibre and are low in fat, salt and sugar. It is suggested that, on an average a man with vegetarian or non-vegetarian food habit needs to consume 50 g of leafy vegetables, 150 g of other vegetables and 100 g of roots and tubers (Rao, 2013).

India secures 5th rank in area and production of total vegetables. The area under vegetable cultivation was 10.35 million ha with a production of 191.77 MT. On the other hand, in Maharashtra, area under vegetable cultivation was 0.81 million ha with a production of 14.75 MT. Cucurbits constitute the largest group of summer vegetables grown all over the world. Cucumber is the most popular crop in the cucurbitaceae family which is grown in low and mid-hills of Himachal Pradesh, Jammu and Kashmir and plains throughout India.

Cucumber (*Cucumis sativus*) is consumed in different ways like sweet, vegetable and salads. It is locally known as 'Kakadi' in Maharashtra which comes under cucurbitaceae family and possess antibacterial, antimicrobial, anti-fungal characteristics and shows antioxidant, phytochemical and hypoglycaemic activity. It is cultivated for the fresh consumption and for pickling cucumber for preservation, marinated with vinegar, salt, dill or other spices.

Cucumber is considered to be native of India. It is an important salad vegetablecultivated both in north and south region and as well as lower and higher hills in India. Each 100 g of fresh weight cucumber contains 0.4 per cent protein, 2.5 per cent carbohydrates, 1.5 mg iron and 2 mg of vitamin C with varying size, shape and colour of fruits. It is good for people suffering from constipation, jaundice and indigestion. In

India, it has been cultivated on 0.028 million ha area with 0.175 MT production and productivity of 6.3 t ha^{-1} (FAO-STAT, 2022).

Cucurbits are attacked by a number of insect pests starting from germination up to the harvest of the crop. Insects pests attacking cucumber crop includes red pumpkin beetle, leaf miner, flea beetle, thrips, fruit fly etc. at different stages of the crop which drastically affect the quality and quantity of crop. Thrips and fruit fly are one of the major and devastating pests of cucumber which causes heavy nuisance to the crop quality as well asyield.

Thrips, (*Thrips Tabaci* Lindane.) is considered as one of the most devastating pests of cucumber due to its direct feeding habit which leads to damage plant parts such as foliage and flower. Direct damage causing fruits to curl and rendering it unmarketable. In case of indirect damage its feeding on parenchyma of leaves results into subsequent reduction in photosynthetic activity of the plant and act as a disease transmuting vector which eventually cause significant yield drop. Thrips causes severe injury to plants by rasping and sucking cell sap from leaves which in turns becomes yellow, white or whirled in appearance and then ultimately plant dies. The damaged cells turn greenish brown to yellow. The silvering and yellowing of leaves is termed as 'white blight' or 'white spot' (Lall and Singh, 1968).

The minute size, thigmotactic behavior, high fecundity with rapid growth and development leads to insecticide resistance which make this insect difficult to manage (Gerin *et al*., 1999). Chemical use is not always effective and may kill natural enemies leading to resurgence of the pests as well as it may also cause residual effects, resulting in ground water contamination, environmental problems and impacting human health also (Wabale and Kharde, 2010). For these reasons, their has been considerable interest in adoption of environment friendly pesticides as a part of integrated pest management (IPM) practices.

Some alternative pesticides, such as botanical extract from neem (*Azadirachta indica*) is considered promising because it is safer to biocontrol agents such as parasitoids and predators and having a short residual activity which also recurring in the nature (Miller and Uetz, 1998; Saxena, 2006). Neem Seed Extracts has been shown to reduce feeding, deter pests, inhibit the growth of insects and affect oviposition activity of insects (Gujar, 1992). In general, botanically originated insecticides are thought to be ecologically acceptable and safe, while offering effective control when used in conjunction with other IPM modules (Nathan *etal*., 2004).

Another important pest of cucumber is fruit fly, *Bactrocera cucurbitae* which belongs to Tephritidae family. It is one of the largest, most diversified and fascinatingacalypterate families of order Diptera which includes more than 4200 known species of true flies arranged in 471 genera (Norrbom *et al*., 1998). The average time period for completionof the life cycle by passing through various life stages *viz.* Egg, larva, pupa and adult is 23.5 ± 5.94 days. The longevity of the adult male and female fly is about 13 ± 2.41 and 15.5 ± 3.49 days, respectively (Sharma *et al.,* 2017).

It is one of the most destructive pests of cucurbit that cause direct yield loss and result in non marketable fruits which are hard to sale. In India, because of the polyphagous nature of the pest (maggots), fruit flies are considered as one of the most serious insect pest ofthe entire agriculture and horticulture ecosystem. Out of 207 species of fruit flies, nine species are found to be major one and are economically important in India. After hatching, maggots feed on pulp of the fruits and simultaneously secondary infection develops, resulting in rotting of fruits with weird kind of smell.

For the complete success or for developing any other strategy for fruit fly management, the knowledge of seasonal dynamics and biology, is an important prerequisite. This study is helpful in developing efficient management strategies that will prevent ill effects of insecticides (Mir *et al*., 2014). In India, there are different ways to control this pest such as use of insecticides as chemical control (Dashad *et al*., 1999), combinations of insecticides and plant products (Saikia and Dutta, 1997) and culture filtrates of fungi (Purnima *et al*., 1999). Due to the cryptic nature of fruit fly maggots, they mostly remain unaffected by insecticides and further lead to increase in insecticide residues in the fruits. Therefore, their is a need to explore the alternative methods of pest control and development of an effective management strategies against this pest.

One such approach influencing the population dynamics, by using lures or traps, food baits or attractants), application of poison baits (containing an attractant + insecticide mixture) and use of plant extracts that possesses insecticidal properties. As female fruit flies are the dominant factor for multiplication therefore, it is essential to apply different attractive baits for females for monitoring fluctuations in the population of this pest and for direct control as well. These traps (baits) have high specificity, low cost, environmental safety and ecological advantage (Sureshbabu and Viraktamath, 2003). Pheromone traps provide an easy and efficient method to monitor the activities of fruit fly populations (Alyokhin *et al*., 2000) and they have been successfully used worldwide.

In nature, the normal sex ratio of this pest for male to female is around 1:1. The best way to prevent fruit fly infestation is to follow an integrated approach of traps (at least 30 days prior to harvest) + sanitation (Removal and destruction of all fallen fruits, 40 days prior to harvest) and soil raking below the tree (Once or twice starting a month prior to harvest, if possible). The trap consists of methyl eugenol (ME), a para-pheromone (mixed with a toxicant), which attracts only males of certain species of *Bactrocera* and therefore, is called male annihilation technique (MAT) (Verghese *et al*., 2006).

Keeping these points in a view, current research topic entitled, "Environment friendly management of thrips and fruit flies on cucumber" was undertaken with the following objectives.

1. To determine seasonal dynamics of thrips and fruit flies in cucumber.
2. To develop environment friendly management practices for thrips and fruit flies on cucumber.

2. REVIEW OF LITERATURE

The present investigation entitled, "Environment friendly management of thrips and fruit flies on cucumber" was undertaken during summer 2022 at PG Research Farm, Department of Agricultural Entomology, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri. The literature pertaining to seasonal incidence and managementof thrips and fruit flies on cucumber is reviewed and presented below.

2.1 Seasonal dynamics of thrips, *T. tabaci* on cucumber

Chhatrola *et al.* (2006) detected seasonal abundance of thrips in garlic during 2000-01 at Junagadh, Gujarat. The activity of thrips was comparatively higher in garlic at 6^{th}, 9^{th} to 16^{th} and 19^{th} week after sowing of the crop.

Ullah *et al*. (2010) recorded the seasonal incidence of onion thrips (*T. tabaci*) in onion crop. However, thrips population of 1.20 thrips per plant was recorded in first week of February and reached to its peak (100 thrips per plant) during last week of April. Later, the population declined to 3.85 thrips per plant towards the end of May as the crop started to mature.

Bukero *et al.* (2015) conducted a field experiment to investigate the activity of thrips on rose. From the results it was noticed that, maximum population of thrips was recorded on 2^{nd} April (15.78 ± 0.79 thrips/leaf; 18.32 ± 0.86 thrips/flower) whereas, minimum thrips population was observed on May 28^{th}, 2014 (0.96 ± 0.20 thrips/leaf; 2.28 ± 0.30 thrips/flower). Further it was found that, thrips population was negatively correlated with temperature (r= - 0.36) and relative humidity (r= -0.75).

According to Madankar *et al.* (2015), thrips population commenced from 30^{th} standard meteorological week (SMW) and reached to its peak during 32^{nd} SMW. Thereafter, the population decreased up to 52^{nd} SMW. The correlation studies showed that, maximum temperature, morning relative humidity and rainfall was positively corelated with thrips population whereas, negative correlation obtained with minimum temperature and evening relative humidity.

According to Soni and Dhakad (2016), first incidence of cotton thrips was noted during mid-July and peak activity was noticed in first fortnight of October when crop was in boll development stage. The population of thrips remained fluctuated and active throughout crop season. Maximum temperature exhibited significant positive correlation (r=0.434) whereas, rainfall expressed a significant negative correlation (r = -0.485) with thrips population.

Subba and Ghosh (2016) studied the population dynamics of thrips (*Thrips tabaci* L.) in relation to abiotic factors in tomato for two consecutive seasons during 2011-2013. Minimum thrips population (0.42-53 thrips/leaf) was recorded during 38th to 44th standard meteorological week and maximum level of population was observed during 45th to 2nd (1.05-1.89 thrips/leaf) and 6th to 20th (1.00-2.22/leaf) standard meteorological week. Correlation studies revealed that, maximum temperature had significant positive influence on thrips population while it had significant negative correlation with minimum temperature, relative humidity (minimum, average) and weekly total rainfall.

Venu Gopal *et al*. (2018) conducted a field experiment during *kharif* 2014-15to study the seasonal incidence and impact of weather parameters on chilli thrips. The population of thrips was first noticed during 43rd standard meteorological week and it gradually increased from 3rd standard meteorological week. The peak population of thrips was observed in 4th SMW which was 169 thrips/ 50 fruit. Thrips population had significant negative correlation with maximum temperature, minimum temperature, mean temperature, rainfall, rainy days and evaporation.

Aishwarya *et al.* (2019) conducted a study during summer 2019 in Tamil Nadu, India to understand influence of weather parameters (Temperature, RH and rainfall) on vector population. The result showed that thrips population was ranged from 0.5 to 18.1 thrips/plant. Thrips incidence started at 10 DAS and reached to its maximum at 30 DAS. The incidence of thrips was positively correlated with temperature and it was negatively correlated with relative humidity (r=-0.5) and rainfall (r=-0.5).

Lad *et al.* (2021) conducted an experiment to study the seasonal activity of thrips and their relation with weather parameters infesting bitter gourd during rabi-summer season of 2017-18 at Centre of Excellence for Mango, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S). Results showed that, their were marked differences observed in infestation of thrips. The population of thrips (4.60 ± 1.05) was noticed in 13th SMW (26th March - 1st April). Minimum thrips population (1.00 ± 1.05) was recorded in 23rd SMW (5th - 11th June), while maximum (4.60 ± 1.05) population was recorded during 13th SMW (26th March - 1st April). The data on correlation between mean population of thrips and different weather parameters revealed that, minimum temperature had significant negative correlation with thrips population whereas, remaining all meteorological parameters *viz*. Maximum temperature, morning relative humidity and evening relative humidity were found to be non- significant.

Gangurde *et al.* (2021) studied seasonal incidence of sucking pests on bitter gourd during *kharif* 2019. Result revealed that, maximum population of *T. palmi* (11.37 thrips/leaf) was observed during 40th SMW. The incidence of thrips, showed nonsignificant positive correlation with maximum temperature and nonsignificant negative correlation with minimum temperature. Sunshine hours played a major role with non-significant positive influence on thrips population.

According to Bhojane *et al*. (2022) incidence of thrips was highest in cucumber crop under polyhouse condition during 43rd standard meteorological week (50.06 thrips/3 leaves/plant) whereas, it was minimum in 1st standard meteorological week (25.86 thrips/3 leaves/plant). There was a significant positive correlation between temperature and thrips population whereas, humidity was negatively correlated.

2.2 Seasonal dynamics of fruit flies, *B. cucurbitae* on cucumber

Babu *et al*. (2002) delineated the population of *B. cucurbitae* increased gradually from 32nd to 44th SMW, coinciding with 2nd week of August to last week ofOctober ranging from 10.0 to 20.25 fruit flies/trap/week. Thereafter, it declined gradually up to 49th standard week and further rose during 5th SMW (19.00 fruit flies/trap/week).

Banerji *et al*. (2005) recorded highest incidence of *B. cucurbitae* on bitter gourd during *kharif* followed by summer and lowest in *rabi*. The per cent fruitinfestation was positively correlated with minimum temperature during *rabi* and summer seasons.

Shivayya and Kumar (2008) examined peak incidence of *B. Cucurbitae* on bitter gourd during September and lowest incidence during November at Bangalore. The incidence and population fluctuations were significantly correlated with maximum temperature, rainfall, evening relative humidity and average relative humidity.

Lashkar and Chatterjee (2010) studied the seasonal dynamics pattern of

B. cucurbitae by trapping melon fly by using attractant cue lure in pumpkin field round the year at Instructional Farm, Cooch Behar, West Bengal. The results revealed that, during warm rainy months *viz*. June, July, August at 25-37 ^{o}C, the flies were more as compared to dry and winter months (December, January, February) at 8-23 ^{0}C. Significant positive correlation of fly incidence was noticed with minimum (r = + 0.7596) and maximum temperature (r = +0.7376) whereas, temperature gradient correlated negatively (r = -0.4789) with fly incidence. Negative correlation of fly incidence was recorded with maximum humidity (r = -0.4249) and humidity gradient (r = -0.5481) and positive (r = +0.4366) with minimum humidity. The rainfall and sunshine hours per day showed positive and negative correlation with fly incidence, respectively.

