

**Survey of Major Phytophagous mites, its associated  
natural enemies and their management through Acaricides  
on Brinjal Crop during Summer Season**

**By**

**IROM SANJUKTA**



**MASTER OF SCIENCE IN AGRICULTURE  
(ENTOMOLOGY)**

**DEPARTMENT OF ENTOMOLOGY**

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**DR RAJENDRA PRASAD CENTRAL AGRICULTURAL UNIVERSITY  
PUSA, SAMASTIPUR, BIHAR – 848125**

**2023**

**Registration No.Ento./069/2020-21**

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natural enemies and their management through Acaricides  
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**A THESIS SUBMITTED TO THE  
DR RAJENDRA PRASAD CENTRAL  
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IN PARTIAL FULFILLMENT OF THE  
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OF**

**MASTER OF SCIENCE IN AGRICULTURE  
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This is to certify that the work record in this thesis entitled "Survey of Major Phytophagous mites, its associated natural enemies and their management through Acaricides on Brinjal Crop during Summer Season" submitted in partial fulfillment of the requirement for the award of the degree of MASTER OF SCIENCE IN AGRICULTURAL (ENTOMOLOGY) of the faculty of Post-Graduate College of Agriculture, Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur) Bihar is a faithful record of bonafide research work carried out by Miss. Irom Sanjukta, Reg. No. Ento./069/2020-21 under my supervision and guidance.

The findings of the investigation reported in this thesis has no so far been submitted for any other degree or diploma. The assistance and help received during the investigation and resource of literature have been duly acknowledged.

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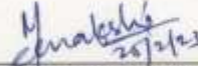
  
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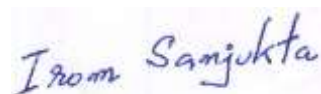
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**Irom Sanjukta**



Phytophagous mites

207

# Survey of Major Phytophagous mites, its associated natural enemies and their management through Acaricides on Brinjal Crop during Summer Season

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### **ABSTRACT**

The research entitled “Survey of Major Phytophagous mites, its associated natural enemies and their management through Acaricides on Brinjal Crop (*Solanum melongena* L.) during Summer Season” were conducted at Birauli Farm, KVK, Samastipur during summer season, 2022.

During the course of study, two species of tetranychid mites, two species of predatory mites and six natural enemies were recorded viz., *Tetranychus urticae*, *T. neocaeledonicus*, *Amblyseius indicus*, *A. tetranychivorous*, *Chrysoperla carnea*, Coccinellids, Anthocorid bugs, Mirid bugs, Scolothrips and Black ants. During the course of survey under Samastipur District, a maximum of 26.21 tetranychid mites per leaf (2.5cm<sup>2</sup> leaf area) was observed in Harpur village while the highest number of natural enemies was recorded in Chadauli village (5 types of natural enemies/visit). In the district of Muzaffarpur, the tetranychid mite's occurrence trend, viz., Ittha>Mirapur>Lautan>Muraul. In terms of natural enemies, Muraul village had the highest number of natural enemies (6 types per visit).

In the seasonal incidence studies, *T. urticae* population started recording during the 1<sup>st</sup> fortnight of January and was noticed up to the 2<sup>nd</sup> fortnight of June. The highest *T. urticae* population was recorded throughout the first fortnight of June (35.15 mites /2.5cm<sup>2</sup> leaf area) while the least number of population was observed in the 1<sup>st</sup> fortnight of February (05.26 mites / 2.5cm<sup>2</sup> leaf area). The data pertaining to the relationship between the *T. urticae* population and weather parameters indicated that maximum and minimum temperature had positive and significant effects on the mite

population ( $r=0.783^*$  and  $r=0.744^{**}$ ). However, the relationship of mites with morning relative humidity was significant and negative ( $r= -0.834^{**}$ ). The predatory mite, *A. indicus* population was first noted in the 1<sup>st</sup> fortnight of January and was observed until the 2<sup>nd</sup> fortnight of June.

The maximum *A. indicus* population was recorded during the 1<sup>st</sup> fortnight of June (12.23 mites /2.5 cm<sup>2</sup> leaf area) while the lowest population (00.75 mites /2.5cm<sup>2</sup> leaf area) was found in the 1<sup>st</sup> fortnight of February. The maximum and minimum temperature had positive and significant effects on the *A. indicus* population ( $r=0.733^{**}$  and  $r= 0.715^{**}$ ). However, the relationship of *A. indicus* with morning relative humidity was significant and negative ( $r= -0.775^{**}$ ). The coccinellid population started recording during the 1<sup>st</sup> fortnight of January and was noticed up to the 2<sup>nd</sup> fortnight of June. The highest coccinellid population (12.09 coccinellids / 5 plants) was observed during the 2<sup>nd</sup> fortnight of April, while the lowest coccinellid population (01.75 coccinellids / 5 plants) was observed during the 2<sup>nd</sup> fortnight of January. The maximum temperature had a positive and significant effects ( $r=0.694^*$ ) while minimum temperature had positive and non-significant effect ( $r=0.486^{NS}$ ) on the coccinellid population. However, the relationship of coccinellids with morning and evening relative humidity was significant and negative ( $r= -0.638^*$  and  $r=-0.790^*$ ). Population of green lace wings were first noted in the 2<sup>nd</sup> fortnight of January and was observed until the 2<sup>nd</sup> fortnight of June. The maximum green lacewing population (07.55 green lacewing /5 plants) was recorded during the 2<sup>nd</sup> fortnight of April and the population of green lacewing reached its lowest point (01.02 green lacewing/5 plants) on the 2<sup>nd</sup> fortnight of January. The maximum temperature had positive and significant effects on the green lace wing population ( $r=0.670^*$ ). However, the relationship of mites with evening relative humidity was significant and negative ( $r=-0.535^*$ ).

Data pertaining to the acaricides efficacy of different treatments on the mean population of mites , the treatment Spiromesifen 240%EC was found most effective than the rest of the treatments which was at par with Chlofenapyr 10% SC followed by Abamectin 1.9% EC >Propargite 57% EC > Fenpyroximate 5% EC. On the other hand, the highest number of active mites was present in Azadirachtin treated plots in both the sprays.



## CONTENTS

<b>CHAPTER</b>	<b>PARTICULARS</b>	<b>PAGE NO.</b>
<b>I.</b>	<b>INTRODUCTION</b>	1-3
<b>II.</b>	<b>REVIEW OF LITERATURE</b>	4-19
<b>III.</b>	<b>MATERIALS AND METHODS</b>	20-29
<b>IV.</b>	<b>RESULTS AND DISCUSSION</b>	30-64
<b>V.</b>	<b>SUMMARY AND CONCLUSION</b>	65-71
	<b>BIBLIOGRAPHY</b>	i-x
	<b>APPENDIX</b>	I



## LIST OF TABLES

TABLE NO.	PARTICULARS	PAGE NO.
1	Details of survey work and the sample collected from different locations	21
2	Details of farmers brinjal field from where sample were collected.	22
3	Details of Acaricides for Efficacy Study against Phytophagous Mites on Brinjal	24
4	Survey on phytophagous mites and their natural enemies in the districts of Muzaffarpur and Samastipur during 2022	32
5	Seasonal incidence of <i>T. urticae</i> on brinjal during the crop period, 2022	35
6	Seasonal incidence of predatory mite, <i>Amblyseius indicus</i> on brinjal crop during crop period 2022	39
7	Seasonal incidence of coccinellids on brinjal during the crop period, 2022.	42
8	Seasonal incidence of green lace wing on brinjal during the crop period, 2022.	45
9	Correlation coefficients of phytophagous mite and natural enemies with weather parameters on brinjal crop during crop period 2022.	48
10	Regression equation of phytophagous mite and natural enemies with weather parameters on brinjal crop during crop period 2022.	49
11	Field efficacy of different acaricides against phytophagous mites on brinjal (First spray).	53
12	Field efficacy of different acaricides against phytophagous mites on brinjal (2 <sup>nd</sup> spray)	56
13	Effect of different acaricides against brinjal mite, <i>T. urticae</i> after two sprays	59
14	Effect of different acaricides on brinjal fruit yield during crop period 2022.	62
15	Economics of different treatments evaluated for efficacy against Brinjal tetranychid mites, <i>Tetranychus urticae</i> during 2022	63



## LIST OF FIGURES

FIG. NO.	PARTICULARS	PAGE NO.
1	Layout plan of experimental trial for acaricides application on brinjal crop	25
2	Map showing localities where survey of phytophagous mites of brinjal was undertaken	28
3	Weather parameters trend during the experimental period, 2022.	29
4	Influence of weather parameters with phytophagous mites, <i>Tetranychus urticae</i> on brinjal crop during the crop period , 2022.	36
5	Influence of weather parameters with predatory/phytoseiid mite, <i>Amblyseius indicus</i> on brinjal crop during the crop period , 2022.	40
6	Influence of weather parameters with coccinellids on brinjal crop during the crop period , 2022	43
7	Influence of weather parameters with green lacewing on brinjal crop during the crop period , 2022	46
8	Fig. 8: Effect of natural enemies ( predatory insects and predatory mite) with phytophagous mite on brinjal crop	47
9	Correlation coefficients of phytophagous mite and natural enemies with weather parameters on brinjal crop during crop period 2022.	50
10	Field efficacy of different acaricides against phytophagous mites on brinjal crop (First spray)	54
11	Field efficacy of different acaricides against phytophagous mites on brinjal crop (2 <sup>nd</sup> spray)	57
12	Effect of different acaricides against brinjal mite, <i>T. urticae</i> after two sprays	61
13	Benefit cost ratio against different acaricides on brinjal crop	64



## LIST OF PLATES

PLATE NO.	PARTICULARS	AFTER PAGE NO.
1	Survey on phytophagous mites and their natural enemies	28
2	Nursery bed of brinjal	28
3	Overview of experimental plot	28
4	Taking observations during research work	28
5	Brinjal leaves affected by mites	28
6	The Vegetable Mite <i>Tetranychus neocaledonicus</i>	28
7	Red Spider Mite, <i>Tetranychus urticae</i>	28
8	Predatory mite, <i>Amblyseius indicus</i>	28
9	Microscopic view of <i>Amblyseius indicus</i>	28
10	Predatory mite, <i>Amblyseius tetranychivorous</i>	28
11	Natural enemies on brinjal	28



## ABBREVIATIONS

%	: per cent
@	: at the rate of
<	: less than
>	: More than
a.i.	: active ingredient
C.V.	: Coefficient of variance
CD	: Critical difference
cm	: Centimetre
DAS	: Day after spray
EC	: Emulsifiable concentrate
et al.	: ( <i>et alii</i> ) other people
Fig.	: Figure
g	: Gram
ha	: Hectare
hrs	: Hours
i.e.	: that is
Kg	: Kilogram
Km h <sup>-1</sup>	: Kilometre per hour
L	: Litre
m	: Meter
Max.	: Maximum
mg	: Milligram
Min.	: Minimum
ml	: Millilitre
°C	: Degree Celsius
t	: ton
RBD	: Randomized Block Design
RH	: Relative Humidity
Rs	: Rupees
S. Em.	: Standard error of mean
SC	: Suspension concentrate
SL	: Soluble liquid
FN	: Fornight
Temp	: Temperature
Viz.	: Namely
NS	: Non- significant





# **CHAPTER - I**



## **INTRODUCTION**



## INTRODUCTION

---

Brinjal (*Solanum melongena* L.), a member of the Solanaceae family and a purported native of India. Egg plant and aubergine are the other names for brinjal. It is among the most well-liked and commonly cultivated vegetable crops in both India and the rest of the world. By sharing 26% of global production, India is the second-largest producer of brinjal after China. It is a warm-season crop that needs a long, warm growth season because it is highly frost-sensitive. The ideal pH range for this crop's cultivation is 5.5 to 6.6, and the best temperature range for its successful production is 13 to 21°C. Due to its popularity among small-scale farmers and low-income consumers, it is also known as the "poor man's vegetable." After the potato, tomato, pepper, and tobacco, brinjal is the fifth most significant solanaceous crop in terms of economic importance. West Bengal, Odisha, Gujarat, Bihar, Madhya Pradesh, Chattisgarh, Karnataka, Maharashtra, Andhra Pradesh, and Haryana are the primary brinjal-producing states in India. Brinjal fruits are frequently used in meals such as sliced bhaji, packed curry, bertha, chutney, vangibath, and pickles. It has a high nutritional value because it is rich in minerals including calcium, magnesium, potassium, iron, phosphorus, and fatty acids as well as vitamins A, B, and C. Brinjal has a relatively low calorie count and is regarded as the healthiest vegetable due to its high concentration of nutrients, including vitamins, minerals, and bioactive substances that are beneficial to human health (Raigon *et al.*, 2008; Docimo *et al.*, 2016).

In addition to being used as a fresh vegetable, it is known to have health advantages in the management of diabetes and liver issues. The fruit brinjal is an excellent cholesterol-lowering food. In addition, brinjal contains significant amounts of phenolics and ascorbic acid, both of which are strong antioxidants. Additionally, brinjal is an excellent source of dietary fibre, which lowers the risk of coronary heart disease (Wagner, 2006). Brinjal, commonly known as eggplant, is an economically significant vegetable that grows over an area of 753 thousand hectares in India. Its productivity is 17.29 MT/ha, and its estimated annual production is 13,023 thousand MT (Ministry of Agriculture and Family Welfare, (2021-2022)). It is grown in Bihar on an area of 58.2 thousand hectares, producing 1241.7 MT year at a productivity of 21.3 MT/ha (Directorate of Horticulture, Bihar, 2018).

Even though brinjal is farmed all year round, several insect and non-insect pests attack it from the nursery stage to the fruiting stage, which lowers output and degrades the quality of brinjal fruits. Shoot and fruit borer, leaf roller, stem borer, blister beetle, spotted beetles, and other pests have been cited as the major pest of brinjal. The most infamous non-insect pests are arguably mites, which have become incredibly important in recent years due to their destructive nature. In particular, the two spotted spider mite, *Tetranychus urticae* (Koch) is the most famous one that, along with the shoot and fruit borer, is accountable for major yield losses in brinjal crops (Basu and Pramanik, 1968). Two major concepts regarding mite epidemics in recent decades were put forth by Huffaker *et al.*, in 1969, one widespread increase in mites brought on by the stimulatory effects of herbicides and fertilizers, which encourage greater plant growth and better sustenance for mites. Mites now have greater capacity for reproduction as a result of this. Another one is negative impact of pesticides on natural enemies of mite.

Damage from spider mites reduces vegetable output by 10% to 15%. (Anon., 1991). There are 37 different types of mites that eat plants. *Tetranychus cinnabarinus* (Boisduval) (=urticae Koch), *T. neocaledonicus* Andre, *T. ludeni* Zacher, and *T. macfarlanei* Baker and Pritchard are among the prominent tetranychids that attack the brinjal among these (Gupta, 1991).

More than 1270 spider mite species are classified into 95 genera and two subfamilies, Tetranychinae and Bryobinae, which make up the family Tetranychidae (Zeity, 2015). Members of this family are soft-bodied, brightly coloured, and range in size from 0.20 to 0.90 mm (red, green, yellow and orange). Mites are sometimes known as spider mites because member species of the Tetranychinae subfamily create silk from glands that open on the tarsus of pedipalps.

Tetranychids are classified into subfamilies, tribes, and genera mostly based on the females' empodial feature. Taxonomically significant characteristics include the shape of the male aedeagus, the chaetotaxy of the legs, the shape of the peritreme, and the shape of the structure(s) on the palpal tarsus which is used for spinning web (Zeity, 2015).

Few species like *Tetranychus urticae* Koch, *T. neocaledonicus* Andre, *T. pacificus* (McGregor), *T. kanzawai* (Kishida), *T. macfarlanei* (Baker), *T. Ludeni*

(Zacher), *Oligonychus punicae* (Hirst), *O. coffeae* (Nietner) and *Eutetranychus orientalis* (Kelin) are considered as major pests across crops (vegetable, fruits, flowers and weed plants) as well as geographical locations, among these, two spotted spider mite, *T. urticae* has a worldwide distribution. This species, which is the most common, may be of complex due to its distinct population and range of biological characteristics. Since 1758, "Spider Mites Web" has provided comprehensive, up-to-date information on every reported species under the Tetranychidae mite family, including taxonomy, distribution, host plants, and reference material (Migeon *et al.*, 2010).

According to numerous reports, mites typically produces tiny white specks that gradually dry and fall off by sucking the sap from the bottom of the leaves. Plant development, flowering, and fruiting are negatively impacted by the diminished vigour and leaf loss. Tetranychid mites can produce a thick sheath of webbing that covers the entire plant during a severe infection (Grandjean, 1948 and Jeppson *et al.*, 1975). In windy conditions, these webs fill with soil particles and stop the plant from photosynthesizing. Thus, it has been established that the mite is an indirect pest that reduces the yield's quality and quantity (Butani and Mittal, 1992).

For better management of these destructive spider mites, knowledge on their seasonal population fluctuation, natural enemy complex, information on effective acaricides are pre-requisite. Further, to develop economically feasible management strategy and to reduce unwarranted pesticide load in the environment, knowledge on safer pesticides is also very much essential.

