BIOLOGY, HOST PREFERENCE AND MANAGEMENT OF MELON FRUIT FLY, *Bactrocera cucurbitae* (Coquillett) ON CUCUMBER

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M.Sc. (Agriculture)

DOCTOR OF PHILOSOPHY

IN

AGRICULTURE

(AGRICULTURAL ENTOMOLOGY)

DEPARMENT OF AGRICULTURAL ENTOMOLOGY

COLLEGE OF AGRICULTURE, PARBHANI

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PARBHANI - 431 402 (M.S.) INDIA

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BY

INGALE ANUJA SURESH

M.Sc. (Agriculture)

A thesis submitted to

Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani

In partial fulfilment of the requirement for the degree of

DOCTOR OF PHILOSOPHY

IN

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2022

DECLARATION OF CANDIDATE

I hereby declare that the thesis entitled, **"BIOLOGY, HOST PREFERENCE AND MANAGEMENT OF MELON FRUIT FLY, *Bactrocera cucurbitae* (Coquillett) ON CUCUMBER"** submitted by me is based on the actual work carried out by me under the guidance and supervision of **D. R. Kadam**, Associate Professor, Department of Agricultural Entomology. The extent of information derived from the existing literature have been duly cited and referenced. The existing research work or its any part is not submitted anywhere else for the award of any degree or diploma.

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Place: Parbhani

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AIngale.

(Ingale A. S.)

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ABBREVIATION

AM.	:	*Anti meridian* (Before noon)
Av.	:	Average
Bi	:	Regression coefficient
B_0	:	Intercept
C.D.	:	Critical differences
C.V.	:	Coefficient variance
Cm	:	Centimeter
DAS.	:	Days after spray
et al.,	:	And others
ETL	:	Economic threshold level
Fig	:	Figure
G	:	Gram
Ha	:	Hectare
Hr	:	Hour (s)
i.e.	:	That is
ICBR	:	Incremental Cost Benefit Ratio
Kg	:	Kilogram
L	:	Liter
Ltd.	:	Limited
Max.	:	Maximum
Min.	:	Minimum
Met.	:	Meteorological
kg/ha	:	Kilogram per hectare
Ml	:	Milliliter
Mm	:	Millimeter

No.	:	Number (s)
NS	:	Non-significant
^0C	:	Degree celcious
Res.	:	Research
RBD	:	Randomized Block Design
SE	:	Standard error
PM	:	*Post meridiem* (After noon)
Sci.	:	Science
Univ.	:	University
p/pp	:	Page/pages
Q	:	Quintal
Rs	:	Rupees
RH	:	Relative humidity
SD	:	Standard deviation
SMW	:	Standard Meteorological Week
Sp.	:	Species
Viz.,	:	*Vide licet,* namely
EC	:	Emulsifiable Concentrate
SC	:	Suspension Concentrate
@	:	At the rate
/	:	Per
%	:	Per cent
>	:	More than

THESIS ABSTRACT

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
COLLEGE OF AGRICULTURE,
VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH, PARBHANI

1.	Title of thesis	:	"Biology, host preference and management of melon fruit fly, *Bactrocera cucurbitae* (Coquillett) on cucumber"
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3.	Full name of research guide	:	Dhirajkumar Rajaram Kadam
4.	Department	:	Department of Agricultural Entomology
5.	College	:	College of Agriculture, VNMKV, Parbhani
6.	Degree to be awarded	:	Doctor of Philosophy (Agriculture)

ABSTRACT

The present investigations on biology, host preference and management of melon fruit fly, *Bactrocera cucurbitae* (Coquillett) on cucumber was conducted at Department of Agricultural Entomology, VNMKV, Parbhani during *Summer* 2021 and 2022. The experiments on host preference of melon fruit fly on different hosts under field condition, influence of intercrops on incidence of major insect pests of cucumber, bioefficacy of different combination insecticides against major insect pests of cucumber was conducted in RBD with three replications and eight treatments and host preference and biology of melon fruit fly on different hosts under laboratory condition was carried out in CRD with three replications and eight treatments.

The seasonal incidence of major insect pests of cucumber in relation to weather parameters was carried out throughout the season. On the basis of seasonal incidence of major insect pests during *Summer*, *Kharif* and *Rabi* 2021 revealed that population of pests was more in *Summer* than *Kharif* and *Rabi* due to variation in weather parameters. Further, seasonal incidence of predators *viz*., lady bird beetle and predatory spiders in cucumber was more in *Summer* than *Kharif* and *Rabi*. The predators were present throughout the cropping period when there was more incidence of sucking pests. The correlation studies indicated that the significant correlation was observed between pest population and different weather parameters.

The studies on host preference of melon fruit fly on different hosts carried out under field condition revealed that sponge gourd was the least preferred host with lowest mean per cent fruit infestation (38.08 %) and bitter gourd was the most highly preferred host with maximum per cent fruit infestation (64.48 %).

The host preference of the melon fruit fly with choice test using eight different cucurbitaceous hosts carried out under laboratory conditions revealed that bitter gourd was highly preferred host. The maximum number of eggs (65 ± 1.14), larvae (58 ± 1.13), pupae (52 ± 0.92) and adults (52 ± 0.92) were observed in bitter gourd followed by cucumber, pumpkin, watermelon, muskmelon, ridge gourd, bottle gourd and sponge gourd, respectively. Melon fruit fly was reared on eight different cucurbitaceous hosts under non-choice laboratory condition and the results indicated that bitter gourd was most preferred host of melon fruit fly which formed maximum number of eggs, larvae, pupae and adults followed by cucumber, pumpkin, watermelon, muskmelon, ridge gourd, bottle gourd and sponge gourd, respectively.

The biology of the melon fruit fly on different cucurbitaceous hosts carried out under laboratory conditions revealed that the incubation period of melon fruit fly, *B. cucurbitae* (Coquillett) on different hosts was ranged from 1-2 days. The lowest incubation period recorded on cucumber and pumpkin (1.20 ± 0.45 and 1.20 ± 0.45 days). The maggots developmental period varied from 6.00 to 10.00 days with a mean of 7.00 ± 0.71 to 8.90 ± 0.74 days on different hosts. Significantly shortest mean maggot duration was observed on bitter gourd (7.00 ± 0.71 days). The duration of pre-pupal period ranged from 1.0 - 2.0 days with average duration of 1.10 ± 0.55 to 1.40 ± 0.55 days on different hosts. The mean pre-oviposition period was varied when reared on different hosts. The females had a pre-oviposition period of 7 to 13 days on different hosts. The oviposition period ranged from 1-3 days. The female fly lived for 2 to 5 days after completion of egg laying on all the eight cucurbitaceous hosts. The female lived longer time than the male when reared on all the eight cucurbitaceous hosts. The female longevity varied from 12 to 20 days. The fecundity of females ranged from 62 to 90 eggs. The highest numbers of eggs were laid by female fruit fly on cucumber 87.80 ± 1.92 (85-90 eggs/female). The hatching percentage on different hosts ranged from 62 to 88 per cent. The maximum egg hatching percentage of 80 to 88, (83.80 ± 3.19 %) was recorded on cucumber followed by pumpkin, ridge gourd, watermelon, bitter gourd, bottle gourd and sponge gourd. While, minimum egg hatching *i.e.* 62 to 79 (68.20 ± 6.46 %) was recorded in muskmelon. The highest (male: female) ratio was observed (1:1.31) in cucumber followed by bottle gourd (1:1.24), sponge gourd (1:1.22), pumpkin (1:1.21), bitter gourd (1:1.18), muskmelon (1:1.17), ridge gourd (1:1.12) and watermelon (1:1.12). The longest life cycle was observed on sponge gourd (30.20 ± 1.48 days) followed by bottle gourd (28.00 ± 1.23 days), muskmelon (27.80 ± 1.92 days), pumpkin (27.60 ± 2.07 days), cucumber (27.00 ± 2.17 days), watermelon (26.40 ± 1.67 days), bitter gourd (25.80 ± 2.28 days) and shortest life cycle of male fruit fly observed on ridge gourd (24.60 ± 2.17 days).

The field experiment conducted to find out better intercropping systems for major insect pests of cucumber. All intercrops were superior over sole cucumber for pests population. Cucumber intercropped with spinach followed by chukka, safflower, fenugreek and lettuce, respectively emerged as most suitable intercrops to minimize the incidence of fruit fly. For ecofriendly management of whitefly, cucumber can be intercropped with spinach, chukka and lettuce. The population of thrips was minimum when cucumber was intercropped with spinach, lettuce, coriander, chukka and fenugreek, respectively. The highest count natural enemies *i.e* lady bird beetle and predatory spider was noticed in cucumber + spinach followed by chukka, lettuce, safflower, coriander and fenugreek. The treatment cucumber + chukka had produced significantly highest yield as compared to sole cucumber. Per cent increase in fruit yield over sole cucumber was found to be higher in all the treatments.

Bio-efficacy of different combination insecticides against major insect pests of cucumber indicated that all the insecticides were found to be significantly superior in recording minimum number of melon fruit fly, whitefly and thrips over untreated control. The results revealed that among all insecticide combinations, chlorantraniliprole 8.8% + thiamethoxam 17.5 % SC treated plots showed minimum per cent infestation followed by thiamethoxam 12.6 % + lambda-cyhalothrin 9.5 % ZC and novaluron 5.25 % + indoxacarb 14.5 % SC (25.26 % and 29.14 %) for melon fruit fly on both number and weight basis. Pyriproxyfen 5 % + fenpropatrin 15 % EC followed by thiamethoxam 12.6 % + lambda-cyhalothrin 9.5 % ZC and chlorantraniliprole 8.8 % + thiamethoxam 17.5 % SC were found most effective treatment in reducing whitefly population. Minimum incidence of thrips was found in thiamethoxam 12.6 % + lambda-cyhalothrin 9.5 % ZC which was at par with indoxacarb 14.5 % + acetamiprid 7.7 % SC. The treatment novaluron 5.25 % + emamectin benzoate 0.9 % SC and chlorantraniliprole 8.8 % + thiamethoxam 17.5 % SC proved to be comparatively safer insecticide for lady bird beetle and predatory spider. The treatment thiamethoxam 12.6 % + lambda-cyhalothrin 9.5 % ZC was highly toxic to natural enemies.

The highest fruit yield of cucumber was found in chlorantraniliprole 8.8 % + thiamethoxam 17.5 % SC followed by thiamethoxam 12.6 % + lambda-cyhalothrin 9.5% ZC. The treatment indoxacarb 14.5 % + acetamiprid 7.7 % SC was most economical treatment by recording maximum net monetary returns and highest incremental cost benefit ratio.

(**Keywords**: Seasonal incidence, major insect pests of cucumber, biology of melon fruit fly, host preference, intercrops treatments, bioefficacy, combination insecticides).

CHAPTER I

INTRODUCTION

CHAPTER-I

INTRODUCTION

Cucumber (*Cucumis sativus*) is a widely cultivated crop in the gourd family, Cucurbitaceae. It is a creeping vine that bears cylindrical fruits that are used as culinary vegetables. The cucumber is originally from Southern Asia, but now grows on most continents. It is essentially warm season crop but is successfully grown in tropical subtropical and temperate region with optimum temperature is 26 to 35 ^{0}C.

Cucumber is most commonly used for food, medicinal and industrial purposes. It is either eaten raw or prepared in various forms especially as components of vegetable salad. Cucumber commonly processed into fresh products like pickles, kimchi and salad or as beverages like juice. Cucumber can also be used for beauty purposes such as body scrub and cleansing cream. It contains antioxidants including flavonoids and tannins, which prevent the accumulation of harmful free radicals and may reduce the risk of chronic disease. Also, cucumber is low in calories and composed of about 96 % water, which may increase hydration and help you meet your daily fluid needs and aiding in weight loss (Anonymous, 2010)[1].

Cucumber contains several important vitamins *viz*., vit K (62 %) and vitamin C (14 %) and minerals like Mg (10 %), K (13 %) Mn (12 %) and soluble fiber which may help to prevent constipation and increase regularity. The nutritional composition of cucumber fruit per 100 g edible portion is water (96.30 %), carbohydrate (2.7 %), protein (0.40 %), total fat (0.10 %), fiber (0.40 %), mineral matter (0.4 %) and enrich the diet of people living in the tropical regions (Vimala *et al*., 1999)[2]. Eating cucumbers with the peel provide maximum amount of nutrients. People in India have grown cucumbers for food and medicinal purposes since ancient times and they have long been part of Mediterranean diet (Anonymous, 2019)[3].

In India, due to the wide-range of climatic conditions different types of vegetable and fruit crops are grown. India ranks second in the production of vegetables and fruits next to China. Cucumber crop is grown worldwide and it ranks fourth in the list of economic vegetables in Asia after tomato, cabbage and onion. In 2019-2020, the annual production of cucumber in India was 1638 million tonnes with 111 million ha area under cultivation (Anonymous, 2020)[4].

Cucumber crop is attacked by several insect pests, the major being fruit fly (*Bactrocera cucurbitae* Coquillett), red pumpkin beetle (*Aulacophora foveicollis* Lucas), whitefly (*Bemisia tabaci* Gennadius), aphid (*Aphis gossypii* Glover), thrips (*Thrips palmi* Karny). The pest infestation affects the quality and quantity of the produce adversely and one of the main constraints not attaining higher yields of cucurbits, as they are infested right from early stages of crop growth up to harvesting stage. Besides the direct damage, many pests act as vector for viruses. Most of the insect-pests cause damage at any stage of plant growth, but some of them are serious at seedling stage *viz*., red pumpkin beetle, leaf minor, flea beetle, while fruit fly appears at fruiting stage (at crop maturity) (Ram *et al*., 2009)[5].

Melon fruit fly, *Bactrocera cucurbitae* is a serious pest of pumpkin, bitter gourd, sponge gourd and squash wherein, extensive damage is caused by this pest. Yield losses of 90 per cent to 100 per cent can occur due to this pest in vegetables (Sapkota 2019)[6]. It is native to India.

The female fruit flies puncture the soft, green and tender fruits with ovipositor and lay eggs below the epidermis of fruits about 2 to 4 mm deep. A watery fluid oozes out from the puncture, which becomes slightly concave with seepage of fluid and transforms into a brown resinous deposit. After hatching, maggots bore into the pulpy tissues by making galleries and feeding on it. The fruits then become unfit for human consumption. Pseudo-punctures (punctures without eggs) have also been observed on the skin of fruit and these punctures reduce the market value of the produce (Dhillon *et al*., 2005)[7].

Thrips palmi Karny has been commonly found on cucumber plants. It is very serious pest for many vegetable crops such as cucumber, eggplant, sweet peppers, water melons and many ornamentals. Nymph and adults of *Thrips palmi* feed on the leaves, stems, flowers and fruits of crop, producing many scars and deformities, thereby decreasing yield and marketability. In addition, it also transmits some plant tospo viruses, such as Watermelon silvery mottle virus (WSMoV) and Melon yellow spot virus (MYSV) on cucurbits and Calla lily chlorotic spot virus (CCSV) on calla lily which further increases crop damage and economic losses (Huang and Lin, 2012)[8].

Whitefly sucks the sap from phloem and excreting honeydew, a sugar-rich substrate that promotes the growth of sooty mold (*Capnodium* spp) on harvestable plant parts and leaves. They also damage the plant by transmitting viruses and physiological disorders. *Bemisia tabaci* biotype B transmit Gemini viruses to cucurbits in persistent manner. The Cucurbit leaf crumple virus (CuLCrV) is an important Gemini virus transmitted by *B. tabaci* and during the period of high infestations plant can become stunted and low yield (Liburd *et al*., 2015)[9].

Red pumpkin beetles initiates feeding just after the germination and retard the growth of seedlings due to severe foliar damage. Both the grubs and adults cause damage where the grubs that live underground are destructive to the roots of the crop. The grubs enter into the roots, underground stem and also sometimes the fruits touching the ground. The adult beetles are mainly responsible for damaging the plant parts above the ground resulting in complete defoliation thus sometimes entire field require resowing. The beetles resume its activity in March and remains in the field till October. The peak period of activity is from April to June and the population starts declining from September onwards.

Damage caused by insect pests depends mostly on prevailing climatic conditions and the diversity of hosts in a particular agro ecosystem. Therefore, it is necessary to study the seasonal abundance pattern in relation to weather parameters which helps in determining appropriate time of action and suitable method of management. Monitoring pest population round the year is one of the most important information necessary for formulating IPM strategy to manage insect pests. The present study was aimed to get a preliminary idea about the seasonal incidence pattern of important insect pests and natural enemies associated with cucumber in relation to various weather parameters during three seasons which would be useful in the proper planning of sustainable and timely pest interventions.

The insect's preference on the host plants can affect the development, life table and regeneration of insect and can determine their behavior. The host plant preference of fruit fly species must be studied and observed in order to inform and enable pest management in the field. The present studies were carried out to examine the host preference of melon fruit fly on various cucurbitaceous fruits and study the life history and behavior.

The knowledge of biology and different life stages of insect pests is helpful in developing efficient management strategies that will prevent wasteful use of costly as well as hazardous chemicals. It gains precise knowledge of the morphometrics of the various developmental stages, their duration, adult longevity, preoviposition, oviposition periods, fecundity, ecology, habitat-oriented changes may highly useful to frame out and execute the proper management tactics in time. The management of fruit fly is troublesome because of its characteristics of polyphagous, multivoltine, and adult with high mobility, fecundity and unexposed developmental stages (Sharma *et al.,* 2011)[12]. Hence, considering the importance of host factors on biology of melon fruit fly, morphometric studies were carried out on biology of melon fruit fly on different cucurbitaceous hosts.

From the onset of agricultural modernization, farmers and researchers have been facing many hurdles arising from the homogenization of agricultural systems: an increased vulnerability of crops to insect pests and diseases, insecticide resistance and environmental pollution. The adoption and expansion of monocultures has decreased the abundance and activity of natural enemies by destruction of critical food resources and overwintering sites. For this reason, adoption of suitable intercropping combination is necessary in present time to tackle the agro ecosystems from vulnerable to pest outbreaks and other environmental problems. The successful use of intercropping to manage pests depends on a thorough knowledge of insect ecology and crop characteristics (Seni, 2018)[13]. Intercropping is the cultivation of two or more crops simultaneously in the same field. The science of intercropping based on the principle that the different crops planted are unlikely to share the same insect pests and disease-causing pathogens and may conserve the soil and also get economic benefit to farmers because of continuous returns and reduced cost of inputs. In the present study various intercrops were studied to find out their role in abundance of insect pests in cucumber.

By overuse and misuse of chemical insecticides, the natural balance has been disturbed leading to enormous problems such as resistance, residues, resurgence, destruction of natural enemies *etc*. To combat such situation, simultaneous administration of two or more toxic chemicals in ready-mix formulation has become popular and is available in the market. At present, number new combinations of insecticides are available but less information available about their efficacy against many insect pests of vegetables, hence there is constant need to evaluate newer insecticides combinations against insect pests of cucumber. Hence, keeping the above point of view, the present investigation was undertaken with following objectives.

1. To study the seasonal incidence of major insect pests of cucumber in relation to weather parameters
2. To study the host preference and biology of melon fruit fly on different hosts
3. To study the influence of intercrops on incidence of major insect pests of cucumber
4. To study the bio-efficacy of different combination insecticides against major insect pests of cucumber

CHAPTER II

REVIEW OF LITERATURE

CHAPTER-II

REVIEW OF LITERATURE

2.1 Seasonal incidence of major insect pests of cucumber in relation to weather parameters

2.1.1 Seasonal incidence of melon fruit fly of cucumber in relation to weather parameters

Borah (2001) studied on effect of different sowing dates on incidence of melon fruit fly on cucumber at Assam and showed that the sowing date from 20 April to 20 May recorded significantly lower infestation than sowing from 20 June to 20 July.

Jalaluddin *et al*. (2001) reported that the weekly trap catches were positively and significantly correlated with maximum, minimum temperatures, relative humidity and rainfall indicating that the adult activity was governed by the combined influence of abiotic factors.

Babu *et al*. (2002) conducted study at Bangalore which showed that *B. cucurbitae* increased gradually from 32 to 44 SMW, coinciding with 2nd week of August to last week of October 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).

Ingoley *et al.* (2002) conducted study on the seasonal abundance of *B. cucurbitae* on cucumber in Himachal Pradesh and result revealed that a positive correlation existed between temperature, relative humidity and rainfall and *B. cucurbitae* incidence.

Babu and Viraktamath (2003) observed four species of fruit flies, *B. correcta, B. cucurbitate, B. dorsalis, B. zonata* caught in methyl eugenol traps installed in cucurbit fields during August 2001 to 2002 in Ranebennur, Karnataka. Among these four species *B. cucurbitate, B. dorsalis* were the dominant species comprising 48 and 21 of total catch respectively. The maximum catch of fruit flies occurred during the 14th standard week *i.e*., first fortnight of November.

Abu-Manzar and Srivastava (2004) conducted field experiment on comparative efficacy of cue-lure and methyl eugenol on fruit flies *B. cucurbitae, B. dorsalis* infesting bitter gourd in Kanpur. The peak population was found to be 395.6 fruit flies/trap and 297.3 fruit flies/trap during the 23rd standard week with methyl eugenol trap and cure-lure, respectively during 2002 while peak population was 423.3 fruit flies/trap and 396.3 fruit flies/trap, respectively during 2003 in the 20th standard week.

The activity of melon fruit fly, *B. cucurbitae* was high in April-May, when the weather remained warm (26.2 - 38.0 ^{0}C) and humid (90 % RH) according to Patnaik *et al*. (2004)

Banerji *et al.* (2005) reported that the highest incidence of *B. cucurbitae* on bitter gourd during *Kharif* followed by *Summer* and lowest in *Rabi*. The percent fruit infestation was positively correlated with minimum temperature during *Rabi* and *Summer* seasons.

Krishnakumar *et al*. (2006) conducted field experiment on relative incidence of *B. cucurbitae* and *Dacus ciliates* on cucurbitaceous vegetables. The result noticed that *B. cucurbitae* prevailed throughout the year and maximum number of adults were trapped during August (14.14/trap/week) and trap catches of *B. cucurbitae* were significantly and positively correlated with relative humidity.

Mandal *et al.* (2006) reported that *B. cucurbitae* exhibited significant positive correlation with minimum temperature and relative humidity and non-significant correlation with the maximum temperature.

Nath and Bhusan (2006) revealed that positive correlation between relative humidity, rainfall, temperature and fruit fly population during summer and negative during rainy season.

Singh and Naik (2006) studied on seasonal incidence of *B.cucurbitae* infesting bitter gourd during January to April in the year 2004 at Bhubneswar, Orissa. The result revealed that the lowest pest population observed during January and then gradually increased and attained peak in March, thereafter declined subsequently. The pest population showed positive correlation with maximum temperature but humidity showed negative correlation.

Hasyim *et al.* (2008) reported that the number of flies trapped with cue lure had a positive and highly significant correlation with rainfall and temperature.

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

Kate *et al*. (2009) studied on seasonal incidence of *B. cucurbitae* on cucumber and the result revealed that infestation commenced during 5th week after germination and increased during next four weeks (6th, 7th, 8th and 9th) formed the peak with an infestation of 22.4 per cent and then declined gradually (12.00 per cent) during last week of April (12th week). The correlation studies revealed that the temperature (maximum and minimum) and morning relative humidity had a positive correlation, whereas evening relative humidity had a negative correlation with fruit infestation.

Lutap *et al*. (2009) revealed that the peak population of fruit flies during May - June when monitored using methyl eugenol trap showed reduction in population at the end of monitoring period.

Lashkar and Chatterjee (2010) investigated the incidence pattern of *B. cucurbitae* by trapping melon fly using attractant cue lure in the pumpkin field around the year at the instructional farm Cooch Behar, West Bengal. The results revealed that during warm rainy month *viz*., June, July, August at 25-37 ^{0}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) studied the influence of weather parameters on mixed population of *B. cucurbitae* and *B. tau* infesting cucumber during 2006-2007 at Nauni, Solan, indicated that in the cropping season of 2006, the minimum infestation was observed in 24th SMW, while maximum in 30th SMW. Whereas, during 2007, the minimum 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 significance with minimum temperature. As regarding relative humidity, significant positive correlation was noticed; however, rainfall had non-significant positive correlation.

Raguvanshi *et al.* (2012) recorded the incidence of *B. cucurbitae* with two peaks in *Summer* and *Kharif* during 14th and 43rd standard weeks with trap catches of 127.30 and 115 fruit flies, respectively in bitter gourd. The temperature (maximum and minimum) had significantly positive correlation with abundance, damage and pupal population.

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

Lanjar *et al.* (2013) observed three population peaks of melon fruit flies during first and 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 a field experiment in South Kordofan State, Sudan, particularly in Abugubeiha region to identify fruit fly species which prevailed in the area and infestation levels causes by fruit fly species. The field monitoring of Tephritid fruit fly species using cue-lure as a food attractant revealed the presence of three species, namely mango fruit fly which was the dominant species in the region, melon fly, *Bactrocera cucurbitae* and the Asian fruit fly, *Bactrocera invadens*. Infestation level caused by fruit fly in Abugubeiha area was much higher (67%) in guava the second season and in the first season, the highest recorded level was also in guava (51%) followed by mango (31%) and grapefruit (18%), respectively.

Maharjan *et al*. (2015) studied the population dynamics of cucurbit fruit fly using four different types of traps. The highest number of fruit flies (167.5 male fruit flies/3traps) was recorded in the cue-lure trap during 1st week of September.

Vignesh and Viraktamath (2015) studied population dynamics of melon fruit fly, *Bactrocera cucurbitae* (Coq.) on (*Cucumis sativus* L.) 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. Pooled incidence data of melon fruit fly showed significant positive correlation with minimum temperature (r = 0.388*), morning (r = 0.372*) and evening relative humidity (r = 0.427).

Abhilash *et al*. (2017) conducted studies on monitoring of melon fruit fly in relation to weather parameters in the farmers field at three locations *viz*. Bommankatte, Basavnaganangur and Abbalgere using Barrix cue-lure trap during *Rabi* 2016-17. The result revealed that the initial incidence of the melon fruit fly population begins from the flowering stage of ridge gourd and peak incidence coincides with the peak fruiting period of the crop. At peak fruiting period highest trap catches of 28.40 fruit flies/trap/week were recorded in Mid-March at Abbalgere, However at Bommankatte and Bhasavnagangur peak trap catches of 21.40 and 22.20 fruit flies/trap/week. The incidence of melon fruit fly from three locations showed significant positive correlation with maximum and minimum temperature. Whereas afternoon relative humidity and rainfall had significant negative correlation with melon fruit fly incidence from all three locations. The incidence was influenced to an extent of 83.60, 67.50 and 85.90 per cent from respective location by all the weather parameter together.

Abro *et al.* (2017) conducted field an experiment on population magnitude of the melon fruit fly, in three different cucurbit crops using cue-lure baited traps. The trapping of *B. cucurbitae* was positively correlated with the temperature while negatively correlated with relative humidity.

Das *et al*. (2017) revealed that maximum population of melon fruit fly was observed in the months of May 2014 (17^{th} and 24^{th} May) and showed a higher positive correlation with seasonal average maximum temperature (823**) and positive correlation with minimum temperature (0.123) and morning humidity (0.4). Negative correlation with afternoon humidity (-0726*) and rainfall (-0.54).

Sunil and Jayaran (2017) observed the peak fruit fly infestation during first week of September (52 %) and in last week of February (33 %). The incidence of fruit fly in *Kharif* recorded significant positive correlation with rainfall (r = 0.71) and positively correlated with maximum temperature (r = 0.35) and maximum RH (r = 0.59). During *Rabi*, significant positive correlation with maximum temperature (r = 0.76). Multiple linear regression suggests that incidence of fruit fly on bitter gourd 8 was influenced by 51 per cent by rainfall during *Kharif* and 59 per cent by maximum temperature during *Rabi.*

Sohrab *et al*. (2018) carried out investigation on population fluctuation of cucurbit fruit flies, *B. cucurbitae* associated with cucurbit crops. The population of cucurbit fruit flies, of bitter gourd was found to be very much fluctuating at block Daurala, District Meerut. Negative effect of decreasing temperature was observed in cucurbits fruit flies'population at district Meerut but positive effect of temperature was observed in cucurbit fruit population at district Saharangpur. Fruit flies population on cucurbits fruits increased with increase in relative humidity, rainfall and decreased temperature while negative relationship was observed with maximum correlation in cucurbits in *Zaid* and *Kharif*. Moderate to high negative correlation coefficient were observed between maximum temperature and population fluctuation of cucurbit fruit flies in cucurbits at both places. The significant positive and negative correlation coefficients were present between relative humidity, rainfall and temperature and percentage of fruit flies population.

Tamoghnasaha *et al*. (2018) revealed that melon fruit fly (*B. cucurbitae* Coquillett) showed significant positive correlation with maximum and minimum temperature whereas negative and non-significant correlation with relative humidity and rainfall.

Afroz *et al*. (2019) observed that fruit fly showed the highest level of infestation during 3rd week of December, 3rd week of January and 4th week of February. Relative humidity had insignificant positive correlation with temperature. Temperature, relative humidity and rainfall showed 43.2 per cent contribution on fruit fly abundance and the individual effect of relative humidity was the highest (27.0%).

Meena *et al*. (2019) carried out field experiment on seasonal incidence of fruit fly, *B. cucurbutae* on bottle gourd and their correlation with abiotic factors at agronomy instructional farm, college of agriculture, SKRAU Bikaner, during the *Summer* 2017 and 2018. The peak infestation was recorded in first week of June while maximum and minimum temperature had significant positive correlation with fruit fly infestation. The morning and evening relative humidity had non- significant correlation with the fruit infestation due to fruit fly however rainfall had non-significant negative correlation.

Nehra *et al*. (2019) studied on seasonal incidence of fruit fly, *B. cucurbitae* (Coquillett) on round gourd in relation to abiotic factors. The investigation was carried out at horticultural farm of SKN college of Agriculture, Jobner, Jaipur during *Summer*, 2016. The initial infestation of fruit fly with 8.52 per cent was observed in mid-march *i.e*., 30-35 days after sowing of the crop which increased gradually and reached to its peak, 36.42 per cent in the first week of April and there after it strated declining. During peak period of infestation the maximum and minimum temperature 36.40 ^{0}C and 20 ^{0}C, respectively and relative humidity 38.5 per cent. There was no rainfall observed during study period. The correlation studies revealed that the infestation of fruit flies on round gourd showed significantly positive correlation with maximum and minimum temperature (r=0.6072 and 0.6119 respectively), while significant negative with relative humidity (r=-0.5678).

Nahid *et al*. (2020) studied and monitored seasonal abundance and infestation of fruit fly on cucumber, *Cucumis sativus* using methyl eugenol trap during *Summer* and *Autumn* in 2017 at Gazipur, Bangladesh. The result revealed that fruit fly population in *Summer* and *Autumn* varied from 21-34 and 10-19/trap/4-days respectively. In *Summer*, the highest number of fruit fly catch was recorded on 11th April and the lowest number on 7th April. In *Autumn*, the fruit fly showed the highest abundance on 15th July and lowest on 11th July. The mean abundance in *Summer* and *Autumn* were 26.0±2.5 and 14.2±1.7/trap/4days, respectively. The mean larval population in the infested fruit of *Summer* and *Autumn* were 24.9±7.5 and 1.5±0.5/fruits respectively. The fruit fly showed significantly lower level of infestation in methyl eugenol treated plots as compared to controls in both *Summer* and *Autumn*.

Nair *et al*. (2020) observed seasonal incidence of fruit fly (*Zeugodacus tau*). The study of two-year duration was carried out in cucurbit ecosystem in Tripura from July 2015 to June 2017. Para-pheromone lure (cure-lure) baited traps were used for catching male fruit flies. The population of male fruit flies showed almost similar fluctuation during the study period with two peaks in end of March to April and

September to October. The population of adult males was low (≤ 20 flies/trap/week) during the winter. 5-18 adult male flies per trap were caught from 45th SW of 2015 to 5th SW of 2017. Lowest trap catches (more than 20 flies/trap/week) and 51st SW of 2016 (9 flies/trap/week). Moderate high trap catches more than 20 flies per trap per week. Two peaks were recorded in the study, one in last week of March - April and other one during September - October. The number of fruit flies captured in cue lure baited traps correlated positively with temperature, relative humidity and rainfall. Maximum temperature and minimum temperature have significant influence on *Z. tau* population.

Sen *et al*. (2022) reported that trap catches of *B. cucurbitae* was found maximum which varied in different weeks during February to June at both the locations in 2016 and 2017.

Sarade *et al*. (2021) reported that the maximum fruit infestation by Melon fly was recorded of 56.67 per cent in 5th MW.

2.1.2 Seasonal incidence of sucking insect pests of cucumber in relation to weather parameters

Kajita *et al.* (1996) conducted a field survey to estimate the abundance of thrips on different vegetable crops and result found that *Thrips palmi* Karny attacked ridge gourd, bitter gourd, cucumber, aubergine, goat pepper, muskmelon, pumpkin, squash, watermelon and wax gourd.

Li *el al*. (2011) observed that the family compositae, cruciferae, cucurbitaceae, solanaceae as well as leguminosae were the most preferred species for whitefly, *Bemisia tabaci* and thus large populations were frequently recorded on these species, regardless of the geographical distributions.

Lekshmi *et al.* (2014) revealed that in bitter gourd, higher population of whiteflies was observed when the crop was young and the population declined later. However, aphid population started from the second week of March (seven days after planting) and there were no significant incidence aphids on the crop. Correlation with weather factors indicated that maximum, minimum and average temperature had significant negative correlation on the population buildup of both whitefly and aphid population.

Picault (2014) found that the aphid (*Aphis gossypii)* and thrips (*Thrip tabaci*) could cause severe damage, first on cucurbit vegetables and second on *Allium* crops.

Qureshi *et al.* (2017) monitored on the population fluctuation of insect pests of Indian squash at Government seed farm, Baluchistan and result revealed that Indian squash foliage and fruits were infested by whitefly, squash bug, squash beetle, squash vine borer and fruit fly. The total population of nymph and the adults of whitefly were in the range of 3.54-14.32 averaging 7.92 per leaf and peak population (14.32 /leaf).

Sunil *et al*. (2017) conducted a study on seasonal incidence of sucking pests (aphids, leafhoppers, thrips and whitefly) on bitter gourd and their association with predatory coccinellids beetles during *Kharif* and *Rabi* seasons, 2014-15. The result revealed that mean population of aphid, leafhopper, thrips and whitefly varied from 0.40, 0.65, 0.30 and 0.60 in *Kharif*, 3.86, 1.66,1.50 and 0.48 in *Rabi*.

According to Tamoghnasaha *et al*. (2018) whitefly (*Bemisia tabaci* Gennadius) showed significant positive correlation with maximum and minimum temperature whereas negative and non-significant correlation with relative humidity and rainfall.

Gangurde *et al*. (2021) revealed that the maximum population of *Thrips palmi* (11.37 thrips/leaf), *Bemisia tabaci* (11.43 whitefly/leaf), *Aphis gossypi* (12.90 aphids/leaf), *Amrasca biguttula biguttula* (11.90 jassids/leaf respectively) was observed during 14^{th} SMW, 39^{th} SMW, 40^{th} SMW and 41^{st} SMW. The incidence of thrips, whitefly, aphids and jassids showed non-significant and positive correlation with maximum temperature and non-significant negative correlation with minimum temperature. Sunshine hour plays a major role with non-significant positive influence on the population build-up of sucking pest *viz*., thrips, white fly and jassids.

Sarade *et al*. (2021) conducted field experiment during *Rabi* season of 2017-18 on population dynamics of cucumber revealed that, the whitefly population was recorded in 3^{rd} MW (5 whitefly/leaf).

Sen *et al*. (2022) revealed that the population of whitefly *Bemisia tabaci* was recorded during the month of April, May and June at Sekhampur and Kalyani in 2016 and 2017, respectively.

2.1.3 Seasonal incidence of red pumpkin beetle of cucumber in relation to weather parameters

AL-Ali *et al*. (1982) reported that red pumpkin beetle larvae and adults were most active at a temperature range between 27 to 32 ^{0}C, but they were unable to survive at a temperature exceeding 35.2 ^{0}C.

Roy and Pande (1991) observed that red pumpkin beetle remained active throughout the year, but a negative relationship between the insect population and the two abiotic factors, temperature and rainfall.

Borah (1999) conducted field experiment on the seasonality of red pumpkin beetle on cucumber in Assam and recorded the highest number of beetles in rainy season (June) in all the three varieties (AAUC 1, AAUC 2 and Diphu Local) with 3.6 - 4.2 beetles/plant and 39.2 - 46.6 per cent plant damage followed by *Summer* crop with 2.8 beetles/plant and 33.6 per cent plant damage and winter crop with 2.1 beetles/plant and 21.1 per cent plant damage.

Rajak (2000) reported that overwintering beetles become active during 7th standard week (February) reach maximum population (28.6 beetles/5 plants) during 18th (April) and minimum population (1.66 beetles/5 plants) during 7th (February) standard weeks at an average temperature of 28.8 ^{0}C and 19.0 ^{0}C, respectively and population started declining with gradual increase in temperature. Among the climatic factors temperature has a significant effect and relative humidity non-significant effect on pest population of the overwintering pumpkin beetles.

According to Johri and Johri (2003) the beetle incidence was more during March to September ranging from 27.70 to 47.49 per cent and the lowest of 3.92 per cent in February. The influence of weather factors *viz.,* temperature, humidity and rainfall had a no significant effect on plant infestation by this pest.

Sheikh *et al*. (2013) studied the population dynamics of *Aulacophora foveicollis* Lucas in relation to abiotic factors on cucumber *var.*'Khira-90' during 2009 and 2010. Incidence of red pumpkin beetle in field indicated that its initial activity and peak period varied with the locations and prevailing weather conditions at Palampur, the insect was found active from second forth night of April with three peaks during 2nd and 4th weeks of May and 3rd week of July, 2009 Whereas, one major peak during 2nd week of May was recorded in 2010. At farmers field, Bara (Hamirpur) the insect first appearance was noticed during first fortnight of March and reached to its peak during 3rd and 2nd weeks of April, 2009 and 2010, respectively. The highest plant infestation (100 %) was observed when the crop at its early growing stage. The correlation studies revealed that average minimum temperature showed significant negative correlation at farmer's field whereas other weather parameters had no significant effect on the beetle population at Palampur as well as Bara.

Bisen (2015) conducted a study on population build-up of red pumpkin beetle, *Aulacophora foveicollis* Lucas on ash gourd at Horticultural Research cum Instructional farm, Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The result revealed that the per cent plant infestation was observed to be 10.00 with corresponding infestation index of 0.041 during 36th SMW. The number of plants infested increased gradually with increased of total population of red pumpkin beetle. The total population and per cent population varied from 0.2 to 4.5 insects per plant and 10 to 80 per cent, respectively. Infestation index varied between 0.009 and 0.568 and highest infestation index coinciding with the peak total population of red pumpkin beetle and highest per cent plant infestation.

Kumar and Saini (2018) conducted a field trial on population dynamics of red pumpkin beetle, *Aulacophora foveicollis* (Lucas) on cucumber during *Kharif* 2012 at horticulture farm, RCA, Udaipur. The results revealed that red pumpkin beetle, occurrence began during 35th SMW (27th August to 2th September). The peak population of red pumpkin beetle (4.80 beetles/five plant) was observed during the first week of October, 2012. The population of red pumpkin beetle showed positive correlation with mean temperature but significant negative correlation with mean relative humidity and rainfall.

Shinde *et al*. (2018) carried out field experiment on seasonal incidence of red pumpkin beetle and flea beetle infesting cucumber during *kharif* season of 2017 at central experimental station, Wakawali, Dist. Ratnagiri. The results revealed that the initiation of red pumpkin beetle infestation (2.48) was observed in the 26th SMW (25 June - 01 July). The infestation of red pumpkin beetle was minimum (0.48 ± 1.20) in 37th SMW (10-16 September), while maximum (3.64 ± 1.20) infestation was recorded during 32nd SMW (06-12August).

Red pumpkin beetle (*Aulacophora foveicollis* Lucas) showed significant positive correlation with maximum and minimum temperature whereas negative and non-significant correlation with relative humidity and rainfall Tamoghnasaha *et al*. (2018).

According to Afroz *et al*. (2019) red pumpkin beetle showed the highest level of infestation during 3rd week of December, 3rd week of January and 4th week of February. Relative humidity had significant positive correlation with temperature. The weather parameters jointly contributed 35.2 per cent abundance and red pumpkin beetle and temperature individually depicted the highest effect (18.9%).

Gharde *et al*. (2019) was observed that red pumpkin beetle start infesting the crop from 8th SW with mean population of 6.22/plant.

Pansara *et al*. (2022) studied on population dynamics of red pumpkin beetle, *Aulacophora foveicollis* Lucas on cucumber, *Cucumis sativus* Linneaus during *Summer*, 2020. The result revealed that population of red pumpkin beetle on cucumber initiated from 3rd week of March (11th SMW, 4th WAS) and persisted till 4th week of May (21th SMW, 14th WAS) in the range of 0.13 to 3.30 beetles/plant with an average of 1.49 beetle/plant. The population reached to the first (2.53 beetles/plant) and second as well as the highest (3.30 beetles/plant) peak during 2nd week of April (15th SMW, 8th WAS) and 1st week of May (18th SMW, 11th WAS), respectively. The correlation studies revealed that bright sunshine hrs (r=0.64906*) and evapotranspiration rate (r=0.66310*) significantly positively correlated while, maximum temperature (r=0.72768**) and wind speed (r=0.79715**) showed highly significant and positively associated with the activity of red pumpkin beetle. The other weather parameters had non-significant association with red pumpkin beetle population.

Sen *et al*. (2022) studied on seasonal incidence of important insect's pests of bitter gourd along with natural enemies during spring summer seasons (2016 and 2017) at RRSS, Sekhampur and 'C' Block Farm, Kalyani and result revealed that the population of red pumpkin beetle, *Aulocophora foveicollis*, was recorded during the month of April, May and June at Sekhampur and Kalyani in 2016 and 2017, respectively.

2.1.4 Seasonal incidence of natural enemies of cucumber in relation to weather parameters

Sunil *et al*. (2017) revealed that increased incidence of sucking insect pests led to increased population of predatory coccinellid beetles on bitter gourd. Numbers of predatory beetles and other natural enemies should maintain populations of sucking pests below economic injury level on bitter gourd.

Tamoghnasaha *et al*. (2018) revealed that the natural enemies such as coccinellids and spiders showed significant positive correlation with maximum and minimum temperature, relative humidity and rainfall.

Sen *et al*. (2022) revealed that the population of predatory cocconellids was recorded during the month of April, May and June at Sekhampur and Kalyani in 2016 and 2017, respectively and the incidence of predatory *coccinellids* was positive and significantly correlated with temperature (maximum and minimum) at both locations but at Sekhampur, rainfall and morning relative humidity were also exhibited significant positive association.

2.2 Host preference and biology of melon fruit fly on different hosts

2.2.1 Host preference of melon fruit fly on different hosts under field condition

Singh *et al*. (2000) reported that bitter gourd as the more susceptible and highly preferred host to cucurbit fruit fly among the two hosts *viz*., bitter gourd and watermelon.

Rajpoot *et al*. (2002) revealed that among the various cucurbit crops bitter gourd was most preferred host, muskmelon, round gourd and cucumber were moderately preferred while ridge gourd, bottle gourd and pumpkin were the least preferred host.

Kumar *et al*. (2006) reported that bitter gourd as a highly preferred host with maximum fruit infestation (77.03%) followed by ridge gourd (75.65%) and cucumber (73.83%)

Li-Li *et al*. (2008) observed that cucumber to be more susceptible to oriental fruit fly, *B. dorsalis* than than brinjal and pumpkin.

Vayssieres *et al*. (2008) reported significantly higher fecundity of melon fly on cucumber and pumpkin and lower on squash.

Mwatawala *et al*. (2010) reported cucumber, melon and watermelon as highly preferred cucurbit hosts for *B. cucurbitae.*

Gaine *et al*. (2013) revealed that infestation by cucurbit fruit fly occurred at same level for both in bitter gourd and ridge gourd.

Sarwar *et al*. (2013) studied comparative host preference of fruit fly, *Bactrocera zonata* (Saunder) on mango, peach and apple fruits and *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae) on bitter gourd, brinjal, muskmelon and pumpkin vegetables in the field experiments and revealed that mango was recorded as most preferred host followed by peach and apple, due to the maximum number of pupae formed (173.17), pupae weight (6.40 mg) obtained and emergence of adult fruit flies (84.53%). The bitter gourd was found as most preferred host demonstrating the maximum pupae formation (134.08), pupae weight obtained (4.91 mg) and percent adult emergence (82.64%) of fruit flies. Brinjal was observed as moderately preferred host, while, muskmelon and pumpkin were sorted out as least preferred hosts. These results provide experimental support that flies can respond differently to the host experienced in the field and the hosts that are of advantageous to the pests may be more adapted.

Koswanudin *et al*. (2018) studied comparative host preference for *Bactrocera carambolae* (Drew & Hancock) and *Bactrocera dorsalis* (Drew & Hancock) with regard to malaya varieties of star fruit (*Averrhoa carambolae*), manalagi varieties of mango (*Mangifera indica*), guava aka water apple (*Psidium guajava*), citra water guava (*Eugenia aquae*), jamaicabol guava (*Eugenia malaccenensis*), and california papaya (*Carica papaya*) and results suggest that strongest preference for malaya star fruit by *B. carambolae* followed by manalagi mango; and for california papaya followed by manalagi mango by *B. dorsalis.* The study also found that welahan variety star fruit is least preferred by both species of fruit fly.

2.2.2 Host preference of melon fruit fly on different hosts under laboratory condition

Ullah *et al*. (2008) conducted a comparative study on five different cucurbit species *viz*., squash (*Cucurbita pepo*), bottle gourd (*Lagenaria siceraria*), sweet gourd (*Curcurbita moschata*), bitter gourd (*Momordica charantia*) and snake gourd (*Trichosanthes anguina*). The result showed that the fecundity, oviposition and incubation period was high on squash, sweet gourd and bottle gourd compared to bitter gourd and snake gourd. The mean larval period was longest (8.67 days) on bitter gourd and shortest on squash (7.00 days). The duration of pupal period differed significantly among the hosts and it was highest in squash (8.33 days). Both male and female longevity was highest on squash (45.62 days for male and 48.33 days for female) whereas shortest longevity was recorded on bitter gourd (25.33 days for male and 26.00 days for female). The duration of life cycle of fruit fly was almost double on sweet gourd, bottle gourd or squash compared to other two hosts irrespective of sex. Based on most of the biological attributes, the suitability of five host species for cucurbit fruit fly was ranked as squash > sweet gourd >bottle gourd > snake gourd > bitter gourd.

Shahzadi *et al*. (2019) studied the fruit fly's relative host preference on five vegetables which include bitter gourd, brinjal, cucumber and pumpkin. Vegetables were incubated and egg, larva, pupa and adult were developed in the laboratory under choice and non-choice tests. Length and breadth of all the four developmental stages of fruit fly were measured also the duration of different stages of life cycle of fruit fly was studied. The results showed that in the non-choice test, bitter gourd was most preferred host followed by the pumpkin, brinjal, cucumber and muskmelon. The maximum egg hatched (58 per 500 grams), larva formed (51per 500g), pupa developed (45 per 500 g) and adult developed (41 per 500g) of fruit fly. While in the case of choice test, findings showed that (67.33 per 500g) eggs, (59 per 500 g) larvae, (52 per 500g) pupa, (40per 500g) adult of fruit fly were developed which showed that bitter gourd was most preferred vegetable plant host. The mean length and breadth of different developmental stages of fruit fly showed similar results. The length and breadth of male cucurbit fruit fly on bitter gourd was (8.75 mm) and (12.69 mm), respectively whereas, the female measured (10.2 mm) in length and (16.9 mm) in breadth. Duration of different stages of life cycle of fruit fly exhibited that fruit fly (*B. cucurbitae*) on the bitter gourd host completed its life cycle earlier as compare to other vegetable hosts. The mean pre-oviposition period (11.75 days) and oviposition period (12 days) while, mean mating period (0.084 hours), fecundity (249 eggs/life cycle) and incubation period of eggs varied from (12.5 days) was observed of cucurbit fruit fly in bitter gourd host. Further results concluded that if a favorable host was available with breeding site, then preference shifted towards the suitable host.

Farooq *et al*. (2020) conducted laboratory experiments on evaluation of host susceptibility, preference and offspring performance of *Zeugodacus cucurbitae* (Coquillett) (Diptera: Tephritidae) on different hosts *i.e*., brinjal (*Solanum melongena* L.), bitter gourd (*Momordica charantia* L.), zucchini (*Cucurbita pepo* L.), bottle gourd (*Lagenaria siceraria* [Molina] Standley) and cucumber (*Cucumis sativus* L.). The tested under no choice and free choice condition showed that *C. sativus* and *C. pepo* have highest number of visits/host and oviposition puncture/host. *C. sativus* showed highest pupal recovery and pupal weight in both only or no choice and free choice test. While, highest percentage of emergence and female off springs were observed in *C. pepo* under only choice and free choice scenarios. Furthermore, maximum deformities in progeny were observed in case of *L. siceraria* under both test case scenarios. The current study provides exploratory support that fruit flies respond differently to host species that co-exists in field under choice and no choice test.

2.2.3 Biology of melon fruit fly on different hosts

Mukherjee *et al*. (2007) conducted laboratory experiment on life history and management of cucurbit fruit fly *B. cucurbitae* on sweet gourd and result showed that the mean pre-oviposition, incubation, larval and pupal period were 11.25, 9.75, 0.81, 12.25 and 7.75 days, respectively. The mean longevity of adult male was 18.25 days and the longevity of adult female was 23.50 days. The mean fecundity of a female was 52.75 per female. The average length of eggs, larvae, pupae, adult male and female were 1.48, 10.13, 6.00, 7.50 and 8.75 mm, respectively. Whereas, the mean breadth of eggs, larvae, pupae, adult male and female were 0.48, 3.38, 2.18, 3.25 and 5.50 mm, respectively.

Ullah *et al*. (2008) carried out biology investigation on comparative biology and host suitability of cucurbit fruit fly, *B. cucurbitae* (Coq.) considering squash, bottle gourd, sweet gourd, bitter gourd and snake gourd. Fecundity, oviposition and incubation period was high on squash, sweet gourd and bottle gourd compared to bitter gourd and snake gourd. The mean larval period was longest (8.67 days) on bitter gourd and shortest on squash (7.00 days). The duration of pupal period differed significantly among the hosts and it was highest in squash (8.33days). Both male and female longevity was highest on squash (45.62 days for male and 48.33 days for female) whereas shortest longevity was recorded on bitter gourd (25.33 days for male and 26.00 days for female). The duration of life cycle of fruit fly was almost double on sweet gourd, bottle gourd or squash compared to other two hosts irrespective of sex. Based on most of the biological attributes, the host suitability for cucurbit fruit fly was ranked as squash > sweet gourd > bottle gourd > snake gourd >bitter gourd.

Manzar and Srivastava (2009) conducted laboratory experiments on biology of melon fruit fly *B. cucurbitae* (Coq.) on bitter gourd (*Momordica charantia* L.) and result showed that the total larval periods was 5.9±0.979 and 5.19 ± 0.245 days while, pupal period was 7.3 ± 0.23 and 7.03 ± 0.245 days during both the years in the month of June and July respectively. The average longevity of male was 12.74 ± 2.83 and 13.09 ± 2.37 days whereas, that of female was 15.03 ± 3.14 and 15.56 ± 2.67 days during both the months of year. The total life cycle was 15.5 ± 1.952 and 13.66 ± 2.482 days during 2002 and 2003 in June and July respectively.

Waseem *et al*. (2012) reported that incubation period of egg varied from 24.4 to 38 hours in cucumber.

Laskar (2013) conducted laboratory experiments on biology and biometrics of melon fly, *B. cucurbitae* (Coq). The result revealed that average length and breadth of egg was more or less similar when reared on bitter gourd and pumpkin (1.28 ± 0.059 mm, 0.26 ± 0.057 mm and 1.26 ± 0.060 mm, 0.25 ± 0.053 mm, respectively). The length of mature maggots also does not show much variation on both the hosts whereas weight of mature maggots was found to be slightly higher in bitter gourd as compared to that of pumpkin. Similarly, length and breadth of pre-pupal stage was also noted slightly higher on bitter gourd (6.89 ± 0.46 mm. and 2.04 ± 0.23 mm. respectively) that pumpkin (6.70 ± 0.60 mm. and 1.99 ± 0.22 mm. respectively). In both bitter gourd and pumpkin, size of the females was larger than the males. Fecundity and hatchability were noted very close on bitter gourd (138.40 ± 44.05 and 86.40 ± 7.09 % respectively) and pumpkin (135.60 ± 33.04 and 89.60 ± 6.07% respectively). Sex ratio (male: female) was recorded 1.102 ± 0.136 and 0.976 ± 0.104 on bitter gourd and pumpkin, respectively.

Mir *et al*. (2014) studied biology of melon fruit fly, *B.cucurbitae* (Diptera: Tephritidae) on cucumber and the reported that the freshly laid eggs were glistening white, slightly curved, tapering at one end while rounded at the other end. The mean length and breadth of the egg were found to be 1.13 ± 0.14 mm and 0.28 ± 0.05 mm.

The first and second instars measured 1.49 ± 0.28 mm and 6.40 ± 0.86 mm in length, respectively, and 0.31 ± 0.07 mm and 1.21 ± 0.09 mm in breadth, respectively. The third instar was very mobile and measured 9.62 ± 0.87 mm in length and 2.05 ± 0.32 mm in breadth. The puparium measured 5.72 ± 0.13 mm in length and 2.46 ± 0.11mm in breadth. The length and breadth of male was 8.74 ± 0.32 mm and 11.46 ± 1.16 mm, whereas, the female measured 9.94 ± 0.20 mm in length and 15.92 ± 0.74 mm in breadth. The duration of egg incubation, and the larval, prepupal and pupal periods were 16.8 ± 4.9 hours, and 4.5 ± 1.13, 0.8 ± 0.25 and 8.4 ± 0.51 days, respectively. Pre-oviposition and oviposition periods ranged from 10-15 and 12-28 days respectively. Fecundity varied from 58-92 eggs, while egg viability was 86.1± 0.54. Sex ratio (male: female) was 1.10 ± 0.14. Longevity of adults was extended to 30-52 days for males and 30-60 days for females when fed either water, molasses and honey or water, molasses and proteinex. Lack of access to water led to sudden death of the flies.

Das *et al*. (2017) conducted experiment on seasonal activity weather relations and biology of melon fly *B. cucurbiate* on pumpkin. The result revealed that average length and breadth of egg was 1.30 ± 0.08 and 0.25 ± 0.05 mm, respectively. The incubation period was 1.9 ± 0.65 day. The average length and breadth of first, second, and third instar maggots were 1.57 ± 0.26 and 0.25 ± 0.907, 4.71 ± 0.34 and 0.93 ± 0.31, 8.44 ± 0.88 and 1.57 ± 0.29 mm respectively. The mean duration of corresponding instar was 1.4 ± 0.55, 1.4 ± 0.55 and 3.6 ± 0.55 days respectively. The average length and breadth of pupa was 5.65 ± 0.42 and 2.3 ± 0.18 mm respectively, the pupal period was 6.2 ± 0.45 days. The average length and breadth of male and female were 6.79 ± 0.40 and 13.14 ± 1.05, 8.55 ± 0.71 and 14.95 ± 1.48 mm respectively. The male flies lived shorter (25 ± 8.72) than female (30 ± 10.07) days. Similarly, total life period of male was shorter (39.5 ± 8.82) than female (44.5 ± 10.56) days.

Sharma *et al*. (2017) examined the biology and life history of *Bactrocera cucurbitae* and revealed that a gravid female lays eggs in small clusters about 2-3 mm deep in fruit pulp. The average time period for completion of 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 flies is about 13±2.41 and 15.5±3.49 days respectively. Adults are strong fliers and have characteristic markings on the thorax and abdomen.

Desai *et al*. (2018) studied the biology of melon fruit fly on sponge gourd and stated that eggs were white, slightly curved, elongated and tapered towards both end and the length of egg varied between 1.21 to1.33 mm while width was 0.19 to 0.29 mm.

Patel and Patel (2018) conducted laboratory experiment on comparative biology of melon fruit fly, *Bactrocera cucurbiate* in different cucurbitaceous crops *viz*., bitter gourd, bottle gourd and watermelon. The significant differences were observed in the life cycle of the pest when reared on bitter gourd, bottle gourd and watermelon. The mean incubation period, total larval period, pre pupal period, pupal period, adult male longevity, adult female longevity, fecundity, hatching percentage, sex ratio and total life cycle for male and female were recorded as 1.28 ± 0.458, 6.08 ± 0.493, 1.08 ± 0.277, 5.88 ± 0.600, 10.33 ± 0.617, 15.10 ± 0.738, 32 to 35 eggs, 92.00%, 1: 0.67, 24.80 ± 1.32 and 29.20 ± 1.033 days respectively, for bitter gourd, 1.32 ± 0.476, 8.12 ± 0.332, 1.12 ± 0.332, 7.16 ± 0.374, 12.81 ± 0.655, 17.22 ± 0.833, 42 to 46 eggs, 88.00 %, 1: 0.56, 30.19 ± 0.750 and 35.80 ± 1.814 days respectively, for bottle gourd and 1.36 ± 0.700, 8.08 ± 0.812, 1.08 ± 0.277, 9.40 ± 0.645, 13.11 ± 2.111, 16.86 ± 2.734, 50 to 55 eggs, 80.00 %, 1: 0.39, 32.56 ± 2.382 and 38.00 ± 3.512 days respectively, when the larva reared on watermelon.

Sohrab *et al*. (2018) conducted an investigation on the biology and life cycle of cucurbit fruit fly, *Bactrocera cucurbitae* the mean pre-oviposition period 13.5 ± 1.5 days and oviposition period 18.0 ± 6 days while, mean mating period (3 ± 1Hrs), fecundity 80.0 ± 20 eggs/life cycle and incubation period of eggs varied from 1.25 ± 0.25 days were observed of cucurbit fruit fly. Hatching % of fruit fly 87.5 ± 2.5 was observed in 2015 at average maximum and minimum temperature 34.36 to 25.46 ^{0}C and average relative humidity 87.5 per cent. The total maggot periods (3 larval instars) was 5.180 ± 1.16 days, while, pre-pupal period and pupal period was 0.75 ± 0.25 and 9.5 ± 0.5 days during experiment in the month of June and July respectively. The average longevity of adult fruit flies was neither food nor water immediately, die after range of 1.5 ± 0.5 days after emergence of pupa. When was provided with cucurbit vegetables material to fruit flies then fruit flies were live 13.5 ± 1.5 days. The duration of total life cycle was 16.81 ± 2.18 days during 2015 in June and July under room temperature in Meerut condition.

Akter and Sohel (2020) investigated the biology of cucurbit fruit fly, *Bactriocera cucurbitae* on bottle gourd, *Langenaria siceraria*, using variety 'BARI-Lau 1'. The mean incubation period, larval (1st, 2nd and 3rd instars), pre-pupal and total development periods of *B. cucurbitae* were 1.69 ± 0.28, (1.72 ± 0.33, 1.41 ± 0.31, 2.31 ± 0.51), 0.74 ± 0.28, 9.2 ± 0.78 and 36 ± 1.69 days. The mean adult longevity, with food and without food was 14.1 ± 1.28 and 5.0 ± 0.81 days, respectively. The lengths of all three larval instars were 1.1 ± 0.9, 3.03 ± 0.95 and 6.42 ± 0.90 mm, and the widths were 0.22 ± 0.11, 1.12 ± 0.01 and 2.13 ± 0.20 mm respectively. The length and width of the pre-pupa and the pupa were 5.86 ± 0.48, 5.68 ± 0.26mm and 1.94 ± 0.23, 2.39 ± 0.20 mm respectively. The length of male and female were 6.61 ± 0.59 and 8.28 ± 0.52 mm. The widths of males and females with wing span were 10.97 ± 0.43 and 13.02 ± 1.28 mm respectively. The incidence of *B. cucurbitae* as maggot population in bottle gourd was higher in January during the study period from December 2018 to March 2019.

Gaddanakeri and Rolania (2020) conducted research on biology and morphometrics of melon fruit fly (*Bactrocera cucurbitae* Coquillett) on Bitter Gourd during 2018-19 at Department of Entomology, Chaudhari Charan singh Haryana Agricultural University, Hissar. The mean incubation period of eggs of *B. cucubitae* was 18.0 ± 6.32 hours. The total maggot period ranged from 5-7 days with a mean period of 5.8 ± 0.78 days. Pupation to place insight the soil (5-6cm thick) provided in cylindrical glass jar. Mean pupal duration was 6.9 ± 0.87 days having a length and breadth of 5.98 ± 0.38 mm and 2.54 ± 0.14 mm, respectively. Total life period of male fruit fly ranged from 30 - 46 days with a mean of 36.2 ± 5.77 days. In case of female fruit fly total life period was slightly longer ranging from 32-50 days with a mean of 40.4 ± 6.24 days. Sex ratio in *B. cucurbitae* was recorded as 1:0.84 (male: female).

Sowmiya *et al*. (2021) carried out investigation on biology and morphometry of melon fruit fly, *Zeugodacus cucurbitae* (coquillett) in different cucurbitaceous hosts. The variation in the biology of *Z. Cucurbitae* studied in the varied cucurbitaceous hosts revealed that the average egg length and breadth were high (0.66 ± 0.88 mm and 0.13 ± 0.01 mm (in bitter gourd > ridge gourd > snake gourd). The mean length and breadth of maggot in bitter gourd and ridge gourd are almost similar.

Pre pupa and pupa length and breadth were maximum in bitter gourd (6.22 ± 0.11 mm, 1.83 ± 0.06 mm respectively) and (5.69 ± 0.38 mm, 2.05 ± 0.08 mm respectively). The length and breadth of adult male and female was maximum in ridge gourd host with a mean range of 10.21-10.57 mm and 11.95-1.31 mm. In comparison with three hosts, all the developmental stages *viz*., egg (1.45 ± 0.76 days), first instar (0.70 ± 0.25 days), second instar (2.85 ± 0.74 days), third instar (4.3 ± 0.85 days), pre pupal (0.80±0.25 days) and pupal (8.25±0.82 days) was shorter in bitter gourd host. The longevity of adult males and females was maximum in ridge gourd 20.60 ± 4.35 days and 20.70 ± 3.88 days, respectively.

2.3 Influence of intercropping on incidence of major insect pests of cucumber

2.3.1 Influence of intercrops on incidence of melon fruit fly of cucumber

Pitan and Esan (2014) conducted field experiment on intercropping cucumber with amaranthus (*Amaranthus cruentus* L.) to suppress population of major insect pests of cucumber (*Cucumis sativus* L.) and result showed that the population of cucumber beetles and fruit flies were lower with amranthus established 2 weeks before cucumber and same day as cucumber than with 2 weeks after cucumber. The damage was reduced in the intercrop compared with the monocropped cucumber.

2.3.2 Influence of intercrops on incidence of sucking insect pests of cucumber

Zhao *et al*. (2014) investigated the effectiveness of four less preferred vegetables celery, asparagus lettuce, Malabar spinach, and edible amaranth for suppression of two biotypes of sweet potato whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) on cucumber, *Cucumis sativus* L. (Cucurbitaceae). The result revealed that intercropping celery and Malabar spinach with cucumber significantly reduced whitefly numbers on cucumber. Y-tube olfactometer behavioral assays revealed that whiteflies were strongly repelled from the aqueous extracts of the less preferred vegetables. The level of whitefly repellency varied with combinations of intercropped vegetables, and also differed between the two whitefly biotypes. For whitefly biotype B, the greatest repellency was observed with asparagus lettuce extract, whereas celery and Malabar spinach extracts were more repellent to whitefly biotype Q. Two major volatile constituent compounds were identified, D-limonene from celery and geranyl nitrile from Malabar spinach. Sprayable 1 per cent formulations of these compounds significantly reduced whitefly colonization on cucumber under field conditions.