Sharma *et al*. (2010) scrutinized the influence of weather parameters on mixed population of *B. cucurbitae* and *B. tau* infesting cucumber during 2006-2007 at Nauni, Solan. Further they noticed that, in the cropping season of 2006 the minimum infestation was observed during 24th SMW, while it was maximum in 30th SMW. However, during 2007 minimum fruit fly infestation was recorded during 25th SMW and maximum in 32nd SMW. Correlation studies revealed that, fruit fly infestation had non-significant negative correlation with maximum temperature and significant positive correlation with minimum temperature. As regards to relative humidity, significant positive correlation was noticed however, rainfall had non- significant positive correlation.

Raguvanshi *et al.* (2012) recorded incidence of *B. cucurbitae* with two peaks in summer and *kharif* during 14th and 43rd standard meteorological weeks with trap catches of 127.30 and 115 fruit flies, respectively in bitter gourd. Temperature (maximum and minimum) had significant positive correlation with its abundance, damage and pupal population.

Ganie *et al.* (2013) checked that, minimum temperature was negatively correlated with population of melon fruit flies from July to October on different cucurbit crops *viz.* Cucumber, bottle gourd, ridge gourd and bitter gourd in Jammu and Kashmir.

Lanjar *et al.* (2013) observed three population peaks of melon fruit flies during first, third week of April and first week of May (91.4 ± 3.56, 77.4 ± 2.48, 56.2 ± 2.67 fruit flies/trap) on musk melon and two population peaks during first and third week of April (81.8 ± 3.44 and 66.4 ± 3.50 fruit flies/trap) on Indian squash, respectively.

Ali *et al*. (2014) carried out trials to identify fruit fly species which prevailed in the area and infestation levels caused by fruit fly species. The field monitoring of tephritid fruit fly species using Nu-lure as a food attractant revealed the presence of three species namely mango fruit fly, *Ceratitis cosyra* which was dominant species in the region, melon fly, *Bactrocera cucurbitae* and Asian fruit fly, *Bactrocera invadens*.

Vignesh and Viraktamath (2015) analyzed the population dynamics of melon fruit fly, *Bactrocera cucurbitae* (Coq.) during *kharif* and *rabi* season of 2014-2015 at Dharwad and Navalur by using cue-lure traps on cucumber. Incidence of fruit fly was high (55.67 fruit flies/trap/week) on the crop planted during *kharif* and low (19.67 fruit flies/trap/week) on the crop planted in *rabi*. The level of fruit infestation by *B. cucurbitae* was 70.90 per cent during *kharif* 2014.

According to Sunil *et al.* (2017), fruit fly infestation was at its peak during first week of September (52.0 %) and in last week of February (33.0 %). The incidence of fruit fly in *kharif* recorded significant positive correlation with rainfall (r=0.71), maximum temperature (r = 0.35) and maximum RH (r=0.59). During *rabi*, fruit fly infestation had significant positive correlation with maximum temperature (r = 0.76).

Shinde *et al*. (2018) carried out a study on influence of abiotic factors on relative abundance of fruit flies infesting cucumber during *kharif* 2017. The initiation of fruit fly infestation was started after fruit setting in the last week of July (30^{th} SMW). Minimum per cent fruit flies infestation (35.71 ± 36.91) was recorded in 34^{th} SMW, while maximum (100.00 ± 36.91) per cent infestation was recorded during 30^{th} SMW and 31^{st} SMW. The data on correlation between fruit flies with different meteorological parameters showed that, various meteorological parameters were found to be non-significant.

Dubale *et al*. (2018) carried out an experiment to study the incidence of fruit flies in relation to weather parameters on ridge gourd and results revealed that, there were marked differences in infestation of fruit flies. The infestation of fruit flies started after fruit setting in the 3^{rd} week of August (33^{th} SMW). Minimum per cent infestation (16.67 ± 18.25) of fruit flies was recorded during 36^{th} SMW, while maximum per cent infestation (50.00 ± 18.25) was observed during 40th SMW. The data on correlation between per cent infestation of fruit flies with different meteorological parameters showed significant negative correlation (r = 0.720) with morning relative humidity, while remaining various meteorological parameters were found to be non-significant. To develop environment friendly management practices for thrips on cucumber.

2.3 Bioefficacy of different treatments against thrips on cucumber

Pallai and Ponnah (1988) carried out experiments for the control of thrips with neem products. NSE @ 5 and 10 %, neem oil @ 2 % were evaluated for the control of thripsin Tamil Nadu. Neem oil @ 2 % was as effective as phosphamidon and fenthion for controlling rice thrips.

Hazara *et al.* (1999) made neem and tobacco leaves extract and compared with commercial insecticide pandophos 60 SL against *T. tabaci*. All treatments had significantly lower incidence of *T. tabaci*. The treatments with pandaphos 60 SL and tobacco leaf extract were most effective followed by neem leaves extract.

Pearsall *et al.* (2003) carried out field trails to access the efficacy of 4 % azadirachtin against damage by western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) on nectarine crops in Similkameen valley, Canada. Several trails were conducted during the years of 1993 to 1995 to assess the repellent and larvicidal properties of azadirachtin. Results showed that, azadirachtin had only limited effectiveness as a control agent against western flower thrips.

Sharma *et al.* (2001) inspected that, IPM module consisting seed treatment with carbosulfan @ 50 g/kg seed and sprays of NSE 5 % reduced the population of sucking pestsincluding *Aphis gossypii*, *T. tabaci* and *Empoasca* spp effectively.

Momol *et al*. (2002) conducted a study on tomato spotted wilt virus vectored by western flower thrips (*Frankliniella occidentalis*). Insecticides applied on a calendarschedule for thrips vector control were not effective in preventing disease. They determined the separate and combined effects of a reduced risk insecticide (spinosad), a systemic acquired resistance inducer (Actigard) and UV-reflective metalized mulch for management of thrips. The metalized mulch was most effective in reducing the pest incidence. The regimen of metalized mulch, Actigard and insecticides reduced thrips incidence upto 76 per cent.

Maniania and Sithanantham (2003) reviewed that, in all the trials densities of non-targeted organisms were higher in plots treated with *M. anisopliae* than in dimethoate treated plots. Moreover, in the third season trial, *M. anisopliae* applied weekly recorded highest onion bulb yield (24 metric tons/ha). The results indicated the potential of using *M. anisopliae* for the control of *Thrips tabaci* while protecting biodiversity in onion agro-ecosystem.

Azaizeh *et al.* (2002) studied biological control of western flower thrips *Frankinilella occidentalis* using entomopathogenic fungus, *Metarhizium anisopliae*- 7 (M.a-7) strain in three consecutive seasons under greenhouse conditions. Cucumber plants infested with western flower thrips were sprayed with spore suspension of fungus. M.a-7 (0.5 g m^{-2}) and soil was treated with dry powder of fungus (o.5 g m^{-2}). From the results, it was noticed that spray treatment was effective in reducing the population growth to a lower level than in the other treatments including control. The M.a-7 strain was found to be effective in reducing population growth of western flower thrips under greenhouse conditions.

Maniania *et al*. (2003) carried out tests to find out the potential of *Metarhizium anisopliae* for the control of *Frankliniella occidentalis* on chrysanthemum cuttings. The fungus significantly reduced both adult and larval population of *F. occidentalis*, although the level of control of larval population was much lower than for adults. Combined application of *M. anisopliae* and methomyl resulted in a significant reduction of both larval and adult stages.

Silva *et al.* (2011) investigated the effect of biopesticides like *Metarhizium anisopliae*, *Lecanicillium lecanii* and *Beauveria bassiana* on thrips in potato crop. Biopesticides application significantly reduced *T. palmi* population on potato crop. However highest mortality percentage was recorded in the plots treated with *M. anisopliae*.

Thangavel *et al*. (2011) carried out a field experiment at Agriculture College and Research Institute, Madurai during June - November 2009 to evaluate the field efficacy of botanicals and fish oil rosin soap against major pests of coleus. Ten rounds of application of six botanicals and one animal origin insecticide at fortnightly interval were made and the incidence of thrips, scale insects and defoliator on coleus were recorded. Azadirachtin 0.15 % EC (Neem Gold) @ 1.5 ml/L was effective in reducing the incidence of thrips and defoliator, with mean leaf damage of 6.1 per cent for thrips and 6.6 per cent for defoliator.

Patel *et al*. (2013) carried out a field trial at Centre for Research on Seed Spices, Junagad during *rabi* 2010–11 and 2011–12 to determine the effective doses of tolfenpyrad 15 EC against thrips on cumin along with neonicotinoid group of insecticides. Eight different treatments viz. Tolfenpyrad 15 EC @ 100 g a.i./ha, 125 g a.i./ha, 150 g a.i./ha, 300 g a.i./ha (only for phytotoxicity), imidacloprid 17.8 SL @ 25 g a.i./ha, acetamiprid 20 SP @ 20 g a.i./ha, thiamethoxam 25 WG @ 25 g a.i./ha and untreated control were evaluated against thrips in cumin. Amongst them, tolfenpyrad 15 EC @ 125 and 150 g a.i./ ha were highly effective in controlling thrips in cumin. Tolfenpyrad 15 EC @ 150 g a.i./ha recorded maximum seed yield of cumin (415 kg/ha) as compared to the rest of the treatments.

Walunj *et al*. (2016) carried out a field experiment to study the efficacy of new insecticide tolfenpyrad 15 EC in comparison with neonicotinoids and synthetic pyretrhroids against thrips (*Scriothrips dorsalis*) infesting pomegranate c.v. Bhagwa at AICRP on Arid Zone Fruits, Department of Horticulture, MPKV, Rahuri during the ambe bahar of 2011-12 and 2012-13. All the treatments were significantly superior over untreated control. Thetreatment of new chemistry molecule tolfenpyrad 15 EC at 150 g a.i./ha showed significantly least survival of thrips on 5th, 7th and 10th days after spray and resulted in least fruit scaring damage over rest of the treatment at the time harvest. Furthermore, the treatment realized in gaining the higher yield of marketable fruits over untreated control.

Lekha *et al.* (2018) conducted field trials at R.C.A., Udaipur during 2016 and 2017 to evaluate bioefficacy of tolfenpyrad 15 EC at different dosages for the management of major sucking insect pests of brinjal (*Solanum melongena*). The standard insecticides viz. Imidacloprid 17.8 SL @ 22.5 g a.i. /ha, chlorantraniliprole 18.5 SC @ 40 g a.i. /ha, cypermethrin 25 EC @ 50 g a.i. /ha and pyriproxyfen 5 EC + fenpropathrin 15 EC @ 100 g a.i. /ha were used for comparison. Overall, the field trials results revealed that, tolfenpyrad 15 EC @ 150 g a.i/ha provided cross-spectrum control of insect pests as it registered highest mean reduction of thrips (86.47 %) during 2016.

Razzak *et al*. (2019) evaluated the efficacy of different coloured and UV-reflective plastic mulches for managing *T. palmi* in cucumber (*Cucumis sativus* L.) The five mulch treatments were Metalized top and black bottom, Metalized top and white bottom, Plastic black-on-black, Black-on-white, White-on-black and bare soil with no mulch. Metalized mulch reduced *T. palmi* population early in the season when plants canopy did not shade the mulched area. These results suggested that, use of metalized reflective mulch had the potential to manage *T. palmi* at low population densities.

Shivaleela and Chowdary (2020) carried out field trials to evaluate the bio efficacy of tolfenpyrad 15 EC against insect pests of cucumber (*Cucumis sativus*). The experiment was grounded with seven treatments with three doses of tolfenpyrad 15 EC @ 100.5, 124.5 and 150 g a.i. /ha along with standard insecticides *viz.* Imidacloprid 17.8 SL @ 22.5 g a.i. /ha, fipronil 5 SC @ 40 g a.i. /ha and chlorpyriphos 20 EC @ 200 g a.i./ha were used for comparison. Overall the field trials revealed that, tolfenpyrad 15 EC @ 150 g a.i/ha provided cross-spectrum and superior in managing leafhoppers, thrips and red pumpkin beetles with highest yield and it was at par with its next lowest dosage treatments i.e. Tolfenpyrad 15 EC @ 124.5 g a.i./ha and 100.50 g a.i./ha which recorded yield of 5.85 t/ha and 5.21 t/ha in the year 2015-16, respectively.

Balasko *et al*. (2021) conducted a trial to test the efficacy of azadirachtin on western flower thrips mortality and feeding intensity, as well as oviposition. Azadirachtin was used in three doses in laboratory trials. The results showed that, it was not sufficiently effective against the western flower thrips adults, but it reduced the feeding damage on leaves and prevented egg laying. The results indicated that, even though azadirachtin did not have a significant adverse effect on the adult western flower thrips but, it reduced the overall population by affecting the feeding intensity and egg laying in western flower thrips.

Reddy *et al*. (2021) undertook a field experiment at Agricultural Engineering College and Research Institute, Kumulur, Tamil Nadu with the objectives to test the performance of different cladding (blue and white colour polyethylene) and plastic mulches (silver on black colour) on the growth and yield of cucumber *(Cucumis sativus* L. Fadia F1 hybrid). Further they reported that, among the plastic mulch and without mulch treatments, the plastic mulch showed negative results under polyhouse cultivation whereas, positive results on growth and yield parameters at open condition (control).

Priyanka *et al*. (2022) conducted a field trial to study the efficacy of newer insecticides on sucking insect pests of groundnut at Regional Agricultural Research Station, Palem, Nagarkurnool district, Telangana, India during rabi 2021-22. Amongst all the insecticidal treatments, clothianidin @ 0.3 g L^{-1} worked very effectively in reducing the population of thrips. The other effective treatments were afidopyropen @ 2 ml L^{-1} followed by tolfenpyard 15 EC @ 2.5 ml L^{-1}, thiamethoxam + lambda cyhalothrin @ 0.4 ml L^{-1}.