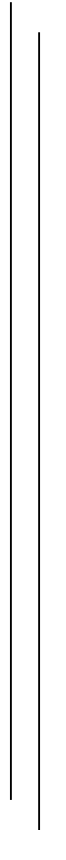
Keeping in view the above information the present investigation has been planned with the following objectives:

1. Survey of major phytophagous mites and its natural enemies on brinjal in Samastipur and Muzaffarpur district.
2. Seasonal incidence of major phytophagous and natural enemies on Brinjal crop.
3. Field efficacy of acaricides against phytophagous mites on Brinjal crop.

❧❧❧



## **CHAPTER - II**



## **REVIEW OF LITERATURE**



## REVIEW OF LITERATURE

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Literature on various particulars of the present investigation is conducted and reviewed as,

### **2.1 Survey of Major Phytophagous mites and its natural enemies on Brinjal in Samastipur and Muzaffarpur district**

According to Bellotti *et al.*, (1987), more than 40 species of predatory mites belonging to the family Phytoseiidae were found in Columbia which feed on cassava green mites, *Mononychellus tanajoa*. The most common species among them were *Typhlodromalus limonicus* and *Neoseiulus anonymus*.

Bayan *et al.*, (1988) conducted a survey of mites on plum trees in Lebanon between 1984 and 1986 and found 18 species and 8 undetermined mites from 11 families. It contained one species from each of the families Tarsonemidae, Stigmaeidae, and Neophyllobiidae, as well as four tetranychids, four tetrapodilids, three tenuipalpids, four tydeids, five phytoseiids, and two chiggers. The broad-haired apple flat mite, *Typhlodromus erevanicus*, bug-beaked plum mite, plum vagrant leaf mite, and plum silver rust mite were all discovered for the first time in Lebanon.

Loganathan *et al.*, (2000) conducted a survey of phytophagous mites in *Areca catechu* in Coimbatore, Tamil Nadu and discovered three species of mites viz., *Dolicho tetranychus*, *Raoiella indica*, and *Oligonychus indicus*.

El-Banhawy *et al.*, (2002) discovered 13 species, including a new species in the various geographical regions of Lesotho. They also stated that *Amblyseius addoensis* was frequently found in lowlands and *Amblyseius sehlabatein*.sp. was typically found in foothills and highlands.

Thakur *et al.*, (2010) conducted research during the year 1999 to 2001 on the host range and distribution of mite species linked with fruit crops in several districts of Himachal Pradesh. He discovered that *T. urticae* predominated on apple crops in Kullu district while *Panonychus ulmi* was the main phytophagous species on apple crops in Shimla district. *Amblyseius finlandicus*, a voracious mite that feeds on apple, pecan nut, and walnut, was widely distributed in the Shimla district together with *P. ulmi*, *B. californicus*, *A. malus*, and, *Brevipalpus phoenicis*-infested guava and citrus in the Una district were abundant with *Phytoseius crinitus*. *Amblyseius longispinosus* was a

common pest in the Solan district, and it only accepted Tetranychus species from fig, papaya, apple, and bean plants as hosts.

Hassan *et al.*, (2013) recorded 26 species of mites while conducting a survey in three places at Ismailia during the year 2010 and 2011. He stated that 12 of these species are from the Gamasida order and 14 are from the Actinedida order. *Neoseiulus enab* and *Phytoseiulus persimilis* were the most prevalent predatory mites. The majorities of mite is phytophagous and are dominated by Tetranychidae.

Singh and Chauhan (2014) performed a survey in order to study the mite diversity in variety of vegetables and ornamental crops in mid-hills of Himachal Pradesh. The results showed that six species under two genera belonged to the two phytophagous families Tetranychidae, and Eriophyidae. *T. urticae* Koch was found on red cabbage, roses, marigolds, anturiums, carnations, cucumbers, okra, tomatoes, and beans among other members of the Tetranychidae family. Rose, anthurium, carnation, and cucumber were found to be infected with *Tetranychus ludeni* Zacher.

Sivakumar and Kunchithapatham (2014) surveyed on diversity of phytophagous mites *Oligonychus* spp. and *Tetranychus* spp. (Acari: Tetranychidae) on a variety of host plants in the Coimbatore District and found that six different Tetranychus species, five different Oligonychus species, two new species of spider mites—*Tetranychus bauhini* sp. nov. and *Oligonychus pongami* sp. nov.-from the hosts *Bauhinia* sp. and *Pongamia glabra*, respectively, as well as the first Indian reports of *Tetranychus taiwanicus* Ehara on citrus and *Oligonychus grypus* Baker on sugarcane crops.

Stojnica *et al.*, (2014) conducted research on the species complexes of leaf-inhabiting mites on apples in actively managed and abandoned apple orchards as well as on wild apple trees in Serbia, from 1981 to 2013. Nine spider mite species and a complex of 18 phytoseiid species were found. Three species of spider mite, five in abandoned apple stands, and seven in forest habitats were all discovered in commercial apple orchards.

Migeon and Dorkeld (2015) listed more than 1275 tetranychid species under 71 genera on 3938 host plant species, while 106 species are known from India under 20 genera and the two subfamilies Tetranychunae, and Bryobiinae.

Singh (2015) investigated the natural enemies of phytophagous mites in different horticultural ecosystems in Himachal Pradesh and he reported that fruit crops had the highest diversity of phytophagous and predatory mite species *i.e.*, forty eight species, as opposed to vegetable and ornamental crops, which had seventeen phytophagous and thirty one predatory mite species. Tetranychidae family members dominated by the phytophagous mite community, while Phytoseiidae family members dominated by the predatory mite community and were found in a variety of environment.

Zeity (2015) conducted an experiment and examined the Tetranychid mite fauna of the main agro-ecosystem in the Chitradurga District of Karnataka. He found two species of tetranychid mites, *T. urticae* on tomatoes and *T. macfarlanei* on brinjal and ridge gourd.

Cobanoglu and Kumral (2016) studied mite biodiversity and density on *Capsicum annuum* between 2009 and 2010 in the temperate regions (Yalova and Bursa provinces) and semi-arid (Ankara province) parts of Turkey. The only dominant species on the plants in all zones was *T. urticae* (Tetranychidae), with *Phytoseius plumifer*, *Neoseiulus californicus* (Phytoseiidae), and *Tarsonemus bifurcatus* (Tarsonemidae) also being frequent species. In the same areas, the cosmopolitan species *T. urticae* was also discovered on other solanaceous plants, including tomato and egg plant. Due to the presence and concentration of various secondary metabolites in the leaves, *C. annuum* is not as favored by *T. urticae* as many other hosts, yet this spider mite was known to exist everywhere.

Lenin and Bhaskar (2016) conducted a survey to document the diversity of mite pests and their natural enemies and recorded tetranychids such as *Tetranychus truncatus* on cucumber and amaranthus, *T. urticae*, *T. okinawanus* and *Eutetranychus orientalis* on cucumber and *T. macfarlanei* on cowpea and french bean and a tarsonemid, *Polyphagotarsonemus latus* (Bankson) cowpea, chilli, tomato, capsicum, cucumber, bitter gourd and amranthus.

Lekha *et al.*, (2019) discovered 12 species of phytophagous mites in the northern region of Kerala that belonged to 4 families, with spider mites from the family Tetranychidae emerging as the most prevalent species.

Shosa *et al.*, (2020) surveyed six pomegranate orchards in the Manphalut and Sidfa areas of Egypt associated with the mites and he reported a total of six species of both phytophagous and predatory mites. Two of these species are phytophagous mites from the Tenuipalpidae family, and four are predatory mites from the Phytoseiidae and Stigmaeidae families.

Yadav *et al.*, (2021) reported citrus mite *Eutetranychus banksi* (Trombidiformes: Tetranychidae) for the first time in the Zamania, and Ghazipur district of Uttar Pradesh, India as a new pest of neem, *Azadirachta indica*. It damaged most of the plants in the early stage especially during the cold winter season.

Kar *et al.*, (2021) discovered phytoseiid mites in Sundarban, West Bengal in the year March, 2019. He found 13 phytoseiid species, of which three were, namely *Typhlodromus gosabaensis* sp. nov., *Proprioseiopsis indicus* sp. nov., and *Euseius sajnekhhalicus* sp. nov.

According to Kar *et al.*, (2022), 250 phytoseiid mite specimens from seven new species were found in Tripura during their study. These species include *E. tripuraensis* sp. nov., *E. spontaneum* sp. nov., *E. tripurii* sp. nov., *Phytoseius birbikrami* sp. nov., *Typhlodromus sonajhuriaie* sp. nov., and *Phytoseius baramuracus* sp. nov.

## **2.2 Seasonal incidence of major phytophagous and natural enemies on Brinjal crop**

### **2.2.1 Host range and Pest Status of Phytophagous mites**

The spider mite, *T. urticae* Koch (Acarina: Prostigmata: Tetranychidae) was initially identified by Koch in 1836 (Pritchard and Baker, 1955) and is believed to have originated in temperate areas (Fasulo and Denmark, 2000). It is a widespread agricultural pest that is significant economically and feeds on a variety of host plant species (3877) all over the world. Vegetable, fruit tree, fibre crop, and ornamental plant pest status is thoroughly reported globally. Beans, brinjal, cucurbits, tomato, soybean, okra, cowpea, and cucumber are among the most sensitive plants that have been reported thus far (Bindra and Singh, 1970; Singh, 1995; Sirvi and Singh, 2014). In India, *T. urticae* was discovered to be a significant vegetable pest (Meyer, 1974; Prasad, 1974; Natarajan, 1989).

According to reports from Haryana (Meyer, 1974; Khanna, 1991; Sunita, 1996; Gulati, 2004), Kerala (Lal, 1982), Punjab (Kaur *et al.*, 2010), Tamil Nadu (Nandagopal and Gedia, 1995), Uttar Pradesh (Singh and Singh, 1993), and West Bengal, (Mukherjee and Somchoudhary, 1981; Dhar *et al.*, 2000) *T. urticae* is regarded as a pest of vegetable crops in India.

The two-spotted spider mite (*T. urticae*), which is distributed all over the world, is the most polyphagous species in the Tetranychidae family. This mite species has been observed on more than 300 hosts with some economic significance, including weeds, decorative crops, and the majority of agricultural crops (Jeppson *et al.*, 1975; Anonymous 1999; Zhang 2003). *T. urticae* has been identified in India as a significant pest of numerous vegetables, including beans, brinjal, capsicum, cucurbits, and okra (Dhooria, 2003; Bhullar and Singh, 2009).

*T. urticae* attacks brinjal in the post-rainy season (Gupta and Gupta 1985; Singh and Mukherjee 1991). Citrus, apple, pear, (Chhillar *et al.*, 2007) raspberry (Gordan *et al.*, 1990; Charles *et al.*, 1985 ; Mariethoz *et al.*, 1994; Shanks *et al.*, 1992) , cassava (Lal, 1982), strawberry (Congdon *et al.*, 1993), withania and soybean (Sharma and Pati, 2012) and geranium (Opit *et al.*, 2005) also suffer economic losses as a result of it.

### **2.2.2 Phytophagous mites biology**

Depending on changes in the following factors: temperature, host plant species, host plant nutrition, cultivar, phenological stage, pesticide exposure, relative humidity, etc., *T. urticae* population growth factors, such as developmental rate, survival, reproduction, and longevity, may fluctuate (Mitchell, 1973). The life cycle of *T. urticae*, which includes the five developmental phases of egg, larva, protonymph, deutonymph, and adult, has been researched by a number of writers (Boudreaux, 1958). Under ideal conditions of 25–30 °C and 45–55% relative humidity, eggs are spherical and translucent, turn orange, and larvae hatch in about 5 days.

According to Khanamani *et al.*, (2012), several cultivars of brinjal had a gross fecundity rate ranging from 14.46 to 59.72 eggs per female and a one-day-old adult life expectancy ranging from 3.95 to 8.38 days. On brinjal, a female deposited 59 eggs and experienced longevity of 13.6 days as opposed to 10.17 days for a male,

according to Kumar and Raghuraman (2013). The respective periods for larvae, protonymphs, and deutonymphs were 1.81, 1.4, and 1.68 days.

### 2.2.3 Population distribution of phytophagous mites on the plant canopy

Tetranychids were abundant on the middle and lower leaves of the brinjal (Anon, 1992). However, in raised crop from June to August, there were more mites visible on the leaves of the upper canopy. In contrast, the intermediate canopy leaves harboured a greater number of mites from September to December (Anon, 1994). *T. urticae* preferred lower canopy leaves above middle and top canopy leaves, according to Rai *et al.*, (1995). Middle canopy had the highest mite density among the three levels of canopies (50.75/4 cm<sup>2</sup> leaf area), followed by bottom (49.00/4 cm<sup>2</sup> leaf area) and top (23.65/4 cm<sup>2</sup> leaf area). Immature and adult red mites populations varied significantly in the top canopy with middle and bottom canopies, although the population between middle and bottom canopies did not differ significantly (Roopa, 2005).

### 2.2.4 Seasonal incidence of phytophagous mites and their natural enemies

Yousaf *et al.*, (1982) saw *Tenuipalpus granati* and *Tetranychus urticae* embryonic stages being preyed upon successfully by *Phytoseius gossipi* and *Agistemus exsertus*. In China, Zhang and Kong (1986) discovered that *Tetranychus viennensis* may be controlled in apple orchards with *Phytoseius fallacies*. *Phytoseius deleoni* was observed feeding on *Panonychus citri*, according to Schicha (1987).

Haque *et al.*, (2011) studied on a seasonal population of spider mite, *T. urticae* on ornamental and vegetable plants in Rajshahi. He found that during the month of August, nine different vegetable plants-joscpeks coat, kathua, lady's finger, cucumber, brinjal, tomato, bottle gourd, bean, and loofah-had the highest number of mites per leaf. The highest population on spinach was recorded in October, followed by cowpea in November, pointed gourd and radish in December, and bitter melon in January.

According to Ghosh (2013) the pest on okra was active throughout its growing season, with a high population (6.18 mites/leaf) recorded during the 23<sup>rd</sup>SMW (the final week of May) in the pre-kharif crop. The pest crop had the maximum population (7.56/leaf) on the 42<sup>nd</sup>SMW (the first week of October). Because of the heavy rains in the last week of June, there was a sudden decline in population. The plant's top canopy always had a greater incidence of mite population. Weekly mite population

counts revealed substantial positive correlation with minimum and average relative humidity and non-significant positive correlation ( $p = 0.05$ ) with temperature, maximum relative humidity, and total rainfall. According to Kanika *et al.*, (2013), a period of poor rainfall, low RH, and high temperature led to a rise in the mite population.

Kumar *et al.*, (2013) conducted an experiment on the impact of abiotic variables on the population of two spotted spider mites in eggplant during the months of October 2008 to April 2009. The study's findings revealed that the population of mites was adversely connected with relative humidity ( $r = -0.471$ ) and rainfall ( $r = -0.398$ ) and favorably correlated with maximum temperature ( $r = +0.701$ ). However, the dynamics of the two-spotted spider mite population were not significantly impacted by minimum temperature, wind speed, or sunshine hours. Models for two spotted spider mite infection were created using environmental factors.

According to Kumar *et al.*, (2014) incidence of *T.urticae* began in 2010 and 2011 during the ninth and tenth standard weeks, respectively. In 2010, the maximum number of phytophagous mites per 2.5 cm<sup>2</sup> of leaf area was observed on the 21st standard week (47.75), whereas in 2011, the highest number was recorded on the 18<sup>th</sup> standard week (45.99). It was discovered that the mite infestation was severe in May of both years, and that abiotic parameters including mean temperature, daylight hours, and wind velocity significantly correlated positively with the mite pest, whereas relative humidity and rainfall significantly correlated negatively.

Monica *et al.*, (2014) conducted an experiment of the population dynamics of the two-spotted spider mite *Tetranychus urticae* Koch on brinjal crops in north Bihar. She showed the results that the population of mites gradually increased from April to June, reaching a maximum of 6.91 mites per cm<sup>2</sup> leaf area in the first week of June, before rapidly declining from the fourth week of June onward. When the temperature increased, the mite population also increased, and when the relative humidity increased at 07: 00 hours, the mite population decreased. The population of *T. urticae* and weather parameters showed a significant positive correlation with maximum temperature and a significant negative correlation with relative humidity.

Shah and Shukla (2014) evaluated the seasonal occurrence of the two-spotted spider mite, *T. urticae*, on gerbera under polyhouse circumstances from January 2013

to December 2013. The findings showed that the mite population remained active year-round under these conditions. The last week of July 2013 saw the highest mite population, with 12.86 mites per leaf ( $2 \text{ cm}^2$ ). According to correlation studies between weather parameters and mite population, the mite had a non-significantly negative correlation with minimum, maximum, and average temperature ( $r = -0.248$ ,  $-0.186$ , and  $-0.135$ , respectively), whereas the average relative humidity had a significantly positive correlation ( $r = 0.346$ ) with the mite population. Under the polyhouse on gerbera, the top strata had the highest mite population as compared to the middle and bottom strata.