2.4 Bio-efficacy of different combination insecticides against insect pest of cucumber

2.4.1 Bio-efficacy of different combination insecticides against melon fruit fly of cucumber

Das *et al*. (2015) reported that mixed formulation of novaluron 5.25% + indoxacarb 4.5% SC @ 80 g a.i/ha was found to be most effective with per cent reduction of *Helicoverpa* larval population and the highest yield was also recorded in novaluron + fipronil @ 80 g a.i/ha treated plot (18.6 q/ha) followed by novaluron 5.25% + indoxacarb 4.5% SC (16.4 q/ha).

Ghosal *et al*. (2016) observed that novaluron 5.25% + indoxacarb 4.56 @ 875 ml/ha recorded only 3.75 per cent fruit damage while in control plot it was 45.6%. Highest cost benefit ratio (1:6.17) was obtained when plethora was applied at 825 ml/ha.

Malathi and Kumar (2017) evaluated the efficacy of ready-mix insecticide novaluron 5.25% + indoxacarb 4.5% SC three different doses (750, 825, 875 ml/ha) against *Helicoverpa armigera Maruca vitrata* and *Melanagromyza obtuse* in pigeonpea. Among the treatments *viz*., novaluron 5.25% + indoxacarb 4.5% SC at three different doses of 750, 825, 875 ml/ha, novaluron 5.25% + indoxacarb 4.5% SC @ 875 ml/ha recorded lowest larval population of *H. armigera, M. vitrata,* lowest pod damage by *H. armigera, M. vitrata* and *M. obtuse* followed by novaluron 5.25% + indoxacarb 4.5% SC @ 825 ml/ha. The treatment novaluron 5.25% + indoxacarb 4.5% SC @ 875 ml/ha recorded significantly higher yield closely followed by novaluron 5.25% + indoxacarb 4.5% SC @ 825 ml/ha with almost equal incremental benefits costs ratios.

Roy *et al*. (2017) revealed that chlorantraniliprole + thiamethoxam showed maximum impact (60.68%) than emamectin benzoate + fipronil (60.66 %) and considering the mean percent reduction of pod damage caused by pod borer, while later proved most superior among all the test combinations in percent reduction of *Maruca testulalis* larval population in pigeon pea with highest persistency. Highest cost benefit ratio was obtained from emamectin benzoate + fipronil.

Bhujade *et al.* (2018) reported the application of chlorantraniliprole 8.8% + thiamethoxam 17.5% SC proved effective in recording minimum green fruiting bodies damage as well as per cent shed material, which was at par with indoxacarb 14.5% + acetamiprid 7.7% SC, chlorantraniliprole 9.3% + lambda-cyhalothrin 4.6% ZC, thiamethoxam 12.6% + lambda-cyhalothrin 4.6% ZC.

Borude *et al*. (2018) reported that indoxacarb 14.5% + acetamiprid 7.7% SC proved effective in recording minimum green fruiting bodies damage which was closely followed by novaluron 5.25% + indoxacarb 4.5% and thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC. Significantly minimum open boll damage due to bollworms at harvest was recorded in the insecticidal treatment indoxacarb 14.5% + acetamiprid 7.7% SC followed by novaluron 5.25% + indoxacarb 4.5% SC and thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC. The highest seed cotton yield was recorded in the plot sprayed with indoxacarb 14.5% + acetamiprid 7.7% SC which was followed by novaluron 5.25% + indoxacarb 4.5% SC and thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC. The treatment thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC, indoxacarb 14.5% + acetamiprid 7.7% SC, novaluron 5.25% + indoxacarb 4.5% SC and pyriproxyfen 5% + Fenpropathrin 15% EC proved to be most economically viable.

Rohokale *et al*. (2018) revealed that the lowest shoot infestation by *Leucinodes orbonalis*, were observed in chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC (1.38%). Chlorantraniliprole 8.8 % + thiamethoxam17.5 % SC (10.47 %) was the most superior treatment shows lowest fruit damage was statistically at par with flubendiamide 19.92 % + thiacloprid 19.92 % (10.78 %), followed by chlorantraniliprole 9.3 % + lambda cyhalothrin 4.6 % ZC (11.27%), indoxacarb 14.5 % + acetamiprid 7.7 % SC (12.52 %). Chlorantraniliprole 8.8 % + thiamethoxam 17.5 % SC (9.22 %), was the most superior treatment showing lowest fruit damage which was statistically at par with flubendiamide 19.92 % + thiacloprid 19.92 % (9.64 %) on number and weight basis respectively. Chlorantraniliprole 8.8 % + thiamethoxam 17.5 % SC registered the highest yield (149 q/ha) followed by chlorantraniliprole 9.3 % + lambda-cyhalothrin 4.6 % ZC (140 q/ha).

Subbireddy *et al*. (2018) conducted field experiment to evaluate the effectiveness of seven ready-mix insecticides against fruit borer *i.e., Earias vittella* and *Helicoverpa armigera* in okra. Among seven different ready-mix insecticides, chlorantraniliprole 9.3 % + lambda cyhalothrin 4.6% ZC (0.007 %) and indoxacarb 14.5 % + acetamiprid 7.7 % SC (0.022 %) found most effective against fruit borers by recording less larval population and fruit damage both number and weight basis. The maximum fruit yield of okra fruit was harvested from the plots treated with chlorantraniliprole 9.3 % + lambda cyhalothrin 4.6 % ZC (68.44 and 151.12 q/ha) followed by indoxacarb 14.5 % + acetamiprid 7.7 % SC (62.72 and 145.83 q/ha) during *summer* and *kharif*, respectively. Maximum net realization was obtained in the treatment of chlorantraniliprole 9.3 % + lambda cyhalothrin 4.6 % ZC (87895/ha and 85103/ha) followed by indoxacarb 14.5 % + acetamiprid 7.7 % SC (76868/ha and 80226/ha) during *summer* and *kharif*, respectively.

Floret and Regupathy (2019) reported the order of efficacy against *L. trifoli* was chlorantraniliprole 9.3% w/w + lambda-cyhalothrin 4.6% w/w 150 ZC > novaluron 5.25% + indoxacarb 4.5% SC > chlorantraniliprole 18.5% + lambda-cyhalothrin 4.9% CS. Chlorantraniliprole 9.3% w/w + lambda-cyhalothrin 4.6% w/w 150 ZC treatment resulted in significantly higher yield as compared to untreated check.

2.4.2 Bio-efficacy of different combination insecticides against sucking insect pests of cucumber

Roy *et al*. (2017) revealed that highest aphid mortality recorded in pyriproxyfen + fenpropathrin (80.71 % and 80.90 %) treated plots after first and second spray respectively, during both years.

Padaliya *et al*. (2018) conducted field experiment on bio-efficacy of ready-mix insecticides against thrips infesting *Bt* cotton and result revealed that thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC was found most effective on basis population of thrips. The maximum seed cotton yield (2691 kg/ha) was recorded in the treatment of acephate + imidacloprid followed by thiamethoxam 12.6 % + lambda cyhalothrin 9.5 % ZC (2645 kg/ha). The highest NICBR obtained with the treatment of thiamethoxam 12.6 % + lambda cyhalothrin 9.5 % ZC.

Reddy *et al*. (2018) revealed that chlorantraniliprole 8.8 % + thiamethoxam 17.5 % SC @ 150 g a.i/ha was found effective in managing the population of pod bug and aphid followed by thiamethoxam 12.6 % + lambda cyhalothrin 9.5 % ZC @ 150 g a.i/ha.

2.4.3 Effect of different combination insecticides on population of natural enemies

Roy *et al*. (2017) reported that chlorantraniliprole + thiamethoxam proved least toxic to prevailing predatory fauna *Miracraspis discolor* (Fabricius) and *Chrysoperla sp*., with less than 10 per cent mortality after 15 days of each insecticide imposition.

CHAPTER III
MATERIALS AND METHODS

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled "Biology, host preference and management of melon fruit fly, *Bactrocera cucurbitae* (Coquillett) on cucumber" was carried out in the laboratory as well as on the Research Farm of Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (MS) during *Summer* season of 2021 and 2022. The material used and methods adopted for recording observations during the course of investigations are given below under following subheads.

3.1 Experimental material

The different materials were used such as experimental land, various agricultural implements required for preparatory tillage, bullock pair, sowing and intercultural operations and various inputs such as fertilizers, seeds of cucumber and intercrops, labels, threads, wooden sticks, polythene bags, insecticides, measuring cylinder, knapsack sprayer, buckets, weighing balance, glass jars, muslin cloth, honey, petri-dishes, camel hair brush, hand lens, digital varnier caliper, rubber and cotton swab *etc* had been procured from Department of Agricultural Entomology, VNMKV, Parbhani.

3.2 Location of experiment

Field experiments were conducted during *Summer* 2021 and 2022 at Research Farm, Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra) which is geographically situated on 19^0 16' North latitude and 76^0 47' East longitudes with an altitude of 408.50 meter above mean sea level.

3.3 Climatic conditions

The mean annual rainfall of Parbhani is 800-900 mm receiving mostly during June to September. Summer is hot and dry while winter is cool. The mean daily maximum temperature varied from 29.4^0C in December to 45^0C in May. The minimum temperature varied from 11.32^0C (winter) to 25.77^0C (summer). The mean relative humidity ranges from 30 to 90 per cent. The climate is subtropical. The meteorological data for season *Summer*, *Kharif* and *Rabi* 2021 are given in Appendix-

I, II and III.

3.4 Soil type

The experiment was conducted on well drained typical black cotton soil with uniform level of fertility. The depth of soil varied from 2 to 3 meters.

3.5 Agronomic practices/ Cultural operations

The necessary tillage operations (before and after sowing) were performed as per the requirements considering the recommendations of Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani for growing cucumber crop.

3.5.1 Land preparation

The land was prepared by ploughing, clod crushing, cross harrowing and field was cleaned by collecting stubbles. The experiments were laid out as given in plan of layout.

3.5.2 Sowing

Sowing was done on prepared land by hand dibbling method by placing two seed per hill. The crop was sown at a spacing of 1.5 m x 0.50 m.

3.5.3 Gap filling and thinning

Gap filling was done at 7 days after emergence of crop and thinning was done at 15 days after emergence, keeping one healthy seedling per hill.

3.5.4 Application of fertilizers

Application of fertilizers was done @ 100:50:50 NPK Kg/ha in the form of urea, single super phosphate and murate of potash. Complete dose of P and K and half dose of N was applied at the time of sowing and remaining 50 kg N was applied at 30 days after sowing. No extra fertilizers were applied to intercrops.

3.5.5 Intercultural operations

Weeding was done from time to time to remove weeds and improve soil aeration and also conserve soil moisture. In both experiments, two weeding were undertaken during the crop season.

3.6 Experimental details

The details of experiments conducted and methods of observations adopted are given below.

3.6.1 Seasonal incidence of major insect pests of cucumber in relation to weather parameters

The experiment was conducted in unprotected plot which was non-replicated and the plot was divided in four quadrants.

The details of experiments are given below.

Year and Season	:	*Summer*-2021, *Kharif*-2021, *Rabi*-2021, *Summer*-2022
Variety	:	Gipsy+ (Namdeo Umaji Agritech India Pvt. Ltd.)
Design	:	Non-replicated
Plot size	:	10 x 10 m^2
Spacing	:	1.5 m x 0.50 m
Date of sowing	:	*Summer*-2021 (20/01/2021), *Kharif*-2021 (2/7/2021), and *Rabi*-2021 (15/10/2021)

3.6.1.1 Sampling and collection of experimental data

Five vines were randomly selected from each quadrant for observations. The observations recorded during the course of investigations are given below.

3.6.1.2 Method of recording observation

3.6.1.3 Seasonal incidence of melon fruit fly of cucumber in relation to weather parameters

The seasonal incidence of melon fruit fly of cucumber in relation to weather parameters was carried out by installing Para-pheromone trap (cue-lure trap) in the 10 m x 10 m^2 plot size. The fruit flies trapped weekly in the trap were correlated with the various weather parameters *i.e.* maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, and rainfall. The fruit flies trapped were recorded during each collection and monitored separately. The observations were recorded at weekly interval.

3.6.1.4 Seasonal incidence of sucking insect pests of cucumber in relation to weather parameters

The observations on whiteflies and thrips were recorded at weekly interval from three leaves (each from top, middle and bottom canopy) on five randomly selected vines from each quadrant.

3.6.1.5 Seasonal incidence of red pumpkin beetle of cucumber in relation to weather parameters

The observations for the incidence of red pumpkin beetles were recorded on five randomly selected tagged cucumber vines from each quadrant from 15 days after sowing. The population of red pumpkin beetles on five tagged vines was visually counted and recorded on the whole vine at weekly interval during morning (8-9 am) and evening hours (5-6 pm).

3.6.1.6 Seasonal abundance of natural enemies in cucumber in relation to weather parameters

The observations on number of natural enemies *viz*., ladybird beetles, and spiders were recorded weekly interval from per vine on five randomly selected tagged cucumber vines from each quadrant.

3.6.1.7 Relationship between weather parameters major insect pests of cucumber

Meteorological data on weekly basis for *Summer*, *Kharif* and *Rabi* during the year 2021 were obtained from Meteorological Observatory of Department of Agricultural Meteorology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani from the same campus. The obtained data was analyzed to find out simple correlation, simple regression and multiple regressions between pest population and weather parameters.

3.6.2 Host preference and biology of melon fruit fly on different hosts

3.6.2.1 Host preference of melon fruit fly on different hosts under field condition

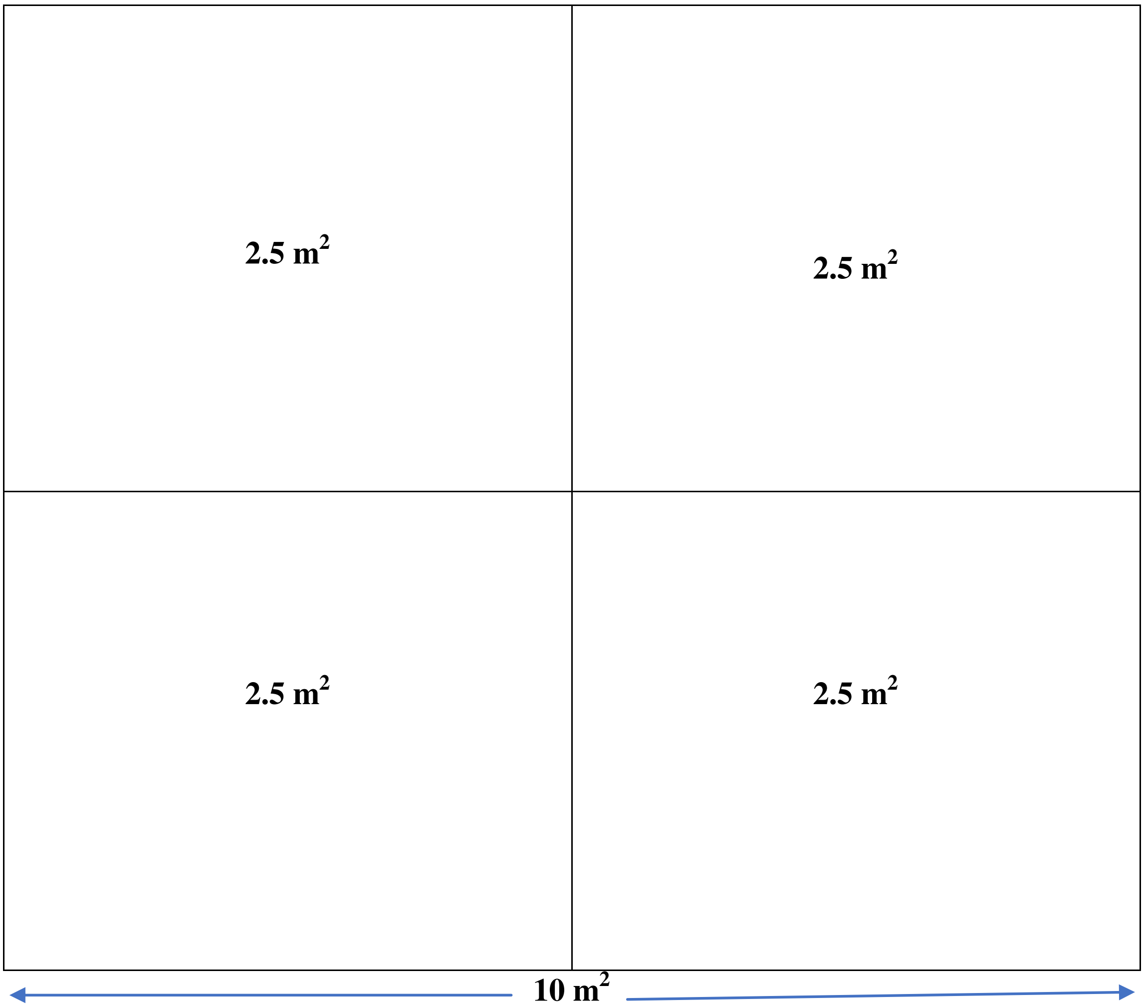

Fig.3.1: Experimental plot for seasonal incidence of major insect pests of cucumber

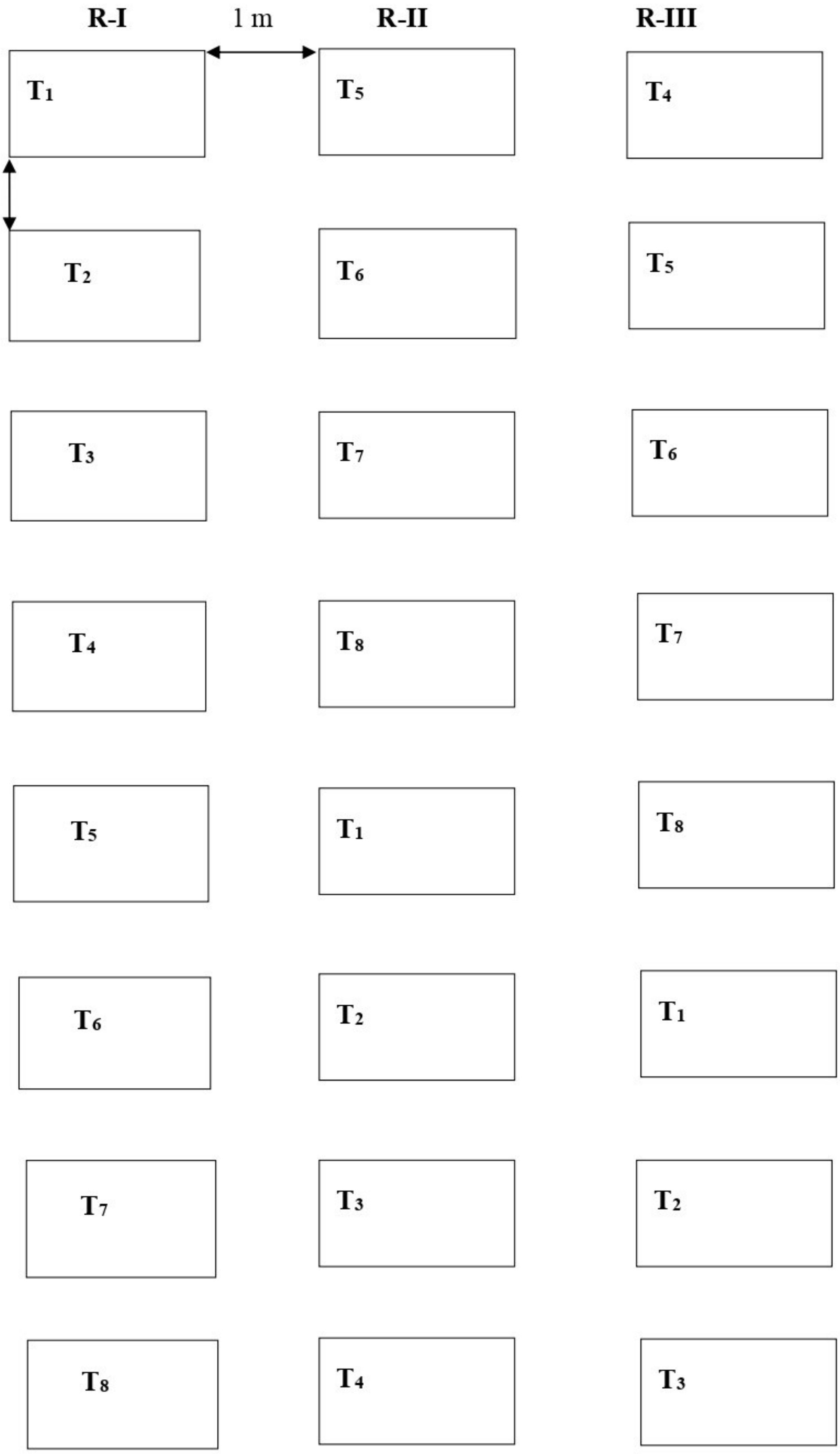

Fig. 3.2: Layout of host preference of melon fruit fly on different hosts under field condition

Plate 3.1: General view of seasonal incidence plot

Plate 3.2: General view of host preference plot

3.6.2.1.1 Experimental details

The details of experiments are given below

Experimental Design	:	Randomized Block Design (RBD)
Replications	:	Three (3)
Treatments	:	Eight (8)
Plot size	:	3 m x 2 m
Spacing	:	1.5 m x 0.5 m
Crop	:	Cucumber
Variety	:	Gipsy+
Distance between two replications	:	1 m
Distance between two plots	:	0.5 m
Season	:	*Summer* 2020-21and 2021-22
Date of sowing	:	20 January 2021 and 22 February 2022

3.6.2.1.2 Treatment details

Tr. No.	Treatment
T_1	Cucumber
T_2	Bitter gourd
T_3	Ridge gourd
T_4	Pumpkin
T_5	Watermelon
T_6	Sponge gourd
T_7	Muskmelon
T_8	Bottle gourd

3.6.2.1.3 Method of recording observation

To investigate preference of melon fruit fly on different cucurbitaceous host vines under field condition, total fruit count and infested fruits/plot were counted and computed to work out the per cent fruit damage.

3.6.2.2 Host preference of melon fruit fly on different hosts under laboratory condition

3.6.2.2.1 Experimental details

The details of experiments are given below

Experimental Design	:	Complete Randomized Block Design (CRD)
Replications	:	Three (3)
Treatments	:	Eight (8)

3.6.2.2.2 Treatments Details

In the present investigation, eight different cucurbitaceous hosts were evaluated to investigate preference of melon fruit fly under laboratory condition.

Tr. No.	Treatment
T_1	Cucumber
T_2	Bitter gourd
T_3	Ridge gourd
T_4	Pumpkin
T_5	Watermelon
T_6	Sponge gourd
T_7	Muskmelon
T_8	Bottle gourd

3.6.2.2.3 Method of recording observations

Different vegetable hosts like cucumber, bitter gourd, ridge gourd, pumpkin, watermelon, sponge gourd, muskmelon and bottle gourd were used which were collected from local market. Vegetables which were mature, healthy and undamaged were collected from the market, 100 g of sample retained in bags and labeled with appropriate data. Fruit fly’s host preference on different vegetables and developmental stages were evaluated by installing pheromone traps, the fruit fly populations were collected which is baited with methyl eugenol, act as a attractant, pheromone trap was made up of plastic material and hung in the field. Adult flies which were captured from pheromone traps were identified in the laboratory. Plastic containers were secured to prevent the other small flies entry and emission. Simplified diets were prepared which consist of fruit pulp (banana), yeast and egg. Banana without peel and egg were blended well in a blender and added in a plastic cup. Yeast was mixed in that mixture. From fresh vegetables, these diets varied because of increase egg production and physical texture.

Choice test: Choice experiment was undertaken in plastic cages in the Entomology Laboratory, VNMKV, Parbhani. 100 g of fruits of treatment vegetables *viz.,* cucumber, bitter gourd, ridge gourd, pumpkin, water melon, sponge gourd, muskmelon and bottle gourd were placed in the cage and distance between each vegetable was 5 cm. Vegetable species were checked. Twenty adults of fruit flies were released into the cages for 24 hours. Vegetables were removed and placed separately in different plastic cages for incubation. Data were recorded for egg, larval, pupal and adult emergence.

Non-Choice test: In this process, different vegetables of 100 g weight were used and kept separately in different cages. Every cage contains melon fruit fly adult (male and female) for oviposition. Fruit flies were removed from the cages and development period was continued. To check the hatch out rate, eggs were placed into wet blotting paper and observed under microscope. Processes proceed as explain in choice test. Data were recorded for egg, larval, pupal and adult emergence.

3.6.2.3 Biology of melon fruit fly on different hosts

3.6.2.3.1 Experimental details

The details of experiments are given below

Experimental Design	:	Complete Randomized Block Design (CRD)
Replications	:	Three (3)
Treatments	:	Eight (8)

3.6.2.3.2 Material used

Plastic jars, white muslin cloth, honey, petri dishes, camel hair brush, hand lens, cotton swab, culture of melon fruit fly, rubber band, glass tubes, microscope, sand all these materials were required for rearing of melon fruit fly under laboratory condition.

3.6.2.3.3 Rearing technique

Initial cultures of fruit flies were raised by collecting infested fruits from the plots of cucurbitaceous crops from Horticulture Farm, VNMKV, Parbhani. The infested fruits were kept in plastic jars (diameter 15 cm and height 20 cm) containing 5 cm thick layer of sieved sand at bottom of jar to obtain pupae. The top of the jar was covered with clean white muslin cloth duly tightened with rubber band to prevent the maggots from escaping.

Such jars were used for maintaining the culture of fruit fly, *Bactrocera cucurbitae* (C.), when all the full-grown maggots entered in the sand for pupation, the rotted fruits were removed from the container. After 4-5 days, the sand in the container was sieved to collect pupae. The pupae were transferred in a glass tubes (1.5 cm diameter, 7.5 cm height), individually. The tubes were plugged with cotton lint to prevent the escaping of adult fruit flies when emerged. The flies emerged were utilized for further studies on life history.

The freshly emerged adults were paired and confined in the plastic jars (diameter 15 cm, height 20 cm) covered with a white muslin cloth bag. On end of the bag was kept open for introducing the adults into the jar. The open end of the bags was tightened with rubber band to prevent the adult from escaping. Such jars were kept in the wooden cages (68 x 53 x 37 cm) to prevent the damage from ants and rodents. A cotton swab with 5 per cent sugar solution was suspended inside the jar as food to the adult flies. Premature uninfected fruits were placed inside the jar for oviposition. The fruits were replaced after observing the punctures. The fruits punctured due to egg laying was cut open with a fine razor blade and egg laid if, any was confirmed using magnifying lens. About 2 x 1 x 1 cm size piece of fruit having eggs were smoothly cut and transferred in a separate petri dish and observed twice a day for their hatching. Eggs were carefully transferred with a fine camel hair brush (No. 1) on a glass slide and observed under microscope to study their morphometric characters.

After hatching of eggs, the neonate maggots were gently transferred on a fresh fruit slice (2 x 2 x 1 cm), the later was kept in petri dish for further rearing. The food (fruit slice) as well as petri dishes were changed every day to avoid microbial development on fruit slice. The maggots were reared following this method until they were full grown and transferred along with petri dish in a small plastic jar (diameter 15 cm, height 20 cm) filled with a layer of 5 cm sand. The jars were covered with muslin cloth and tightened with rubber bands for preventing the escaping of maggots.

The observations on fecundity, oviposition period, incubation period, hatching percentage, larval period, per cent larvae pupated, pre-pupal and pupal duration, per cent adult emergence and total life-cycle of male and female were recorded on different hosts.

3.6.2.3.4 Pre-oviposition, oviposition and post-oviposition period

The pre-oviposition period on fruits were calculated from the date of emergence of female to the date of starting of egg laying. The oviposition period was calculated from the time and date of starting of egg laying to the time and date of ceasing of egg laying. The post-oviposition period was calculated from the date of ceasing of egg laying to the death of female.

3.6.2.3.5 Fecundity

The number of eggs laid on fruits by each female was recorded till the egg laying stops and average fecundity will be calculated.

3.6.2.3.6 Egg

Eggs were observed under the microscope for studying their colour, shape and size. Similarly, for measurement, the eggs were gently transferred under compound microscope with the help of moist hair brush. The microscope was calibrated with stage and ocular micrometer before measuring the eggs. Incubation period was studied by keeping known number of freshly laid eggs in fruit slice by making a small hole with the help of sharp pointer and observed daily in the morning and evening till hatching. The eggs were considered as hatched, when the tiny maggots came out from it, whereas hatching percentage was calculated from the number of eggs hatched out of total number of eggs kept under observation.

3.6.2.3.7 Maggot (Larva)

A thick (2 cm) slice of fruits was kept individually in a petri dish. It was slightly ruptured with the help of scalpel for easy entry of the maggot. The newly hatched maggots were transferred individually on fruit slice. The maggots were reared till they underwent for pupation. The food was changed every morning to maintain the sanitation in the petri dish. The first instar (newly hatched) and fully grown maggots were observed under microscope for studying the shape, size and colour.

6.3.2.3.8 Pre-pupa

A stage, when full grown maggots ceased feeding and became inactive was considered as pre-pupal stage. These maggots were transferred with food to plastic jar (diameter 15 cm, height 20 cm) with 5 cm layer of sieved sand at the bottom for pupation. The observations on shape, size and colour of pre-pupal stage was recorded. The breadth and length of pre-pupal stage was measured under microscope. The pre-pupal period was recorded for individual maggot reared on fruits.

3.6.2.3.9 Pupa

The pupal period was calculated from the date of formation of pupa to the date of emergence of the adult from the pupa. The pupae were studied for their shape, size, colour and period. The breadth and length were also measured.

3.6.2.3.10 Adult

The newly emerged adults from fruits were critically observed under microscope for their size, shape, colour and sex differences. The breadth and length of adults were also measured.

3.6.2.3.11 Sex Ratio

Sex ratio was studied, and pupae were kept in a plastic jar on the layer 5 cm sieved sand and jars were covered with white muslin cloth fixed with a rubber band to prevent the escape of adults. The sex ratio was calculated by separating the males and females, based on their morphological characters.

3.6.2.3.12 Longevity

The longevity of male and female was calculated separately from the date of emergence to the death of adult.

3.6.2.3.13 Total Life Cycle

The period from egg laid to the death of adult was considered as the total life cycle.

3.6.3 To study the influence of intercrops on incidence of insect pests of cucumber

3.6.3.1 Experimental details

The details of experiments are given below

Experimental Design	:	Randomized Block Design (RBD)
Replications	:	Three (3)
Treatments	:	Eight (8)
Plot size	:	3 m x 2 m
Spacing	:	1.5 m x 0.5 m
Crop	:	Cucumber
Variety	:	Gipsy+
Distance between two replications	:	1 m
Distance between two plots	:	0.5 m
Season	:	*Summer* 2020-21and 2021-22
Date of sowing	:	20 January 2021 and 22 February 2022

3.6.3.2 Treatments Details

In the present investigation, eight intercrops were evaluated and compared with sole cucumber for the incidence of major insect pests of cucumber.

Tr. No.	Treatments
T_1	Cucumber + Coriander (*Coriandrum sativum*)
T_2	Cucumber + Safflower (*Carthamus tinctorius*)
T_3	Cucumber + Chukka (*Rumex vesicarius*)
T_4	Cucumber + Spinach (*Spinacia oleracea* L.)
T_5	Cucumber + Fenugreek (*Trigonella foenum-graecum*)
T_6	Cucumber + Lettuce (*Lactuca sativa*)
T_7	Cucumber + Dill (*Anethum graveolens* L.)
T_8	Sole Cucumber (*Cucumis sativus)*

3.6.3.3 Method of recording observations.

3.6.3.4 Influence of intercrops on incidence of melon fruit fly of cucumber

Influence of different intercrops on melon fruit fly, total fruit count and infested fruits/plot was counted and computed to work out the per cent fruit damage. Fruit yield/plot was also recorded.

3.6.3.5 Influence of intercrops on incidence of sucking insect pests of cucumber

The observations on whiteflies and thrips were recorded at weekly interval from three leaves (each from top, middle and bottom canopy) on five randomly selected cucumber vines. Simultaneously the observations on number of ladybird beetles, and spiders were recorded weekly from five randomly selected cucumber vines from each net plot during both the years.

3.6.4 To study the bio-efficacy of different combination insecticides against insect pests of cucumber

3.6.4.1 Experimental details

The details of experiments are given below

Experimental Design	:	Randomized Block Design (RBD)
Replications	:	Three (3)
Treatments	:	Eight (8)
Plot size	:	3 m x 2 m
Spacing	:	1.5 m x 0.5 m
Crop	:	Cucumber
Variety	:	Gipsy+
Distance between two replications	:	1 m
Distance between two plots	:	0.5 m
Season	:	*Summer* 2020-21and 2021-22
Date of sowing	:	20 January 2021 and 22 February 2022
Date of spraying	:	

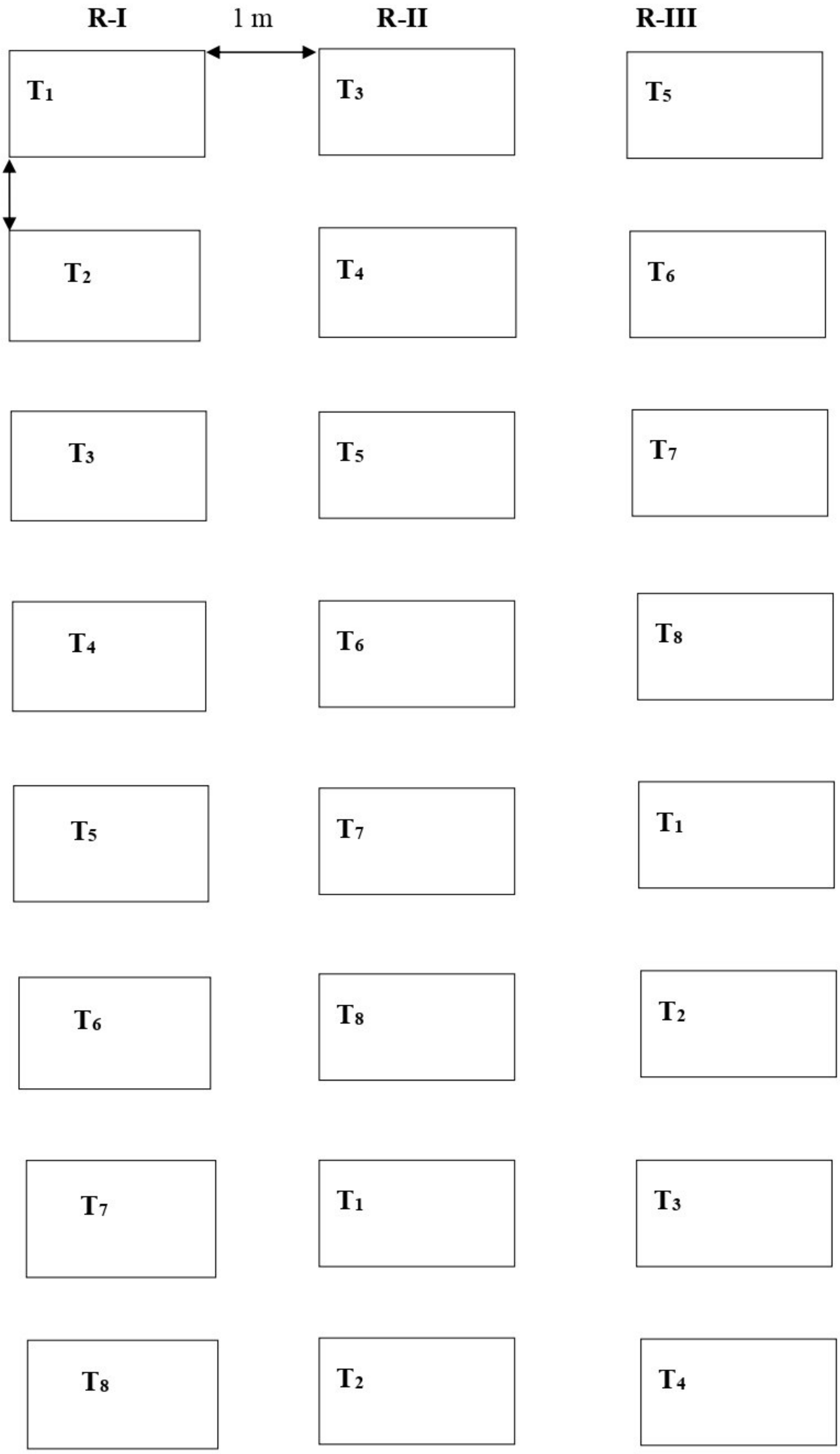

Fig. 3.3: Layout of influence of intercrops on incidence of major insect pests of cucumber

Plate 3.3: General view of intercropping plot

No. of spraying	**Date of spraying**	
	2021	**2022**
First spray	19/03/2021	21/04.2022
Second spray	05/04/2021	08/05/2022

Date of picking

No. of picking	**Dates of picking**	
	***Summer* 2021**	***Summer* 2022**
1^{st} picking	15/03/2021	19/04/2022
2^{nd} picking	22/03/2021	22/04/2022
3^{rd} picking	24/03/2021	25/04/2022
4^{th} picking	27/03/201	28/04/2022
5^{th} picking	30/03/2021	02/05/2022
6^{th} picking	05/04/2021	05/05/2022
7^{th} picking	08/04/2021	08/05/2022
8^{th} picking	15/04/2021	13/05/2022
9^{tht} picking	20/04/2021	18/05/2022

Table 3.1: Treatment details

Tr. No	Treatment	Trade name	Company name	Dose (ml/ha)
T_1	Emamectin benzoate 1.5 % + Fipronil 3.5 % SC	Apex	Crystal crop protection Pvt. LTD	700
T_2	Novaluron 5.25 % + Emamectin benzoate 0.9 % SC	Barazide	Adama India Pvt. Limited	875
T_3	Indoxacarb 14.5 % + Acetamiprid 7.7 % SC	Kite	Gharda Chemical Pvt. Limited	500
T_4	Novaluron 5.25 % + Indoxacarb 4.5 % SC	Plethora	Adama India Pvt. Limited	875
T_5	Pyriproxifen 5 % + Fenpropathrin 15 % EC	Sumiprempt	Sumotomo Chemical India Pvt. Limited	700
T_6	Thiamethoxam 12.6 % + Lamda-cyhalothrin 9.5 % ZC	Alika	Syngenta India Pvt. Limited	500
T_7	Chlorntraniliprole 8.8 % + Thiamethoxam 17.5 % SC	Voliam flexi	Syngenta India Pvt. Limited	200
T_8	Untreated control (Water spray)	**--**	**--**	--

3.6.4.2 Application of insecticides

Insecticides at their prescribed doses were administered only when pests crossed their ETLs. Total two foliar sprays were given at 15 days interval. Volume of spray material was worked out before insecticidal spray by spraying plain water on control plot. Spraying was done in morning hours to avoid mid-day heat. Measured quantity of insecticides were taken in 500 ml capacity beaker and mixed in small quantity of water and then added in spray tank containing known quantity of water. Spraying was done by using knapsack sprayer with solid cone nozzle.

3.6.4.3 Method of recording observations

3.6.4.4 Bio-efficacy of different combination insecticides against melon fruit fly of cucumber

Per cent fruit infestation

i. On number basis

One day before each application of insecticides all the fruits were harvested from all plots. Picking wise observations were recorded on total number of fruit and number of infested fruits on five randomly selected vines from treated as well as control plots. From the total fruits, infested fruits were counted and computed to work out the per cent fruit damage using the formula.

$$\text{Per cent fruit infestation (Number basis)} = \frac{\text{No. of infested fruit}}{\text{Total no. of fruit}} \times 100$$

i. On weight basis

Picking wise observations were also recorded on weight of total fruits and weight of infested fruits on five randomly selected vines from treated as well as control plots. From the weight of total fruits, weight of infested fruits was counted and computed to work out the per cent fruit damage using the formula.

$$\text{Per cent fruit infestation (Weight basis)} = \frac{\text{Weight of infested fruit}}{\text{Weight of total fruit}} \times 100$$

3.6.4.5 Bio-efficacy of different combination insecticides against sucking insect pests of cucumber

Five vines from each net plot were selected randomly and tied with tags, border vines were avoided for recording observations. The precount of sucking pests was recorded one day before and 3, 7 and 14 days after application of insecticides. Simultaneously the observations of natural enemies *viz*., lady bird beetles and spiders were also recorded after each spray. Also, per cent reduction of sucking pests over control was calculated by using Henderson-Tilton formula. The effect of insecticidal treatments was also expressed in terms of per cent reduction.

$$\text{Per cent reduction} = 1 - \left\{ \frac{\text{n in Co before treatment x n in T after treatment}}{\text{n in Co after treatment x n in T before treatment}} \right\} \text{x } 100$$

Whereas,

N = Insect population

Co = Control

T = Treated

3.6.4.6 Details of insecticides treatments

In present investigation seven insecticides *viz*., Emamectin benzoate 1.5 % + Fipronil 3.5 % SC, Novaluron 5.25 % + Emamectin benzoate 0.9 % SC, Indoxacarb 14.5 % + Acetamiprid 7.7 % SC, Novaluron 5.25 % + Indoxacarb 4.5 % SC, Pyriproxifen 5 % + Fenpropathrin 15 % EC, Thiamethoxam 12.6 % + Lamda-cyhalothrin 9.5 % ZC and Chlorntraniliprole 8.8 % + Thiamethoxam 17.5 % SC were tested against major insect pests of cucumber.

Important properties of test insecticides are given below.

1. Emamectin benzoate 1.5 % + Fipronil 3.5 % SC

It is the combination of chemical group avermectin and phenylpyrezole family. It is broad spectrum insecticide which controls both caterpillars and thrips simultaneously. It is a contact and systemic insecticide. It has ovilarvicidal activity, therefore kills the larvae immediately after hatching which ensures no further loss to the crop. It also has phytotonic action which results in healthy crops and better yield. It is available in market by trade name Apex (Crystal crop protection Pvt. LTD).

2. Novaluron 5.25 % + Emamectin benzoate 0.9 % SC

It is an effective combination of two advanced insecticide molecules with broad spectrum systemic, contact and ingestion action. Its effective solutions for the control a wide range of lepidopteran pests which can cause significant yield losses. Its quick knock down effect controls the damage instantly and through its long duration of control it helps in reduction in the cost of pest management. It has a two-way action. It interferes with the neuromuscular process at the nerve-muscle junction causing permanent prevention of muscle contraction leading to paralysis and death of insect. It also affects biochemical processes and act as chitin inhibitor inside the insect causing abortive moulting. Hence the insect cannot move to the next instar and finally dies. It is used against control of diamond back moth, fruit borer, pod borer and stem borer. It is available in market by trade name Barazide (Adama India Pvt. Limited).

3. Indoxacarb 14.5 % + Acetamiprid 7.7 % SC

Indoxacarb acts on the sodium channel of nervous system resulting paralysis and death of insects. Acetamiprid causes hyper- excitation to cause lethargy and paralysis to insect. It is an insecticide used for the control of jassids, whiteflies and bollworms on cotton and thrips and fruit borer on chillies. It is available in market by trade name Kite (Gharda Chemical Pvt. Limited).

4. Novaluron 5.25 % + Indoxacarb 4.5 % SC

It is a broad-spectrum insecticide. It acts as a chitin synthesis inhibitor and also affects the insect nervous systems by inhibiting sodium ions entry into nerve cells hence, the insecticide hampers moulting and also paralyses the insect. It has phytotonic effect on the crop. It is used for the control of pod borer complex, fruit borer, fruit borer complex, leaf eating caterpillar and rice leaf folder. It is available in market by trade name Plethora (Adama India Pvt. Limited).

5. Pyriproxifen 5 % + Fenpropathrin 15 % EC

It is highly recommended to control whitefly and pink bollworms in cotton, whitefly, shoot and fruit borer in brinjal, whitefly and fruit borer in okra and chilli. Pyriproxyfen disturb the metabolic growth stages in insect larvae and it also affects the adult egg laying capacity. It has rainfast action. It is a low cost, high effective insecticide. Fenpropathrin makes the prolonged opening of the sodium channel, it’s a major membrane for actions which leads to hyper-excitation of the central nervous system and kills the insects. It is available in market by trade name Sumiprempt (Sumotomo Chemical India Pvt. Limited).

6. Thiamethoxam 12.6 % + Lamda-cyhalothrin 9.5 % ZC

It is used for control of jassids, aphids, thrips and bollworms on cotton, aphid, shoot fly and stem borer on maize, leaf hopper and leaf eating caterpillar on grountnut, stem fly, semilooper and girdle beetle on soybean, thrips and fruit borer on chilli, tea mosquito bug, thrips and semilooper on tea and thrips, whiteflies and fruit borer on tomato. Combined insecticides of two active ingredients for controls a wide range of insect pests in soils or on foliage in variety of crops, by contact, ingestion and vapour action. Thiamethoxam belongs to the group of neonicotinoid pesticides and Lamda-cyhalothrin is a synthetic pyrethroid. It is a stomach and contact insecticides. It has an irreversible blockage of postsynaptic nicotinic acetylcholine receptors leads to the hyper-excitation of the nerves. Hyper-excitation followed by convulsions and eventual paralysis of the insects. It is available in market by trade name Alika (Syngenta India Pvt. Limited).

7. Chlorntraniliprole 8.8 % + Thiamethoxam 17.5 % SC

The anthranilic diamide class of insecticides, which includes chlorantraniliprole, activates ryanodine receptors and stimulates calcium ion release from muscle cells causing paralysis and death in vulnerable species. Thiamethoxam is a broad spectrum, systemic insecticides, which means it is absorbed quickly by vines and transported to all of its parts, including pollen, where it acts to deter insect feeding. Its complementary, dual modes of action result in convenient broad-spectrum control of key sucking and chewing pests. It is available in market by trade name Voliam flexi (Syngenta India Pvt. Limited).

3.6.5.1 Yield of cucumber

The cucumber fruits from each net plot were picked at each picking and weighted separately. Nine pickings were carried out at the time of harvesting. The total yield was worked out by adding the yield of all the pickings. Total yield from each net plot was calculated and computed on hectare basis.

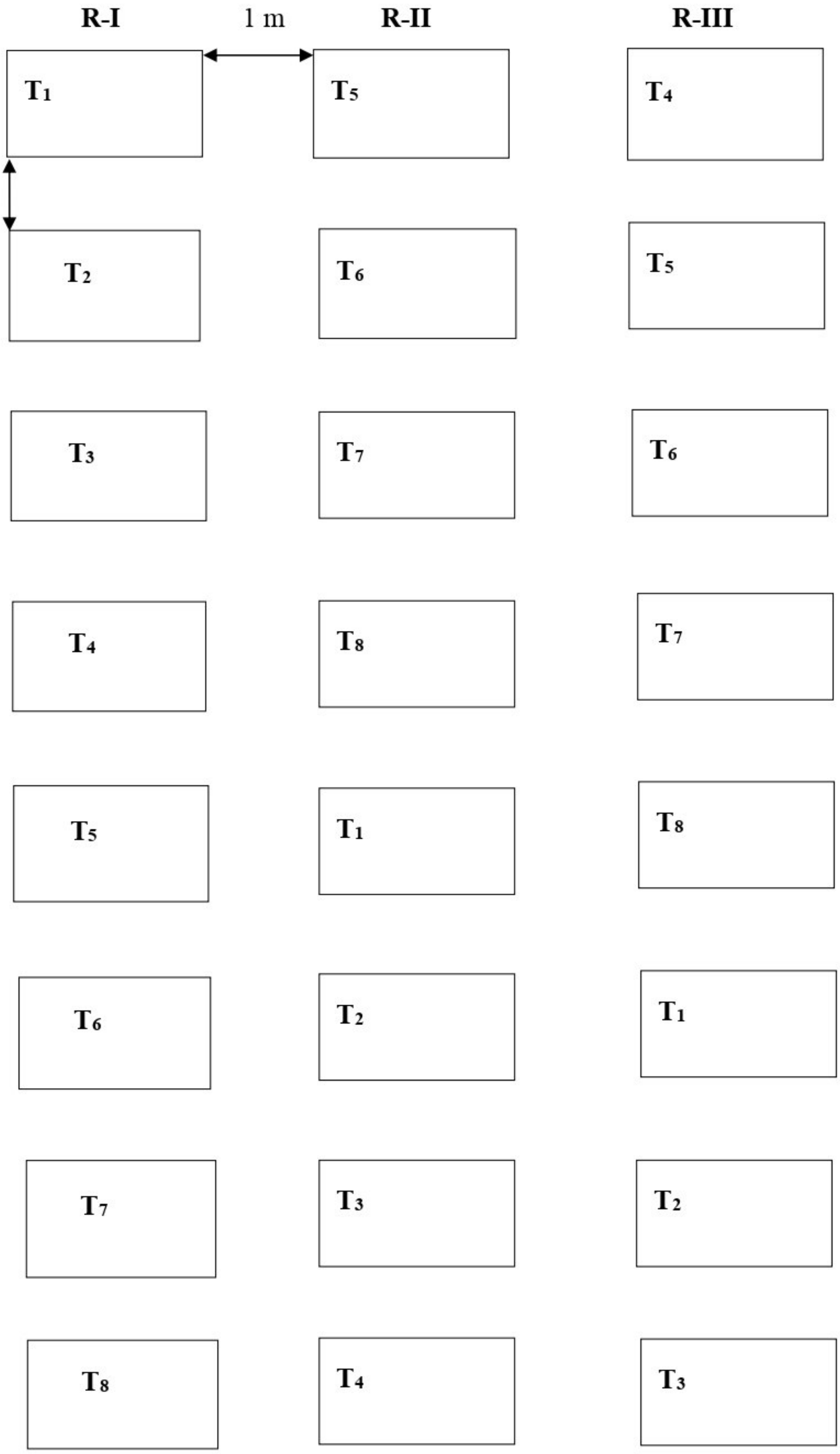

Fig. 3.4: Layout of bioefficacy of different combination insecticides against major insect pests of cucumber

Plate 3.4: General view of bioefficacy plot

3.6.5.2 Yield of intercrops

The yield of cucumber (main crop) and intercrops were recorded separately plot wise and replication wise and same were expressed as kg/ha. The per cent increase in yield over control was also calculated by using following formula:

$$\% \text{ increase in yield over control} = \frac{\text{Yield of treatment} - \text{Yield of control}}{\text{Yield of treatment}} \times 100$$

3.6.5.3 Economics

The economics of treatments is of prime importance. The yield of individual treatment was converted to monetary return per hectare by considering the price declared by Maharashtra Government for respective years. The cost of vine protection measures applied was worked out.

3.6.5.4 Gross Monetary Returns (GMR)

For working out GMR the yield obtained from untreated control was subtracted from the yield recorded from different treatments presuming that certain minimum yield was obtained even without vine protection measures. Thus, the yield so obtained was termed as ‘increased yield over control’. The value of increased yield was termed as GMR.

3.6.5.5 Net Monetary Returns (NMR)

The net monetary return was calculated by subtracting the expenditure on cost of treatments. The economics was worked out year wise as well as on the basis of pooled data as presented in respective tables.

3.6.5.6 Incremental cost benefit ratio (ICBR)

ICBR is a final judgment to be taken into consideration for comparing the different treatments and to sort out the most economical one. ICBR is the ratio between additional expenditure on treatment application and net profit. It is based on the total cucumber yield in terms of rupees per ha and cost of inputs including treatments and labour charges, cost of application. The net monetary returns were calculated at the prevailing market rates declared by State Government during the period of experimentation in order to evaluate cost of different treatments against major insect pests of cucumber. ICBR thus worked out is presented in respective tables.

3.7 Statistical analysis

The data obtained were analyzed statistically after using appropriate transformation. The data on sucking pests and natural enemies was compiled. The data obtained in number was subjected to transformation using Poisson formula $\sqrt{x + 0.5}$ before analysis. The data on melon fruit fly (per cent data) was transformed using arc sine transformation $\text{Sin}^{-1}\sqrt{x/100}$ before further statistical analysis. The mean data on efficacy and yield were statistically analyzed and subjected to the analysis of variance by adopting the appropriate methods as outlined by Panse and Sukhatme (1978) and Gomez and Gomez (1984) by adopting "Fishers analysis of variance technique".

3.8 Meteorological data

Meteorological data on weekly basis for *Summer*, *Kharif*, and *Rabi* during the year 2021 were obtained from Meteorological Observatory of Department of Agricultural Meteorology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani from the same campus (Appendix-I, II and III).

CHAPTER IV
RESULTS AND DISCUSSION

CHAPTER-IV

RESULTS AND DISCUSSION

The present investigation was carried out to study the biology, host preference and management of melon fruit fly, *Bactrocera cucurbitae* (Coquillett) on cucumber at Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during 2020-21 and 2021-22. The results obtained are presented under the following heads.

4.1 Seasonal incidence of major sucking insect pests of cucumber in relation to weather parameters

The data on seasonal incidence of major insect pests of cucumber in relation to weather parameters is presented in below tables. The investigations were carried out during *Summer*, *Kharif* and *Rabi* season of 2021. The weather parameters *viz.*, maximum temperature, minimum temperature, rainfall, morning and evening relative humidity were taken for consideration.

4.1.1 Seasonal incidence of melon fruit fly, *Bactrocera cucurbitae* (Coquillett)

4.1.1.1 *Summer* 2021

Seasonal incidence of melon fruit fly infesting cucumber during *Summer* 2021 is presented in Table 4.1 and graphically depicted in Fig 4.1. The data revealed that the population of melon fruit fly was ranged from 65.00 (10th SMW) to 92.00 (13th SMW) fruit flies catches/trap. The incidence was started from 10th SMW (65 fruit flies catches/trap). The peak level of melon fruit fly population was 92.00 fruit flies catches/trap observed in 13th SMW. Thereafter population showed decreasing trend and it was 55.00 fruit flies catches/trap during 15th SMW.

4.1.1.2 *Kharif* 2021

During *Kharif* 2021 (Table 4.1 and Fig. 4.2) melon fruit fly population in cucumber was ranged between 34.00 to 90.00 fruit flies catches/trap. The incidence was first noted in 35th SMW (34.00 fruit flies catches/trap). The highest incidence was recorded in 37th SMW (90.00 fruit flies catches/trap). Thereafter melon fruit fly population declined and noted as 40 fruit flies catches/trap in 39th SMW.

4.1.1.3 *Rabi* 2021

Seasonal incidence of melon fruit fly infesting cucumber during *Rabi* 2021 is presented in Table 4.1 and graphically depicted in Fig 4.3. The data indicated that the melon fruit fly population was ranged from 35.00 to 73.00 fruit flies catches/trap in 49th SMW and 52nd SMW. The first incidence was started from 49th SMW (35 fruit flies catches/trap). The peak level of population melon fruit fly was observed during 52nd SMW (73.00 fruit flies catches/trap). After 52nd SMW the population decreased and reached to minimum (48 fruit flies catches/trap) in 2nd SMW.

Thus overall, it was observed that the maximum incidence of melon fruit fly was noticed during *Summer* than *Kharif* and *Rabi* season at fruiting stage.

The trend of melon fruit fly recorded in present investigations are more or less similar to those reported by Babu *et al*. (2002) who noticed B. *cucurbitae* increased gradually from 32th to 44th SMW, coinciding with 2nd week of August to last week of October thereafter it declined gradually up to 49th standard week and further rose during 5th SMW). Babu and Viraktamath (2003) observed that the maximum catch of fruit flies occurred during the 14th standard week i.e., first fortnight of November. Patnaik *et al*. (2004) the activity of melon fruit fly, *B. cucurbitae* was high in April-May. Banerji *et al.* (2005) reported that the highest incidence of *B. cucurbitae* on bitter gourd during *Kharif* followed by *Summer* and lowest in *Rabi*. Krishnakumar *et al*. (2006) noticed that *B. cucurbitae* prevailed throughout the year and maximum number of adults were trapped during August (14.14/trap/week). Singh and Naik (2006) revealed that the lowest melon fruit fly population observed during January and then gradually increased and attained peak in March, thereafter declined subsequently. Shivayya and Kumar (2008) observed that peak incidence of *B. cucurbitae* on bitter gourd during September and lowest incidence during November. Raguvanshi *et al.* (2012) recorded the incidence of *B. cucurbitae* with two peaks in *Summer* and *Kharif* during 14th and 43rd standard weeks with trap catches of 127.30 and 115 fruit flies, respectively in bitter gourd. 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

Table 4.1: Seasonal incidence of melon fruit fly of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

***Summer* 2021**			***Kharif* 2021**			***Rabi* 2021**		
SMW	**Period (Date)**	**Fruit flies catches/trap**	**SMW**	**Period (Date)**	**Fruit flies catches/trap**	**SMW**	**Period (Date)**	**Fruit flies catches/trap**
5	1.2.2021	0.00	29	16.7.2021	0.00	44	29.10.2021	0.00
6	8.2.2021	0.00	30	23.7.2021	0.00	45	5.11.2021	0.00
7	15.2.2021	0.00	31	30.7.2021	0.00	46	12.11.2021	0.00
8	22.2.2021	0.00	32	6.8.2021	0.00	47	19.11.2021	0.00
9	1.3.2021	0.00	33	13.8.2021	0.00	48	26.11.2021	0.00
10	8.3.2021	65.00	34	20.8.2021	34.00	49	3.12.2021	35.00
11	15.3.2021	75.00	35	27.8.2021	61.00	50	10.12.2021	45.00
12	22.3.2021	81.00	36	2.9.2021	83.00	51	17.12.2021	65.00
13	29.3.2021	92.00	37	9.9.2021	90.00	52	24.12.2021	73.00
14	5.4.2021	69.00	38	16.9.2021	45.00	1	1.1.2021	52.00
15	12.4.2021	55.00	39	23.9.201	40.00	2	8.1.2021	48.00

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. Maharjan *et al*. (2015) reported that highest number of fruit flies (167.5 male fruit flies/3traps) was recorded in the cue-lure trap during 1st week of September. The present findings are in accordance with Afroz *et al*. (2019) who observed that fruit fly showed the highest level of infestation during 3rd week of December, 3rd week of January and 4th week of February. Sen *et al*. (2022) reported that trap catches of *B. cucurbitae* was found maximum which varied in different weeks during February to June. The present findings are also supported by those of Nahid *et al*. (2020), Nair *et al*. (2020) and Sarade *et al*. (2021).

4.1.2 Seasonal incidence of whitefly, *Bemisia tabaci* (Gennadius)

4.1.2.1 *Summer* 2021

The data on fluctuations of whitefly population infesting cucumber during *Summer* 2021 (Table 4.2 and Fig. 4.4) revealed that the population of whitefly was ranged between 1.85 to 44.40 whiteflies/3 leaves/vine during 5th and 9th SMW. The incidence was first noticed in 5th SMW with peak during 9th SMW.

4.1.2.2 *Kharif* 2021

During *Kharif* 2021 (Table 4.2 and Fig. 4.5) whitefly population in cucumber was ranged between 1.05 to 13.20 whiteflies/3 leaves/vine. The incidence was first noted in 29th SMW (1.35 whiteflies/3 leaves/vine). The highest incidence was recorded in 32nd SMW (13.20 whiteflies/3 leaves/vine). Thereafter whitefly population declined and recorded as 5.23 whiteflies/3 leaves/vine in 36th SMW.

4.1.2.3 *Rabi* 2021

Seasonal incidence of whitefly infesting cucumber during *Rabi* 2021 is presented in Table 4.2 and depicted in Fig 4.6. The data indicated that the population ranged from 5.70 to 20.00 whiteflies/3 leaves/vine. The first incidence was started from 44th SMW (15.11 whiteflies/3 leaves/vine). The peak level was observed during 50th SMW (20.00 whiteflies/3 leaves/vine).

Recently we can make a hypothesis that *Summer* is more congenial to whitefly as that of *Kharif* and *Rabi*.

The present findings are in agreement with those of earlier researchers like Li *et al*. (2011) who observed that the family compositae, cruciferae, cucurbitaceae,

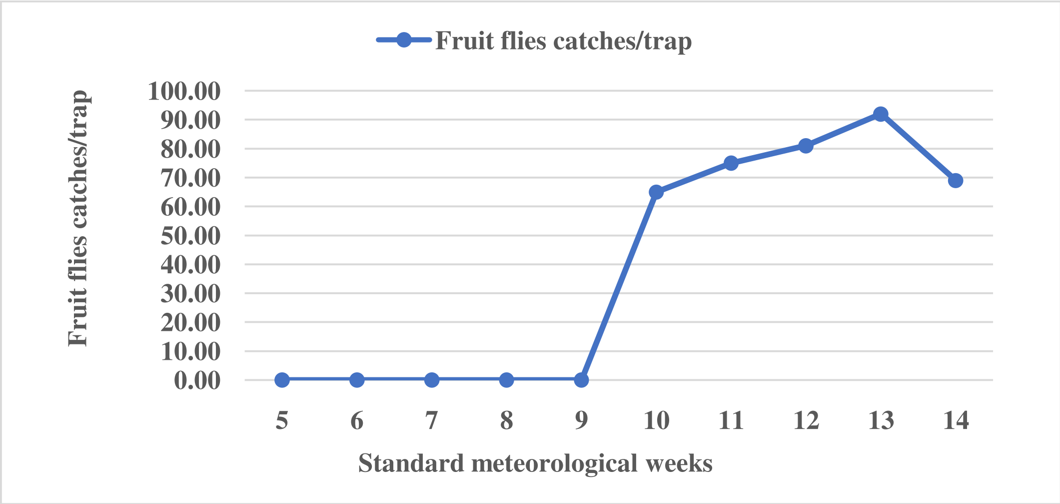

Fig. 4.1: Seasonal incidence of melon fruit fly of cucumber during *Summer* 2021

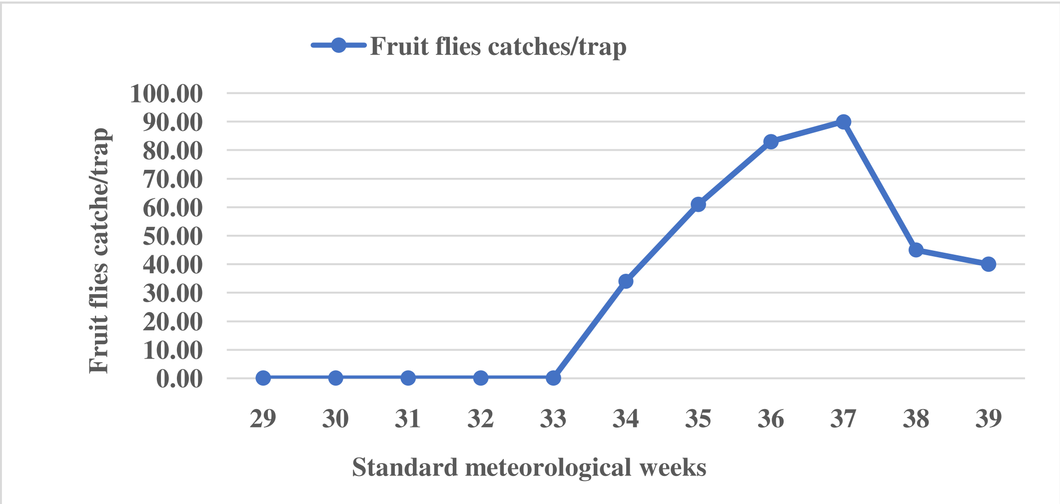

Fig. 4.2: Seasonal incidence of melon fruit fly of cucumber during *Kharif* 2021

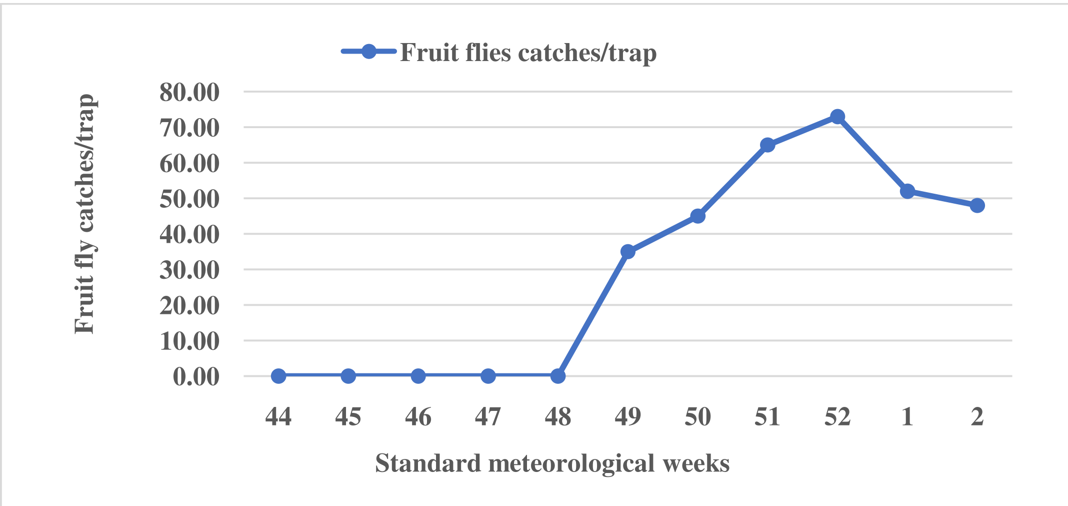

Fig. 4.3: Seasonal incidence of melon fruit fly of cucumber during *Rabi* 2021

solanaceae as well as leguminosae were the most preferred species for whitefly, *Bemisia tabaci* and thus large populations were frequently recorded on these species, regardless of the geographical distributions. Lekshmi *et al.* (2014) revealed that in bitter gourd, higher population of whiteflies was observed when the crop was young and declined later. Qureshi *et al.* (2017) revealed that the total nymph and adult whitefly population were in the range of 3.54-14.32 averaging 7.92 per leaf in Indian squash. Sunil *et al*. (2017) reported that mean population of whitefly observed in *Kharif* 0.60 and in *Rabi* 0.48. Gangurde *et al*. (2021) revealed that the maximum population of whitefly, *B. tabaci* (11.43 whitefly/leaf) was observed during 40^{th} SMW. Sarade *et al*. (2021) conducted field experiment during *Rabi* season and revealed that, the whitefly population was recorded in 3^{rd} MW (5 whitefly/leaf). Sen *et al*. (2022) revealed that the population of whitefly *B. tabaci* was recorded during the month of April, May and June, respectively.