2.4 Bioefficacy of different treatments against fruit flies on cucumber

Stark *et al*. (1990) noted that, adult emergence was completely inhibited at 14 ppm concentration of azadirachtin for *Ciratitis capitata* (Wiedemann) and *B. dorsalis*. However, *B. cucurbitae* was significantly more susceptible to azadirachtin @ 10 ppm than *C. capitata* and *B. dorsalis*.

Kumar and Agarwal (2005) carried out field trials during the year 2001 and 2002 to evaluate efficacy of different combinations of baits, attractant and insecticide in annihilation of males of melon fly, *Bactrocera cucurbitae*. Maximum numbers of malesof *B. cucurbitae* were trapped in the month of November during first year and in the month ofJune in the second year. The formulation consisting of soya powder (2 g) + cue-lure (1 ml) + malathion 50 EC (1 ml) was found most effective in annihilation of male flies of *B. cucurbitae.*

Verma and Nath (2006) carried out a research work on different aspects of management of fruit flies through trapping. Various trapping strategies *viz.* bait sprays, traps and lures had been discussed along with the bait composition used by different workers. The baits offered an effective method of fruit fly control especially in the pre-oviposition stage.

Uchida *et al.* (2006) reported that, in an area wide male annihilation test (5.2 km^2 plot) for 60 days using cue-lure in Hawaii, over 99 per cent of melon fly *B. cucurbitae* males were reduced.

Nath *et al.* (2007) revealed that, NSE 5 per cent, bait spray (Malathion 50 ml + molasses 500 g + water 50 L) and cypermethrin applied one after another as per schedule resulted in minimum fruit damage by fruit fly whereas, the control plots exhibitedmaximum damage in bottle gourd fruits.

Oke (2008) verified and assessed two insecticides v*iz.* Deltamethrin and lambda cyhalothrin for the control of *Bactrocera cucurbitae* on cucumber and found that, both the insecticides were effective against this pest. However, lambda cyhalothrin was found tobe better in respect of reducing the oviposition marks and number of pupae than that of deltamethrin.

Khalid (2009) tested neem oil and neem seed water extract at all concentrations (1.00, 1.50 and 2.00 % and 1.00, 2.00 and 3.00 %, respectively) in the field trials to reducethe fruit fly infestation and recorded significantly a smaller number of pupae in the treated plots as compared to control. The effect of both neem derivatives was dose dependent.

Sharma and Sinha (2009) assessed total of six insecticides *viz.* Alphamethrin, cypermethrin, endosulfan, spinosad, emamectin benzoate and neembaan against *B. cucurbitae* on bitter gourd during *kharif* 2007. Further they revealed that, alphamethrin @ 20 g a.i./ha was most effective and resulted in 5.52 per cent damage as compared to 15.14 per cent in control. Emamectin benzoate @ 15 g a.i. /ha and neembaan @ 1ml/L too were also found effective.

Waseem *et al*. (2009) evaluated the efficacy of different chemicals against *B. cucurbitae* in cucumber variety "Dharwad green". The treatments *i.e.* Spinosad 45 SC and imidacloprid 17.8 SL recorded 4.00 per cent and 5.67 per cent damage, respectively and wereon par with Nimbex (0.15 %). The highest per cent fruit damage was recorded in untreated check (43.67 %). Moreover, the treatments with indoxacarb 14.5 SC, emamectin benzoate 5 SG and diafenthiuron 50 WP recorded fruit damage of 17.67, 19.67 and 32.67 per cent, respectively and all the treatments were at par.

Khan *et al.* (2010) carried out research on methyl eugenol and cue-lure where they did evaluation for monitoring population of melon fruit fly during 2007 in Faisalabadand Sahiwal districts. The experiment showed that, cue-lure traps appeared as more effective and resulted in higher male catches of fruit flies (171.82 fruit flies/ trap/week) as compared to methyl eugenol traps (81.69 fruit flies/trap/week).

Sawai *et al*. (2014) evaluated relative efficacy of different insecticides under field conditions. The cumulative pooled data of the year 2011 and 2012 pertaining to fruit damage by fruit fly revealed that, treatment deltamethrin (0.0016 %) recorded significantly lowest fruit damage (20.15 %) and it was statistically at par with the treatments with DDVP (0.05 %), emamectin benzoate (0.0016 %) and azadirachtin (0.0025 %) with 22.83, 24.05 and 24.79 per cent fruit damage, respectively.

Ranganath *et al.* (2015) conducted a field experiment during 2010-11, 2011- 12 and 2012-13 at Indian Institute of Horticultural Research, Bengaluru to evaluate the efficacy of chemicals, botanical neem soap and bait sprays consisting of jaggery @ 15 g/L mixed with deltamethrin @ 1 ml/L and deployment of cuelure traps @ 15/acre against melon fly. Bait spray treatment coupled with sanitation and cue lure traps recorded lowest fruit damage (14.38 %) with a yield of 24.1 t/ha. The rest of the treatments showed significantly higher damage and lower yield as compared to bait sprays.

Balikai and Mallapur (2017) conducted a field experiment for two consecutive rabi/summer seasons of 2009-10 and 2010-11 in the farmers fields in Kalaghatagi village in Dharwad district, Karnataka, India to evaluate flubendiamide against gherkin fruit borer, *Diaphania indica* (Saunders). Results revealed that, three sprays of flubendiamide 480 SC @ 60 g a.i./ha and indoxacarb 14.5 SL @ 21.75 g a.i./ha afforded highest protection against fruitborer with 91.3 and 90.5 per cent during first season and 89.1 and 87.0 per cent duringsecond season, respectively over untreated check and produced higher marketable fruit yield of 10.45 and 10.24 t/ha during first season and 9.65 and 9.52 t/ha during second season, respectively and were significantly superior over rest of the insecticidal treatments.

Vinutha and Kotikal (2018) conducted a field experiment to study the bio efficacy of some botanicals, insecticides and plant extracts against fruit fly, *Bactocera cucurbitae* on oriental pickling melon. The results indicated that, the molecules *viz.* Deltamethrin 2.8 % EC @ 0.5 ml/L, azadirachtin 10000 ppm @ 1ml/L, NSE 4 % @ 40 ml/L and indoxacarb 15.8 EC @ 0.3 ml/L of water were found very effective in minimizing the fly population and were superior in reducing the fruit damage and also fetched higher yields of 18.33, 18.16 18.2 and 18.2 t/ha, respectively throughout experimental period.

Divya *et al.* (2019) conducted an experiment to assess effectiveness of different combination of traps and lure in trapping melon fruit fly and then found out that when the traps are placed at 10 m distance for each replication was effective. The mean of overall captured of *B. cucurbitae* in jar trap + cue lure + methyl eugenol combination was significantly greater than all the other treatments.

Kaur *et al*. (2020) conducted an experiment at Entomological Research Farm, PAU, Punjab during 2017 and 2018, to screen out effective insecticide *i.e*. Belt Expert 480 SC (flubendiamide 19.92 % + thiacloprid 19.92 % SC) against thrips and fruit fly on cucumber. Results revealed that, Belt Expert 480 SC @ 200 and 250 ml/ha was found effective in controlling both insects (thrips and fruit fly) at same time. New molecule has no phytotoxicity on cucumber plants and gave high yield to the producers.

Sakar *et al*. (2020) conducted an experiment at 'C' unit Farm, BCKV, Kalyani, West Bengal on okra to study the bioefficacy of flubendiamide 90 % + deltamethrin 60 % w/v against the fruit borer and its effect on natural enemies during the pre *kharif* season of 2017 and 2018. Three doses of flubendiamide 90% + deltamethrin 60% SC @ 250, 300 and 400 ml/ha along with some other insecticides were sprayed to work out their efficacy against this menace of okra fruit borer. The study revealed that flubendiamide 90 % + deltamethrin 60 % SC @ 400 ml/ha was the most effective for controlling fruit borer and recorded the highest yield during both years.

Parkash *et al.* (2021) conducted a study to test comparative efficacy of different insecticides along with botanicals against fruit fly on cucurbit crop. Further they found that, malathion 50 EC (1 ml/l) in addition with jaggery (3 g/l) was highly efficient with highest fruit yield (233.42 q/ha) and minimum fruit infestation after two sprays (19.53 %). Nimbecidine and NSE (10 %) were statistically at par and observed as the second best effective treatments with fruit infestation of 27.41 and 27.79 %, respectively. NSE (5 %), *Beauveria bassiana* and *Metarhizum anisopliae* were also effective to certain extent with 50.59, 47.31 and 41.85 per cent reduction in fruit infestation over untreated control, respectively.

Subedi *et al*. (2021) conducted an experiment to evaluate the effect of net house and mulching on incidence of *B. cucurbitae* infesting cucumber during June to August 2017in Rampur, Chitwan, Nepal. The net house with black mulching treatment totally restricted the adult cucurbit fruit fly to enter in the cucumber field. The lowest cucumber fruit fly population was recorded in deltamethrin 1 % EC + trizophos 35 % EC @ 2 ml/L treated plot along with black mulch. The highest marketable yield was recorded inside the net house with black plastic mulch (59.08 mt ha^{-1}) followed by reflective plastic mulch (42.95 mt ha^{-1}). Fruit fly damage was not recorded in net house with black mulch (0.00 %) followed by black mulch with deltamethrin + triazophos treated plot (3.46 %).

Bade *et al*. (2022) carried out an experiment to test bioefficacy of nine test insecticides and biopesticides along with untreated check against *B. cucurbitae* on cucumber at PG Research Farm, Department of Entomology, Mahatma Phule Krishi Vidyapeeth, Rahuri during *kharif*, 2019 and *kharif*, 2021. On the basis of pooled data of both the years, it was revealed that the lambda cyhalothrin, deltamethrin, emamectin benzoate and spinosad in the descending order of preference were most promising treatments followed by azadirachtin, NSE, acephate, lufenuron followed by *Metarhizium anisopliae*.

Onsongo *et al*. (2022) carried out research to evaluate the pathogenicity of thirteen isolates of *M. anisopliae* and two isolates of *B. bassiana* against melon fly, *Z. cucurbitae* by exposing adults to 0.3 g dry conidia (3×10^9 conidia) of each isolate for 5 min and monitored mortality up to 5 days. *M. anisopliae* ICIPE 69 caused the highest pupal mortality of 74 per cent, with 15 days post-exposure. Horizontal transmission of *M. anisopliae* ICIPE 69 among male and female, *Z. cucurbitae* was confirmed by 59 and 67 % mortality after exposure to infected donor males and females, respectively. *M. anisopliae* ICIPE 69 affected the oviposition, but not hatchability, of infected *Z. cucurbitae* females. *M. anisopliae* ICIPE 69 proved a potential isolate for biopesticide development against *Z. cucurbitae* management in cucurbit production systems.

Solanki *et al.* (2022) conducted a field experiment during 2018 at Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to evaluate efficacy of insecticides by foliar application against fruit fly, *Bactrocera cucurbitae* in cucumber. Amongst the different treatments, the least fruit damage at 10 and 14 days after second spray was observed with flubendiamide 480 SC @ 0.3 ml/L+ jaggery 5 kg/ ha. The maximum fruit yield (48.29 q/ ha) was obtained with foliar application of flubendiamide 480 SC @ 0.3 ml/L + jaggery 5 kg/ha.

Yaligar *et al.* (2022) carried out a field experiment to evaluate bioefficacy and phytotoxicity of flubendiamide 90 + deltamethrin 60-150 SC (15 % w/v) against cucumber fruit fly for two seasons. The treatment with flubendiamide 90 + deltamethrin 60- 150 SC @ 22.5 + 15g a. i./ha was found to be the most effective dose in reducing the per centfruit damage and recorded higher fruit yield. Further, it had less impact on natural enemies and did not cause phytotoxicity to cucumber crop.

3. MATERIAL AND METHODS

The present investigation entitled, “Environment friendly management of thrips and fruit flies on cucumber” was undertaken to determine the seasonal dynamics of thrips and fruit flies on cucumber and to develop environment friendly management practices for thrips and fruit flies in cucumber. A field experiment was carried out at Post Graduate Research Farm, Department of Agril. Entomology, Mahatma Phule Krishi Vidyapeeth, Rahuri during summer 2022. The materials used and methods engaged during the research are described below.

3.1 Experimental Site

The field experiments were conducted at PG Research Farm, Department of Agril. Entomology, Mahatma Phule Krishi Vidyapeeth, Rahuri during summer 2022. The geographical situation of Rahuri is on 19.38 ^{0}N latitude and 74.65 ^{0}N longitude with an elevation of 511 meters above mean sea level.

3.2 Climatic Conditions

Rahuri’s rainfall was found to vary with a mean annual rainfall of 611 mm scattered over a four to five months period and with two peaks in the month of July and September. The temperature and relative humidity ranges from 14 to 40^{0}C and 21 to 92 per cent, respectively.

3.3 Cultural Operations

3.3.1 Land Preparation

The field was uniformly prepared by a deep ploughing followed by inter cross harrowing. The soil was qualified with well decomposed farm yard manure (FYM) @ 20 t /ha and then mixed with harrowing. After that, clean-up campaign was done by picking stubbles and debris of earlier crop.

3.3.2 Fertilizer Application

To provide the crop with its nutritional requirement nitrogen, phosphorous and potash were applied in the form of urea, single super phosphate and murate of potash, respectively. The fertilizer dose of 100:50:50 kg NPK/ha was applied. Half dose of nitrogen, full dose of phosphorous and potash was applied as a basal dose and other half dose of nitrogen was applied as a top dressing at 40 days after sowing.

3.3.3 Intercultural Operations

Weeding and hoeings were carried out to enhance the seedling growth, soil moisture conservation and soil aeration.