Waqas *et al.*, (2014) studied the temperature's impact on *Euseius scutalis*, a predatory mite, and its seasonal abundance in cotton and their findings showed that temperature enhanced the population of phytoseiid mites. At a temperature of  $41^\circ\text{C}$ , the maximum population was observed to be 3.3 and the minimum population to be 0.4. The mite population suffered a great deal by the highest and minimum temperatures.

Pokle and Shukla (2015) conducted an experiment on the population dynamics of the two-spotted spider mite, *T. urticae*, on tomato cv. Heemshna in polyhouse condition. Under the circumstances of the polyhouse, the spider mite population, *T. urticae*, continues to be active all through the crop season. During the growing season, there were three distinct maxima in the egg stage. Three peaks were noted: the first during the 18<sup>th</sup> SMW, the second during the 12<sup>th</sup> SMW, and the third during the 24<sup>th</sup> SMW. Two different maxima were seen for mobile stages, the first during the 15<sup>th</sup> SMW and the second during the 24<sup>th</sup> SMW. *T. urticae* favours the top leaf canopy of the tomato plant for both the egg and mobile stages. A considerable positive link between the egg and mobile stages and temperature and relative humidity averages of the polyhouse on tomato crop.

According to Singh and Singh (2015) the number of predatory mites increased throughout time, going from 2.92/leaf in the second fortnight of February to 9.74 mites/leaf in the first fortnight of April. Predatory mite showed a significant negative correlation with morning relative humidity ( $r = -0.696$ ), evening relative humidity ( $r = -0.812$ ), and rainfall ( $r = -0.563$ ), along with a favourable association with the highest temperature ( $r = +0.087$ ) and an unfavourable correlation with the lowest temperature ( $r = -0.363$ ).

A study on the dynamics of the two-spotted red spider mite *T. urticae* population in grapevines and its interactions with abiotic variables and a predator was undertaken by Veerendra *et al.*, (2015). From the 47<sup>th</sup> and 45<sup>th</sup> standard weeks of November 2012 until the 15<sup>th</sup> and 17<sup>th</sup> standard weeks of April 2013, the mite incidence was present in Jumnal and Atharga. In these two villages, the seasonal mean mite incidence was 13.7 and 14.6 per square inch of leaf, with January through April seeing the highest incidence. Predatory mite activity peaked around the 15<sup>th</sup> and 17<sup>th</sup> standard weeks at both locations. The 15<sup>th</sup> SW observed the highest prevalence of predatory mites at Jumnal, which was  $3.48 \pm 0.9$  mites per leaf and  $3.1 \pm 1.3$  mites per leaf in Atharga.

Premalatha *et al.*, (2016) studied to be able to evaluate the population dynamics of two spotted spider mites throughout their two main seasons, *kharif* 2014 and summer 2015, under field conditions. The population density of *T. urticae* was found to be lower in the *kharif* of 2014 (2.01 to 6.45 / 2 cm<sup>2</sup> area of leaf) and gradually higher in the summer of 2015 (8.42 to 11.72 / 2 cm<sup>2</sup> area of leaf). Additionally, it was discovered that the two-spotted spider mite population on tomatoes significantly correlated positively with the highest temperature and negatively with relative humidity and rainfall.

Mahendrakumar and Abhishek (2016) conducted a research on the population dynamics of the predatory mite, *Amblyseius alstoniae* Evans during January 2015 and June 15 on brinjal which is infested by the spider mite, *T. urticae*. They revealed that the activities of predatory mites were peaked during 18<sup>th</sup> SMW with 4.67 mites per plant. *A. alstoniae*, a predatory mite, and *T. urticae*, its prey, had a substantial positive connection ( $r=0.860$ ). The predatory mite and maximum, minimum, and average temperatures revealed a strong positive association. Additionally, the middle leaves of the brinjal had the highest concentration of the predatory mite, *A. alstoniae*, followed by the top and bottom leaves.

Pokle and Shukla (2016) studied on the population dynamics of predatory mite, *Amblyseius longispinosus* on the brinjal crop which are infected by phytophagous mites namely *Tetranychus urticae*, and *Aceria lycopersici*. They noticed that the population of predatory mites saw two maxima at the time of growing season. The first peak was seen in the 13<sup>th</sup> SMW, and the second peak in the 25<sup>th</sup> SMW. The egg and mobile stages of *T. urticae* and *A. lycopersici* revealed a substantial positive

connection with the predatory mite population *A. longispinosus* ( $r=0.515$ ,  $0.401$ ,  $0.758$ , and  $0.563$ , respectively). The predatory mite significantly positively correlated with both the average tomato poly house temperature ( $r=0.799$ ) and relative humidity ( $r=0.727$ ). Additionally, the tomato plant top leaves had the highest population of the predatory mite *A. longispinosus*, followed by the middle, and bottom leaves.

Nain *et al.*, (2017) reported that only relative humidity ( $r = 0.77$ ) had a significantly ( $P 0.05$ ) positive link with the mite incidence during 2009–10 while researching the two-spotted spider mite, *T. urticae* Koch, population dynamics on okra and also found that other weather variables showed no correlation.

Tamilnayan *et al.*, (2017) studied on the populations dynamics of the two spotted spider mite of the ash gourd and found that the number of *T. urticae* was maximum in the fourth week of March ( $18.20 / \text{cm}^2$  leaf area). Temperature and relative humidity were found to have a substantial impact based on the increase in the two-spotted mite population, according to a correlation analysis between weather variables and the abundance of ash gourd pests. According to Priyanka *et al.*, (2017) mite incidence on *Withania somnifera* revealed a significant negative connection with the morning relative humidity and daylight hours.

Tripathi and Srivastava (2018) carried out a study to evaluate the population dynamics of two predatory mite *Amblyseius indicus*, and *A. tetranychivorus* on two summer vegetable crops namely okra, and brinjal. They discovered that the highest populations of *Amblyseius indicus* and *A. tetranychivorus* mites were identified in the crops brinjal (09.20), and okra (11.10), respectively, of okra and brinjal. Predatory mite populations ranged from 200 to 800 throughout the summer months in all crops. Low prevalence of predatory mites, *A. indicus* was discovered in both crops and mites, including brinjal (0.20) and okra (1.20) during the first week of March. Okra (1.40) and brinjal (0.90) showed similar trends to *A. tetranychivorus*, respectively.

Mohan kumar *et al.*, (2020) studied and examined the prevalence of phytophagous mites on various sugarcane crop cultivars. He discovered that all the types showed an occurrence and abundance of *Oligonychus indicus* beginning 30 days after planting and lasting for 120 days. *O. indicus* was found to have the lowest population on Co 0323 and to be extremely vulnerable on Co 419. *Abacarus*

*sacchari*, the sugarcane rust mite, first appeared 90 days, or the third month after planting, and persisted for 250 days. Co 0323 had the lowest occurrence, whereas VCF 0517 had the highest. *Aceria sacchari*, a sugarcane blister mite, was also seen from 90 days after planting till the crop was harvested. Phytoseiid mites (*Amblyseius* spp., *Neoseiulus longispinosus*, and *Euseius* spp.), predatory coccinellids (*Stethorus* spp.), and predatory thrips (*Scolothrips rhagebianus*) were known to suppress these phytophagous mites during the study period.

Shinde *et al.*, (2021) examined *Tetranychus urticae* Koch, red spider mite for its seasonal occurrence on brinjal. At 15.44 mites per cm<sup>2</sup> of leaf area, he demonstrated that the third week of April, or the 16th standard metrological week, had the largest mite population. He came to the conclusion that the correlation coefficient revealed a significant positive relationship between the mite population and bright sunshine hours, but a significant negative relationship between the mite population and rainfall.

Bhullar *et al.*, (2022) looked into the seasonal prevalence of mites on capsicum in net house conditions. His examination of the simple, partial, and multiple correlation/regression coefficients of mite incidence with weather variables revealed a significant negative correlation between minimum temperature and a significant positive correlation between morning relative humidity and the yellow mite, *Polyphagotarsonemus latus* (Banks). Predatory phytoseiid and stigmatid mites, as well as the two-spotted spider mite, *Tetranychus urticae* Koch, were found to have a significantly negative association with morning RH but a significantly positive correlation with maximum, minimum, and mean temperatures. The preference of the two-spotted spider mite and yellow mite for a certain plant canopy level was also examined. It was found that *T. urticae* liked the intermediate canopy, followed by the top, while *P. latus* chose top canopy.

### **2.3 Field efficacy of acaricides against phytophagous mites on Brinjal crop**

According to Sudha *et al.*, (2008), diafenthiuron, dicofol, and abamectin cause an 80 to 87 per cent reduction in the mite population after two sprays, followed by propargite (with a 77 per cent reduction) and fenazaquin (with a 75 per cent reduction) in the mite population.

Bhullar and Singh (2009) conducted a field trial to assess the efficacy of novel acaricides, including fenazaquin at 300 and 400 ml per ha, diafenthiuron at 300 and 400 g.a.i per ha and propargite at 750 and 1000 ml per ha, in addition to the recommended dicofol at 750 ml per acre (2009). Fenazaquin at both doses was incredibly effective in decreasing the mite population up to 14 days after spraying, after propargite @750 ml per ha. No indications of phytotoxicity were present in any of the treatments.

The effectiveness of six acaricides against *Panonychus ulmi* (Koch) and *Tetranychus urticae* Koch, two phytophagous mites in apple orchards, was tested in the field by Khajuria and Sharma (2010). Fenpropathrin, and bifenthrin showed considerable toxicity after three days of spraying, but spiromesifen, clofentezine, propargite, and dicofol treatments had reduced acute toxicity. The predatory mites were shown to be exceedingly poisonous to bifenthrin and fenpropathrin, but dicofol was found to be less effective for just 3-7 days.

In an experiment, Martin *et al.*, (2010) used a novel method to manage phytophagous mites on the African egg plant, *Solanum macrocarpon*. It required wrapping plants in a net that was treated with the acaricide dicofol. He found that the dicofol-treated net completely eliminated the broad mite, *Polyphagotarsonemus latus* (Banks), the main pest of *S. macrocarpon* that causes significant damage to leaves, and the spider mites (*Tetranychus* spp.). In contrast to the 12-94 percent damaged leaves in the unprotected control plots, no mites were seen on plants with the dicofol treated net. It has a very minimal danger of polluting the environment and may be used again while also cost effectively lowering.

Sarkar *et al.*, (2013) investigated the impact of various chlorfenapyr 10 SC dosages, together with conventional fenazauin 10 EC and imidacloprid 17.8 SL and untreated control, on chilli mites. Chlorfenapyr @ 100 and 125 g a.i. per ha was shown to be the most effective against the chilli mite based on post-treatment mite population. Up to 10 days following treatment, there was much decreased infestation at both the specified concentrations (100 and 125 g a.i. / ha).

According to Abou (2014) the four acaricide *viz.*, cypermethrin, fenpyroximate, abamectin, and Delmite can be used successfully to control the spider

mite, *T. urticae*, when there are predators around (insects, mites, and spiders) as a result of their mild or nonexistent effects on these natural enemies.

The effectiveness of spiromesifen 240 SC against tomato-infesting whitefly and red spider mites, *Tetranychus* spp., was tested by Alam *et al.*, 2014. According to the tests, spiromesifen 240 SC @ 150 g a.i. per ha greatly decreased the red spider mite infestation and ranked second best for reducing the population of whiteflies. At 150 g a.i. per hectare, spiromesifen 240 SC had the maximum yield. Additionally, spiromesifen demonstrated excellent residual activity over a period of three weeks, whereas standards failed to do so despite three or four treatments. Additionally, observations showed that *Stethorus sp.* and *Amblyseius sp.* were extremely safe with the spiromesifen.

Monika *et al.*, (2014) investigated the bioefficacy of acaricides against *Tetranychus urticae* Koch on brinjal crop. She came to the conclusion that dicofol @ 4ml/l was mostly efficient, had outstanding acaricidal qualities, was followed by fenpyroximate @0.8ml/lit, and also recorded a notable rise in production. According to Rai *et al.*, (2010), dicofol caused the greatest amount of death in brinjal crops, followed by abamectin, propargite, and ethion, with respective mortality rates of 91.56 per cent, 87.44 per cent, 81.66 per cent, and 72.94 per cent.

Niu *et al.*, (2014) investigated the effectiveness of acaricides with their specific modes of action against the two-spotted spider mite, *T. urticae*, on strawberries. The results showed that, bifenzate reduced adult mite numbers by 91% to 99% and juvenile mite levels by 98% to 100%; pyridaben reduced adult mite numbers by 41% to 64% and young mite numbers by up to 67%. Abamectin reduced the immature by 59% at one week after therapy.

According to Kavya *et al.*, (2015), after three days of application on brinjal crops, propargite (0.78mites/leaf), and spiromesifen (1.05mites/leaf) considerably reduced the overall *Tetranychus urticae* populations more than other acaricides, increasing fruit yield.

According to Bajya and Ranjith (2016) the chemical treatments, cyenopyrafen 30 per cent SC @ 200ml/ha and fenpyroximate 5 per cent EC with records of 1.56 to 2.18 mites per leaf and documenting 84.36 to 89.15% reduction over the untreated control (13.46 mites per leaf) at 10 days after spraying in chilli, emerged considerably

the best at 14 days after spraying. According to Padhmashree (2016), the highest cost-benefit ratio for capsicum was found in fenpyroximate 5 SC, followed by diafenthiuron (1: 2.79), and the lowest was found in dicofol 18.5 EC (1: 1.95).

Novel and conventional acaricides' relative toxicities against various stages of *Tetranychus urticae* were explored by Kumari *et al.*, in 2017. She came to the conclusion that spiromesifen was the most effective treatment for ovicidal mites, while hexythiazox was the least harmful and abamectin was the most poisonous to adults and nymphs. Alternative uses for these acaricides include the efficient and long-term benefits.

Singh *et al.*, (2018) investigated the seasonal occurrence and control of *Tetranychus urticae* Koch, the red spider mite, on okra. He stated that avamectin was the most effective treatment in lowering the mite population on okra (74.64%), followed by diafenthiuron (68.02%) and fenazaquin (60.43%). Pongamia oil and neem oil application were the most effective biopesticides, each reducing the population of pests by 46.32%.

Abou-Shosha and M.A.A (2020) investigated the efficiency of plant extracts against the two-spotted spider mite *Tetranychus urticae*, namely *Datura stramonium* leaves, *Hyoscyamus muticus* flowers, and *Jatropha curcas* seeds. They discovered that the efficiency of plant extracts is comparable to that of acaricides since they significantly reduced the amount of *Tetranychus urticae*. These plant extracts were administered to diseased fields of the *Phaseolus vulgaris* and *Solanum melongena* bean and eggplant crops at a 4 percent dosage. *J. Curcas* achieved 90.58 and 90.56 percent reduction percentages on *S. melongena* and *P. vulgaris* respectively, while the extract of *H. muticus* recorded 95.40 and 87.46 percent mortality rates on the same crops. *D. stramonium* reached 92.30 and 94.12 mortality on eggplant and bean, respectively. However, Vertemic performed better on *Tetranychus urticae*.

In an experiment, analysed by Patel *et al.* in 2020 the effectiveness of nine different bio-pesticides against the brinjal mite. He stated that among the nine bio-pesticides against the brinjal mite, and neem oil at a concentration of 0.5 per cent and neem seed kernel extract at a concentration of 5 per cent were determined to be the most effective.

The efficiency of biological and natural treatments against the two-spotted spider mite, *Tetranychus urticae* Koch, which infests brinjal under protected farming, was investigated by Bhullar *et al.*, 2021. He discovered that using pepper extract at a concentration of 30 ml/l, preceded by neemastra and brahmastra at a concentration of 50 ml/l, resulted in the greatest percentage reduction in mite population (>76 and up to 90%). The mite population was decreased by 82-84 percent by the chrysopid bug *Chrysoperla zastrowi sillemi* and by 10 nymphs/plant by the anthocorid insect *Blaptostethus pallescens*, respectively. He said that under controlled circumstances, these organic materials and biorationals could be used in integrated mite management programmes for brinjal.

Farouk *et al.*, (2021) investigated the effectiveness of mustard fixed oil or the essential oils of jasmine and lavender against two-spotted spider mites on egg plant. He disclosed that of all natural oils, JEO (Jasmine essential oil) exhibits the most acaricidal activity against TSSM. These organic oils spraying greatly enhanced eggplant growth and increased eggplant production. Additionally, the application of natural oils significantly boosted the levels of phenols, ascorbic acid, phosphorus, and potassium as well as photosynthetic pigment.

Garc'ez *et al.*, (2021) did research on the effects of botanical acaricides on *Raoiella indica*, *Oligonychus* sp., and two species of phytoseiid predatory mites. He showed that red palm mite (*R. indica*) in the field was significantly suppressed by CinnAcar for a period of 30 days after treatment, whereas EPA-90 (acaricide derived from soybean oil) had significant effects on papaya mite *Olygonychus* sp. suppression in greenhouse for a period of 14 days after treatment. Following residual exposure, these biorational acaricides displayed low to moderate toxic effects on *P. persimilis* and *N. californicus*, two predatory mites.