Table 4.2: Seasonal incidence of whitefly on *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

***Summer* 2021**			***Kharif* 2021**			***Rabi* 2021**		
SMW	**Period (Date)**	**No. of whitefly/3 leaves/vine**	**SMW**	**Period (Date)**	**No. of whitefly/3 leaves/vine**	**SMW**	**Period (Date)**	**No. of whitefly/3 leaves/vine**
5	1.2.2021	1.85	29	16.7.2021	1.35	44	29.10.2021	15.11
6	8.2.2021	3.75	30	23.7.2021	1.05	45	5.11.2021	19.23
7	15.2.2021	6.25	31	30.7.2021	1.15	46	12.11.2021	9.35
8	22.2.2021	4.50	32	6.8.2021	13.20	47	19.11.2021	10.15
9	1.3.2021	44.40	33	13.8.2021	1.40	48	26.11.2021	13.50
10	8.3.2021	24.95	34	20.8.2021	1.80	49	3.12.2021	8.10
11	15.3.2021	13.90	35	27.8.2021	8.25	50	10.12.2021	20.00
12	22.3.2021	16.20	36	2.9.2021	5.23	51	17.12.2021	5.70
13	29.3.2021	22.50	37	9.9.2021	11.85	52	24.12.2021	13.35
14	5.4.2021	20.25	38	16.9.2021	6.20	1	1.1.2021	10.85
15	12.4.2021	9.40	39	23.9.201	6.00	2	8.1.2021	10.00

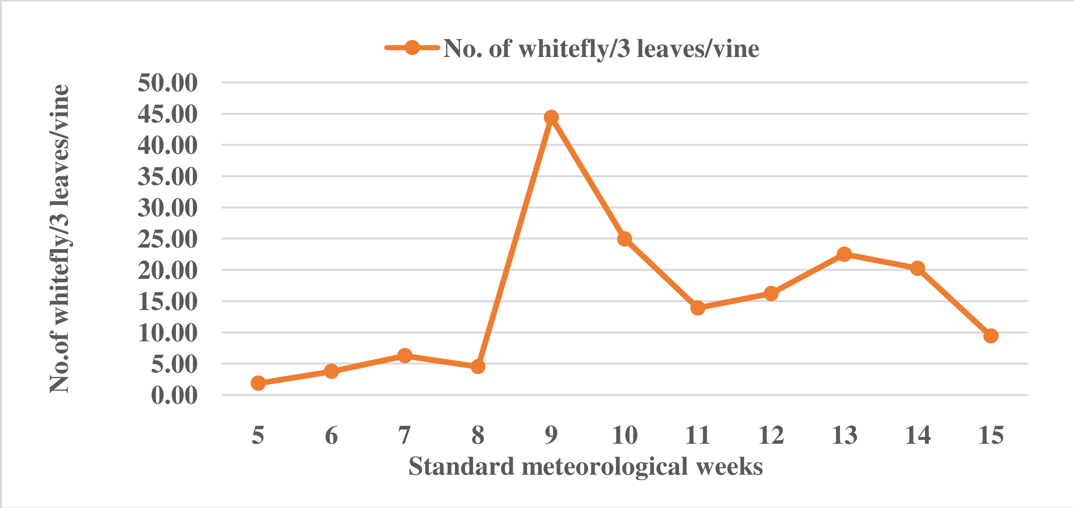

Fig. 4.4: Seasonal incidence of whitefly on cucumber during *Summer* 2021

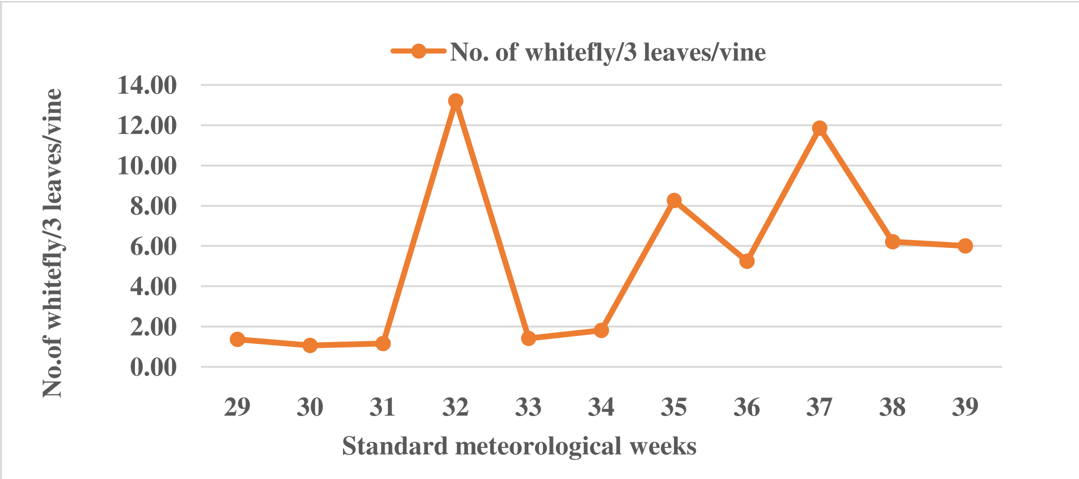

Fig. 4.5: Seasonal incidence of whitefly on cucumber during *Kharif* 2021

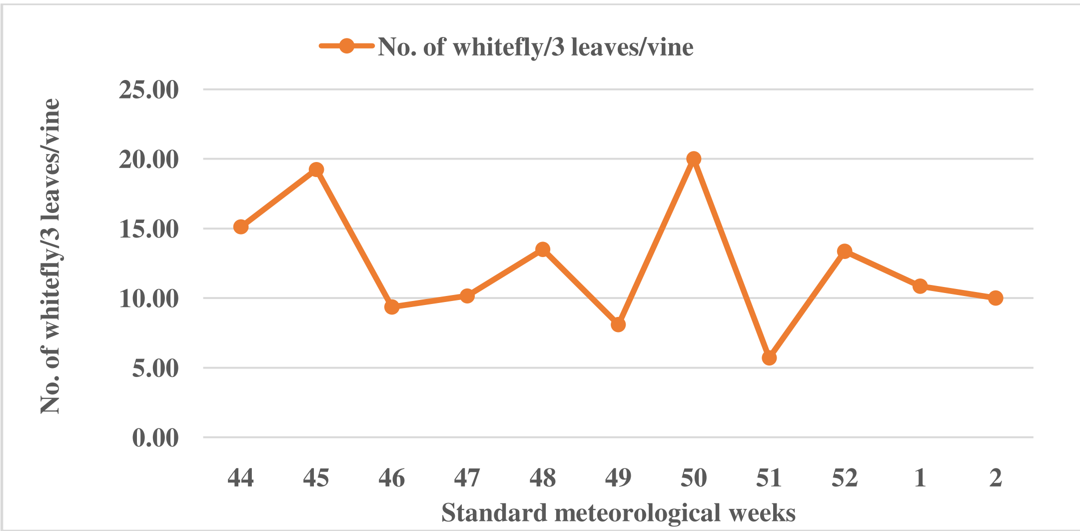

Fig. 4.6: Seasonal incidence of whitefly on cucumber during *Rabi* 2021

4.1.3 Seasonal incidence of thrips, *Thrips palmi* (Karny)

4.1.3.1 *Summer* 2021

The data on population of thrips on cucumber during *Summer* 2021 (Table 4.3 and Fig. 4.7) ranged between 2.20 to 23.10 thrips/3 leaves/vine. The incidence was initiated at 5th SMW (2.95 thrips/3 leaves/vine).

4.1.3.2 *Kharif* 2021

The population of thrips during *Kharif* 2021 (Table 4.3 and Fig. 4.8) was ranged from 5.22 to 15.23 thrips/3 leaves/ vine in 29th and 32nd SMW. The incidence was started from 29th SMW (5.22 thrips/3 leaves/vine). The highest population of thrips was recorded in 32nd SMW (15.23 thrips/3 leaves/vine). Thereafter thrips population declined and recorded as 7.50 thrips/3 leaves/vine in 39th SMW.

4.1.3.3 *Rabi* 2021

Seasonal activity of thrips on cucumber during *Rabi* 2021 is presented in Table 4.3 and depicted in Fig 4.9. The data showed that the thrips population was ranged from 1.25 to 14.70 thrips/3 leaves/vine.

Thus overall, it can be concluded that the incidence of thrips recorded throughout the season but maximum incidence was observed in *Summer* than *Kharif* and *Rabi* season at vegetative stage of crop.

The present findings are similar with the findings of earlier workers Picault (2014) found that the thrips (*Thrip tabaci*) could cause severe damage, first on cucurbitaceous vegetables. Sunil *et al*. (2017) reported that mean population of thrips 0.30 in *Kharif* and 1.50 in *Rabi* season. Gangurde *et al*. (2021) revealed that the maximum population of *T. palmi* (11.37 thrips/leaf) was observed during 14th SMW. Kajita et al. (1996) found that *Thrips palmi* Karny attacked ridge gourd, bitter gourd, cucumber, aubergine, goat pepper, muskmelon, pumpkin, squash, watermelon, wax gourd.

Table 4.3: Seasonal incidence of thrips of *Cucumis sativus* during *Summer* 2021, *Kharif* 2021 and *Rabi* 2021

***Summer* 2021**			***Kharif* 2021**			***Rabi* 2021**		
SMW	**Period (Date)**	**No. of thrips /3 leaves/vine**	**SMW**	**Period (Date)**	**No. of thrips /3 leaves/vine**	**SMW**	**Period (Date)**	**No. of thrips /3 leaves/vine**
5	1.2.2021	2.95	29	16.7.2021	5.22	44	29.10.2021	1.25
6	8.2.2021	4.85	30	23.7.2021	8.50	45	5.11.2021	2.55
7	15.2.2021	4.00	31	30.7.2021	12.50	46	12.11.2021	7.00
8	22.2.2021	2.20	32	6.8.2021	15.23	47	19.11.2021	9.30
9	1.3.2021	20.12	33	13.8.2021	11.10	48	26.11.2021	13.15
10	8.3.2021	18.20	34	20.8.2021	12.41	49	3.12.2021	13.50
11	15.3.2021	8.10	35	27.8.2021	11.90	50	10.12.2021	14.70
12	22.3.2021	10.20	36	2.9.2021	11.95	51	17.12.2021	14.65
13	29.3.2021	12.50	37	9.9.2021	13.85	52	24.12.2021	13.85
14	5.4.2021	23.10	38	16.9.2021	9.90	1	1.1.2021	14.30
15	12.4.2021	8.60	39	23.9.201	7.50	2	8.1.2021	10.50

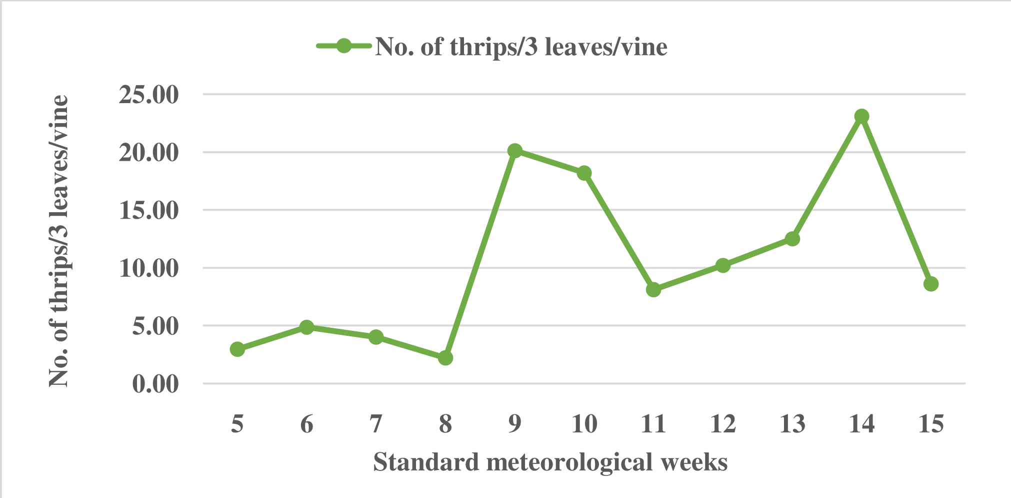

Fig. 4.7: Seasonal incidence of thrips on cucumber during *Summer* 2021

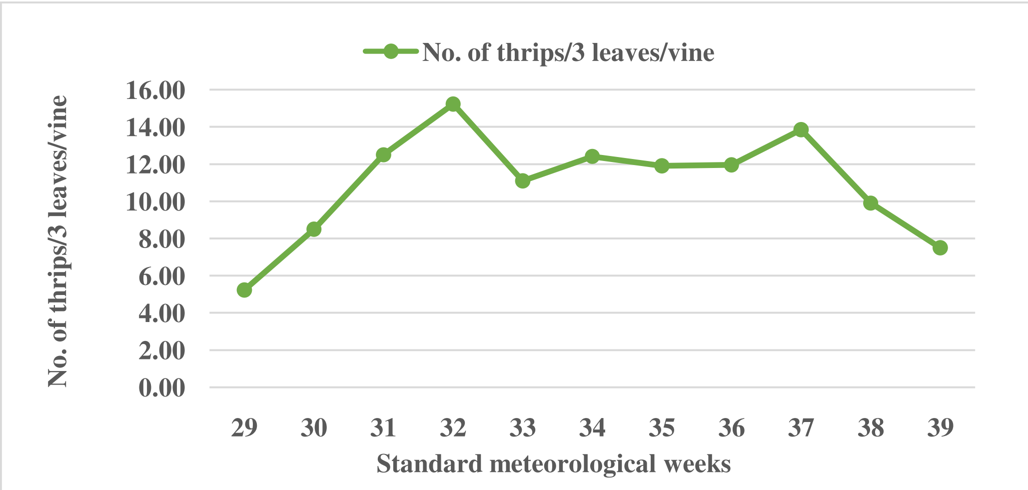

Fig. 4.8: Seasonal incidence of thrips on cucumber during *Kharif* 2021

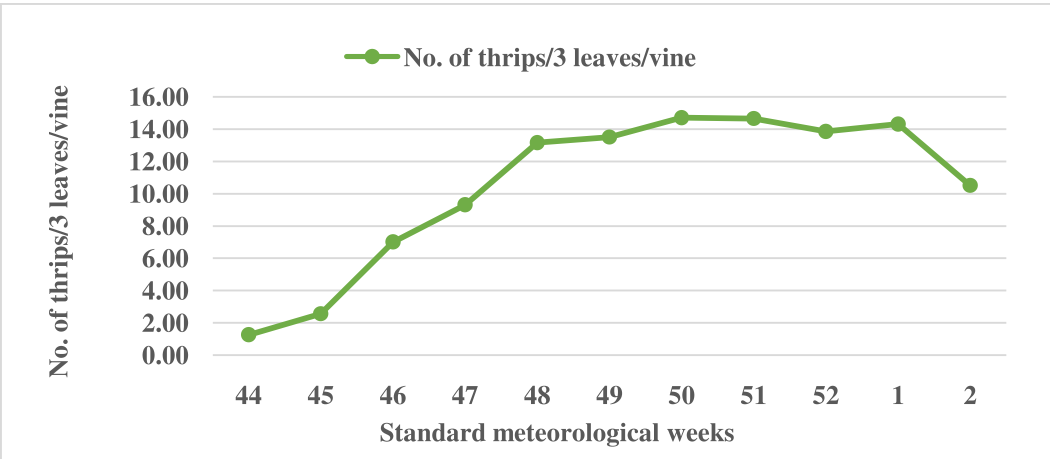

Fig. 4.9: Seasonal incidence of thrips on cucumber during *Rabi* 2021

4.1.4 Seasonal incidence of red pumpkin beetle, *Aulacophora foveicollis* (Lucas)

4.1.4.1 *Summer* 2021

Observations noted on seasonal incidence of red pumpkin beetle are presented in Table 4.4 and Fig. 4.10. It clearly indicated that the pest was prevalent throughout the cropping season. The incidence was first appeared in 7th SMW (0.50 beetle/vine) and thereafter it steadily increased. The highest incidence was noted in 8th SMW (2.50 beetle/vine).

4.1.4.2 *Kharif* 2021

During *Kharif* 2021 (Table 4.4 and Fig. 4.11) red pumpkin beetle population was ranged between 0.50 to 2.50 beetle/vine during 31st and 32nd SMW. The population steadily increased and reached to its peak in the 32nd SMW (2.50 beetle/vine).

4.1.4.3 *Rabi* 2021

The data presented in Table 4.4 and depicted in Fig. 4.12 revealed that the red pumpkin beetle was ranged from 0.40 to 1.35 beetles/vine in 46th and 52nd SMW. The first incidence was noticed in 46th SMW (0.40 beetles/vine).

Thus overall, by the study of seasonal incidence of red pumpkin beetle during three seasons, it can be concluded that maximum incidence was noticed in *Summer* as compare to *Kharif* and *Rabi* season

The present findings on incidence of red pumpkin beetles are more or less similar as sowing period may vary confirming with those of Borah (1999) who recorded that highest number of beetles in rainy season (June) in all the three varieties (AAUC 1, AAUC 2 and Diphu Local) with 3.6 - 4.2 beetles/plant and 39.2 - 46.6 per cent plant damage followed by *Summer* crop with 2.8 beetles/plant and 33.6 per cent plant damage and winter crop with 2.1 beetles/plant and 21.1% plant damage. Rajak (2000) reported that overwintering beetles become active during 7th SW (February) reach maximum population (28.6 beetles/5 plants) during 18th (April) and minimum population (1.66 beetles/5 plants) during 7th SW (February). According to Johri and Johri (2003) beetle incidence was more during March to September ranging from

Table 4.4: Seasonal incidence of red pumpkin beetle of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

***Summer* 2021**			***Kharif* 2021**			***Rabi* 2021**		
SMW	**Period (Date)**	**Red pumpkin beetle/vine**	**SMW**	**Period (Date)**	**Red pumpkin beetle/vine**	**SMW**	**Period (Date)**	**Red pumpkin beetle/vine**
5	1.2.2021	0.00	29	16.7.2021	0.00	44	29.10.2021	0.00
6	8.2.2021	0.00	30	23.7.2021	0.00	45	5.11.2021	0.00
7	15.2.2021	0.50	31	30.7.2021	0.50	46	12.11.2021	0.40
8	22.2.2021	2.50	32	6.8.2021	2.50	47	19.11.2021	0.75
9	1.3.2021	1.25	33	13.8.2021	1.20	48	26.11.2021	0.65
10	8.3.2021	1.55	34	20.8.2021	1.00	49	3.12.2021	0.75
11	15.3.2021	1.30	35	27.8.2021	1.15	50	10.12.2021	0.95
12	22.3.2021	2.10	36	2.9.2021	1.20	51	17.12.2021	1.30
13	29.3.2021	1.65	37	9.9.2021	1.25	52	24.12.2021	1.35
14	5.4.2021	1.75	38	16.9.2021	1.30	1	1.1.2021	1.40
15	12.4.2021	1.55	39	23.9.201	1.35	2	8.1.2021	0.95

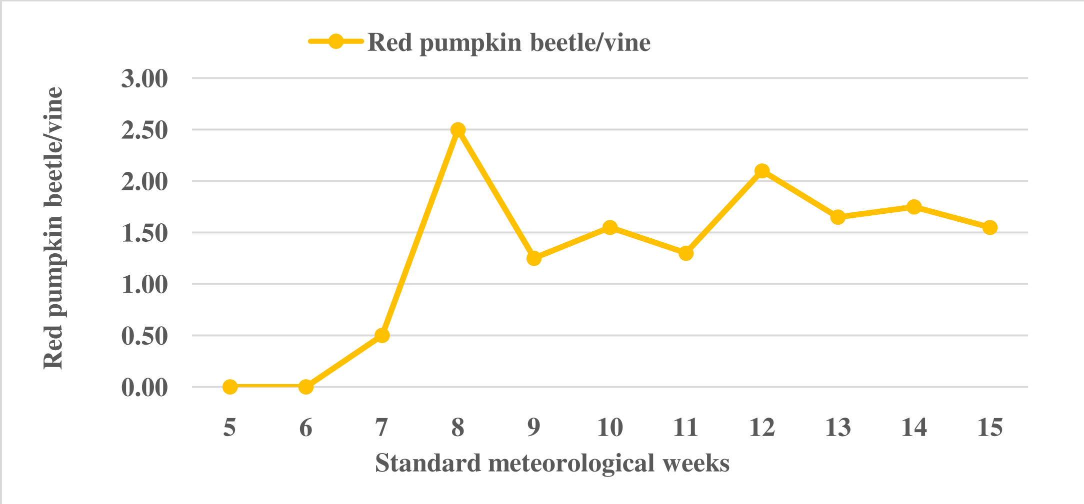

Fig. 4.10: Seasonal incidence of red pumpkin beetle on cucumber during *Summer* 2021

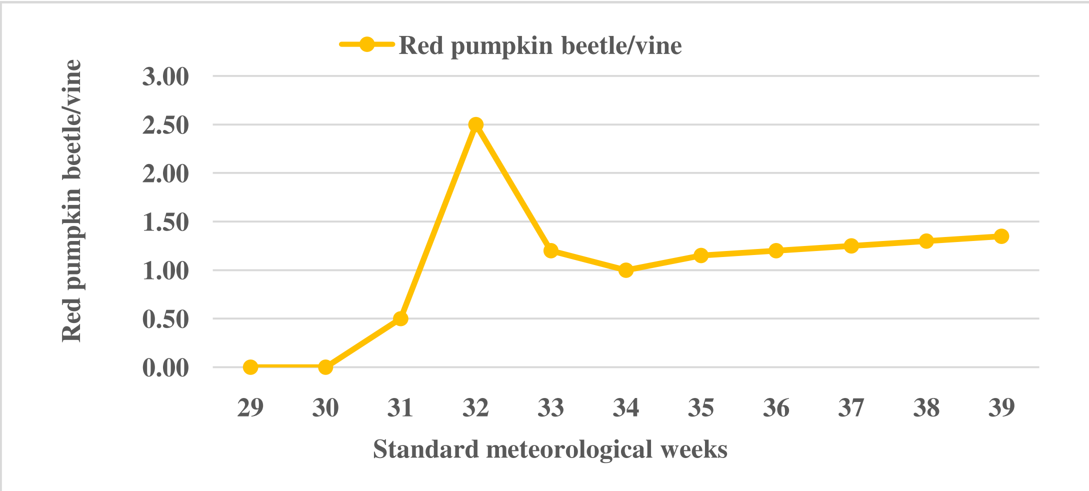

Fig. 4.11: Seasonal incidence of red pumpkin beetle on cucumber during *Kharif* 2021

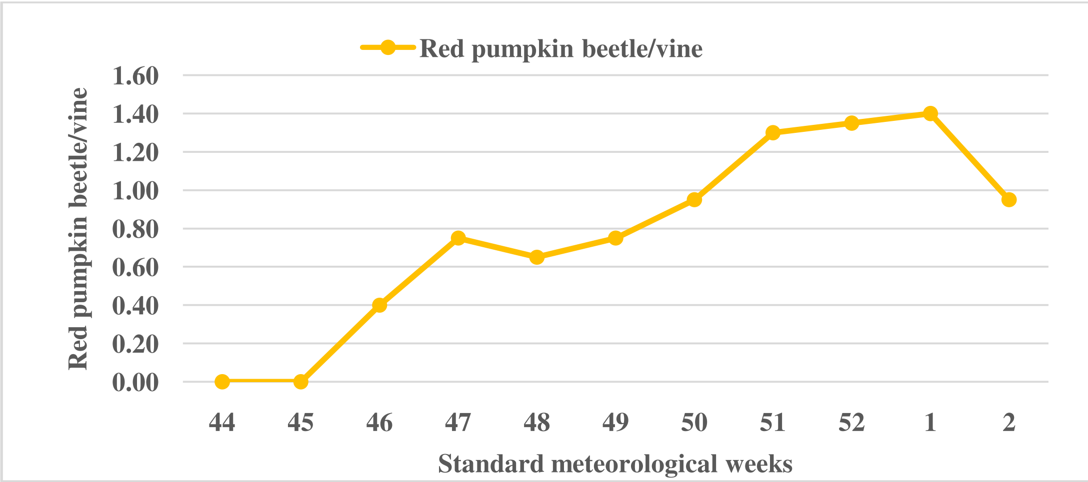

Fig. 4.12: Seasonal incidence of red pumpkin beetle on cucumber during *Rabi* 2021

27.70 to 47.49 per cent and the lowest at 3.92 per cent in February. Sheikh *et al.* (2013) noticed that first appearance during first fortnight of March and reached to its peak during 3rd and 2nd weeks of April, 2009 and 2010. Ravi Kumar and Saini (2018) revealed that red pumpkin beetle, occurrence began during 35th SMW (27th August to 2th September). The peak population (4.80 beetles/five plant) was observed during the first week of October, 2012. Shinde *et al.* (2018) noticed initiation of red pumpkin beetle infestation (2.48) in the 26th SMW (25 June-01July). Minimum red pumpkin beetle infestation (0.48 ± 1.20) was recorded in 37th SMW (10-16 September), while maximum (3.64 ± 1.20) infestation was recorded during 32nd SMW (06-12August). Afroz *et al.* (2019) reported that red pumpkin beetle showed the highest level of infestation during 3rd week of December, 3rd week of January and 4th week of February. Gharde *et al.* (2019) observed that red pumpkin beetle started infesting the crop from 8th SW with mean population (6.22). Pansara *et al.* (2022) reported that population of red pumpkin beetle on cucumber initiated from 3rd week of March (11th SMW, 4th WAS) and persisted till 4th week of May (21th SMW, 14th WAS) in the range of 0.13 to 3.30 beetles/plant with an average of 1.49 beetles/plant. The population reached to the first (2.53 beetles/plant) and second as well as the highest (3.30 beetles/plant) peak during 2nd week of April (15th SMW, 8th WAS) and 1st week of May (18th SMW, 11th WAS), respectively. Sen *et al.* (2022) revealed that the population of red pumpkin beetle, was recorded during the month of April, May and June, respectively.

4.1.5 Seasonal abundance of lady bird beetle

4.1.5.1 *Summer* 2021

The population of lady bird beetle ranged from 0.20 to 2.00 lbbs/vine during 7^{th} and 11^{th} SMW. The highest population was noticed in 11^{th} SMW *i.e.* 2.00 lbbs/vine, thereafter the population decreased (Table 4.5 and Fig. 4.13)

4.1.5.2 *Kharif* 2021

During *Kharif* 2021 (Table 4.5 and Fig. 4.14) lady bird beetle population was ranged between 0.20 to 3.50 lbbs/vine. The incidence was first appeared in 29^{th} SMW (0.20 lbbs/vine) thereafter population steadily increased.

4.1.5.3 *Rabi* 2021

Seasonal abundance of lady bird beetle on cucumber during *Rabi* 2021 is presented in Table 4.5 and graphically depicted in Fig 4.15. The results revealed that lady bird beetle population was noticed first in 46th SMW (0.20 lbbs/vine). Thereafter the population increased and highest population was observed in 50th SMW (1.20 lbbs/vine)

4.1.6 Seasonal abundance of predatory spider

4.1.6.1 *Summer* 2021

The population of natural enemies ranged between 0.20 to 1.00 spiders/vine observed in 15th and 12th SMW. The natural enemies were first noticed in 10th SMW (0.50 spiders/vine) thereafter population steadily increased (Table 4.6 and Fig. 4.16)

4.1.6.2 *Kharif* 2021

During *Kharif* 2021 (Table 4.6 and Fig. 17) the natural enemies was first appeared during 34th SMW (1.10 spiders/vine). The population increased after 34th SMW and reached to the peak level of 2.00 spiders/vine in 36th SMW. Thereafter population was declined and lowest population was observed in 39th SMW (0.20 spiders/vine).

4.1.6.3 *Rabi* 2021

The population of spiders on cucumber during *Rabi* 2021 is presented in Table 4.6 and depicted in Fig 4.18. The results found that the first appearance spiders were noted in 49th SMW (0.20 spiders/vine). Thereafter the population increased and highest population of spiders was recorded in 52nd SMW (1.00 spiders/vine).

The population of natural enemies *viz.*, lady bird beetle and predatory spider was observed throughout the cropping period in all the seasons, but maximum population of natural enemies was noticed in *Summer* than *Kharif* and *Rabi* season when there was more incidence of sucking pests.

Table 4.5: Seasonal abundance of lady bird beetle of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

***Summer* 2021**			***Kharif* 2021**			***Rabi* 2021**		
SMW	**Period (Date)**	**Lady bird beetle/vine**	**SMW**	**Period (Date)**	**Lady bird beetle/vine**	**SMW**	**Period (Date)**	**Lady bird beetle/vine**
5	1.2.2021	0.00	29	16.7.2021	0.20	44	29.10.2021	0.00
6	8.2.2021	0.00	30	23.7.2021	0.85	45	5.11.2021	0.00
7	15.2.2021	0.20	31	30.7.2021	1.05	46	12.11.2021	0.20
8	22.2.2021	0.70	32	6.8.2021	3.50	47	19.11.2021	0.60
9	1.3.2021	1.00	33	13.8.2021	1.25	48	26.11.2021	0.40
10	8.3.2021	1.20	34	20.8.2021	0.50	49	3.12.2021	1.00
11	15.3.2021	2.00	35	27.8.2021	0.65	50	10.12.2021	1.20
12	22.3.2021	1.10	36	2.9.2021	0.50	51	17.12.2021	0.70
13	29.3.2021	1.50	37	9.9.2021	0.45	52	24.12.2021	0.50
14	5.4.2021	1.00	38	16.9.2021	0.80	1	1.1.2021	0.20
15	12.4.2021	0.40	39	23.9.201	0.65	2	8.1.2021	0.00

Table 4.6: Seasonal abundance of predatory spider of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

***Summer* 2021**			***Kharif* 2021**			***Rabi* 2021**		
SMW	**Period (Date)**	**Predatory spider/vine**	**SMW**	**Period (Date)**	**Predatory spider/vine**	**SMW**	**Period (Date)**	**Predatory spider/vine**
5	1.2.2021	0.00	29	16.7.2021	0.00	44	29.10.2021	0.00
6	8.2.2021	0.00	30	23.7.2021	0.00	45	5.11.2021	0.00
7	15.2.2021	0.00	31	30.7.2021	0.00	46	12.11.2021	0.00
8	22.2.2021	0.00	32	6.8.2021	0.00	47	19.11.2021	0.00
9	1.3.2021	0.00	33	13.8.2021	0.00	48	26.11.2021	0.00
10	8.3.2021	0.50	34	20.8.2021	1.10	49	3.12.2021	0.20
11	15.3.2021	0.70	35	27.8.2021	1.80	50	10.12.2021	0.35
12	22.3.2021	1.00	36	2.9.2021	2.00	51	17.12.2021	0.80
13	29.3.2021	0.80	37	9.9.2021	0.80	52	24.12.2021	1.00
14	5.4.2021	0.50	38	16.9.2021	0.60	1	1.1.2021	0.60
15	12.4.2021	0.20	39	23.9.201	0.20	2	8.1.2021	0.40

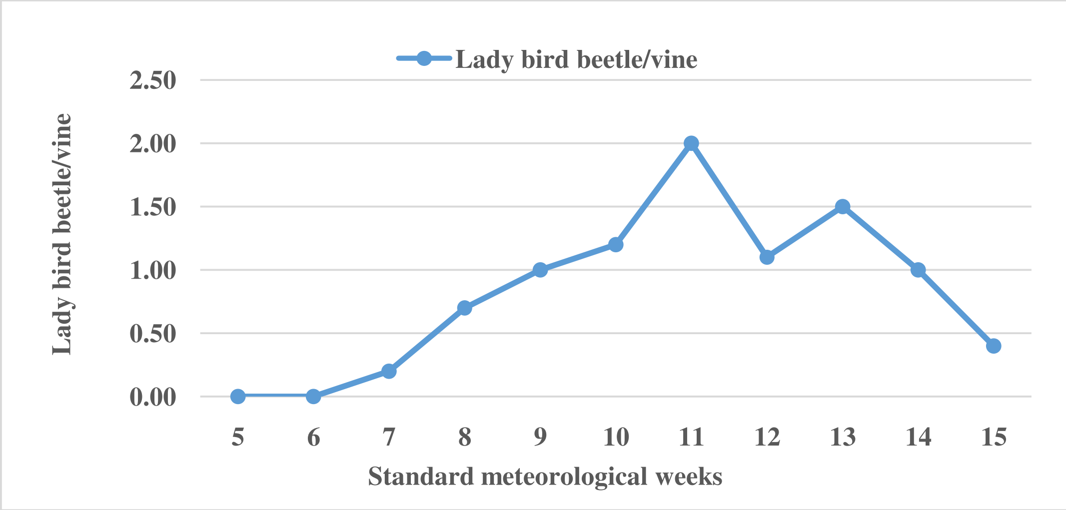

Fig. 4.13: Seasonal abundance of lady bird beetle on cucumber during *Summer* 2021

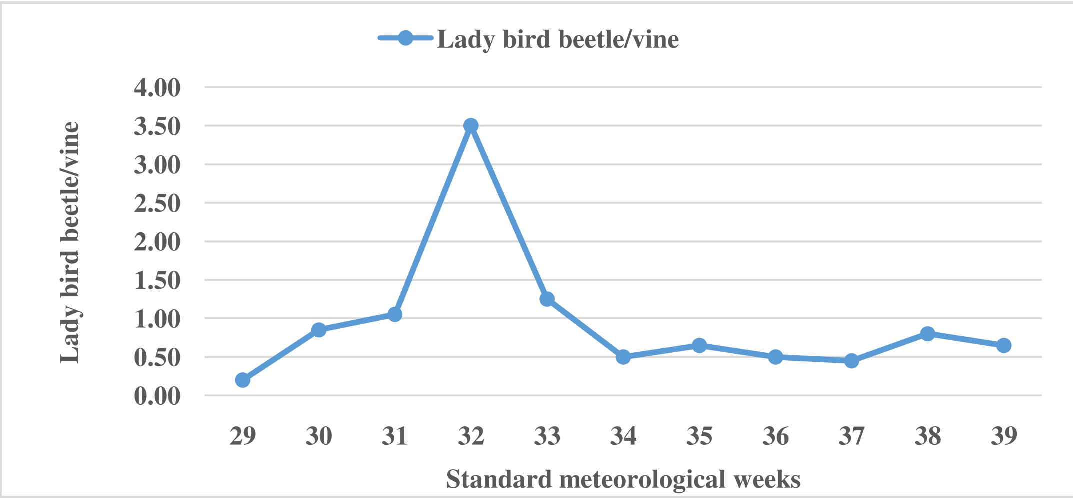

Fig. 4.14: Seasonal abundance of lady bird beetle on cucumber during *Kharif* 2021

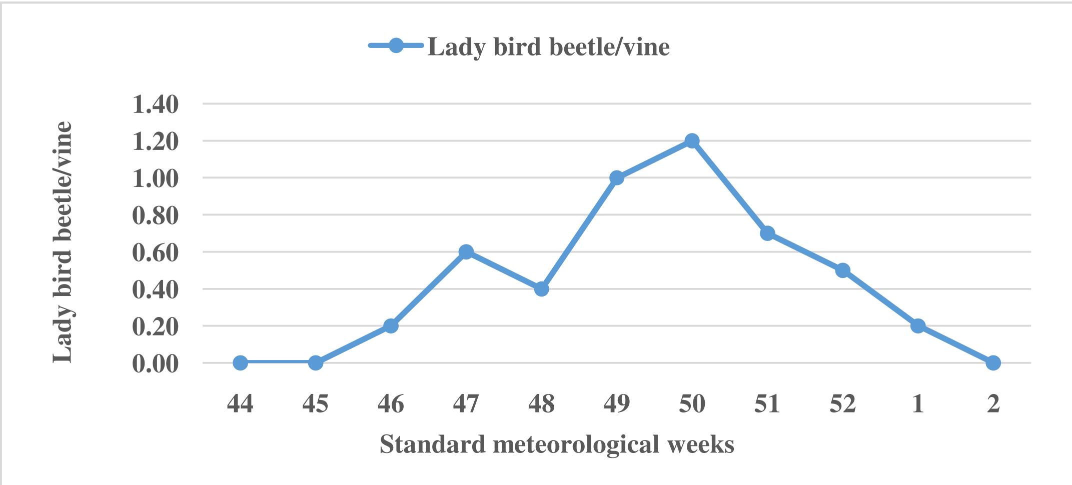

Fig. 4.15: Seasonal abundance of lady bird beetle on cucumber during *Rabi* 2021

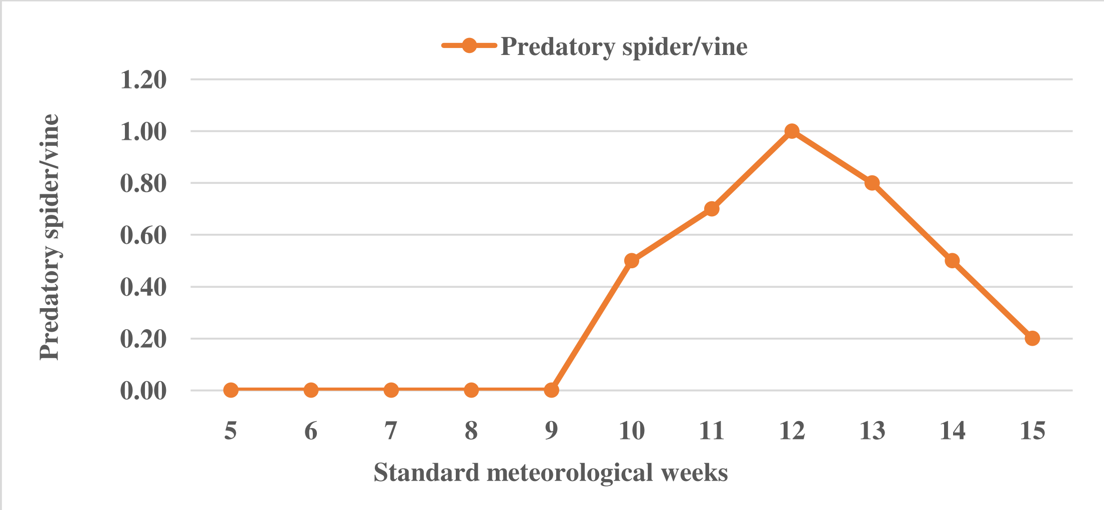

Fig. 4.16: Seasonal abundance of predatory spider on cucumber during *Summer* 2021

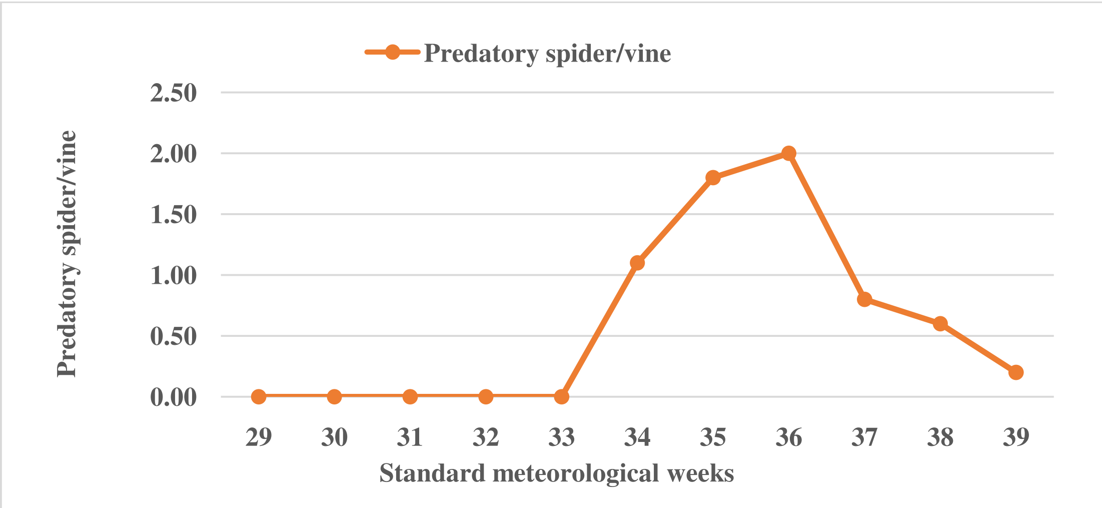

Fig. 4.17: Seasonal abundance of predatory spider on cucumber during *Kharif* 2021

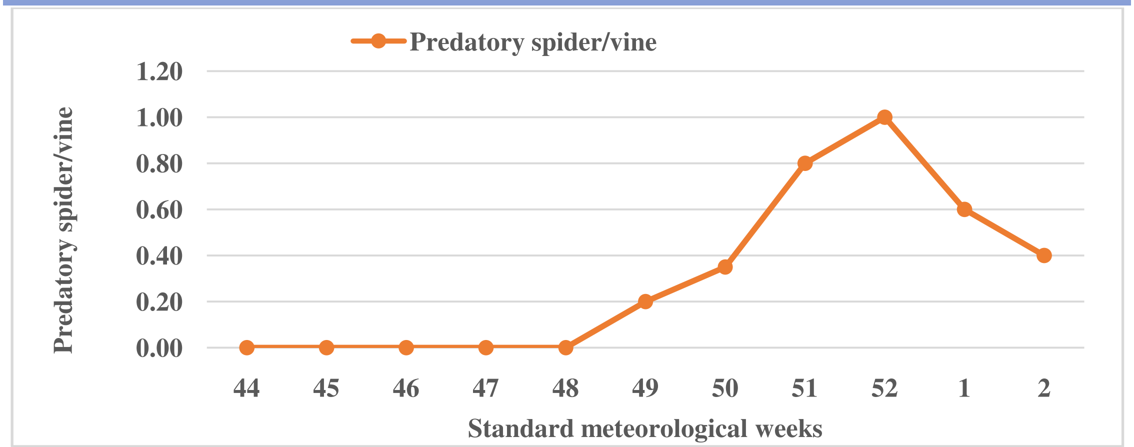

Fig. 4.18: Seasonal abundance of predatory spider on cucumber during *Rabi* 2021

The above findings are in confirmation with those of Sunil *et al*. (2017) who revealed that increased in the incidence of sucking insect pests led to increased population of predatory coccinellid beetles on bitter gourd. Numbers of predatory beetles and other natural enemies should maintain populations of sucking pests below economic injury level on bitter gourd. Sen *et al*. (2022) revealed that the population of predatory coccinellids was recorded during the month of April, May and June. The present findings are also supported by Tamoghnasaha *et al*. (2018).

4.1.7 Simple correlation between weather parameters and major insect pests of cucumber

The data pertaining to the population of major insect pests in cucumber were correlated with weather parameters *viz*., maximum temperature, minimum temperature, rainfall morning and evening relative humidity and simple correlation workout.

4.1.7.1 Simple correlation between weather parameters and melon fruit fly, *Bactrocera cucurbitae* (Coquillett)

The data presented in Table 4.7 pertaining to simple correlation for melon fruit fly showed that positive and highly significant correlation with maximum temperature (r = 0.79**) and minimum temperature (r = 0.75**). While negatively non-significant with rainfall (r = -0.01^{NS}) and evening relative humidity (r = -0.41^{NS}), whereas morning relative humidity was negatively significant with melon fruit fly (r = -0.72^{NS}) during *Summer* 2021

During *Kharif* 2021 the population of fruit fly showed negatively non-significant correlation with maximum temperature (r = -0.47^{NS}) and minimum temperature (r = -0.19^{NS}). While positively non-significant with morning relative humidity (r = 0.26^{NS}) and evening relative humidity (r = 0.52^{NS}), whereas rainfall was positively significant (r = 0.60*).

The population of fruit fly showed negative and highly significant correlation with maximum temperature (r = -0.80**) and minimum temperature (r = -0.66**) and negatively non-significant with rainfall (r = -0.01^{NS}) and evening relative humidity (r = 0.07^{NS}) whereas morning relative humidity was positively significant (r = 0.59*).

The above findings are in consonance with those of earlier research workers Jalaluddin *et al*. (2001) who reported that the weekly trap catches were positively and significantly correlated with maximum, minimum temperatures, relative humidity and rainfall.

Table 4.7: Correlation between weather parameters and melon fruit fly of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

Weather parameters	Correlation coefficient value (r)		
	***Summer*2021**	***Kharif* 2021**	***Rabi* 2021**
Maximum temperature (^{0}C)	0.79**	-0.47 ^{NS}	-0.80**
Minimum temperature (^{0}C)	0.75**	-0.19 ^{NS}	-0.66*
Rainfall (mm)	-0.01^{NS}	0.60*	-0.01^{NS}
Morning relative humidity (%)	-0.72*	0.26^{NS}	0.59*
Evening relative humidity (%)	-0.41 ^{NS}	0.52^{NS}	-0.067^{NS}
*Significant at 5% level, **Significant at 1% level			

Ingoley *et al.* (2002) revealed that a positive correlation existed between temperature, relative humidity and rainfall and *B. cucurbitae* incidence. Banerji *et al.* (2005) reported that the per cent fruit infestation was positively correlated with minimum temperature during *Rabi* and *Summer* seasons. Krishnakumar *et al*. (2006) noticed that *B. cucurbitae* was significantly and positively correlated with relative humidity. Mandal *et al.* (2006) reported that *B. cucurbitae* exhibited significant positive correlation with minimum temperature and relative humidity and non-significant correlation with the maximum temperature. Singh and Naik (2006) revealed that the pest population showed positive correlation with maximum temperature but humidity showed negative correlation. Hasyim *et al.* (2008) reported that the number of flies trapped with cue lure had a positive and highly significant correlation with rainfall and temperature. Shivayya and Kumar (2008) observed that the incidence and population fluctuation were significantly correlated with maximum temperature, rainfall, evening relative humidity and average relative humidity. More or less similar observations were also recorded by Lashkar and Chatterjee (2010), Sharma *et al*. (2010), Raguvanshi *et al.* (2012), Vignesh and Viraktamath (2015), Abhilash *et al*. (2017), Abro *et al.* (2017), Das *et al*. (2017) Sunil *et al.* (2017), Sohrab *et al*. (2018), Tamoghnasaha *et al*. (2018), Afroz *et al*. (2019) and Nair *et al*. (2020).

4.1.7.2 Simple correlation between weather parameters and whitefly fly, *Bemisia tabaci* (Gennadius)

The population of whitefly (Table 4.8) in relation to maximum temperature was positively significant (r = 0.65*). While positively non-significant with minimum temperature (r = 0.34^{NS}) and morning relative humidity (r = 0.10^{NS}) whereas rainfall was found negatively non-significant (r = -0.24^{NS}). Evening relative humidity was negatively significant correlation (r = -0.64^{NS}) during *Summer* 2021.

During *Kharif* 2021 the population of whitefly showed positively non-significant correlation with maximum temperature (r = 0.44^{NS}) and minimum temperature (r = 0.32^{NS}). While negatively non-significant with rainfall (r = -0.04^{NS}), morning relative humidity (r = -0.15^{NS}) and evening relative humidity (r = -0.34^{NS}).

The population of whitefly in relation to maximum temperature was positively non-significant (r = 0.43^{NS}). The other parameters like minimum temperature, rainfall, morning relative humidity and evening relative humidity were found negatively non-significant during *Rabi* 2021.

Table 4.8: Correlation between weather parameters and whitefly of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

Weather parameters	Correlation coefficient value (r)		
	***Summer* 2021**	***Kharif* 2021**	***Rabi* 2021**
Maximum temperature (^{0}C)	0.65*	0.44^{NS}	0.43^{NS}
Minimum temperature (^{0}C)	0.34^{NS}	0.32^{NS}	-0.12^{NS}
Rainfall (mm)	-0.24^{NS}	-0.04^{NS}	-0.36^{NS}
Morning relative humidity (%)	0.10^{NS}	-0.15^{NS}	-0.24^{NS}
Evening relative humidity (%)	-0.64*	-0.34^{NS}	-0.43^{NS}
*Significant at 5% level, **Significant at 1% level			

The above findings are parallel with those of earlier workers Lekshmi *et al.* (2014) who reported that maximum, minimum and average temperature had significant negative correlation on the population buildup of whitefly. Tamoghnasaha *et al*. (2018) reported that whitefly (*Bemisia tabaci* Gennadius) showed significant positive correlation with maximum and minimum temperature whereas negative and non-significant correlation with relative humidity and rainfall. Gangurde *et al*. (2021)

showed non-significant and positive correlation with maximum temperature and non-significant negative correlation with minimum temperature in respect of whitefly population.

4.1.7.3 Simple correlation between weather parameters and thrips, *Thrips palmi* (Karny)

During *Summer* 2021, the population of thrips (Table 4.9) in relation to maximum temperature was positive and highly significant (r = 0.81**). Minimum temperature was positively non-significant (r = 0.52^{NS}). Rainfall (r = -0.33^{NS}) and morning relative humidity (r = -0.32^{NS}) was found negatively non-significant while evening relative humidity (r = 0.77**) showed negative highly significant correlation

The population of thrips showed positively non-significant correlation with maximum temperature (r = 0.47^{NS}) and minimum temperature (r = 0.11^{NS}). While negatively non-significant with rainfall (r = -0.38^{NS}) and morning relative humidity (r = -0.38^{NS}) whereas evening relative humidity (r = -0.58*) was found negatively significant during *Kharif* 2021.

The population of thrips was found positive, highly significant correlation with maximum temperature (r = 0.71**) and morning relative humidity (r = 0.83**). Rainfall (0.19^{NS}) and evening relative humidity (0.06^{NS}) was showed that positively non-significant correlation while minimum temperature found negatively non-significant with thrips population during *Rabi* 2021.

The present findings are more or less in accordance with the findings of Gangurde *et al*. (2021) who revealed that the incidence of thrips showed non-significant and positive correlation with maximum temperature and non-significant negative correlation with minimum temperature.

Table 4.9: Correlation between weather parameters and thrips of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

Weather parameters	**Correlation coefficient value (r)**		
	***Summer* 2021**	***Kharif* 2021**	***Rabi* 2021**
Maximum temperature (^{0}C)	0.81**	0.47^{NS}	0.71**
Minimum temperature (^{0}C)	0.52^{NS}	0.11^{NS}	-0.38^{NS}
Rainfall (mm)	-0.33^{NS}	-0.38^{NS}	0.19^{NS}
Morning relative humidity (%)	-0.32^{NS}	-0.38^{NS}	0.83**
Evening relative humidity (%)	-0.77**	-0.58*	0.06^{NS}
*Significant at 5% level, **Significant at 1% level			

4.1.7.4 Simple correlation between weather parameters and red pumpkin beetle, *Aulacophora foveicollis (*Lucas)

During *Summer* 2021 the incidence of red pumpkin beetle (Table 4.10) in relation to maximum temperature (r = 0.40^{NS}), morning relative humidity (r = 0.01^{NS}) and evening relative humidity (r = 0.15^{NS}) were found positively non-significant. The other parameters like minimum temperature (r = 0.57*) and rainfall (r = 0.61*) were found positively significant.

The population of red pumpkin beetle showed non-significant positive response with maximum temperature (r = 0.34^{NS}) and minimum temperature (r = 0.38^{NS}). While non-significant negative response with rainfall (r = -0.05^{NS}), morning relative humidity (r = -0.04^{NS}) and evening relative humidity (r = -0.34^{NS}) during *Kharif* 2021.

The red pumpkin beetle population showed negative, highly significant correlation with maximum temperature (r = -0.72**) and positive, highly significant correlation with morning relative humidity (r = 0.79**). While minimum temperature (r = -0.44^{NS}) and rainfall (r = -0.01^{NS}) showed negatively non-significant correlation whereas evening relative humidity (r = -0.34^{NS}) was positively non-significant during *Rabi* 2021.

Table 4.10: Correlation between weather parameters and red pumpkin beetle of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

Weather parameters	Correlation coefficient value (r)		
	***Summer* 2021**	***Kharif* 2021**	***Rabi* 2021**
Maximum temperature (^{0}C)	0.40^{NS}	0.34^{NS}	-0.72**
Minimum temperature (^{0}C)	0.57*	0.38^{NS}	-0.44^{NS}
Rainfall (mm)	0.61*	-0.05^{NS}	-0.0^{NS}
Morning relative humidity (%)	0.01^{NS}	-0.04^{NS}	0.79**
Evening relative humidity (%)	0.15^{NS}	-0.34^{NS}	0.10^{NS}
*Significant at 5% level, **Significant at 1% level			

The above findings are in confirmation with those of Rajak (2000) who reported that temperature has a significant effect and relative humidity has non-significant effect on pest population of the overwintering pumpkin beetles. Johri and Johri (2003) reported that temperature, humidity and rainfall had no significant effect on plant infestation by this pest. Sheikh *et al*. (2013) revealed that average minimum temperature showed significant negative correlation whereas other weather parameters had no significant effect on the beetle population. Ravi Kumar and Saini (2018) revealed that the population of red pumpkin beetle showed positive correlation with mean temperature but significant negative correlation with mean relative humidity and rainfall. More or less similar observations are also documented by Tamoghnasaha *et al*. (2018), Pansara *et al*. (2022) and Roy and Pande (1991).

4.1.7.5 Simple correlation between weather parameters and lady bird beetle

During *Summer* 2021 the population of lady bird beetle (Table 4.11) in relation to maximum temperature (r = 0.69**) was positive and highly significant. The minimum temperature (r = 0.46^{NS}) and rainfall (r = 0.01^{NS}) was positively non-significant whereas morning relative humidity (r = -0.31^{NS}) and evening relative humidity (r = 0.36^{NS}) were found negatively non-significant.

The population of lady bird beetle showed highly positive and significant response with maximum temperature (r = 0.69**) and evening relative humidity (r = -0.69^{**}) was found negatively highly significant. The rainfall (r = -0.41^{NS}) and morning relative humidity (r = -0.30^{NS}) was negatively non-significant whereas minimum temperature (r = 0.20^{NS}) exhibited positively non-significant correlation during *Kharif* 2021.

The lady bird beetle population showed negatively non-significant correlation with maximum temperature (r = -0.24^{NS}), minimum temperature (r = -0.14^{NS}) and evening relative humidity (r = -0.14^{NS}). While rainfall (r = 0.47^{NS}) and morning relative humidity (r = 0.49^{NS}) was found positively non-significant correlation during *Rabi* 2021.

Table 4.11: Correlation between weather parameters and lady bird beetle of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

Weather parameters	Correlation coefficient value (r)		
	***Summer* 2021**	***Kharif* 2021**	***Rabi* 2021**
Maximum temperature (^{0}C)	0.69**	0.69**	-0.24^{NS}
Minimum temperature (^{0}C)	0.46^{NS}	0.20^{NS}	-0.14^{NS}
Rainfall (mm)	0.01^{NS}	-0.41^{NS}	0.47^{NS}
Morning relative humidity (%)	-0.31^{NS}	-0.30^{NS}	0.49^{NS}
Evening relative humidity (%)	-0.36^{NS}	-0.69**	-0.14^{NS}
*Significant at 5% level, **Significant at 1% level			

4.1.7.6 Simple correlation between weather parameters and predatory spiders

During *Summer* 2021 the population of spiders (Table 4.12) in relation to maximum temperature (r = 0.64*) and minimum temperature (r = 0.65*) was positively significant whereas rainfall was positively non-significant (r = 0.17^{NS}). Morning relative humidity (r = -0.55*) was negatively significant and evening relative humidity (r = -0.30^{NS}) showed negatively non-significant response.

The population of spiders showed negatively non-significant correlation with maximum temperature (r = -0.42^{NS}) and morning relative humidity (r = -0.08^{NS}) whereas minimum temperature (r = 0.21^{NS}), rainfall (r = 0.43^{NS}) and evening relative humidity (r = 0.14^{NS}) was found negatively significant during *Kharif* 2021.

The population of spiders was found negatively significant correlation with maximum temperature (r = -0.66*) and minimum temperature (r = -0.67*). While rainfall (r = -0.17^{NS}) and evening relative humidity (r = -0.12^{NS}) whereas morning relative humidity (r = 0.56*) was positively significant.

Table 4.12: Correlation between weather parameters and predatory spiders of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

Weather parameters	Correlation coefficient value (r)		
	***Summer* 2021**	***Kharif* 2021**	***Rabi* 2021**
Maximum temperature (^{0}C)	0.64*	-0.42^{NS}	-0.66*
Minimum temperature (^{0}C)	0.65*	0.21^{NS}	-0.67*
Rainfall (mm)	0.17^{NS}	0.43^{NS}	-0.17^{NS}
Morning relative humidity (%)	-0.55*	-0.08^{NS}	0.56*
Evening relative humidity (%)	-0.30^{NS}	0.14^{NS}	-0.12^{NS}
*Significant at 5% level, **Significant at 1% level			

The present findings are supported by the findings of earlier researchers. Tamoghnasaha *et al*. (2018) revealed that the natural enemies such as coccinellids and spiders showed significant positive correlation with maximum and minimum temperature, relative humidity and rainfall. Sen *et al*. (2022) revealed that the incidence of predatory *Coccinellids* was positive and significantly correlated with temperature (maximum and minimum) the rainfall and morning relative humidity were also exhibited significant positive association.

4.1.8 Simple linear regression between weather parameters and major insect pests of cucumber

4.1.8.1 Simple linear regression between weather parameters and melon fruit fly, *Bactrocera cucurbitae* (Coquillett)

The simple linear regression worked out between weather parameters and melon fruit fly along with regression coefficient ‘b’ and constant ‘a’ (Table 4.13) and their equations were set up and presented below.

4.1.8.1.1 *Summer* 2021

$Y = 610.99 - 19.48 X_1$: for every unit increase in maximum temperature melon fruit fly population decreased by 19.48

$Y = 150.54 - 7.19 X_2$: for every unit increase in minimum temperature melon fruit fly population decreased by 7.19

$Y = 37.80 + 3.78\ X_3$: for every unit increase in rainfall melon fruit fly population increased by 3.78

$Y = -516.71 + 6.43\ X_4$: for every unit increase in morning relative humidity melon fruit fly population increased by 6.43

$Y = 57.18 - 0.42\ X_5$: for every unit increase in evening humidity melon fruit fly population decreased by 0.42

4.1.8.1.2 *Kharif* 2021

$Y = 378.28 - 11.37\ X_1$: for every unit increase in maximum temperature melon fruit fly population decreased by 11.37

$Y = 64.35 - 1.40\ X_2$: for every unit increase in minimum temperature melon fruit fly population decreased by 1.40

$Y = 18.19 + 0.24\ X_3$: for every unit increase in rainfall melon fruit fly population increased by 0.24

$Y = 59.62 + 1.03\ X_4$: for every unit increase in morning relative humidity melon fruit fly population increased by 1.03

$Y = -92.74 – 1.88\ X_5$: for every unit increase in evening humidity melon fruit fly population increased by 1.88

4.1.8.1.3 *Rabi* 2021

$Y = 459.16 – 14.67\ X_1$: for every unit increase in maximum temperature melon fruit fly population decreased by 14.67

$Y = 115.30 – 5.60\ X_2$: for every unit increase in minimum temperature melon fruit fly population decreased by 5.60

$Y = 29.07 - 0.33\ X_3$: for every unit increase in rainfall melon fruit fly population decreased by 0.33

$Y = -392.33 + 4.87\ X_4$: for every unit increase in morning relative humidity melon fruit fly population increased by 4.87

$Y = 38.04 - 0.22\ X_5$: for every unit increase in evening humidity melon fruit fly population decreased by 0.22

Table 4.13: Simple linear regression between weather parameters and melon fruit fly of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

Weather parameters	*Summer* 2021		*Kharif* 2021		*Rabi* 2022	
	Intercept (a)	Slope (b)	Intercept (a)	Slope (b)	Intercept (a)	Slope (b)
Maximum temperature (X_1)	610.99	-19.48	378.28	-11.37	459.16	-14.67
Minimum temperature (X_2)	150.54	-7.19	64.35	-1.40	115.30	-5.60
Rainfall (X_3)	37.80	3.78	18.19	0.24	29.07	-0.33
Morning relative humidity (X_4)	-516.71	6.43	-59.62	1.03	-392.33	4.87
Evening relative humidity (X_5)	57.18	-0.42	-92.74	1.88	38.04	-0.22

4.1.8.2 Simple linear regression between weather parameters and whitefly, *Bemisia tabaci* (Gennadius)

The simple linear regression worked out between weather parameters and whitefly along with regression coefficient ‘b’ and constant ‘a’ (Table 4.14) and their equations were set up and presented below.

4.1.8.2.1 *Summer* 2021

$Y = -63.77 + 2.28\ X_1$: for every unit increase in maximum temperature whitefly population increased by 2.28

$Y = -7.02 + 1.40\ X_2$: for every unit increase in minimum temperature whitefly population increased by 1.40

$Y = 16.82 – 0.52\ X_3$: for every unit increase in rainfall whitefly population decreased by 0.52

$Y = 9.65 + 0.08\ X_4$: for every unit increase in morning relative humidity whitefly population increased by 0.08

$Y = 34.26 - 0.89\ X_5$: for every unit increase in evening humidity whitefly population decreased by 0.89

4.1.8.2.2 *Kharif* 2021

$Y = -\ 40.21 + 1.50\ X_1$: for every unit increase in maximum temperature whitefly population increased by 1.50

$Y = -67.09 + 3.27\ X_2$: for every unit increase in minimum temperature whitefly population increased by 3.27

$Y = 5.39 – 0.01\ X_3$: for every unit increase in rainfall whitefly population increased by 0.01

$Y = 14.12 – 0.10\ X_4$: for every unit increase in morning relative humidity whitefly population decreased by 0.10

$Y = 18.66 - 0.20\ X_5$: for every unit increase in evening humidity whitefly population decreased by 0.20

4.1.8.2.3 *Rabi* 2021

$Y = -\ 22.71 + 1.19\ X_1$: for every unit increase in maximum temperature whitefly population increased by 1.19

$Y = 14.74 - 0.16\ X_2$: for every unit increase in minimum temperature whitefly population decreased by 0.16

$Y = 12.95 - 1.27\ X_3$: for every unit increase in rainfall whitefly population decreased by 1.27

$Y = 38.47 - 0.30\ X_4$: for every unit increase in morning relative humidity whitefly population decreased by 0.30

$Y = 21.33 - 0.22\ X_5$: for every unit increase in evening humidity whitefly population decreased by 0.22

Table 4.14: Simple linear regression between weather parameters and whitefly of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

Weather parameters	*Summer* 2021		*Kharif* 2021		*Rabi* 2022	
	Intercept (a)	Slope (b)	Intercept (a)	Slope (b)	Intercept (a)	Slope (b)
Maximum temperature (X_1)	-63.77	2.28	-40.21	1.50	-22.71	1.19
Minimum temperature (X_2)	-7.02	1.40	-67.09	3.27	14.74	-0.16
Rainfall (X_3)	16.82	-0.52	5.39	0.01	12.95	-1.27
Morning relative humidity (X_4)	9.65	0.08	14.12	-0.10	38.47	-0.30
Evening relative humidity (X_5)	34.26	-0.89	18.66	-0.20	21.33	-0.22

4.1.8.3 Simple linear regression between weather parameters and thrips, *Thrips palmi* (Karny)

The simple linear regression worked out between weather parameters and thrips along with regression coefficient ‘b’ and constant ‘a’ (Table 4.15) and their equations were set up and presented below.