3.3.4 Irrigation

The irrigations were given on a regular basis in the experimental field plots as per the crop requirement.

3.4 Seasonal dynamics of thrips, *T. tabaci* and fruit flies, *B. cucurbitae* in cucumber during summer 2022

In order to study the seasonal dynamics of thrips and fruit flies in cucumber, an experiment was carried out during summer 2022 at PG Research Farm, Department of Agril. Entomology, MPKV, Rahuri. The crop was sown in 100 m^2 with the spacing of 1.5 m x 0.5 m. The crop was raised by following standard recommended agronomical practices but without use of any insecticidal spray application.

3.4.1 Method of Recording Observations

A. Thrips, *T. tabaci*

Observations on number of thrips were recorded from five randomly selected and tagged plants. Total number of thrips were recorded from three leaves of each randomly selected and tagged plant and then converted to number of thrips/plant. The observations were recorded at weekly interval starting from first appearance of pest and continued till harvest of the crop.

B. Fruit flies, *B. cucurbitae*

The study was carried out by installing pheromone traps (Cue-lure traps) @ 20/ha in the experimental plot. Number of adult flies trapped were recorded from each trap. The observations were recorded at weekly interval.

3.5 Observations on Meteorological Parameters

Different meteorological parameters *viz.* maximum and minimum temperature (°C), morning and evening relative humidity (%), bright sunshine hours (hr/day) and rainfall (mm) were taken into account to workout correlation study. Data on meteorological parameters were obtained from the meteorological observatory located at Central Campus, MPKV, Rahuri. Then correlation coefficient between various climatic factors and incidence of thrips and fruitflies was worked out by using standard statistical procedure (Steel and Torrie, 1980)

3.6 Environment Friendly Management Practices for Thrips and Fruit flies on Cucumber

3.6.1 Material

A. Seeds

Cucumber seeds of var. Gypsy+ (M/s. Namdeo Umaji Agritech India Pvt. Ltd) was purchased from local market to conduct the experiment. To achieve the tilth, the experimental site was ploughed and harrowed couple of times. The plots were laid out according to the experimental design. Seeds were sown at a spacing of 1.5 m x 0.5 m. Gap filling was done as per requirement to ensure uniform plant stand in each treatment plot.

B. Insecticides

Chemical insecticides required to conduct the field experiment were made available by the Department of Agril. Entomology, PGI, MPKV, Rahuri. Biopesticides required to conduct the field experiment were obtained from Biocontrol Laboratory, Department of Agricultural Entomology, MPKV, Rahuri.

Table 3.1. Details of different insecticides and biopesticides used in experiment

Sr. No.	Common name and formulation of insecticide/biopesticide	Trade name	Source
1.	Cue lures	Melon fly lure	Rev Agro Services Pvt Ltd., Nashik
2.	*Metarhizium anisopliae* 1.15 WP	Phule Metarhizium	Biocontrol Laboratory, Department of Agril. Entomology, MPKV, Rahuri
3.	Azadirachtin 300 ppm	Nimbecidine	M/s. T. Stanes and Company Ltd., Mumbai
4.	Tolfenpyrad 15 EC	Keefun	M/s. PI Industries Pvt Ltd., Gujrat
5.	Flubendiamide 8.33 % + Deltamethrin 5.56 % w/w SC	Fenos Quick	M/s. Bayer Crop Science Ltd., Mumbai

C. Equipments

Different equipments including high volume knapsack sprayer, weighing balance, measuring cylinder, magnifying lens and other materials like labels, threads and iron pegs were obtained from Department of Agril. Entomology, PGI, MPKV, Rahuri to conduct the field experiments.

3.7 Experiment Details

1	Crop	Cucumber
2	Variety	Gypsy+
3	Season	Summer 2022
4	Date of sowing	02/02/2022
5	Design	Randomized Block Design
6	No. of treatments	11
7	Replications	3
8	Plot size	4.0 X 3.0 m^2
9	Spacing	1.5 m X 0.5 m
10	Type of bed	Ridges and furrows
11	No. and date of spraying	Two, 30/3/2022 and 10/4/2022
12	Equipment	High volume knapsack sprayer
13	Spray fluid used	500 lit. water/ha
14	Date of pickings	29/3/2022, 04/04/2022, 09/04/2022, 15/04/2022, 21/04/2022

Table 3.2. Treatment Details

Tr. No.	Treatments	Dose (g or ml)
T_1	Cue lure traps @ 20/ha	-
T_2	Azadirachtin 300 ppm	5 ml/L
T_3	Soil application of *M. anisopliae* 1.15 WP (Mixed with 25 Kg FYM)	5 kg/ha
T_4	Mulching with polythene sheet of 25 µ size	-
T_5	Cue lure traps @ 20/ha + Azadirachtin 300 ppm @ 5ml/l	-
T_6	Soil application of *M. anisopliae* 1.15 WP (5 kg/ha) + Cue lure traps @ 20/ha + Azadirachtin 300 ppm @ 5ml/l	-
T_7	Mulching with polythene sheet of 25 µ size + Cue lure traps @ 20/ha + Azadirachtin 300 ppm @ 5ml/l	-
T_8	Tolfenpyrad 15 EC @ 150 g a.i/ha	2 ml/L
T_9	Flubendiamide 8.33 % + Deltamethrin 5.56 % w/w SC @ 250 g a.i/ha	0.5 ml/L
T_{10}	Water spray @ 500 lit/ha	-
T_{11}	Untreated control	-

3.7.1 Preparation of Spray

The insecticidal spray solution for the experimental site was freshly made every timejust before commencement of the spraying activity.

Desired concentration of spray fluid was worked out by using following formula.

$$V = \frac{100}{a.i.} \times \text{recommended dose (g a.i./ha)}$$

Where,

V = Quantity of insecticide/ biopesticide required for spraying per hectare

a.i. = Active ingredient in commercial product

The appropriate amount of insecticides were completely mixed with the water according to spray concentration at the time of spraying and the solution was used for spraying.

3.7.2 Spraying Procedure

Spraying was carried out with the help of high volume knapsack sprayer during the morning hours between 7.00 to 9.00 am. The plots were sprayed according to treatments given. During spraying, required dose of different insecticides in the sprayer were constantly swirled. After application of each treatment, the equipment was washed out with fresh water andthen used for application of next treatment. Due care was taken to mitigate migration of spray fluid into adjacent plots.

3.7.3 Method of Recording Observations

3.7.3.1 Thrips, *T. tabaci*

The observations on number of thrips per plant were taken at one day before spray as pre-count and at 3^{rd}, 7^{th}, 10^{th} day after each spray as post count. Five plants were randomly selected from each treatment plot. Thrips population was recorded on three leaves from each randomly selected and tagged plant. The number of thrips per plant in various treatments on 3^{rd}, 7^{th}, 10^{th} day after each spray were worked out for statisticalanalysis. The post treatment observations taken at 10 days after first spray were considered aspre-treatment count for second application.

3.7.3.2 Fruit Fly, *B. cucurbitae*

The observations on per cent fruit damage due to incidence of cucumber fruit fly, *B. cucurbitae* were recorded on number basis at each picking. Per cent fruit damage was worked out and transformed into arcsine values for statistical analysis. The yield of marketable fruits of cucumber were recorded from each treatment plot and worked out on hectare basis.

At plucking, the entire marketable size fruits of the crop irrespective of healthy and infested fruits were plucked and infested and healthy fruits were sorted out to calculateper cent fruit damage as:

$$\text{Per cent fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \times 100$$

3.8 Yield

The data on yield of cucumber fruits from each plot was recorded at the time of each picking and then total yield from the plot (kg/plot) was converted to quintals per hectare.

3.9 Increase in yield

With a view to evaluate the effect of different treatments on cucumber yield, fruits of net plot were harvested. The per cent increase in yield over control was calculated by using formula**:**

$$\text{Yield increased over control (\%)} = \frac{T - C}{C} \times 100$$

Where,

T = Yield of respective treatment (q/ha)

C = Yield of control (q/ha)

3.10 Statistical Analysis

The data on number of thrips per plant was transformed into square root transformation $\sqrt{x + 0.5}$. However, data on per cent fruit damage due to fruit fly was transformed into arcsine transformed values and then subjected to statistical analysis. The standard error (SE) and critical difference (CD) at 5 % level of probability was calculated to determine efficacy of each treatment. The yield data was then subjected to statistical analysis.

4. RESULTS AND DISCUSSION

Present investigation entitled, "Environment friendly management of thrips and fruit flies on cucumber" was carried out at PG Research Farm, Department of Agricultural Entomology, Mahatma Phule Krishi Vidyapeeth, Rahuri during summer 2022. The results obtained are presented as under.

4.1 Seasonal dynamics of thrips and fruit flies in cucumber

4.1.1 Thrips, *T. tabaci*

The data on incidence of thrips on cucumber during summer 2022 is presented in Table 4.1 and graphically depicted in Fig. 4.1.

From the data, it was observed that thrips incidence started from 6th standard meteorological week and lasted upto harvesting of the crop *i.e.* 19th standard meteorologicalweek. Thrips population ranged from 0.34 to 15.22 thrips/plant during the crop growth period.

Minimum population of thrips was noticed during 6th standard meteorological week *i.e.* 2nd week of February and it may be due to less influence of abiotic factors. Afterwards, population of thrips gradually increased upto 13th standard meteorological week *i.e.* last week of March (8.45 thrips/plant) and reached to its peak (15.22 thrips/plant) during 17th standard meteorological week *i.e.* 4th week of April. During this period various meteorological parameters *viz.* Maximum and minimum temperature, morning and evening relative humidity, bright sunshine hours and rainfall were 39.4 ºC and 27.5 ºC, 45 and 17 %, 8.7 hr/day and 0.0 mm, respectively.

Results of the present finding are in close conformity with Kumawat *et al*. (2018) who noticed maximum population of thrips during 13th standard meteorological week. Similarly, the results of the present findings on seasonal incidence of thrips are corroborated with the finding of Vinuthan *et al*. (2018) who also supported the results of the present study.

4.1.2 Fruit fly, *B. cucurbitae*

The data pertaining to incidence of fruit fly on cucumber during summer 2022 ispresented in Table 4.1 and Fig. 4.2.

From the results, it was found that, fruit fly incidence on cucumber started from 6th standard meteorological week and continued till harvesting of the crop *i.e.* 19th standard meteorological week. Fruit fly population varied from 3.0 to 24.0 fruit flies/trap/week during the crop growth period.

Table 4.1. Seasonal dynamics of thrips, *T. tabaci* and fruit fly, *B. cucurbitae* on cucumber during summer 2022

S. M. W.	Number of thrips/plant	Number of fruit flies/trap/ week	Temperature (⁰C)		Relative Humidity (%)		Bright sunshine hour (hr/day)	Rainfall (mm)
			Max.	Min.	Morn.	Even.		
5	0.0	0.0	28.7	12.1	82	24	10.0	0.0
6	0.34	3.0	27.3	13.2	81	33	9.6	0.0
7	2.66	6.0	29.2	14.4	80	30	9.5	0.0
8	3.65	8.0	33.0	16.1	73	23	9.7	0.0
9	3.92	9.0	33.1	18.1	55	21	9.0	0.0
10	5.12	8.0	32.0	19.7	73	30	7.0	0.0
11	6.71	10.0	35.7	21.1	59	18	9.0	2.4
12	7.9	12.0	37.6	22.5	55	16	7.1	0.0
13	8.45	18.0	38.2	22.3	55	14	9.0	0.0
14	8.12	24.0	39.7	23.4	52	12	9.4	0.0
15	10.11	22.0	38.4	24.5	59	17	8.6	0.0
16	12.01	19.0	38.3	24.4	52	16	9.2	0.0
17	15.22	16.0	39.4	27.5	45	17	8.7	0.0
18	8.77	10.0	39.9	26.4	50	17	10.2	0.0
19	1.33	5.0	40.9	28.1	50	21	7.0	0.0

Table 4.2. Correlation of weather parameters with incidence of thrips, *T. tabaci* and fruitfly, *B. cucurbitae* on cucumber during summer 2022

Weather parameters	Correlation coefficient values (r)	
	Mean number of thrips	Fruit fly catches
Maximum temperature (⁰C)	0.636*	0.618*
Minimum temperature (⁰C)	0.649*	0.504^{NS}
Morning relative humidity (%)	-0.665**	-0.554*
Evening relative humidity (%)	-0.700**	-0.784**
Bright sunshine hours (hr)	0.070^{NS}	0.111^{NS}
Rainfall (mm)	-0.001^{NS}	-0.094^{NS}

* 5 % level of significance df = 0.533 (Table value)
** 1 % level of significance df = 0.661 (Table value)

Least number of fruit flies were recorded during 6th standard meteorological week *i.e.* 2nd week of February. Later on, population of fruit flies gradually increased and reached to its maximum during 14th standard meteorological week *i.e.* First week of April (24 fruit flies/trap/week). At highest fruit fly incidence, maximum and minimum temperature, morning and evening relative humidity, bright sunshine hours and rainfall were 39.7 ºC and 23.4 ºC, 52 and 12 %, 9.4 hr/day and 0.0 mm, respectively.

Results of the present finding are in close conformity with Abhilash *et al*. (2017) who noticed maximum population of fruit fly in 9th standard meteorological week. Moreover, the results of present finding on seasonal incidence of fruit fly are corroborated with the findings of Raguvanshi *et al.* (2012) who also reported highest fruit fly activity during 14th standard meteorological week.