Cua-Basulto *et al.*, (2021) tested the effects of conventional acaricides on the papaya mite and on the predatory mites *Neoseiulus californicus* and *Phytoseiulus persimilis* in a laboratory setting as well as in a greenhouse and small field plots. On the first day following application, he discovered that the three chemicals abamectin, spiroticlofen, and fenpyroximate produced the highest mortality rates (95–100%) of the predatory mites *Oligonychus* spp. adults and nymphs. All *Oligonychus* sp. eggs are destroyed by spiroticlofan and etoxazole.

Singh (2022) investigated the effectiveness of various acaricide doses against *Panonychus ulmi* Koch, a phytophagous mite in apple orchards. After seven days of spraying, he claimed that fenazaquin @ 0.20 ml/ l (0.50 mites/ leaf) had the most efficacy and was comparable to other test concentrations of fenazaquin @ 0.15, 0.25ml/ l, hexythiazox @ 0.5, 1.0 ml/ l, etoxazole @ 0.25, 0.4, 0.55 ml/ l, and abamectin@0.5,0.6ml/ l. After 14 and 21 days of post-treatment observations, all hexythiazox, fenazaquin, and etoxazole concentrations were determined to be significantly better. Again, after 28 days of spraying, the highest level of efficacy was obtained with fenazaquin @ 0.25 ml/ l, which was on par with hexythiazox (0.5, 1.0 ml/ l), and etoxazole (0.25, 0.4, 0.55 ml/ l), and these were noticeably superior. He found that the most extremely toxic to the natural enemies was fenazaquin.





## **CHAPTER - III**



## **MATERIALS AND METHODS**



## **MATERIAL AND METHODS**

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The different methodologies, techniques and the materials used for conducting experiments to achieve the objectives identified in the studies are presented here with. The laboratory work was done in the Department of Entomology while, the field experiments at the Krishi Vigyan Kendra, Birauli, Samastipur field and survey was done in Samastipur and Muzaffarpur districts.

### **3. Climate and physiographic situation**

KVK Birauli is located in Samastipur District of Bihar state with the 26.4677°N and 85.6756°E latitude and longitude and an altitude of 48m (157feet) above the mean sea level with total recorded rainfall of 15.63 mm, during experiment period with peak in the month of June 2022. The maximum and minimum mean temperature ranging between 30.19°C and 18.13°C during the study period from January to June 2022. The climate of Birauli is warm, sub-tropical and has alluvial soil. The source of meteorological data of the study period was taken from Meteorological Section, RPCAU, Pusa and is presented in the Appendix.

### **3.1 Survey of Major phytophagous mites and its Natural Enemies on Brinjal in Samastipur and Muzaffarpur district**

#### **3.1.1 Locations**

The survey on phytophagous mites and their natural enemies on brinjal crops was carried out in the farmers' field of Chandauli, Harpur, Naranyanpur and Gopalpur Thara village of Samastipur and Lautan, Mirapur, Ittha and Muraul village of Muzaffarpur district at fortnight interval from January to June 2022. Total 31 farmers brinjal field were surveyed. During the survey the Brinjal crops frequently produced in these regions were found infested by phytophagous mites and their leaf samples were collected for further study.

#### **3.1.2 Sampling and Observations**

In each field, 5 plants were randomly chosen for sampling and six leaves (2 from upper, 2 from middle and 2 from bottom) were plucked after their presence was confirmed with hand lens help (20x) and mite infested leaves were collected in polythene bags separately with labels indicating the host, date and village name. The leaves samples infested with mites were brought to the laboratory and numbers of

mites were counted in 2.5 cm<sup>2</sup> leaf area under stereoscopic microscope in the Department of Entomology, RPCAU, Pusa. The predatory phytoseiid mites which are fast moving in nature and of bigger size were collected directly from the plant with the help of fine camel hair brush and then preserved in 70% alcohol. The arthropods were counted, photographed and collected using net.

### **3.1.3 Extraction of Mites**

Mites from the samples were individually removed using a fine brush and observed under a stereo-binocular microscope before being transferred to glass vials with 75% alcohol.

### **3.1.4 Identifications of Phytophagous and Predatory Mites**

The different phytophagous mites were identified with the help of key given by Krantz and Walter (2009).

**Table 1: Details of survey work and the sample collected from different locations**

<b>District</b>	<b>Village</b>	<b>Host</b>
Samastipur	1. Chandauli	Brinjal ( <i>Solanum melongena</i> L.)
	2. Gopalpur Thara	Brinjal ( <i>Solanum melongena</i> L.)
	3. Narayanpur	Brinjal ( <i>Solanum melongena</i> L.)
	4. Harpur	Brinjal ( <i>Solanum melongena</i> L.)
Muzaffarpur	1. Lautan	Brinjal ( <i>Solanum melongena</i> L.)
	2. Muraul	Brinjal ( <i>Solanum melongena</i> L.)
	3. Mirapur	Brinjal ( <i>Solanum melongena</i> L.)
	4. Itha	Brinjal ( <i>Solanum melongena</i> L.)

**Table 2: Details of farmers brinjal field from where sample were collected.**

District	Village	No. of Fields
Samastipur	Chandauli	4
	GopalpurThara	4
	Harpur	5
	Narayanpur	5
Muzaffarpur	Muraul	6
	Lautan	2
	Mirapur	1
	Ittha	4

### 3.2 Seasonal incidence of major phytophagous mites and natural enemies on Brinjal crop

Field investigations were carried out at Birauli Farm, KVK, Samastipur to understand the seasonal variation in the phytophagous mites and natural enemies population on Brinjal crop from January 2022 to June 2022.

#### 3.2.1. Field preparation and fertilizer application

The brinjal crop requires well drained fertile soil. The experimental plot was ploughed to make fine tilth by giving 4-5 ploughing, after which planking was done for proper leveling. The plot was then designed into beds and irrigation channel. Farm yard manure @ 25 t/ha was thoroughly incorporated at the time of field preparation. Brinjal requires 100 kg N: 60 kg P<sub>2</sub>O<sub>5</sub> and 60kg K<sub>2</sub>O per ha as it is a long duration crop. Half dose of N along with full dose of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O is applied in field at the time of final ploughing and thoroughly mixed.

The experimental plot was of 2 m × 3 m with a spacing of 75 cm x 60 cm. All recommended agronomic procedure was followed in the experimental plot and variety Kashi Taru of Brinjal was used in the study. On 14<sup>th</sup> of November seed was sowing and during the last week of 27<sup>th</sup> December 2021, healthy 45 days seedlings having uniform development were transplanted into the main field with a spacing of 75 cm x 60 cm and a shallow depth of 2 to 2.5 cm.

### **3.2.2. Sampling and observations**

To investigate the seasonal incidence of both phytophagous mites and natural enemies, sampling was carried out at fortnightly intervals in which 5 plants randomly chosen were tagged for the samples. From each tagged plant six leaves were taken, two each from the top, middle, and bottom of the brinjal canopy and put in separate polythene bags and well labeled. These samples were taken to the lab where a stereo binocular microscope was used to count the mites present on 2.5 cm<sup>2</sup> at four spots per leaf and the observations were duly recorded.

### **3.2.3 Natural enemies**

Population of different natural enemies *viz.*, insects predators and predatory mites were recorded as per the standard procedure given below.

#### **3.2.3.1 Predatory insects**

Observations of the number of predatory insects were recorded at fortnight intervals from 5 randomly chosen tagged plants and they were counted, photographed and collected by using net.

#### **3.2.3.2 Predatory mites**

On five randomly chosen tagged brinjal plants, predatory mites samples were taken at every fortnight. Care was taken not to disturb to the predatory mites which are very fast movers and the leaf samples taken from top, middle and bottom of plant (2 leaf each) were separately placed in polythene bags for studying in the Department of Entomology laboratory for counting under stereo-binocular microscope. Each leaf was counted for the total number of predatory mites.

### **3.2.4. Correlation study**

The weather parameters *viz.*; temperature (°C), relative humidity (%) and rainfall (mm) in the corresponding fortnightly interval was collected from the Meteorological Section, RPCAU, Pusa. To study the relationship between the dependent variables *viz.*, mites, natural enemies and the independent variables *viz.*, temperature (maximum and minimum), relative humidity, and rainfall. Simple correlation analysis was used on the data collected on the phytophagous mite population and that of their natural enemies.

### 3.3.1 Field preparation and fertiliser application

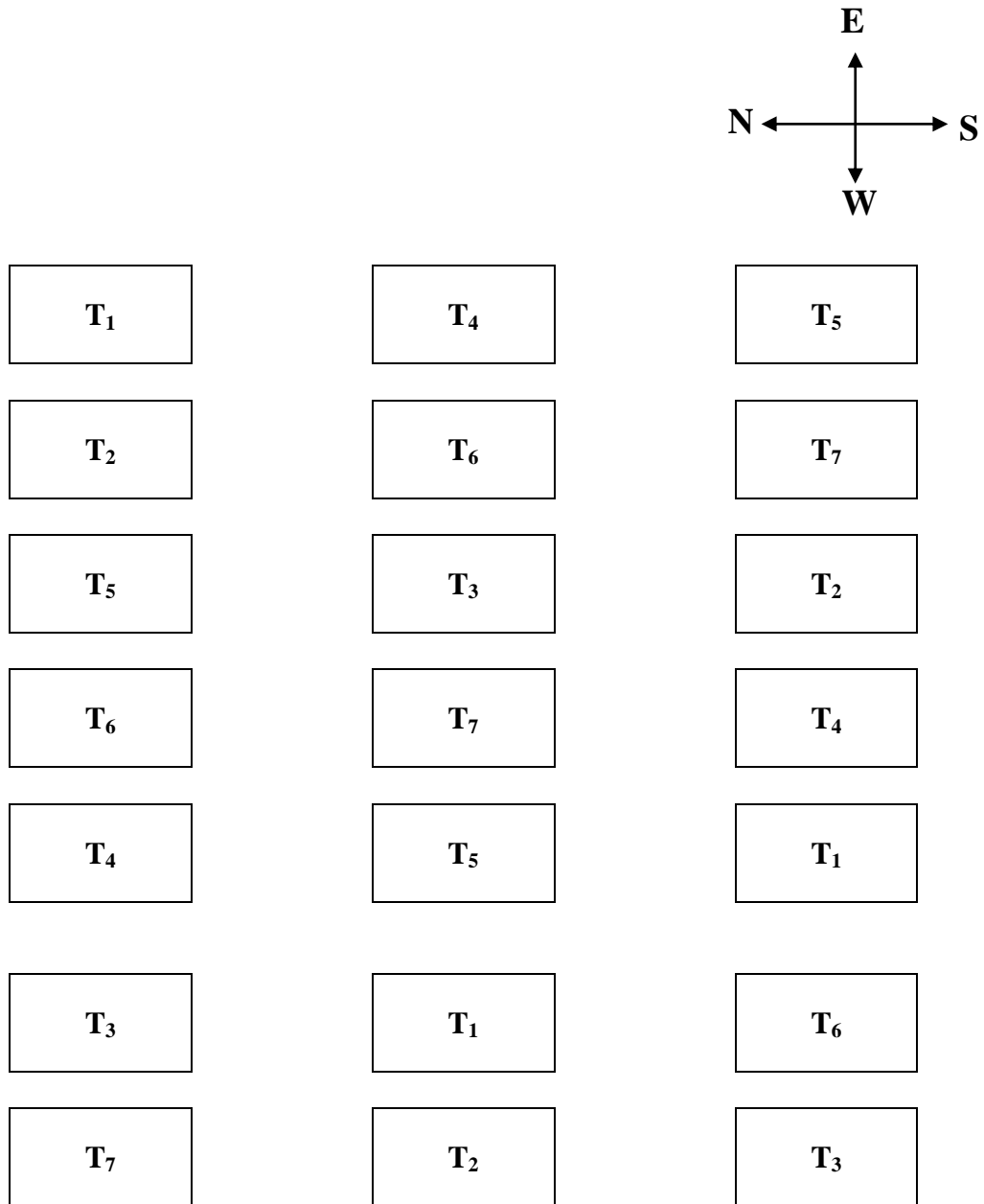
Fertile soil that drains effectively is necessary for the brinjal crop. The trial plot was ploughed four times to create fine tilth, and then planking was done to ensure perfect levelling. The site was then laid out with irrigation channels and beds. When preparing the field, farm yard manure @ 25 t/ha was fully integrated. As a crop with a lengthy growing season, brinjal requires 100 kg N, 60 kg P<sub>2</sub>O<sub>5</sub>, and 60 kg K<sub>2</sub>O per hectare. When final ploughing was completed, a half-dose of N was applied along with full doses of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O, and everything was completely mixed.

The treatment details are given below:

Treatments	: 7 (including untreated control)
Replication	: 03
Design	: Randomized Block Design
Variety	: Kashi Taru
Row to row spacing	: 75cm
Plant to plant spacing	: 60 cm
Plot size	: 2 x 3 m

**Table 3: Details of Acaricides for Efficacy Study against Phytophagous Mites on Brinjal**

No.	Common Name	Trade name	Strength of pesticides (%)	Dose/litre of water
T1	Propargite	Omite	57 EC	2.00 ml
T2	Spiromesifen	Oberon	240 SC	0.8 ml
T3	Fenpyroximate	Pyromite	5 EC	1.0 ml
T4	Abamectin	Dynamite	1.9 EC	0.8 ml
T5	Chlofenapyr	Lepido	10 SC	1.5 ml
T6	Azadirachtin	Neem Baan	0.15 EC	5.00 ml
T7	Control	-	-	-



**Fig.1: Layout plan of experimental trial for acaricides application on brinjal crop**

### **3.3.2 Seedling preparation**

For transplantation into the main field, Kashi Taru variety of brinjal seeds were seeded on a raised nursery bed with dimensions of 2 x 3 m on 14<sup>th</sup> November, 2021.

### **3.3.3 Transplanting**

Seedlings of Kashi Taru variety of brinjal crops grown in the nursery of the Birauli Farm, KVK, were transplanted at a plant spacing of 75cm x 60cm after 45 days old. After transplanting, the field was irrigated immediately, and as per the need.

### **3.3.4 Irrigation**

Depending on meteorological requirements and the frequency of rainfall over the course of the experiment, irrigations were performed after transplanting at intervals of 15 days. After transplanting first irrigation was done followed by subsequent irrigations at 15 days interval, depending upon weather requirement and frequency of rainfall during the experimental period.

### **3.3.5 Intercultural operation**

Two hoeing operations were performed after carefully earthing up the crop to hide the plant's roots and as per the need weeding was performed in the experimental plot.

### **3.3.6 Spraying**

Knapsack sprayer was used in spraying and the six acaricides, including the control plot (water), were sprayed in the month of June when the population of mites was highest and cloth fabric screen were utilized to prevent drifting of spray from one plot to other. The following formula was used to determine the amount of acaricide in the proprietary ingredient:

$$A = B \times C/D$$

Where,

A = Amount of acaricides grams / ml.

B = Desired concentration.

C = Amount of spray fluid required.

D = Formulation's toxicant percentage

A litre of water and the determined proprietary component were combined before being sprayed over plants.

### **3.3.7 Observations**

Five carefully chosen and marked plants from each plot served as the subject of the observations. Thirty leaves from each plot, or six leaves from the tagged plant's upper, middle, and lower portions, were collected and placed in polythene bags for laboratory counting. The total mite population was counted from four different areas on 2.5cm<sup>2</sup> each using a stereo binocular microscope. The mite population was counted before and after treatment at 1, 3, 7 and 14 days after spraying, and the percentage of population reduction was calculated.

### **3.3.8 Statistical analysis**

Before analysing variance to determine the treatment impact, the percent reduction values were converted to arc sine values. C.D. used a 5% level of significance. To determine the importance of the differences between the treatments, C.D. was used at a 5% level of significance.