4.1.8.3.1 *Summer* 2021

$Y = -46.76 + 1.65 X_1$: for every unit increase in maximum temperature thrips population increased by 1.65

$Y = -9.42 + 1.24 X_2$: for every unit increase in minimum temperature thrips population increased by 1.24

$Y = 11.70 – 0.42 X_3$: for every unit increase in rainfall thrips population decreased by 0.42

Y = 21.00 - 0.15 X_4: for every unit increase in morning relative humidity thrips population decreased by 0.15

Y = 23.64 - 0.62 X_5: for every unit increase in evening humidity thrips population decreased by 0.62

4.1.8.3.2 *Kharif* 2021

Y = -21.31 + 1.06 X_1: for every unit increase in maximum temperature thrips population increased by 1.06

Y = -5.30 + 0.73 X_2: for every unit increase in minimum temperature thrips population increased by 0.73

Y = 11.89 - 0.02 X_3: for every unit increase in rainfall thrips population decreased by 0.02

Y = 25.72 - 0.16 X_4: for every unit increase in morning relative humidity thrips population decreased by 0.16

Y = 26.10 - 0.23 X_5: for every unit increase in evening humidity thrips population decreased by 0.23

4.1.8.3.3 *Rabi* 2021

Y = 74.61 - 2.19 X_1: for every unit increase in maximum temperature thrips population decreased by 2.19

Y = 18.74 - 0.54 X_2: for every unit increase in minimum temperature thrips population decreased by 0.54

Y = 10.07 + 0.71 X_3: for every unit increase in rainfall thrips population increased by 0.71

Y = -88.00 + 1.14 X_4: for every unit increase in morning relative humidity thrips population increased by 1.14

Y = 9.11 + 0.03 X_5: for every unit increase in evening humidity thrips population increased by 0.03

Table 4.15: Simple linear regression between weather parameters and thrips of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

Weather parameters	*Summer* 2021		*Kharif* 2021		*Rabi* 2022	
	Intercept (a)	Slope (b)	Intercept (a)	Slope (b)	Intercept (a)	Slope (b)
Maximum temperature (X_1)	-46.76	1.65	-21.31	1.06	74.61	-2.19
Minimum temperature (X_2)	-9.42	1.24	-5.30	0.73	18.74	-0.54
Rainfall (X_3)	11.70	-0.42	11.89	-0.02	10.07	0.71
Morning relative humidity (X_4)	21.00	-0.15	25.72	-0.16	-88.00	1.14
Evening relative humidity (X_5)	23.64	-0.62	26.10	-0.23	9.11	0.03

4.1.8.4 Simple linear regression between weather parameters and red pumpkin beetle *Aulacophora foveicollis* (Lucas)

The simple linear regression worked out between weather parameters and red pumpkin beetle along with regression coefficient 'b' and constant 'a' (Table 4.16) and their equations were set up and presented below.

4.1.8.4.1 *Summer* 2021

$Y = -1.91 + 0.09\ X_1$: for every unit increase in maximum temperature red pumpkin beetle population increased by 0.09

$Y = -1.15 + 0.15\ X_2$: for every unit increase in minimum temperature red pumpkin beetle population increased by 0.15

$Y = 1.03 + 0.09\ X_3$: for every unit increase in rainfall red pumpkin beetle population increased by 0.09

$Y = 1.27 + 0.02\ X_4$: for every unit increase in morning relative humidity red pumpkin beetle population increased by 0.02

$Y = 0.99 + 0.01 X_5$: for every unit increase in evening humidity red pumpkin beetle population increased by 0.01

4.1.8.4.2 *Kharif* 2021

$Y = -4.62 + 0.19 X_1$: for every unit increase in maximum temperature red pumpkin beetle population increased by 0.19

$Y = -12.53 + 0.61 X_2$: for every unit increase in minimum temperature red pumpkin beetle population increased by 0.61

$Y = 1.07 + 0.01 X_3$: for every unit increase in rainfall red pumpkin beetle population increased by 0.01

$Y = 1.40 + 0.01 X_4$: for every unit increase in morning relative humidity red pumpkin beetle population increased by 0.01

$Y = 3.19 - 0.03 X_5$: for every unit increase in evening humidity red pumpkin beetle population decreased by 0.03

4.1.8.4.2 *Rabi* 2021

$Y = 7.17 - 0.22 X_1$: for every unit increase in maximum temperature red pumpkin beetle population decreased by 0.22

$Y = 1.72 - 0.06 X_2$: for every unit increase in minimum temperature red pumpkin beetle population decreased by 0.06

$Y = 0.77 + 0.01 X_3$: for every unit increase in rainfall red pumpkin beetle population increased by 0.01

$Y = -8.47 + 0.11 X_4$: for every unit increase in morning relative humidity red pumpkin beetle population increased by 0.11

$Y = 0.55 + 0.01 X_5$: for every unit increase in evening humidity red pumpkin beetle population increased by 0.01

Table 4.16: Simple linear regression between weather parameters and red pumpkin beetle of *Cucumis sativus* during *Summer*, *Kharif* and *Rabi* 2021

Weather parameters	*Summer* 2021		*Kharif* 2021		*Rabi* 2022	
	Intercept (a)	Slope (b)	Intercept (a)	Slope (b)	Intercept (a)	Slope (b)
Maximum temperature (X_1)	-1.91	0.09	-4.62	0.19	7.17	-0.22
Minimum temperature (X_2)	-1.15	0.15	-12.53	0.61	1.72	-0.06
Rainfall (X_3)	1.03	0.09	1.07	0.00	0.77	0.00
Morning relative humidity (X_4)	1.27	0.02	1.40	0.00	-8.47	0.11
Evening relative humidity (X_5)	0.99	0.01	3.19	-0.03	0.55	0.01

4.1.9 Multiple regression between weather parameters and major insect pests of cucumber

4.1.9.1 Multiple regression between weather parameters and melon fruit fly, *Bactrocera cucurbitae* (Coquillett)

The partial regression coefficients for different weather parameters and melon fruit fly population during *Summer*, *Kharif* and *Rabi* 2021 were worked out and presented in Table 4.17, 4.18 and 4.19. The multiple regression equation fitted with weather parameters in order to predict melon fruit fly population in cucumber was as below.

During *Summer* 2021

$Y = -916.66 + 28.03X_1 - 29.98X_2 + 22.50X_3 - 3.03X_4 + 7.81X_5$ with coefficient of determination (R^2) 0.88

During *Kharif* 2021

$Y = 106.95 - 4.93X_1 + 2.35X_2 + 0.21X_3 - 0.62X_4 - 0.67X_5$ with coefficient of determination (R^2) 0.25

During *Rabi* 2021

$Y = -772.35 + 23.10X_1 - 4.08X_2 + 14.40X_3 + 2.52X_4 + 6.53X_5$ with coefficient of determination (R^2) 0.93

Where,

Y = Melon fruit fly population, X_1 = Tmax, X_2 = Tmin,

X_3 = Rainfall, X_4 = Morning RH, X_5 = Evening RH

4.1.9.2 Multiple regression between weather parameters and whitefly, *Bemisia tabaci* (Gennadius)

The partial regression coefficients for different weather parameters and whitefly population during *Summer*, *Kharif* and *Rabi* 2021 were worked out and presented in Table 4.17, 4.18 and 4.19. The multiple regression equation fitted with weather parameters in order to predict whitefly population in cucumber was as below

During *Summer* 2021

$Y = -88.99 + 2.09X_1 + 0.30X_2 + 0.39X_3 - 3.03X_4 + 0.71X_5$ with coefficient of determination (R^2) 0.96

During *Kharif* 2021

$Y = -88.36 + 2.92X_1 + 0.69X_2 + 0.05X_3 - 0.05X_4 - 0.14X_5$ with coefficient of determination (R^2) 0.45

During *Rabi* 2021

$Y = 12.11 + 0.80X_1 - 0.01X_2 - 0.70X_3 - 0.17X_4 - 0.19X_5$ with coefficient of determination (R^2) 0.40

Where,

Y = whitefly population, X_1 = Tmax, X_2 = Tmin,

X_3 = Rainfall, X_4 = Morning RH, X_5 = Evening RH

4.1.9.3 Multiple regression between weather parameters and thrips, *Thrips palmi* (Karny)

The partial regression coefficients for different weather parameters and thrips population during *Summer*, *Kharif* and *Rabi* 2021 were worked out and presented in Table 4.17, 4.18 and 4.19. The multiple regression equation fitted with weather parameters in order to predict whitefly population in cucumber was as below

During *Summer* 2021

$Y = -16.33 + 0.56X_1 + 0.61X_2 + 0.28X_3 + 0.17X_4 - 0.70X_5$ with coefficient of determination (R^2) 0.84

During *Kharif* 2021

$Y = 44.06 + 0.19X_1 - 0.95X_2 + 0.01X_3 + 0.04X_4 - 0.33X_5$ with coefficient of determination (R^2) 0.37

During *Rabi* 2021

$Y = -81.13 + 0.22X_1 - 0.75X_2 + 0.69X_3 + 0.97X_4 - 0.29X_5$ with coefficient of determination (R^2) 0.81

Where,

Y = Thrips population, X_1 = Tmax, X_2 = Tmin,

X_3 = Rainfall, X_4 = Morning RH, X_5 = Evening RH

4.1.9.4 Multiple regression between weather parameters and red pumpkin beetle, *Aulacophora foveicollis* (Lucas)

The partial regression coefficients for different weather parameters and red pumpkin beetle population during *Summer*, *Kharif* and *Rabi* 2021 were worked out and presented in Table 4.17, 4.18 and 4.19. The multiple regression equation fitted with weather parameters in order to predict whitefly population in cucumber was as below

During *Summer* 2021:

$Y = -9.18 + 0.32X_1 - 0.12X_2 + 0.12X_3 + 0.08X_4 + 0.04X_5$ with coefficient of determination (R^2) 0.88

During *Kharif* 2021:

$Y = -0.82 - 0.01X_1 + 0.19X_2 + 0.01X_3 + 0.06X_4 - 0.12X_5$ with coefficient of determination (R^2) 0.43

During *Rabi* 2021:

$Y = -12.99 + 0.20X_1 - 0.21X_2 + 0.08X_3 + 0.09X_4 + 0.07X_5$ with coefficient of determination (R^2) 0.85

Where,

Y = Red pumpkin beetle population, X_1 = Tmax, X_2 = Tmin,

X_3 = Rainfall, X_4 = Morning RH, X_5 = Evening RH

Table 4.17: Multiple regression between weather parameters and major insect pests of *Cucumis sativus* during *Summer* 2021

Pests	Regression coefficient values *Summer* 2021					Regression equation
	Temperature (^{0}C)		Rainfall	Humidity (%)		
	Max	Min		Morning	Evening	
	(X_1)	(X_2)	(X_3)	(X_4)	(X_5)	
Melon fruit fly						
Bi	28.03	-29.98	22.50	3.03	7.81	**Y** = -916.66 + 28.03 -29.98 + 22.50 + 3.03 + 7.81
SE	16.46	10.37	9.31	2.24	2.97	
T values	1.70	-2.89	2.42	1.35	2.63	
N=11	**B_0 =** -916.66	**F value =** 7.03	**R^2 =** 0.88	**SEY** = 19.52		
Whitefly						
Bi	2.09	0.30	0.39	0.71	-1.11	**Y** = -88.99 + 2.09 + 0.30 + 0.39 + 0.71 – 1.11
SE	1.01	0.85	0.34	0.10	0.33	
T values	2.06	0.35	1.14	6.93	-.38	
N=11	**B_0 =** -88.99	**F value=**22.66	**R2 =** 0.96	**SEY =** 3.64		
Thrips						
Bi	0.56	0.61	0.28	0.17	-0.70	**Y** = -16.33 + 0.56 + 0.61 + 0.28 + 0.17 -0.70
SE	1.15	0.97	0.39	0.12	0.37	
T values	0.49	0.63	0.72	1.44	-1.87	
N=11	**B_0 =** -16.33	**F value=** 5.14	**R2 =** 0.84	**SEY =** 4.13		
Red pumpkin beetle						
Bi	0.32	-0.12	0.12	0.08	0.04	**Y** = -9.18 + 0.32 – 0.12 + 0.12 + 0.08 + 0.04
SE	0.11	0.09	0.04	0.05	0.04	
T values	2.87	-1.26	3.14	1.25	1.13	
N=11	**B_0 =** -9.18	**F value=** 7.42	**R2 =** 0.88	**SEY =** 0.39		

Bi= Regression coefficient, B_0 = Intercept, R^2 = Coefficient of determination, N = Total number of weeks, SE = Standard Error

Table 4.18: Multiple regression between weather parameters and major insect pests of *Cucumis sativus* during *Kharif* 2021

Pests	Regression coefficient values *Kharif* 2021					Regression equation
	Temperature (^{0}C)		Rainfall	Humidity (%)		
	Max	Min		Morning	Evening	
	(X_1)	(X_2)	(X_3)	(X_4)	(X_5)	
Melon fruit fly						
Bi	-4.93	2.35	0.21	0.62	-0.67	**Y** = 106.95 – 4.93 + 2.35 + 0.21 + 0.62 – 0.67
SE	25.10	36.15	0.36	3.97	6.28	
T values	-0.20	0.06	0.58	0.16	-0.11	
N=11	**B_0 =** 106.95	**F value**=0.32	**R^2 =** 0.25	**SEY** = 43.62		
Whitefly						
Bi	2.92	0.69	0.05	-0.05	-0.14	**Y** = -88.36 + 2.92 + 0.69 + 0.05 – 0.05 – 0.14
SE	2.66	3.83	0.04	0.42	0.67	
T values						
N=11	**B_0 = -**88.36	**F value**=0.81	**R2 = 0.**45	**SEY =** 4.62		
Thrips						
Bi	0.19	-0.95	0.01	0.04	-0.33	**Y** = 44.06 + 0.19 – 0.95 + 0.01 + 0.04 – 0.33
SE	1.89	2.72	0.03	0.30	0.47	
T values	0.10	-0.35	0.46	0.13	-0.70	
N=11	**B_0 =** 44.06	**F value**=0.58	**R2 =** 0.37	**SEY =** 3.28		
Red pumpkin beetle						
Bi	-0.01	0.19	0.01	0.06	-0.12	**Y** = -0.82 – 0.01 + 0.19 + 0.01 + 0.06 -0.12
SE	0.43	0.62	0.01	0.07	0.11	
T values	-0.02	0.31	1.21	0.94	-1.16	
N=11	**B_0 =** -0.82	**F value**=0.76	**R2 =** 0.43	**SEY =** 0.74		

Bi= Regression coefficient, B_0 = Intercept, R^2 = Coefficient of determination, N = Total number of weeks, SE = Standard Error

Table 4.19: Multiple regression between weather parameters and major insect pests of *Cucumis sativus* during *Rabi* 2021

Pests	Regression coefficient values *Rabi* 2021					Regression equation
	Temperature (^{0}C)		Rainfall	Humidity (%)		
	Max	Min		Morning	Evening	
	(X_1)	(X_2)	(X_3)	(X_4)	(X_5)	
Melon fruit fly						
Bi	23.10	-24.08	14.40	2.52	6.53	**Y** = -772.35 +23.10 – 24.08 + 14.40 +2.52 + 6.53
SE	9.30	5.86	5.26	1.26	1.68	
T values	2.48	-4.11	2.74	1.99	3.89	
N=11	B_0 = -772.32	**F value**=13.16	R^2 = 0.93	**SEY** = 11.03		
Whitefly						
Bi	0.80	-0.01	-0.70	-0.17	-0.19	**Y** = 12.11 + 0.80 – 0.01 – 0.70 – 0.17 – 0.19
SE	4.14	2.61	2.34	0.56	0.75	
T values	0.19	0.02	-0.30	-0.30	-0.26	
N=11	B_0 = 12.11	**F value**=0.65	**R2** = 0.40	**SEY** = 4.91		
Thrips						
Bi	0.22	-0.75	0.69	0.97	0.29	**Y** = -81.13 + 0.22 – 0.75 + 0.69 + 0.97 + 0.29
SE	2.53	1.59	1.43	0.34	0.46	
T values	0.09	-0.47	0.48	2.83	0.65	
N=11	B_0 = -81.13	**F value**= 4.31	**R2** = 0.81	**SEY** = 3.00		
Red pumpkin beetle						
Bi	0.20	-0.21	0.08	0.09	0.07	**Y** = -12.99 + 0.20 – 0.21 + 0.08 + 0.09 + 0.07
SE	0.22	0.14	0.13	0.03	0.04	
T values	0.89	-1.47	0.65	3.14	1.75	
N=11	B_0 = -12.99	**F value**=5.84	**R2** = 0.85	**SEY** = 0.26		

Bi= Regression coefficient, B_0 = Intercept, R^2 = Coefficient of determination, N = Total number of weeks, SE = Standard Error

4.2. Host preference and biology of melon fruit fly on different hosts

4.2.1 Host preference of melon fruit fly on different hosts under field condition

A. *Summer* 2021

The observations on per cent fruit infestation on cucumber are presented in Table 4.20 and depicted in Fig. 4.19. The observations were recorded on mean per cent infestation. The mean per cent fruit infestation data showed that all the cucurbitaceous hosts were significantly different from each other. Sponge gourd was the least preferred host of melon fruit fly with lowest mean per cent fruit infestation of 35.62 which was followed by treatment ridge gourd, bottle gourd, muskmelon and cucumber (44.20%, 44.22%, 45.63% and 45.77%, respectively) and all these treatments were statistically at par with each other. The treatments watermelon (53.46%) and pumpkin (56.89%) were more preferred as compared to earlier. While bitter gourd was the most preferred host with maximum per cent fruit infestation (62.12%).

B. *Summer* 2022

The mean per cent fruit infestation data (Table 4.21 and Fig. 4.19) indicated that sponge gourd was the least preferred host of melon fruit fly (40.54%). It was statistically at par with bottle gourd (43.59%), ridge gourd (47.13%), muskmelon (49.00%), cucumber (50.91%) and watermelon (54.42%). However, pumpkin (56.89%) and bitter gourd were highly preferred host (62.12%).

C. Pooled

The pooled means of two seasons indicated that all the treatments were significantly different from each other. (Table 4.22 and Fig. 4.19). Among all these treatments bitter gourd was the highly preferred host with highest per cent fruit infestation (64.48%) followed by pumpkin (59.03%) Sponge gourd was the least preferred host of melon fruit fly with minimum mean per cent fruit infestation (38.08%) which was followed by treatments bottle gourd, ridge gourd, muskmelon cucumber and watermelon (46.12%, 47.89%, 50.04%, 51.12% and 53.94%, respectively) and all these treatments were statistically at par with each other.

Table 4.20: Host preference of melon fruit fly on different hosts (*Summer* 2021)

Tr. No	Treatments	Per cent fruit infestation						
		Standard meteorological week						Mean
		10	11	12	13	14	15	
T_1	Cucumber	44.37 (41.72)	48.10 (43.91)	52.53 (46.45)	58.37 (49.84)	54.37 (47.53)	50.27 (45.16)	51.33 (45.77)
T_2	Bittergourd	50.83 (45.49)	52.10 (46.21)	60.30 (50.97)	75.03 (60.34)	68.53 (55.92)	65.93 (54.41)	62.12 (52.22)
T_3	Ridge gourd	40.57 (39.48)	43.43 (41.21)	50.43 (45.25)	55.53 (48.19)	52.90 (46.67)	49.00 (44.42)	48.64 (44.20)
T_4	Pumpkin	48.37 (44.06)	51.40 (45.81)	54.80 (47.77)	64.97 (54.01)	62.83 (52.48)	58.97 (50.19)	56.89 (49.05)
T_5	Watermelon	45.90 (42.65)	49.93 (44.96)	53.27 (46.88)	62.17 (52.07)	55.93 (48.46)	53.57 (47.05)	53.46 (47.01)
T_6	Sponge gourd	30.13 (33.29)	33.30 (35.20)	40.43 (39.40)	42.10 (40.44)	35.17 (36.32)	32.60 (34.77)	35.62 (36.57)
T_7	Muskmelon	44.83 (42.03)	42.47 (40.65)	52.23 (46.29)	60.30 (51.04)	55.20 (48.00)	51.37 (45.78)	51.07 (45.63)
T_8	Bottle gourd	35.37 (36.49)	59.81 (50.73)	46.43 (42.95)	52.50 (46.44)	50.67 (45.39)	47.07 (43.31)	48.64 (44.22)
S.E (m) ±		3.40	3.05	2.85	3.68	3.41	3.45	3.31
CD at 5%		10.33	9.24	8.64	11.17	10.34	10.47	10.03
CV %		10.26	8.56	7.63	8.97	8.78	9.27	8.91

Figures in parenthesis are Arc sin transformed values

Table 4.21: Host preference of melon fruit fly on different hosts (*Summer* 2022)

Tr. No	Treatments	Per cent fruit infestation						
		Standard meteorological week						Mean
		14	15	16	17	18	19	
T_1	Cucumber	48.20 (43.96)	51.00 (45.58)	55.53 (48.22)	60.53 (51.11)	47.90 (43.79)	42.27 (40.54)	50.91 (45.53)
T_2	Bitter gourd	55.17 (48.01)	58.97 (50.19)	65.57 (54.11)	80.57 (64.31)	76.13 (61.14)	64.63 (53.58)	66.84 (55.22)
T_3	Ridge gourd	45.17 (42.21)	48.07 (43.89)	50.33 (45.19)	55.50 (48.17)	43.33 (41.15)	40.40 (39.45)	47.13 (43.34)
T_4	Pumpkin	52.10 (46.21)	55.27 (48.04)	62.40 (52.21)	70.47 (57.32)	68.37 (55.83)	58.37 (49.83)	61.16 (51.57)
T_5	Watermelon	50.67 (45.38)	53.17 (46.82)	55.57 (48.21)	61.47 (51.66)	58.80 (50.09)	46.87 (43.20)	54.42 (47.56)
T_6	Sponge gourd	35.20 (36.25)	41.63 (40.16)	45.90 (42.64)	49.20 (44.54)	38.40 (38.27)	32.90 (34.96)	40.54 (39.47)
T_7	Muskmelon	47.40 (43.51)	49.27 (44.58)	52.90 (46.68)	56.17 (48.56)	45.50 (42.38)	42.77 (40.83)	49.00 (44.42)
T_8	Bottle gourd	35.37 (36.45)	44.97 (42.11)	50.43 (45.25)	52.57 (46.48)	40.50 (39.50)	37.73 (37.83)	43.59 (41.27)
S.E (m) ±		2.80	2.60	3.15	3.56	3.45	2.86	3.07
CD at 5%		8.49	7.89	9.55	10.79	10.45	8.68	9.30
CV %		8.01	7.05	8.06	8.45	9.07	8.24	8.15

Figures in parenthesis are Arc sin transformed values

Table 4.22: Host preference of melon fruit fly on different hosts (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Per cent fruit infestation		
		Mean of *Summer* 2021	**Mean of *Summer* 2022**	**Pooled *Summer* 2021 and 2022**
T_1	Cucumber	51.33 (45.77)	50.91 (45.53)	51.12 (45.65)
T_2	Bittergourd	62.12 (52.22)	66.84 (55.22)	64.48 (53.72)
T_3	Ridge gourd	48.64 (44.2)	47.13 (43.34)	47.89 (43.77)
T_4	Pumpkin	56.89 (49.05)	61.16 (51.57)	59.03 (50.31)
T_5	Watermelon	53.46 (47.01)	54.42 (47.56)	53.94 (47.29)
T_6	Sponge gourd	35.62 (36.57)	40.54 (39.47)	38.08 (38.02)
T_7	Muskmelon	51.07 (45.63)	49.00 (44.42)	50.04 (45.03)
T_8	Bottle gourd	48.64 (44.22)	43.59 (41.27)	46.12 (42.75)
S.E (m) ±		3.31	3.07	3.19
CD at 5%		10.03	9.3	9.665
CV %		8.91	8.15	8.53

Moreover, similar trends of results on host preference of melon fruit fly on different Cucurbitaceous hosts were documented by earlier workers. Singh *et al*. (2000) reported that bitter gourd as the more susceptible and highly preferred host to cucurbit fruit fly. Rajpoot *et al*. (2002) documented that bitter gourd was most preferred host, muskmelon, round gourd and cucumber were moderately preferred while ridge gourd, bottle gourd and pumpkin were the least preferred hosts. Kumar *et al*. (2006) reported that bitter gourd as a highly preferred host with maximum fruit infestation (77.03%) followed by ridge gourd (75.65%) and cucumber (73.83%). Gaine *et al*. (2013) revealed that infestation by cucurbit fruit fly occurred at same level for both in bitter gourd and ridge gourd. More or less similar observations were also documented by Li-Li *et al*. (2008), Vayssieres *et al*. (2008), Mwatawala *et al*. (2010) and Koswanudin *et al*. (2018).

4.2.2 Host preference of melon fruit fly on different hosts under laboratory condition

4.2.2.1 Host preference of melon fruit fly on different cucurbitaceous hosts in choice test

The host preference of the melon fruit fly with choice test using eight different cucurbitaceous hosts were performed under laboratory conditions. (Table 4.23) The results demonstrated that the number of eggs, larvae, pupae and adult of melon fruit fly found in the eight cucurbitaceous host-plants were significantly different. In choice test, results demonstrated that bitter gourd received more egg laying. Maximum mean (65 ± 1.14) followed by 59 ± 0.98, 54 ± 0.95, 43 ± 0.91, 38 ± 0.86, 33 ± 0.81, 31 ± 0.78 and 25 ± 0.76 in case of cucumber, pumpkin, watermelon, muskmelon, ridge gourd, bottle gourd and sponge gourd, respectively. Maximum mean 58 ± 1.13 for the number of larvae emerged from *B. cucurbitae* was observed in bitter gourd followed by 52 ± 0.95, 48 ± 0.93, 38 ± 0.85, 33 ± 0.83, 29 ± 0.81, 27 ± 0.80 and 21 ± 0.79 in case of cucumber, pumpkin, watermelon, muskmelon, ridge gourd, bottle gourd and sponge gourd, respectively.

Maximum mean 52 ± 0.92 for pupa developed from melon fruit fly was observed in the bitter gourd followed by 41 ± 0.81, 32 ± 0.78, 26 ± 0.74, 22 ± 0.71, 19 ± 0.68 and 16 ± 0.65 in case of cucumber, pumpkin, watermelon,

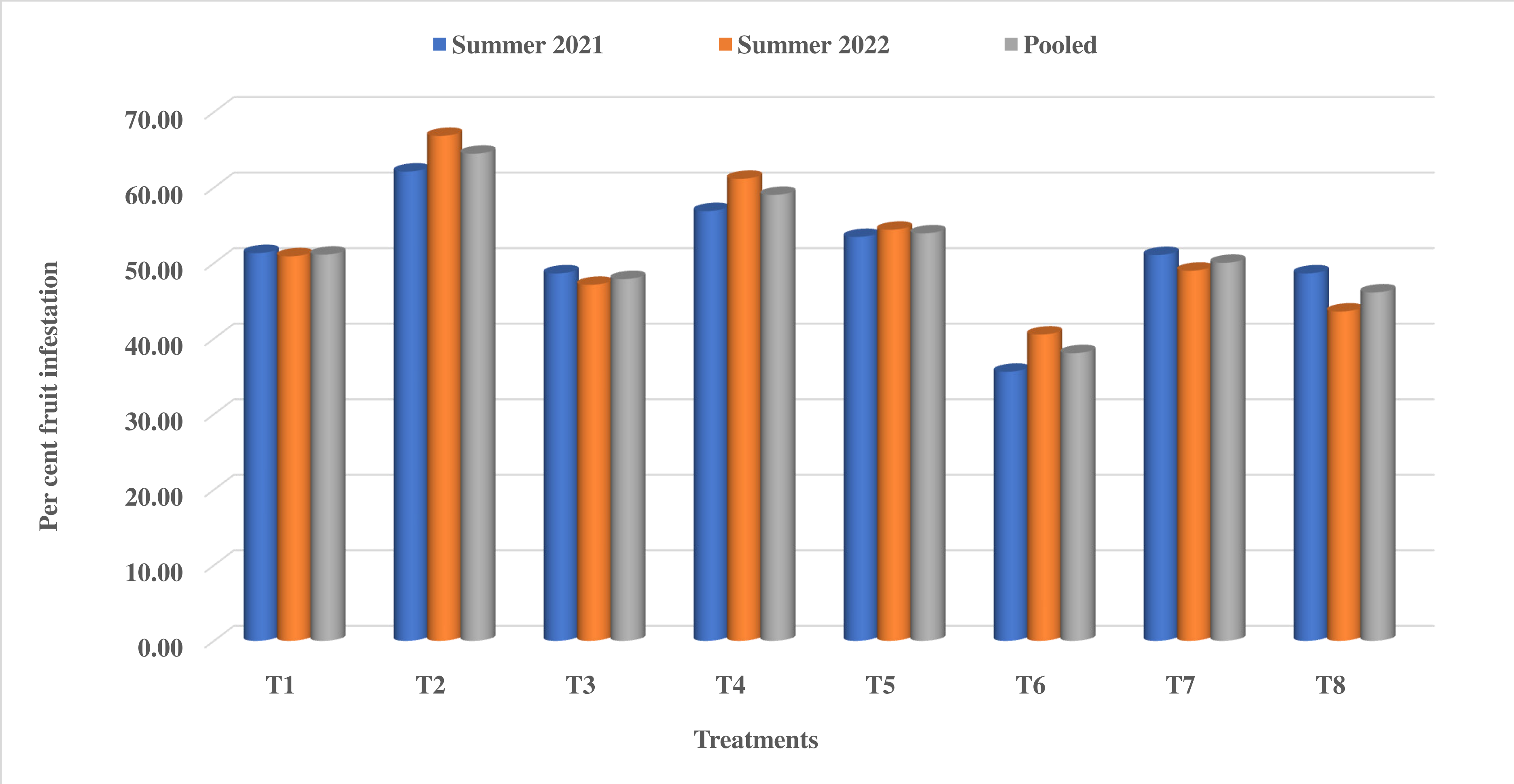

Fig. 4.19: Host preference of melon fruit fly on different hosts cucumber (Pooled *Summer* 2021 and 2022)

Plate 4.1: Damage symptoms of melon fruit fly on different cucurbitaceous hosts

Table 4.23: Host preference of melon fruit fly on different cucurbitaceous hosts in choice test

Tr. No	Treatment	Fecundity ± SE	Larvae formed ± SE	Pupa Developed ± SE	Adults formed ± SE
T_1	Cucumber	59 ± 0.98	52 ± 0.95	45 ± 0.87	38 ± 0.79
T_2	Bitter gourd	65 ± 1.14	58 ± 1.13	52 ± 0.92	41 ± 0.83
T_3	Ridge gourd	33 ± 0.81	29 ± 0.81	22 ± 0.71	17 ± 0.61
T_4	Pumpkin	54 ± 0.95	48 ± 0.93	41 ± 0.81	33 ± 0.72
T_5	Watermelon	43 ± 0.91	38 ± 0.85	32 ± 0.78	27 ± 0.69
T_6	Sponge gourd	25 ± 0.76	21 ± 0.79	16 ± 0.65	13 ± 0.58
T_7	Muskmelon	38 ± 0.86	33 ± 0.83	26 ± 0.74	21 ± 0.64
T_8	Bottle gourd	31 ± 0.78	27 ± 0.80	19 ± 0.68	16 ± 0.60

muskmelon, ridge gourd, bottle gourd and sponge gourd, respectively. Maximum mean 52 ± 0.92 for adults developed from melon fruit fly was observed in the bitter gourd followed by 38 ± 0.79, 33 ± 0.72, 27 ± 0.69, 21 ± 0.64, 17 ± 0.61, 16 ± 0.60 and 13 ± 0.58 in case of cucumber, pumpkin, watermelon, muskmelon, ridge gourd, bottle gourd and sponge gourd, respectively.

The cumulative results of choise test experiments clearly proved that bitter gourd was most preferred host.

The findings are in consistent with the results of Shahzadi *et. al*., (2019) who reported that in choice test, bitter gourd had greater fecundity, larval, pupal and adult rate as compared to other cucurbitaceous hosts *i.e*., 67. 59, 52 and 40, respectively. Manzar and Srivastava (2017) and Sohrab and Hasan (2018) were fairly close to this experiment.

4.2.2.2 Host preference of melon fruit fly on different cucurbitaceous hosts in non-choice test

Melon fruit fly was reared on eight different cucurbitaceous hosts and the results obtained from host preference of fruit flies are indicated in (Table 4.24). In non-choice experiment, number of eggs of *B. cucurbitae* were higher on bitter gourd under lab conditions. Maximum mean number of eggs of *B. cucurbitae* (58 ± 1.11) was observed in the bitter gourd followed by 52 ± 0.98, 44 ± 0.93, 38 ± 0.88, 35 ± 0.85, 29 ± 0.83, 25 ± 0.81 and 20 ± 0.79 in cucumber, pumpkin, watermelon, muskmelon, ridge gourd, bottle gourd and sponge gourd, respectively. Maximum mean 52 ± 1.24 for number of larvae of *B. cucurbitae* was witnessed in the bitter gourd followed by cucumber, pumpkin, watermelon, muskmelon, ridge gourd, bottle gourd and sponge gourd i.e. (48 ± 1.13, 41 ± 1.08, 34 ± 0.98, 28 ± 0.95, 25 ± 0.91, 21 ± 0.90 and 16 ± 0.88), respectively.

The similar trend was observed in the pupal development rate on all these different cucurbitaceous hosts by the *B. cucurbitae* for the host preference. Maximum mean 46 ± 0.88 for number of pupae of *B. cucurbitae* was detected in the bitter gourd followed by 44 ± 0.84, 38 ± 0.81, 31 ± 0.78, 26 ± 0.75, 22 ± 0.71, 17 ± 0.68 and 12 ± 0.61 in case of cucumber, pumpkin, watermelon, muskmelon, ridge gourd, bottle gourd and sponge gourd, respectively. Maximum mean 36 ± 0.92 for

Table 4.24: Host preference of melon fruit fly on different cucurbitaceous hosts in non-choice test

Tr. No	Treatment	Fecundity ± SE	Larvae formed ± SE	Pupa Developed ± SE	Adults formed ± SE
T_1	Cucumber	52 ± 0.98	48 ± 1.13	44 ± 0.84	33 ± 0.88
T_2	Bitter gourd	58 ± 1.11	52 ± 1.24	46 ± 0.88	36 ± 0.92
T_3	Ridge gourd	29 ± 0.83	25 ± 0.91	22 ± 0.71	15 ± 0.71
T_4	Pumpkin	44 ± 0.93	41 ± 1.08	38 ± 0.81	36 ± 0.86
T_5	Watermelon	38 ± 0.88	34 ± 0.98	31 ± 0.78	22 ± 0.83
T_6	Sponge gourd	20 ± 0.79	16 ± 0.88	12 ± 0.61	11 ± 0.65
T_7	Muskmelon	35 ± 0.85	28 ± 0.95	26 ± 0.75	19 ± 0.75
T_8	Bottle gourd	25 ± 0.81	21 ± 0.90	17 ± 0.68	13 ± 0.67

adults developed from melon fruit fly was observed in the bitter gourd followed by 36 ± 0.86, 33 ± 0.88, 22 ± 0.83, 19 ± 0.75, 15 ± 0.71, 13 ± 0.67 and 11 ± 0.65 in case of pumpkin, cucumber, watermelon, muskmelon, ridge gourd, bottle gourd and sponge gourd, respectively. The mean values of different stages of *B. cucurbitae* indicated that the bitter gourd was the most preferred host of melon fruit fly, from all the cucurbitaceous hosts in non-choice test under laboratory conditions. Whereas, the sponge gourd was least preferred by the melon fruit fly.

These host preference readings in non-choice test are in conformity with the findings of Shahzadi *et. al*., (2019) who recorded similar readings in various cucurbitaceous crops. More or less similar results were obtained by Mir *et. al*., (2014) who revealed that in non-choice experiment, bitter gourd was greater ranked as compared to cucumber, brinjal, pumpkin and muskmelon.

4.2.3 Biology of melon fruit fly on different hosts

4.2.3.1 Biology of melon fruit fly on different cucurbitaceous hosts

4.2.3.1.1 The Egg

The incubation period of melon fruit fly, *B. cucurbitae* (Coquillett) on different hosts were ranged from 1-2 days (Table 4.25). The lowest incubation period of melon fruit fly, *B. cucurbitae* were recorded 1.20 ± 0.45 days on cucumber and pumpkin was followed by 1.40 ± 0.55 days on bitter gourd, watermelon and ridge gourd followed by 1.60 ± 0.55 days when reared on sponge gourd and muskmelon whereas, highest incubation period was recorded on bottle gourd *i.e.* 1.80 ± 0.45 days.

These findings are in accordance with the reports of Mir *et al*. (2014) and Langer *et al*. (2013) who also recorded incubation period of the melon fruit fly to be ranging from 24-48 hours in musk melon and cucumber, respectively. Laskar (2013) reported that incubation period was higher in pumpkin compared to bitter gourd, which varied from 1.50 to 2.00 days when reared on bitter gourd and 1.50 to 2.25 days pumpkin, respectively. Das *et al.* (2017) recorded an incubation period of 1.5 to 3 days on pumpkin. However, Koul and Bhagat (1994) reported incubation period of 5-9 days when melon fruit flies were reared on bottle gourd which differs with the results of the present investigation, which may be due to changes in environmental conditions.

4.2.3.1.2 Maggot period

The maggots developmental period varied from 6.00 to 10.00 days with a mean of 7.00 ± 0.71 to 8.90 ± 0.74 days on different hosts (Table 4.25). Significantly shortest mean maggot duration was observed on bitter gourd (7.00 ± 0.71 days) followed by 7.60 ± 0.65, 7.60 ± 0.55 and 7.60 ± 1.10 days when reared on cucumber, pumpkin and muskmelon, respectively followed by 8.40 ± 0.55 days was observed on ridge gourd and watermelon. While melon fruit fly, *B. cucurbitae* completed its maggot period 8.80 ± 0.84 and 8.90 ± 0.74 days on sponge gourd and bottle gourd which was observed to be longest days among the different hosts.

The present findings are in accordance with the reports of Patel and Patel (1998) and Laskar (2013) who reported that total maggot period varied from 5-7 and 5-6.5 days on little gourd and bitter gourd. However, Mir *et al.* (2014) and Desai *et al.* (2018) found maggot period of *B. cucurbitae* to last for about 3.5-6 days on cucumber and sponge gourd. The present results are more or less similar with the findings of Chawla (1966) and Chellaiah (1970) who reported that the larval period varies from 3.0 to 6.0 days on different cucurbits.

4.2.3.1.3 Pre-pupal and pupal period

The present findings revealed that the duration of pre-pupal period ranged from 1.0 – 2.0 days with average duration of 1.10 ± 0.55 to 1.40 ± 0.55 days on different hosts (Table 4.25). The results are in conformity with the results recorded by Waseem *et al.* (2012) and Laskar (2013) who also found pre-pupal duration to be 0.5-1 days on cucumber and bitter gourd. Similarly, the pupal period ranged from 7-8 days with an average of 7.40 ± 0.55 to 9.20 ± 0.45 days. The lowest mean pupal period was observed on cucumber (7.40 ± 0.55 days) followed by 8.20 ± 0.84, 8.60 ± 0.55, 8.60 ± 0.55 and 8.60 ± 0.89 days on bitter gourd, pumpkin, sponge gourd and muskmelon, respectively. However, the pupal period of melon fruit fly on ridge gourd, watermelon and bottle gourd was completed in 9.20 ± 0.45, 9.20 ± 0.45 and 9.20 ± 1.10 days, respectively.

The results obtained during the investigation are in confirmation with Laskar (2013) and Desai *et al.* (2018) who recorded pupal period of 6-8 days on bitter gourd and sponge gourd, respectively. However, Hollingsworth *et al.* (1997) reported that pupal period lasted for 6.5-21.8 days.

4.2.3.1.4 The growth index

The growth index values of *B. cucurbitae* were varied significantly when reared on different hosts (Table 4.25). Significantly highest growth index was observed in the case of maggots reared on cucumber (2.36) over bitter gourd (2.42), muskmelon (1.97), pumpkin (1.71), sponge gourd (1.70), watermelon and ridge gourd (1.66) and lowest value of growth index were observed to be the maggot reared on bottle gourd (1.57).

4.2.3.1.5 Pre- oviposition period

The mean pre-oviposition period of melon fruit fly was varied when reared on different hosts. The data presented in Table 4.25 indicated that the females had a pre-oviposition period of 7 to 13 days. However, mean pre-oviposition period was recorded to be 8.40 ± 1.14 (7 to10 days), 10.80 ± 1.10 (10 to 12 days), 10.40 ± 0.89 (10 to 12 days), 10.60 ± 0.55 (10 to 11 days), 10.40 ± 0.89 (10 to 12 days), 10.60 ±1.52 (9 to 13 days), 9.60 ± 1.95 (7 to 12 days) and 10.80 ± 1.48 (9 to 13 days) for cucumber, bitter gourd, ridge gourd, pumpkin, watermelon, sponge gourd, muskmelon and bottle gourd, respectively. The present investigations are mostly in agreement with the findings of Koul and Bhagat (1994) who also found it in the range of 10- 15 days.

4.2.3.1.6 Oviposition period

It is evident from the Table 4.25 that significant difference in the oviposition periods of female *B. cucurbitae* when reared on all the eight hosts. The oviposition period ranged from 1-3 days with the mean oviposition period of 2.60 ± 0.55 (2 to 3 days), 2.00 ± 0.71 (1 to 3 days), 1.40 ± 0.55 (1 to 2 days), 1.60 ± 0.55 (1 to 2 days), 1.40 ± 0.55 (1 to days), 1.60 ± 0.55 (1 to 2 days), 1.80 ± 0.45 (1 to 2 days), 1.60 ± 0.55 (1 to 2 days) for cucumber, bitter gourd, ridge gourd, pumpkin, watermelon, sponge gourd, muskmelon and bottle gourd, respectively.

The results are in consistent with the findings of Koul and Bhagat (1994) and Langar *et al.* (2013) who reported it to vary between 12-28 days on Indian squash and cucumber. However, the results are in contradictory with the readings of Waseem *et al*. (2012) who found that the oviposition period of *B. cucurbitae* varied from 5-44 days which was even longer in winter while rearing on cucumber.

Table 4.25: Biology of melon fruit fly on different cucurbitaceous hosts

Life stage	Duration (Days)							
	Cucumber		Bitter gourd		Ridge gourd		Pumpkin	
	Range	Mean ± S.D.	Range	Mean ± S.D.	Range	Mean ± S.D.	Range	Mean ± S.D.
Egg	1.00 - 2.00	1.20 ± 0.45	1.00 - 2.00	1.40 ± 0.55	1.00 - 2.00	1.40 ± 0.55	1.00 - 2.00	1.20 ± 0.45
Larva								
I instar	0.50 - 1.00	0.90 ± 0.22	1.00 - 2.00	1.20 ± 0.45	1.00 - 2.00	1.20 ± 0.45	1.00 - 1.00	1.00 ± 0.00
II instar	1.00 - 2.00	1.20 ± 0.45	1.00 - 2.00	1.20 ± 0.45	1.00 - 2.00	1.20 ± 0.45	1.00 - 2.00	1.20 ± 0.45
III instar	5.00 - 6.00	5.80 ± 0.45	3.00 - 6.00	4.60 ± 1.14	5.00 - 6.00	5.80 ± 0.45	5.00 - 6.00	5.40 ± 0.55
Total	6.50 - 8.00	7.60 ± 0.65	6.00 - 8.00	7.00 ± 0.71	8.00 - 9.00	8.40 ± 0.55	7.00 - 8.00	7.60 ± 0.55
Pre-pupa	0.50 - 2.00	1.10 ± 0.55	1.00 - 2.00	1.20 ± 0.45	1.00 - 2.00	1.20 ± 0.45	1.00 - 2.00	1.20 ± 0.45
Pupa	7.00 - 8.00	7.40 ± 0.55	7.00 - 9.00	8.20 ± 0.84	9.00 - 10.00	9.20 ± 0.45	8.00 - 9.00	8.60 ± 0.55
Growth index	2.36		2.42		1.66		1.71	
Adult								
Pre oviposition	7.00 - 10.00	8.40 ± 1.14	10.00 - 12.00	10.80 ± 1.10	10.00 - 12.00	10.40 ± 0.89	10.00 - 11.00	10.60 ± 0.55
Oviposition	2.00 - 3.00	2.60 ± 0.55	1.00 - 3.00	2.00 ± 0.71	1.00 - 2.00	1.40 ± 0.55	1.00 - 2.00	1.60 ± 0.55
Post oviposition	2.00 - 4.00	2.60 ± 0.89	2.00 - 3.00	2.40 ± 0.55	2.00 - 3.00	2.20 ± 0.45	2.00 - 4.00	2.60 ± 0.89
Longevity								
Male	9.00 - 10.00	9.80 ± 0.45	10.00 - 11.00	10.60 ± 0.55	6.00 - 8.00	6.80 ± 0.84	6.00 - 10.00	8.00 ± 1.41
Female	17.00 - 20.00	18.60 ± 1.34	14.00 - 16.00	15.20 ± 1.10	12.00 - 16.00	14.00 ± 1.58	12.00 - 16.00	14.80 ± 1.64
Fecundity	85.00- 90.00	87.80 ± 1.92	80.00 - 85.00	83.80 ± 2.17	75.00 - 87.00	81.00 ± 5.34	77.00 - 89.00	82.80 ± 5.17
Hatching%	80.00 - 88.00	83.80 ± 3.19	66.00 - 78.00	71.00 ± 4.69	68.00 - 74.00	71.20 ± 2.28	70.00 - 82.00	77.20 ± 4.60
Total life cycle								
Male	25.00 - 30.00	27.00 ± 2.17	23.00 - 29.00	25.80 ± 2.28	24.00 - 28.00	24.00 - 28.00	25.00- 30.00	27.60 ± 2.07
Female	29.00 - 34.00	31.00 ± 2.00	28.00 - 32.00	30.00 ± 1.58	25.00 - 30.00	25.00 - 30.00	27.00 - 31.00	29.00 ± 1.58
Sex ratio	1:1.31		1:1.18		1:1.12		1.1.21	

Continue

Life stage	Duration (Days)							
	Watermelon		Sponge gourd		Muskmelon		Bottle gourd	
	Range	Mean ± S.D.	Range	Mean ± S.D.	Range	Mean ± S.D.	Range	Mean ± S.D.
Egg	1.00 - 2.00	1.40 ± 0.55	1.00 - 2.00	1.60 - 0.55	1.00 - 2.00	1.60 ± 0.55	1.00 - 2.00	1.80 ± 0.45
Larva								
I instar	1.00 - 2.00	1.20 ± 0.45	1.00 - 2.00	1.20 - 0.45	1.00 - 1.00	1.00 ± 0.00	0.50 - 1.00	0.90 ± 0.22
II instar	1.00 - 2.00	1.20 ± 0.45	1.00 - 2.00	1.40 - 0.55	1.00 - 2.00	1.40 ± 0.55	1.00 - 2.00	1.20 ± 0.45
III instar	5.00 - 6.00	5.80 ± 0.45	5.00 - 7.00	6.00 - 0.71	4.00 - 6.00	5.40 ± 0.89	6.00 - 7.00	6.20 ± 0.45
Total	8.00 - 9.00	8.40 ± 0.55	8.00 - 10.00	8.80 - 0.84	6.00 - 9.00	7.60 ± 1.10	8.00 - 10.00	8.90 ± 0.74
Pre-pupa	1.00 - 2.00	1.20 ± 0.45	1.00 - 2.00	1.20 - 0.45	1.00 - 1.50	1.10 ± 0.22	1.00 - 2.00	1.40 ± 0.55
Pupa	9.00 - 10.00	9.20 ± 0.45	8.00 - 9.00	8.60 - 0.55	8.00 - 10.00	8.60 ± 0.89	8.00 - 11.00	9.20 ± 1.10
Growth index	1.66		1.70		1.97		1.57	
Adult								
Pre oviposition	10.00 - 12.00	10.40 ± 0.89	9.00 - 13.00	10.60 - 1.52	7.00 - 12.00	9.60 ± 1.95	9.00 - 13.00	10.80 ± 1.48
Oviposition	1.00 - 2.00	1.40 ± 0.55	1.00 - 2.00	1.60 - 0.55	1.00 - 2.00	1.80 ± 0.45	1.00 - 2.00	1.60 ± 0.55
Post oviposition	2.00 - 3.00	2.20 ± 0.45	2.00 - 5.00	2.80 - 1.30	2.00 - 3.00	2.60 ± 0.55	2.00 - 5.00	2.80 ± 1.30
Longevity								
Male	6.00 - 8.00	6.80 ± 0.84	8.00 - 12.00	10.00 - 1.58	5.00 - 7.00	6.20 ± 0.84	5.00 - 9.00	7.00 ± 2.00
Female	12.00 - 16.00	14.00 ± 1.58	14.00 - 16.00	15.00 - 1.00	12.00 - 16.00	14.00 ± 1.41	14.00 - 16.00	15.20 ± 0.84
Fecundity	75.00 - 87.00	81.00 ± 5.34	75.00 - 89.00	80.80 - 5.12	72.00 - 80.00	76.60 ± 3.13	70.00 - 79.00	74.60 ± 3.36
Hatching %	68.00 - 74.00	71.20 ± 2.28	62.00 - 75.00	69.00 - 4.69	62.00 - 79.00	68.20 ± 6.46	67.00 - 76.00	70.20 ± 3.49
Total life cycle								
Male	24.00 - 28.00	26.40 ± 1.67	28.00 - 32.00	30.20 - 1.48	25.00 - 30.00	27.80 ± 1.92	26.00 - 29.00	28.00 ± 1.23
Female	25.00 - 30.00	27.80 ± 1.92	26.00 - 32.00	29.40 - 2.30	26.00 - 29.00	28.00 ± 1.23	26.00 - 32.00	29.20 ± 2.39
Sex ratio	1:1.12		1:1.22		1:1.17		1:1.24	

4.2.3.1.7 Post-oviposition period

It was observed that female fly lived for 2 to 5 days after completion of egg laying on all the eight cucurbitaceous hosts (Table 4.25). The mean post- oviposition period of 2.60 ± 0.89, 2.40 ± 0.55, 2.20 ± 0.45, 2.60 ± 0.89, 2.20 ± 0.45, 2.80 ± 1.30, 2.60 ± 0.55 and 2.80 ± 1.30 days was recorded for cucumber, bitter gourd, ridge gourd, pumpkin, watermelon, sponge gourd, muskmelon and bottle gourd, respectively. The longer post- oviposition periods on bitter gourd (0.50 day) than on bottle gourd (1.20 days) reported by Patel (1989) are in more or less similar with the present findings.

4.2.3.1.8 Adult longevity

Results (Table 4.25) showed that female lived longer time than the male when reared on all the eight cucurbitaceous hosts. The female longevity varied from 12 to 20 days with an average of 18.60 ± 1.34 (17 to 20 days), 15.20 ± 1.10 (14 to 16 days), 14.00 ± 1.58 (12 to 16 days), 14.80 ± 1.64 (12 to 16 days), 14.00 ± 1.58 (12 to 16 days), 15.00 ± 1.00 (14 to 16 days), 14.00 ± 1.41 (12 to 16 days) and 15.20 ± 0.84 (14 to 16 days) on cucumber, bitter gourd, ridge gourd, pumpkin, watermelon, sponge gourd, muskmelon and bottle gourd, respectively. Likewise, the males lived for 5 to 10 days and mean longevity was 9.80 ± 0.45 (9 to 10 days), 10.60 ± 0.55 (10 to 11 days), 6.80 ± 0.84 (6 to 8 days), 8.00 ± 1.41 (6 to 10 days), 6.80 ± 0.84 (6 to 8 days), 10.00 ±1.58 (8 to 12 days), 6.20 ± 0.84 (5 to 7 days) and 7.00 ± 2.00 (5 to 9 days) for cucumber, bitter gourd, ridge gourd, pumpkin, watermelon, sponge gourd, muskmelon and bottle gourd, respectively.

The findings are in line with the findings of Das *et al*. (2017) and Desai *et al*. (2018) who reported that female flies lived comparatively longer than the males. They reported that longevity of female adult was 18-38 (30 ± 10.07) and 17-43 (33.60 ± 6.20) days, respectively, compared to male, whose longevity ranged from 15-32 (25 ± 8.72) and 13-35 (27.53 ± 6.62) days, respectively.

4.2.3.1.9 The fecundity

It becomes clear from Table 4.25 that number of eggs laid by females when reared on different cucurbitaceous hosts varied considerably. The fecundity of females ranged from 62 to 90 eggs with the mean of 74.60 ± 3.36 to 87.80 ± 1.92 eggs per 5 females. The highest numbers of eggs were laid by female fruit fly reared on cucumber 87.80 ± 1.92 (85-90 eggs) followed by bitter gourd 83.80 ± 2.17 (80- 85 eggs), pumpkin 82.80 ± 5.17 (77-89 eggs), ridge gourd 81.00 ± 5.34 (75- 87 eggs), watermelon 81.00 ± 5.34 (75-87 eggs), sponge gourd 80.80 ± 5.12 (75-89 eggs), muskmelon 76.60 ± 3.13 (72-80 eggs). Whereas, lowest numbers of eggs were laid on bottle gourd *i.e*. 74.60 ± 3.36 (70-79 eggs).

The results obtained during the investigation are in confirmation with the readings of Langar *et al.* (2013) and Mir *et al*. (2014) who observed it varying from 50-91 and 58-92 eggs, respectively. However, Koul and Bhagat (1994) and Laskar (2013) recorded fecundity of melon fruit fly in a range of 120-250 eggs and 90-197 eggs on bottle gourd and bitter gourd, respectively, which differed with the findings of the present study**.** Our findings on fecundity of the melon fly under laboratory conditions agree closely with those of Atwal (1986) and who recorded 58-95 and 50-91 eggs per female during her entire life span.

4.2.3.1.10 Hatching percentage

The egg hatching percentage on different hosts ranged from 62 to 88 per cent. It is evident from the data in Table 4.25 that maximum egg hatching percentage of 80 to 88, (83.80 ± 3.19 per cent) was recorded when reared on cucumber followed by pumpkin 70 to 82 (77.20 ± 4.60 per cent), ridge gourd 68 to 74 (71.20 ± 2.28 per cent), watermelon 68 to 74 (71.20 ± 2.28 per cent), bitter gourd 66 to 78 (71.00 ± 4.69 per cent), bottle gourd 67 to 76 (70.20 ± 3.49 per cent), sponge gourd 62 to 75 (69.00 ± 4.69 per cent) while, minimum egg hatching *i.e*. 62 to 79 (68.20 ± 6.46 per cent) was recorded in muskmelon.

The observations on egg hatchability are in close agreement with those of Samalo *et al*. (1991), Dhillon *et al*. (2005) and Laskar (2013) who reported that about 83-88 per cent eggs on fecundity of the melon fly under laboratory conditions agree viability. Our findings closely with those of Atwal (1986) and Langar *et al*. (2013) who recorded 58-95 and 50-91 eggs per female during her entire life span.

4.2.3.1.11 Sex ratio

Sex ratio of melon fruit fly is female oriented in present study. The highest (male: female) ratio was observed (1:1.31) in cucumber followed by bottle gourd (1:1.24), sponge gourd (1:1.22), pumpkin (1.1.21), bitter gourd (1:1.18), muskmelon (1:1.17), ridge gourd (1:1.12) and watermelon (1:1.12) (Table 4.25).

Plate 4.2: Rearing technique of melon fruit fly in laboratory

Eggs

Maggots

Pupa

Adult

Plate 4.3: Different life stages of melon fruit fly

The findings are in consistent with the readings Sisodiya (2007) who also reported that sex ratio was female biased *i.e.*, 1:1.28 on bitter gourd. However, Patel (2018) reported it to be of male biased *i.e.*, 1:0.89 and 1:0.67 on bitter gourd which differs with the results of the present investigation. Seasonal fluctuation and type of food material available decide the sex ratio of melon fruit fly (Mir *et al*. 2014) supports the above findings.

4.2.3.1.12 Total life cycle

Total life period, right from egg to death of the adult of fruit fly varied from male to female when reared on all eight different cucurbitaceous hosts. Male fruit fly lived for 23-32 days with a mean of 25.80 ± 2.28 to 30.20 ± 1.48. In case of female fruit fly total life period was slightly longer ranging from 25-34 days with the mean of 27.80 ± 1.92 to 31.00 ± 2.00 days (Table 4.25). The longest life cycle of male fruit fly was observed on sponge gourd (30.20 ± 1.48 days) followed by bottle gourd (28.00 ± 1.23 days), muskmelon (27.80 ± 1.92 days), pumpkin (27.60 ± 2.07 days), cucumber (27.00 ± 2.17 days), watermelon (26.40 ± 1.67 days), bitter gourd (25.80 ± 2.28 days) and lowest life cycle of male fruit fly observed on ridge gourd (24.60 ± 2.17 days).

However, the longest mean life cycle of female fruit fly was observed on cucumber (31.00 ± 2.00 days) followed by bitter gourd (30.00 ± 1.58 days), sponge gourd (29.40 ± 2.30 days), bottle gourd (29.20 ± 2.39 days), pumpkin (29.00 ± 1.58), muskmelon (28.00 ± 1.23 days), watermelon (27.80 ± 1.92 days) and lowest total life cycle of female fruit fly was observed on the host ridge gourd (25.00 ± 2.23 days).

The findings are in consistent with the findings of Das *et al*. (2017) and Desai *et al.* (2018) who reported that female flies lived comparatively longer than the males. They reported that longevity of female adult was 18-38 (30 ± 10.07) and 17-43 (33.60 ± 6.20) days, respectively, compared to male, whose longevity ranged from 15-32 (25 ± 8.72) and 13-35 (27.53 ± 6.62) days, respectively when fed on 5% honey solution.

4.2.3.2 Morphometrics parameters of different stages of melon fruit fly on different cucurbitaceous hosts

4.2.3.2.1 Egg

The freshly laid eggs of melon fruit fly were pure white in colour, elliptical, nearly flat on the ventral surface and slightly curved on other side. The mean length of the egg was (1.04 ± 0.03 mm) to (1.25 ± 0.03 mm) and breadth was (0.16 ± 0.03 mm) to (0.30 ± 0.44 mm), respectively (Table 4.26). The morphometric analysis of *B. cucurbitae* eggs shown variation between hosts. Freshly laid eggs in cucumber host measured from 1.22 - 1.28 mm in length and 0.23 - 0.34 mm in breadth. The mean length and breadth of eggs were 1.25 ± 0.03 mm and 0.30 ± 0.44 mm which is slightly higher than other hosts. In the bitter gourd host, the mean egg length (1.13 ± 0.11mm) and breadth (0.18 ± 0.02 mm) with the average range of 1.00 - 1.30 mm and 0.16 - 0.20 mm was observed. The mean length and breadth of other cucurbitaceous host like ridge gourd were found to be in the range of (1.08 ± 0.07 and 0.18 ± 0.02 mm), pumpkin (1.13 ± 0.11 and 0.25 ± 0.02 mm), watermelon (1.04 ± 0.03 and 0.16 ± 0.03 mm), sponge gourd (1.15 ± 0.05 and 0.17 ± 0.02 mm), muskmelon (1.07 ± 0.04 and 0.22 ± 0.04) and bottle gourd (1.08 ± 0.05 and 0.25 ± 0.01 mm), respectively.

This observation is in accordance with Desai *et al*. (2018) who recorded mean length and breadth of egg, which varied from 1.26 ± 0.03 mm and 0.26 ± 0.02 mm, respectively on sponge gourd. Das *et al*. (2017) revealed that average length of egg was 1.30 ± 0.08 mm and breadth was 0.25 ± 0.05 mm in pumpkin.

4.2.3.2.2 Maggot

Morphometric observations revealed that the length and breadth of first instar maggot on all the hosts were ranged between 1.13 to 1.94 mm and 0.17 to 0.38 mm, second instar was 3.22 to 7.45 mm and 1.00 to 1.40 mm and third instar was 8.09 to 10.56 mm and 1.40 to 2.20 mm, respectively (Table 4.26). These observations are more or less similar with the findings of Laskar (2013), Mir *et al*. (2014) and Desai *et al*. (2018). From our finding, the length of third instar maggot in bitter gourd (8.34 ± 0.14 mm) was in confirmity with the reports of Barma and Jha (2011) that the third instar larval length was 8.32±0.66 mm in pointed gourd.