4.2 Correlation studies of thrips, *T. tabaci* and fruit fly, *B. cucurbitae* incidence with weather parameters in cucumber during summer 2022

The data pertaining to correlation between incidence of thrips and fruit flies in cucumber with weather parameters is presented in Table 4.2. From the results, it was noticed that thrips incidence had significant positive correlation with maximum temperature (r = 0.636*) and minimum temperature (r = 0.649*). However, highly significant negative correlation was noticed between thrips incidence and morning relative humidity (r = -0.665**) as well as evening relative humidity (r = -0.700**). The correlation coefficient showed non- significant positive correlation between thrips incidence and bright sunshine hours ($r = 0.070^{NS}$) whereas, non-significant negative correlation was noticed between thrips incidence and rainfall ($r = -0.001^{NS}$).

According to Vinuthan *et al*. (2018) increased thrips population was associated with periods of low rainfall, low relative humidity and high temperature. The results of present findings are in line with Kumar *et al*. (2019) who reported significant positive correlation between thrips population and maximum temperature, also non-significant correlation with rainfall whereas, morning and evening relative humidity was found to have highly significant negative relationship. Soni and Dhakad (2016) also reported that, cotton thrips had a significant positive correlation with maximum temperature and significant negative correlation with rainfall, whereas, minimum temperature, morning and evening relative humidity exhibited non-significant positive correlation. All of these investigations are consistent with the present findings.

From the data it was found that, incidence of cucumber fruit fly had significant positive correlation with maximum temperature (r = 0.618*) and non-significant correlation with minimum temperature ($r = 0.504^{NS}$). However, significant negative correlation was found between fruit fly incidence and morning relative humidity (r =-0.554*) whereas, highlysignificant negative correlation was found between fruit fly incidence and evening relative humidity (r = -0.784**). Fruit fly incidence had non-significant positive correlation with bright sunshine hours (r = 0.111^{NS}) non-significant negative correlation with rainfall (r = -0.094^{NS}).

According to Nahid *et al*. (2020) increased fruit fly population was associated with periods of daily mean temperature, low rainfall, low relative humidity. The results of present findings are in line with Meena *et al.* (2019) who reported significant positive correlation between fruit fly population and maximum and minimum temperature whereas, rainfall had non-significant negative correlation. Raguvanshi *et al*. (2012) reported that, fruit fly adult abundance had a significant positive correlation with temperature (maximum and minimum) while relative humidity (morning and evening) had non-significant negative correlation with fruit fly population. Results of the present findings are more or less similar to those.

4.3 Bioefficacy of different treatments against thrips, *T. tabaci* on cucumber during summer 2022

A field experiment was carried out to find out the bioefficacy of different environment friendly treatments against thrips on cucumber. Different treatments *viz.* Cue lure traps @ 20/ha, spraying of azadirachtin 300 ppm @ 5 ml/L, soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha (mixed with 25 kg FYM), mulching with polythene sheet of 25 µ size, combination of $T_1 + T_2$ *i.e.* Cue lure traps + azadirachtin 300 ppm, combination of $T_1 + T_2 + T_3$ *i.e.* Soil application of *M. anisopliae* 1.15 WP mixed with 25 kgFYM + Cue lure traps + azadirachtin 300 ppm, combination of $T_1 + T_2 + T_4$ *i.e.* Cue lure traps + azadirachtin 300 ppm + mulching with polythene sheet of 25µ size, tolfenpyrad 15 EC @ 150 g a.i/ha, flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha, water spray and untreated control were evaluatedfor their efficacy against thrips infesting cucumber during summer 2022. The observations on number of thrips/plant were recorded a day before each spray application as precount and at 3rd, 7th and 10th days after each spray. The post treatment observations taken at 10 days after first spray were considered as pre treatment count for second application.

4.3.1 After first spray

Data on bioefficacy of different treatments against thrips, *T. tabaci* on cucumber after firstspray is presented in Table 4.3 and graphically illustrated in Fig. 4.3.

4.3.1.1 Precount

The precount observations recorded a day before first spray were non significant, indicated that there was uniform incidence of thrips, on cucumber.

Table 4.3. Bioefficacy of different treatments against thrips, *T. tabaci* on cucumber after first spray

Tr. No.	Treatment	Dose (g or ml)	Number of thrips/plant				
			Pre-count	3 DAS**	7 DAS	10 DAS	Mean
T_1	Cue lure traps @ 20/ha	-	14.07 (3.79)*	14.87 (3.92)	15.07 (3.94)	16.44 (4.10)	15.46 (3.99)
T_2	Azadirachtin 300 ppm	5 ml/L.	13.33 (3.72)	7.00 (2.74)	7.47 (2.82)	8.13 (2.94)	7.53 (2.83)
T_3	Soil application of *M. anisopliae* 1.15 WP (Mixed with 25 kg FYM)	5 kg/ha	13.20 (3.70)	8.24 (2.96)	8.80 (3.05)	8.81 (3.05)	8.62 (3.02)
T_4	Mulching with polythene sheet of 25 µ size	-	13.87 (3.79)	8.36 (2.98)	9.07 (3.09)	9.40 (3.15)	8.94 (3.07)
T_5	Cue lure traps @ 20/ha + Azadirachtin 300 ppm @ 5ml/L	-	14.20 (3.83)	7.13 (2.76)	8.00 (2.92)	8.33 (2.97)	7.82 (2.88)
T_6	Soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha + Cue lure traps @ 20/ha + Azadirachtin 300 ppm @ 5ml/L	-	13.93 (3.80)	8.12 (2.94)	8.70 (3.03)	8.73 (3.04)	8.52 (3.00)
T_7	Mulching with polythene sheet of 25 µ size + Cue lure traps @ 20/ha+ Azadirachtin 300 ppm @ 5ml/L	-	13.67 (3.76)	6.87 (2.71)	7.33 (2.80)	8.00 (2.92)	7.40 (2.81)
T_8	Tolfenpyrad 15 EC @ 150 g a.i/ha	2 ml/L.	14.07 (3.82)	6.73 (2.69)	7.13 (2.75)	7.40 (2.80)	7.09 (2.75)
T_9	Flubendiamide 8.33 + Deltamethrin 5.56 SC w/w SC @ 250 g a.i/ha	0.5 ml/L.	13.13 (3.69)	8.02 (2.92)	8.53 (3.00)	8.67 (3.02)	8.41 (2.98)
T_{10}	Water spray @ 500 lit/ha	-	14.40 (3.86)	11.07 (3.39)	12.40 (3.59)	13.73 (3.77)	12.40 (3.59)
T_{11}	Untreated control	-	14.27 (3.84)	15.13 (3.95)	15.93 (4.05)	16.53 (4.13)	15.86 (4.05)
	S.E.(m) ±	-	0.13	0.07	0.08	0.06	0.07
	C.D. at 5%	-	N.S.	0.21	0.24	0.19	0.21

*Figures in the parentheses are ($\sqrt{x + 0.5}$) transformations **DAS- Days after spraying

4.3.1.2 Three days after first spray

From the data it was found that, thrips population varied from 6.73 to 15.13 thrips/plant at 3 days after first spray (Table 4.3). From the results it was noticed that, all the treatments were found to be significantly superior over untreated control and the treatment T1 in reducing thrips population. Amongst the tested treatments, tolfenpyrad 15 EC @ 150 g a.i/ha was found to be most effective treatment against cucumber thrips with minimum thrips population (6.73 thrips/plant). However, it was followed by the treatment T7 (Mulching with polythene sheet of 25 µ size + Cue lure traps+ Azadirachtin 300 ppm) (6.87 thrips/plant), treatment T2 *i.e.* spraying of azadirachtin 300 ppm @ 5ml/L (7.00 thrips/plant) and treatment T5 (Cue lure traps + Azadirachtin 300 ppm) (7.13 thrips/plant) which were at par with each other. Next best treatment was flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha (8.02 thrips/plant) which was followed by the treatment T6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), (Treatment T3 soil application of *M. anisopliae* 1.15 WP @ 5kg/ha) and the treatment consisting mulching with polythene sheet of 25 µ size which recorded 8.12, 8.24 and 8.36 thrips/plant, respectively and were found at par with each other. Moreover, the treatments with water spray (11.07 thrips/plant) and untreated control (15.13 thrips/plant) were the least effective treatment.

4.3.1.3 Seven days after first spray

From the results, it was observed that thrips population ranged from 7.13 to 15.93 thrips/plant at seven days after first spray. All the treatments were significantly superior over untreated control and the treatment with cue lure traps in reducing thrips population. Similar trend of efficacy was also observed at 7 days after first spray. The treatment with tolfenpyrad 15 EC @ 150 g a.i/ha was found to be most effective treatment with minimum number of thrips population (7.13 thrips/plant). However, it was followed by the treatment T_7 (Mulching with polythene sheet of 25 µ size + Cue lure traps+ Azadirachtin 300 ppm) with 7.33 thrips/plant, treatment T_2 *i.e.* spraying of azadirachtin 300 ppm with 7.47 thrips/plant and the treatment T_5 (Cue lure traps + Azadirachtin 300 ppm) with 8.00 thrips/plant and were at par with each other. Next promising treatment was flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha with 8.53 thrips/plant which was followed by treatment T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), (treatment T_3 soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha) and treatment with mulching of polythene sheet of 25 μ size which recorded 8.70, 8.80 and 9.07 thrips/plant, respectively and were found at par with each other. On the other hand the treatment with water spray was found less effective with 12.40 thrips/plant. Highest number of thrips/plant were recorded in untreated control (15.93 thrips/plant).

4.3.1.4 Ten days after first spray

From the results, it was noticed that, thrips population at ten days after first spray varied from 7.40 to 16.53 thrips/plant (Table 4.3). All the treatments were found to be significantly superior over untreated control and the treatment with Cue lure traps @ 20/ha in reducing thrips population. Amongst the tested treatments, tolfenpyrad 15 EC @ 150 g a.i/ha was found to be most effective treatment against cucumber thrips with minimum thrips population of (7.40 thrips/plant). However, it was followed by the treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm) with 8.00 thrips/plant, treatment T_2 *i.e.* spraying of azadirachtin 300 ppm with 8.13 thrips/plant and the treatment T_5 (Cue lure traps+ Azadirachtin 300 ppm) with 8.33 thrips/plant and were found at par with each other. Next best treatment was flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha with 8.67 thrips/plant which was followed by treatment T6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), (treatment T3 soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha) and treatment having mulching with polythene sheet of 25 μ size with 8.73, 8.81 and 9.40 thrips/plant, respectively and were at par with each other. On the other hand treatment containing water spray was the least effective treatment with 13.73 thrips/plant. However untreated control recorded maximum number of thrips/plant at 10 DAS after first spray.

The data on mean number of thrips per plant after first spray revealed that, mean thrips population ranged from 7.09 to 15.86 thrips/plant (Table 4.3). From the results it was revealed that, treatment with tolfenpyrad 15 EC @ 150 g a.i/ha recorded least mean population of thrips (7.09 thrips/plant) and was followed by the treatments T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm), (treatment T_2 spraying of azadirachtin 300 ppm) and treatment T_5 (Cue lure traps + Azadirachtin 300 ppm) with 7.40, 7.53, 7.82 thrips/plant, respectivelyand were at par with each other. The next best treatment was treatment with flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha with 8.41 thrips/plant and was found at par with treatment T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), (treatment T_3 soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha) and (mulching with polythene sheet of 25 μ size) with 8.52, 8.62 and 8.94 thrips/plant, respectively. The water spray was least effective with 12.40 thrips/plant. Whereas untreated control recorded maximum number of thrips (15.86 thrips/plant)

4.3.2 After second spray

Bioefficacy of different treatments against thrips, *T. tabaci* on cucumber after second spray is presented in Table 4.4 and graphically illustrated in Fig. 4.4.

4.3.2.1 Three days after second spray

From the data it was found that, thrips population varied from 2.20 to 16.73 thrips/plant at 3 days after second spray (Table 4.4). From the results it was noticed that, all the treatments were found to be significantly superior over untreated control and the treatment with cue lure traps @ 20/ha in reducing thrips population. Amongst the tested treatments, tolfenpyrad 15 EC @ 150 g a.i/ha was found to be most effective treatment against cucumber thrips with minimum thrips population of 2.20 thrips/plant. However, it was followed by the treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm) with 2.27 thrips/plant, (treatment T_2 azadirachtin 300 ppm @ 5ml/L) with 2.73 thrips/plant and treatment T_5 (Cue lure traps + Azadirachtin 300 ppm) with 3.13 thrips/plant which were at par with each other.Next best treatment was flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha (3.93 thrips/plant) which was followed by the treatment T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), (treatment T_3 soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha) and treatment with mulching with polythene sheet of 25 μ size which recorded 4.07, 4.67 and 5.20 thrips/plant, respectively and were par with each other. Moreover, water spray (11.40 thrips/plant) was the least effective treatment. Untreated control recorded maximum of 16.73 thrips/plant.