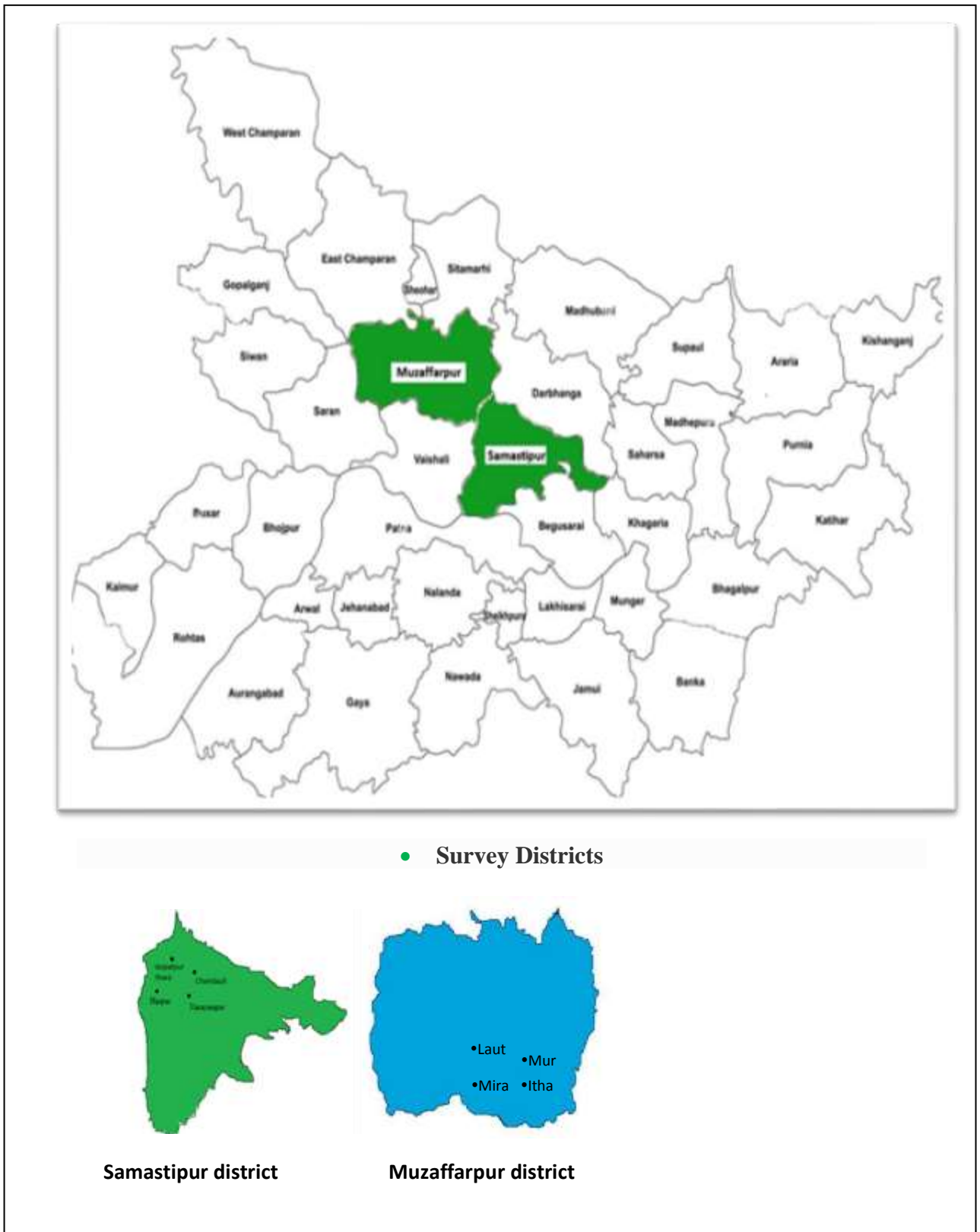


Fig. 2 : Map showing localities where survey of phytophagous mites of brinjal was undertaken



**Plate 1: Survey on phytophagous mites and their natural enemies**



**Plate 2: Nursery bed of brinjal**



**Plate 3: Overview of experimental plot**



**Plate 4: Taking observations during researchwork**



Apical portion of brinjal plant affected by mites



Apical portion of brinjal plant affected by mites



Webbing on brinjal leaf due to heavy infestation of *mite*

Plate 5: Brinjal leaves affected by mites



**Plate 6: The Vegetable Mite *Tetranychus neocaledonicus***



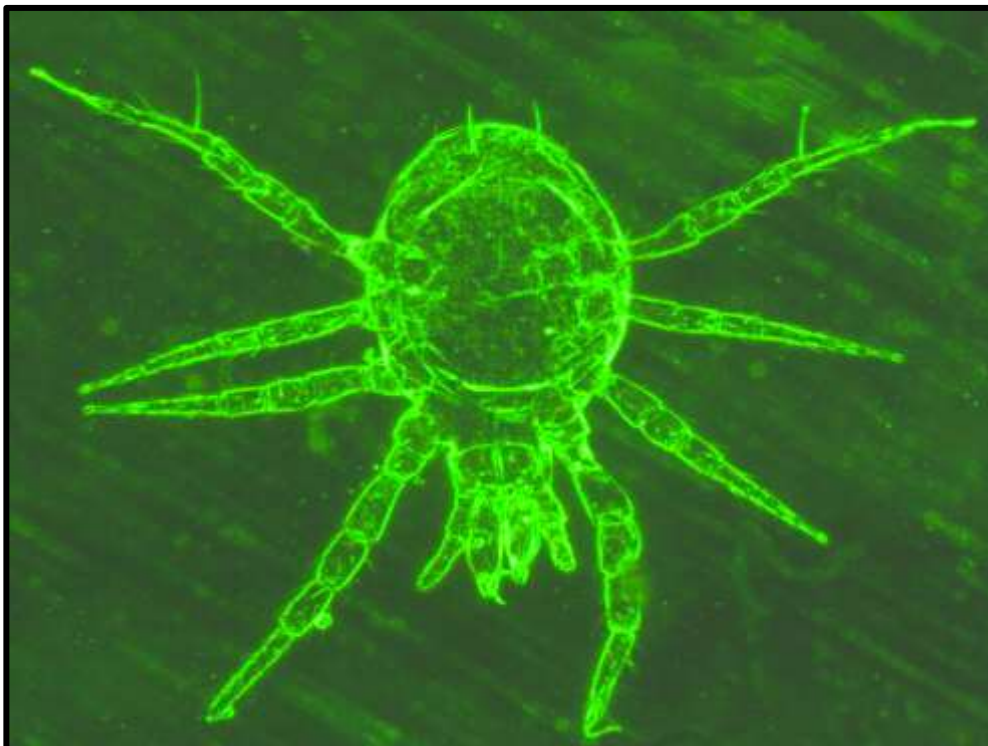
**Plate 7: Red Spider Mite, *Tetranychus urticae***



**Plate 8: Predatory mite, *Amblyseius indicus***



**Plate 9: Microscopic view of *Amblyseius indicus***



**Plate 10 : Predatory mite, *Amblyseius tetranychivorus***



*Coccinella transversalis*



*Coccinella septumpunctata*



*Micraspis discolor*



*Brumoides suturalis*



*Chrysoperla carnea*

**Plate 11: Natural enemies on brinjal**

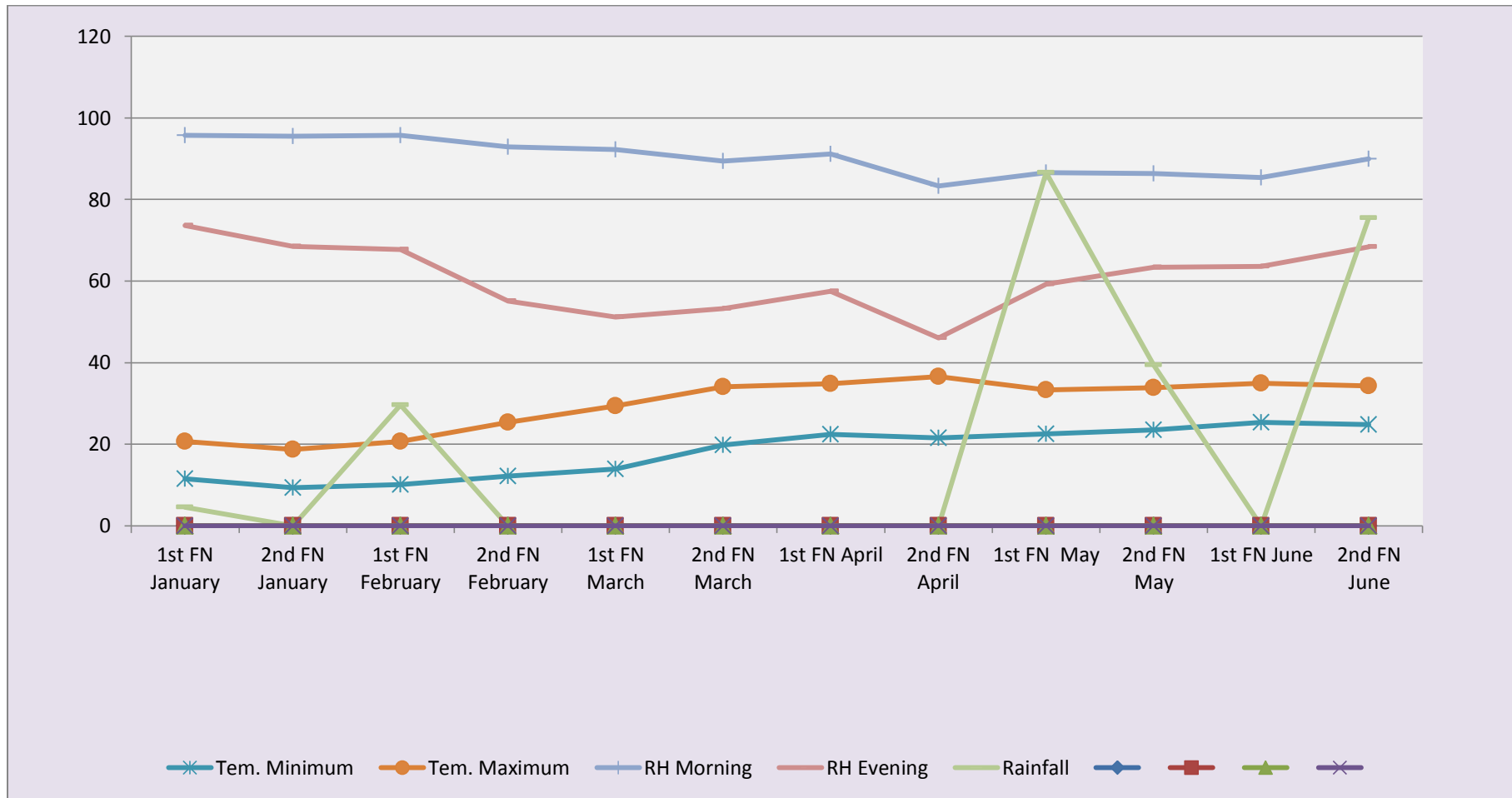


Fig. 3 : Weather parameters trend during the experimental period, 2022.





## **CHAPTER - IV**



## **RESULT AND DICUSSION**



## RESULT AND DICUSSION

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The present research was carried out under field conditions on “*Survey of major phytophagous mites, its associated natural enemies and their management through acaricides on Brinjal Crop during summer season*” during 2022 at Birauli Farm, KVK, Samastipur, Bihar. The findings or the results of various investigations are described below.

### 4.1 Survey of major phytophagous mites and its natural enemies on brinjal in Samastipur and Muzaffarpur district

The study was conducted during the year 2022. During the course of study, two species of tetranychid mites, two species of predatory mites and six predatory insects were recorded and presented in Table 4. Different arthropods were present in the study viz., *Tetranychus urticae*, *T. neocaledonicus*, *Amblysius indicus*, *A. tetranychivorus*, Coccinellids, Green lacewing, Anthocorid bugs, and Mirid bugs. In addition, Black ants and Scolothrips.

In the Samastipur district, four villages were surveyed viz., Chandauli, Gopalpur Thara, Harpur, and Narayanpur. Besides, the other district covered was Muzaffarpur, where also four villages, viz., Lautan, Muraul, Mirapur and Ittha, were surveyed. Among the four villages surveyed in Samastipur district, a maximum of 26.21 tetranychid mites/leaf( 2.5cm<sup>2</sup>) was observed in Harpur followed by Gopalpur Thara (24.25 mites/leaf), Chandauli (17.54 mites/leaf) and Narayanpur (16.11mites/leaf). In the case of natural enemies (predatory insects), Chadauli village registered the largest number of natural enemies, where five types of natural enemies were observed in each visit viz., coccinellids, green lacewing, anthocorid bugs, mirid bugs and black ants, followed by Narayanpur village, where four types of natural enemies were observed in each visit namely, chrysoperla *carnea*, anthocorid bugs, mirid bugs and black ants. The predatory mites found in all four villages were *Amblyseius indicus* and *Amblyseius tetranychivorous*.

In Muzaffarpur district, the tetranychid mite's occurrence trend were Ittha (21.20 mites/plant) >Mirapur (19.52 mites/leaf) >Lautan (15.58 mites/leaf) >Muraul (15.10 mites/leaf). In terms of natural enemies (predatory insects), Muraul village had the highest number of natural enemies (5 types per visit), namely green lacewing, coccinellids, anthocorid bugs, mirid bugs black ants scolothrips while Mirapur village

had the lowest number of natural enemies (2 types per visit) viz., green lacewing and anthocorid bugs. In the case of predatory mites, *Amblyseius indicus* and *Amblyseius tetranychivorous* were observed in all the villages.

The outcome partially concurs with that of Suvash *et al.*, (2021) gathered 1885 mite specimens from various agro-horticulture crops in the Bihar districts of Muzaffarpur, Darbhanga, Madhubani, and Sitamarchi. They discover the predatory mite, *Amblyseius largoensis*, in the brinjal crop and determined that it was the most common species among the others. These results unequivocally demonstrate the significance of phytoseiids in the environment of the brinjal for tetranychid mite natural control. Additionally, two phytophagous mite from the family Tetranychidae, *Tetranychus urticae* and *Eutetranychus orientalis*, were identified and are thought to be the main mite pest in brinjal. Choudhury *et al.*, 2015 witnessed lady bird beetle in brinjal fields during summer season (March to August).

Chandrakumar *et al.*, 2008 reported several natural enemies that associated with brinjal crop. The present study found that the incidence of phytophagous mites are common in the Brinjal field grown by the farmers and with the presence of natural enemies found in all fields in brinjal ecosystem.

**Table 4: Survey on phytophagous mites and their natural enemies in the districts of Muzaffarpur and Samastipur during 2022**

Taluk	Village	Name of tetranychid mites	No. of mites/2.5cm <sup>2</sup> leaf area	Natural enemies	
				Predatory mites	Insect Predators
Samastipur	Chandauli	<i>Tetranychus urticae</i> <i>Tetranychus neocaeledonicus</i>	17.54	<i>Amblyseius indicus</i>	Coccienellids, Green lacewing, Anthocorid bugs, Mirid bugs, Black ants
	Gopalpur Thara	<i>T. urticae</i>	24.25	<i>A. tetranychivorous</i>	Coccienellids, Scolothrips, Black ants
	Narayanpur	<i>T. neocaeledonicus</i> <i>T. urticae</i>	16.11	<i>A. tetranychivorous</i>	Green lacewing, Anthocorid bugs, Mirid bugs, Black ants
	Harpur	<i>T. urticae</i>	26.21	<i>A. indicus</i>	Coccienellids, Green lacewing
Muzaffarpur	Lautan	<i>T. neocaedelonicus</i> <i>T. urticae</i>	15.58	<i>A. indicus</i>	Coccienellids, Mirid bugs, Black ants
	Muraul	<i>T. urticae</i>	15.10	<i>A. tetranychivorous</i>	Coccienellids, Green lacewing, Anthocorid bugs, Mirid bugs, Black ants, Scolothrips
	Mirapur	<i>T. urticae</i>	19.52	<i>A. tetranychivorous</i>	Green lacewing, Anthocorid bugs,
	Ittha	<i>T. neocaeledonicus</i>	21.20	<i>A. tetranychivorous</i>	Coccienellids, Black ants, Scolothrips

**Note 1:** Sampling methods – 6 leaves per plant; 25 plants per location

## 4.2 Seasonal incidences of Phytophagous Mites and different Natural Enemies in Brinjal crop ecosystem.

Seasonal incidence of tetranychid mite (*Tetranychus urticae*), predatory mite (*Amblyseius indicus*), coccinellids, and green lacewing (*Chrysoperla carnea*) was studied in the field at Birauli Farm, KVK, Samastipur. The population fluctuation of the above-mentioned arthropods was monitored from January, 2022 to June, 2022 at a fortnightly interval. Data on the incidence along with meteorological data are presented in the Table 5 to 10.

### 4.2.1. Seasonal incidence of *T. urticae*

The *T. urticae* population started recording during the 1<sup>st</sup> fortnight of January and was noticed up to the 2<sup>nd</sup> fortnight of June. The data was presented in Table 5 and Fig 4. The highest *T. urticae* population of 35.15 mites / 2.5cm<sup>2</sup> leaf area was recorded throughout the first fortnight of June where the maximum, minimum temperature (°C), relative humidity (%) in the morning and evening, and rainfall (mm) were 25.39°C, 34.99°C, 85.35%, 63.64%, and 0.0 mm, followed by 28.20 mites/2.5 cm<sup>2</sup> leaf and 22.14 mites/2.5 cm<sup>2</sup> leaf were observed during the 2<sup>nd</sup> fortnight of April and 1<sup>st</sup> fortnight of April, respectively. In the 1<sup>st</sup> fortnight of February, the population of *T. urticae* was lowest at 5.26 mites/2.5 cm<sup>2</sup> leaf, where the maximum, minimum temperature (°C), relative humidity (%) in the morning and evening, and rainfall (mm) were 10.09°C, 20.74°C, 95.78%, 67.78%, and 29.6 mm, followed by 6.35 mites/2.5 cm<sup>2</sup> leaf and 7.05 mites/2.5 cm<sup>2</sup> leaf, which were observed during the 2<sup>nd</sup> fortnight of February and 1<sup>st</sup> fortnight of January.