Table 4.26: Morphometrics parameters of different stages of melon fruit fly on different cucurbitaceous hosts

Life stages	Parameter (s)	Hosts							
		Cucumber		Bitter gourd		Ridge gourd		Pumpkin	
		Range	Mean ± S.D.	Range	Mean ± S.D.	Range	Mean ± S.D.	Range	Mean ± S.D.
Egg	Length (mm)	1.22 - 1.28	1.25 ± 0.03	1.00 - 1.30	1.13 ± 0.11	1.00 - 1.15	1.08 ± 0.07	1.02 - 1.26	1.13 ± 0.11
	Breadth (mm)	0.23 - 0.34	0.30 ± 0.44	0.16 - 0.20	0.18 ± 0.02	0.16 - 0.22	0.18 ± 0.02	0.22 - 0.28	0.25 ± 0.02
I Instar	Length (mm)	1.17 - 1.94	1.76 ± 0.33	1.15 - 1.85	1.62 ± 0.29	1.22 - 1.88	1.62 ± 0.28	1.13 - 1.62	1.42 ± 0.19
	Breadth (mm)	0.23 - 0.38	0.32 ± 0.06	0.18 - 0.35	0.27 ± 0.07	0.18 - 0.32	0.24 ± 0.05	0.22 - 0.35	0.29 ± 0.06
II Instar	Length (mm)	4.80 - 7.45	6.02 ± 1.04	4.90 - 7.14	5.92 ± 0.92	4.56 - 7.10	5.63 ± 1.05	4.50 - 6.45	5.59 ± 0.80
	Breadth (mm)	1.06 - 1.33	1.20 ± 0.13	1.05 - 1.35	1.23 ± 0.11	1.03 - 1.28	1.17 ± 0.09	1.04 - 1.30	1.15 ± 0.10
III Instar	Length (mm)	8.25 - 10.56	9.28 ± 0.84	8.20 - 10.22	9.11 ± 0.98	8.18 - 9.16	8.84 ± 0.39	8.23 - 9.23	8.82 ± 0.40
	Breadth (mm)	1.70 - 2.20	2.06 ± 0.20	1.75 - 2.30	2.04 ± 0.26	1.65 - 2.15	1.88 ± 0.21	1.58 - 2.10	1.82 ± 0.25
Pre-Pupa	Length (mm)	6.20 - 6.65	6.44 ± 0.19	6.24 - 6.53	6.38 ± 0.14	6.15 - 6.48	6.25 ± 0.13	6.13 - 6.50	6.24 ± 0.15
	Breadth (mm)	1.95 - 2.02	1.98 ± 0.03	1.92 - 2.04	1.97 ± 0.05	1.78 - 1.98	1.87 ± 0.08	1.89 - 2.01	1.94 ± 0.05
Pupa	Length (mm)	5.45 - 5.88	5.73 ± 0.20	5.30 - 5.90	5.64 ± 0.25	5.28 - 5.78	5.51 ± 0.22	5.41 - 5.87	5.60 ± 0.17
	Breadth (mm)	2.32 - 2.72	2.57 ± 0.18	2.30 - 2.68	2.44 ± 0.15	2.28 - 2.68	2.47 ± 0.20	2.30 - 2.70	2.41 ± 0.17
Adult (Male)	Length (mm)	8.04 - 8.72	8.56 ± 0.29	8.03 - 8.70	8.53 ± 0.28	8.30 - 8.68	8.45 ± 0.14	8.02 - 8.68	8.39 ± 0.25
	Breadth (mm)	11.25 - 12.80	12.15 ± 0.64	10.04 - 12.04	10.93 ± 1.01	11.80 - 12.15	11.80 ± 0.31	10.20 - 11.52	10.77 ± 0.58
Adult (Female)	Length (mm)	9.48 - 10.18	9.97 ± 0.29	9.44 - 10.12	9.81 ± 0.33	9.40 - 10.02	9.69 ± 0.31	9.20 - 10.01	9.58 ± 0.39
	Breadth (mm)	14.85 - 16.85	15.84 ± 0.95	14.50 - 16.80	15.52 ± 0.99	14.60 - 16.72	15.48 ± 1.00	14.63 - 16.72	15.55 ± 0.88

Continue

Life stages	Parameter (s)	Hosts							
		Watermelon		Sponge gourd		Muskmelon		Bottle gourd	
		Range	Mean ± S.D.	Range	Mean ± S.D.	Range	Mean ± S.D.	Range	Mean ± S.D.
Egg	Length (mm)	1.00 - 1.08	1.04 ± 0.03	1.08 - 1.20	1.15 ± 0.05	1.02 - 1.12	1.07 ± 0.04	1.02 - 1.13	1.08 ± 0.05
	Breadth (mm)	0.13 - 0.28	0.16 ± 0.03	0.16 - 0.20	0.17 ± 0.02	0.18 - 0.28	0.22 ± 0.04	0.23 - 0.26	0.25 ± 0.01
I Instar	Length (mm)	1.16 - 1.32	1.23 ± 0.06	1.22 - 1.66	1.39 ± 0.19	1.19 - 1.55	1.42 ± 0.14	1.20 - 1.40	1.26 ± 0.08
	Breadth (mm)	0.17 - 0.24	0.21 ± 0.03	0.22 - 0.29	0.26 ± 0.03	0.24 - 0.30	0.26 ± 0.02	0.21 - 0.32	0.26 ± 0.04
II Instar	Length (mm)	4.70 - 6.90	5.66 ± 0.89	3.22 - 5.25	4.10 ± 0.75	4.40 - 6.80	5.62 ± 0.94	3.30 - 4.15	3.61 ± 0.36
	Breadth (mm)	1.04 - 1.25	1.17 ± 0.08	1.03 - 1.30	1.17 ± 0.11	1.04 - 1.25	1.17 ± 0.08	1.00 - 1.40	1.22 ± 0.20
III Instar	Length (mm)	8.12 - 9.60	8.80 ± 0.60	8.13 - 10.15	9.08 ± 0.80	8.09 - 9.42	8.75 ± 0.53	8.23 - 10.54	9.22 ± 0.92
	Breadth (mm)	1.40 - 1.71	1.62 ± 0.13	1.65 - 2.13	1.82 ± 0.18	1.38 - 1.75	1.60 ± 0.14	1.65 - 2.26	1.98 ± 0.27
Pre-Pupa	Length (mm)	6.15 - 6.62	6.36 ± 0.20	6.18 - 6.51	6.32 ± 0.14	6.16 - 6.45	6.32 ± 0.13	6.20 - 6.68	6.40 ± 0.18
	Breadth (mm)	1.90 - 2.01	1.94 ± 0.04	1.80 - 2.23	1.93 ± 0.17	1.88 - 1.98	1.93 ± 0.04	1.84 - 2.31	1.97 ± 0.19
Pupa	Length (mm)	5.30 - 5.88	5.57 ± 0.26	5.40 - 5.54	5.47 ± 0.07	5.22 - 5.86	5.44 ± 0.25	5.38 - 5.78	5.48 ± 0.17
	Breadth (mm)	2.22 - 2.70	2.40 ± 0.19	2.21 - 2.30	2.26 ± 0.03	2.30 - 2.72	2.45 ± 0.19	2.28 - 2.68	2.40 ± 0.16
Adult (Male)	Length (mm)	8.03 - 8.75	8.47 ± 0.32	8.02 - 8.65	8.37 ± 0.27	8.04 - 8.71	8.46 ± 0.27	8.42 -8.70	8.50 ± 0.12
	Breadth (mm)	11.20 - 12.35	11.68 ± 0.55	10.23 - 11.30	10.54 ± 0.45	10.60 - 12.31	11.70 ± 0.71	11.45 - 12.15	11.80 ± 0.31
Adult (Female)	Length (mm)	9.45 - 10.12	9.75 ± 0.34	9.18 - 9.94	9.52 ± 0.35	9.43 - 10.08	9.74 ± 0.30	9.26 - 9.95	9.5 ± 0.34
	Breadth (mm)	14.80 - 16.60	15.48 ± 0.89	14.20 - 16.68	15.50 ± 1.05	14.70 - 16.70	15.46 ± 1.00	14.65 - 16.70	15.72 ± 0.80

4.2.3.2.3 Pre-pupa and pupa

The mature maggots contracted longitudinally to attain pre-pupal stages which were spiral in form. The average length and breadth of pre-pupa was 6.24 ± 0.15 to 6.40 ± 0.18 mm (6.13 to 25 mm) and 1.87 ± 0.08 to 1.97 ± 0.19 mm (1.87 to 1.95), respectively. The average length and breadth of pupa was 5.44 ± 0.25 to 5.73 ± 0.20 mm (5.22 to 5.88) and 2.26 ± 0.03 to 2.57 ± 0.18 mm (2.21 to 2.72), respectively. (Table 4.26 and plate 4.3)

These morphometrical readings are in conformity with the findings of Laskar (2013), Mir *et al*. (2014) and Das *et al*. (2017) who recorded similar readings in various cucurbitaceous crops. Vigneswaran *et al.* (2016) observed and mentioned the mean length and breadth of pupal measurement of 4.97 - 5.83 mm length and 1.90 - 2.20 mm breadth in different cultivars of *Coccinia indica*, which is in tune with the observation recorded in this experiment.

4.2.3.2.4 Adult male and female

Adults were moderate in size, reddish brown with lemon yellow markings on thorax with spotted wings. Wing margin had a large apical spot which is formed by the expansion of posterior cross vein. Adult males were smaller in size than that of the females. They were easily distinguished from female adults by the absence of ovipositor and presence of blunt abdomen (Plate 4.3). The average length and breadth of adult male fly on different cucurbitaceous hosts were measured in the range of 8.37 ± 0.27 to 8.56 ± 0.29 mm (8.02 to 8.72) and 10.54 ± 0.45 to 12.15 ± 0.64 mm (10.4 to 12.80), respectively (Table 4.26). The highest mean length and breadth of male fruit fly was registered in host cucumber 8.56 ± 0.29 and 12.15 ± 0.64 mm whereas the lowest values of adult male fly was measured on sponge gourd *i.e*., 8.37 ± 0.27 and 10.54 ± 0.45 mm, respectively. Length and breadth of the adult female were found to vary from 9.50 ± 0.34 to 9.97 ± 0.29 mm (9.18 to 10.18) and 15.46 ± 1.00 to 15.84 ± 0.95 mm (14.20 to 16.85), respectively.

These morphometrical observations are more or less similar with the findings of Laskar (2013), Mir *et al.* (2014), Desai *et al*. (2018) and Chaudhary and Patel (2007). More or less similar results were obtained by Gaddanakeri and Rolania (2020) who revealed that the average length and breadth (with expanded wings) of male fruit fly was 8.41 ± 0.24 mm and 11.35 ± 0.90 mm, respectively, whereas, the average length and breadth (with expanded wings) of female was 9.74 ± 0.22 mm and 15.61 ± 0.75 mm respectively. Minor deviations in morphometrics may be attributed to the variations in host and environmental conditions.

4.3.1 Influence of different intercrops on incidence of melon fruit fly of cucumber

A. *Summer* 2021

The observations on per cent infested fruits damaged by melon fruit fly on cucumber fruits on cucumber are presented in Table 4.27 and depicted in Fig. 4.20. The observations were recorded on mean per cent infestation. The mean data showed that lower per cent infested fruits were recorded in all intercropping systems and was found statistically significant over sole cucumber (52.34%). The lowest per cent infestion was recorded from the plots intercropped with cucumber + spinach (15.02%) which was found statistically at par with cucumber + chukka (17.83%), cucumber + safflower (20.29%) and cucumber + fenugreek (23.40%). The next promising treatments in minimizing melon fruit fly population were cucumber + lettuce (25.38%), cucumber + coriander (28.76%) and cucumber + dill (30.32%).

B. *Summer* 2022

The average per cent infestation in different intercropping systems noted for six weeks of observations revealed that minimum infestation was observed in plots of cucumber intercropped with chukka (16.78%). This treatment was statistically at par with intercrops *viz*., spinach, safflower, fenugreek, lettuce, coriander and dill (18.69%, 20.64%, 22.41%, 24.23%, 27.76 and 30.37% respectively). Maximum per cent fruit infestation (50.64%) was found in sole cucumber plot (Table 4.28 & Fig. 4.20).

C. Pooled

The pooled means of two years (Table 4.29 & Fig. 4.20) indicated that all the treatments were superior over control in lowering the pest incidence. Lowest per cent fruit infestation (16.86%) was recorded in treatment cucumber intercropped with spinach followed by intercropping with chukka, safflower, fenugreek and lettuce (17.31%, 20.47%, 22.91% and 24.81%, respectively). These treatments were significantly superior over rest of the intercrops and at par with each other.

Table 4.27: Influence of different intercrops on incidence of melon fruit fly of cucumber (*Summer* 2021)

Tr. No	Treatments	Per cent fruit infestation						
		Standard meteorological week						Mean
		10	11	12	13	14	15	
T_1	Cucumber + Coriander	20.07 (26.56)	25.66 (30.39)	30.03 (33.20)	35.50 (36.55)	32.50 (34.73)	28.82 (32.39)	28.76 (32.30)
T_2	Cucumber +Safflower	14.67 (22.32)	18.56 (25.33)	21.96 (27.81)	22.49 (28.22)	22.95 (28.51)	21.13 (27.28)	20.29 (26.58)
T_3	Cucumber + Chukka	12.86 (20.97)	16.92 (24.25)	18.58 (25.49)	20.07 (26.52)	20.58 (26.82)	18.00 (24.99)	17.83 (24.84)
T_4	Cucumber + Spinach	9.99 (18.31)	15.15 (22.82)	16.91 (24.14)	16.77 (24.08)	15.94 (23.34)	15.33 (22.84)	15.02 (22.59)
T_5	Cucumber + Fenugreek	17.57 (24.70)	19.85 (26.35)	25.30 (30.12)	28.67 (32.33)	26.33 (30.79)	22.67 (28.37)	23.40 (28.78)
T_6	Cucumber + Lettuce	19.37 (26.05)	23.28 (28.82)	26.84 (31.07)	31.37 (34.02)	28.50 (32.20)	22.94 (28.50)	25.38 (30.11)
T_7	Cucumber + Dill	23.11 (28.68)	27.23 (31.43)	28.55 (32.26)	36.17 (36.94)	34.50 (35.94)	32.33 (34.58)	30.32 (33.31)
T_8	Sole cucumber	45.27 (42.28)	50.83 (45.48)	53.33 (46.92)	58.97 (50.17)	55.97 (48.43)	49.70 (44.83)	52.34 (46.35)
S.E (m) ±		2.21	2.29	2.39	2.31	2.59	2.70	2.41
CD at 5%		6.69	6.96	7.24	7.01	7.85	8.19	7.32
CV %		10.30	9.57	9.32	8.42	9.73	10.86	9.70

Figures in parenthesis are Arc sin transformed values

Table 4.28: Influence of different intercrops on incidence of melon fruit fly of cucumber (*Summer* 2022)

Tr. No	Treatments	Per cent fruit infestation						
		Standard meteorological week						Mean
		14	15	16	17	18	19	
T_1	Cucumber + Coriander	18.40 (25.29)	25.17 (30.02)	29.52 (32.86)	41.67 (40.15)	28.33 (32.12)	23.50 (28.94)	27.76 (31.56)
T_2	Cucumber +Safflower	13.43 (21.39)	19.32 (25.99)	23.72 (29.10)	31.70 (34.24)	20.50 (26.85)	15.17 (22.82)	20.64 (26.73)
T_3	Cucumber + Chukka	9.50 (17.79)	15.33 (23.01)	18.70 (25.56)	26.50 (30.91)	16.61 (23.98)	14.02 (21.91)	16.78 (23.86)
T_4	Cucumber + Spinach	11.67 (19.80)	17.53 (24.61)	20.58 (26.93)	26.42 (30.88)	19.93 (26.43)	16.00 (23.51)	18.69 (25.36)
T_5	Cucumber + Fenugreek	13.40 (21.37)	20.57 (26.81)	25.67 (30.39)	35.17 (36.26)	22.50 (28.23)	17.17 (24.42)	22.41 (27.91)
T_6	Cucumber + Lettuce	18.82 (25.62)	19.67 (26.22)	25.67 (30.37)	39.50 (38.92)	23.67 (29.03)	18.08 (25.09)	24.23 (29.21)
T_7	Cucumber + Dill	23.67 (29.01)	28.53 (32.24)	31.86 (34.32)	43.75 (41.37)	30.50 (33.46)	23.90 (29.19)	30.37 (33.27)
T_8	Sole cucumber	47.97 (43.83)	51.13 (45.65)	54.97 (47.85)	61.17 (51.48)	46.17 (42.80)	42.43 (40.65)	50.64 (45.38)
S.E (m) ±		2.39	2.51	2.16	2.91	2.30	2.25	2.42
CD at 5%		7.25	7.62	6.54	8.82	6.97	6.83	7.34
CV %		11.48	10.50	8.21	9.37	9.27	10.18	9.84

Figures in parenthesis are Arc sin transformed values

Table 4.29: Influence of different intercrops on incidence of melon fruit fly of cucumber (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Per cent fruit infestation		
		Mean of *Summer* 2021	Mean of *Summer* 2022	Pooled *Summer* 2021 and 2022
T_1	Cucumber + Coriander	28.76 (32.30)	27.76 (31.56)	28.26 (31.93)
T_2	Cucumber +Safflower	20.29 (26.58)	20.64 (26.73)	20.47 (26.66)
T_3	Cucumber + Chukka	17.83 (24.84)	16.78 (23.86)	17.31 (24.35)
T_4	Cucumber + Spinach	15.02 (22.59)	18.69 (25.36)	16.86 (23.98)
T_5	Cucumber + Fenugreek	23.40 (28.78)	22.41 (27.91)	22.91 (28.35)
T_6	Cucumber + Lettuce	25.38 (30.11)	24.23 (29.21)	24.81 (29.66)
T_7	Cucumber + Dill	30.32 (33.31)	30.37 (33.27)	30.35 (33.29)
T_8	Sole cucumber	52.34 (46.35)	50.64 (45.38)	51.49 (45.87)
S.E (m) ±		2.41	2.42	2.42
CD at 5%		7.32	7.34	7.33
CV %		9.7	9.84	9.77

Figures in parenthesis are Arc sin transformed values

The results obtained in present investigation are well supported by earlier workers Pitan and Esan (2014) who noticed that the population of fruit flies was lower with *Amranthus* established 2 weeks before cucumber and same day as cucumber than with 2 weeks after cucumber. The damage was reduced in the intercrop compared with the monocropped cucumber.

4.3.2 Influence of different intercrops on incidence of whitefly on cucumber

A. *Summer* 2021

The mean population data (Table 4.30 and Fig. 4.21) indicated that cucumber + spinach intercropping system recorded lowest population of whitefly (2.58 whitefly/3leaves/vine) and was at par with cucumber + chukka (3.72 whitefly/3leaves/vine), cucumber + lettuce (4.47 whitefly/3leaves/vine) and cucumber + coriander (5.85 whitefly/3leaves/vine). The next treatments that recorded less population of whitefly were cucumber + safflower, cucumber + fenugreek and cucumber + dill recording 7.03, 8.39 and 10.10 whitefly/3leaves/vine, respectively. The sole cucumber crop recorded a greater number of whitefly (16.76 whitefly/3leaves/vine) as compared to intercropped plots.

A. *Summer* 2022

The data presented in Table 4.31 and depicted in Fig 4.21 indicated that cucumber + spinach intercropping system recorded lowest population of whitefly (5.16 whitefly/3leaves/vine) followed by cucumber + chukka (7.01 whitefly/3leaves/vine), cucumber + lettuce (8.46 whitefly/3leaves/vine) and cucumber + safflower (10.07 whitefly/3leaves/vine). These treatments were statistically significant to rest of the treatments and at par to each other. Maximum incidence was observed in sole cucumber (53.53 whitefly/3leaves/vine).

B. Pooled

The analysis of pooled means indicated that all the treatments were superior over control. Lowest infestation (3.87 whitefly/3 leaves/vine) was recorded when spinach was used as intercrop followed by chukka and lettuce (5.37 and 6.52 whitefly/3 leaves/vine, respectively). These treatments exhibited their significance

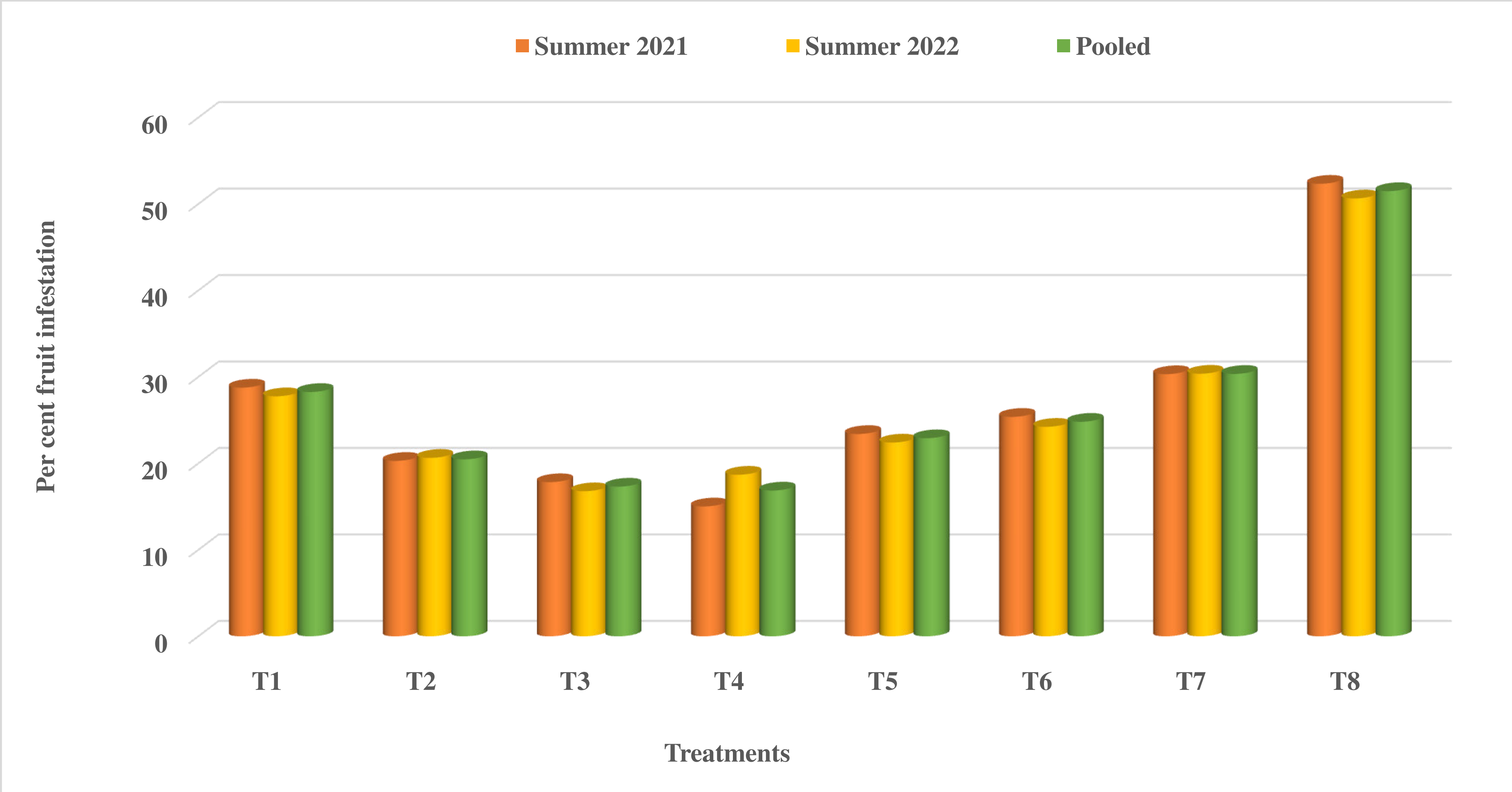

Fig. 4.20: Influence of different intercropping on incidence of melon fruit fly on cucumber (Pooled *Summer* 2021 and 2022)

Melon fruit fly

Whiteflies

Whiteflies

Red Pumpkin Beetle

Plate 4.4: Major insect pests of cucumber

Table 4.30: Influence of different intercrops on incidence of whitefly of cucumber (*Summer* 2021)

Tr. No	Treatments	Average no. of whitefly/3 leaves/vine										
		Standard meteorological week										Mean
		6	7	8	9	10	11	12	13	14	15	
T_1	Cucumber + Coriander	1.83 (1.51)	3.37 (1.97)	3.75 (2.05)	16.07 (4.02)	6.67 (2.67)	4.17 (2.16)	6.83 (2.70)	4.80 (2.29)	6.97 (2.72)	4.03 (2.12)	5.85 (2.42)
T_2	Cucumber +Safflower	2.00 (1.56)	4.14 (2.15)	4.10 (2.13)	17.67 (4.22)	8.50 (3.00)	6.03 (2.54)	8.07 (2.91)	5.57 (2.44)	8.63 (3.00)	5.60 (2.46)	7.03 (2.64)
T_3	Cucumber + Chukka	0.92 (1.18)	3.62 (2.03)	3.00 (1.86)	10.47 (3.30)	4.43 (2.12)	2.53 (1.74)	3.90 (2.08)	2.00 (1.57)	4.00 (2.11)	2.33 (1.67)	3.72 (1.97)
T_4	Cucumber + Spinach	0.75 (1.11)	2.38 (1.70)	2.00 (1.56)	7.02 (2.73)	2.57 (1.72)	1.83 (1.51)	2.83 (1.81)	1.50 (1.41)	3.17 (1.90)	1.75 (1.48)	2.58 (1.69)
T_5	Cucumber + Fenugreek	2.33 (1.65)	4.13 (2.13)	4.30 (2.18)	21.17 (4.65)	10.23 (3.27)	7.37 (2.79)	10.00 (3.23)	7.10 (2.74)	10.27 (3.26)	7.00 (2.73)	8.39 (2.86)
T_6	Cucumber + Lettuce	1.00 (1.21)	2.23 (1.65)	3.50 (2.00)	14.10 (3.76)	4.87 (2.31)	3.90 (2.07)	5.07 (2.35)	3.10 (1.88)	5.13 (2.35)	2.77 (1.80)	4.57 (2.14)
T_7	Cucumber + Dill	3.06 (1.87)	3.70 (2.05)	5.03 (2.35)	24.63 (5.00)	12.73 (3.63)	10.00 (3.24)	12.43 (3.59)	9.00 (3.08)	12.33 (3.57)	8.07 (2.91)	10.10 (3.13)
T_8	Sole cucumber	5.16 (2.38)	7.50 (2.82)	8.13 (2.93)	39.56 (6.30)	25.42 (5.09)	14.63 (3.89)	19.74 (4.49)	13.81 (3.78)	21.22 (4.66)	12.40 (3.58)	16.76 (3.99)
S.E (m) ±		0.21	0.14	0.20	0.44	0.30	0.2	0.24	0.22	0.30	0.23	0.25
CD at 5%		0.65	0.41	0.61	1.33	0.90	0.61	0.73	0.67	0.90	0.69	0.75
CV %		16.86	8.04	11.57	12.65	12.20	9.92	10.24	11.26	12.32	11.87	11.69

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values

Table 4.31: Influence of different intercrops on incidence of whitefly of cucumber (*Summer*2022)

Tr. No	Treatments	Average no. of whitefly/3 leaves/vine										
		Standard meteorological week										Mean
		10	11	12	13	14	15	16	17	18	19	
T_1	Cucumber + Coriander	4.33 (2.18)	6.33 (2.60)	7.07 (2.74)	9.67 (3.18)	8.17 (2.94)	10.67 (3.34)	14.00 (3.75)	16.67 (4.09)	18.33 (4.34)	18.60 (4.37)	11.38 (3.35)
T_2	Cucumber +Safflower	3.10 (1.88)	4.67 (2.26)	6.90 (2.71)	8.87 (3.05)	6.80 (2.69)	9.83 (3.21)	12.17 (3.56)	14.93 (3.92)	16.23 (4.09)	17.23 (4.21)	10.07 (3.16)
T_3	Cucumber + Chukka	1.58 (1.40)	2.20 (1.63)	4.00 (2.08)	6.40 (2.62)	4.00 (2.11)	6.17 (2.58)	8.33 (2.96)	11.53 (3.40)	12.83 (3.61)	13.00 (3.67)	7.01 (2.61)
T_4	Cucumber + Spinach	0.92 (1.18)	1.87 (1.52)	2.50 (1.73)	4.00 (2.11)	2.50 (1.73)	4.17 (2.15)	7.00 (2.73)	9.17 (3.11)	9.27 (3.12)	10.17 (3.24)	5.16 2.26)
T_5	Cucumber + Fenugreek	5.38 (2.41)	7.13 (2.75)	9.20 (3.11)	11.00 (3.31)	9.80 (3.21)	11.33 (3.43)	16.33 (4.09)	18.33 (4.34)	20.30 (4.56)	21.23 (4.64)	13.00 (3.59)
T_6	Cucumber + Lettuce	2.07 (1.59)	2.87 (1.82)	5.10 (2.36)	7.00 (2.69)	5.73 (2.49)	8.17 (2.93)	10.67 (3.31)	12.93 (3.62)	14.83 (3.89)	15.27 (3.97)	8.46 (2.87)
T_7	Cucumber + Dill	6.53 (2.64)	8.73 (3.03)	12.33 (3.55)	13.00 (3.64)	12.00 (3.44)	13.67 (3.71)	18.33 (4.34)	20.17 (4.54)	21.60 (4.70)	22.50 (4.78)	14.89 (3.84)
T_8	Sole cucumber	9.31 (3.13)	13.48 (3.73)	22.40 (4.78)	43.97 (6.67)	41.23 (6.46)	51.67 (7.22)	78.80 (8.90)	87.70 (9.39)	92.53 (9.60)	94.20 (9.68)	53.53 (6.96)
S.E (m) ±		0.26	0.23	0.26	0.36	0.31	0.33	0.35	0.45	0.40	0.42	0.34
CD at 5%		0.79	0.69	0.78	1.08	0.93	1.00	1.07	1.36	1.22	1.26	1.02
CV %		15.47	11.59	10.97	12.78	11.95	11.31	10.24	12.06	10.36	10.58	11.73

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values

Table 4.32: Influence of different intercrops on incidence of whitefly of cucumber (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Average no. of whitefly/3 leaves/vine		
		Mean of *Summer* 2021	Mean of *Summer* 2022	Pooled *Summer* 2021 and 2022
T_1	Cucumber + Coriander	5.85 (2.42)	11.38 (3.35)	8.62 (2.89)
T_2	Cucumber +Safflower	7.03 (2.64)	10.07 (3.16)	8.55 (2.90)
T_3	Cucumber + Chukka	3.72 (1.97)	7.01 (2.61)	5.37 (2.29)
T_4	Cucumber + Spinach	2.58 (1.69)	5.16 (2.26)	3.87 (1.98)
T_5	Cucumber + Fenugreek	8.39 (2.86)	13.00 (3.59)	10.70 (3.23)
T_6	Cucumber + Lettuce	4.57 (2.14)	8.46 (2.87)	6.52 (2.51)
T_7	Cucumber + Dill	10.10 (3.13)	14.89 (3.84)	12.50 (3.49)
T_8	Sole cucumber	16.76 (3.99)	53.53 (6.96)	35.15 (5.48)
S.E (m) ±		0.25	0.34	0.30
CD at 5%		0.75	1.02	0.89
CV %		11.69	11.73	11.71

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values

over rest treatment that showed significance over sole cucumber (35.15 whitefly/3 leaves/vine). (Table 4.32 and fig. 4.21).

Similar trends of results on population of whitefly on cucumber were documented by earlier workers Zhao *et al*. (2014) who revealed that intercropping celery and Malabar spinach with cucumber significantly reduced whitefly numbers on cucumber. Y-tube olfactometer behavioral assays revealed that whiteflies were strongly repelled from the aqueous extracts of the less preferred vegetables. The level of whitefly repellency varied with combinations of intercropped vegetables and also differed between the two whitefly biotypes. For whitefly biotype B, the greatest repellency was observed with asparagus lettuce extract, whereas celery and Malabar spinach extracts were more repellent to whitefly biotype Q. Two major volatile constituent compounds were identified, D-limonene from celery and geranyl nitrile from Malabar spinach. Sprayable 1 per cent formulations of these compounds significantly reduced whitefly colonization on cucumber under field conditions.

4.3.3 Influence of different intercrops on incidence of thrips of cucumber

A. *Summer* 2021

The data pertaining to influence of different intercropping systems on incidence of thrips in cucumber is given in Table 4.33 and graphically presented in Fig. 4.22. The mean data showed that the lower population of thrips was recorded from cucumber + spinach (2.43 thrips/3 leaves/vine), cucumber + lettuce (3.18 thrips/3 leaves/vine), cucumber + coriander (3.87 thrips/3 leaves/vine), cucumber + chukka (4.43 thrips/3 leaves/vine), and cucumber + fenugreek (4.73 thrips/3 leaves/vine). But statistically all these treatments were at par with each other. The intercropping systems; cucumber + dill and cucumber + safflower recorded highest number of thrips (5.71 and 6.25 thrips/3 leaves/vine) but it was also statistically better treatment when compared with sole cucumber (11.58 thrips/3 leaves/vine).

B. *Summer* 2022

During 2022, lower population of thrips was recorded from all the intercrops and was found statistically significant over sole cucumber. However, the treatments with cucumber + spinach, cucumber + lettuce, cucumber + coriander, cucumber + chukka, cucumber + fenugreek and cucumber + safflower (4.10, 4.86,

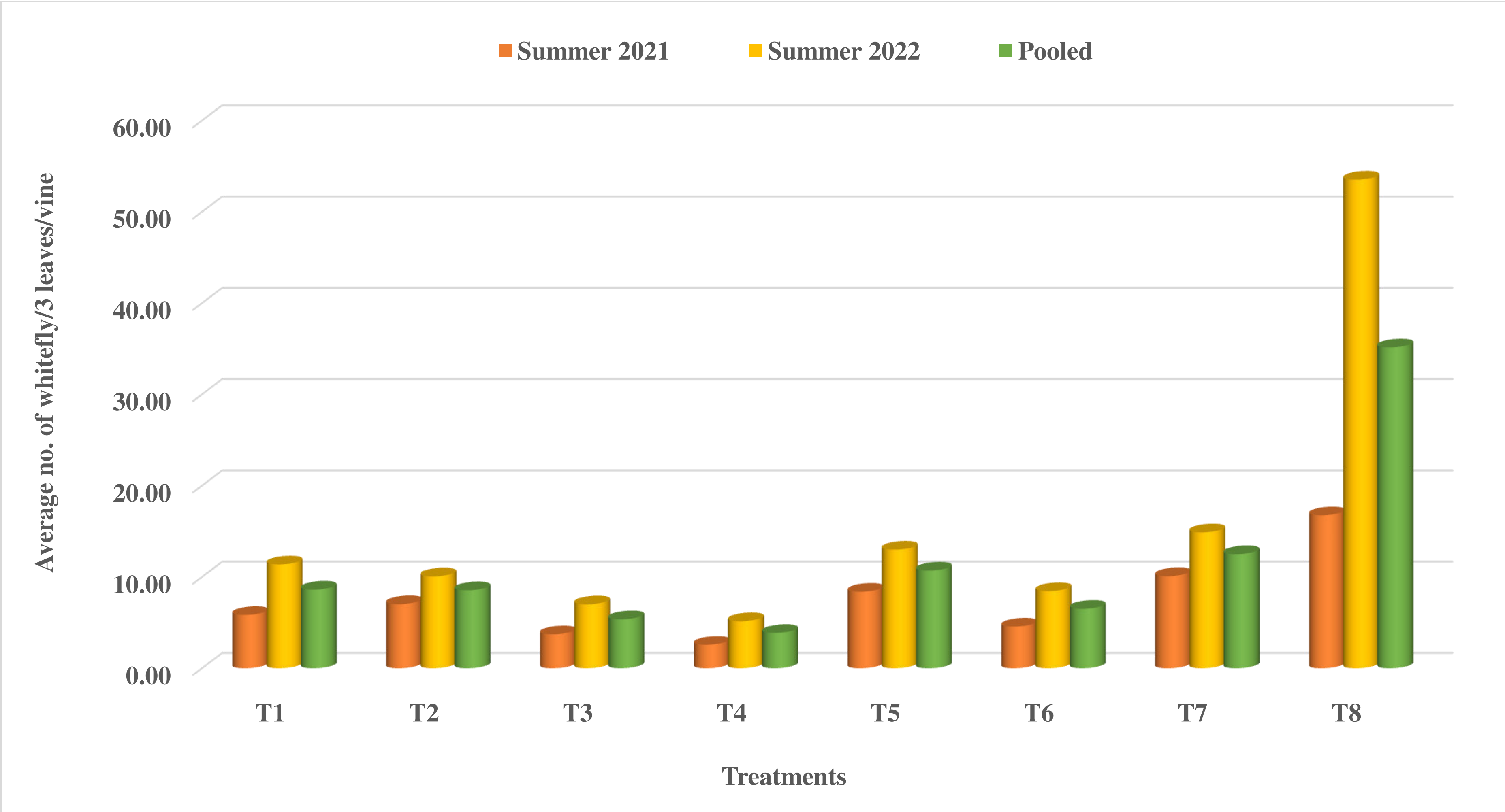

Fig. 4.21: Influence of different intercropping on incidence of whitefly on cucumber (Pooled *Summer* 2021 and 2022)

Table 4.33: Influence of different intercrops on incidence of thrips of cucumber (*Summer* 2021)

Tr. No	Treatments	Average no. of thrips/3 leaves/vine										
		Standard meteorological week										Mean
		6	7	8	9	10	11	12	13	14	15	
T_1	Cucumber + Coriander	3.10 (1.89)	3.17 (1.90)	3.40 (1.96)	7.10 (2.75)	7.40 (2.81)	2.61 (1.76)	2.23 (1.63)	3.23 (1.93)	3.63 (2.03)	2.87 (1.83)	3.87 (2.05)
T_2	Cucumber + Safflower	4.17 (2.15)	4.30 (2.18)	4.27 (2.17)	9.50 (3.16)	9.73 (3.17)	4.10 (2.14)	4.23 (2.17)	6.33 (2.61)	6.43 (2.63)	9.45 (3.15)	6.25 (2.55)
T_3	Cucumber + Chukka	3.30 (1.95)	3.45 (1.98)	3.97 (2.11)	8.03 (2.92)	8.17 (2.94)	2.97 (1.85)	2.73 (1.79)	4.17 (2.16)	4.37 (2.20)	3.17 (1.91)	4.43 (2.18)
T_4	Cucumber + Spinach	1.17 (1.27)	1.67 (1.46)	1.37 (1.36)	5.23 (2.39)	5.63 (2.44)	1.83 (1.51)	1.37 (1.36)	1.97 (1.57)	2.50 (1.73)	1.60 (1.44)	2.43 (1.65)
T_5	Cucumber + Fenugreek	3.90 (2.10)	3.83 (2.07)	4.03 (2.12)	8.37 (2.96)	8.50 (2.99)	3.07 (1.88)	3.03 (1.87)	4.40 (2.21)	4.53 (2.24)	3.60 (2.02)	4.73 (2.25)
T_6	Cucumber + Lettuce	2.07 (1.59)	2.33 (1.68)	2.50 (1.73)	6.07 (2.56)	6.77 (2.68)	1.97 (1.55)	2.03 (1.57)	2.70 (1.78)	3.17 (1.91)	2.20 (1.63)	3.18 (1.87)
T_7	Cucumber + Dill	4.00 (2.11)	4.07 (2.13)	4.17 (2.15)	8.63 (3.01)	8.80 (3.04)	3.57 (2.01)	3.67 (2.04)	5.37 (2.41)	5.50 (2.45)	9.33 (3.14)	5.71 (2.45)
T_8	Sole cucumber	6.03 (2.55)	6.17 (2.57)	7.13 (2.76)	19.04 (4.42)	19.17 (4.43)	8.83 (3.05)	10.57 (3.33)	13.83 (3.76)	15.03 (3.90)	10.03 (3.18)	11.58 (3.40)
S.E (m) ±		0.18	0.17	0.19	0.20	0.28	0.18	0.19	0.20	0.23	0.27	0.21
CD at 5%		0.55	0.53	0.59	0.61	0.86	0.56	0.58	0.62	0.70	0.82	0.64
CV %		11.48	10.72	11.65	8.15	11.34	11.40	11.94	10.88	11.79	14.51	11.38

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed value

Table 4.34: Influence of different intercrops on incidence of thrips of cucumber (*Summer* 2022)

Tr. No	Treatments	Average no. of thrips/3 leaves/vine										
		Standard meteorological week										Mean
		10	11	12	13	14	15	16	17	18	19	
T_1	Cucumber + Coriander	1.37 (1.36)	1.67 (1.46)	3.40 (1.97)	5.50 (2.45)	6.07 (2.54)	6.50 (2.64)	6.70 (2.62)	7.67 (2.84)	8.00 (2.91)	6.67 (2.67)	5.35 (2.35)
T_2	Cucumber +Safflower	2.35 (1.69)	2.73 (1.79)	5.17 (2.37)	7.93 (2.89)	7.90 (2.89)	8.07 (2.92)	8.30 (2.96)	8.83 (3.05)	8.43 (2.98)	7.93 (2.90)	6.76 (2.64)
T_3	Cucumber + Chukka	1.57 (1.430	2.17 (1.62)	4.03 (2.12)	7.03 (2.74)	7.00 (2.73)	7.13 (2.76)	7.23 (2.78)	8.00 (2.91)	8.50 (3.00)	7.17 (2.77)	5.98 (2.49)
T_4	Cucumber + Spinach	0.82 (1.14)	0.91 (1.18)	2.00 (1.56)	4.03 (2.12)	4.53 (2.23)	5.03 (2.31)	5.37 (2.42)	6.00 (2.54)	6.33 (2.61)	6.00 (2.54)	4.10 (2.07)
T_5	Cucumber + Fenugreek	2.01 (1.58)	2.37 (1.68)	4.17 (2.15)	7.27 (2.78)	7.00 (2.73)	7.33 (2.79)	7.83 (2.88)	8.13 (2.93)	8.33 (2.97)	7.53 (2.83)	6.20 (2.53)
T_6	Cucumber + Lettuce	1.00 (1.21)	1.53 (1.42)	3.17 (1.90)	5.00 (2.34)	5.33 (2.40)	6.03 (2.55)	6.00 (2.54)	7.13 (2.76)	7.23 (2.77)	6.17 (2.57)	4.86 (2.25)
T_7	Cucumber + Dill	2.67 (1.78)	3.07 (1.89)	6.17 (2.58)	8.53 (2.99)	9.00 (3.08)	8.40 (2.98)	9.03 (3.09)	9.33 (3.13)	8.67 (3.02)	8.30 (2.97)	7.32 (2.75)
T_8	Sole cucumber	3.00 (1.87)	5.10 (2.36)	12.30 (3.58)	19.01 (4.42)	20.97 (4.63)	24.93 (5.04)	19.97 (4.52)	22.33 (4.78)	15.24 (3.93)	13.17 (3.65)	15.60 (3.88)
S.E (m) ±		0.14	0.16	0.19	0.19	0.21	0.24	0.24	0.21	0.23	0.28	0.21
CD at 5%		0.43	0.48	0.58	0.57	0.65	0.72	0.74	0.62	0.70	0.85	0.63
CV %		11.58	11.59	10.21	8.16	9.00	9.63	10.03	8.06	9.35	11.95	9.96

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values

5.35, 5.98, 6.20 and 6.76 thrips/3 leaves/vine, respectively) emerged as most effective intercrops for reducing incidence of thrips. There was no statistical difference amongst there six treatments. Rest of the intercrops tested were also effective when compared to sole cucumber (15.60 thrips/3 leaves/vine). (Table 4.34 & Fig. 4.22).

C. Pooled

The pooled means of two seasons indicated that all the treatments were significantly superior in minimizing thrips population over untreated control (Table 4.35 and fig. 4.22). The treatment cucumber + spinach showed best results (3.27 thrips/3 leaves/vine) and found statistically at par with treatments cucumber intercropped with lettuce, coriander, chukka and fenugreek (4.02, 4.61, 5.21 and 5.47 thrips/3 leaves/vine, respectively). The rest of the treatments were cucumber + safflower (6.51 thrips/3 leaves/vine) cucumber + dill (6.52 thrips/3 leaves/vine), also effective in lowering thrips population. Maximum infestation was found in sole cucumber (13.59 thrips/3 leaves/vine).

As the literature regarding on influence of different intercropping incidence of thrips on cucumber are not available it is not possible to discuss with earlier research work. In the present investigation, cucumber + spinach, lettuce, coriander, chukka and fenugreek were found most efficient for managing population of thrips on cucumber.

Table 4.35: Influence of different intercrops on incidence of thrips of cucumber (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Average no. of thrips/3 leaves/vine		
		Mean of *Summer* 2021	Mean of *Summer* 2022	Pooled *Summer* 2021 and 2022
T_1	Cucumber + Coriander	3.87 (2.05)	5.35 (2.35)	4.61 (2.20)
T_2	Cucumber +Safflower	6.25 (2.55)	6.76 (2.64)	6.51 (2.60)
T_3	Cucumber + Chukka	4.43 (2.18)	5.98 (2.49)	5.21 (2.34)
T_4	Cucumber + Spinach	2.43 (1.65)	4.10 (2.07)	3.27 (1.86)
T_5	Cucumber + Fenugreek	4.73 (2.25)	6.20 (2.53)	5.47 (2.39)
T_6	Cucumber + Lettuce	3.18 (1.87)	4.86 (2.25)	4.02 (2.06)
T_7	Cucumber + Dill	5.71 (2.45)	7.32 (2.75)	6.52 (2.60)
T_8	Sole cucumber	11.58 (3.40)	15.60 (3.88)	13.59 (5.48)
S.E (m) ±		0.21	0.21	0.21
CD at 5%		0.64	0.63	0.64
CV at 5%		11.38	9.96	10.67

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values

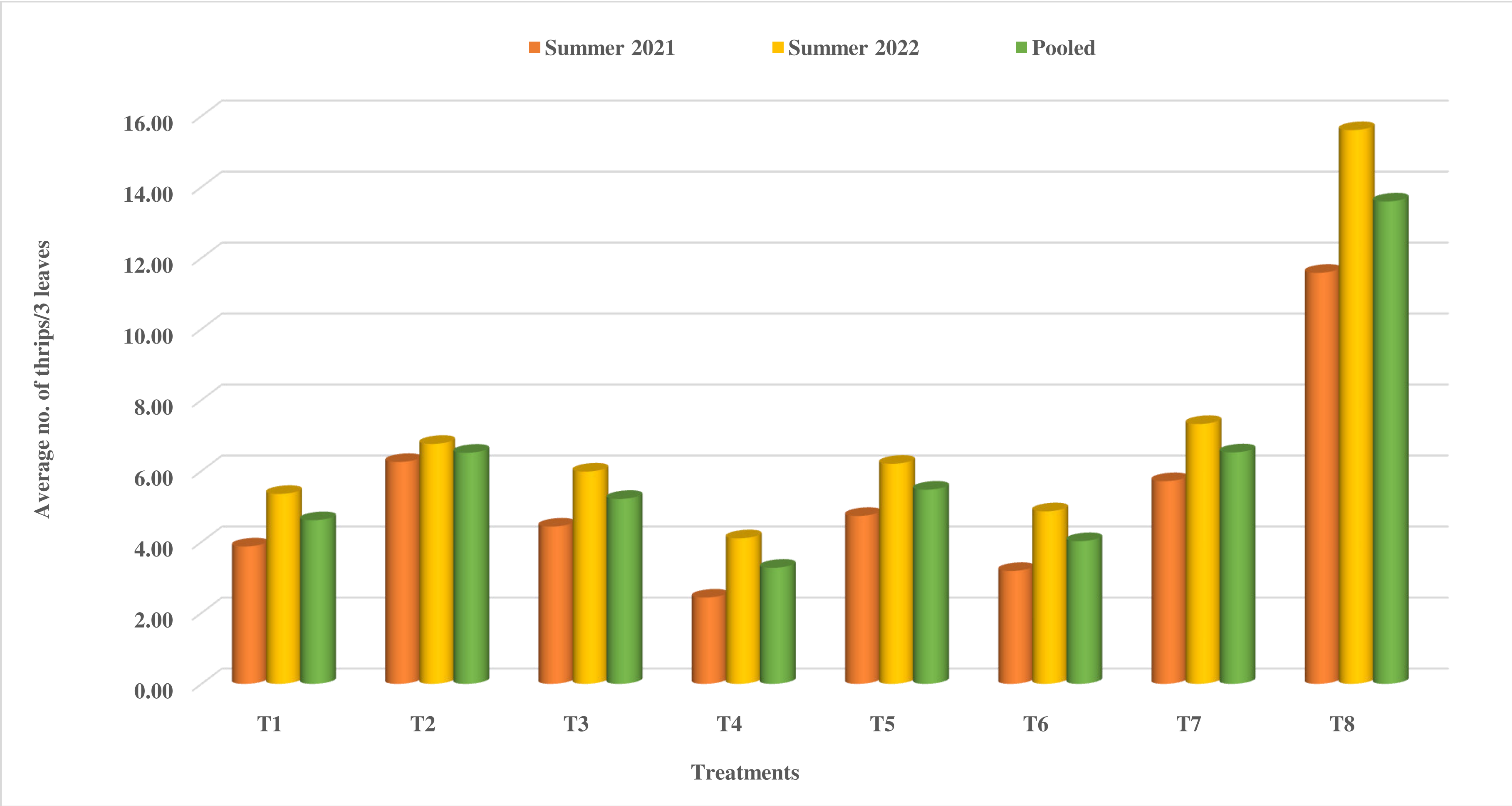

Fig. 4.22: Influence of different intercropping on incidence of thrips on cucumber (Pooled *Summer* 2021 and 2022)

4.3.4 Influence of different intercrops on abundance of lady bird beetles on cucumber

A. *Summer* 2021

The data recorded on effects of different intercropping systems on population of potential predator, lady bird beetle was presented in Table 4.36 and depicted in Fig.4.23. The treatment cucumber + spinach recorded highest numbers of predators (2.04 lbbs/vine) followed by cucumber + chukka (1.93 lbbs/vine), cucumber + lettuce (1.72 lbbs/vine), cucumber + safflower (1.48 lbbs/vine), cucumber + coriander (1.26 lbbs/vine) and cucumber + fenugreek (1.12 lbbs/vine) and these treatments were statistically at par with each other. The count of lady bird beetles in rest of the intercropped plots was also significantly higher than sole cucumber (0.64 lbbs/vine).

A. *Summer* 2022

During 2022 higher counts of lady bird beetles was found in treatment cucumber + spinach (2.54 lbbs/vine) followed by chukka, lettuce, safflower and coriander (2.34, 2.01, 1.77 and 1.57 lbbs/vine, respectively) which were found statistically at par with each other. The number of lady bird beetles in rest of the intercropped plots was also significantly higher than sole cucumber (0.71 lbbs/vine) except dill (0.98 lbbs/vine) (Table 4.37 & fig. 4.23).

B. Pooled

The pooled means showed that the treatment, cucumber + spinach was the most superior treatment showing maximum count of predators (2.29 lbbs/vine) followed by chukka (2.14 lbbs/vine), lettuce (1.87 lbbs/vine), safflower (1.63 lbbs/vine), coriander (1.42 lbbs/vine) and fenugreek (1.20 lbbs/vine) which were found at par with each other. Rest of the intercrop dill (1.00 lbbs/vine) also showed higher count of lady bird beetles. Whereas, minimum predator count of 0.68 lbbs/vine was recorded in sole cucumber (Table 4.38 & Fig. 4.23).

In the present investigation, cucumber + spinach, chukka, lettuce, safflower, coriander and fenugreek were found most efficient treatments in recording higher counts of lady bird beetles.

Table 4.36: Influence of different intercrops on abundance of lady bird beetle of cucumber (*Summer* 2021)

Tr. No	Treatments	Average no. of lady bird beetle/vine										
		Standard meteorological week										Mean
		6	7	8	9	10	11	12	13	14	15	
T_1	Cucumber + Coriander	0.40 (0.95)	0.80 (1.14)	1.50 (1.41)	1.80 (1.52)	2.50 (1.73)	1.80 (1.51)	1.40 (1.37)	1.20 (1.30)	1.00 (1.22)	0.20 (0.83)	1.26 (1.30)
T_2	Cucumber +Safflower	0.65 (1.07)	1.00 (1.22)	2.00 (1.58)	2.10 (1.59)	2.30 (1.67)	2.00 (1.58)	1.93 (1.54)	1.40 (1.37)	1.20 (1.29)	0.20 (0.84)	1.48 (1.37)
T_3	Cucumber + Chukka	1.20 (1.29)	1.40 (1.37)	2.30 (1.67)	2.50 (1.73)	3.00 (1.86)	2.50 (1.73)	2.80 (1.82)	1.50 (1.41)	1.40 (1.38)	0.65 (1.07)	1.93 (1.53)
T_4	Cucumber + Spinach	1.40 (1.37)	1.60 (1.44)	2.40 (1.70)	2.60 (1.76)	3.20 (1.91)	2.60 (1.76)	2.50 (1.73)	1.80 (1.50)	1.50 (1.41)	0.80 (1.14)	2.04 (1.57)
T_5	Cucumber + Fenugreek	0.25 (0.86)	0.65 (1.07)	1.40 (1.36)	1.60 (1.45)	2.30 (1.67)	1.50 (1.41)	1.20 (1.30)	1.10 (1.26)	1.00 (1.22)	0.20 (0.83)	1.12 (1.24)
T_6	Cucumber + Lettuce	0.85 (1.16)	1.20 (1.30)	2.10 (1.61)	2.30 (1.67)	2.50 (1.73)	2.20 (1.64)	2.00 (1.56)	1.80 (1.51)	1.50 (1.41)	0.80 (1.14)	1.72 (1.47)
T_7	Cucumber + Dill	0.20 (0.83)	0.60 (1.05)	1.20 (1.30)	1.50 (1.41)	2.00 (1.58)	1.40 (1.37)	1.20 (1.29)	1.00 (1.22)	0.85 (1.16)	0.20 (0.84)	1.01 (1.21)
T_8	Sole cucumber	0.10 (0.77)	0.45 (0.97)	0.80 (1.14)	1.00 (1.22)	1.25 (1.32)	1.00 (1.22)	0.70 (1.09)	0.50 (1.00)	0.40 (0.95)	0.15 (0.80)	0.64 (1.05)
S.E (m) ±		0.07	0.10	0.11	0.14	0.14	0.13	0.14	0.11	0.11	0.06	0.11
CD at 5%		0.21	0.31	0.33	0.41	0.43	0.40	0.43	0.34	0.33	0.19	0.34
CV %		8.16	10.31	9.04	10.84	10.32	10.52	11.81	10.42	10.62	8.35	10.04

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values

Table 4.37: Influence of different intercrops on abundance of lady bird beetle of cucumber (*Summer* 2022)

Tr. No	Treatments	Average no. of lady bird beetle/vine										
		Standard meteorological week										Mean
		10	11	12	13	14	15	16	17	18	19	
T_1	Cucumber + Coriander	0.80 (1.14)	1.20 (1.29)	1.70 (1.48)	2.10 (1.61)	2.20 (1.64)	2.80 (1.82)	2.00 (1.58)	1.20 (1.30)	1.10 (1.26)	0.60 (1.04)	1.57 (1.42)
T_2	Cucumber +Safflower	1.00 (1.21)	1.40 (1.37)	2.00 (1.57)	2.30 (1.67)	2.50 (1.73)	3.10 (1.90)	2.10 (1.61)	1.40 (1.37)	1.20 (1.30)	0.70 (1.09)	1.77 (1.48)
T_3	Cucumber + Chukka	1.30 (1.32)	1.80 (1.52)	2.30 (1.67)	2.80 (1.81)	3.80 (2.07)	3.80 (2.07)	2.50 (1.73)	2.30 (1.67)	1.80 (1.51)	1.00 (1.22)	2.34 (1.66)
T_4	Cucumber + Spinach	1.50 (1.41)	2.00 (1.56)	2.50 (1.73)	3.00 (1.86)	3.50 (2.00)	4.00 (2.11)	2.80 (1.80)	2.60 (1.76)	2.40 (1.70)	1.10 (1.26)	2.54 (1.72)
T_5	Cucumber + Fenugreek	0.60 (1.05)	1.00 (1.22)	1.50 (1.41)	2.00 (1.56)	1.70 (1.48)	2.50 (1.73)	1.30 (1.34)	1.00 (1.22)	0.80 (1.14)	0.40 (0.94)	1.28 (1.31)
T_6	Cucumber + Lettuce	1.20 (1.28)	1.60 (1.44)	2.10 (1.61)	2.50 (1.73)	2.80 (1.81)	3.50 (1.99)	2.40 (1.70)	1.70 (1.47)	1.50 (1.41)	0.80 (1.13)	2.01 (1.56)
T_7	Cucumber + Dill	0.40 (0.94)	0.80 (1.13)	1.20 (1.29)	1.70 (1.48)	1.20 (1.30)	1.70 (1.48)	1.10 (1.26)	0.90 (1.18)	0.60 (1.04)	0.20 (0.84)	0.98 (1.19)
T_8	Sole cucumber	0.30 (0.89)	0.55 (1.02)	0.85 (1.15)	1.10 (1.26)	1.00 (1.22)	1.50 (1.39)	0.75 (1.12)	0.65 (1.07)	0.40 (0.95)	0.00 (0.71)	0.71 (1.08)
S.E (m) ±		0.16	0.15	0.13	0.16	0.11	0.14	0.13	0.14	0.10	0.10	0.13
CD at 5%		0.48	0.46	0.39	0.47	0.33	0.43	0.39	0.41	0.30	0.31	0.40
CV %		16.61	13.97	10.62	11.76	8.12	9.70	10.41	12.06	9.47	12.01	11.47

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values

Table 4.38: Influence of different intercrops on abundance of lady bird beetle of cucumber (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Average no. of lady bird beetle/vine		
		Mean of *Summer* 2021	Mean of *Summer* 2022	Pooled *Summer* 2021 and 2022
T_1	Cucumber + Coriander	1.26 (1.30)	1.57 (1.42)	1.42 (1.36)
T_2	Cucumber +Safflower	1.48 (1.37)	1.77 (1.48)	1.63 (1.43)
T_3	Cucumber + Chukka	1.93 (1.53)	2.34 (1.66)	2.14 (1.60)
T_4	Cucumber + Spinach	2.04 (1.57)	2.54 (1.72)	2.29 (1.65)
T_5	Cucumber + Fenugreek	1.12 (1.24)	1.28 (1.31)	1.20 (1.28)
T_6	Cucumber + Lettuce	1.72 (1.47)	2.01 (1.56)	1.87 (1.52)
T_7	Cucumber + Dill	1.01 (1.21)	0.98 (1.19)	1.00 (1.20)
T_8	Sole cucumber	0.64 (1.05)	0.71 (1.08)	0.68 (1.07)
S.E (m) ±		0.11	0.13	0.12
CD at 5%		0.34	0.40	0.37
CV %		10.04	11.47	10.76

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values

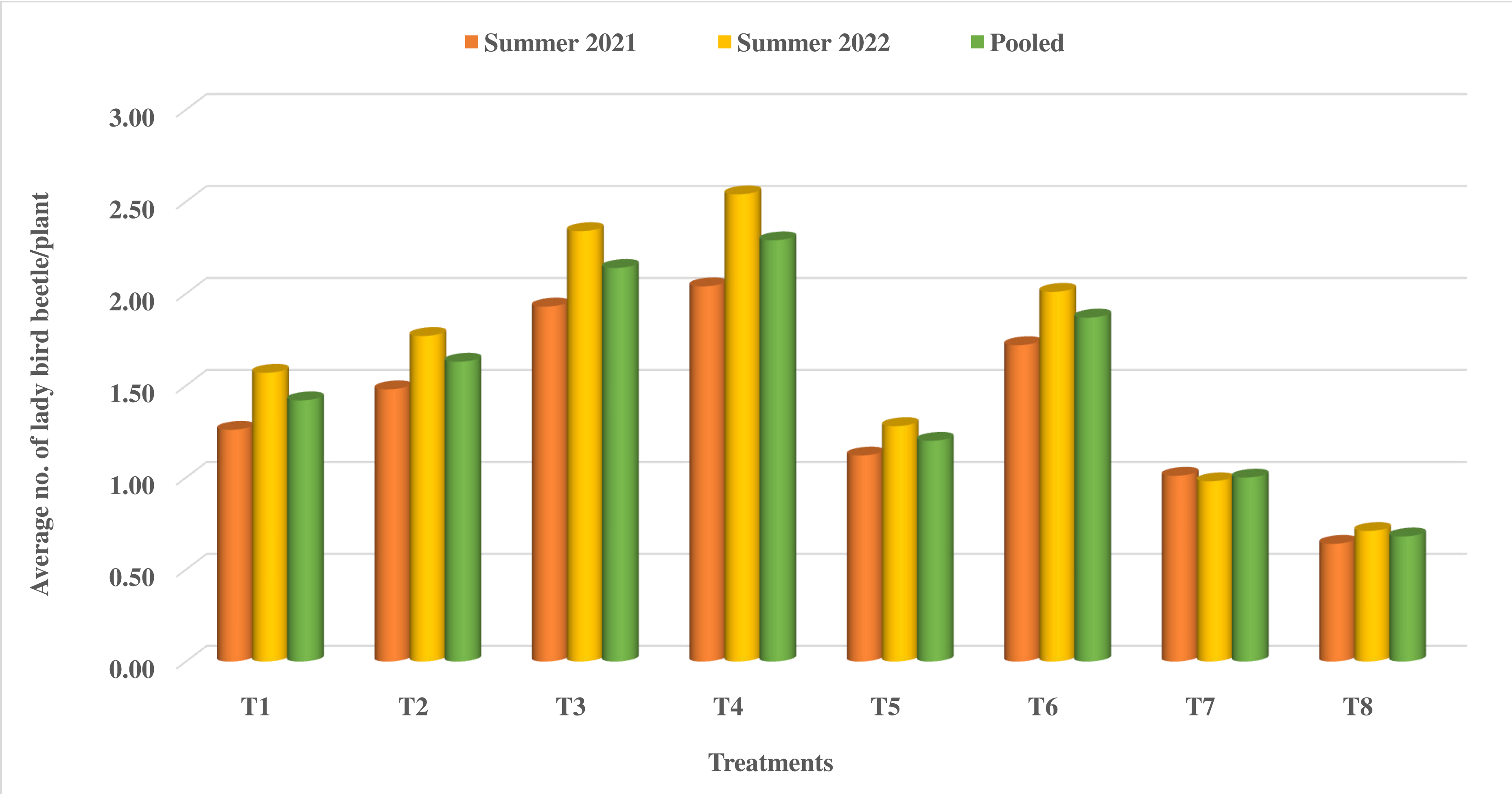

Fig. 4.23: Influence of different intercropping on abundance of lady bird beetle on cucumber (Pooled *Summer* 2021 and 2022)

Grub of LBB

Pupae of LBB

Adult of LBB

Plate 4.5: Major natural enemies of sucking insect pests of cucumber

4.3.5 Influence of different intercrops on abundance of predatory spiders on cucumber

A. *Summer* 2021

During first year of study higher abundance was recorded from intercropping systems as compared to sole crop (0.54 spiders/vine). cucumber + spinach intercropping system recorded maximum spider count (1.93 spiders/vine). Statistically similar number of spiders was also recorded from the plots intercropped with chukka, safflower, fenugreek and lettuce (1.61, 1.27, 1.16 and 0.93 spiders/vine, respectively). (Table 4.39 and fig. 4.24).

B. *Summer* 2022

The results presented in Table 4.40 and Fig. 4.24 revealed that the number of spiders in all the intercropping systems was more and statistically significant over sole cucumber (0.60 spiders/vine). Spinach recorded highest predator count (2.42 spiders/3 plant) followed by chukka (1.96 spiders/3 plant) and safflower (1.64 spiders/vine). There was no statistical difference amongst these three treatments.

C. Pooled

The analysis pooled data clearly showed that all the intercropping systems recorded more numbers of spiders as compared to sole cucumber (0.57 spider/vine). The highest count (2.18 spiders/vine) was observed in spinach intercropped cucumber. However, the treatment intercropped with chukka, safflower and fenugreek (1.79, 1.46 and 1.27 spiders/vine, respectively) were also found statistically equal to cucumber intercropped with spinach (Table 4.41 & Fig. 4.24).

As the literature regarding on influence of different intercropping systems on abundance of natural enemies of cucumber are not available it is not possible to discuss with earlier research work. In the present investigation, spinach, chukka, safflower and fenugreek were found most efficient in recording higher counts of spiders.