Table 4.4. **Bioefficacy of different treatments against thrips, *T. tabaci* on cucumber after second spray**

Tr. No.	Treatment	Dose (g or ml)	Number of thrips/plant			
			3 DAS**	7 DAS	10 DAS	Mean
T_1	Cue lure traps @ 20/ha	-	15.93 (4.05)*	15.40 (3.99)	14.60 (3.88)	15.31 (3.98)
T_2	Azadirachtin 300 ppm	5 ml/L.	2.73 (1.80)	1.08 (1.25)	1.53 (1.42)	1.78 (1.51)
T_3	Soil application of *M. anisopliae* 1.15 WP (Mixed with 25 kg FYM)	5 kg/ha	4.67 (2.27)	2.80 (1.82)	3.33 (1.96)	3.60 (2.02)
T_4	Mulching with polythene sheet of 25 µ size	-	5.20 (2.38)	2.93 (1.84)	3.48 (1.99)	3.87 (2.09)
T_5	Cue lure traps @ 20/ha + Azadirachtin 300 ppm @ 5ml/L	-	3.13 (1.90)	1.20 (1.30)	1.67 (1.47)	2.00 (1.58)
T_6	Soil application of *M. anisopliae* 1.15 WP @ 5kg/ha + Cue lure traps @ 20/ha + Azadirachtin 300 ppm @ 5ml/L	-	4.07 (2.14)	2.13 (1.58)	2.87 (1.82)	3.02 (1.88)
T_7	Mulching with polythene sheet of 25 µ size + Cue lure traps @ 20/ha+ Azadirachtin 300 ppm @ 5ml/L	-	2.27 (1.65)	1.07 (1.24)	1.13 (1.27)	1.49 (1.41)
T_8	Tolfenpyrad 15 EC @ 150 g a.i/ha	2 ml/L.	2.20 (1.64)	0.93 (1.19)	1.07 (1.25)	1.40 (1.38)
T_9	Flubendiamide 8.33 + Deltamethrin 5.56 SC w/w SC @ 250 g a.i/ha	0.5 ml/L.	3.93 (2.11)	1.87 (1.54)	2.47 (1.71)	2.76 (1.80)
T_{10}	Water spray @ 500 lit/ha	-	11.40 (3.44)	10.93 (3.38)	12.27 (3.57)	11.53 (3.47)
T_{11}	Untreated control	-	16.73 (4.15)	15.60 (4.00)	14.93 (3.92)	15.75 (4.03)
	S.E.(m) ±	-	0.09	0.11	0.10	0.10
	C.D. at 5%	-	0.28	0.32	0.30	0.31

*Figures in the parentheses are ($\sqrt{x + 0.5}$) transformations **DAS- Days after spraying

4.3.2.2 Seven days after second spray

From the results, it was observed that thrips population ranged from 0.93 to 15.60 thrips/plant at seven days after second spray (Table 4.4). All the treatments were significantly superior over untreated control and the treatment with cue lure traps in reducing thrips population. Similar trend was observed at 7 days after second spray. The treatment with tolfenpyrad 15 EC @ 150 g a.i/ha was found to be most effective treatment with minimum number of thrips per plant (0.93 thrips/plant). However, it was followed by the treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm) with 1.07 thrips/plant, (treatment T_2 spraying of azadirachtin 300 ppm) with 1.08 thrips/plant and the treatment T_5 (Cue lure traps + Azadirachtin 300 ppm) with 1.20 thrips/plant and were found at par with each other. Next promising treatment was flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha with 1.87 thrips/plantwhich was followed by T6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha and mulching with polythene sheet of 25 μ size which recorded 2.13, 2.80 and 2.93 thrips/plant, respectivelyand were par with each other. On the other hand, the treatment with water spray was found less effective with 10.93 thrips/plant and the untreated control recorded 15.60 thrips/plant.

4.3.2.3 Ten days after second spray

From the results, it was noticed that, number of thrips population at ten days after secondspray ranged from 1.07 to 14.93 thrips/plant. All the treatments were found to be significantly superior over untreated control and the treatment with cue lure traps @ 20/ha in reducing thrips population. Amongst the tested treatments, tolfenpyrad 15 EC @ 150 g a.i/ha was found to be most effective treatment against cucumber thrips with minimum thrips population (1.07 thrips/plant). However, it was followed by the treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm) with 1.13 thrips/plant, (treatment T_2 spraying of azadirachtin 300 ppm) with 1.53 thrips/plant and the treatment T_5 (Cue lure traps + Azadirachtin 300 ppm) with 1.67 thrips/plant and were found at par with each other. Next best treatment was flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha (2.47 thrips/plant) which was followed bytreatment T6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), (treatment T_3 soil application of *M. anisopliae* 1.15 WP @ 5kg/ha) and mulching with polythene sheetof 25 μ size with 2.87, 3.33 and 3.48 thrips/plant, respectively and were at par with each other. Moreover, the treatment containing water spray was the least effective treatment with 12.27 thrips/plant. On the other hand untreated control recorded highest number of thrips per plant (14.93 thrips/plant) at 10 DAS after second spray.

The data on mean number of thrips per plant after the second spray revealed that, mean thrips population ranged from1.40 to 15.75 thrips/plant (Table 4.4). From the results it was revealed that, treatment with tolfenpyrad 15 EC @ 150 g a.i/ha recorded least mean population of thrips (1.40 thrips/plant) and was followed by the treatments T_7 (Mulching withpolythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm), (treatment T_2 azadirachtin 300 ppm) and treatment T_5 (Cue lure traps + Azadirachtin 300 ppm) with 1.49, 1.78, 2.00 thrips/plant, respectivelyand were at par with each other. The next best treatment was treatment with flubendiamide 8.33% + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha (2.76 thrips/plant and was found at par with treatments T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), (treatment T_3 soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha) and mulching with polythene sheet of 25 μ size with 3.02, 3.60 and 3.87 thrips/plant, respectively. The water spray was least effective with 11.53 thrips/plant. Moreover, untreated control recorded highest number of thrips per plant (15.75 thrips/plant).

4.3.3 Pooled Mean

Data pertaining to pooled mean due to bioefficacy of different treatments against thrips, *T. tabaci* on cucumber is presented in Table 4.5 and graphically illustrated in Fig. 4.5.

4.3.3.1 Three days after spray

The data on pooled mean number of thrips after spray revealed that, thrips population varied from 4.47 to 15.93 thrips/plant at 3 days after spray (Table 4.5). From the results it was noticed that, all the treatments were found to be significantly superior over untreated control and the treatment with cue lure traps @ 20/ha in reducing thrips population. Amongst the tested treatments, tolfenpyrad 15 EC @ 150 g a.i/ha was found to be most effective treatment against cucumber thrips with minimum mean number of thrips (4.47 thrips/plant). However, it was followed by the treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps + Azadirachtin 300 ppm) with 4.57 thrips/plant, (treatment T_2 azadirachtin 300 ppm @ 5 ml/ with 4.87 thrips/plant and treatment T_5 (Cue lure traps + Azadirachtin 300 ppm) with 5.13 thrips/plant which were at par with each other. Next best treatment was flubendiamide 8.33 % + deltamethrin 5.56 %

w/w SC @ 250 g a.i/ha (5.70 thrips/plant) which was followed by the treatment T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), (treatment T3 soil application of *M. anisopliae* 1.15 WP @ 5kg/ha and treatment with mulching with polythene sheet of 25 µ size which recorded 5.90, 6.30 and 6.67 thrips/plant, respectively and were found at par with each other.

Table 4.5. Bioefficacy of different treatments against thrips, *T. tabaci* on cucumber (Pooled mean)

Tr. No.	Treatment	Dose (g or ml)	Number of thrips/plant				Mean per cent reduction over control
			3 DAS**	7 DAS	10 DAS	Mean	
T_1	Cue lure traps @ 20/ha	-	15.40 (3.99)	15.23 (3.97)	15.47 (3.99)	15.37 (3.98)	2.78
T_2	Azadirachtin 300 ppm	5 ml/ L.	4.87 (2.32)	4.27 (2.18)	4.83 (2.31)	4.66 (2.27)	70.52
T_3	Soil application of *M. anisopliae* 1.15 WP (Mixed with 25 kg FYM)	5 kg/ ha	6.30 (2.60)	5.73 (2.49)	6.07 (2.56)	6.03 (2.55)	61.85
T_4	Mulching with polythene sheet of 25 µ size	-	6.67 (2.68)	6.02 (2.55)	6.60 (2.66)	6.43 (2.63)	59.32
T_5	Cue lure traps @ 20/ha + Azadirachtin 300 ppm @ 5ml/L	-	5.13 (2.37)	4.60 (2.26)	5.00 (2.64)	4.91 (2.32)	68.94
T_6	Soil application of *M. anisopliae* 1.15 WP @ 5kg/ha + Cue lure traps @ 20/ha+ Azadirachtin 300 ppm @ 5ml/L	-	5.90 (2.53)	5.30 (2.40)	5.80 (2.51)	5.67 (2.48)	64.13
T_7	Mulching with polythene sheet of 25 µ size + Cue lure traps @ 20/ha +Azadirachtin 300 ppm @ 5ml/L	-	4.57 (2.25)	4.20 (2.17)	4.57 (2.25)	4.45 (2.22)	71.85
T_8	Tolfenpyrad 15 EC @ 150 g a.i/ha	2 ml/ L.	4.47 (2.23)	4.03 (2.12)	4.23 (2.17)	4.24 (2.17)	73.18
T_9	Flubendiamide 8.33 + Deltamethrin 5.56 SC w/w SC @ 250 g a.i/ha	0.5 ml/ L.	5.70 (2.49)	5.03 (2.35)	5.57 (2.46)	5.43 (2.43)	65.65
T_{10}	Water spray @ 500 lit/ha	-	11.23 (3.42)	11.67 (3.49)	13.00 (3.67)	11.97 (3.53)	24.28
T_{11}	Untreated control	-	15.93 (4.05)	15.77 (4.03)	15.73 (4.02)	15.81 (4.03)	0.00
	S.E.(m) ±	-	0.08	0.07	0.09	0.08	-
	C.D. at 5%	-	0.25	0.22	0.28	0.25	-

*Figures in the parentheses are ($\sqrt{x + 0.5}$) transformations **DAS- Days after spraying

4.3.3.2 Seven days after spray

From the results, it was observed that mean thrips population ranged from 4.03 to 15.77 thrips/plant at seven days after spray. All the treatments were significantly superior over untreated control and the treatment with cue lure traps in reducing thrips population. Similar trend was observed at 7 days after second spray. The treatment with tolfenpyrad 15 EC @ 150 g a.i/ha was found to be most effective treatment with least mean nuumber of thrips *i.e.* 4.03 thrips/plant. However, it was followed by the treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm) with 4.20 thrips/plant, (treatment T_2 azadirachtin 300 ppm) with 4.27 thrips/plant and the treatment T_5 (Cue lure traps + Azadirachtin 300 ppm) with 4.60 thrips/plant and were found at par with each other. Next promising treatment was flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha with 5.03 thrips/plant which was followed by T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), (treatment T_3 soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha) and mulching with polythene sheet of 25 μ size which recorded 5.30, 5.73 and 6.02 thrips/plant, respectivelyand were found at par with each other. On the other hand, the treatment with water spray was found less effective with 11.67 thrips/plant Highest mean number of thrips recorded from the untreated control with 15.77 thrips/plant.

4.3.3.3 Ten days after spray

From the results, it was noticed that, mean thrips population at ten days after spray ranged from 4.23 to 15.73 thrips/plant. All the treatments were found to be significantly superior over untreated control and the treatment with cue lure traps @ 20/ha in reducing thrips population. Amongst the tested treatments, tolfenpyrad 15 EC @ 150 g a.i/ha was found to be most effective treatment for cucumber thrips with minimum mean thrips population (4.23 thrips/plant). However, it was followed by the treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm) (4.57 thrips/plant), azadirachtin 300 ppm with 4.83 thrips/plant and the treatment T_5 (Cue lure traps+ Azadirachtin 300 ppm) with 5.00 thrips/plant and were found at par with each other. Next best treatment was flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha with 5.57 thrips/plant which was followed bytreatment T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps +

Azadirachtin 300 ppm), soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha and mulching with polythene sheet of 25 µ size with 5.80, 6.07 and 6.60 thrips/plant, respectively and were at par with each other. Moreover, the treatment containing water spray was the least effective treatment with 13.00 thrips/plant.

From the results of the pooled mean efficacy of treatments against thrips on cucumber after spray revealed that, treatment with tolfenpyrad 15 EC @ 150 g a.i/ha recorded least mean population of thrips (4.24 thrips/plant) and was followed by the treatments T_7 (Mulching with polythene sheet of 25 µ size + Cue lure traps+ Azadirachtin 300 ppm), treatment T_2 (azadirachtin 300 ppm) and treatment T_5 (Cue lure traps + Azadirachtin 300 ppm) with 4.45, 4.66, 4.90 thrips/plant, respectively and were at par with each other. The next best treatment against thrips on cucumber was treatment with flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha (5.43 thrips/plant) and was found at par with treatments T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha and mulching with polythene sheet of 25 µ size with 5.67, 6.03 and 6.43 thrips/plant, respectively. The water spray was least effective with 11.97 thrips/plant and untreated control had 15.81 thrips/plant population.

Data on mean per cent reduction over untreated control (Table 4.5) showed that the treatment tolfenpyrad 15 EC @ 150 g a.i/ha recorded highest of 73.18 per cent reduction in average survival population of thrips over untreated control. However, the treatment with treatment T_7(Mulching with polythene sheet of 25 µ size + Cue lure traps+ Azadirachtin 300 ppm), treatment T_2 (azadirachtin 300 ppm), treatment T_5 (Cue lure traps + Azadirachtin 300 ppm), treatment T_9 (flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha), treatment T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), treatment T3 (soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha), treatment T4 (mulching with polythene sheet of 25 µ size), treatment T10 (water spray) and treatment T_1 (cue lure traps) recorded 71.85, 70.52, 68.94, 65.65, 64.13, 61.85, 59.32, 24.28 and 2.78 per cent reduction overuntreated control, respectively. In the current study, tolfenpyrad 15 EC found to be the most effective treatment in reducing thrips population.

The results of the present findings are in conformity with Walunj *et al.* (2015) who reported that, tolfenpyrad 15 EC showed significant least number of thrips population on pomegranate. Shivaleela and Chowdary also reported that, tolfenpyrad 15 EC was highly effective in controlling thrips on cucumber.

According to Lekha *et al.* (2018) tolfenpyrad 15 EC provided a strong cross spectrum management of the sucking pests in brinjal and registered highest mean reduction of thrips. Rajkumar *et al.* (2002) reported that nimbecidine (azadirachtin 300 ppm) was successful in reducing the damage caused by thrips. The present findings are in line with earlierworkers.