Results are somewhat consistent with that of Monica *et al.*, (2014) observed that *Tetranychus urticae* Koch, a two-spotted spider mite seasonally occurs on a crop of brinjal (Plaster variety) which grown in north Bihar throughout the months of March through August of that year was first seen at a lower level (0.57 mites /2.5cm<sup>2</sup> leaf area), grew progressively from April to June, reaching a maximum of 6.91 mites per 2.5 cm<sup>2</sup> leaf area in the first week of June, and then abruptly decreased starting in the fourth week of June.

A substantial spider mite outbreak occurred in May, according to the results of Puttaswamy (1978), Gupta and Gupta (1985), Pande and Sharma (1985), and Mishra *et al.* (1990).

Shinde *et al.*, (2021) noted that the red spider mite, *Tetranychus urticae* Koch, was found highest in the month of April with 15.44 mites per 2.5 cm<sup>2</sup> of leaf area on the

brinjal crop and due to the presence of rain, the second week of January had the lowest amount of mites (0.05 mites/2.5cm<sup>2</sup> leaf area).

#### 4.2.2 Correlation of *T. urticae* in brinjal with weather parameters during summer season 2022.

The data pertaining to the relationship between *T. urticae* population and weather parameters is presented in Table 5 and Fig. 4. The results indicated that maximum and minimum temperatures had positive and significant effects ( $r = 0.744$  and  $0.783$ ) on the mite population. However, the relationship of mites with morning relative humidity was significant and negative ( $r = -0.834$ ). In the case of evening relative humidity, it shows a negative and non-significant relationship ( $-0.469$ ) whereas rainfall had a negative correlation and a non-significant ( $r = -0.162$ ) influence on mite population.

Abiotic factors were determined to be the most significant factors, according to the regression equation by contributing to an extent of ( $R^2 = 0.881$ ) 88.10 percent variation in the *T. urticae* population. The regression equation was fit and studied for the effect of abiotic factors, which showed that for every one percent rise in minimum temperature and maximum temperature, the number of *T. urticae* people has increased up to 0.541 and 0.690, respectively. In the case of morning RH and evening RH, similar results were observed, viz., 0.232 and 0.801 increase in the population of *T. urticae*. Even though rain fall, a similar trend of 0.026 increase in mite population was observed.

The current findings closely align with those of Shinde *et al.*, 2021 who also noted that there was a highly substantial positive connection ( $r = 0.851^{**}$ ) and negative correlation ( $r = 0.636^{**}$ ) between mite incidence and temperature on brinjal crop. However, there was a very strong negative connection found between mite incidence and morning and evening relative humidity ( $r = -0.951$  and  $-0.861$ , respectively). And there was a negative correlation between the mite population and rainfall ( $r = -0.491^*$ ).

According to Patel *et al.*, (2020), which is similar with the present data, brinjal mites showed a strong positive correlation with maximum and minimum temperature but a significant negative correlation with morning and evening relative humidity.

Rajkumar *et al.*, (2005) found that only the maximum and lowest temperatures had a positive and significant link with the mite population, while rainfall and morning and evening relative humidity had a negative and significant connection.

Monica *et al.*, (2014) demonstrated a substantial positive link between the population of *T. urticae* with the highest temperature and a significant negative correlation between the relative humidity.

**Table 5: Seasonal incidence of *T. urticae* on brinjal during the crop period,2022**

	Mean No. of <i>T. urticae</i> mites/2.5cm <sup>2</sup> leaf	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
		Minimum	Maximum	Morning	Evening	
1 <sup>st</sup> Fortnight January	07.05	11.49	20.69	95.73	73.60	4.60
2 <sup>nd</sup> Fortnight January	07.21	09.38	18.70	95.56	68.56	0.00
1 <sup>st</sup> Fortnight February	05.26	10.09	20.74	95.78	67.78	29.6
2 <sup>nd</sup> Fortnight February	06.35	12.18	25.35	92.92	55.07	0.00
1 <sup>st</sup> Fortnight March	15.21	13.92	29.45	92.26	51.20	0.00
2 <sup>nd</sup> Fortnight March	18.23	19.86	34.14	89.37	53.31	0.00
1 <sup>st</sup> Fortnight April	22.14	22.48	34.82	91.21	57.50	0.00
2 <sup>nd</sup> Fortnight April	28.20	21.54	36.57	83.31	46.12	0.00
1 <sup>st</sup> Fortnight May	18.14	22.51	33.35	86.60	59.26	86.6
2 <sup>nd</sup> Fortnight May	17.33	23.51	33.83	86.37	63.43	39.4
1 <sup>st</sup> Fortnight June	35.15	25.39	34.99	85.35	63.64	0.00
2 <sup>nd</sup> Fortnight June	10.23	24.85	34.27	89.93	68.43	75.5

**Note 1:** Sampling methods – 6 leaves per plant; 5 plants per plot

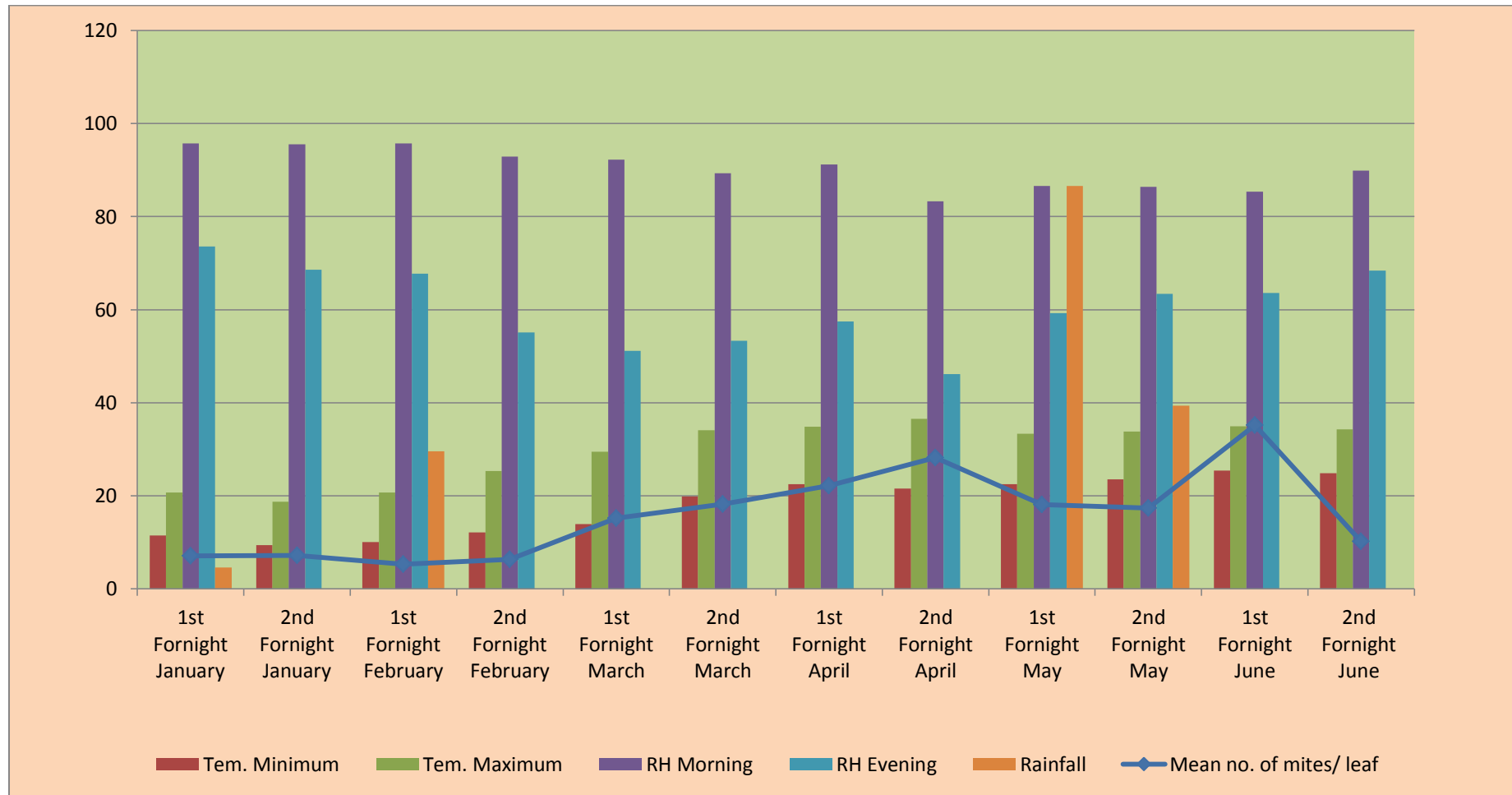


Fig. 4: Influence of weather parameters with phytophagous mites, *Tetranychus urticae* on brinjal crop during the crop period , 2022.

#### 4.2.3 Seasonal incidence of predatory mite, *Amblyseius indicus*

The *A. indicus* population which varied from 0.75 to 12.23 mites/ 2.5 cm<sup>2</sup> of leaf area, was first noted in the 1<sup>st</sup> fortnight January and was observed until the 2<sup>nd</sup> fortnight of June. The information was showed in Table 6 and Fig. 5. The maximum *A. indicus* population of 12.23 mites/2.5cm<sup>2</sup> of leaf area was recorded during the 1<sup>st</sup> fortnight of June, when the maximum and minimum temperature, morning and evening relative humidity, and rainfall were respectively 25.39°C, 34.99°C, 85.55°C, 63.64°C and 0.00mm. The next highest *A. indicus* populations of 8.55 mites/ 2.5 cm<sup>2</sup> leaf area and 7.47 mites/ 2.5 cm<sup>2</sup> of leaf area were recorded during the 2<sup>nd</sup> fortnight of April and the 1<sup>st</sup> fortnight of April. The population of *A. indicus* reached its lowest point in the first fortnight of February, with 0.75mites/ 2.5 cm<sup>2</sup> of leaf area, while the maximum and minimum temperatures, relative humidity in the morning and evening, and rainfall were respectively 10.09°C, 20.74°C, 95.78°C, 67.78°C, and 29.6(mm). This was followed by 1.10 and 1.25 mites per 2.5cm<sup>2</sup> leaf area, which were recorded in the 1<sup>st</sup> and 2<sup>nd</sup> fortnight of January.

The current discoveries is in partial agreement with that of Tripathi and Srivastava (2018) observed that predatory mite populations ranged from 2.0 to 8.0 were found during the summer months in all crops. The predatory mite populations ranged from 2.0 to 8.0 during the summer months in all crops. Low prevalence of predatory mites, *A. indicus* was discovered in brinjal crop (0.20) during the first week of March.

#### 4.2.4 Correlation of *Amblyseius indicus* with weather parameters during summer season 2022

The data pertaining to the relationship between *A. indicus* population and weather parameters is presented in Table 6 and Fig. 5. The results indicated that maximum and minimum temperatures had positive and significant effects ( $r = 0.715$  and  $0.733$ ) on the mite population. However, the relationship of mites with morning relative humidity was significant and negative ( $r = -0.775$ ). In the case of evening relative humidity, it shows a negative and non-significant relationship ( $-0.410$ ). Whereas, rainfall had a negative correlation and a non-significant ( $r = -0.207$ ) influence on mite population. The regression equation revealed that abiotic factors were the most significant ones, contributing to an extent of ( $R^2 = 0.865$ ) 86.5 per cent of the variation in the *A. indicus* population. The regression equation was fit and

studied about the effect of abiotic factors, which showed that for every one percent ( $1^{\circ}\text{C}$ ) rise in minimum and maximum temperature, there was an increase in the population of *A. indicus* up to 0.269 and 0.372, respectively. On the other hand, when morning and evening relative humidity increased by one percent (1%), the population of *A. indicus* increased by up to 0.496. When the rainfall increased by 1mm, there was a 0.018 mite population increase.

#### 4.2.5 Seasonal incidence of Coccinellids

During the course of study, four species of coccinellids were observed viz., *Coccinella septumpunctata*, *Coccinella transversalis*, *Micrapis discolor*, and *Brumoides suturalis*. The coccinellids population started recording during the 1<sup>st</sup> fortnight of January and was noticed up to the 2<sup>nd</sup> fortnight of June. The data were presented in Table 7 and Fig. 6. The highest coccinellid population of 12.09 coccinellids/ 5 plants was recorded during the second fortnight of April where the maximum, minimum temperature ( $^{\circ}\text{C}$ ), relative humidity (%) in the morning and evening, and rainfall (mm) were 21.54 $^{\circ}\text{C}$ , 36.57 $^{\circ}\text{C}$ , 83.31%, 46.12%, and 0.00 followed by 9.32 coccinellids/ 5 plants and 8.26 coccinellids/ 5 plants were observed during the 1<sup>st</sup> fortnight of April and 2<sup>nd</sup> fortnight of March, respectively. In the 2<sup>nd</sup> fortnight of January, the population of coccinellids was lowest at 1.75 coccinellids/5 plants, where the maximum, minimum temperature ( $^{\circ}\text{C}$ ), relative humidity (%) in the morning and evening, and rainfall (mm) were 9.38 $^{\circ}\text{C}$ , 18.70 $^{\circ}\text{C}$ , 95.56%, 68.56%, and 0.00, followed by 2.01 coccinellids/ 5 plants, which were observed during the 1<sup>st</sup> fortnight of January and 1<sup>st</sup> fortnight of February.

Choudhury *et al.*, 2015 observed lady bird beetle in brinjal fields at 40 DAT (1.33 per 5 branches), and the largest population (8.73 per 5 branches) was observed at 85 DAT in summer from March to August. The *Menochilus sex maculatus* species was more prevalent in brinjal fields. The lady bird beetle is the most common aphid feeder. The present findings are in confirmation with high coccinellids were observed in the month of April.

#### 4.2.6 Correlation of coccinellids with weather parameters during the crop season 2021-2022

The data pertaining to the relationship between coccinellid population and weather parameters is presented in Table 7 and Fig. 6. The results indicated that maximum temperatures had positive and significant effects ( $r = 0.694$ ) while minimum temperature had positive and non-significant effect effect (0.486) on the

**Table 6: Seasonal incidence of predatory mite, *Amblyseius indicus* on brinjal crop during crop period 2022**

Fort nights (FN) (2022)	Mean No. of <i>A. indicus</i> mites/ leaf area	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
		Minimum	Maximum	Morning	Evening	
1 <sup>st</sup> Fortnight January	01.10	11.49	20.69	95.73	73.60	4.60
2 <sup>nd</sup> Fortnight January	01.25	09.38	18.70	95.56	68.56	0.00
1 <sup>st</sup> Fortnight February	00.75	10.09	20.74	95.78	67.78	29.6
2 <sup>nd</sup> Fortnight February	01.47	12.18	25.35	92.92	55.07	0.00
1 <sup>st</sup> Fortnight March	03.55	13.92	29.45	92.26	51.20	0.00
2 <sup>nd</sup> Fortnight March	04.24	19.86	34.14	89.37	53.31	0.00
1 <sup>st</sup> Fortnight April	07.47	22.48	34.82	91.21	57.50	0.00
2 <sup>nd</sup> Fortnight April	08.55	21.54	36.57	83.31	46.12	0.00
1 <sup>st</sup> Fortnight May	04.52	22.51	33.35	86.60	59.26	86.6
2 <sup>nd</sup> Fortnight May	04.45	23.51	33.83	86.37	63.43	39.4
1 <sup>st</sup> Fortnight June	12.23	25.39	34.99	85.35	63.64	0.00
2 <sup>nd</sup> Fortnight June	02.27	24.85	34.27	89.93	68.43	75.5