Table 4.39. Influence of different intercrops on abundance of predatory spider of cucumber (*Summer* 2021)

Tr. No	Treatments	Average no. of predatory spider/vine										
		Standard meteorological week										Mean
		6	7	8	9	10	11	12	13	14	15	
T_1	Cucumber + Coriander	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.80 (1.13)	1.50 (1.41)	1.20 (1.30)	1.10 (1.26)	0.60 (1.05)	0.00 (0.71)	0.74 (1.08)
T_2	Cucumber +Safflower	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.40 (1.37)	2.50 (1.73)	2.00 (1.56)	1.80 (1.51)	1.20 (1.29)	0.00 (0.71)	1.27 (1.27)
T_3	Cucumber + Chukka	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.40 (0.94)	1.60 (1.44)	3.20 (1.92)	3.00 (1.86)	2.10 (1.59)	1.00 (1.22)	0.00 (0.71)	1.61 (1.38)
T_4	Cucumber + Spinach	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.60 (1.05)	2.20 (1.64)	3.00 (1.86)	3.50 (2.00)	2.50 (1.73)	1.50 (1.41)	0.20 (0.84)	1.93 (1.50)
T_5	Cucumber + Fenugreek	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.20 (0.84)	1.20 (1.30)	2.20 (1.64)	1.80 (1.52)	1.50 (1.41)	1.00 (1.22)	0.20 (0.84)	1.16 (1.25)
T_6	Cucumber + Lettuce	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.20 (0.84)	1.00 (1.21)	2.00 (1.58)	1.50 (1.39)	1.00 (1.22)	0.80 (1.13)	0.00 (0.71)	0.93 (1.15)
T_7	Cucumber + Dill	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.60 (1.05)	1.20 (1.30)	1.00 (1.21)	0.80 (1.13)	0.40 (0.94)	0.00 (0.71)	0.57 (1.01)
T_8	Sole cucumber	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.60 (1.05)	0.80 (1.13)	1.00 (1.21)	1.20 (1.30)	0.20 (0.84)	0.00 (0.71)	0.54 (0.99)
S.E (m) ±		0.00	0.00	0.00	0.07	0.12	0.12	0.18	0.12	0.11	0.03	0.11
CD at 5%		0.00	0.00	0.00	0.21	0.37	0.36	0.55	0.37	0.34	0.08	0.33
CV %		0.00	0.00	0.00	10.27	11.84	9.25	14.75	10.74	12.06	4.20	10.44

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values

Table 4.40: Influence of different intercrops on abundance of spider of cucumber (*Summer* 2022)

Tr. No	Treatments	Average no. of predatory spider/vine										
		Standard meteorological week										Mean
		10	11	12	13	14	15	16	17	18	19	
T_1	Cucumber + Coriander	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.20 (1.30)	2.00 (1.58)	2.40 (1.70)	0.80 (1.14)	0.60 (1.04)	0.00 (0.71)	1.00 (1.17)
T_2	Cucumber +Safflower	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.20 (0.84)	2.00 (1.58)	2.50 (1.73)	3.00 (1.86)	1.80 (1.51)	1.60 (1.45)	0.40 (0.94)	1.64 (1.42)
T_3	Cucumber + Chukka	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.40 (0.94)	2.00 (1.56)	3.00 (1.86)	3.40 (1.97)	2.50 (1.73)	1.80 (1.51)	0.60 (1.05)	1.96 (1.52)
T_4	Cucumber + Spinach	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.65 (1.06)	2.50 (1.73)	3.50 (2.00)	4.00 (2.11)	3.00 (1.86)	2.50 (1.73)	0.80 (1.14)	2.42 (1.66)
T_5	Cucumber + Fenugreek	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.50 (1.39)	2.40 (1.70)	2.70 (1.79)	1.50 (1.41)	1.20 (1.29)	0.30 (0.89)	1.37 (1.31)
T_6	Cucumber + Lettuce	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.40 (1.37)	2.20 (1.64)	2.50 (1.73)	1.00 (1.22)	0.80 (1.14)	0.00 (0.71)	1.13 (1.22)
T_7	Cucumber + Dill	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.00 (1.22)	1.50 (1.41)	1.80 (1.51)	0.60 (1.05)	0.40 (0.94)	0.00 (0.71)	0.76 (1.08)
T_8	Sole cucumber	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.80 (1.14)	0.90 (1.18)	1.10 (1.26)	1.20 (1.30)	0.20 (0.84)	0.00 (0.71)	0.60 (1.02)
S.E (m) ±		0.00	0.00	0.00	0.07	0.16	0.13	0.13	0.12	0.11	0.06	0.11
CD at 5%		0.00	0.00	0.00	0.22	0.49	0.39	0.40	0.36	0.32	0.18	0.34
CV %		0.00	0.00	0.00	11.08	13.91	9.67	9.38	10.30	10.52	8.51	10.48

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values

Table 4.41: Influence of different intercrops on abundance of predatory spider of cucumber (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Average no. of predatory spider/vine		
		Mean of *Summer* 2021	**Mean of *Summer* 2022**	**Pooled *Summer* 2021 and 2022**
T_1	Cucumber + Coriander	0.74 (1.08)	1.00 (1.17)	0.87 (1.13)
T_2	Cucumber +Safflower	1.27 (1.27)	1.64 (1.42)	1.46 (1.35)
T_3	Cucumber + Chukka	1.61 (1.38)	1.96 (1.52)	1.79 (1.45)
T_4	Cucumber + Spinach	1.93 (1.50)	2.42 (1.66)	2.18 (1.58)
T_5	Cucumber + Fenugreek	1.16 (1.25)	1.37 (1.31)	1.27 (1.28)
T_6	Cucumber + Lettuce	0.93 (1.15)	1.13 (1.22)	1.03 (1.19)
T_7	Cucumber + Dill	0.57 (1.01)	0.76 (1.08)	0.67 (1.05)
T_8	Sole cucumber	0.54 (0.99)	0.60 (1.02)	0.57 (1.01)
S.E (m) ±		0.11	0.11	0.11
CD at 5%		0.33	0.34	0.34
CV %		10.44	10.48	10.46

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values

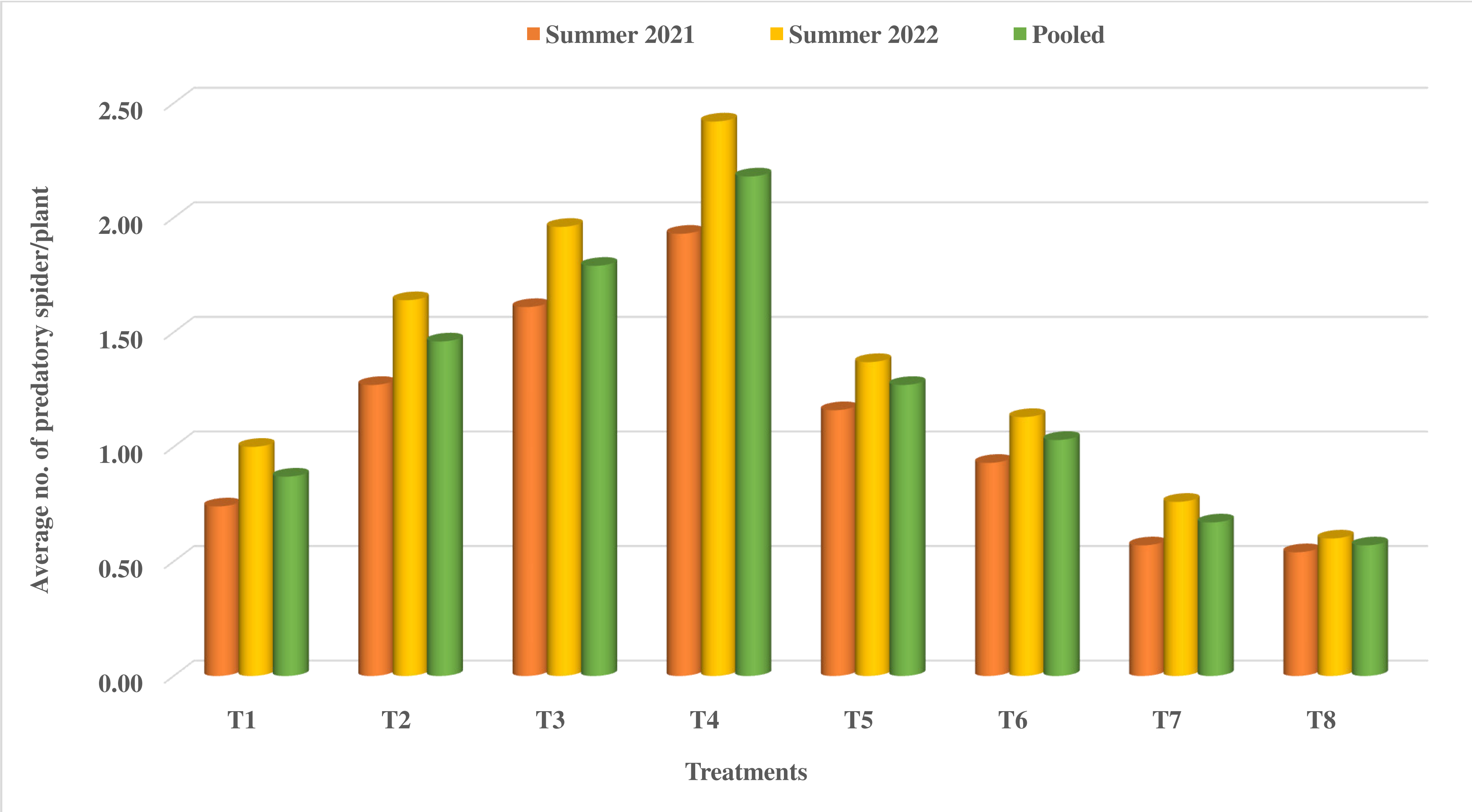

Fig. 4.24: Influence of different intercropping on abundance of predatory spider on cucumber (Pooled *Summer* 2021 and 2022)

4.3.6 Effect of different intercrops on marketable fruit yield of cucumber

A. *Summer* 2021

Cucumber fruit yield harvested from different treatments under study indicated that cucumber crop intercropped with chukka was highly significant treatment and showed highest yields (235.45 qt/ha) as compared to sole cucumber (150.57 qt/ha). The rest of the treatments intercropped with cucumber *viz*., spinach, fenugreek, safflower, lettuce, coriander and dill (227.86 qt/ha, 219.12 qt/ha, 214.35 qt/ha, 210.62 qt/ha, 203.66 qt/ha and 195.45 qt/ha, respectively) were also found higher fruit yield. Per cent increase in fruit yield over the sole cucumber was found to be higher in all the treatments intercropped with cucumber *viz*., chukka, spinach, fenugreek, safflower, lettuce, coriander and dill (56.37, 51.33, 45.53, 42.36, 39.88, 35.26 and 29.81 per cent, respectively) (Table 4.42 and Fig. 4.25).

B. *Summer* 2022

During 2022, fruit yield of cucumber obtained from various intercropping systems revealed that the highest yield (230.12 qt/ha) was recorded in treatment cucumber + chukka. Rest of the treatment *viz*., cucumber + safflower, cucumber + spinach, cucumber + fenugreek, cucumber + lettuce, cucumber + coriander and cucumber + dill (224.34 qt/ha, 218.12 qt/ha, 211.24 qt/ha, 207.45 qt/ha, 200.46 qt/ha and 193.78 qt/ha, respectively) were also found significantly higher yield over sole cucumber (151.12 qt/ha) (Table 35 fig. 6). Per cent increase in fruit yield over sole cucumber was found to be more in all the treatments *viz*., chukka, safflower, spinach, fenugreek, lettuce, coriander and dill (52.28, 48.45, 44.39, 39.78, 37.31, 28.68 and 28.23 per cent, respectively) (Table 4.43 & Fig. 4.25).

C. Pooled

Pooled results (Table 4.44 & Fig. 4.25). revealed that the treatment cucumber + chukka produced significantly highest yield (232.79 qt/ha) as compared to sole cucumber (150.85 qt/ha). Rest of the treatments also recorded higher yield (222.99 qt/ha, 219.35 qt/ha, 215.18 qt/ha, 209.04 qt/ha, 202.06 qt/ha and 194.62 qt/ha, respectively) when cucumber intercropped with spinach, safflower, fenugreek, lettuce, coriander and dill. Per cent increase in fruit yield over sole cucumber was found to be higher in all the treatments.

Table 4.42: Effect of different intercrops on marketable fruit yield of cucumber (*Summer* 2021)

Tr. No	Treatments	Fruit yield (q/ha)	% Increase in fruit yield over sole cucumber
T_1	Cucumber + Coriander	203.66	35.26
T_2	Cucumber + Safflower	214.35	42.36
T_3	Cucumber + Chukka	235.45	56.37
T_4	Cucumber + Spinach	227.86	51.33
T_5	Cucumber + Fenugreek	219.12	45.53
T_6	Cucumber + Lettuce	210.62	39.88
T_7	Cucumber + Dill	195.45	29.81
T_8	Sole cucumber	150.57	
SE (m) ±		1.71	
CD at 5 %		5.20	
CV %		11.80	

Table 4.43: Effect of different intercrops on marketable fruit yield of cucumber (*Summer* 2022)

Tr. No	Treatments	Fruit yield (q/ha)	% Increase in fruit yield over sole cucumber
T_1	Cucumber + Coriander	200.46	28.68
T_2	Cucumber + Safflower	224.34	48.45
T_3	Cucumber + Chukka	230.12	52.28
T_4	Cucumber + Spinach	218.12	44.39
T_5	Cucumber + Fenugreek	211.24	39.78
T_6	Cucumber + Lettuce	207.45	37.31
T_7	Cucumber + Dill	193.78	28.23
T_8	Sole cucumber	151.12	
SE (m) ±		1.27	
CD at 5 %		3.84	
CV %		10.33	

Table 4.44: Effect of different intercrops on marketable fruit yield of cucumber (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Fruit yield (q/ha)	% Increase in fruit yield over sole cucumber
T_1	Cucumber + Coriander	202.06	31.97
T_2	Cucumber + Safflower	219.35	45.41
T_3	Cucumber + Chukka	232.79	54.33
T_4	Cucumber + Spinach	222.99	47.86
T_5	Cucumber + Fenugreek	215.18	42.66
T_6	Cucumber + Lettuce	209.04	38.60
T_7	Cucumber + Dill	194.62	29.02
T_8	Sole cucumber	150.85	
SE (m) ±		1.49	
CD at 5 %		4.52	
CV %		11.07	

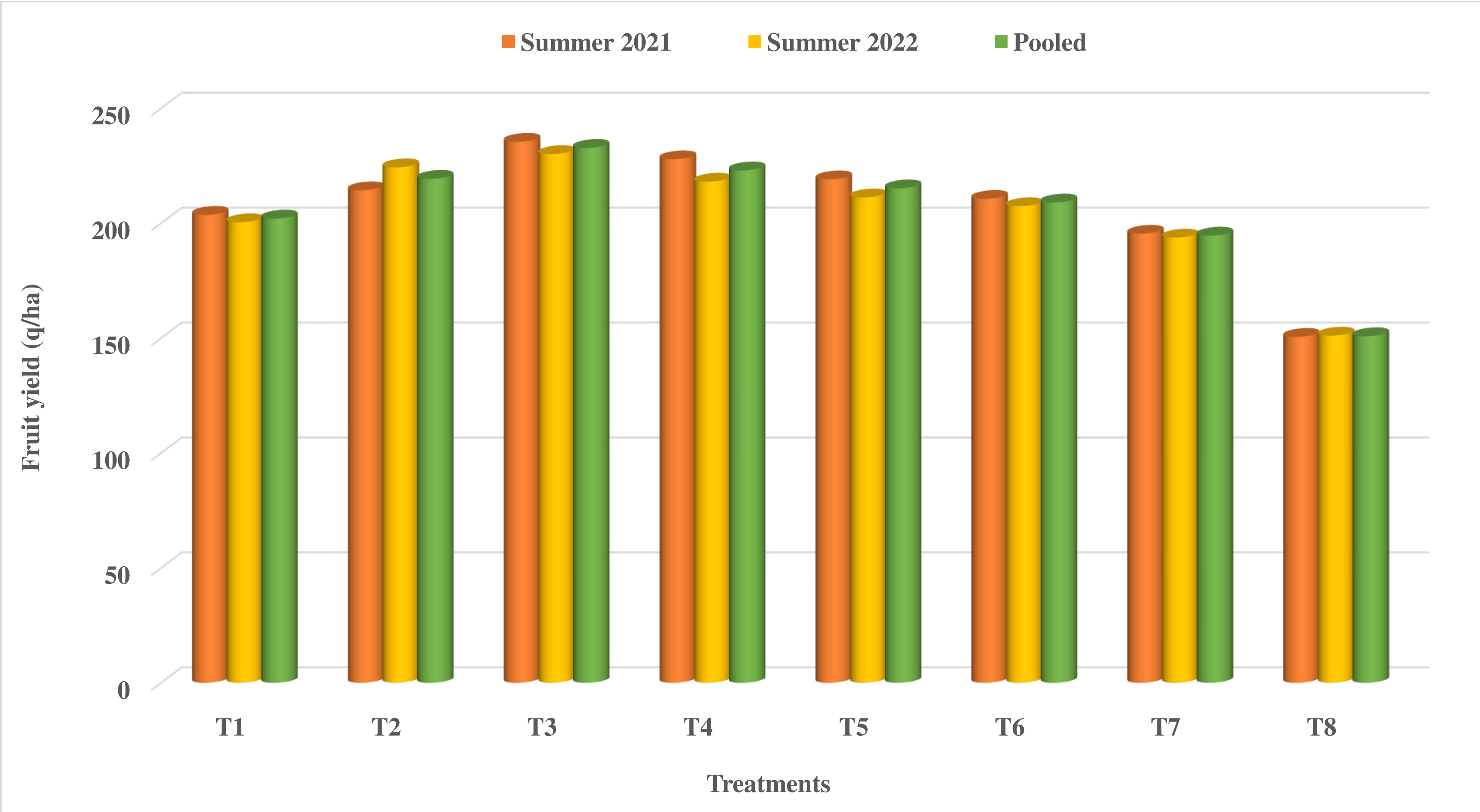

Fig. 4.25: Effect of different intercropping on marketable fruit yield of cucumber (Pooled Summer 2021 and 2022)

Plate 4.6: Different intercrops treatments

As the literature regarding on effect of different intercropping systems on marketable fruit yield of cucumber are not available it is not possible to discuss with earlier research work. In the present investigation, all the intercrop treatments produced higher yield over the sole cucumber.

4.4. Bioefficacy of different combination insecticides against insect pests cucumber

4.4.1 Bioefficacy of different combination insecticides against melon fruit fly on cucumber (number basis)

The results in respect of bio efficacy of combination insecticides against melon fruit fly on cucumber fruits based on number basis after first and second spray are presented in Table 4.45 and Fig. 4.26. The observations were recorded on mean per cent fruit infestation after each application of insecticides.

4.4.1.1 *Summer* 2021

A. Performance of insecticides after first spray

The post treatment observations recorded at 1st, 2nd, 3rd and 4th picking after first spray indicated that all the insecticidal treatments were significantly superior over control (60.86%) in reducing melon fruit fly population. Among these treatments, the mean of first spray showed that lowest fruit infestation was recorded in plots treated with chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (20.35%). It was followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, novaluron 5.25% + indoxacarb 14.5% SC, novaluron 5.25 + emamectin benzoate 0.9% SC and emamectin benzoate 1.5% + fipronil 3.5% SC. (23.53%, 26.88%, 30.01%, and 33.12%, respectively) which were found statistically at par with each other. The plots treated with chlorantraniliprole 8.8% + thiamethoxam 17.5% SC recorded minimum infested fruits at 1st, 2nd and 3rd picking (21.77%, 13.43% and 18.80%, respectively).

B. Performance of insecticides after second spray

The observations after second spray revealed that all the insecticides were found to be significantly effective in controlling melon fruit fly population over

Table 4.45: Bio efficacy of different combination insecticides against melon fruit fly (*Summer* 2021) (number basis)

Tr. No	Treatments	Dose (ml/ha)	Per cent fruit infestation										
			Precount	Picking after 1st spray					Picking after 2nd spray				
				1st	2nd	3rd	4th	Mean	1st	2nd	3rd	4th	Mean
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	57.13 (49.25)	40.60 (39.53)	22.67 (28.36)	28.50 (32.22)	40.70 (39.60)	33.12 (34.93)	35.83 (36.75)	30.90 (33.73)	33.00 (35.00)	36.17 (36.95)	33.98 (35.61)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	60.63 (51.14)	35.47 (36.52)	20.83 (27.03)	25.43 (30.16)	38.30 (38.19)	30.01 (32.98)	32.93 (34.98)	25.40 (29.97)	30.23 (33.32)	33.33 (35.22)	30.48 (33.37)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	59.87 (50.77)	42.57 (40.71)	24.13 (29.36)	33.30 (35.23)	45.27 (42.24)	36.32 (36.89)	38.50 (38.33)	31.37 (33.99)	34.40 (35.88)	38.10 (38.10)	35.59 (36.58)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	58.53 (49.96)	30.73 (33.63)	18.17 (25.20)	23.53 (28.98)	35.07 (36.28)	26.88 (31.02)	29.80 (33.05)	25.20 (30.08)	27.83 (31.80)	32.22 (34.52)	28.76 (32.36)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	60.73 (51.23)	43.90 (41.47)	38.37 (38.27)	44.93 (42.08)	51.43 (45.82)	44.66 (41.91)	40.83 (39.70)	33.40 (35.27)	41.23 (39.94)	44.93 (42.07)	40.10 (39.25)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	58.57 (49.93)	25.33 (30.14)	16.13 (23.50)	21.23 (26.96)	31.43 (33.86)	23.53 (28.61)	28.30 (32.10)	22.43 (28.20)	25.17 (29.74)	30.37 (33.25)	26.57 (30.82)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	60.40 (51.00)	21.77 (27.75)	13.43 (21.11)	18.80 (25.60)	27.40 (31.51)	20.35 (26.49)	22.67 (27.77)	15.17 (22.79)	19.93 (26.42)	25.33 (29.96)	20.78 (26.73)
T_8	Untreated control	--	59.36 (50.55)	59.77 (50.70)	60.76 (51.23)	61.04 (51.40)	61.87 (51.90)	60.86 (51.31)	62.14 (52.06)	55.33 (48.07)	55.53 (48.18)	50.27 (45.15)	55.82 (48.37)
S.E (m) ±			4.57	3.14	2.86	3.01	3.48	3.12	3.54	3.10	3.28	3.53	3.36
CD at 5%			NS	9.51	8.67	9.14	10.55	9.47	10.74	9.39	9.96	10.69	10.20
CV %			11.10	10.23	11.48	10.83	10.67	10.80	11.77	11.57	11.48	11.70	11.63

Figures in parenthesis are Arc sin transformed values NS – Non - Significant

control (55.82%). All the insecticides applied proved their significance over untreated plots. Comparatively, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (20.78%) was the superior treatment. The treatments thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, novaluron 5.25% + indoxacarb 14.5% SC, novaluron 5.25 + emamectin benzoate 0.9% SC, emamectin benzoate 1.5% + fipronil 3.5% SC and indoxacarb 14.5% + acetamiprid 7.7% (26.57%, 28.76%, 30.48%, 33.98% and 35.59%, respectively) were statistically equal to chlorantraniliprole 8.8% + thiamethoxam 17.5% SC.

4.4.1.2 *Summer* 2022

A. Performance of insecticides after first spray

During *Summer* 2022, pre-count of per cent fruit infestation ranged from 63.55% to 64.50% (Table 4.46 and Fig. 4.26).

The data recorded on mean basis revealed that chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (23.83%) was significantly superior over untreated control (64.01%) followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, novaluron 5.25% + indoxacarb 14.5% SC and emamectin benzoate 1.5% + fipronil 3.5% SC (26.99%, 31.41% and 35.69%, respectively), all these treatments were statistically at par with each other.

B. Performance after second spray

All insecticidal treatments were significantly superior over control (59.07%) in minimizing the pest incidence. The mean data recorded at 1st, 2nd, 3rd and 4th picking after second spray revealed that the plots treated with chlorantraniliprole 8.8% + thiamethoxam 17.5% SC showed minimum infestation (22.51%) followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, novaluron 5.25% + indoxacarb 14.5% SC, emamectin benzoate 1.5% + fipronil 3.5% SC and novaluron 5.25% + emamectin benzoate 0.9% SC (25.90%, 30.15%, 34.13 and 38.97%, respectively), which were statistically at par with each other and significantly superior over other combinations insecticides. The maximum mean per cent fruit infestation was recorded in untreated control 65.24%.

Table 4.46: Bioefficacy of different combination insecticides against melon fruit fly (*Summer* 2022) (number basis)

Tr. No	Treatments	Dose (ml/ha)	Per cent fruit infestation										
			Precount	Picking after 1st spray					Picking after 2nd spray				
				1st	2nd	3rd	4th	Mean	1st	2nd	3rd	4th	Mean
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	63.97 (53.11)	37.00 (37.32)	29.03 (32.50)	35.27 (36.29)	41.47 (39.91)	35.69 (36.51)	35.83 (36.66)	27.30 (31.50)	33.13 (35.14)	40.23 (39.37)	34.13 (35.67)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	64.17 (53.31)	41.80 (40.27)	34.47 (35.94)	40.40 (39.44)	45.40 (42.36)	40.52 (39.50)	40.27 (39.37)	33.47 (35.35)	38.37 (38.25)	43.77 (41.42)	38.97 (38.60)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	63.67 (53.16)	42.57 (40.71)	36.50 (37.17)	42.57 (40.70)	48.43 (44.09)	42.52 (40.67)	42.00 (40.34)	35.13 (36.35)	41.00 (39.82)	47.27 (43.43)	41.35 (39.99)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	63.77 (53.22)	32.43 (34.53)	25.47 (30.31)	31.10 (33.69)	36.63 (37.19)	31.41 (33.93)	30.43 (33.42)	24.37 (29.14)	30.37 (33.44)	35.43 (36.36)	30.15 (33.09)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	64.50 (53.60)	46.97 (43.26)	38.37 (38.13)	45.03 (42.14)	54.03 (47.33)	46.10 (42.72)	45.40 (42.29)	37.57 (37.80)	43.53 (41.28)	51.33 (45.78)	44.46 (41.79)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	64.17 (53.46)	26.50 (30.83)	22.40 (28.22)	27.37 (31.52)	31.70 (34.27)	26.99 (31.21)	27.47 (31.33)	19.93 (25.85)	25.60 (30.00)	30.60 (33.38)	25.90 (30.14)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	64.03 (53.15)	25.27 (30.09)	18.10 (25.18)	24.23 (29.36)	27.70 (31.48)	23.83 (29.03)	23.17 (28.77)	16.27 (23.79)	22.37 (28.22)	28.23 (32.10)	22.51 (28.22)
T_8	Untreated control	--	63.55 (53.09)	64.19 (53.24)	64.26 (53.31)	64.71 (53.60)	62.87 (52.46)	64.01 (53.15)	64.96 (53.70)	66.16 (54.43)	67.25 (55.33)	62.60 (52.42)	65.24 (53.97)
S.E (m) ±			4.89	3.66	2.42	3.61	3.58	3.32	3.59	3.47	3.40	3.69	3.54
CD at 5%			NS	11.10	7.34	10.95	10.86	10..06	10.90	10.52	10.30	11.20	10.73
CV %			11.25	11.55	8.45	11.53	10.66	10.55	11.51	12.39	11.04	11.16	11.52

Figures in parenthesis are Arc sin transformed values NS – Non - Significant

4.4.1.3 Pooled data

A. Performance of insecticides after first spray

Pooled data of two seasons *i.e., Summer* 2021 and 2022 regarding fruits infestion are presented in Table 4.47 and graphically depicted in Fig. 4.26. The pre-treatment count of per cent fruit infestation before initiation of the spray treatments was in the range of 60.55% to 61.46%. The data recorded at 1st, 2nd, 3rd and 4th picking after first spray on mean basis revealed that chlorantraniliprole 8.8% + thiamethoxam 17.5% SC treated plots showed minimum incidence (22.09%). The treatments thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC and novaluron 5.25% + indoxacarb 14.5% SC (25.26% and 29.14) were statistically at par with each other and significantly superior over other test insecticides.

B. Performance of insecticides after second spray

All insecticidal treatments were significantly superior over control in reducing the pest incidence.

Similar trend of results was noted on mean data recorded at 1st, 2nd, 3rd and 4th picking after second spray. The plots treated with chlorantraniliprole 8.8% + thiamethoxam 17.5% SC was showed minimum per cent fruit infestation (22.58%) and significantly superior treatment. It was followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, novaluron 5.25% + indoxacarb 14.5% SC and emamectin benzoate 1.5% + fipronil 3.5% SC (26.97, 30.05 and 34.57, respectively) were found statistically equal and significantly effective as compared to rest of the treatments. The highest per cent fruit infestation was recorded in untreated control plot (59.07%). The minimum per cent fruit infestation was observed at 2nd picking and after that gradually increased up to the 4th picking.

Table 4.47: Bioefficacy of different combination insecticides against melon fruit fly (Pooled *Summer* 2021and 2022) (number basis)

Tr. No	Treatments	Dose (ml/ha)	Per cent fruit infestation										
			Precount	Picking after 1st spray					Picking after 2nd spray				
				1st	2nd	3rd	4th	Mean	1st	2nd	3rd	4th	Mean
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	60.55 (51.15)	38.80 (38.53)	25.85 (30.54)	31.88 (34.35)	41.08 (39.80)	34.40 (35.80)	35.83 (36.72)	31.20 (33.95)	33.07 (35.09)	38.20 (38.17)	34.57 (35.98)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	62.40 (52.20)	38.63 (38.42)	27.65 (31.72)	32.92 (34.97)	41.85 (40.30)	35.26 (36.35)	36.60 (37.21)	30.37 (33.40)	34.30 (35.83)	38.55 (38.37)	34.96 (36.20)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	61.77 (51.94)	42.57 (40.71)	30.32 (33.40)	37.93 (38.02)	46.85 (43.19)	39.42 (38.83)	40.25 (39.34)	33.86 (35.57)	37.70 (37.87)	42.68 (40.79)	38.62 (38.39)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	61.15 (51.47)	31.58 (34.11)	21.82 (27.84)	27.32 (31.48)	35.85 (36.74)	29.14 (32.54)	30.12 (33.27)	27.17 (31.39)	29.10 (32.64)	33.83 (35.47)	30.05 (33.19)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	62.62 (52.38)	45.43 (42.37)	38.37 (38.24)	44.98 (42.11)	52.73 (46.58)	45.38 (42.32)	43.12 (41.01)	35.60 (36.62)	42.38 (40.62)	48.13 (43.93)	42.31 (40.55)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	61.37 (51.61)	25.92 (30.57)	19.27 (25.98)	24.30 (29.42)	31.57 (34.12)	25.26 (30.02)	27.88 (31.85)	24.14 (29.42)	25.38 (29.99)	30.48 (33.32)	26.97 (31.14)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	62.22 (52.07)	23.52 (28.95)	15.77 (23.32)	21.52 (27.54)	27.55 (31.56)	22.09 (27.84)	22.92 (28.46)	19.48 (26.17)	21.15 (27.36)	26.78 (31.11)	22.58 (28.27)
T_8	Untreated control	--	61.46 (51.62)	61.98 (51.95)	62.51 (52.24)	62.88 (52.46)	62.37 (52.17)	62.43 (52.21)	63.55 (52.87)	54.88 (47.80)	61.39 (51.63)	56.43 (48.72)	59.07 (50.26)
S.E (m) ±			2.93	2.25	1.65	2.32	2.78	2.25	2.63	1.58	2.74	2.78	2.43
CD at 5%			NS	6.81	4.99	7.03	8.45	6.82	7.97	4.79	8.30	8.45	7.38
CV 5 %			6.91	7.20	6.12	7.82	8.41	7.39	8.56	5.63	9.22	8.80	8.05

Figures in parenthesis are Arc sin transformed values NS – Non - Significant

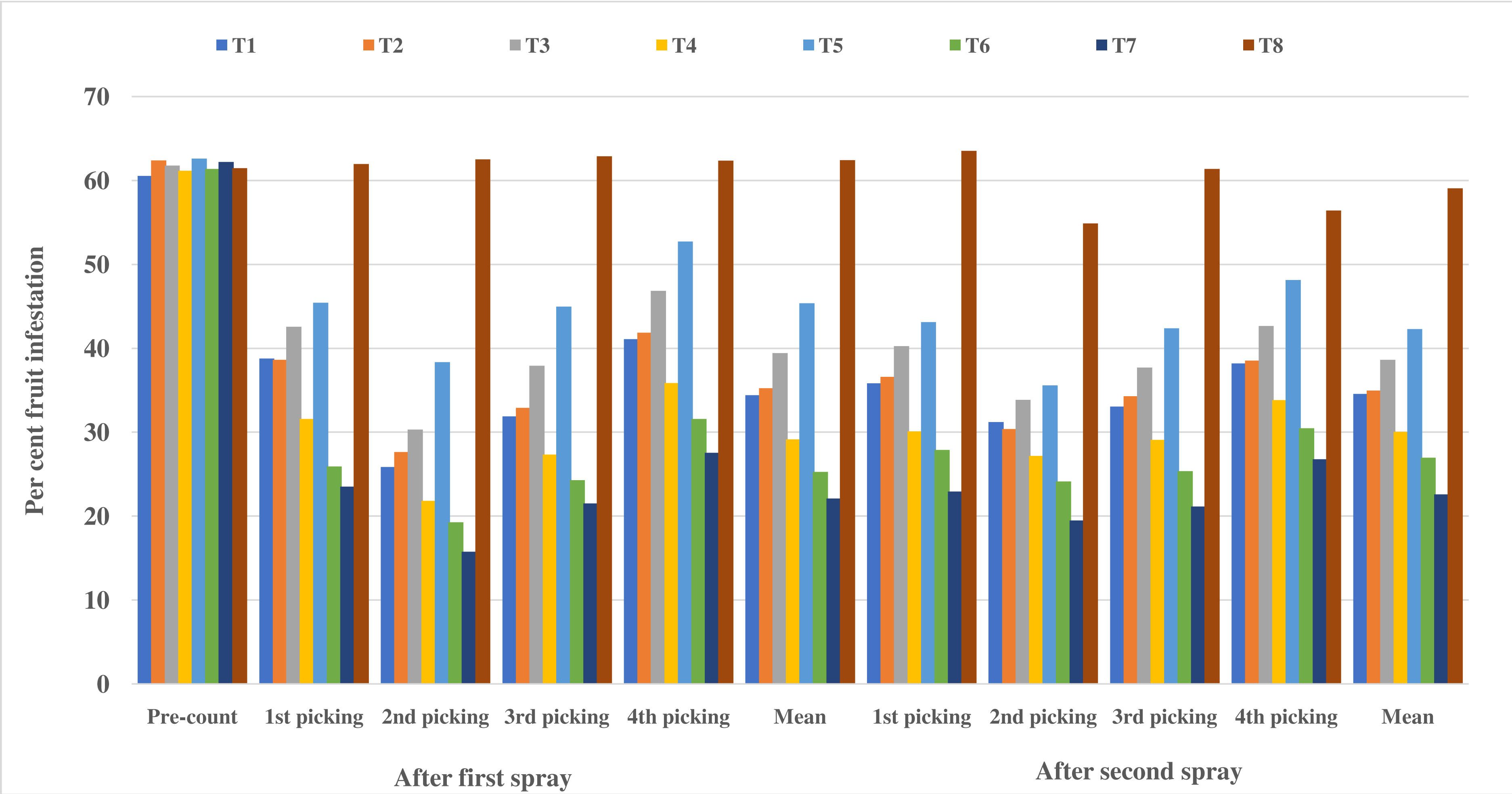

Fig. 4.26: Bioefficacy of different combination insecticides against melon fruit fly (Pooled *Summer* 2021and 2022) (number basis)

4.4.1.4. Per cent reduction in melon fruit fly population due to combination insecticides (number basis)

A. Performance of insecticides after first spray

The pooled data of two years (Table 4.48 and Fig. 4.27) indicated that chlorantraniliprole 8.8% + thiamethoxam 17.5% SC was showed maximum per cent reduction (65.05%) and the most effective treatment for reduction in melon fruit fly population which was at par with thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (59.48%).

B. Performance of insecticides after second spray

After second spray, melon fruit fly population was most effectively managed by chlorantraniliprole 8.8% + thiamethoxam 17.5% SC and recorded maximum per cent reduction (62.24%).

The present results are compared with the reports of earlier researchers on chemical control of different pests infesting many field and vegetable fruit crops and are discussed here. Roy *et al*. (2017) revealed that chlorantraniliprole + thiamethoxam showed maximum impact (60.68%) closely followed by emamectin benzoate + fipronil (60.66%) and considering the mean percent reduction of pod damage caused by pod borer, while later proved most superior among all the test combinations in percent reduction of *Meruca testulalis* larval population with highest persistency. Bhujade *et al.* (2018) reported that the application of chlorantraniliprole 8.8% + thiamethoxam 17.5% SC proved effective in recording minimum green fruiting bodies damage as well as per cent shed material, which was at par with indoxacarb 14.5% + acetamiprid 7.7% SC, chlorantraniliprole 9.3% + lambda-cyhalothrin 4.6% ZC, thiamethoxam 12.6% + lambda-cyhalothrin 4.6% ZC. Rohokale *et al*. (2018) revealed that the lowest shoot infestation by *L. orbonalis*, was observed in chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC (1.38%). Chlorantraniliprole 8.8% + thiamethoxam17.5% SC (10.47%) was the most superior treatment that showed lowest fruit damage and it was statistically at par with flubendiamide 19.92% + thiacloprid 19.92% (10.78%) followed by chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC (11.27%), indoxacarb 14.5% + acetamiprid 7.7% SC (12.52%). Chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (9.22%), was the most superior treatment showing lowest fruit damage on number basis.

Table 4.48: Per cent reduction in melon fruit fly population due to combination insecticides (Pooled *Summer* 2021 and 2022) (number basis)

Tr. No	Treatments	Dose (ml/ha)	Per cent fruit infestation												
			Precount	Picking after 1st spray				Mean	% Reduction	Picking after 2nd spray				Mean	% Reduction
				1st	2nd	3rd	4th			1st	2nd	3rd	4th		
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	60.55 (51.15)	38.80 (38.53)	25.85 (30.54)	31.88 (34.35)	41.08 (39.80)	34.40	44.07	35.83 (36.72)	31.20 (33.95)	33.07 (35.09)	38.20 (38.17)	34.57	40.59
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	62.40 (52.20)	38.63 (38.42)	27.65 (31.72)	32.92 (34.97)	41.8 (40.30)	35.26	44.37	36.60 (37.21)	30.37 (33.40)	34.30 (35.83)	38.55 (38.37)	34.96	41.71
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	61.77 (51.94)	42.57 (40.71)	30.32 (33.40)	37.93 (38.02)	46.85 (43.19)	39.42	37.18	40.25 (39.34)	33.86 (35.57)	37.70 (37.87)	42.68 (40.79)	38.62	34.94
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	61.15 (51.47)	31.58 (34.11)	21.82 (27.84)	27.32 (31.48)	35.85 (36.74)	29.14	53.09	30.12 (33.27)	27.17 (31.39)	29.10 (32.64)	33.83 (35.47)	30.05	48.86
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	62.62 (52.38)	45.43 (42.37)	38.37 (38.24)	44.98 (42.11)	52.73 (46.58)	45.38	28.66	43.12 (41.01)	35.60 (36.62)	42.38 (40.62)	48.13 (43.93)	42.31	29.70
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	61.37 (51.61)	25.92 (30.57)	19.27 (25.98)	24.30 (29.42)	31.57 (34.12)	25.26	59.48	27.88 (31.85)	24.14 (29.42)	25.38 (29.99)	30.48 (33.32)	26.97	54.27
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	62.22 (52.07)	23.52 (28.95)	15.77 (23.32)	21.52 (27.54)	27.55 (31.56)	22.09	65.05	22.92 (28.46)	19.48 (26.17)	21.15 (27.36)	26.78 (31.11)	22.58	62.24
T_8	Untreated control	--	61.46 (51.62)	61.98 (51.95)	62.51 (52.24)	62.88 (52.46)	62.37 (52.17)	62.43		63.55 (52.87)	54.88 (47.80)	61.39 (51.63)	56.43 (48.72)	59.07	
S.E (m) ±			2.93	2.25	1.65	2.32	2.78			2.63	1.58	2.74	2.78		
CD at 5%			NS	6.81	4.99	7.03	8.45			7.97	4.79	8.30	8.45		
CV %			6.91	7.20	6.12	7.82	8.41			8.56	5.63	9.22	8.80		

Figures in parenthesis are Arc sin transformed values NS – Non - Significant

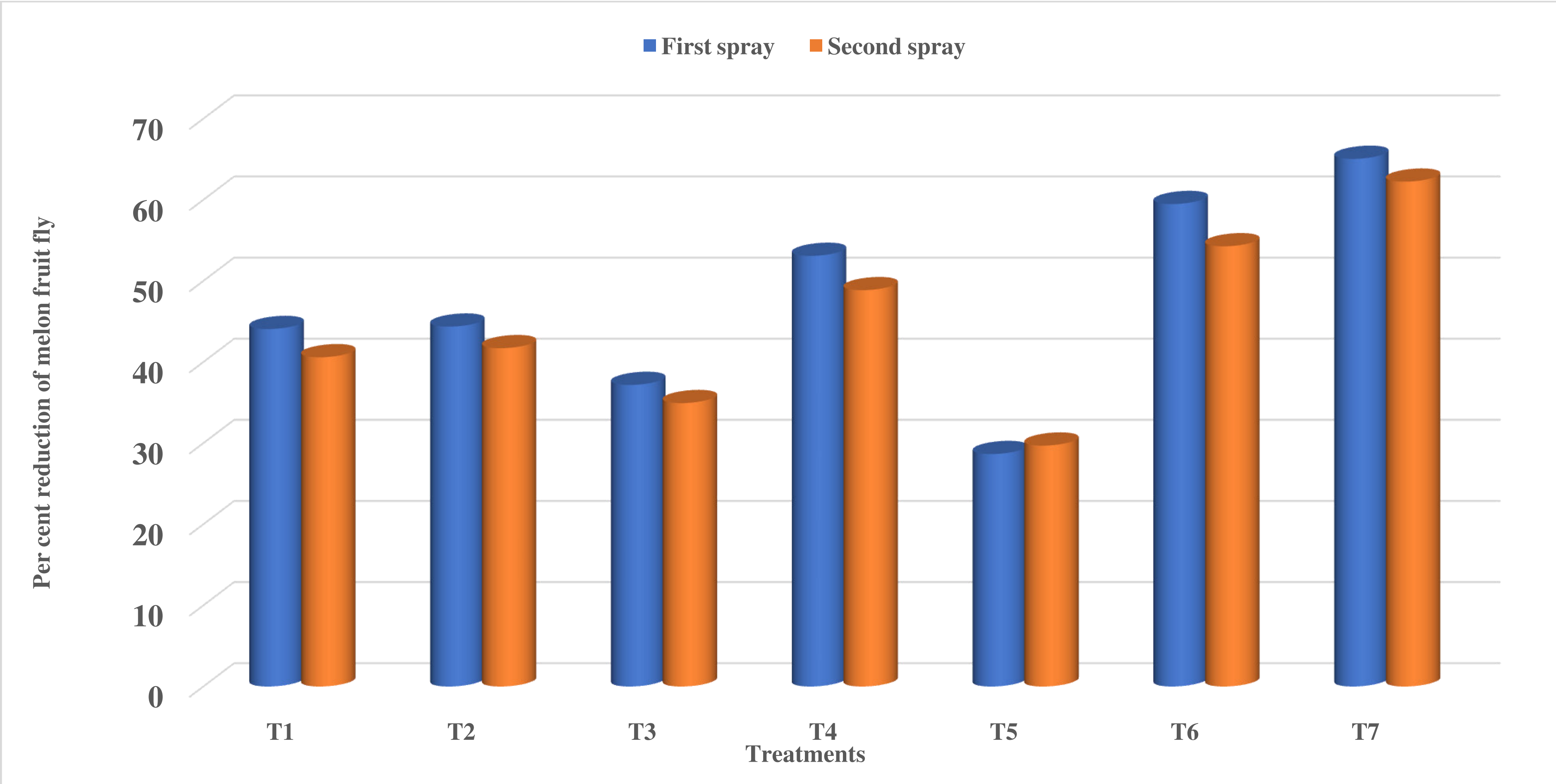

Fig. 4.27: Per cent reduction in melon fruit fly population due to combination insecticides (Number basis) (Pooled *Summer* 2021 and 2022)

The present findings are also supported by those of Malathi and Kumar (2017), Das *et al*. (2015), Ghosal *et al*. (2016), Borude *et al*. (2018), Subbireddy *et al*. (2018) and Floret and Regupathy (2019).

4.4.2 Bioefficacy of different combination insecticides against melon fruit fly on cucumber (weight basis)

The results in respect of bioefficacy of combination insecticides against melon fruit fly on cucumber fruits based on weight basis after first and second spray are presented in Table 4.49 and Fig. 4.28. The observations were recorded on mean per cent fruit infestation after each application of insecticides.

4.4.2.1 *Summer* 2021

A. Performance of insecticides after first spray

The post treatment observations recorded at 1st, 2nd, 3rd and 4th picking after first spray on mean basis indicated that all the insecticidal treatments were significantly superior over control in minimizing melon fruit fly infestation. Among these treatments, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC was recorded least per cent infested fruit (15.89%). It was followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, novaluron 5.25% + indoxacarb 14.5% SC and novaluron 5.25 + emamectin benzoate 0.9% SC (19.03%, 22.66% and 26.58%, respectively) and these four treatments found statistically at par with each other. Maximum mean per cent fruit infestation was recorded in untreated control 46.91 per cent. The plot treated with treatment chlorantraniliprole 8.8% + thiamethoxam 17.5% SC at 2nd picking was recorded minimum per cent infested fruits (12.35%) which were followed by treatments *viz*., thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, novaluron 5.25% + indoxacarb 14.5% SC and novaluron 5.25 + emamectin benzoate 0.9% SC (15.00%, 18.21% and 21.33%, respectively).

B. Performance of insecticides after second spray

Similar trend of result was observed during *Summer* 2022 as observed during first year study *i.e*., the order of efficacy was chlorantraniliprole 8.8% + thiamethoxam 17.5% SC > thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC > novaluron 5.25% + indoxacarb 14.5% SC > novaluron 5.25 + emamectin benzoate 0.9% SC.

Table 4.49: Bio efficacy of different combination insecticides against melon fruit fly (*Summer* 2021) (weight basis)

Tr. No	Treatments	Dose (ml/ha)	Per cent fruit infestation										
			Precount	Picking after 1st spray					Picking after 2nd spray				
				1st	2nd	3rd	4th	Mean	1st	2nd	3rd	4th	Mean
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	45.22 (42.24)	33.11 (35.09)	22.30 (28.09)	26.21 (30.74)	34.78 (36.11)	29.10 (32.51)	28.18 (32.05)	23.27 (28.82)	27.00 (31.26)	34.38 (35.87)	28.21 (32.00)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	46.73 (43.12)	27.80 (31.77)	21.33 (27.35)	25.10 (29.95)	32.10 (34.46)	26.58 (30.89)	26.76 (31.14)	21.32 (27.40)	25.40 (30.26)	31.23 (33.93)	26.18 (30.68)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	47.21 (43.40)	35.78 (36.73)	25.32 (30.19)	28.47 (32.19)	38.20 (38.17)	31.94 (34.32)	31.35 (34.02)	24.89 (29.89)	30.24 (33.32)	37.65 (37.84)	31.03 (33.77)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	45.00 (42.09)	21.43 (27.55)	18.21 (25.23)	22.43 (28.23)	28.56 (32.27)	22.66 (28.32)	24.11 (29.33)	19.20 (25.97)	23.11 (28.70)	25.14 (30.02)	22.89 (28.51)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	44.98 (42.11)	38.78 (38.51)	27.11 (31.35)	31.34 (33.99)	41.00 (39.81)	34.56 (35.91)	33.50 (35.36)	27.22 (31.41)	31.20 (33.93)	40.23 (39.34)	33.04 (35.01)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	46.86 (43.20)	18.45 (25.21)	15.00 (22.62)	17.56 (24.72)	25.11 (30.03)	19.03 (25.65)	20.45 (26.82)	16.22 (23.71)	22.54 (28.27)	23.30 (28.75)	20.63 (26.89)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	47.00 (43.27)	15.32 (22.95)	12.35 (20.53)	14.17 (22.02)	21.72 (27.73)	15.89 (23.31)	18.40 (25.11)	13.56 (21.55)	17.45 (24.60)	21.45 (27.52)	17.72 (24.69)
T_8	Untreated control	--	45.52 (42.42)	46.00 (42.70)	46.87 (43.20)	47.00 (43.28)	47.77 (43.71)	46.91 (43.22)	46.66 (43.08)	45.68 (42.51)	46.69 (43.10)	47.00 (43.28)	46.51 (42.99)
S.E (m) ±			2.85	2.43	2.27	2.26	2.55	2.38	2.55	2.02	2.20	2.46	2.31
CD at 5%			NS	7.38	6.88	6.87	7.74	7.22	7.74	6.14	6.66	7.48	7.00
CV %			8.16	9.15	9.72	9.05	8.85	9.19	9.73	8.57	8.49	8.73	8.88

Figures in parenthesis are Arc sin transformed values NS – Non - Significant

4.4.2.2 *Summer* 2022

Before initiation of insecticidal spray, the pre-count of per cent infested fruits ranged from 46.34 per cent to 47.00 per cent (Table 4.50 and Fig. 4.28).

A. Performance of insecticides after first spray

The post treatment observations recorded on mean basis at 1st, 2nd, 3rd and 4th picking after first spray showed that all the insecticidal treatments were significantly effective over control in reducing melon fruit fly infestation. Among these treatments, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC was recorded minimum per cent infested fruits (22.41%). It was followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (23.89%), novaluron 5.25% + indoxacarb 14.5% SC (22.96%) novaluron 5.25 + emamectin benzoate 0.9% SC (28.88%), emamectin benzoate 1.5% + fipronil 3.5% SC (30.14%) and indoxacarb 14.5% + acetamiprid 7.7% SC (33.41%). All these treatments found statistically at par with each other. Maximum mean per cent fruit infestation was recorded in untreated control 43.47 per cent.

B. Performance of insecticides after second spray

During the second spray, the plots treated with chlorantraniliprole 8.8% + thiamethoxam 17.5% SC recorded lowest per cent infested fruits (18.22). Rest of the treatments *viz*., thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, novaluron 5.25% + indoxacarb 14.5% SC, novaluron 5.25 + emamectin benzoate 0.9% SC and emamectin benzoate 1.5% + fipronil 3.5% also showed minimum per cent infested fruits as compared to control (21.65%, 23.19%, 25.74% and 28.75%, respectively) and all these treatments were statistically at par with each other.

Table 4.50: Bio efficacy of different combination insecticides against melon fruit fly (*Summer* 2022) (weight basis)

Tr. No	Treatments	Dose (ml/ha)	Per cent fruit infestation										
			Precount	Picking after 1st spray					Picking after 2nd spray				
				1st	2nd	3rd	4th	Mean	1st	2nd	3rd	4th	Mean
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	47.00 (43.25)	34.15 (35.74)	24.00 (29.18)	27.00 (31.24)	35.42 (31.34)	30.14 (31.88)	28.12 (31.99)	24.00 (29.28)	27.89 (31.85)	35.00 (36.24)	28.75 (32.34)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	47.56 (43.60)	30.44 (33.45)	22.24 (28.09)	24.31 (29.46)	38.54 (28.90)	28.88 (29.97)	25.32 (30.20)	22.45 (28.21)	24.00 (29.18)	31.20 (33.94	25.74 (30.38)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	46.78 (43.15)	37.32 (37.63)	27.20 (31.43)	28.92 (32.50)	40.20 (27.23)	33.41 (32.20)	30.41 (33.44)	25.11 (30.05)	29.10 (32.60)	39.00 (38.63)	30.91 (33.68)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	48.00 (43.84)	26.73 (31.10)	18.23 (25.23)	22.54 (28.30)	24.32 (47.00)	22.96 (32.91)	23.56 (28.94)	20.34 (26.78)	22.00 (27.92)	26.86 (31.22)	23.19 (28.72)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	46.72 (43.12)	39.31 (38.81)	28.90 (32.42)	30.46 (33.46)	36.49 (33.98)	33.79 (34.67)	32.65 (34.78)	26.35 (30.85)	30.67 (33.58)	41.20 (39.91)	32.72 (34.78)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	48.67 (44.24)	21.33 (27.40)	16.34 (23.80)	19.55 (26.21)	38.36 (32.50)	23.89 (27.48)	22.20 (28.11)	17.33 (24.36)	21.35 (27.42)	25.70 (30.40)	21.65 (27.57)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	47.83 (43.75)	18.55 (25.39)	14.67 (22.46)	17.10 (24.36)	39.33 (31.38)	22.41 (25.90)	19.20 (25.99)	15.00 (22.72)	15.11 (22.77)	23.56 (28.91)	18.22 (25.10)
T_8	Untreated control	--	46.34 (42.90)	48.00 (43.85)	48.79 (44.31)	47.56 (43.60)	29.52 (43.28)	43.47 (43.76)	48.79 (44.31)	46.34 (42.90)	46.12 (42.77)	46.00 (42.70)	46.82 (43.17)
S.E (m) ±			2.89	2.46	2.43	2.27	2.41	2.39	2.11	2.42	2.63	2.42	2.39
CD at 5%			NS	7.47	7.36	6.88	7.30	7.25	6.39	7.34	7.97	7.35	7.26
CV at 5%			8.14	8.82	10.04	8.93	8.28	9.02	8.01	10.09	10.38	8.42	9.22

Figures in parenthesis are Arc sin transformed values NS – Non - Significant

4.4.2.3 Pooled data for *Summer* 2021 and *Summer* 2022

Before initiation of insecticidal spray treatments, the pre-count of per cent infested fruits ranged from 45.93 per cent to 47.00 per cent (Table 4.51 and Fig. 4.28).

A. Performance of insecticides after first spray

The post treatment observations recorded at 1st, 2nd, 3rd and 4th picking after first spray on mean basis (Table 52 and Fig. 32) indicated that all the insecticidal treatments were significantly effective over untreated control in minimizing melon fruit fly population. Among these treatments, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC was most effective treatments (17.28%) which was statistically at par with the treatment thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (20.07%) and novaluron 5.25% + indoxacarb 14.5% SC (23.38%). Highest mean per cent infested fruits was found in untreated control 47.37 per cent.

B. Performance of insecticides after second spray

All the insecticidal treatments were significantly superior over untreated control in reducing melon fruit fly infestation. Minimum per cent infested fruits were observed in the plots treated with chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (17.97%). The treatments thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (21.14%) and novaluron 5.25% + indoxacarb 14.5% SC (23.04%) also showed minimum per cent infested fruits and all these treatments were found statistically at par with each other.

Table 4.51: Bioefficacy of different combination insecticides against melon fruit fly (Pooled *Summer* 2021and 2022) (weight basis)

Tr. No	Treatments	Dose (ml/ha)	Per cent fruit infestation										
			Precount	Picking after 1st spray					Picking after 2nd spray				
				1st	2nd	3rd	4th	Mean	1st	2nd	3rd	4th	Mean
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	46.11 (42.74)	33.63 (35.44)	23.15 (28.71)	26.60 (31.04)	35.10 (36.33)	29.62 (32.88)	28.15 32.04	23.63 29.05	27.45 31.56	34.69 36.07	28.48 (32.18)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	47.15 (43.36)	29.12 (32.66)	21.79 (27.75)	24.70 (29.71)	31.72 (34.27)	26.83 (31.10)	26.04 30.68	21.88 27.86	24.70 29.77	31.22 33.96	25.96 (30.57)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	47.00 (43.27)	36.55 (37.18)	26.26 (30.82)	28.70 (32.35)	38.37 (38.27)	32.47 (34.65)	30.88 33.75	25.00 29.97	29.67 32.97	38.33 38.24	30.97 (33.73)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	46.50 (42.99)	24.08 (29.38)	18.22 (25.26)	22.49 (28.31)	28.73 (32.39)	23.38 (28.83)	23.84 29.20	19.77 26.38	22.56 28.35	26.00 30.64	23.04 (28.64)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	45.85 (42.62)	39.04 (38.66)	28.00 (31.94)	30.90 (33.74)	40.60 (39.57)	34.64 (35.98)	33.08 35.08	26.78 31.15	30.93 33.79	40.72 39.63	32.88 (34.91)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	47.76 (43.72)	19.89 (26.45)	15.67 (23.26)	18.56 (25.48)	26.17 (30.71)	20.07 (26.48)	21.33 27.49	16.78 24.16	21.95 27.86	24.50 29.67	21.14 (27.29)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	47.42 (43.52)	16.94 (24.21)	13.51 (21.52)	15.63 (23.25)	23.02 (28.67)	17.28 (24.41)	18.80 25.63	14.28 22.14	16.28 23.79	22.51 28.28	17.97 (24.96)
T_8	Untreated control	--	45.93 (42.66)	47.00 (43.28)	47.83 (43.76)	47.28 (43.44)	47.38 (43.50)	47.37 (43.49)	47.73 43.70	46.01 42.71	46.41 42.94	46.50 42.99	46.66 (43.08)
S.E (m) ±			2.00	1.48	1.57	1.94	1.43	1.60	1.51	1.64	1.65	1.75	1.64
CD at 5 %			NS	4.49	4.75	5.88	4.33	4.86	4.58	4.98	4.99	5.30	4.96

Figures in parenthesis are Arc sin transformed values NS – Non - Significant

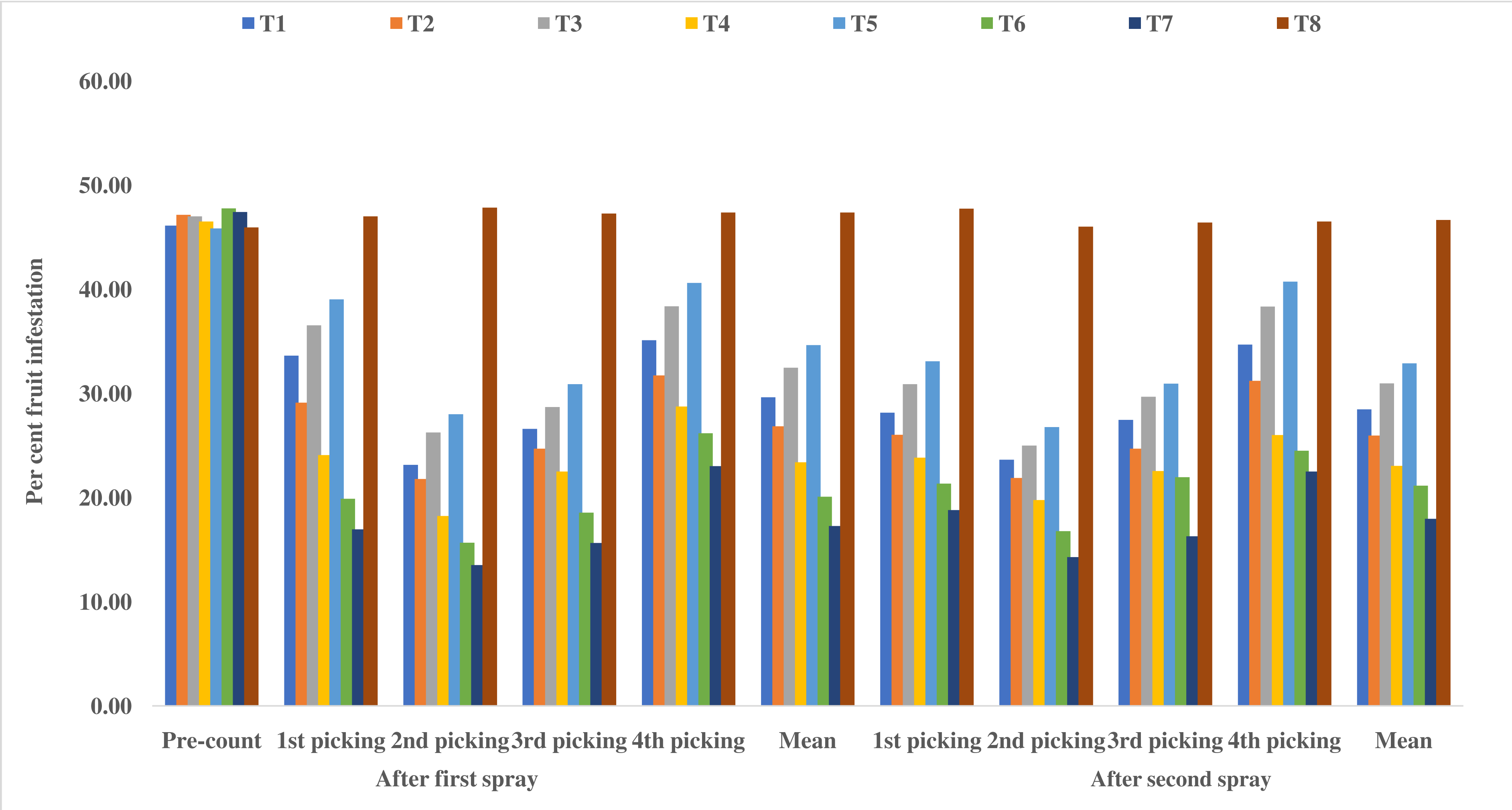

Fig. 4.28: Bioefficacy of different combination insecticides against melon fruit fly (Weight basis) (Pooled *Summer* 2021and 2022)

4.4.2.4 Per cent reduction in melon fruit fly population due to combination insecticides (Pooled data of *Summer* 2021 and *Summer* 2022)

A. Performance of insecticides after first spray

The pooled data of two years (Table 4.52 and Fig 4.29) indicated that chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (64.68%) was found to be most effective treatments providing satisfactory reduction in per cent infested fruits.

B. Performance of insecticides after second spray

During second spray maximum per cent reduction in infested fruits infested by melon fruit fly was noted from plots treated with chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (62.70%) and thiamethoxam 17.5% SC (56.44%).

The results obtained are in close agreement with the findings of Bhujade *et al.* (2018) who found that chlorantraniliprole 8.8% + thiamethoxam 17.5% SC proved effective in recording minimum green fruiting bodies damage as well as per cent shed material, which was at par with indoxacarb 14.5% + acetamiprid 7.7% SC, chlorantraniliprole 9.3% + lambda-cyhalothrin 4.6% ZC, thiamethoxam 12.6% + lambda-cyhalothrin 4.6% ZC. Rohokale *et al*. (2018) revealed that the lowest shoot infestation by *L. orbonalis*, was observed in chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC (1.38%). Chlorantraniliprole 8.8% + thiamethoxam17.5% SC (10.47%) was the most superior treatment that showd lowest fruit damage followed by chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC (11.27%), indoxacarb 14.5% + acetamiprid 7.7% SC (12.52%). Chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (9.22%), was the most superior treatment showing lowest fruit damage on weight basis. Ghosal *et al*. (2016) observed that novaluron 5.25% + indoxacarb 4.56 @ 875 ml/ha recorded only 3.75% fruit damage while in control plot it was 45.6%. The present findings are also supported by those of Das *et al*. (2015), Malathi and Kumar (2017), Roy *et al*. (2017), Borude *et al*. (2018), Subbireddy *et al*. (2018) and Floret and Regupathy (2019).