4.4 Bioefficacy of different treatments against fruit flies, *B. cucurbitae* on cucumber during summer 2022

A field experiment was carried out to find out the bioefficacy of different treatments against fruit fly, *B. cucurbitae* infesting cucumber. Different treatments *viz.* Cue lure traps @ 20/ha, azadirachtin 300 ppm @ 5 ml/L, soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha (mixed with 25kg FYM), mulching with polythene sheet of 25 μ size, combination of (T_1 + T_2) *i.e.* Cue lure traps + azadirachtin 300 ppm, combination of (T_1 + T_2 + T_3) *i.e.* Cue lure traps + azadirachtin 300 ppm, soil application of *M. anisopliae* 1.15 WP mixed with 25 kg FYM, combination of (T_1 + T_2 + T_4) *i.e.* Cue lure traps + azadirachtin 300 ppm + mulching with polythene sheet of 25 μ size, tolfenpyrad 15 EC @ 150 g a.i/ha, flubendiamide 8.33% + deltamethrin 5.56% w/w SC @ 250 g a.i/ha, water spray and untreated control were evaluated for their efficacy against fruit flies infesting cucumber during summer 2022. The data on per cent fruit damage due to fruit fly on cucumber was recorded at the day of 1st picking as pre count and at 2nd, 3rd, 4th and 5th pickings and presented in Table 4.6 and graphically in Fig.4.6.

4.4.1 First picking

The observations at first picking were taken as pre count and per cent fruit damage due to cucumber fruit fly ranged from 12.17 to 15.33 per cent and was found statistically non-significant, it meant that, the per cent fruit damage due to fruit fly on cucumber was uniform in the field.

4.4.2 Second picking

The data on second picking revealed that, the per cent fruit damage due to cucumber fruit fly varied from 4.73 to 23.09 per cent in various treatments (Table 4.6). All the treatments were found to be significantly superior over untreated control in reducing per cent fruit damage. The treatment with flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha was found to be the most effective treatment with minimum per cent fruit damage of 4.73 per cent and was at par with treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm) with 5.98 per cent fruit damage. The next besttreatments were T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm) with 6.66 per cent fruit damage and it was followed by treatment T_5 (Cue lure traps + Azadirachtin 300 ppm), Cue lure traps @ 20/ha, Azadirachtin 300 ppm @ 5 ml/L with 7.10, 8.33, 8.75 per cent fruit damage, respectively and were at par with each other. The next effective treatment was soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha (11.93 % fruit damage) which was at par with treatment consisted mulching with polythene sheet of 25 μ size and tolfenpyrad 15 EC @ 150 g a.i/ha with 12.94 and 14.13 per cent fruit damage, respectively. The treatment with water spray was found to be least effective with 22.22 per cent fruit damage. However, the untreated control recorded highest per cent fruit damage of 23.09 per cent.

4.4.3 Third picking

From the results, it was found that, per cent fruit damage due to cucumber fruit flyranged from 2.39 to 24.95 per cent at third picking (Table 4.6). All the treatments were found to be significantly superior over untreated control in reducing per cent fruit damage due to cucumberfruit fly. Moreover, the treatment with flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha was found to be the most promising treatment with minimum per cent fruit damage of 2.39 per cent which was followed by the treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm) which recorded 2.41 per cent fruit damage and were at par with each other. However, the next best treatment was T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm) with 4.60 per cent fruit damage and was followed by treatments T_5 (Cue lure traps + Azadirachtin 300 ppm), Cue lure traps @ 20/ha, Azadirachtin 300 ppm @ 5 ml/L with 6.05, 7.20, 7.35 per cent fruit damage, respectively and were at par with each other. The next effective treatment was treatment T3 *i.e.* soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha with 9.95 per cent fruit damage and was found at par with treatment having mulching with polythene sheet of 25 μ size and tolfenpyrad 15 EC @ 150 g a.i/ha with 10.60 and 12.19 per cent fruit damage, respectively. The water spray was found to be least effective treatment with 24.95 per cent fruit infestation. Highest per cent fruit damage was recorded in untreated control (24.95 %).

4.4.4 Fourth picking

The data on fourth picking revealed that, the per cent fruit damage due to cucumber fruit fly varied from 1.45 to 34.33 per cent in various treatments. All the treatments were found to be significantly superior over untreated control in reducing per cent fruit damage by cucumber fruit fly. The treatment with flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha was found to be the most effective treatment with minimum per cent fruit damage of 1.45 per cent and it was found at par with treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm) with 1.59 per cent fruit damage. The next best treatment was treatment T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm) with 4.61 per cent fruit damage and it was followed by treatment T_5 (Cue lure traps + Azadirachtin 300 ppm), Cue lure traps @ 20/ha, Azadirachtin 300 ppm @ 5 ml/L with 5.59, 6.61, 7.12 per cent fruit damage, respectively and were at par with each other. The next effective treatment was soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha with 8.55 per cent fruit damage and was found at par with treatment consisting mulching with polythene sheet of 25 μ size and tolfenpyrad 15 EC @ 150 g a.i/ha with 9.97 and 10.88 per cent fruit damage, respectively. The water spray was found to be least effective treatment with 30.00 per cent fruit infestation. Whereas, the untreated control recorded highest per cent fruit damage of 34.33 per cent.

4.4.5 Fifth picking

From the results, it was found that, per cent fruit damage due to cucumber fruit flyranged from 1.10 to 30.60 per cent at fifth picking. All the treatments were found to besignificantly superior over untreated control in reducing per cent fruit damage due to cucumber fruit fly. Moreover, the treatment with flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha was found to be the most promising treatment with minimum per cent fruit damage of 1.10 per cent which was followed by the treatment T_7 (Mulching with polythene sheet of25 μ size + Cue lure traps+ Azadirachtin 300 ppm) with 1.96 per cent fruit damage and were at par with each other. However, the next best treatment was T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm) with 5.21 per cent fruit damage and was followed by treatments T5 (Cue lure traps + Azadirachtin 300 ppm), Cue lure traps @ 20/ha and Azadirachtin 300 ppm @ 5ml/L with 6.27, 8.40 and 8.59 per cent fruit damage, respectivelyand were at par with each other. The next effective treatment was found to soil application of *M. anisopliae* 1.15 WP @ 5kg/ha (9.70 % fruit damage) and was found at par with treatment having mulching with polythene sheet of 25 μ size and tolfenpyrad 15 EC @ 150 g a.i/ha with 13.37 and 14.00 per cent fruit infestation, respectively. The water spray was found to be least effective treatment with 28.19 per cent fruit infestation. Highest per cent fruit damage was recordedin untreated control (30.60 %).

From the data pertaining to mean efficacy of various treatments against fruit fly on cucumber after five pickings, it was observed that, per cent fruit damage of varied from 3.96 to 25.03 per cent (Table 4.6). All the treatments were found to be significantly superior over untreated control in reducing per cent fruit damage due to cucumber fruit fly. Moreover, the treatment with flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha was found to be the most promising with minimum per cent fruit damage of 3.96 per cent which was followed by the treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps + Azadirachtin 300 ppm) which recorded 5.00 per cent fruit damage and were at par with each other. However, the next best treatment was T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm) with 6.65 per cent fruit damage and was followed by treatment T5 (Cue luretraps + Azadirachtin 300 ppm), Cue lure traps @ 20/ha and Azadirachtin 300 ppm @ 5 ml/L with 7.93, 8.57 and 9.25 per cent fruit damage, respectively and were at par with each other. The next effective treatment soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha with 10.88 per cent fruit damage and was found at par with treatment consisted mulching with polythene sheet of 25μ size and tolfenpyrad 15 EC @ 150 g

Table 4.6. Bioefficacy of different treatments against fruit fly, *B. cucurbitae* on cucumber during summer 2022

Tr. No.	Treatment	Dose (g or ml)	Fruit damage (%)						Mean per cent reduction over control
			Picking 1	Picking 2	Picking 3	Picking 4	Picking 5	Mean	
T_1	Cue lure traps @ 20/ha	-	12.33 (20.53)*	8.33 (16.78)	7.20 (15.56)	6.61 (14.89)	8.40 (16.84)	8.57 (17.02)	65.76
T_2	Azadirachtin 300 ppm	5 ml/L.	14.42 (22.30)	8.75 (17.21)	7.35 (15.72)	7.12 (15.47)	8.59 (17.04)	9.25 (17.71)	63.04
T_3	Soil application of *M. anisopliae* 1.15 WP (Mixed with 25 kg FYM)	5 kg/ha	14.26 (22.13)	11.93 (20.21)	9.95 (18.38)	8.55 (17.00)	9.70 (18.14)	10.88 (19.26)	56.53
T_4	Mulching with polythene sheet of 25 µ size	-	13.61 (21.58)	12.94 (21.08)	10.60 (19.00)	9.97 (18.40)	13.37 (21.44)	12.10 (20.36)	51.65
T_5	Cue lure traps @ 20/ha + Azadirachtin 300 ppm @ 5ml/L	-	14.64 (22.43)	7.10 (15.45)	6.05 (14.24)	5.59 (13.67)	6.27 (14.49)	7.73 (16.35)	69.11
T_6	Soil application of *M. anisopliae* 1.15 WP + Cue lure traps@ 20/ha + Azadirachtin 300 ppm @ 5ml/L	-	12.18 (20.42)	6.66 (14.96)	4.60 (12.38)	4.61 (12.39)	5.21 (13.19)	6.65 (14.94)	73.43
T_7	Mulching with polythene sheet of 25 µ size + Cue lure traps @ 20/ha+ Azadirachtin 300 ppm @ 5ml/L	-	13.07 (21.13)	5.98 (14.15)	2.41 (8.93)	1.59 (7.24)	1.96 (8.04)	5.00 (12.92)	80.02
T_8	Tolfenpyrad 15 EC @ 150 g a.i/ha	2 ml/L.	14.07 (22.03)	14.13 (22.08)	12.19 (20.43)	10.88 (19.25)	14.00 (21.97)	13.05 (21.18)	47.86
T_9	Flubendiamide 8.33 + Deltamethrin 5.56 SC w/w SC @ 250 g a.i/ha	0.5 ml/L.	14.39 (22.22)	4.73 (12.56)	2.39 (8.89)	1.45 (6.92)	1.10 (6.02)	3.96 (11.47)	84.17
T_{10}	Water spray@ 500 lit/ha	-	15.33 (23.05)	22.22 (28.12)	23.27 (28.83)	30.00 (33.21)	28.19 (32.07)	23.80 (29.06)	4.91
T_{11}	Untreated control	-	12.17 (20.33)	23.09 (28.70)	24.95 (29.96)	34.33 (35.87)	30.60 (33.58)	25.03 (30.32)	0.0
	S.E.(m) ±	-	1.05	0.76	1.15	1.12	1.31	1.15	-
	C.D. at 5%	-	NS	2.29	3.47	3.37	3.93	3.45	-

*Figures in the parentheses are arcsine transformed value a.i/ha with 12.10 and 13.05 per cent fruit damage, respectively. The water spray was found to be least effective treatment with 23.80 per cent fruit infestation. Highest per cent fruit damage of 25.03 per cent was recorded in untreated control.

The data on mean per cent reduction over control showed that, the treatment with flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha recorded highest of 84.17 per cent reduction over control in mean per cent fruit damage by cucumber fruit fly over untreated control. However, the treatment T_7 (Mulching with polythene sheet of 25 µ size + Cue lure traps+ Azadirachtin 300 ppm), T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), T_5 (Cue lure traps + Azadirachtin 300 ppm), Cue lure traps @ 20/ha, Azadirachtin 300 ppm @ 5 ml/L, soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha, mulching with polythene sheet of 25 µ size, tolfenpyrad 15 EC @ 150 g a.i/ha and water spray recorded 80.02, 73.43, 69.11, 65.76, 63.04, 56.53, 51.65, 47.86 and 4.91 per cent reduction over control, respectively. In the present study, flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha was found to be the most effective treatment in reducing per cent fruit damage caused by cucumber fruit fly.

The result of present findings are in conformity with Yaligar *et al*. (2022) who reported that, flubendiamide 90 + deltamethrin 60 – 150 SC (15 % w/v) @ 22.5 + 15 g a.i/ha was found to be the most effective dose in reducing per cent fruit damage caused by fruit fly. Divya *et al*. (2019) reported that cue lure traps placed at 10 m distance for each replication and found out that combination of jar trap + cue lure + ME disc was effective in controlling fruit fly.

Srinivas *et al*. (2018) reported that, azadirachtin 300 ppm was able to reduce overall mean per cent fruit infestation in cucumber significantly. Vargas *et al*. (2009) who tested different traps with methyl eugenol and cue lure and observed that *B. cucurbitae* was captured in cue lure traps. The results of present findings are in lines with earlier workers.

4.5 Effect of different treatments on yield of cucumber during summer 2022

The data pertaining to marketable fruit yield of cucumber is presented in Table 4.7 and graphically illustrated in Fig. 4.7. Among the treatments, highest fruit yield of 331.33 q/ha was harvested from plots with treatment T_7 (Mulching with polythene sheet of 25 µ + Cue lure traps + Azadirachtin 300 ppm) followed by T_9 (flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha) and T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm) with 305.00 and 310.00 q/ha, respectively and were at par with each other. Next best treatments were T_5 (Cue lure traps + Azadirachtin 300 ppm), T_8 (tolfenpyrad 15 EC @ 150 g a.i/ha), T_1 (cue lure traps), T_2 (azadirachtin 300 ppm), T_3 (soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha) and T_4 (mulching of polythene sheet of 25 µ) with 300.67, 299.67, 290.00, 285.10, 281.67 and 272.67 q/ha, respectively and were at par with each other. The treatment T_{10} (water spray) recorded 245.33 q/ha and untreated control recorded 240.33 q/ha fruit yield of cucumber.