**Note 1:** Sampling methods – 6 leaves per plant; 5 plants per plot

**Note 2:** The entire table data was 6 months average data

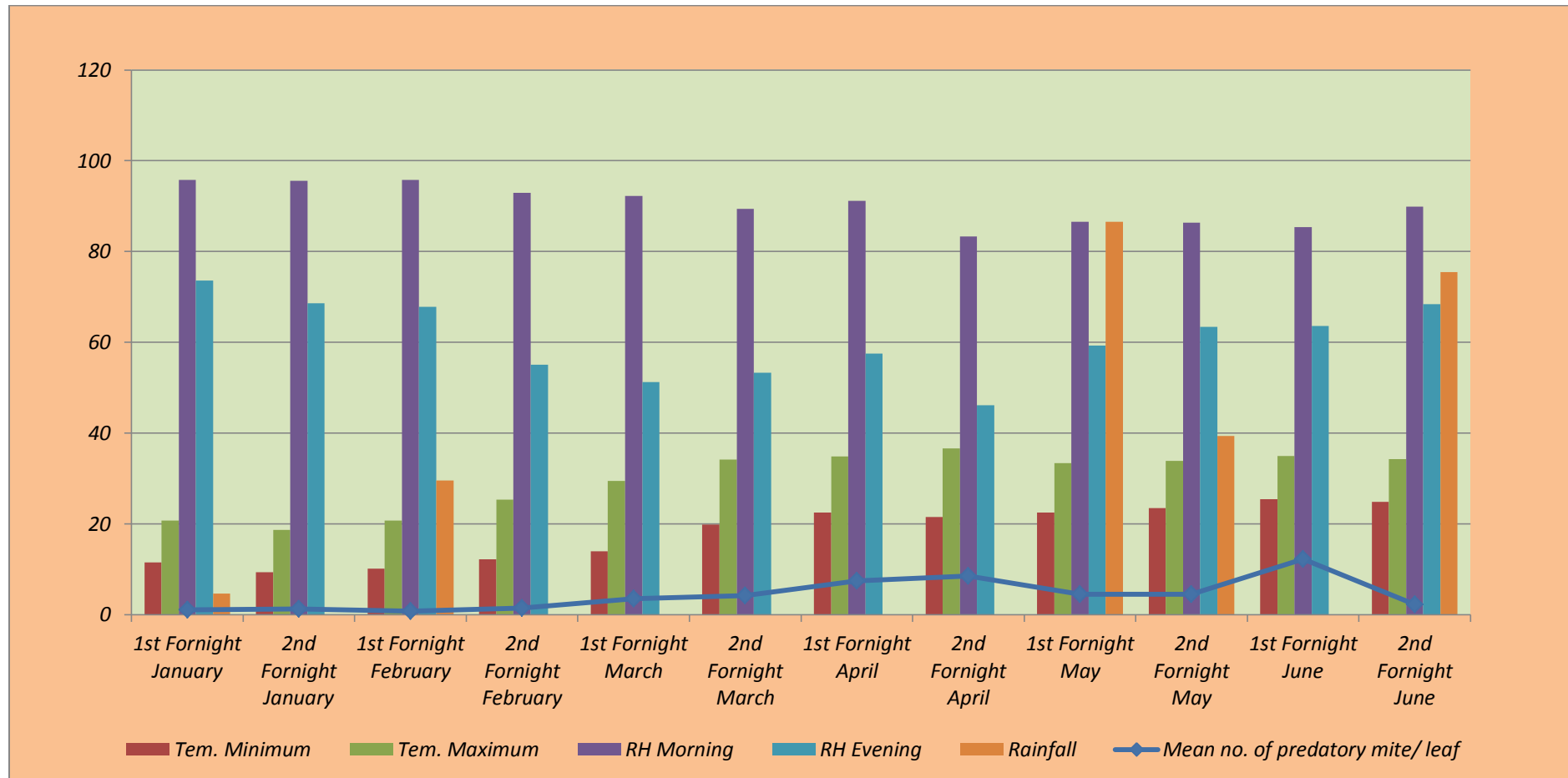


Fig. 5: Influence of weather parameters with predatory/phytoseiid mite, *Amblyseius indicus* on brinjal crop during the crop period ,2022.

coccinellid population. However, the relationship of coccinellids with morning and evening relative humidity was significant and negative ( $r = -0.638$  and  $r = -0.790$ ). Whereas rainfall had a negative correlation and a non-significant ( $r = -0.432$ ) influence on coccinellid population.

The regression equation showed that abiotic factors were found to be the most influential factors, contributing to an extent of ( $R^2 = 0.894$ ) 89.40 percent variation in the coccinellid population. The regression equation was fit and studied for the effect of abiotic factors, which showed that for every one percent rise in minimum temperature and maximum temperature, there was an increase in the population of coccinellid up to 0.497 and 0.736, respectively. In the case of morning RH and evening RH, similar results were observed, *viz.*, 0.966 and 0.894 increases in the population of coccinellids. Even though rain fall, a similar trend of 0.485 increase in coccinellid population was observed.

Our present study is supported by Chandrakumar *et al.*, 2008, They observed Coccinellid density was significantly positively correlated with wind speed velocity (0.580), but negatively correlated with maximum temperature and rainfall (-0.641 and -0.776, respectively). Relative humidity was found to be non-significant and unrelated to the coccinellid density.

The present findings are closely conformity to Sarta *et al.*, 2022 who showed that the correlation between coccinellids and maximum temperature (0.594) was positive and significant, the correlation between minimum temperature (0.430) and relative humidity (0.291) was positive and non-significant, but the correlation between rainfall (-2.022) was found to be negative and non-significant.

#### **4.2.7 Seasonal incidence of green lacewing**

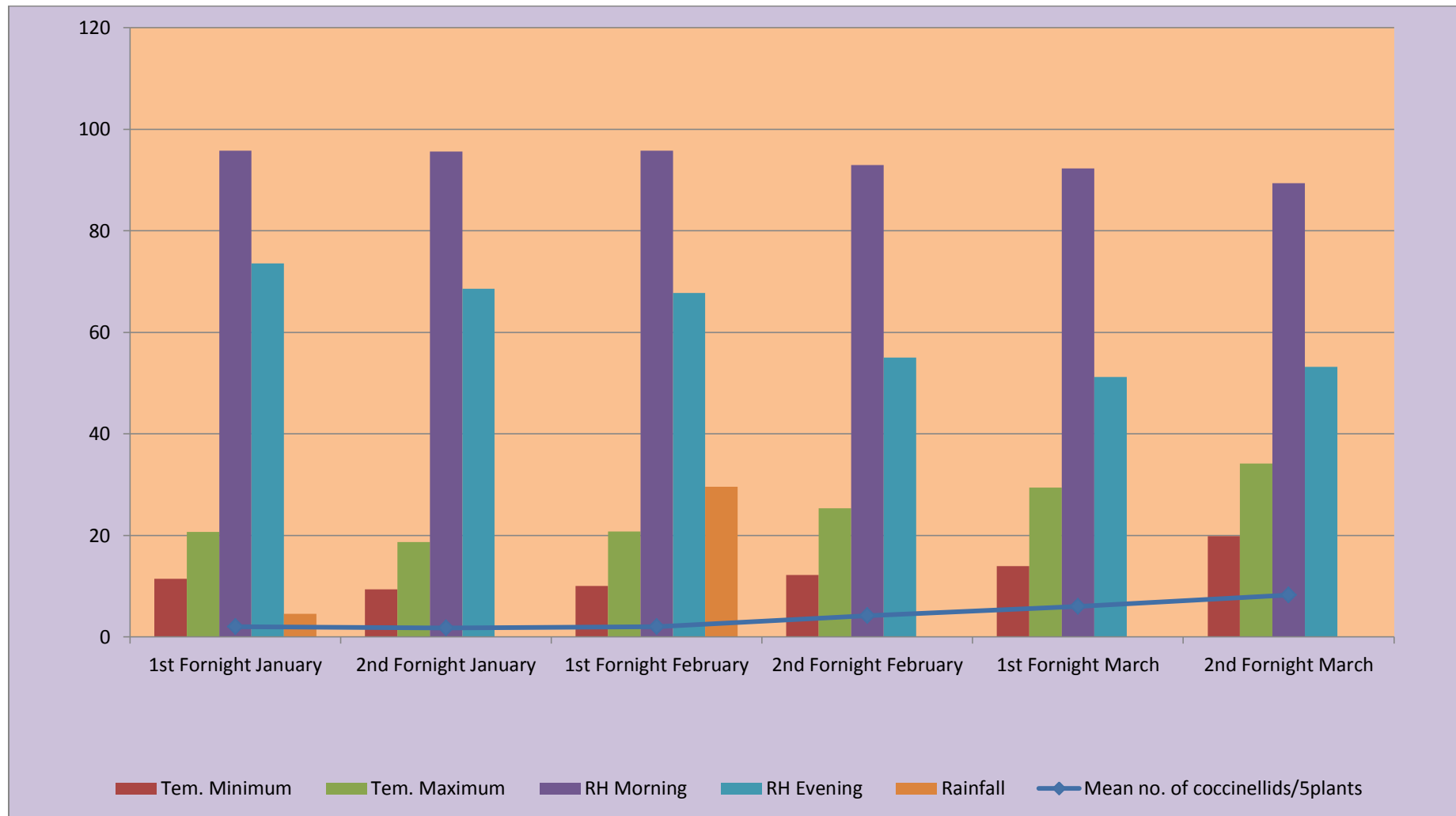
The green lace wing population which varied from 0.00 to 7.55 green lace wing / 5 plants, was first noted in the 2<sup>nd</sup> fortnight of January and was observed until the 2<sup>nd</sup> of fortnight of June. The information was showed in Table 8 and Fig. 7. The maximum green lace wings population of 7.55 green lace wing/5 plants was recorded during the 2<sup>nd</sup> fortnight of April, when the maximum and minimum temperature, morning and evening relative humidity, and rainfall were respectively 21.54°C, 36.57°C, 83.31%, 46.12%, and 0.00mm. The next highest green lace wings populations of 6.92 coccinellids/ 5 plants and 6.25 coccinellids/ 5 plants were

**Table 7: Seasonal incidence of coccinellids on brinjal during the crop period, 2022.**

<b>Fort nights (FN) (2022)</b>	<b>Mean No. of Coccinellids/ 5 plants</b>	<b>T<sub>Min</sub></b>	<b>T<sub>Max</sub></b>	<b>RH<sub>Min</sub></b>	<b>RH<sub>Max</sub></b>	<b>Rainfall</b>
1 <sup>st</sup> Fortnight January	02.01	11.49	20.69	95.73	73.60	4.60
2 <sup>nd</sup> Fortnight January	01.75	09.38	18.70	95.56	68.56	0.00
1 <sup>st</sup> Fortnight February	02.01	10.09	20.74	95.78	67.78	29.6
2 <sup>nd</sup> Fortnight February	04.23	12.18	25.35	92.92	55.07	0.00
1 <sup>st</sup> Fortnight March	06.05	13.92	29.45	92.26	51.20	0.00
2 <sup>nd</sup> Fortnight March	08.26	19.86	34.14	89.37	53.31	0.00
1 <sup>st</sup> Fortnight April	09.32	22.48	34.82	91.21	57.50	0.00
2 <sup>nd</sup> Fortnight April	12.09	21.54	36.57	83.31	46.12	0.00
1 <sup>st</sup> Fortnight May	04.17	22.51	33.35	86.60	59.26	86.6
2 <sup>nd</sup> Fortnight May	03.26	23.51	33.83	86.37	63.43	39.4
1 <sup>st</sup> Fortnight June	08.14	25.39	34.99	85.35	63.64	0.00
2 <sup>nd</sup> Fortnight June	02.32	24.85	34.27	89.93	68.43	75.5

**Note 1:** Sampling methods – 5 plants per plot

**Note 2:** The entire table data was 6 months average data



**Fig. 6: Influence of weather parameters with coccinellids on brinjal crop during the crop period, 2022**

recorded during the 1<sup>st</sup> fortnight of April and the 2<sup>nd</sup> fortnight of March. The population of green lace wing reached its lowest point in the 2<sup>nd</sup> fortnight of January, with 1.02 coccinellids per 5 plants, while the maximum and minimum temperatures, relative humidity in the morning and evening, and rainfall were respectively 9.38°C, 18.70°C, 95.56%, 68.56%, and 0.0 mm. This was followed by 1.45 and 1.85 coccinellids per 5 plants, which were recorded in the 2<sup>nd</sup> fortnight of January and 1<sup>st</sup> fortnight of February.

#### **4.2.7 Correlation of Green Lace Wing population with weather parameters during the crop period 2022**

The data pertaining to the relationship between green lace wing population and weather parameters is presented in Table 8 and Fig. 7. The results indicated that maximum temperatures had positive and significant effects ( $r = 0.670$ ) on the green lace wing population, On the other hand minimum temperature shows positive and non-significant ( $r = 0.427$ ) relationship with green lace wings. However, the relationship of mites with evening relative humidity was significant and negative ( $r = -0.839$ ). In the case of morning relative humidity, it shows a negative and non-significant relationship ( $-0.535$ ), whereas rainfall had a negative correlation and a non-significant ( $r = -0.420$ ) influence on mite population.

The regression equation showed that abiotic factors were found to be the most influential factors, contributing to an extent of ( $R^2 = 0.901$ ) 90.1 per cent of the variation in the green lace wing population. The regression equation was fit and studied about the effect of abiotic factors, which showed that for every one percent ( $1^{\circ}\text{C}$ ) rise in min and max temperature, there was an increase in the population of green lace wings up to 0.663 and 0.995, respectively. On the other hand, when morning and evening relative humidity increased by one percent (1%), the population of green lace wings increased by up to 0.365 and 0.315. In Rainfall (1mm) increase, there was a 0.040 green lace wing population increase.

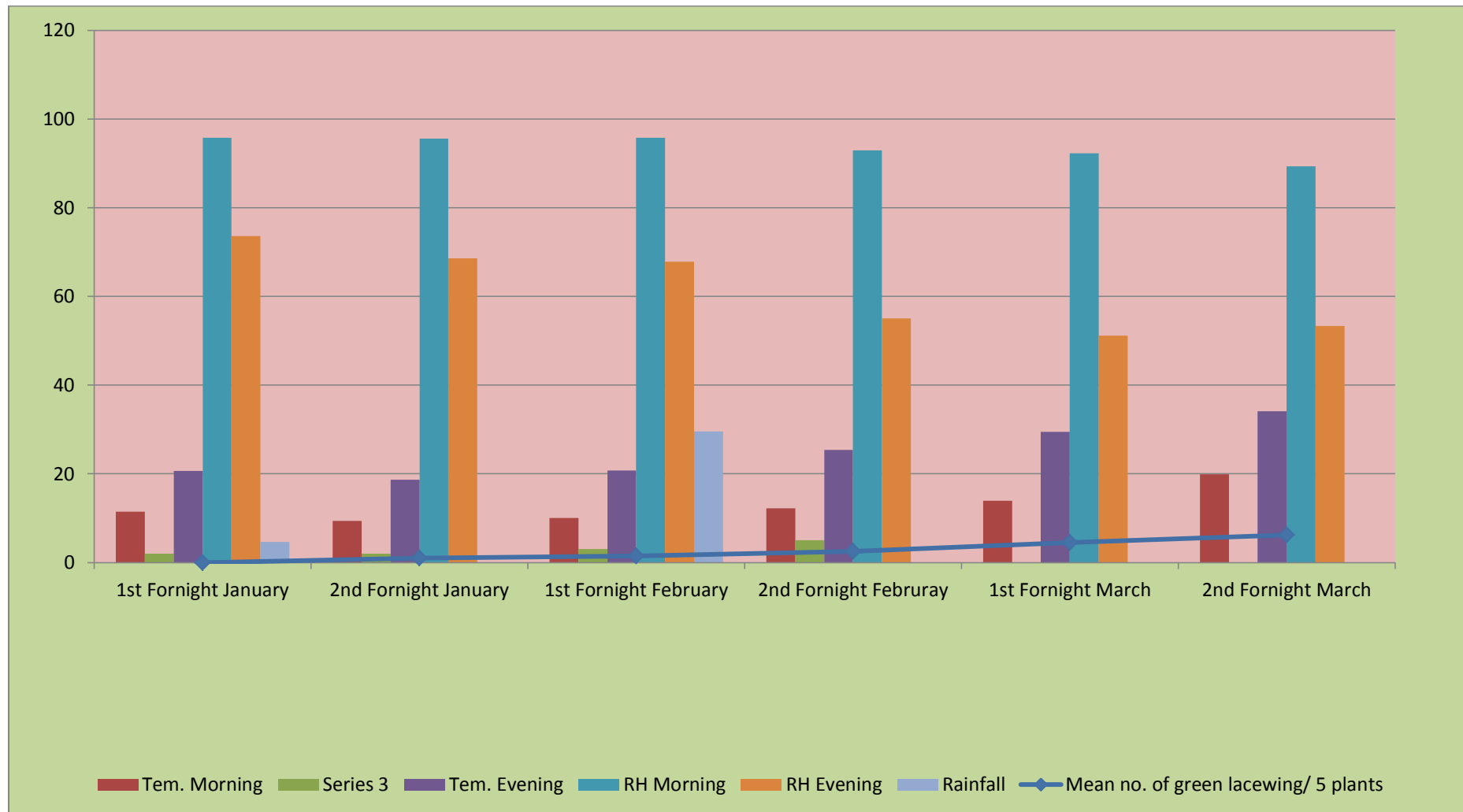
The present study is supported by Chandrakumar *et al.*, 2008 who found that the rainfall and relative humidity were found to have a very poor correlation ( $-0.747$ ) and displayed a favourable connection with wind speed and maximum temperature.