Table 4.52: Per cent reduction in melon fruit fly population due to combination insecticides (Pooled *Summer* 2021 and 2022) (weight basis)

Tr. No	Treatments name	Dose (ml/ha)	Per cent fruit infestation												
			Precount	Picking after 1st spray				Mean	% Reduction	Picking after 2nd spray				Mean	% Reduction
				1st	2nd	3rd	4th			1st	2nd	3rd	4th		
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	46.11 (42.74)	33.63 (35.44)	23.15 (28.71)	26.60 (31.04)	35.10 (36.33)	29.62	37.72	28.15 (32.04)	23.63 (29.05)	27.45 (31.56)	34.69 (36.07)	28.48	39.21
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	47.15 (43.36)	29.12 (32.66)	21.79 (27.75)	24.70 (29.71)	31.72 (34.27)	26.83	44.83	26.04 (30.68)	21.88 (27.86)	24.70 (29.77)	31.22 (33.96)	25.96	45.81
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	47.00 (43.27)	36.55 (37.18)	26.26 (30.82)	28.70 (32.35)	38.37 (38.27)	32.47	33.02	30.88 (33.75)	25.00 (29.97)	29.67 (32.97)	38.33 (38.24)	30.97	35.14
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	46.50 (42.99)	24.08 (29.38)	18.22 (25.26)	22.49 (28.31)	28.73 (32.39)	23.38	51.25	23.84 (29.20)	19.77 (26.38)	22.56 (28.35)	26.00 (30.64)	23.04	51.23
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	45.85 (42.62)	39.04 (38.66)	28.00 (31.94)	30.90 (33.74)	40.60 (39.57)	34.64	26.77	33.08 (35.08)	26.78 (31.15)	30.93 (33.79)	40.72 (39.63)	32.88	29.43
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	47.76 (43.72)	19.89 (26.45)	15.67 (23.26)	18.56 (25.48)	26.17 (30.71)	20.07	59.26	21.33 (27.49)	16.78 (24.16)	21.95 (27.86)	24.50 (29.67)	21.14	56.44
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	47.42 (43.52)	16.94 (24.21)	13.51 (21.52)	15.63 (23.25)	23.02 (28.67)	17.28	64.68	18.80 (25.63)	14.28 (22.14)	16.28 (23.79)	22.51 (28.28)	17.97	62.70
T_8	Untreated control	--	45.93 (42.66)	47.00 (43.28)	47.83 (43.76)	47.28 (43.44)	47.38 (43.50)	47.37		47.73 (43.70)	46.01 (42.71)	46.41 (42.94)	46.50 (42.99)	46.66	
S.E (m) ±			2.00	1.48	1.57	1.94	1.43			1.51	1.64	1.65	1.75		
CD at 5 %			NS	4.49	4.75	5.88	4.33			4.58	4.98	4.99	5.30		

Figures in parenthesis are Arc sin transformed values NS – Non - Significant

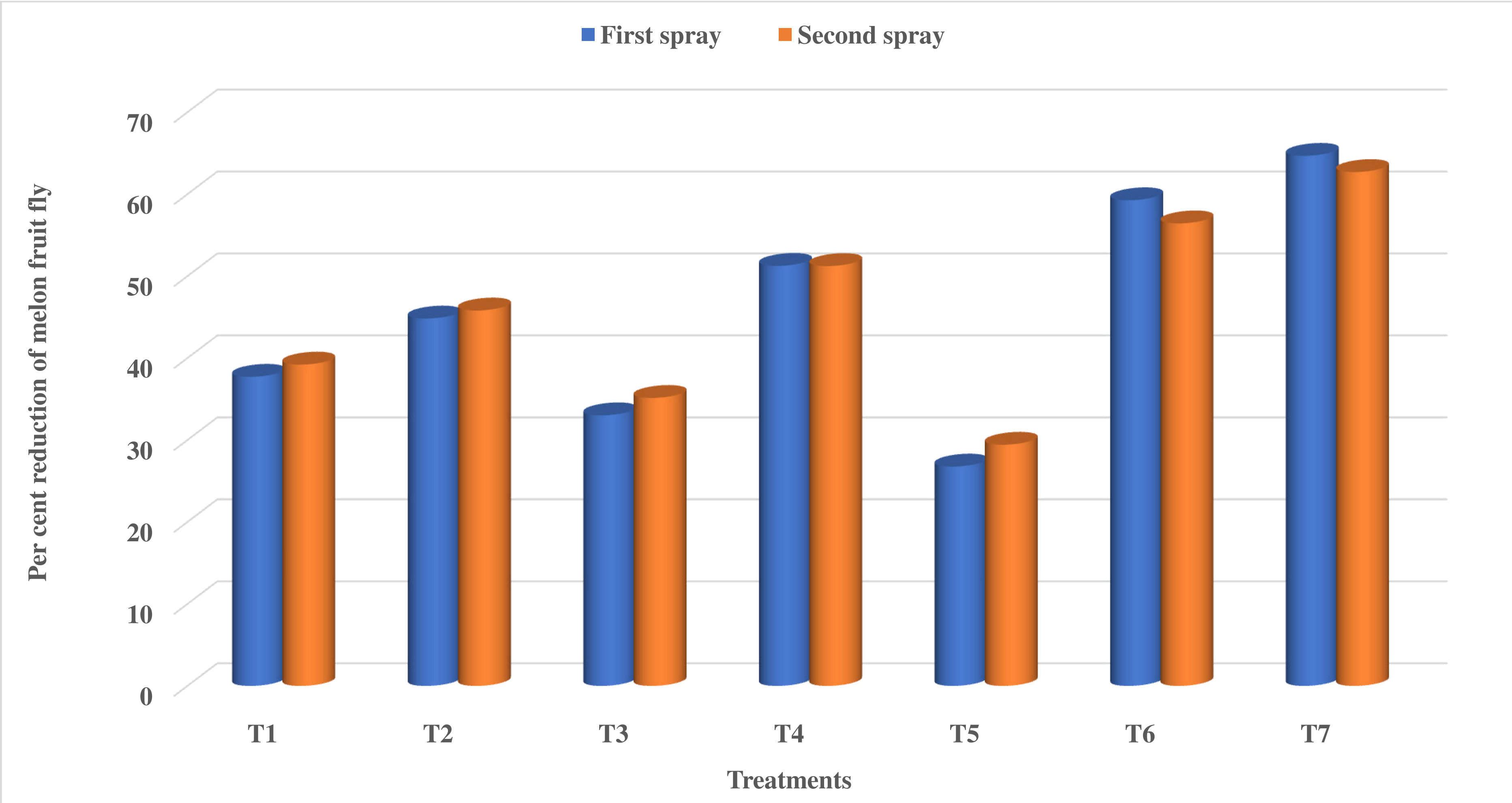

Fig. 4.29: Per cent reduction in melon fruit fly population due to combination insecticides (Pooled *Summer* 2021 and 2022) (weight basis)

4.4.3 Bioefficacy of different combination insecticides against whitefly

4.4.3.1 *Summer* 2021

A. Bioefficacy of insecticides after first spray

Data pertaining to bioefficacy of different combination insecticides against whitefly after first spray are presented in Table 4.53 and depicted in Fig. 4.30. No significance differences were observed among various treatments before one day of the spray (precount).

The results revealed that all the insecticides were found significantly superior over untreated control in reducing population of whitefly at 3, 7 and 14 days after first application.

At three days after first spray, significantly minimum population of whitefly (3.43 whiteflies/3 leaves/vine) was recorded from plots treated with pyriproxyfen 5% + fenpropatrin 15% EC which was followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (4.17 whiteflies/3 leaves/vine), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (4.67 whiteflies/3 leaves/vine), indoxacarb 14.5% + acetamiprid 7.7% SC (5.63 whiteflies/3 leaves/vine) and emamectin benzoate 1.5% + fipronil 3.5% SC (6.67 whiteflies/3 leaves/vine) and all these treatments were found statistically at par with each other. The treatment novaluron 5.25 + emamectin benzoate 0.9% SC and novaluron 5.25% + indoxacarb 14.5% SC were next effective treatments in managing whiteflies by recording 7.63 and 8.00 whiteflies/3 leaves/vine, respectively. The highest population of whiteflies *i.e.* 17.80 whiteflies/3 leaves/vine was observed in treatment T_8 i.e. untreated control.

More or less similar trend was noticed seven days after first spray and significantly lowest population of whitefly (5.03 whiteflies/3 leaves/vine) was recorded from plots treated with treatment pyriproxyfen 5% + fenpropatrin 15% EC which was followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (6.23 whiteflies/3 leaves/vine), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (6.73 whiteflies/3 leaves/vine), indoxacarb 14.5% + acetamiprid 7.7% SC (7.60 whiteflies/3 leaves/vine) and emamectin benzoate 1.5% + fipronil 3.5% SC (8.87 whiteflies/3 leaves/vine). All these treatments were found statistically at par with each other. The untreated control plots recorded the highest population of whiteflies of 18.17 whiteflies/3 leaves/vine.

A slight increase in whitefly population was noticed at 14 days after first spray. The treatment pyriproxyfen 5% + fenpropatrin 15% EC exhibited significantly lowest population of whitefly (8.03 whiteflies/3 leaves/vine) and found statistically at par with the treatments *viz*., thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC, indoxacarb 14.5% + acetamiprid 7.7% SC, emamectin benzoate 1.5% + fipronil 3.5% SC, novaluron 5.25 + emamectin benzoate 0.9% SC and novaluron 5.25 + indoxacarb 14.5% (9.23, 10.00, 10.73, 11.80, 13.30 and 14.23 whiteflies/3 leaves/vine, respectively). The highest population of whiteflies (20.13 per three leaves/vine) was recorded in untreated control.

B. Bioefficacy of insecticides after second spray

All the insecticides under investigation were observed to be significantly superior over untreated control in reducing the population of whiteflies on cucumber at all the days of observations after second spray.

At three days after second spray significantly minimum number of whiteflies (2.53 whiteflies/3 leaves/vine) was recorded from the plots treated with pyriproxyfen 5% + fenpropatrin 15% EC followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (3.60 whiteflies/3 leaves/vine), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (4.80 whiteflies/3 leaves/vine) and indoxacarb 14.5% + acetamiprid 7.7% SC (5.53 whiteflies/3 leaves/vine). These treatments showed no statistical difference in terms of their efficacy. The next effective treatment was emamectin benzoate 1.5% + fipronil 3.5% SC (5.87 whiteflies/3 leaves/vine). The treatment novaluron 5.25 + emamectin benzoate 0.9% SC (7.20 whiteflies/3 leaves/vine) and novaluron 5.25 + indoxacarb 14.5% (8.07 whiteflies/3 leaves/vine) were found to be subsequently effective in reducing whitefly population. The highest population of whitefly (21.60 whiteflies/3 leaves/vine) was observed in treatment untreated control.

At 7 seven days after second spray, pyriproxyfen 5% + fenpropatrin 15% EC, thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC, indoxacarb 14.5% + acetamiprid 7.7% and emamectin benzoate 1.5% + fipronil 3.5% SC were showed statistically similar effects on whiteflies recording minimum count of 4.03, 5.83, 6.67, 7.47 and 8.10 whiteflies/3 leaves/vine, respectively.

At 14 days after second spray, significantly lowest population of whitefly (7.63 whiteflies/3 leaves/vine) was recorded from the plots treated with treatment pyriproxyfen 5% + fenpropatrin 15% EC which was followed by the treatments *viz.*, thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC, indoxacarb 14.5% + acetamiprid 7.7% SC, emamectin benzoate 1.5% + fipronil 3.5% SC, novaluron 5.25 + emamectin benzoate 0.9% SC and novaluron 5.25 + indoxacarb 14.5% (8.87, 9.77, 10.07, 11.43, 12.37 and 12.63 whiteflies/3 leaves/vine, respectively). The highest population of whitefly (30.17 whiteflies/3leaves/vine) was recorded in treatment untreated control.

Thus overall, it was observed that the insecticidal treatments supress the whitefly population for initial period only. The population increased slowly after seven days onwards of the spray. Also, among the insecticides tested pyriproxyfen 5% + fenpropatrin 15% EC was found most effective as it recorded significantly lowest population of whitefly on cucumber to the extent of 2.53, 4.03 and 7.63 per three leaves per plant at 3, 7 and 14 days after spraying, respectively over rest of the insecticides.

Table 4.53. Bioefficacy of different combination insecticides against whitefly (*Summer* 2021)

Tr. No	Treatments	Dose (ml/ha)	Average no. of whitefly/3 leaves						
			Precount	1st spray			2nd spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	16.00 (4.02)	6.67 (2.68)	8.87 (3.06)	11.80 (3.51)	5.87 (2.51)	8.10 (2.93)	11.43 (3.44)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	16.60 (4.12)	7.63 (2.85)	9.63 (3.18)	13.30 (3.71)	7.20 (2.77)	9.23 (3.08)	12.37 (3.59)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	16.60 (4.10)	5.63 (2.40)	7.60 (2.84)	10.73 (3.35)	5.53 (2.45)	7.47 (2.82)	10.07 (3.25)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	16.70 (4.15)	8.00 (2.91)	10.27 (3.27)	14.23 (3.84)	8.07 (2.91)	10.20 (3.27)	12.63 (3.62)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	16.60 (4.10)	3.43 (1.98)	5.03 (2.35)	8.03 (2.92)	2.53 (1.74)	4.03 (2.13)	7.63 (2.85)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	16.43 (4.11)	4.17 (2.16)	6.23 (2.59)	9.23 (3.12)	3.60 (2.02)	5.83 (2.52)	8.87 (3.06)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	16.33 (4.10)	4.67 (2.27)	6.73 (2.69)	10.00 (3.24)	4.80 (2.30)	6.67 (2.67)	9.77 (3.20)
T_8	Untreated control	--	17.37 (4.23)	17.80 (4.27)	18.17 (4.28)	20.13 (4.44)	21.60 (4.67)	28.07 (5.31)	30.17 (5.49)
S.E (m) ±			0.39	0.24	0.25	0.34	0.24	0.28	0.31
CD at 5%			NS	0.73	0.76	1.04	0.72	0.85	0.93
CV %			11.47	11.03	10.18	11.92	10.83	11.15	10.59

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values DAS – Days after spraying NS – Non-Significant

4.4.3.2 *Summer* 2022

A. Bioefficacy of insecticides after first spray

The post treatment observations recorded at 3, 7 and 14 days after first spray (Table 4.54 Fig. 4.30) indicated that all the insecticidal treatments were found significantly superior over untreated control in reducing whitefly population.

The data recorded at 3 and 7 DAS revealed that plot treated with pyriproxyfen 5% + fenpropatrin 15% EC was showed lowest whitefly count (10.03 and 13.07 whiteflies/3 leaves/vine) and which was statistically similar with the thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (14.23 and 17.63 whiteflies/3 leaves/vine), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (16.90 and 20.93 whiteflies/3 leaves/vine), indoxacarb 14.5% + acetamiprid 7.7% SC (19.60 and 22.63 whiteflies/3 leaves/vine) and emamectin benzoate 1.5% + fipronil 3.5% SC (19.97 and 24.10 whiteflies/3 leaves/vine). The highest population of whiteflies (59.17 and 66.17 whiteflies/3 leaves/vine) was observed in untreated control.

A slight increase in whitefly population was observed at 14 days after first spray. The treatment pyriproxyfen 5% + fenpropatrin 15% EC recorded significantly lowest population of whitefly (17.73 whiteflies/3 leaves/vine) and found statistically equal with the treatments *viz.*, thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC, indoxacarb 14.5% + acetamiprid 7.7% SC, emamectin benzoate 1.5% + fipronil 3.5% SC, novaluron 5.25 + emamectin benzoate 0.9% SC (21.20, 24.77, 26.00, 28.50 and 30.77 whiteflies/3 leaves/vine, respectively). The maximum population of whitefly recorded in untreated control *i.e.* 71.57 whiteflies/3 leaves/vine.

B. Performance of insecticides after second spray

The population of whitefly recorded from untreated control plots was ranged between 79.57 to 92.33 whiteflies/3 leaves/vine over a period of 14 dats during second spray.

The data recorded at three days after second spray revealed that pyriproxyfen 5% + fenpropatrin 15% EC (8.50 whiteflies/3 leaves/vine) was better treatment followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (12.20 whiteflies/3 leaves/vine), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (14.10 whiteflies/3 leaves/vine) and indoxacarb 14.5% + acetamiprid 7.7% SC (16.73 whiteflies/3 leaves/vine) which were statistically at par with each other and significantly superior over rest of the insecticides. The next better treatment was emamectin benzoate 1.5% + fipronil 3.5% SC (18.10 whiteflies/3 leaves/vine) which found statistically similar with the treatment novaluron 5.25 + emamectin benzoate 0.9% SC (19.90 whiteflies/3 leaves/vine) and novaluron 5.25 + indoxacarb 14.5% (22.83 whiteflies/3 leaves/vine).

At 7 seven days after second spray, there was no statistical difference in effectiveness of pyriproxyfen 5% + fenpropatrin 15% EC, thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC, indoxacarb 14.5% + acetamiprid 7.7%, emamectin benzoate 1.5% + fipronil 3.5% SC and novaluron 5.25 + emamectin benzoate 0.9% SC against whitefly.

The data recorded at 14 days after second spray revealed that treatment pyriproxyfen 5% + fenpropatrin 15% EC (12.63 whiteflies/3 leaves/vine) which was followed by the treatments *viz*., thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC, indoxacarb 14.5% + acetamiprid 7.7% SC and emamectin benzoate 1.5% + fipronil 3.5% SC (16.60, 18.87, 20.97 and 22.97 whiteflies/3 leaves/vine, respectively) proved to be most effective insecticides against whitefly infesting cucumber. All these treatments were found statistically at par with each other**.**

Table 4.54: Bioefficacy of different combination insecticides against whitefly (*Summer* 2022)

Tr. No	Treatments	Dose (ml/ha)	Average no. of whitefly/3 leaves						
			Precount	1st spray			2nd spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	41.17 (6.41)	19.97 (4.48)	24.10 (4.96)	28.50 (5.36)	18.10 (4.31)	22.97 (4.84)	22.97 (4.84)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	41.33 (6.46)	22.53 (4.76)	26.17 (5.15)	30.77 (5.54)	19.90 (4.42)	24.37 (4.99)	24.37 (4.99)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	42.17 (6.53)	19.60 (4.48)	22.63 (4.78)	26.00 (5.15)	16.73 (4.15)	20.97 (4.53)	20.97 (4.63)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	41.17 (6.41)	24.63 (5.01)	29.27 (5.44)	36.13 (6.01)	22.83 (4.78)	27.67 (5.31)	27.67 (5.31)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	41.17 (6.41)	10.03 (3.24)	13.07 (3.59)	17.73 (4.27)	8.50 (3.00)	12.63 (3.62)	12.63 (3.62)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	41.53 (6.48)	14.23 (3.84)	17.63 (4.25)	21.20 (4.63)	12.20 (3.56)	16.60 (4.08)	16.60 (4.13)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	41.90 (6.47)	16.90 (4.12)	20.93 (4.56)	24.77 (5.03)	14.10 (3.80)	18.87 (4.39)	18.87 (4.32)
T_8	Untreated control	--	41.23 (6.44)	59.17 (7.71)	66.17 (8.15)	71.57 (8.47)	79.57 (8.94)	88.57 (9.43)	92.33 (9.58)
S.E (m) ±			0.60	0.45	0.51	0.47	0.40	0.47	0.45
CD at 5%			NS	1.37	1.54	1.43	1.22	1.42	1.36
CV %			11.39	11.77	12.20	10.37	10.68	11.17	10.58

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values DAS – Days after spraying NS – Non-Significant

4.4.3.3 Pooled data for *Summer* 2021 and 2022

A. Performance of insecticides after first spray

Pooled data on incidence of whitefly of two seasons *i.e. Summer* 2021 and 2022 are presented in Table 4.55 graphically depicted in Fig. 4.30. The pre-treatment count of whitefly before initiation of spray treatments was in range of 28.58 to 29.38 whiteflies/3 leaves/vine.

The results revealed that all the insecticides were found significantly superior over untreated control in minimizing population of whitefly at 3, 7 and 14 days after first spray.

At three days after first spray, significantly lowest population of whitefly was recorded from plots treated with treatment pyriproxyfen 5% + fenpropatrin 15% EC (6.73 whiteflies/3 leaves/vine) which were followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (9.20 whiteflies/3 leaves/vine) and chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (10.78 whiteflies/3 leaves/vine). All these three treatments were found statistically at par with each other. The next effective treatments in managing whitefly population were indoxacarb 14.5% + acetamiprid 7.7% SC (12.62 whiteflies/3 leaves/vine) which found statistically similar with treatments emamectin benzoate 1.5% + fipronil 3.5% SC (13.32 whiteflies/3 leaves/vine) and novaluron 5.25 + emamectin benzoate 0.9% SC (15.08 whiteflies/3 leaves/vine) The highest population of whitefly was observed in treatment T_8 i.e. untreated control (38.48 whiteflies/3 leaves/vine).

Data recorded at 7 and 14 DAS, revealed that plots treated with the treatment pyriproxyfen 5% + fenpropatrin 15% was recorded significantly lowest population of whitefly (9.05 and 12.88 whiteflies/3 leaves/vine) which were followed by treatments thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (11.93 and 15.22 whiteflies/3 leaves/vine), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (13.83 and 17.38 whiteflies/3 leaves/vine) and indoxacarb 14.5% + acetamiprid 7.7% SC (15.12 and 18.37 whiteflies/3 leaves/vine) which were found statistically at par with each other and significantly superior over rest of the treatments.

B. Performance of insecticides after second spray

The results in respect of bioefficacy of different combination insecticides on population of whitefly after second spray are presented in Table 4.55 and Fig. 4.30.

The data revealed that all the insecticides under investigation were significantly superior over untreated control in reducing the population of whitefly on cucumber at 3,7 and 14 after second spray.

At 3 days after second spray, significantly minimum population of whitefly (5.52 whiteflies/3 leaves/vine) was recorded from the plots treated with treatment pyriproxyfen 5% + fenpropatrin 15% EC followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (7.90 whiteflies/3 leaves/vine), and chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (9.45 whiteflies/3 leaves/vine) and all these treatments showed no statistical difference in terms of their efficacy. Rest of the treatments also showed better results against whitefly on cucumber.

The post treatment count of live population whitefly at 7 days after second spray clearly indicated superiority of pyriproxyfen 5% + fenpropatrin 15% EC (8.33 whiteflies/3 leaves/vine) over other treatments. It was followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC and indoxacarb 14.5% + acetamiprid 7.7% SC for managing whitefly population 11.22, 12.77 and 14.22 whiteflies/3 leaves/vine, respectively. These four treatments were statistically at par with each other and significantly superior over rest of the insecticide treatments.

The observations recorded at 14 days after second spray showed that pyriproxyfen 5% + fenpropatrin 15% (10.13 whiteflies/3 leaves/vine) EC proved to be most promising insecticide which was statistically at par with the thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC and chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (12.73 and 14.32 whiteflies/3 leaves/vine).

Table 4.55: Bioefficacy of different combination insecticides against whitefly (Pooled *Summer* 2021and 2022)

Tr. No	Treatments	Dose (ml/ha)	Average no. of whitefly/3 leaves						
			Precount	1st spray			2nd spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	28.58 (5.38)	13.32 (3.70)	16.48 (4.12)	20.15 (4.53)	11.98 (3.53)	15.53 (4.00)	17.20 (4.21)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	28.97 (5.42)	15.08 (3.93)	17.90 (4.28)	22.03 (4.72)	13.55 (3.71)	16.80 (4.15)	18.37 (4.34)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	29.38 (5.46)	12.62 (3.62)	15.12 (3.94)	18.37 (4.34)	11.13 (3.41)	14.22 (3.80)	15.52 (4.00)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	28.93 (5.41)	16.32 (4.10)	19.77 (4.50)	25.18 (5.04)	15.45 (3.96)	18.93 (4.41)	20.15 (4.54)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	28.88 (5.42)	6.73 (2.69)	9.05 (3.05)	12.88 (3.66)	5.52 (2.45)	8.33 (2.97)	10.13 (3.26)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	28.98 (5.43)	9.20 (3.11)	11.93 (3.52)	15.22 (3.95)	7.90 (2.90)	11.22 (3.40)	12.73 (3.64)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	29.12 (5.42)	10.78 (3.33)	13.83 (3.75)	17.38 (4.23)	9.45 (3.14)	12.77 (3.64)	14.32 (3.82)
T_8	Untreated control	--	29.30 (5.45)	38.48 (6.24)	42.17 (6.51)	45.85 (6.81)	50.58 (7.13)	58.32 (7.67)	61.25 (7.85)
S.E (m) ±			0.32	0.28	0.33	0.28	0.29	0.27	0.20
CD at 5%			NS	0.85	1.02	0.84	0.87	0.83	0.61
CV %			7.28	8.95	9.74	7.27	9.30	7.87	5.52

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values DAS - Days after spraying NS – Non-Significant

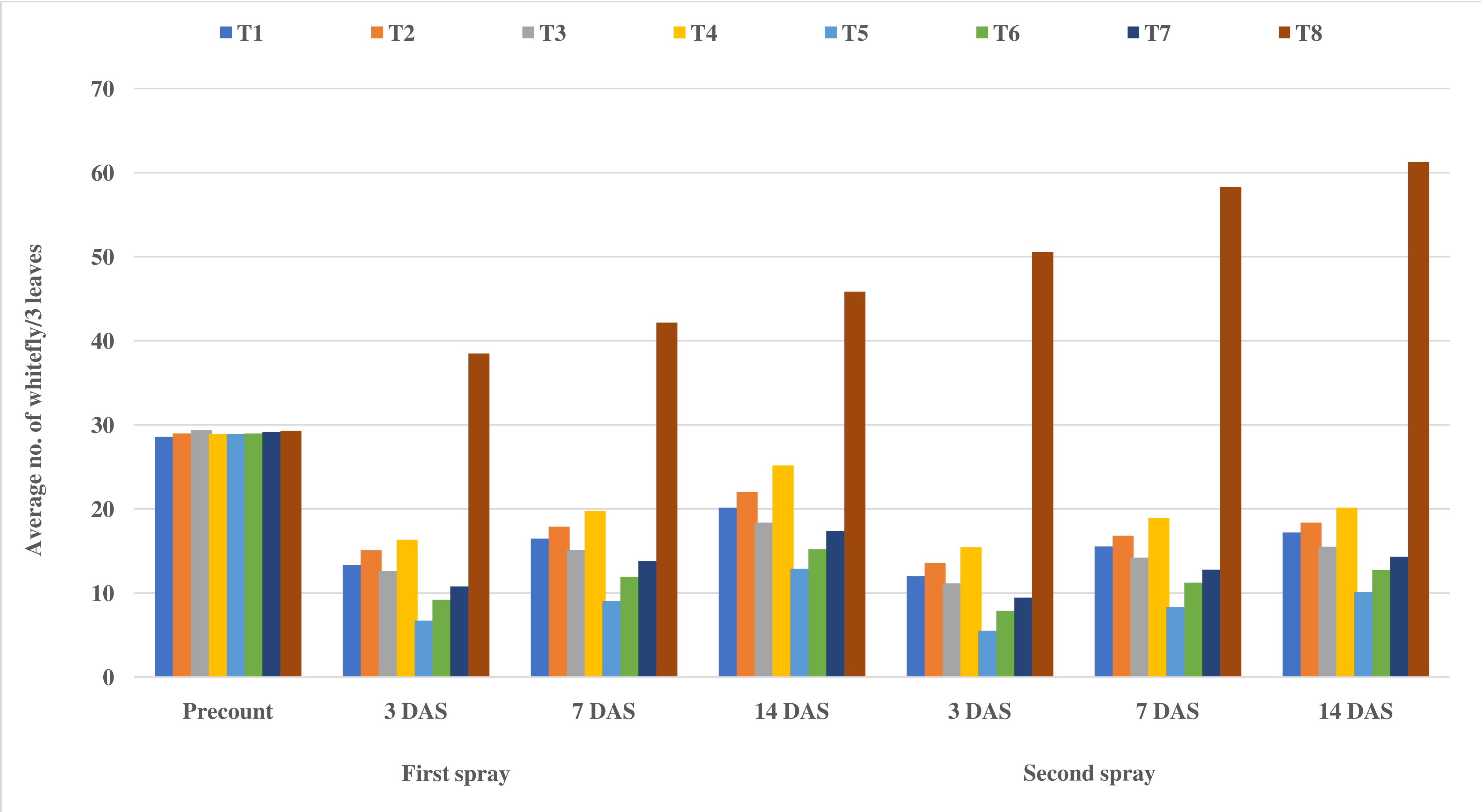

Fig. 4.30: Bioefficacy of different combination insecticides against whitefly (Pooled *Summer* 2021and 2022)

4.4.2.4 Per cent reduction in whitefly population due to combination insecticides (Pooled data of *Summer* 2021 and 2022)

A. Performance of insecticides after first spray

Pooled data of two years are presented in Table 4.56 and graphically depicted in Fig. 4.31 indicated that the treatments pyriproxyfen 5% + fenpropatrin 15% EC (77.01%) and thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (70.95%) were the most effective insecticides for lowering whitefly population.

B. Performance of insecticides after first spray

The treatments pyriproxyfen 5% + fenpropatrin 15% EC (85.13%), thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (80.30%) and chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (77.56%) suppressed the whitefly population most effectively.

In present investigation overall, it was observed that combination insecticidal treatments suppress the whitefly population for initial period only. The population increased slowly after three days onwards of the first spray. Among all the combination insecticides tested pyriproxyfen 5% + fenpropatrin 15% was found most effective as it recorded minimum population of whitefly on cucumber to the extent of 6.73, 9.05 and 12.88 and 5.52, 8.33 and 3.26 per three leaves per vine at 3, 7 and 14 days after first spray and second spray (pooled data), respectively. The above findings are in conformity with those of Roy *et al*. (2017) who revealed that highest aphid mortality recorded in pyriproxyfen + fenpropathrin (80.71% and 80.90%) treated plots after first and second spray respectively, during both years in pigeon pea. Reddy *et al*. (2018) who noticed that chlorantraniliprole 8.8% + thiamethoxam 17.5% SC @ 150 g a.i/ha was found effective in managing the population of pod bug and aphid followed by thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC @ 150 g a.i/ha.

Table 4.56: Per cent reduction in whitefly population due to combination insecticides (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Dose (ml/ha)	Average no. of whitefly/3 leaves/vine										
			Precount	1st spray					2nd spray				
				3 DAS	7 DAS	14 DAS	Mean	% Reduction	3 DAS	7 DAS	14 DAS	Mean	% Reduction
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	28.58 (5.38)	13.32 (3.70)	16.48 (4.12)	20.15 (4.53)	16.65	59.52	11.98 (3.53)	15.53 (4.00)	4.21 (18.37)	10.57	72.15
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	28.97 (5.42)	15.08 (3.93)	17.90 (4.28)	22.03 (4.72)	18.34	56.01	13.55 (3.71)	16.80 (4.15)	4.34 (15.52)	11.56	69.94
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	29.38 (5.46)	12.62 (3.62)	15.12 (3.94)	18.37 (4.34)	15.37	63.66	11.13 (3.41)	14.22 (3.80)	4.00 (20.15)	9.78	74.93
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	28.93 (5.41)	16.32 (4.10)	19.77 (4.50)	25.18 (5.04)	20.42	50.95	15.45 (3.96)	18.93 (4.41)	4.54 (10.13)	12.98	66.23
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	28.88 (5.42)	6.73 (2.69)	9.05 (3.05)	12.88 (3.66)	9.56	77.01	5.52 (2.45)	8.33 (2.97)	3.26 (12.73)	5.70	85.13
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	28.98 (5.43)	9.20 (3.11)	11.93 (3.52)	15.22 (3.95)	12.12	70.95	7.90 (2.90)	11.22 (3.40)	3.64 (14.32)	7.58	80.30
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	29.12 (5.42)	10.78 (3.33)	13.83 (3.75)	17.38 (4.23)	14.00	59.47	9.45 (3.14)	12.77 (3.64)	3.82 (61.25)	8.68	77.56
T_8	Untreated control	--	29.30 (5.45)	38.48 (6.24)	42.17 (6.51)	45.85 (6.81)	42.17		50.58 (7.13)	58.32 (7.67)	61.25 7.85	56.71	
S.E (m) ±			0.32	0.28	0.33	0.28			0.29	0.27	0.20		
CD at 5%			NS	0.85	1.02	0.84			0.87	0.83	0.61		
CV %			7.28	8.95	9.74	7.27			9.30	7.87	5.52		

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values DAS - Days after spraying NS – Non-Significant

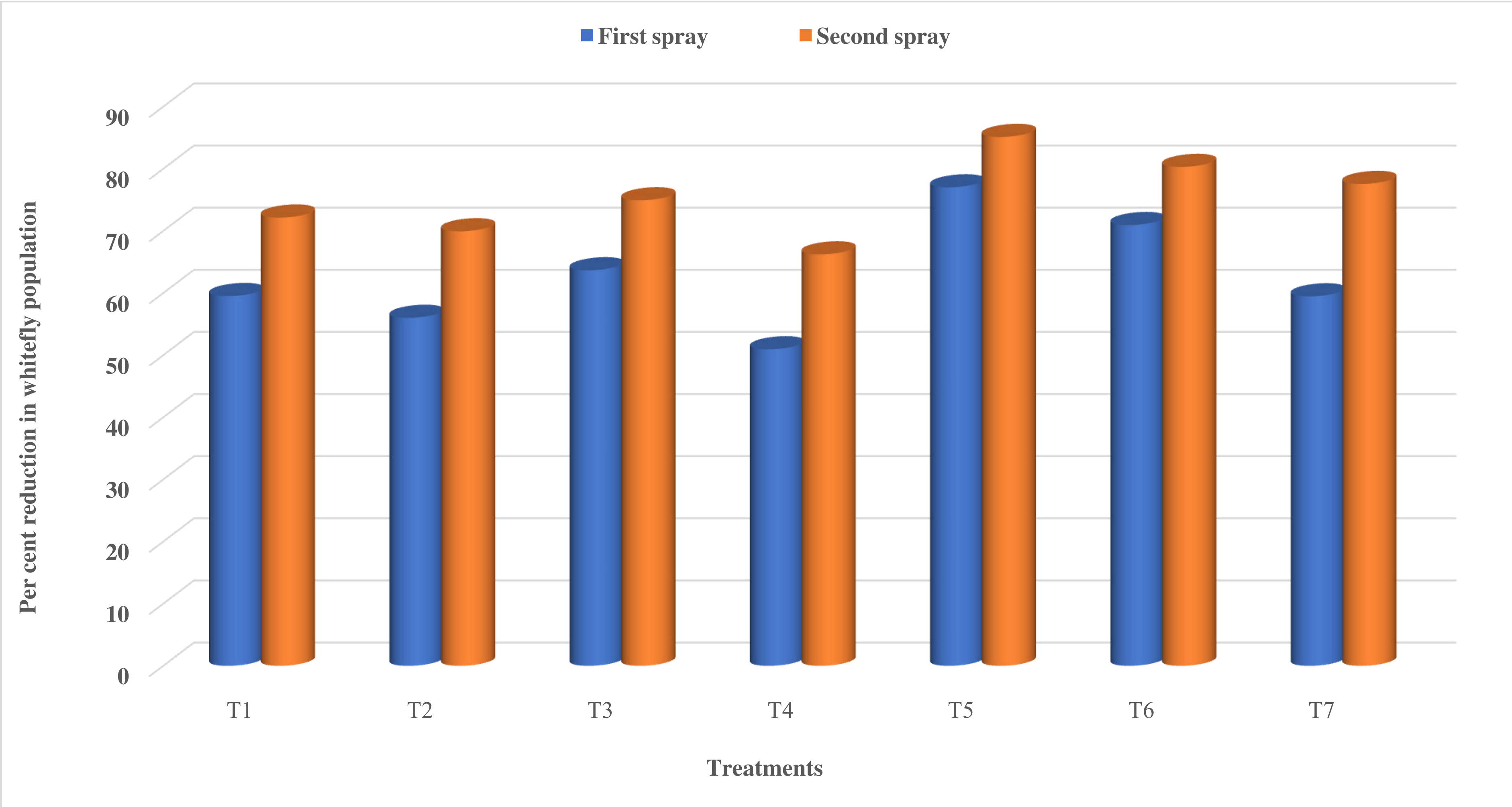

Fig. 4.31: Per cent reduction in whitefly population due to combination insecticides (Pooled *Summer* 2021 and 2022)

4.4.4 Bioefficacy of different combination insecticides against thrips

4.4.4.1 *Summer* 2021

A. Bioefficacy of insecticides after first spray

The precount population of thrips was uniform in all the experimental plots, since the average population of thrips was statistically non-significant. The average precount population was ranging from 13.40 to 14.10 thrips/3 leaves/vine (Table 4.57 and Fig. 4.32).

The results showed that all the insecticide treatments were found significantly superior over untreated control in minimizing thrips population at 3, 7 and 14 days after first application.

At three days after first spray, significantly lowest thrips count (2.60 thrips/3 leaves/vine) was recorded from plots treated with thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC followed by treatments indoxacarb 14.5% + acetamiprid 7.7% SC (3.43 thrips/3 leaves/vine) and emamectin benzoate 1.5% + fipronil 3.5% SC (4.57 thrips/3 leaves/vine). All these three treatments were found statistically at par with each other. Chlorantraniliprole 8.8% + thiamethoxam 17.5% SC was the next effective treatment in managing thrips population by recording 5.97 thrips/3 leaves/vine which was followed by novaluron 5.25% + indoxacarb 14.5% SC (6.70 thrips/3 leaves/vine) and these two treatments statistically equal to each other.

The post treatments observations recorded at 7 and 14 DAS revealed that plots treated with thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC recorded significantly minimum population of thrips (4.30 and 6.53 thrips/3 leaves/vine) followed by indoxacarb 14.5% + acetamiprid 7.7% SC (4.57 and 7.77 thrips/3 leaves/vine), emamectin benzoate 1.5% + fipronil 3.5% SC (6.80 and 10.70 thrips/3 leaves/vine), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (7.23 and 11.30 thrips/3 leaves/vine) and novaluron 5.25% + indoxacarb 14.5% SC (7.77 and 12.27 thrips/3 leaves/vine). All these treatments were found statistically at par with each other. The highest population of thrips was observed in untreated control (15.17 and 16.50 thrips/3 leaves/vine).

B. Bioefficacy of insecticides after second spray

During second spray there was a gradual increase in live count of thrips (nymph and adults) on untreated control plots (17.77 to 19.83 thrips/3 leaves/vine) over a period of 14 days.

The result showed that all the insecticidal treatments were found to significantly superior over the untreated control.

The observations recorded on 3 DAS showed that thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC was found to be the most effective treatment (2.07 thrips/3 leaves/vine) followed by indoxacarb 14.5% + acetamiprid 7.7% SC (3.10 thrips/3 leaves/vine) and emamectin benzoate 1.5% + fipronil 3.5% SC (4.33 thrips/3 leaves/vine). There was no statistically difference amongst these three treatments. The next effective treatment was chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (5.47 thrips/3 leaves/vine) which was statistically at par with novaluron 5.25% + indoxacarb 14.5% SC (6.27 thrips/3 leaves/vine).

The post treatment observations recorded at 7 DAS indicated that thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (3.73 thrips/3 leaves/vine) emerged as most effective treatment for managing thrips population which was statistically at par with indoxacarb 14.5% + acetamiprid 7.7% SC (4.33 thrips/3 leaves/vine), emamectin benzoate 1.5% + fipronil 3.5% SC (6.30 thrips/3 leaves/vine) and chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (6.37 thrips/3 leaves/vine).

At 14 days after second spray, significantly lowest population of thrips (6.17 thrips/3 leaves/vine) was recorded from the plots treated with thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC which was followed by indoxacarb 14.5% + acetamiprid 7.7% SC (6.77 thrips/3 leaves/vine), emamectin benzoate 1.5% + fipronil 3.5% SC (9.50 thrips/3 leaves/vine), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (10.67 thrips/3 leaves/vine) and novaluron 5.25% + indoxacarb 14.5% SC (11.63 thrips/3 leaves/vine). All these treatments were found statistically at par with each other.

Table 4.57: Bioefficacy of different combination insecticides against thrips (*Summer* 2021)

Tr. No	Treatments	Dose (ml/ha)	Average no. of thrips /3 leaves						
			Precount	1st spray			2nd spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	14.07 (3.82)	4.57 (2.25)	6.80 (2.70)	10.70 (3.35)	4.33 (2.09)	6.30 (2.55)	9.50 (3.16)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	14.33 (3.85)	8.40 (2.98)	9.43 (3.15)	15.23 (3.97)	7.87 (2.89)	9.00 (3.08)	14.27 (3.84)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	13.83 (3.79)	3.43 (1.98)	4.57 (2.25)	7.77 (2.88)	3.10 (1.90)	4.33 (2.15)	6.77 (2.61)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	13.63 (3.76)	6.70 (2.68)	7.77 (2.87)	12.27 (3.57)	6.27 (2.60)	7.30 (2.79)	11.63 (3.44)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	14.10 (3.74)	7.70 (2.86)	7.97 (2.91)	14.20 (3.77)	7.13 (2.76)	7.80 (2.88)	13.40 (3.73)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	13.80 (3.78)	2.60 (1.76)	4.30 (2.05)	6.53 (2.65)	2.07 (1.60)	3.73 (2.06)	6.17 (2.58)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	13.83 (3.79)	5.97 (2.54)	7.23 (2.78)	11.30 (3.41)	5.47 (2.44)	6.37 (2.62)	10.67 (3.34)
T_8	Untreated control	--	13.40 (3.66)	14.20 (3.77)	15.17 (3.96)	16.50 (4.12)	17.77 (4.27)	18.43 (4.35)	19.83 (4.51)
S.E (m) ±			0.35	0.25	0.28	0.31	0.25	0.23	0.32
CD at 5%			NS	0.76	0.85	0.96	0.75	0.71	0.96
CV %			11.37	11.75	12.14	11.13	11.84	10.14	11.42

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values DAS - Days after spraying NS – Non-Significant

4.4.4.2 *Summer* 2022

Before initiation of insecticidal spray treatments, the mean precount of thrips was ranged from 17.57 to 18.37 thrips/3 leaves/vine (Table 4.58 and Fig. 4.32).

A. Bioefficacy of insecticides after first spray

All the insecticide treatments were found significantly superior over untreated control in reducing thrips population on cucumber.

The mean thrips count observed in thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC during post spray period of 3 DAS was 4.13 thrips/3 leaves/vine, which was followed by treatments indoxacarb 14.5% + acetamiprid 7.7% SC (5.10 thrips/3 leaves/vine), emamectin benzoate 1.5% + fipronil 3.5% SC (6.07 thrips/3 leaves/vine), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (6.70 thrips/3 leaves/vine) and novaluron 5.25% + indoxacarb 14.5% SC (7.27 thrips/3 leaves/vine). The highest population of thrips was recorded in untreated control (18.73 thrips/3 leaves/vine).

At 7 DAS, lowest population of thrips was observed in thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (6.60 thrips/3 leaves/vine) and it was at par with indoxacarb 14.5% + acetamiprid 7.7% SC (7.43 thrips/3 leaves/vine), emamectin benzoate 1.5% + fipronil 3.5% SC (8.37 thrips/3 leaves/vine), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (9.03 thrips/3 leaves/vine), novaluron 5.25% + indoxacarb 14.5% SC (9.83 thrips/3 leaves/vine) and pyriproxyfen 5% + fenpropatrin 15% EC (11.33 thrips/3 leaves/vine). All these treatments were found statistically at par with each other. The maximum thrips population was noticed in untreated control (19.13 thrips/3 leaves/vine).

The thrips incidence was found more in all the treatment plots at 14 days after spray and significantly minimum population of thrips was recorded in thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (8.53 thrips/3 leaves/vine) which was followed by indoxacarb 14.5% + acetamiprid 7.7% SC (10.40 thrips/3 leaves/vine), emamectin benzoate 1.5% + fipronil 3.5% SC (12.47 thrips/3 leaves/vine) and chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (13.77 thrips/3 leaves/vine).

B. Bioefficacy of insecticides after second spray

Pre-count of thrips (nymph and adults) on untreated control plots was ranged from 22.43 to 19.03 thrips/3 leaves/vine over a period of 14 days. All the insecticidal treatments were significantly superior over the untreated control in minimizing the pest incidence.

At 3 after second spray the plots treated with treatment thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (3.23 thrips/3 leaves/vine) recorded minimum incidence followed by treatments indoxacarb 14.5% + acetamiprid 7.7% SC (4.63 thrips/3 leaves/vine), emamectin benzoate 1.5% + fipronil 3.5% SC (5.97 thrips/3 leaves/vine) and chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (6.23 thrips/3 leaves/vine) indicating no statistical difference in their efficacy against cucumber thrips. The next effective treatment for managing thrips population was novaluron 5.25% + indoxacarb 14.5% SC (7.03 thrips/3 leaves/vine) and it was at par with the treatments pyriproxyfen 5% + fenpropatrin 15% EC (7.43 thrips/3 leaves/vine) and novaluron 5.25% + emamectin benzoate 0.9% SC (8.80 thrips/3 leaves/vine).

Similar trend of results was obtained during 7 days after second spray as observed during 7 days after first spray.

The post treatments observations recorded at 14 days after second spray revealed that significantly lower number thrips noted in plots treated with treatment thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (7.43 thrips/3 leaves/vine) which was statistically at par with treatments indoxacarb 14.5% + acetamiprid 7.7% SC (9.23 thrips/3 leaves/vine), emamectin benzoate 1.5% + fipronil 3.5% SC (11.37 thrips/3 leaves/vine), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (12.87 thrips/3 leaves/vine) and novaluron 5.25% + indoxacarb 14.5% SC (14.47 thrips/3 leaves/vine). Pyriproxyfen 5% + fenpropatrin 15% EC (16.10 thrips/3 leaves/vine) was next better treatment for managing thrips population on cucumber.

Table 4.58: Bioefficacy of different combination insecticides against thrips (*Summer* 2022)

Tr. No	Treatments	Dose (ml/ha)	Average no. of whitefly/3 leaves						
			Precount	1st spray			2nd spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	18.03 (4.27)	6.07 (2.54)	8.37 (2.98)	12.47 (3.59)	5.97 (2.54)	7.73 (2.87)	11.37 (3.40)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	18.13 (4.32)	9.37 (3.14)	13.77 (3.73)	18.60 (4.35)	8.80 (3.03)	12.60 (3.61)	17.90 (4.28)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	17.57 (4.25)	5.10 (2.37)	7.43 (2.82)	10.40 (3.29)	4.63 (2.22)	6.90 (2.71)	9.23 (3.12)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	17.90 (4.29)	7.27 (2.79)	9.83 (3.16)	15.50 (3.98)	7.03 (2.74)	9.17 (3.11)	14.47 (3.84)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	700	18.07 (4.30)	8.23 (2.95)	11.33 (3.44)	17.30 (4.21)	7.43 (2.82)	10.43 (3.28)	16.10 (4.05)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	17.87 (4.25)	4.13 (2.05)	6.60 (2.66)	8.53 (3.00)	3.23 (1.91)	5.33 (2.41)	7.43 (2.82)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	17.57 (4.20)	6.70 (2.68)	9.03 (3.09)	13.77 (3.77)	6.23 (2.57)	8.23 (2.92)	12.87 (3.64)
T_8	Untreated control	--	18.37 (4.33)	18.73 (4.39)	19.13 (4.43)	21.43 (4.67)	22.43 (4.78)	19.27 (4.43)	19.03 (4.42)
S.E (m) ±			0.39	0.26	0.30	0.30	0.26	0.30	0.34
CD at 5%			NS	0.78	0.91	0.92	0.79	0.90	1.03
CV %			11.18	11.06	11.20	9.66	11.25	11.45	11.30

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values DAS - Days after spraying NS – Non-Significant

4.4.4.3 Pooled data for *Summer* 2021 and 2022

The data presented in Table 4.59 graphically depicted in Fig. 4.32 showed that pre-count of thrips before initiation of spray treatments was ranged from 15.70 to 16.23 thrips/3 leaves/vine which were found non-significant statistically.

A. Bioefficacy of insecticides after first spray

The results revealed that all the insecticides were found significantly superior over untreated control in reducing population of thrips at 3, 7 and 14 days after first spray.

The observation recorded on three days after first spray, thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC was found superior (3.37 thrips/3 leaves/vine) followed by treatments indoxacarb 14.5% + acetamiprid 7.7% SC (4.27 thrips/3 leaves/vine) and emamectin benzoate 1.5% + fipronil 3.5% SC (5.32 thrips/3 leaves/vine) and all these three treatments found statistically at par with each other. The next effective treatment was chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (6.33 thrips/3 leaves/vine). The treatment novaluron 5.25% + indoxacarb 14.5% SC (6.98 thrips/3 leaves/vine) and pyriproxyfen 5% + fenpropatrin 15% EC (7.97 thrips/3 leaves/vine) were found to be subsequently effective in reducing thrips population.

A pooled data after 7 DAS revealed that thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC treated plots showed lowest population of thrips (5.45 thrips/3 leaves/vine). It was followed by treatments indoxacarb 14.5% + acetamiprid 7.7% SC (6.00 thrips/3 leaves/vine), emamectin benzoate 1.5% + fipronil 3.5% SC (7.58 thrips/3 leaves/vine) and chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (8.13 thrips/3 leaves/vine) and these treatments were statistically at par with each other and significantly superior over other insecticide treatments. Novaluron 5.25% + indoxacarb 14.5% SC (8.80 thrips/3 leaves/vine) was next better treatment for reducing thrips population.

At 14 DAS, population of thrips increased in all treatments and was in the range of 7.53 thrips/3 leaves/vine (thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC) to 16.92 thrips/3 leaves/vine (novaluron 5.25% + emamectin benzoate 0.9% SC).

B. Performance of insecticides after second spray

The thrips population on untreated plots showed increasing trend from 18.85 to 20.10 thrips/3 leaves/vine during a span of 14 days. All the insecticidal treatments proved to be effective when compared to untreated control.

At 3 days after second spray, significantly minimum population of thrips (2.65 thrips /3 leaves/vine) was recorded from the plots treated with thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC which was statistically at par with indoxacarb 14.5% + acetamiprid 7.7% SC (3.87 thrips/3 leaves/vine). The next effective treatment was emamectin benzoate 1.5% + fipronil 3.5% SC (5.15 thrips/3 leaves/vine).

At 7 seven days after second spray, thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC recorded lowest number thrips *i.e*. 4.53 thrips/3 leaves/vine and it was at par with indoxacarb 14.5% + acetamiprid 7.7% SC (5.62 thrips/3 leaves/vine) and emamectin benzoate 1.5% + fipronil 3.5% SC (7.02 thrips/3 leaves/vine). Chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (7.30 thrips/3 leaves/vine) proved to be next better treatment for managing thrips population which was followed by treatment novaluron 5.25% + indoxacarb 14.5% SC (8.23 thrips/3 leaves/vine), these two treatments were found statistically at par with each other.

The observation recorded on 14 days after second spray showed that thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (6.80 thrips/3 leaves/vine) proved to be most promising insecticide which was statistically at par with indoxacarb 14.5% + acetamiprid 7.7% SC (8.00 thrips/3 leaves/vine), emamectin benzoate 1.5% + fipronil 3.5% SC (10.43 thrips/3 leaves/vine) and chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (11.77 thrips/3 leaves/vine). The next better treatment for reducing thrips population was novaluron 5.25% + indoxacarb 14.5% SC (13.05 thrips/3 leaves/vine).

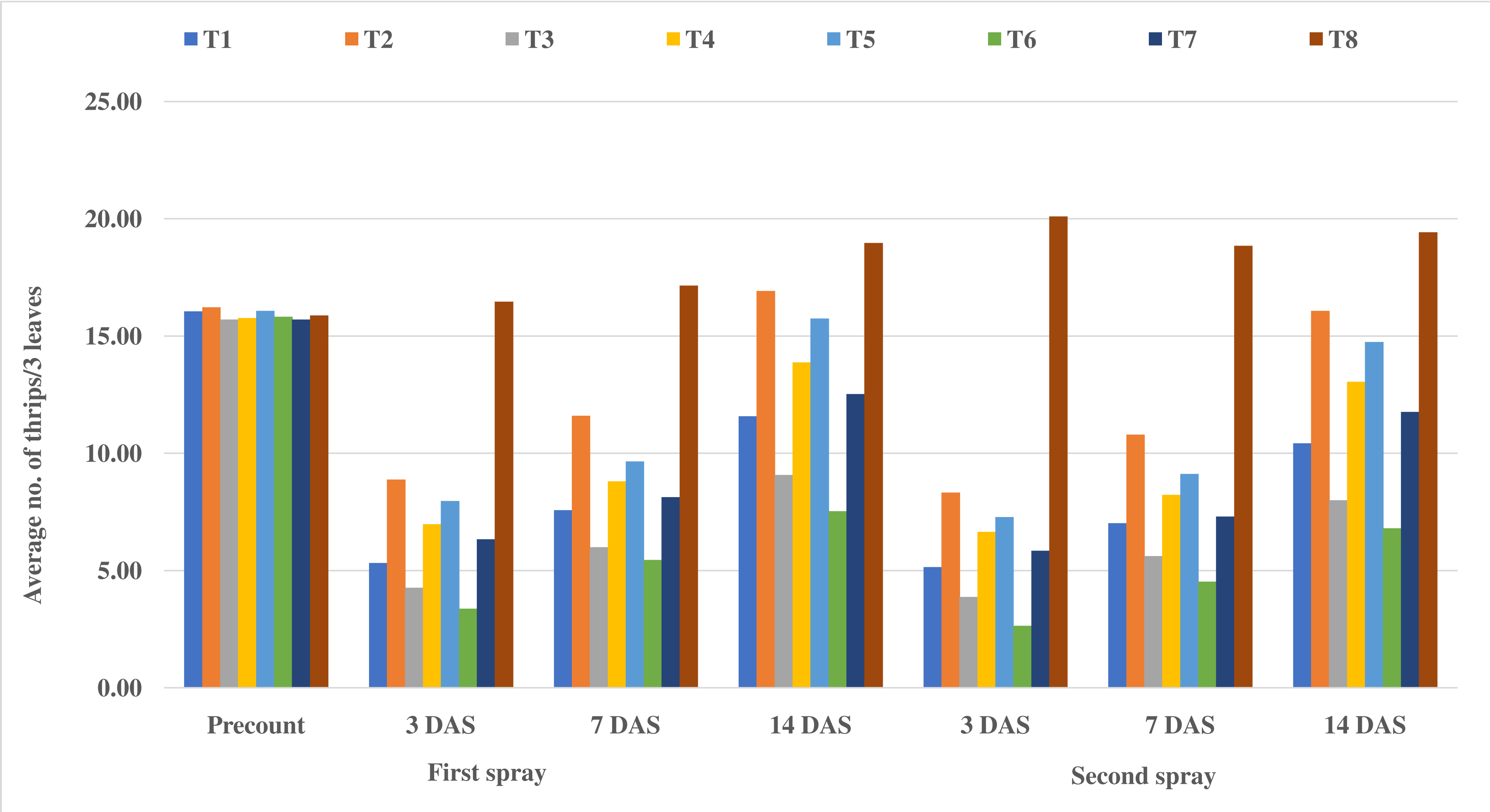

Fig. 4.32: Bioefficacy of different combination insecticides against thrips (Pooled *Summer* 2021 and 2022)

Table 4.59: Bioefficacy of different combination insecticides against thrips (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Dose (ml/ha)	Average no. of thrips/3 leaves						
			Precount	1st spray			2nd spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	16.05 (4.06)	5.32 (2.41)	7.58 (2.84)	11.58 (3.47)	5.15 (2.36)	7.02 (2.73)	10.43 (3.30)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	16.23 (4.09)	8.88 (3.06)	11.60 (3.46)	16.92 (4.17)	8.33 (2.97)	10.80 (3.36)	16.08 (4.07)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	15.70 (4.02)	4.27 (2.18)	6.00 (2.55)	9.08 (3.09)	3.87 (2.08)	5.62 (2.47)	8.00 (2.89)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	15.77 (4.03)	6.98 (2.74)	8.80 (3.04)	13.88 (3.79)	6.65 (2.67)	8.23 (2.96)	13.05 (3.65)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	16.08 (4.05)	7.97 (2.91)	9.65 (3.19)	15.75 (4.01)	7.28 (2.79)	9.12 (3.09)	14.75 (3.90)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	15.83 (4.03)	3.37 (1.93)	5.45 (2.42)	7.53 (2.83)	2.65 (1.77)	4.53 (2.24)	6.80 (2.70)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	15.70 (4.01)	6.33 (2.61)	8.13 (2.94)	12.53 (3.60)	5.85 (2.52)	7.30 (2.78)	11.77 (3.50)
T_8	Untreated control	--	15.88 (4.04)	16.47 (4.11)	17.15 (4.20)	18.97 (4.41)	20.10 (4.54)	18.85 (4.39)	19.43 (4.46)
S.E (m) ±			0.26	0.18	0.19	0.24	0.14	0.16	0.27
CD at 5%			NS	0.54	0.57	0.74	0.44	0.49	0.82
CV %			7.91	7.96	7.54	8.17	6.51	6.54	9.29

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values DAS - Days after spraying NS – Non-Significant

4.4.4.4 Per cent reduction in thrips population due to combination insecticides (Pooled data of *Summer* 2021 and 2022)

A. Performance of insecticides after first spray

The pooled data of two years Table 4.60 and Fig. 4.33 showed that thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (68.81%) and indoxacarb 14.5% + acetamiprid 7.7% SC (62.77%) were the most effective insecticides providing satisfactory reduction in thrips population in cucumber.

B. Performance of insecticides after second spray

During second spray maximum per cent reduction in thrips population was noted from thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC (75.97%), indoxacarb 14.5% + acetamiprid 7.7% SC (69.70%) and emamectin benzoate 1.5% + fipronil 3.5% SC (61.69%).

In present investigation overall, it was noticed that combination insecticidal treatments suppress the thrips population for initial period only. Among all the combination insecticides tested thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC was found most promising insecticide as it recorded lowest population of thrips on cucumber to the extent of 3.37, 5.54 and 7.53 and 2.65, 4.53 and 6.80 per three leaves per vine at 3, 7 and 14 days after first spray and second spray (pooled data), respectively over the rest of insecticides. The result obtained in respect of thrips are in close agreement with the findings of Padaliya *et al.* (2018) who revealed that thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC was found most effective on basis population of thrips. Reddy *et al.* (2018) revealed that chlorantraniliprole 8.8% + thiamethoxam 17.5% SC @ 150 g a.i/ha was found effective in managing the population of pod bug and aphid followed by thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC @ 150 g a.i/ha.

Table 4.60: Per cent reduction in thrips population due to combination insecticides (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Dose (ml/ha)	Average no. of thrips/3 leaves										
			Precount	1st spray			Mean	% Reduction	2nd spray			Mean	% Reduction
				3 DAS	7 DAS	14 DAS			3 DAS	7 DAS	14 DAS		
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	16.05 (4.06)	5.32 (2.41)	7.58 (2.84)	11.58 (3.47)	8.16	53.92	5.15 (2.36)	7.02 (2.73)	10.43 (3.30)	7.53	61.69
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	16.23 (4.09)	8.88 (3.06)	11.60 (3.46)	16.92 (4.17)	12.47	30.41	8.33 (2.97)	10.80 3.36	16.08 (4.07)	11.74	40.98
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	15.70 (4.02)	4.27 (2.18)	6.00 (2.55)	9.08 (3.09)	6.45	62.77	3.87 (2.08)	5.62 (2.47)	8.00 (2.89)	5.83	69.70
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	15.77 (4.03)	6.98 (2.74)	8.80 (3.04)	13.88 (3.79)	9.89	43.16	6.65 (2.67)	8.23 (2.96)	13.05 (3.65)	9.31	51.80
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	16.08 (4.05)	7.97 (2.91)	9.65 (3.19)	15.75 (4.01)	11.12	37.33	7.28 (2.79)	9.12 (3.09)	14.75 (3.90)	10.38	47.31
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	15.83 (4.03)	3.37 (1.93)	5.45 (2.42)	7.53 (2.83)	5.45	68.81	2.65 (1.77)	4.53 (2.24)	6.80 (2.70)	4.66	75.97
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	15.70 (4.01)	6.33 (2.61)	8.13 (2.94)	12.53 (3.60)	9.00	48.05	5.85 (2.52)	7.30 (2.78)	11.77 (3.50)	8.31	56.82
T_8	Untreated control	--	15.88 (4.04)	16.47 (4.11)	17.15 (4.20)	18.97 (4.41)	17.53		20.10 (4.54)	18.85 (4.39)	19.43 (4.46)	19.46	
S.E (m) ±			0.26	0.18	0.19	0.24			0.14	0.16	0.27		
CD at 5%			NS	0.54	0.57	0.74			0.44	0.49	0.82		
CV %			7.91	7.96	7.54	8.17			6.51	6.54	9.29		

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values DAS - Days after spraying NS – Non-Significant

4.4.5 Effect of different combination insecticides on population of lady bird beetle

4.4.5.1 *Summer* 2021

The data related to effect of combination insecticides on population of lady bird beetle are presented in Table 4.61 and Fig. 4.34. The precount of lady bird beetles was ranged from 1.37 to 1.67 beetles/vine. At 3,7 and 14 days after all two sprays clearly indicated that novaluron 5.25% + emamectin benzoate 0.9% SC was the safest molecule showing count of lady bird beetles in the range of 1.10 to 1.33 lbb/vine.

4.4.5.2 *Summer* 2022

The data related to effect of combination insecticides on population of lady bird beetle during 2022 are presented in Table 4.62 and Fig. 4.34.

Before initiation of sprays the precount of lady bird beetles was ranged of 1.35 to 1.50 lbb/vine. At 3,7 and 14 days after all two sprays, maximum number of lady bird beetles was observed in novaluron 5.25% + emamectin benzoate 0.9% SC (1.10 to 1.30 lbb/vine). Whereas, thiamethoxam12.6% + lambda-cyhalothrin 9.5% ZC (0.20 to 0.75 lbb/vine) was most harmful insecticide.

4.4.5.3 Pooled data of *Summer* 2021 and 2022

The data in respect of effect of combination insecticides on population of lady bird beetles are presented in Table 4.63 and graphically represented in Fig. 4.34.

The precount of lady bird beetles was ranged from 1.39 to 1.57 lbb/vine. At 3,7 and 14 days after all two sprays, novaluron 5.25% + emamectin benzoate 0.9% SC proved to be safer insecticide (1.10 to 1.30 lbb/vine). The thiamethoxam12.6% + lambda-cyhalothrin 9.5% ZC (0.33 to 0.78) was most harmful insecticide.

In present investigation overall, it was found that the maximum count (12.6, 1.16 and 1.32., 1.17, 1.10 and 1.28 of lady bird beetle per vine noticed in plots treated with treatment novaluron 5.25% + emamectin benzoate 0.9% SC after both the spray (pooled data) and proved that it was the safer insecticides for lady bird beetle. The results of present study are more or less in agreement with findings of Roy *et al*. (2017) who mentioned that chlorantraniliprole + thiamethoxam proved least toxic to prevailing predatory fauna *Miracraspis discolor* (Fabricius) and *Chrysoperla sp*., with less than 10% mortality after 15 days of each insecticide imposition.