Table 4.7. Effect of different treatments on yield of cucumber during summer 2022

Tr. No.	Treatment	Dose (g or ml)	Marketable fruit yield (q/ha)	Per cent increase in yield over control
T_1	Cue lure traps	20/ha	290.00	20.66
T_2	Azadirachtin 300 ppm	5 ml/L.	285.10	18.62
T_3	Soil application of *M. anisopliae* 1.15 WP (Mixed with 25 kg FYM)	5 kg/ha	281.67	17.20
T_4	Mulching with polythene sheet of 25 µ size	-	272.67	13.45
T_5	Cue lure traps + Azadirachtin 300 ppm	-	300.67	25.10
T_6	Soil application of *M. anisopliae* 1.15 WP (Mixed with 25 kg FYM) + Cue lure traps + Azadirachtin 300 ppm	-	310.00	28.98
T_7	Mulching with polythene sheet of 25 µ size + Cue lure traps+ Azadirachtin 300 ppm	-	331.33	37.86
T_8	Tolfenpyrad 15 EC @ 150 g a.i/ha	2 ml/L.	299.67	24.69
T_9	Flubendiamide 8.33 + Deltamethrin 5.56 SC w/w SC @ 250 g a.i/ha	0.5 ml/L.	305.00	26.90
T_{10}	Water spray @ 500 lit/ha	-	245.33	2.08
T_{11}	Untreated control	-	240.33	0.00
	S.E.(m) ±	-	8.80	-
	C.D. at 5%	-	26.47	-

5. SUMMARY AND CONCLUSION

Present investigation entitled, "Environment friendly management of thrips and fruit flies on cucumber" was carried out at PG Research Farm, Department of Agricultural Entomology, Mahatma Phule Krishi Vidyapeeth, Rahuri during summer 2022. The results of the studies were summarized and concluded in this chapter.

5.1 Summary

5.1.1 Seasonal dynamics of thrips and fruit flies in cucumber

5.1.1.1 Thrips, *T. tabaci*

Thrips incidence started from 6^{th} standard meteorological week and lasted up to the harvesting of the crop *i.e.* 19^{th} standard meteorological week. Thrips population ranged from 0.34 thrips/plant to 15.22 thrips/plant during the crop growth period. Minimum populationof thrips was noticed in the 6^{th} standard meteorological week *i.e.* 2^{nd} week of February. Afterwards, population of thrips gradually increased upto 13^{th} standard meteorological week *i.e.* Last week of March (8.45 thrips/plant) and reached to its peak (15.22 thrips/plant) during 17^{th} standard meteorological week *i.e.* 4^{th} week of April. During this period various meteorological parameters *viz.* Maximum and minimum temperature, morning and evening relative humidity, bright sunshine hours and rainfall were 39.4 and 27.5 ºC, 45 and 17 per cent, 8.7 hr./day and 0.0 mm, respectively.

From the results it was revealed that, thrips incidence had significant positive correlation with maximum temperature (r = 0.636*) and minimum temperature (r = 0.649*). However, highly significant negative correlation was noticed between thrips incidence and morning relative humidity (r = -0.665**) as well as evening relative humidity (r = -0.700**). The correlation coefficient showed non-significant positive correlation between thrips incidence and bright sunshine hours ($r = 0.070^{NS}$) whereas, non-significant negative correlation was noticed between thrips population and rainfall ($r = -0.001^{NS}$).

5.1.1.2 Fruit fly, *B. cucurbitae*

The fruit fly incidence on cucumber started from 6^{th} standard meteorological week and continued till the harvesting of the crop *i.e.* 19^{th} standard meteorological week. Fruit fly population varied from 3.0 to 24.0 fruit flies/trap/week during the crop growth period. Least number of fruit flies were recorded during 6^{th}

standard meteorological week *i.e.* 2nd week of February. Later on,population of fruit flies gradually increased and reached to its maximum during 14th standard meteorological week *i.e.* first week of April (24 fruit flies/trap). At highest fruit fly incidence, maximum and minimum temperature, morning and evening relative humidity, bright sunshinehours and rainfall were 39.7 and 23.4 ºC, 52 and 12 per cent, 9.4 hr./day and 0.0 mm, respectively.

From the results it was noticed that, incidence of cucumber fruit fly had significant positive correlation with maximum temperature (r = 0.618*) and non-significant correlation with minimum temperature (r = 0.504^{NS}). However, significant negative correlation was found between fruit fly incidence and morning relative humidity (r =-0.554*) whereas highlysignificant negative correlation was found between fruit fly incidence and evening relative humidity (r = -0.784**). Fruit fly incidence had non-significant positive correlation with bright sunshine hours (r = 0.111^{NS}) and non-significant negative correlation with the rainfallparameter (r = -0.094^{NS}).

5.1.2 Bioefficacy of different treatments against thrips, *T. tabaci* on cucumber during summer 2022

From the data pertaining to bioefficacy of different treatments against thrips, *T. tabaci* on cucumber during summer 2022 it was found that, the treatment with tolfenpyrad 15 EC @ 150 g a.i/ha recorded least mean population of thrips (4.24 thrips/plant) and was followed by the treatment T_7 (Mulching with polythene sheet of 25 µ size + Cue lure traps + Azadirachtin 300 ppm), azadirachtin 300 ppm and T_5 (Cue lure traps + Azadirachtin 300 ppm) with 4.45, 4.66 and 4.90 thrips/plant, respectively and were at par with each other. The next best treatment flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha with 5.43 thrips/plant and it wasfound at par with treatment T6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps +Azadirachtin 300 ppm), soil application of *M. anisopliae* 1.15 WP @ 5kg/ha and mulching with polythene sheet of 25 µ size with 5.67, 6.03 and 6.43 thrips/plant, respectively. The water spray was found least effective with 11.97 thrips/plant. Whereas, untreated control recorded maximum of 15.81 thrips/plant.

Data on mean per cent reduction over control showed that treatment with tolfenpyrad 15 EC @ 150 g a.i/ha recorded highest of 73.18 per cent reduction in average survival population of thrips over untreated control. However, the treatment T_7(Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm), azadirachtin 300 ppm, treatment T5 (Cue lure traps + Azadirachtin 300 ppm), flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha, treatment T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), soil application of *M. anisopliae* 1.15 WP @ 5kg/ha, mulching with polythene sheet of 25 μ size, water spray and cue lure trapsrecorded 71.85, 70.52, 68.94, 65.65, 64.13, 61.85, 59.32, 24.28 and 2.78 per cent reduction over untreated control, respectively. In the current study, tolfenpyrad 15 EC found to be the most effective treatment in reducing thrips population.

5.1.3 Bioefficacy of different treatments against fruit flies, *B. cucurbitae* on cucumber during summer 2022

From the data pertaining to bioefficacy of different treatments against fruit flies, *B. cucurbitae* on cucumber during summer 2022 revealed that, treatment with flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha was found to be most promising treatment with least fruit damage of 3.96 per cent which was followed by the treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm) with 5.00 per cent fruit damage and were at par with each other. However, the next best treatment was T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm) with 6.65 per cent fruit damage and was followed by treatment T5 (Cue lure traps + Azadirachtin 300 ppm), Cue lure traps @ 20/ha and Azadirachtin 300 ppm @ 5ml/L with 7.93, 8.57 and 9.25 per cent fruit damage, respectively and were at par with each other. The next effective treatment was found to soil application of *M. anisopliae* 1.15 WP @ 5kg/ha with 10.88 per cent fruit damage and was found at par with treatment consisting of mulching with polythene sheet of 25μ size and tolfenpyrad 15 EC @ 150 g a.i/ha with 12.10 and 13.05 per cent fruit damage, respectively. The water spray was found to be least effective with 23.80 per cent fruit damage. However, highest per cent fruit damage of 25.03 per cent was recorded in untreated control.

The data on mean per cent reduction over control showed that, the treatment with flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha recorded highest of 84.17 per cent reduction over control in mean per cent fruit damage caused by cucumber fruit fly over untreated control. However, the treatment T7 (Mulching with polythene sheet of 25 µ size + Cue lure traps+ Azadirachtin 300 ppm), T6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm), T5 (Cue lure traps + Azadirachtin 300 ppm), Cue lure traps @ 20/ha, Azadirachtin 300 ppm @ 5 ml/L, soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha, mulching with polythene sheet of 25 µ size, tolfenpyrad 15 EC @ 150 g a.i/ha and water spray recorded 80.02, 73.43, 69.11, 65.76, 63.04, 56.53, 51.65, 47.86 and 4.91 per cent reduction over control, respectively.

5.1.4 Effect of different treatments on yield of cucumber during summer 2022

Amongst the various treatments, significantly highest marketable fruit yield of 331.33 q/ha was harvested from the plots treated with the treatment T_7 which was followed by the treatment T_9 (flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha) and T_6 (Soil application of *M. anisopliae* 1.15 WP + Cue lure traps + Azadirachtin 300 ppm) with 305.00 and 310.00 q/ha, respectively and were at par with each other. Next promising treatments were T_5 (Cue lure traps + Azadirachtin 300 ppm), T_8 (tolfenpyrad 15 EC @ 150 g a.i/ha), T_1 (Cue lure traps @ 20/ha), T_2 (Azadirachtin 300 ppm @ 5 ml/L), T_3 (soil application of *M. anisopliae* 1.15 WP @ 5 kg/ha) and T_4 (mulching with polythene sheet of 25 µ size) with 300.67, 299.67, 290.00, 285.10, 281.67 and 272.67 q/ha, respectively and were at par with each other. The treatment with waterspray was found to be least effective treatment with 245.33 q/ha fruit yield of cucumber. On the other hand, untreated control recorded minimum of 240.33 q/ha marketable fruit yield of cucumber.

5.2 Conclusions

From the study it can be concluded that,

1. The thrips incidence started from 6th meteorological week (0.34 thrips/plant) and lasted upto the harvesting of the crop *i.e.* 19th standard meteorological week (1.3 thrips/plant). Highest population of thrips observed during17th standard meteorological week *i.e.*4th week of April (15.22 thrips/plant).

2. From the correlation study it was revealed that, significant positive correlation was noticed between thrips incidence had significant positive correlation with maximum temperature (r = 0.636*) and minimum temperature (r = 0.649*). However, highly significant negative correlation was noticed between thrips incidence and morning relative humidity (r = -0.665**) as well as evening relative humidity (r = -0.700**). The correlation coefficient showed non-significant positive correlation between thrips incidence and bright sunshine hours (r = 0.070NS) whereas, non-significant negative correlation was noticed between thrips population and rainfall (r = -0.001NS).
3. The fruit fly incidence started from 6th standard meteorological week (3 fruit flies/trap) and lasted upto the harvesting of the crop *i.e.* 19th standard meteorological week (5 fruit flies/trap). Highest fruit fly population recorded during 14th standard meteorological week *i.e.* 1st week of April (24 fruit flies/trap).
4. From the correlation study it was revealed that, incidence of cucumber fruit fly had significant positive correlation with maximum temperature (r = 0.618*) and non-significant correlation with minimum temperature (r = 0.504NS). However, significant negative correlation was found between fruit fly incidence and morning relative humidity (r =-0.554*) whereas highly significant negative correlation was found between fruit fly incidence and evening relative humidity (r = -0.784**). Fruit fly incidence had non-significant positive correlation with bright sunshine hours (r = 0.111NS) and non-significant negative correlation with the rainfall parameter (r = -0.094NS).
5. From the bioefficacy study, it was found that, being a chemical insecticide the treatment with tolfenpyrad 15 EC @ 150 g a.i/ha was found promising in reducing thrips population (4.24 thrips/plant). However, the treatment T_7 (Mulching with polythene sheet of 25 μ size + Cue lure traps+ Azadirachtin 300 ppm), with 4.45 thrips/plant, T_2 (Azadirachtin 300 ppm) with 4.66 thrips/plant and treatment T_5 (Cue lure traps + Azadirachtin 300 ppm) with 4.91 thrips/plant were equally effective in reducing thrips population as compared to chemical insecticide *i.e.* tolfenpyrad 15 EC. The treatment tolfenpyrad 15 EC

@ 150 g a.i/ha recorded highest of 73.18 per cent reduction in average survival population of thrips over untreated control.

6. From the bioefficacy study, it was revealed that, being a chemical insecticide the treatment with flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha was found most promising treatment with least per cent fruit damage of 3.96 per cent. However the treatment T_7 (Mulching with polythene sheet of 25 µ size + Cue lure traps+ Azadirachtin 300 ppm) was found equally effective treatment against cucumber fruit fly with 5.00 per cent fruit damage and also obtained highest marketable yield of 331.33 q/ha. The treatment flubendiamide 8.33 % + deltamethrin 5.56 % w/w SC @ 250 g a.i/ha recorded highest of 84.17 per cent reduction over control in mean per cent fruit damage of fruit fly over untreated control.

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7. APPENDIX

Details of meteorological data during summer 2022

S.M.W	Temperature (ºC)		R.H. (%)		Bright Sunshine hour (hr./day)	Rainfall (mm)
	Maximum	Minimum	Morning	Evening		
5	28.7	12.1	82	24	10.0	0.0
6	27.3	13.2	81	33	9.6	0.00
7	29.2	14.4	80	30	9.5	0.00
8	33.0	16.1	73	23	9.7	0.00
9	33.1	18.1	55	21	9.0	0.00
10	32.0	19.7	73	30	7.0	0.00
11	35.7	21.1	59	18	9.0	00.2
12	37.6	22.5	55	16	7.1	0.00
13	38.2	22.3	55	14	9.0	0.00
14	39.7	23.4	52	12	9.4	0.00
15	38.4	24.5	59	17	8.6	0.00
16	38.3	24.4	52	16	9.2	0.00
17	39.4	27.5	45	17	8.7	0.00
18	39.9	26.4	50	17	10.2	0.00
19	40.9	28.1	50	21	7.0	0.00

8. VITAE

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MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL ENTOMOLOGY

2023

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