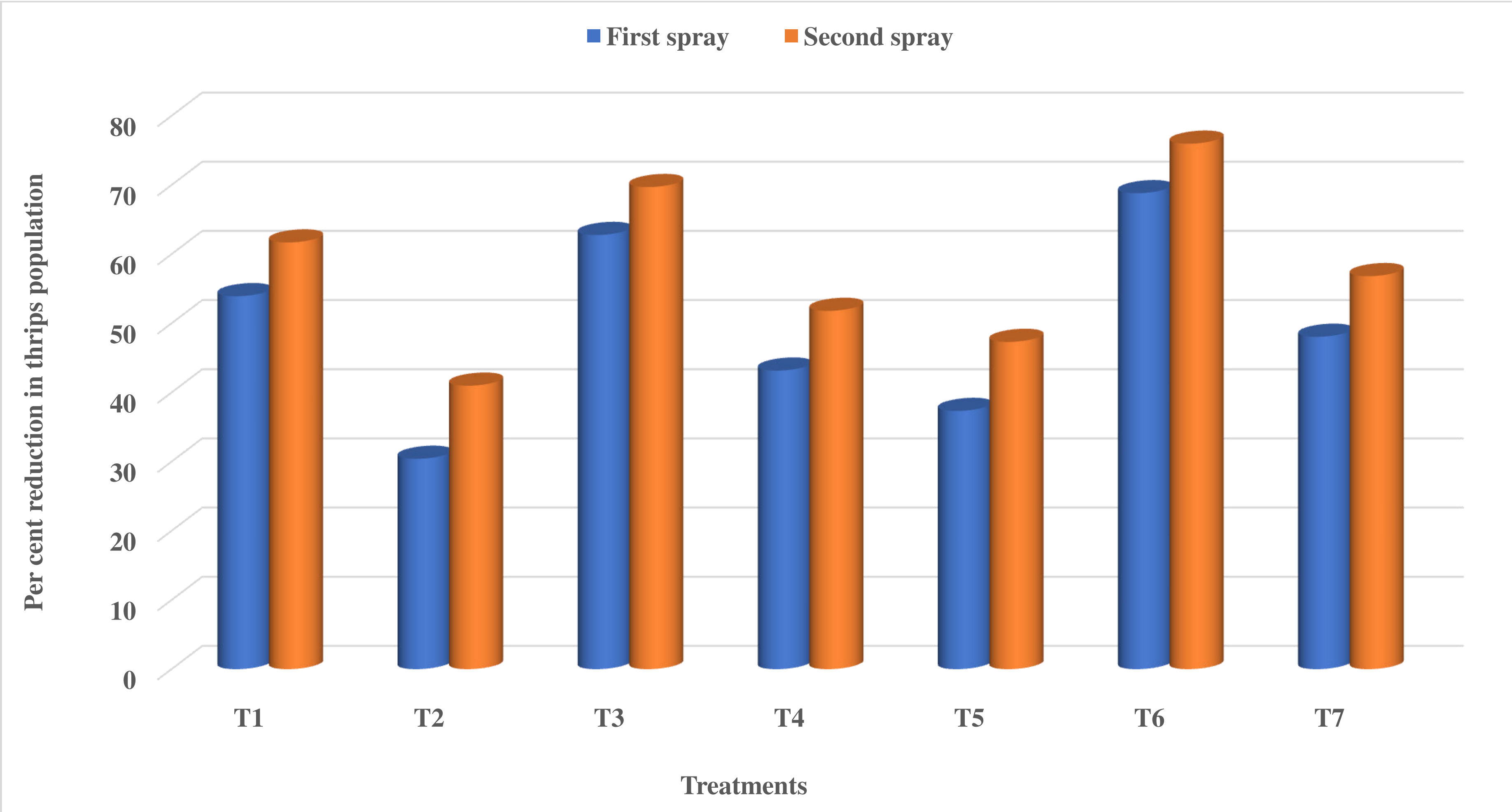

Fig. 4.33: Per cent reduction in thrips population due to combination insecticides (Pooled *Summer* 2021 and 2022)

Table 4.61: Effect of different combination insecticides on population of lady bird beetle (*Summer* 2021)

Tr. No	Treatments	Dose (ml/ha)	Average no. of lady bird beetle/vine						
			Precount	1st spray			2nd spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	1.50 (1.41)	1.23 (1.31)	1.13 (1.26)	1.27 (1.33)	1.17 (1.29)	1.07 (1.25)	1.23 (1.31)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	1.53 (1.42)	1.27 (1.33)	1.17 (1.27)	1.33 (1.35)	1.15 (1.28)	1.10 (1.26)	1.30 (1.34)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	1.67 (1.47)	0.88 (1.18)	0.77 (1.12)	0.95 (1.20)	0.78 (1.13)	0.67 (1.07)	0.77 (1.12)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	1.60 (1.44)	0.90 (1.18)	0.87 (1.16)	0.97 (1.20)	0.83 (1.15)	0.75 (1.11)	0.90 (1.18)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	1.37 (1.37)	1.10 (1.26)	1.03 (1.23)	1.40 (1.38)	1.02 (1.23)	1.00 (1.22)	1.07 (1.25)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	1.47 (1.40)	0.75 (1.11)	0.50 (0.99)	0.82 (1.11)	0.57 (1.03)	0.47 (0.98)	0.62 (1.06)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	1.57 (1.43)	1.00 (1.21)	0.90 (1.17)	1.15 (1.28)	0.97 (1.20)	0.80 (1.14)	1.13 (1.28)
T_8	Untreated control	--	1.50 (1.41)	1.77 (1.50)	2.07 (1.60)	2.17 (1.63)	2.20 (1.64)	2.23 (1.65)	2.30 (1.67)
S.E (m) ±			0.12	0.10	0.15	0.13	0.10	0.10	0.10
CD at 5%			NS	0.30	0.44	0.40	0.30	0.30	0.29
CV %			10.34	9.47	14.63	12.44	9.79	9.89	9.25

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values DAS - Days after spraying NS – Non-Significant

Table 4.62: Effect of different combination insecticides on population of lady bird beetle (*Summer* 2022)

Tr. No	Treatments	Dose (ml/ha)	Average no. of lady bird beetle/vine						
			Precount	1st spray			2nd spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	1.46 (1.39)	1.15 (1.28)	1.10 (1.26)	1.20 (1.30)	1.10 (1.26)	1.00 (1.21)	1.16 (1.29)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	1.43 (1.38)	1.25 (1.32)	1.15 (1.28)	1.30 (1.34)	1.18 (1.30)	1.10 (1.26)	1.25 (1.32)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	1.47 (1.39)	0.88 (1.18)	0.60 (1.05)	0.80 (1.14)	0.60 (1.04)	0.45 (0.98)	0.72 (1.10)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	1.35 (1.36)	0.80 (1.14)	0.75 (1.10)	0.90 (1.18)	0.70 (1.09)	0.50 (0.99)	0.81 (1.14)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	1.42 (1.38)	1.00 (1.22)	0.90 (1.18)	1.10 (1.26)	0.95 (1.20)	0.75 (1.11)	1.00 (1.21)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	1.45 (1.39)	0.60 (1.03)	0.50 (0.99)	0.75 (1.11)	0.40 (0.95)	0.20 (0.84)	0.55 (1.02)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	1.50 (1.41)	0.90 (1.18)	0.87 (1.16)	1.00 (1.21)	0.82 (1.15)	0.60 (1.04)	0.93 (1.19)
T_8	Untreated control	--	1.40 (1.37)	1.50 (1.41)	1.70 (1.48)	1.90 (1.54)	2.00 (1.57)	2.10 (1.59)	2.30 (1.67)
S.E (m) ±			0.11	0.09	0.10	0.11	0.12	0.14	0.10
CD at 5%			NS	0.28	0.32	0.33	0.35	0.43	0.30
CV %			10.16	9.41	10.78	10.41	11.89	15.35	9.70

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values DAS - Days after spraying NS – Non-Significant

Table 4.63: Effect of different combination insecticides on population of lady bird beetle (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Dose (ml/ha)	Average no. of lady bird beetle/vine						
			Precount	1st spray			2nd spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	1.48 (1.40)	1.19 (1.30)	1.12 (1.27)	1.23 (1.31)	1.13 (1.28)	1.03 (1.23)	1.20 (1.30)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	1.48 (1.41)	1.26 (1.33)	1.16 (1.28)	1.32 (1.35)	1.17 (1.22)	1.10 (1.26)	1.28 (1.33)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	1.57 (1.43)	0.88 (1.18)	0.68 (1.09)	0.88 (1.17)	0.69 (1.09)	0.56 (1.03)	0.74 (1.11)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	1.48 (1.40)	0.85 (1.16)	0.81 (1.13)	0.93 (1.20)	0.77 (1.12)	0.63 (1.06)	0.85 (1.16)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	1.39 (1.37)	1.05 (1.24)	0.97 (1.21)	1.25 (1.32)	0.98 (1.22)	0.88 (1.17)	1.03 (1.23)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	1.46 (1.40)	0.68 (1.08)	0.50 (1.00)	0.78 (1.12)	0.48 (0.99)	0.33 (0.91)	0.59 (1.04)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	1.53 (1.43)	0.95 (1.20)	0.88 (1.17)	1.08 (1.24)	0.89 (1.18)	0.70 (1.09)	1.03 (1.23)
T_8	Untreated control	--	1.45 (1.39)	1.63 (1.46)	1.88 (1.54)	2.03 (1.59)	2.10 (1.61)	2.17 (1.63)	2.30 (1.67)
S.E (m) ±			0.08	0.06	0.09	0.09	0.07	0.08	0.08
CD at 5%			NS	0.18	0.27	0.27	0.21	0.24	0.25
CV %			7.40	5.75	8.92	8.42	6.96	8.13	8.06

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values DAS - Days after spraying NS – Non-Significant

4.4.6 Effect of different combination insecticides on population of spider

4.4.6.1 *Summer* 2021

The data related to effect of combination insecticides on population of spider during 2021 are presented in Table 4.64 and Fig. 4.35.

The population of spiders in different plots was ranged from 0.40 to 0.53 spiders/vine before application of insecticides sprays. At 3,7 and 14 days after all two sprays, the population of spiders was significantly lower in insecticidal treatments than the control. Amongst all the insecticides, maximum number of spiders was recorded in plots treated with novaluron 5.25% + emamectin benzoate 0.9% SC (0.20 to 0.45 spiders/vine) which was followed by treatment chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (0.20 to 0.35 spiders/vine) and these two treatments were found statistically at par with each other. Thiamethoxam12.6% + lambda-cyhalothrin 9.5% ZC was most harmful treatment recording least population of 0.07 to 0.25 spiders/vine. The highest population of spiders was observed in control plots (0.67 to 2.00 spiders/vine).

4.4.6.2 *Summer* 2022

The observations on population of spiders during 2022 are presented in Table 4.65 and graphically presented in Fig. 4.35.

Before initiation of sprays the precount of spiders was ranged of 0.64 to 0.77 spiders/vine. At 3,7 and 14 days after all two sprays, maximum number of spiders was observed in chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (0.35 to 0.70 spiders/vine) which was statistically at par with the treatment indoxacarb 14.5% + acetamiprid 7.7% SC (0.30 to 0.55 spiders/vine). Thiamethoxam12.6% + lambda-cyhalothrin 9.5% ZC was most harmful treatment recorded minimum number of spiders *i.e.* 0.08 to 0.28 spiders/vine. The highest population of spiders was noticed in untreated control plots (0.80 to 2.00 spiders/vine).

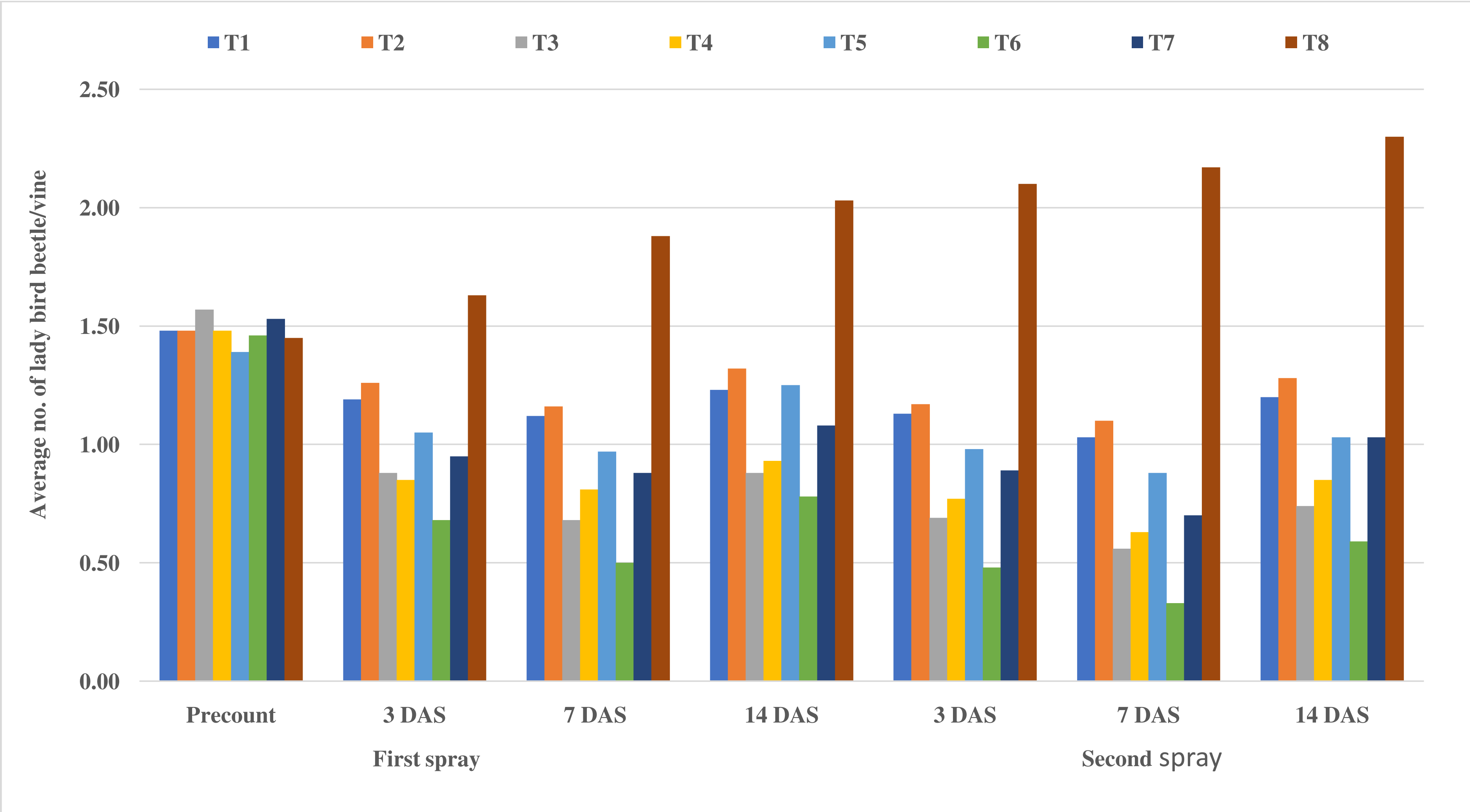

Fig. 4.34: Effect of different combination insecticides on population of lady bird beetle (Pooled *Summer* 2021 and 2022)

Table 4.64: Effect of different combination insecticides on population of spider (*Summer* 2021)

Tr. No	Treatments	Dose (ml/ha)	Average no. of spider/vine						
			Precount	1st spray			2nd spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	0.47 (0.98)	0.20 (0.83)	0.25 (0.86)	0.30 (0.89)	0.10 (0.77)	0.22 (0.85)	0.26 (0.87)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	0.40 (0.94)	0.35 (0.92)	0.40 (0.94)	0.45 (0.97)	0.20 (0.83)	0.27 (0.88)	0.37 (0.93)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	0.40 (0.94)	0.27 (0.88)	0.31 (0.90)	0.40 (0.94)	0.22 (0.85)	0.25 (0.87)	0.32 (0.90)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	0.48 (0.99)	0.11 (0.78)	0.20 (0.83)	0.30 (0.89)	0.08 (0.76)	0.12 (0.79)	0.22 (0.84)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	0.53 (1.01)	0.13 (0.79)	0.28 (0.88)	0.35 (0.92)	0.12 (0.79)	0.20 (0.83)	0.28 (0.88)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	0.52 (1.01)	0.07 (0.75)	0.10 (0.77)	0.25 (0.86)	0.04 (0.74)	0.08 (0.76)	0.22 (0.85)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	0.46 (0.98)	0.33 (0.91)	0.35 (0.92)	0.20 (0.83)	0.25 (0.86)	0.30 (0.89)	0.24 (0.86)
T_8	Untreated control	--	0.51 (0.99)	0.67 (1.08)	0.80 (1.14)	1.07 (1.25)	1.50 (1.41)	1.80 (1.51)	2.00 (1.56)
S.E (m) ±			0.07	0.10	0.07	0.09	0.07	0.07	0.09
CD at 5%			NS	0.30	0.22	0.29	0.20	0.21	0.28
CV %			8.82	9.47	9.83	12.30	9.12	9.16	11.80

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values DAS – Days after spraying NS – Non-Significant

Table 4.65: Effect of different combination insecticides on population of spider (*Summer* 2022)

Tr. No	Treatments	Dose (ml/ha)	Average no. of spider/vine						
			Precount	1st spray			2nd spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	0.77 (1.12)	0.25 (0.86)	0.31 (0.90)	0.40 (0.94)	0.20 (0.84)	0.24 (0.86)	0.38 (0.93)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	0.73 (1.10)	0.27 (0.87)	0.33 (0.91)	0.45 (0.97)	0.25 (0.87)	0.27 (0.88)	0.34 (0.91)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	0.75 (1.11)	0.33 (0.91)	0.40 (0.95)	0.55 (1.02)	0.41 (0.95)	0.30 (0.89)	0.32 (0.90)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	0.65 (1.07)	0.20 (0.83)	0.25 (0.87)	0.35 (0.92)	0.15 (0.81)	0.21 (0.84)	0.15 (0.81)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	0.70 (1.09)	0.40 (0.95)	0.45 (0.97)	0.60 (1.04)	0.32 (0.90)	0.36 (0.92)	0.45 (0.97)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	0.72 (1.10)	0.15 (0.81)	0.20 (0.84)	0.28 (0.88)	0.08 (0.76)	0.14 (0.80)	0.20 (0.83)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	0.64 (1.06)	0.47 (0.98)	0.53 (1.01)	0.70 (1.09)	0.35 (0.91)	0.45 (0.97)	0.55 (1.02)
T_8	Untreated control	--	0.67 (1.08)	0.80 (1.13)	1.00 (1.21)	1.20 (1.30)	1.50 (1.41)	2.00 (1.56)	1.80 (1.51)
S.E (m) ±			0.11	0.07	0.08	0.09	0.08	0.11	0.11
CD at 5%			NS	0.22	0.25	0.29	0.23	0.35	0.32
CV %			12.05	9.54	10.72	11.38	10.17	14.49	13.12

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values DAS – Days after spraying NS – Non-Significant

4.4.6.3 Pooled data of *Summer* 2021 and 2022

The data pertaining to effect of combination insecticides on population of spiders (pooled data of *Summer* 2021 and 2022) are presented in Table 4.66 and graphically depicted in (Fig. 4.35).

The population of spiders was ranged from 0.57 to 0.60 spiders/vine before application of insecticides sprays. The post treatment count at 3,7 and 14 days after all two sprays indicated that maximum number of spiders was recorded in plots treated with chlorantraniliprole 8.8 % + thiamethoxam 17.5 % SC (0.30 to 0.45 spiders/vine). The treatment thiamethoxam 12.6 % + lambda-cyhalothrin 9.5 % ZC was most harmful treatment recorded lowest number of spiders *i.e*. 0.06 to 0.26 spiders/vine. The highest population of spiders was recorded in untreated control plots (0.74 to 1.90 spiders/vine).

In present investigation the overall results of study were noticed that the maximum population of spiders observed in plots treated with treatment chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (0.40, 044 and 0.45., 0.30, 0.38 and 0.40 spiders/vine) after both the spray and proved that it was the safer insecticides for spiders. The results of present study are in agreement with Roy *et al*. (2017) who reported that chlorantraniliprole + thiamethoxam proved least toxic to prevailing predatory fauna *Miracraspis discolor* (Fabricius) and *Chrysoperla sp*., with less than 10 per cent mortality after 15 days of each insecticide imposition.

Table 4.66: Effect of different combination insecticides on population of spider (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Dose (ml/ha)	Average no. of spider/vine						
			Precount	1st spray			2nd spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	0.77 (1.12)	0.23 (0.85)	0.29 (0.89)	0.38 (0.93)	0.18 (0.82)	0.25 (0.86)	0.30 (0.89)
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	0.58 (1.04)	0.30 (0.89)	0.36 (0.92)	0.43 (0.96)	0.20 (0.84)	0.26 (0.87)	0.38 (0.93)
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	0.58 (1.03)	0.30 (0.89)	0.36 (0.92)	0.48 (0.99)	0.32 (0.90)	0.28 (0.88)	0.32 (0.90)
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	0.57 (1.03)	0.16 (0.81)	0.23 (0.85)	0.33 (0.91)	0.12 (0.78)	0.17 (0.82)	0.19 (0.83)
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	0.62 (1.05)	0.27 (0.87)	0.37 (0.93)	0.48 (0.98)	0.22 (0.85)	0.28 (0.88)	0.37 (0.93)
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	0.62 (1.06)	0.11 (0.78)	0.15 (0.81)	0.26 (0.87)	0.06 (0.75)	0.11 (0.78)	0.21 (0.84)
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	0.55 (1.02)	0.40 (0.95)	0.44 (0.97)	0.45 (0.97)	0.30 (0.89)	0.38 (0.93)	0.40 (0.95)
T_8	Untreated control	--	0.59 (1.04)	0.74 (1.10)	0.90 (1.18)	1.13 (1.28)	1.50 (1.41)	1.90 (1.55)	1.90 (1.53)
S.E (m) ±			0.06	0.06	0.05	0.07	0.05	0.03	0.09
CD at 5%			NS	0.17	0.15	0.21	0.16	0.10	0.27
CV %			6.76	7.66	6.59	8.49	7.35	7.40	11.19

Figures in parenthesis are $\sqrt{x + 0.5}$ transformed values DAS – Days after spraying NS – Non-Significant

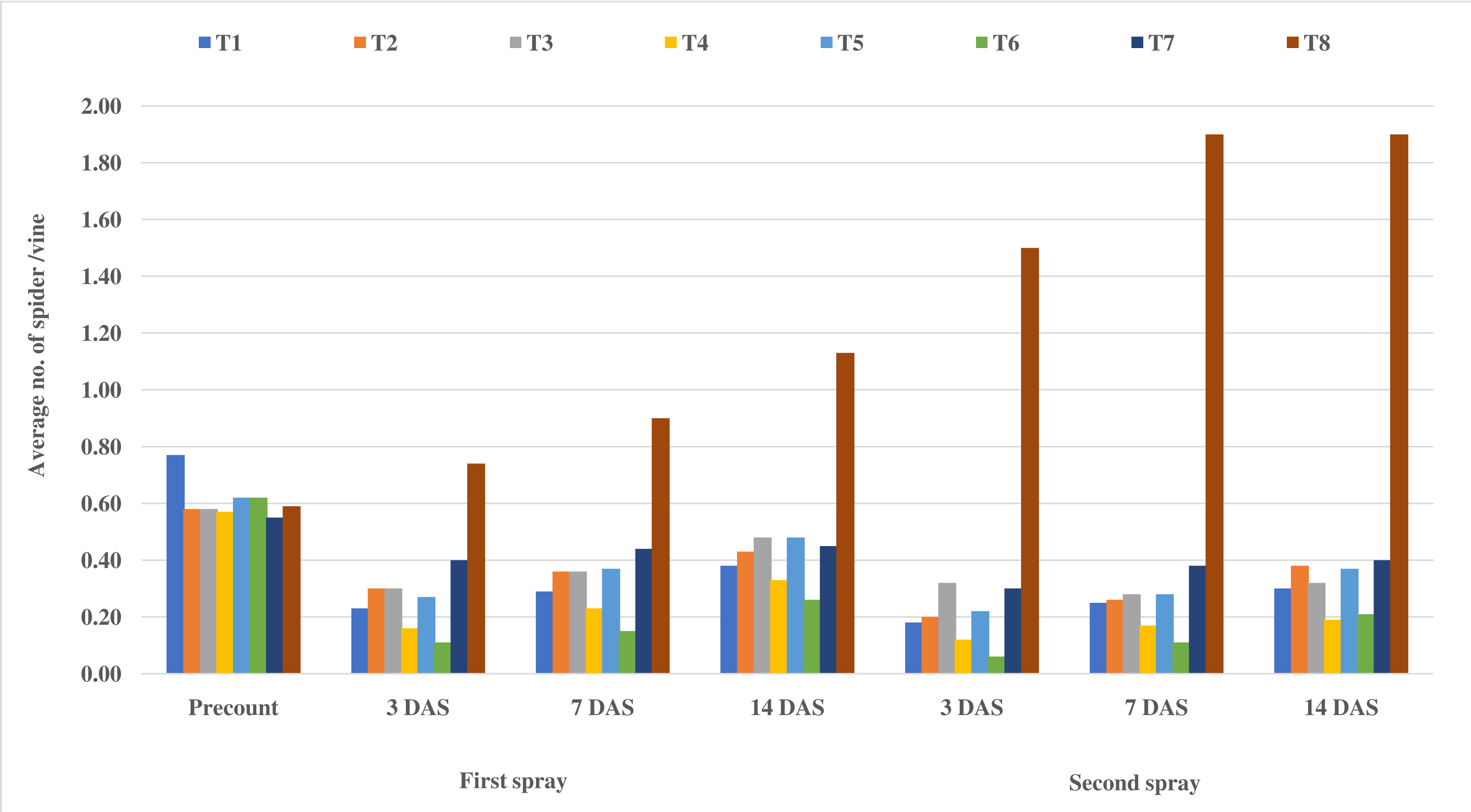

Fig. 4.35: Effect of different combination insecticides on population of spider (Pooled *Summer* 2021 and 2022)

4.4.7. Effect of different combination insecticides on marketable fruit yield of cucumber (*Summer* 2021, 2022 and Pooled *Summer* 2021 and 2022)

All the treatments were statistically significantly superior in increasing fruit yield of cucumber over untreated control during *Summer* 2021, *Summer* 2022 and pooled data of *Summer* 2021 and 2022 are presented in Table 4.67 depicted in Fig. 4.36.

4.4.7.1 *Summer* 2021

During *Summer* 2021, the fruit yield of cucumber in different treatments varied from 152.54 to 239.23. Significantly highest fruit yield (239.23 q/ha) of cucumber was recorded from plots treated with chlorantraniliprole 8.8% + thiamethoxam 17.5% SC. However, the lowest fruit yield of 152.54 q/ha was registered in treatment untreated control.

4.4.7.2 *Summer* 2022

Similarly, during *Summer* 2022, significantly higher fruit yield (235.23 q/ha) of cucumber was obtained in chlorantraniliprole 8.8% + thiamethoxam 17.5% SC treated plots. Lowest fruit yield (150.24 q/ha) was recorded in treatment untreated control.

4.4.7.3 Pooled data of *Summer* 2021 and 2022

The years pooled data showed that highest fruit yield (237.23 q/ha) of cucumber was obtained in chlorantraniliprole 8.8% + thiamethoxam 17.5% SC treated plots. Lowest fruit yield (150.24 q/ha) was recorded in treatment untreated control. Thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC was next treatment recorded higher fruit yield (229.71 q/ha) of cucumber.

The present results are similar with the results of earlier workers. Rohokale *et al*. (2018) who reported that chlorantraniliprole 8.8 % + thiamethoxam 17.5 % SC registered the highest yield (149 q/ha) followed by chlorantraniliprole 9.3% + lambda-cyhalothrin 4.6% ZC (140 q/ha). Padaliya *et al*. (2018) revealed that the maximum seed cotton yield (2691 kg/ha) was recorded in the treatment of thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC

Table 4.67: of different combination insecticides on marketable fruit yield of cucumber (Pooled data *Summer* 2021 and 2022 and)

Tr. No	Treatments	Dose (ml/ha)	Yield of marketable fruit (q/ha)		
			***Summer* 2021**	***Summer* 2022**	**Pooled *Summer* 2021 and 2022**
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	221.56	215.56	218.56
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	204.17	208.42	206.30
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	216.34	212.34	214.34
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	228.12	221.45	224.79
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	210.27	201.37	205.82
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	231.45	227.97	229.71
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	239.23	235.23	237.23
T_8	Untreated control	--	152.54	150.24	151.39
S.E ±			1.68	1.72	1.70
CD at 5%			5.10	5.21	5.16
CV %			11.14	11.81	11.48

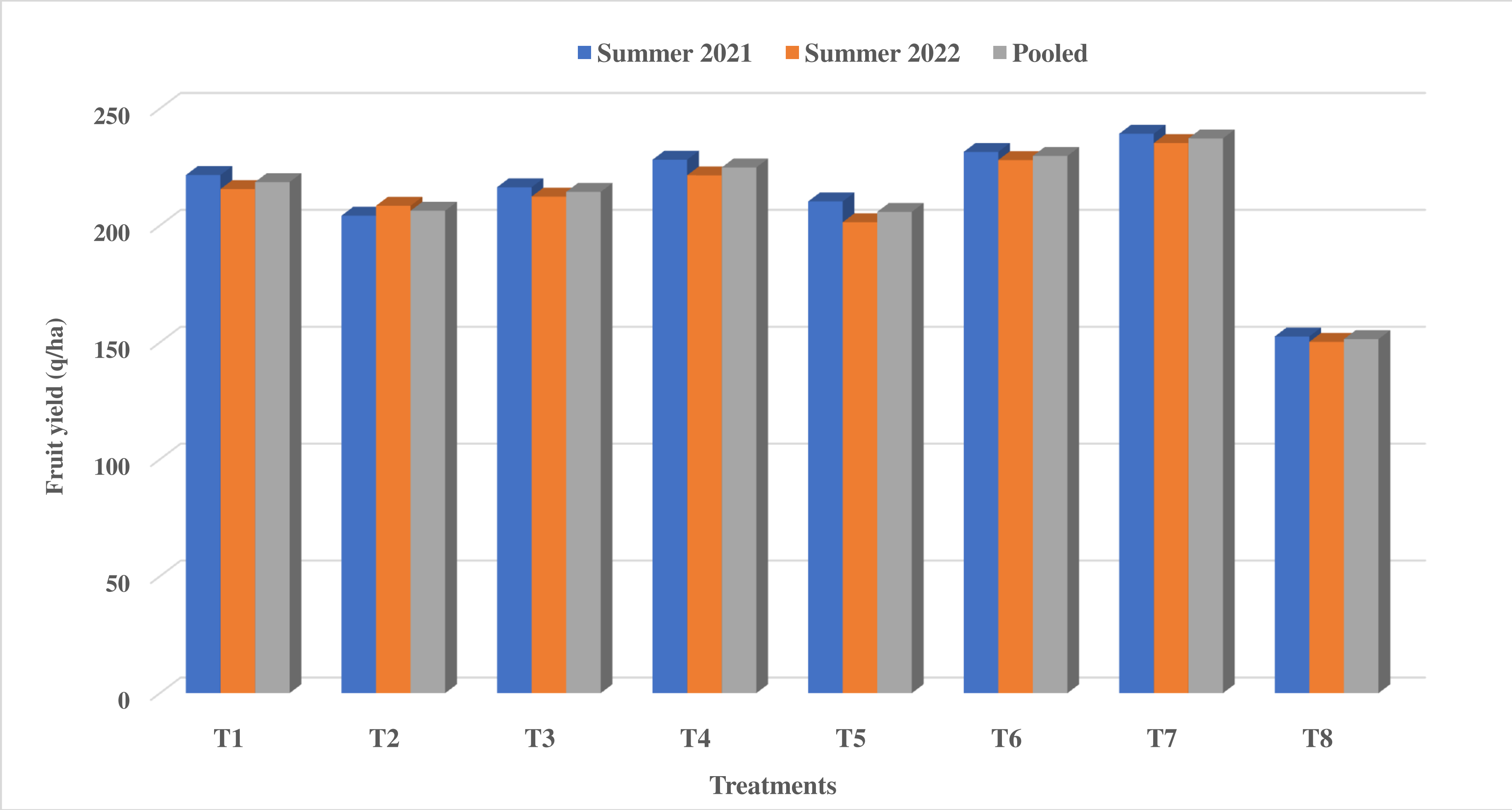

Fig. 4.36: Effect of different combination insecticides on marketable fruit yield of cucumber (Pooled *Summer* 2021 and 2022 and data)

(2645 kg/ha). Floret and Regupathy (2019) reported that chlorantraniliprole 9.3% w/w + lambda-cyhalothrin 4.6% w/w 150 ZC treatment resulted in significantly higher yield as compared to untreated check. Malathi and Kumar (2017) who reported that the treatment novaluron 5.25% + indoxacarb 4.5% SC @ 875 ml/ha recorded significantly higher yield closely followed by novaluron 5.25% + indoxacarb 4.5% SC @ 825 ml/ha with almost equal incremental benefits costs ratios. Das *et al*. (2015) mentioned that the highest yield was also recorded in novaluron + fipronil @ 80 g a.i/ha treated plot (18.6 q/ha) followed by novaluron 5.25% + indoxacarb 4.5% SC (16.4 q/ha).

4.4.8 Incremental cost benefit ratio for different combination insecticides in cucumber (*Summer* 2021, 2022 and Pooled *Summer* 2021 and 2022)

The data generated on incremental cost benefit ratio for different combination insecticides applied against major insect pests of cucumber during *Summer* 2021, *Summer* 2022 and pooled data of *Summer* 2021 and 2022 are tabulated in Table 4.68, 4.69 and 4.70 respectively and depicted by Fig. 4.37.

4.4.8.1 *Summer* 2021

Among all the treatments, highest incremental cost benefit ratio (1:41.93) was attained by treatment indoxacarb 14.5% + acetamiprid 7.7% SC which was followed by novaluron 5.25% +indoxacarb 14.5% (1:41.32), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (1:33.73), thiamethoxam12.6% + lambda-cyhalothrin 9.5% ZC (1:33.52), emanectin benzoate 1.5% + fipronil 3.5% SC (1:23.34), pyriproxifen 5% EC + fenpropatrin 15% EC (1:21.90) and novaluron 5.25% + emamectin benzoate 0.9% SC (1:17.78).

4.4.8.2 *Summer* 2022

It is evident from Table 4.69 that during *Summer* 2022, maximum incremental cost benefit ratio to the tune of 1:40.79 was obtained by application of indoxacarb 14.5% + acetamiprid 7.7% SC which was followed by novaluron 5.25% +indoxacarb 14.5% (1:1.38.87), chlorantraniliprole 8.8% + thiamethoxam 17.5% SC (1:1.33.05), thiamethoxam12.6% + lambda-cyhalothrin 9.5% ZC (1:33.00), emanectin benzoate 1.5% + fipronil 3.5% SC (1:22.03), novaluron 5.25% + emamectin benzoate 0.9% SC (1:20.17) and pyriproxifen 5% EC + fenpropatrin 15% EC (1:19.28).

Table 4.68: Incremental cost benefit ratio for different combination insecticides in cucumber (*Summer* 2021)

Tr. No	Treatments	Dose (ml/ha)	No of spray	Cost of insecticides/ha	Labour cost Rs. 368/day	Total cost of plant protection (A)	Yield (q/ha)	Increased yield over control (q/ha)	Values of increased yield (B)	Increment benefit (C) (B-A)	ICBR (C/A)
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	2	4200	1472	5672	221.56	69.02	138040	132368	1:23.34
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	2	4025	1472	5497	204.17	51.63	103260	97763	1:17.78
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	2	1500	1472	2972	216.34	63.80	127600	124628	1:41.93
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	2	2100	1472	3572	228.12	75.58	151160	147588	1:41.32
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	2	3570	1472	5042	210.27	57.73	115460	110418	1:21.90
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	2	3100	1472	4572	231.45	78.91	157820	153248	1:33.52
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	2	3520	1472	4992	239.23	86.69	173380	168388	1:33.73
T_8	Untreated control	--	--	--	--	--	152.54	--	--	--	--

Market price of cucumber fruit during *Summer* 2021 was Rs 2000/q.

Table 4.69: Incremental cost benefit ratio for different combination insecticides in cucumber (*Summer* 2022)

Tr. No	Treatments	Dose (ml/ha)	No of spray	Cost of insecticides/ha	Labour cost Rs. 368/day	Total cost of plant protection (A)	Yield (q/ha)	Increased yield over control (q/ha)	Values of increased yield (B)	Increment benefit (C) (B-A)	ICBR (C/A)
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	2	4200	1472	5672	215.56	65.32	130640	124968	1:22.03
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	2	4025	1472	5497	208.42	58.18	116360	110863	1:20.17
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	2	1500	1472	2972	212.34	62.10	124200	121228	1:40.79
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	2	2100	1472	3572	221.45	71.21	142420	138848	1:38.87
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	2	3570	1472	5042	201.37	51.13	102260	97218	1:19.28
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	2	3100	1472	4572	227.97	77.73	155460	150888	1:33.00
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	2	3520	1472	4992	235.23	84.99	169980	164988	1:33.05
T_8	Untreated control	--	--	--	--	--	150.24	--	--	--	--

Market price of cucumber fruit during *Summer* 2022 was Rs 2000/q

4.4.8.3 Pooled data of *Summer* 2021 and 2022

The years pooled data from Table 4.70 showed that highest incremental cost benefit ratio (1:41.36) was attained by treatment indoxacarb 14.5% + acetamiprid 7.7% SC which was followed by novaluron 5.25% +indoxacarb 14.5%, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC, thiamethoxam12.6% + lambda-cyhalothrin 9.5% ZC, emanectin benzoate 1.5% + fipronil 3.5% SC, pyriproxifen 5% EC + fenpropatrin 15% EC and novaluron 5.25% + emamectin benzoate 0.9% SC (1:40.10, 1:33.39, 1:33.26, 1:22.69, 1:20.59 and 1:18.98).

The present findings are in agreement with those of Ghosal *et al*. (2016) who observed that novaluron 5.25% + indoxacarb 4.56 @ 875 ml/ha recorded highest cost benefit ratio (1:6.17). Malathi and Kumar (2017) noticed that novaluron 5.25% + indoxacarb 4.5% SC @ 875 ml/ha recorded significantly higher incremental benefits cost ratios. Borude *et al*. (2018) reported that the treatment thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC, indoxacarb 14.5% + acetamiprid 7.7% SC, novaluron 5.25% + indoxacarb 4.5% SC and pyriproxyfen 5% + Fenpropathrin 15% EC proved to be most economically viable. Subbireddy *et al*. (2018) concluded that maximum net realization was obtained in the treatment of chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC (87895/ha and 85103/ha) followed by indoxacarb 14.5% + acetamiprid 7.7% SC (76868/ha and 80226/ha) during *summer* and *kharif*, respectively. Roy *et al*. (2017) found that highest cost benefit ratio was obtained from emamectin benzoate + fipronil.

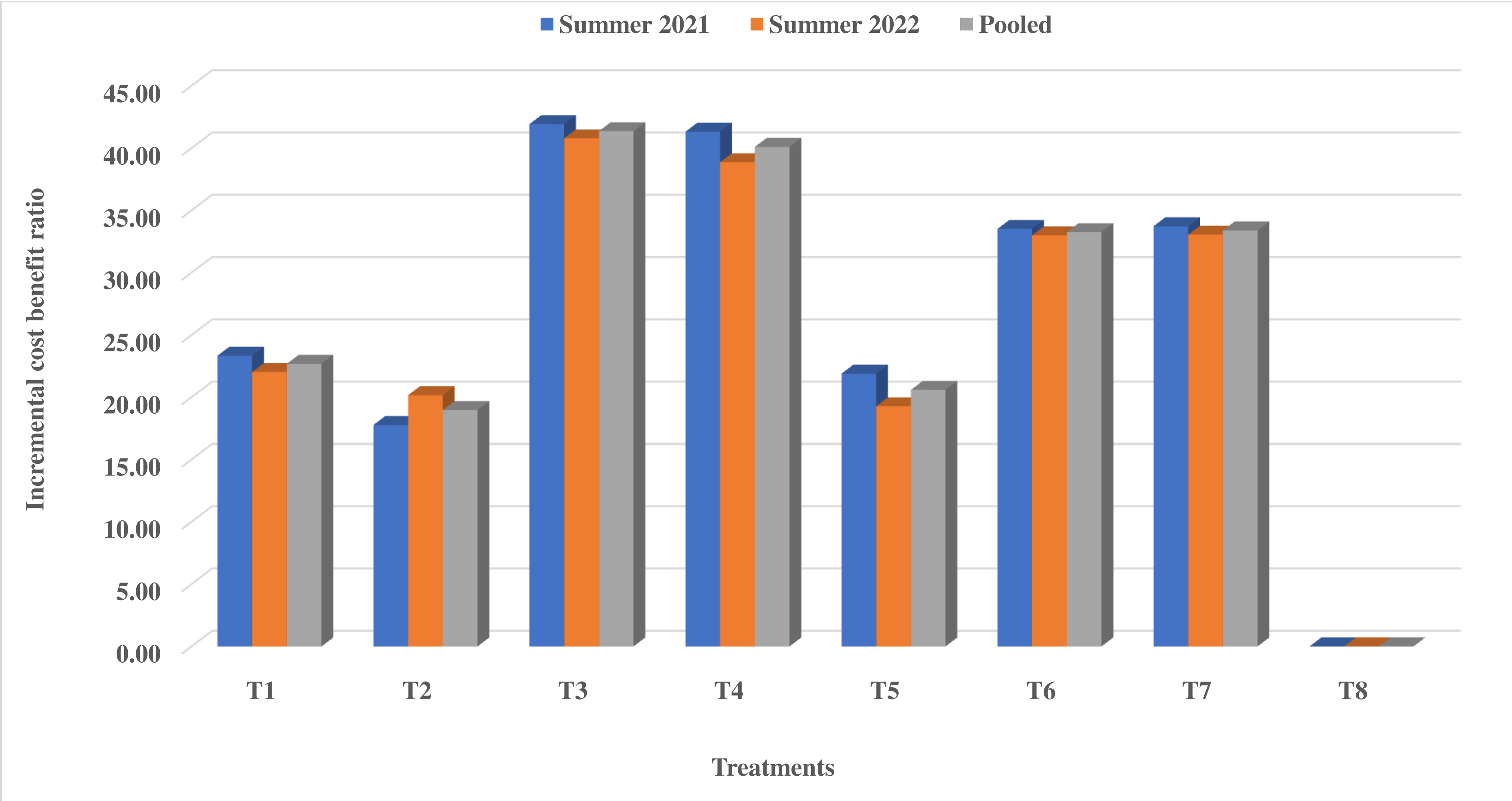

Fig. 4.37: Incremental cost benefit ratio for different combination insecticides in cucumber (Pooled *Summer* 2021 and 2022)

Table 4.70: Incremental cost benefit ratio for different combination insecticides in cucumber (Pooled *Summer* 2021 and 2022)

Tr. No	Treatments	Dose (ml/ha)	No of spray	Cost of insecticides/ha	Labour cost Rs. 368/day	Total cost of plant protection (A)	Yield (q/ha)	Increased yield over control (q/ha)	Values of increased yield (B)	Increment benefit (C) (B-A)	ICBR (C/A)
T_1	Emanectin benzoate 1.5% + Fipronil 3.5% SC	700	2	4200	1472	5672	218.56	67.17	134340	128668	1:22.69
T_2	Novaluron 5.25% + Emamectin benzoate 0.9% SC	875	2	4025	1472	5497	206.30	54.91	109810	104313	1:18.98
T_3	Indoxacarb 14.5% + Acetamiprid 7.7% SC	500	2	1500	1472	2972	214.34	62.95	125900	122928	1:41.36
T_4	Novaluron 5.25% +Indoxacarb 14.5%	875	2	2100	1472	3572	224.79	73.40	146790	143218	1:40.10
T_5	Pyriproxifen 5% EC + Fenpropatrin 15% EC	750	2	3570	1472	5042	205.82	54.43	108860	103818	1:20.59
T_6	Thiamethoxam12.6% + Lambda-cyhalothrin 9.5% ZC	500	2	3100	1472	4572	229.71	78.32	156640	152068	1:33.26
T_7	Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC	200	2	3520	1472	4992	237.23	85.84	171680	166688	1:33.39
T_8	Untreated control	--	--	--	--	--	151.39	--	--	--	--

Market price of cucumber fruit during *Summer* 2021 and 2022 was Rs 2000/q

CHAPTER V

SUMMARY AND CONCLUSIONS

CHAPTER-V

SUMMARY AND CONCLUSION

Cucumber (*Cucumis sativus*) belongs Cucurbitaceae family possess antibacterial, antimicrobial, antifungal characteristics. It is essentially warm season crop but is successfully grow in tropical subtropical and temperate region. It is commonly used for food, medicinal and industrial purposes. Cucumber crop is attacked by several insect pests *viz*., fruit fly (*Bactrocera cucurbitae* Coquillett), red pumpkin beetle (*Aulacophora foveicollis* Lucas), whitefly (*Bemisia tabaci* Gennadius), aphid (*Aphis gossypii* Glover), thrips (*Thrips palmi* Karny). Infestation of these pests not only reduce the yield but also deteriorate the quality of fruits. Overuse and misuse of chemical insecticides, the natural balance has been disturbed leading to enormous problems such as resistance, residues, resurgence, destruction of natural enemies *etc*. The adoption and expansion of monocultures decreases the abundance and activity of natural enemies by destruction of critical food resources and overwintering sites. The present investigation was carried out during *Summer* 2021 and 2022 to study the seasonal incidence of major insect pests of cucumber in relation to weather parameters. To study the host preference and biology of melon fruit fly on different hosts. To study the influence of intercropping on incidence of major insect pests of cucumber. Furthermore, the bio-efficacy of different combination insecticides against major insect pests of cucumber to ascertain most effective molecules that can be taken in spray schedules of cucumber pest management.

5.1 Summary

5.1.1 Seasonal incidence of major insect pests of cucumber in relation to weather parameters

Seasonal incidence of major insect pests and their natural enemies of cucumber *viz*., melon fruit fly, whitefly, thrips and red pumpkin beetle and their natural enemies *i.e.* lady bird beetle and spiders was studied during *Summer*, *Kharif* and *Rabi* 2021.

The maximum incidence of melon fruit fly was observed during *Summer* than *Kharif* and *Rabi* season at fruiting stage. *Summer* is more congenial to whitefly as that of *Kharif* and *Rabi*. The incidence of thrips recorded throughout the season but maximum incidence was observed in *Summer* than *Kharif* and *Rabi* season at vegetative stage of crop. The maximum incidence of red pumpkin beetle was noticed in *Summer* as compared to *Kharif* and *Rabi* season. The population of natural enemies *viz*., lady bird beetle and predatory spider was observed throughout the cropping period in all the seasons but maximum population of natural enemies was noticed in *Summer* than *Kharif* and *Rabi* season when there was more incidence of sucking pests.

As regards the correlation study, fruit fly population showed positive highly significant correlation with maximum temperature and minimum temperature. While negatively non-significant with rainfall and evening relative humidity whereas morning relative humidity was negatively significant with melon fruit fly during *Summer* 2021. During *Kharif* 2021 negatively non-significant correlation with maximum temperature and minimum temperature. While positively non-significant with morning relative humidity and evening relative humidity whereas rainfall was positively significant. Whereas during *Rabi* 2021 negatively highly significant correlation with maximum temperature and minimum temperature. While negatively non-significant with rainfall and evening relative humidity while morning relative humidity was positively significant with melon fruit fly population.

The population of whitefly in relation to maximum temperature was positively significant. While positively non-significant with minimum temperature and morning relative humidity whereas rainfall was found negatively non-significant. Evening relative humidity was negatively significant correlation during *Summer* 2021. While during *Kharif* 2021 it showed positively non-significant correlation with maximum temperature and minimum temperature while negatively non-significant with rainfall, morning relative humidity and evening relative humidity. It was positively non-significant the other parameters like minimum temperature, rainfall, morning relative humidity and evening relative humidity were found negatively non-significant during *Rabi* 2021.

During *Summer* 2021 maximum temperature was positively highly significant. Minimum temperature was positively non-significant. Rainfall and morning relative humidity was found negatively non-significant while evening relative humidity was negatively highly significant correlation with thrips population. It showed positively non-significant correlation with maximum temperature and minimum temperature while negatively non-significant with rainfall and morning relative humidity whereas evening relative humidity was found negatively significant during *Kharif* 2021. The population of thrips was found positive, highly significant correlation with maximum temperature and morning relative humidity. Rainfall and evening relative humidity was showed that positively non-significant correlation while minimum temperature found negatively non-significant with thrips population during *Rabi* 2021.

During *Summer* 2021 the incidence of red pumpkin beetle in relation to maximum temperature, morning relative humidity and evening relative humidity were found positively non-significant. The other parameters like minimum temperature and rainfall found positively significant. It showed non-significant positive response with maximum temperature and minimum temperature while non-significant negative response with rainfall morning relative humidity and evening relative humidity during *Kharif* 2021. The red pumpkin beetle population showed negative, highly significant correlation with maximum temperature and positive, highly significant correlation with morning relative humidity while minimum temperature and rainfall was showed negatively non-significant correlation whereas evening relative humidity was positively non-significant correlation during *Rabi* 2021.

During *Summer* 2021 the population of lady bird beetle in relation to maximum temperature was positive and highly significant. The minimum temperature and rainfall were positively non-significant whereas morning and evening relative humidity found negatively non-significant. The population of lady bird beetle showed highly positive and significant response with maximum temperature. Evening relative humidity was found negative and highly significant. The rainfall and morning relative humidity was negatively non-significant whereas minimum temperature exhibited positively non-significant correlation during *Kharif* 2021. The lady bird beetle population showed negatively non-significant correlation with maximum temperature, minimum temperature and evening relative humidity. While rainfall and morning relative humidity was found positively non-significant correlation during *Rabi* 2021.

During *Summer* 2021 the population of spiders in relation to maximum temperature and minimum temperature was positively significant whereas rainfall was positively non-significant. Morning relative humidity was negatively significant and evening relative humidity showed negatively non-significant response. The population of spiders showed negatively non-significant correlation with maximum temperature and morning relative humidity whereas minimum temperature, rainfall and evening relative humidity was found negatively significant during *Kharif* 2021. The population of spiders was found negatively significant correlation with maximum temperature and minimum temperature. While rainfall and evening relative humidity whereas morning relative humidity was positively significant.

The multiple regression studies on major insect pests and weather parameters revealed that the weather parameters contributed for 88.00, 96.00, 84.00 and 88.00 per cent of total variation in the population of melon fruit fly, whitefly, thrips and red pumpkin beetle in cucumber, respectively during *Summer* 2021. During *Kharif* 2021 weather parameters contributed for 25.00, 45.00, 37.00 and 43.00 per cent of total variation in the population of melon fruit fly, whitefly, thrips and red pumpkin beetle in cucumber. Whereas during *Rabi* 2021 weather parameters contributed for 93.00, 40.00, 81.00 and 85.00 per cent of total variation in the population of melon fruit fly, whitefly, thrips and red pumpkin beetle in cucumber, respectively.

5.1.2 Host preference and biology of melon fruit fly on different hosts

5.1.2.1 Host preference of melon fruit fly on different hosts under field condition

The pooled data of two years showed that sponge gourd was the least preferred host and bitter gourd was the highly preferred host followed by pumpkin for melon fruit fly.

5.1.2.2 Host preference of melon fruit fly on different hosts under laboratory condition

5.1.2.2.1 Host preference of melon fruit fly on different cucurbitaceous hosts in choise test

The cumulative results of choise test experiments clearly proved that bitter gourd was most preferred host.

5.1.2.2.2 Host preference of melon fruit fly on different cucurbitaceous hosts in non-choise test

The overall results of non-choise experiments clearly indicated that the bitter gourd was the most preferred host and the sponge gourd was least preferred of melon fruit fly from all the cucurbitaceous hosts.

5.1.2.3 Biology of melon fruit fly on different hosts

5.1.2.3.1 Biology of melon fruit fly on different cucurbitaceous hosts

The lowest incubation period of melon fruit fly, *B. cucurbitae* were recorded 1.20 ± 0.45 days and 1.20 ± 0.45 days on cucumber and pumpkin whereas highest incubation period was recorded on bottle gourd *i.e.* 1.80 ± 0.45 days. Significantly shortest mean maggot duration of was observed on bitter gourd (7.00 ± 0.71 days) while melon fruit fly completed its maggot period 8.80 ± 0.84 and 8.90 ± 0.74 days on sponge gourd and bottle gourd which was observed to be longest days among the different hosts. The lowest mean pupal period was observed on cucumber (7.40 ± 0.55 days) as compared to other hosts. Significantly highest growth index was observed in the case of maggot reared on cucumber (2.36) over hosts. The females had a pre-oviposition period of 7 to 13 days. The oviposition period ranged from 1-3 days. Female lived longer time than the male when reared on all the eight cucurbitaceous hosts. The female longevity varied from 12 to 20 days. The fecundity of females ranged from 62 to 90 eggs with the mean of 74.60 ± 3.36 to 87.80 ± 1.92 eggs per 5 females. The highest numbers of eggs were laid by female fruit fly reared on cucumber 87.80 ± 1.92 (85-90 eggs). Whereas, lowest numbers of eggs were laid on bottle gourd *i.e*. 74.60 ± 3.36 (70-79 eggs). The egg hatching percentage on different hosts ranged from 62 to 88 per cent. The maximum egg hatching percentage of 80 to 88, (83.80 ± 3.19 per cent) was recorded when reared on cucumber while minimum egg hatching *i.e.* 62 to 79 (68.20 ± 6.46 per cent) was recorded in muskmelon. The highest (male: female) ratio was observed (1:1.31) in cucumber. Male fruit fly lived for 23-32 days with a mean of 25.80 ± 2.28 to 30.20 ± 1.48. Total life period of female fruit fly was slightly longer ranging from 25-34 days with the mean of 27.80 ± 1.92 to 31.00 ± 2.00 days. The longest life cycle of male fruit fly was observed on sponge gourd (30.20 ± 1.48 days) and shortest total life cycle of female fruit fly was observed on the host ridge gourd (25.00 ± 2.23 days).

5.1.2.3.2 Morphometrics parameters of different stages of melon fruit fly on different cucurbitaceous hosts

The freshly laid eggs of melon fruit fly were pure white in colour, elliptical, nearly flat on the ventral surface and slightly curved on other side. The mean length of the egg was (1.04 ± 0.03 mm) to (1.25 ± 0.03 mm) and breadth was (0.16 ± 0.03 mm) to (0.30 ± 0.44 mm). The morphometric analysis of *B. cucurbitae* eggs shown variation between hosts. Freshly laid eggs in cucumber host measured from 1.22 - 1.28 mm in length and 0.23 - 0.34 mm in breadth. The mean length and breadth of eggs were 1.25 ± 0.03 mm and 0.30 ± 0.44 mm which is slightly higher than other hosts. The length and breadth of first instar maggot on all the hosts were ranged between 1.13 to 1.94 mm and 0.17 to 0.38 mm, second instar was 3.22 to 7.45 mm and 1.00 to 1.40 mm and third instar was 8.09 to 10.56 mm and 1.40 to 2.20 mm, respectively. The average length and breadth of pre-pupa was 6.24 ± 0.15 to 6.40 ± 0.18 mm (6.13 to 25 mm) and 1.87 ± 0.08 to 1.97 ± 0.19 mm (1.87 to 1.95), respectively. The average length and breadth of pupa was 5.44 ± 0.25 to 5.73 ± 0.20 mm (5.22 to 5.88) and 2.26 ± 0.03 to 2.57 ± 0.18 mm (2.21 to 2.72), respectively. Adults were moderate in size, reddish brown with lemon yellow markings on thorax with spotted wings. Wing margin had a large apical spot which is formed by the expansion of posterior cross vein. Adult males were smaller in size than that of the females. They were easily distinguished from female adults by the absence of ovipositor and presence of blunt abdomen. The average length and breadth of adult male fly on different cucurbitaceous host were measured in the range of 8.37 ± 0.27 to 8.56 ± 0.29 mm (8.02 to 8.72) and 10.54 ± 0.45 to 12.15 ± 0.64 mm (10.4 to 12.80), respectively. The highest mean length and breadth of male fruit fly was registered in host cucumber 8.56 ± 0.29 and 12.15 ± 0.64 mm whereas the lowest values of adult male fly was measured on sponge gourd *i.e*., 8.37 ± 0.27 and 10.54 ± 0.45 mm. Length and breadth of the adult female were found to vary from 9.50 ± 0.34 to 9.97 ± 0.29 mm (9.18 to 10.18) and 15.46 ± 1.00 to 15.84 ± 0.95 mm (14.20 to 16.85).

5.1.3 Influence of different intercrops on incidence of major insect pests of cucumber

The field experiment was conducted during *Summer* 2021 and 2022 to find out better intercrops treatment for managing the population of major insect pests of cucumber and also build-up the natural enemies and lower down the load of insect pests of cucumber.

5.1.3.1 Influence of different intercrops on incidence of major insect pests of cucumber

5.1.3.1.1 Melon fruit fly, *Bactrocera cucurbitae* (Coquillett)

The pooled means of two years indicated that all the treatments were superior over control in lowering the pest incidence. Lowest per cent fruit infestation was recorded in treatment cucumber intercropped with spinach followed by intercropping with chukka, safflower, fenugreek and lettuce, respectively.

5.1.3.1.2 Whitefly, *Bemisia tabaci* (Gennadius)

The analysis of pooled means indicated that all the treatments were superior over control. Lowest infestation was recorded when spinach was used as intercrop followed by chukka and lettuce.

5.1.3.1.3 Thrips, *Thrips palmi* (Karny)

The pooled means of two seasons indicated that all the treatments were significantly superior in minimizing thrips population over untreated control (Table 36 The treatment cucumber + spinach showed best results followed by cucumber intercropped with lettuce, coriander, chukka and fenugreek, respectively. Maximum infestation was found in sole cucumber.

5.1.3.2 Influence of different intercrops on abundance of natural enemies of cucumber

5.1.3.2.1 Lady bird beetle

The pooled means showed that the treatment cucumber + spinach was the most superior treatment showing maximum count of predators followed by chukka, lettuce, safflower, coriander and fenugreek. Whereas, minimum predator count was recorded in sole cucumber.

5.1.3.2.2 Predatory spider

The analysis pooled data showed that all the intercrops recorded more numbers of spiders as compared to sole cucumber. The highest count was observed in spinach intercropped with cucumber followed by chukka, safflower and fenugreek, respectively.

5.1.3.3 Effect of different intercrops on marketable fruit yield of cucumber

Pooled results revealed that the treatment cucumber + chukka was produced significantly highest yield as compare to sole cucumber. Rest of the treatments were recorded higher yield when cucumber intercropped with spinach, safflower, fenugreek, lettuce, coriander and dill. Per cent increase in fruit yield over sole cucumber was found to be higher in all the treatments.

5.1.4 Bioefficacy of different combination insecticides against major insect pests of cucumber

Seven insecticides *viz*., emanectin benzoate 1.5% + fipronil 3.5% SC, novaluron 5.25% + emamectin benzoate 0.9% SC, indoxacarb 14.5% + acetamiprid 7.7% SC, novaluron 5.25% + indoxacarb 14.5%, pyriproxifen 5% EC + fenpropatrin 15% EC, thiamethoxam12.6% + lambda-cyhalothrin 9.5% ZC, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC were evaluated for their bioefficacy against major insect pests and its effect on natural enemies on cucumber during *Summer* 2021 and 2022.

5.1.4.1 Bioefficacy of different combination insecticides against major insect pests of cucumber

5.1.4.1.1 Melon fruit fly, *Bactrocera cucurbitae* (Coquillett) (number basis)

Pooled data of two seasons showed that chlorantraniliprole 8.8% + thiamethoxam 17.5% SC treated plot showed minimum incidence followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC and novaluron 5.25% + indoxacarb 14.5% SC (25.26% and 29.14) were statistically at par with each other and significantly superior over other test insecticides. The highest per cent fruit infestation was recorded in untreated control plot.

5.1.4.1.2 Melon fruit fly, *Bactrocera cucurbitae* (Coquillett) (weight basis)

The pooled mean of two season indicated that chlorantraniliprole 8.8% + thiamethoxam 17.5% SC was recorded least per cent infested fruit which was statistically at par with thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC and novaluron 5.25% + indoxacarb 14.5% SC. Highest mean per cent infested fruits was found in untreated control.

5.1.4.1.3 Whitefly, *Bemisia tabaci* (Gennadius)

Pooled data on incidence of whitefly of two seasons revealed that significantly minimum population of whitefly was recorded from the plots treated with pyriproxyfen 5% + fenpropatrin 15% EC followed by thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC and chlorantraniliprole 8.8% + thiamethoxam 17.5% SC.

5.1.4.1.4 Thrips, *Thrips* (palmi Karny)

The pooled data showed that thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC proved to be most promising insecticide for managing thrips population which was statistically at par with the indoxacarb 14.5% + acetamiprid 7.7% SC.

5.1.4.2 Effect of different combination insecticides on population of natural enemies

5.1.4.2.1 Effect of different combination insecticides on population of lady bird beetle

The pooled data of two years indicated that novaluron 5.25% + emamectin benzoate 0.9% SC proved to be safer insecticide and thiamethoxam12.6% + lambda-cyhalothrin 9.5% ZC (0.33 to 0.78) was most harmful insecticide for lady bird beetle.

5.1.4.2.1 Effect of different combination insecticides on population of predatory spider

The pooled data showed that maximum count of spiders was recorded in plots treated with chlorantraniliprole 8.8% + thiamethoxam 17.5% SC. The treatment thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC was most harmful treatment recorded lowest number of spiders. The highest population of spiders was recorded in untreated control plots.

5.1.4.3 Effect of different combination insecticides on marketable fruit yield of cucumber

The two years pooled data showed that highest fruit yield of cucumber was obtained in chlorantraniliprole 8.8% + thiamethoxam 17.5% SC treated plots over the untreated control.

5.1.4.4 Incremental cost benefit ratio for different combination insecticides in cucumber

The two years pooled data showed that highest incremental cost benefit ratio was attained by treatment indoxacarb 14.5% + acetamiprid 7.7% SC which was followed by novaluron 5.25% +indoxacarb 14.5%, chlorantraniliprole 8.8% + thiamethoxam 17.5% SC, thiamethoxam12.6% + lambda-cyhalothrin 9.5% ZC, emanectin benzoate 1.5% + fipronil 3.5% SC, (1:23.34), pyriproxifen 5% EC + fenpropatrin 15% EC and novaluron 5.25% + emamectin benzoate 0.9% SC.

5.2 Conclusions

On the basis of result and discussion of present investigations the following recommendations/conclusions can be withdrawn.

1. Melon fruit fly, whitefly, thrips, red pumpkin beetle were found to be major insect pest of cucumber and their incidence recorded throughout the season. Maximum incidence of fruit fly noticed at fruiting stage and maximum incidence of sucking pest observed at vegetative stage of crop. *Summer* season was more congenial to pest population than *Kharif* and *Rabi* season.
2. Maximum population of natural enemies *viz*., lady bird beetle and predatory spider was also observed throughout the cropping period when there was more incidence of sucking pests.
3. Simple correlation and regression studies revealed that there was significant effect of weather parameters on incidence of major insect pests of cucumber and their natural enemies.
4. Sponge gourd was the least preferred host and bitter gourd was the most highly preferred host of melon fruit fly under field condition.
5. Bitter gourd was the most highly preferred host of melon fruit fly under laboratory condition in both choice non choice test.
6. Melon fruit fly is a serious pest of cucumber but the present investigation strongly concludes that biology of this pest completed on all the different cucurbitaceous hosts under laboratory condition without showing any adverse effect.
7. All the intercrops treatments proved effective in minimizing population of major insect pests of cucumber over sole cucumber. The treatment cucumber + spinach

was most effective for managing melon fruit fly, whitefly and thrips. This intercrop treatment can be advocated to the farmers.

8. The maximum count of natural enemies *viz*., lady bird beetles and predatory spider was observed in treatment cucumber + spinach.
9. The treatment cucumber + chukka was produced significantly highest yield as compared to sole cucumber.
10. Considering damage caused by major insect pests of cucumber *viz*., melon fruit fly, whitefly and thrips responsible for loss in economic yield of crop. Spraying of combination molecules *viz*., chlorantraniliprole 8.8% + thiamethoxam 17.5% SC, thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC and novaluron 5.25% + indoxacarb 14.5% SC for melon fruit fly (on both number and weight basis), pyriproxyfen 5% + fenpropatrin 15% EC thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC and chlorantraniliprole 8.8% + thiamethoxam 17.5% SC for whitefly and thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC indoxacarb 14.5% + acetamiprid 7.7% SC for thrips management can be advocated.
11. The treatment novaluron 5.25% + emamectin benzoate 0.9% SC and chlorantraniliprole 8.8% + thiamethoxam 17.5% SC proved to be safer insecticide for lady bird beetle and predatory spider. The treatment thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC was higly toxic to natural enemies.
12. The highest fruit yield of cucumber was obtained in chlorantraniliprole 8.8% + thiamethoxam 17.5% SC over untreated control. Thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC was next better treatment recorded higher fruit yield of cucumber.
13. The treatment indoxacarb 14.5% + acetamiprid 7.7% SC was most economical by recording maximum net monetary returns and highest incremental cost benefit ratio.

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APPENDIX

APPENDIX - I

Weekly weather data during *Summer* 2021

SMW	Rainfall (mm)	Temperature (^0C)		Humidity (%)	
		Maximum	Minimum	AM	PM
5	0.00	30.40	12.90	78.00	29.00
6	0.00	30.10	11.20	66.00	18.00
7	1.80	32.70	14.20	76.00	24.00
8	14.50	29.50	13.00	93.00	40.00
9	0.00	36.10	15.50	97.00	14.00
10	0.00	36.50	16.60	61.00	14.00
11	0.00	36.60	16.80	60.00	21.00
12	14.30	34.90	20.10	74.00	28.00
13	0.00	38.90	15.90	56.00	11.00
14	0.00	39.90	19.10	48.00	11.00
15	2.00	36.20	20.40	63.00	25.00

APPENDIX - II

Weekly weather data during *Kharif* 2021

SMW	Rainfall (mm)	Temperature (^{0}C)		Humidity (%)	
		Maximum	Minimum	AM	PM
29	126.70	30.10	22.57	92.00	73.29
30	9.90	30.50	21.36	88.86	65.14
31	1.40	30.90	21.63	84.43	62.57
32	2.30	33.07	22.53	84.43	52.43
33	48.50	29.43	22.24	89.14	70.00
34	5.90	30.64	22.36	91.71	63.57
35	48.80	29.96	22.70	77.71	59.00
36	233.10	28.16	21.84	93.57	77.71
37	44.40	30.94	21.96	90.14	69.43
38	48.60	30.87	22.30	104.57	71.43
39	133.90	28.93	21.80	94.29	74.86

APPENDIX - III

Weekly weather data during *Rabi* 2021

SMW	Rainfall (mm)	Temperature (^{0}C)		Humidity (%)	
		Maximum	Minimum	AM	PM
44	0.00	31.10	15.70	79.00	36.00
45	0.00	31.00	14.30	85.00	29.00
46	0.00	30.70	20.60	81.00	54.00
47	1.20	31.70	21.70	88.00	49.00
48	0.00	29.40	15.30	89.00	39.00
49	4.20	27.80	16.90	87.00	45.00
50	0.00	29.20	13.20	88.00	35.00
51	0.00	27.70	9.40	91.00	30.00
52	0.00	28.90	13.60	88.00	44.00
1	0.00	28.00	13.00	89.00	39.00
2	0.20	27.10	15.90	87.00	55.00

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