**Table 8 : Seasonal incidence of green lace wing on brinjal during the crop period, 2022.**

Fort nights (FN) (2022)	Mean No. of green lace wings/ 5 plants	T <sub>Min</sub>	T <sub>Max</sub>	RH <sub>Min</sub>	RH <sub>Max</sub>	Rainfall	R <sup>2</sup> Value
1 <sup>st</sup> Fortnight January	0.00	11.49	20.69	95.73	73.60	4.60	
2 <sup>nd</sup> Fortnight January	01.02	09.38	18.70	95.56	68.56	0.00	
1 <sup>st</sup> Fortnight February	01.45	10.09	20.74	95.78	67.78	29.6	
2 <sup>nd</sup> Fortnight February	02.56	12.18	25.35	92.92	55.07	0.00	
1 <sup>st</sup> Fortnight March	04.55	13.92	29.45	92.26	51.20	0.00	
2 <sup>nd</sup> Fortnight March	06.25	19.86	34.14	89.37	53.31	0.00	
1 <sup>st</sup> Fortnight April	06.92	22.48	34.82	91.21	57.50	0.00	
2 <sup>nd</sup> Fortnight April	07.55	21.54	36.57	83.31	46.12	0.00	
1 <sup>st</sup> Fortnight May	02.35	22.51	33.35	86.60	59.26	86.6	
2 <sup>nd</sup> Fortnight May	1.85	23.51	33.83	86.37	63.43	39.4	
1 <sup>st</sup> Fortnight June	4.21	25.39	34.99	85.35	63.64	0.00	
2 <sup>nd</sup> Fortnight June	1.32	24.85	34.27	89.93	68.43	75.5	

**Note 1:** Sampling methods – 5 plants per plot

**Note 2:** The entire table data was 6 months average data



**Fig. 7: Influence of weather parameters with green lacewing on brinjal crop during the crop period, 2022**

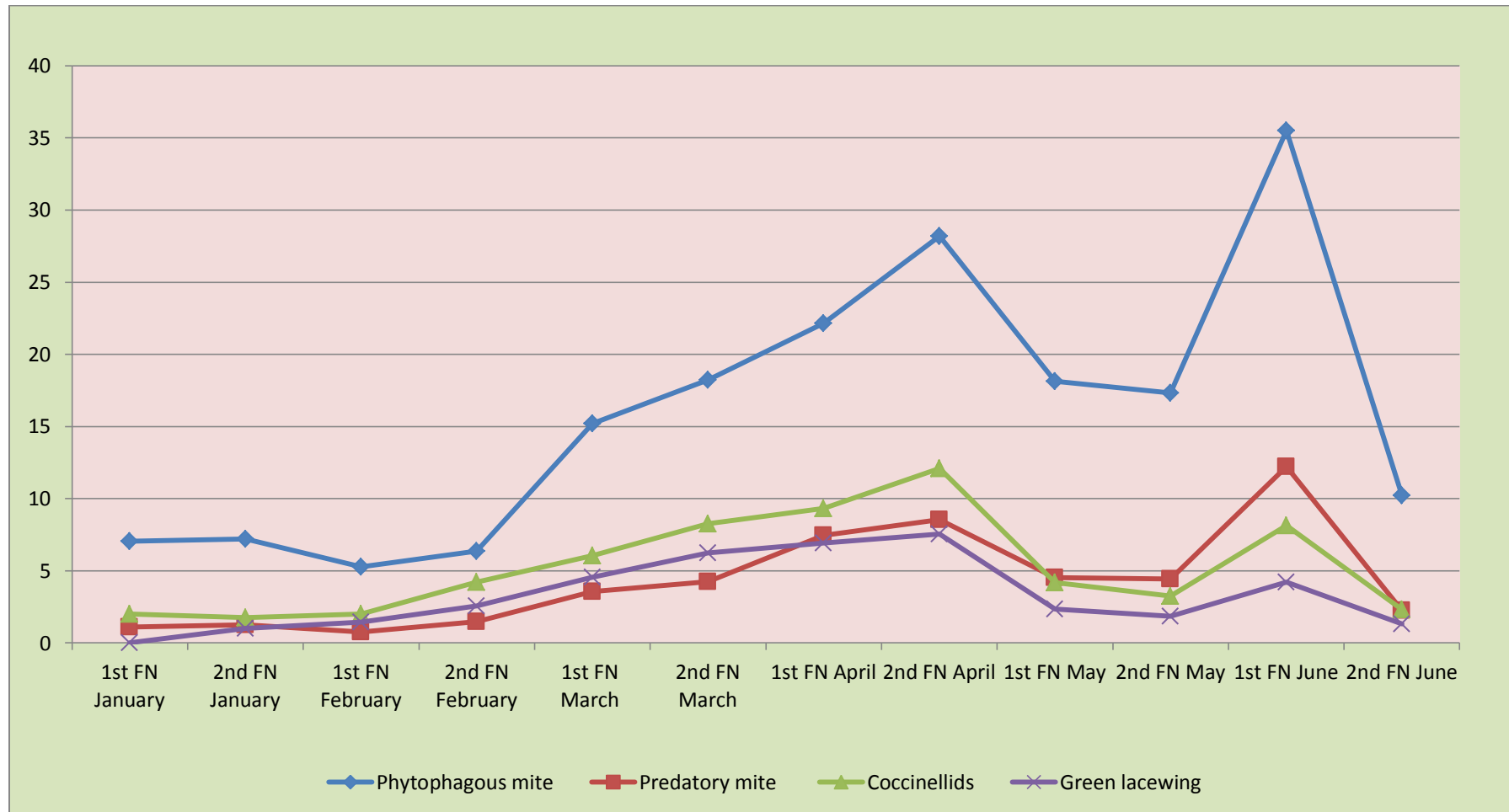


Fig. 8: Effect of natural enemies (predatory insects and predatory mite) with phytophagous mite on brinjal crop

**Table 9: Correlation coefficients of phytophagous mite and natural enemies with weather parameters on brinjal crop during crop period 2022.**

Correlation Factor	Temperature (°C)		Relative humidity (%)		Rainfall
	Minimum	Maximum	Morning	Evening	
Red spider mite	0.744**	0.783*	-0.834**	-0.469	-0.162
Predatory mite	0.715**	0.733**	-0.775**	-0.410	-0.207
Coccinellids	0.486	0.694*	-0.638*	-0.790**	-0.432
Green lace wing	0.427	0.670*	-0.535	-0.839**	-0.420

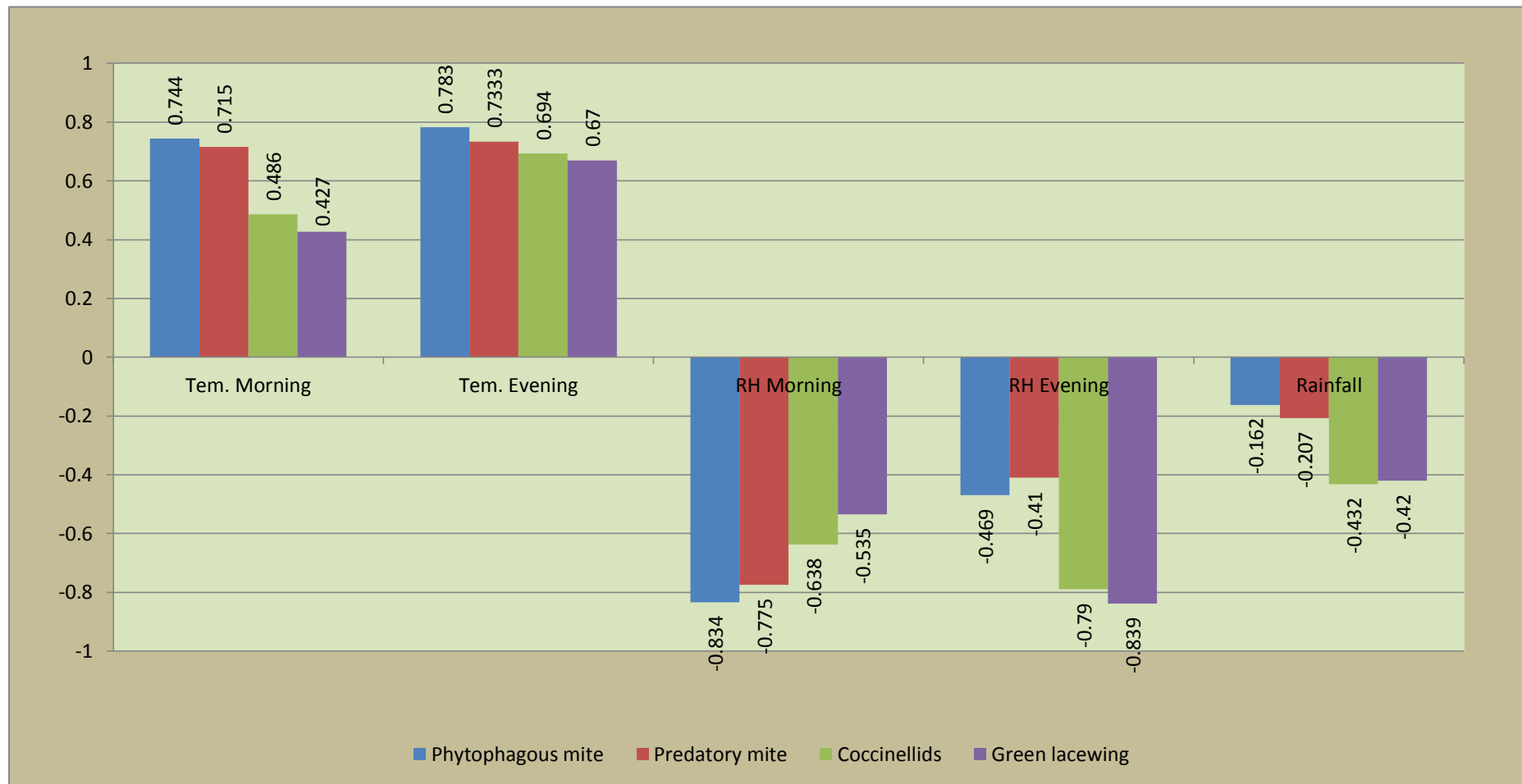
Note: \*\*Correlation is significant at the 0.01 level

\*Correlation is significant at the 0.05 level

**Table 10: Regression equation of phytophagous mite and natural enemies with weather parameters on brinjal crop during crop period 2022.**

<b>Regression factor</b>	<b>Regression equation</b>	<b>R<sup>2</sup> Value</b>
Red Spider Mite	$X_1 (0.541) + X_2 (0.690) + X_3 (0.232) + X_4 (0.801) + X_5 (0.026) + 140.97$	0.881
Predatory Mite	$X_1 (0.269) + X_2 (0.372) + X_3 (0.496) + X_4 (0.496) + X_5 (0.018) + 49.97$	0.865
Coccinellids	$X_1 (0.497) + X_2 (0.736) + X_3 (0.966) + X_4 (0.894) + X_5 (0.485) + 18.61$	0.894
Green lace wing	$X_1 (0.663) + X_2 (0.995) + X_3 (0.365) + X_4 (0.315) + X_5 (0.040) - 07.16$	0.901

X<sub>1</sub>- Maximum temperature, X<sub>2</sub>- Minimum Temperature, X<sub>3</sub>-Relative humidity 7hrs, X<sub>4</sub>- Relative humidity 14 hrs, X<sub>5</sub>- Rainfall, R<sub>2</sub>- Coefficient of Determination.



**Fig. 9: Correlation coefficients of phytophagous mite and natural enemies with weather parameters on brinjal crop during crop period 2022.**

### 4.3. Field efficacy of different acaricides against phytophagous mites on brinjal crop

The effectiveness of different acaricides against the phytophagous mites on brinjal crop was evaluated in a field trial during the crop period, 2022. The first spray was done at the flowering stage and after 10 days interval second spray was done. One day prior to spraying, observations were made at 1, 3, 7, and 10 days thereafter. Data on the application of various acaricides against the populations of phytophagous mite after first spray and second spray are presented in Table 11 and 12 respectively.

#### 4.3.1 Efficacy of acaricides application on phytophagous mite, *T. urticae* after first spray

Data pertaining to the efficacy of various acaricides after the first spray is presented in Table 11 and Fig. 10. The initial population of tetranychid mites before imposing the treatments ranged from 26.92 to 30 mites per leaf, which were on par with each other.

At one day after spray (1 DAS), Spiromesifen 240SC @ 0.8ml/l recorded the lowest number of mites (7.32 mites/ plant), which was found on par with Chlofenapyr 10SC @ 1.5ml/l (8.21 mites/leaf). On the other hand, the highest number of active mites was present in Azadirachtin 0.15 EC @ 5ml/l treated plots at 17.27 mites per leaf, followed by propargite 57EC @ 2ml/l (15.26 mites per leaf). However, all the treatments give superior control over the control plots (28.40 mites/leaf).

At three days after spray (3 DAS), the lowest number of mites was found in chlofenapyr treated plots at 4.21 mites per leaf while the highest number of mites was found in azadirachtin treated plots at 17.27 mites per leaf, compared to control plots (30.87 mites/leaf).

At seven days after spray (7 DAS), spiromesifen treated plots had the fewest mites (3.89 mites/leaf) followed by Chlofenapyr treated plot (4.02) while azadirachtin-treated plots had the most mites (15.15 mites/leaf), compared to control plots (32.09 mites/leaf).

At 14 days after spray (14 DAS), the lowest number of active mites was observed in spiromesifen treated plots at 8.24 mites/leaf, whereas the highest number of active mites was observed in azadirachtin treated plots at 19.72 mites/leaf, as compared to control plots (32.45 mites/leaf).

The highest mean number of mites activity was observed in azadirachtin treated plots at 16.80 mites/leaf, followed by fenpyroximate at 13.66 mites/leaf, and

the lowest number of mites activity was observed in spiromesifen treated plots at 5.94 mites/leaf, followed by chlofenapyr treated plot at 6.55 mites/leaf, as compared to control plots at 34.06 mites/leaf.

The highest per cent reduction over control was observed in plots treated with Spiromesifen 240 SC on par with chlofenapyr 10SC and abamectin 1.9 EC viz., 88.60 %, 88.00 %, and 85.75 %, respectively. The lowest percent reduction over control was observed in plots treated with azadirachtin at 57.25 %, followed by fenpyroximate at 62.95 %

#### **4.3.2. Efficacy of acaricides application on phytophagous mite, *T. urticae* after second spray**

Data pertaining to the effectiveness of different acaricides after the second spray is presented in Table 12 and Fig. 11. The initial population of tetranychid mites before imposing the treatments ranged from 8.24 to 34.83 mites/leaf, which were on par with each other.

At one day after spray (1 DAS), Spiromesifen 240SC @ 0.5ml/l recorded the lowest number of mites (4.34 mites/leaf), which was found on par with Chlofenapyr 10SC @ 2.50ml/l (5.24 mites/leaf) and abamectin 1.9EC @ 1ml/l (6.24 mites/leaf). On the other hand, the highest number of active mites was present in Azadirachtin treated plots at 12.12 mites/leaf, followed by Fenpyroximate treated plot (8.01 mites/leaf). However, all the treatments give superior control over the control plots (39.01 mites/leaf).

Three days after spray (3 DAS), the lowest number of mites was found in spiromesifen treated plots at 2.85 mites/leaf followed by chlofenapyr (4.26 mites/leaf) while the highest number of mites was found in Azadirachtin treated plots at 13.25 mites/leaf, compared to control plots (41.25 mites/leaf).

At seven days after spray (7 DAS) spiromesifen treated plots had the lowest mites (2.36 mites/leaf), while azadirachtin treated plots had the most mites (15.36 mites/leaf), compared to control plots (47.02 mites/leaf).

At 14 days after spray (14 DAS), the lowest number of active mites was observed in spiromesifen treated plots at 5.21 mites/leaf, whereas the highest number of active mites was observed in Azadirachtin treated plots at 21.24 mites/leaf, as compared to control plots (52.20 mites/leaf).

**Table 11: Field efficacy of different acaricides against phytophagous mites on brinjal (First spray).**

S. No	Treatment Details	Before Spraying (Pre count mites/leaf)	After Spraying* (DAS) (mites/leaf)					Percent reduction over control**
			1	3	7	14	Mean	
1	Propargite 57% EC	30.00 (5.57)	12.21 (3.63)	08.04 (3.01)	5.12 (2.47)	13.66 (3.83)	9.76 (3.17)	77.09 (61.52)
2	Spiromesifen 240% EC	27.00 (5.29)	07.32 (2.88)	04.32 (2.31)	3.89 (2.21)	8.24 (3.04)	5.94 (2.63)	88.60 (70.36)
3	Fenpyroximate 5% EC	27.20 (5.31)	15.26 (4.03)	13.24 (3.77)	10.03 (3.32)	16.09 (4.13)	13.66 (3.28)	62.95 (52.60)
4	Abamectin 1.5% EC	29.10 (5.48)	10.83 (3.44)	5.26 (2.50)	6.98 (2.82)	13.02 (3.74)	9.02 (3.17)	85.75 (67.25)
5	Chlofenapyr 10% SC	26.92 (5.20)	08.21 (3.03)	04.21 (2.28)	4.02 (2.24)	09.75 (3.28)	6.55 (2.75)	88.00 (69.95)
6	Azadirachtin 0.15% EC	29.80 (5.55)	17.27 (4.27)	15.05 (4.01)	15.15 (4.02)	19.72 (4.55)	16.80 (4.22)	57.25 (49.20)
7	Control	28.40 (5.42)	30.87 (5.65)	32.09 (5.75)	34.45 (5.95)	38.83 (6.31)	34.06 (5.92)	-
	CD (0.05)	NS	0.32	0.23	0.20	0.30	0.22	3.01
	SE. m ( $\pm$ )	0.12	0.10	0.08	0.07	0.09	0.08	1.05
	CV	5.07	6.55	5.23	7.29	6.46	8.22	12.67

**Note 1:** \* Figures were transformed by square root transformation and the original values are given in the parenthesis.

**Note 2:** \*\* Figures were transformed by arcsine transformation and the original values are given in the parenthesis.

**Note 3:** Sampling methods – 6 leaves per plant; 5 plants per plot

**Note 4:** The entire table data was two weeks of average data

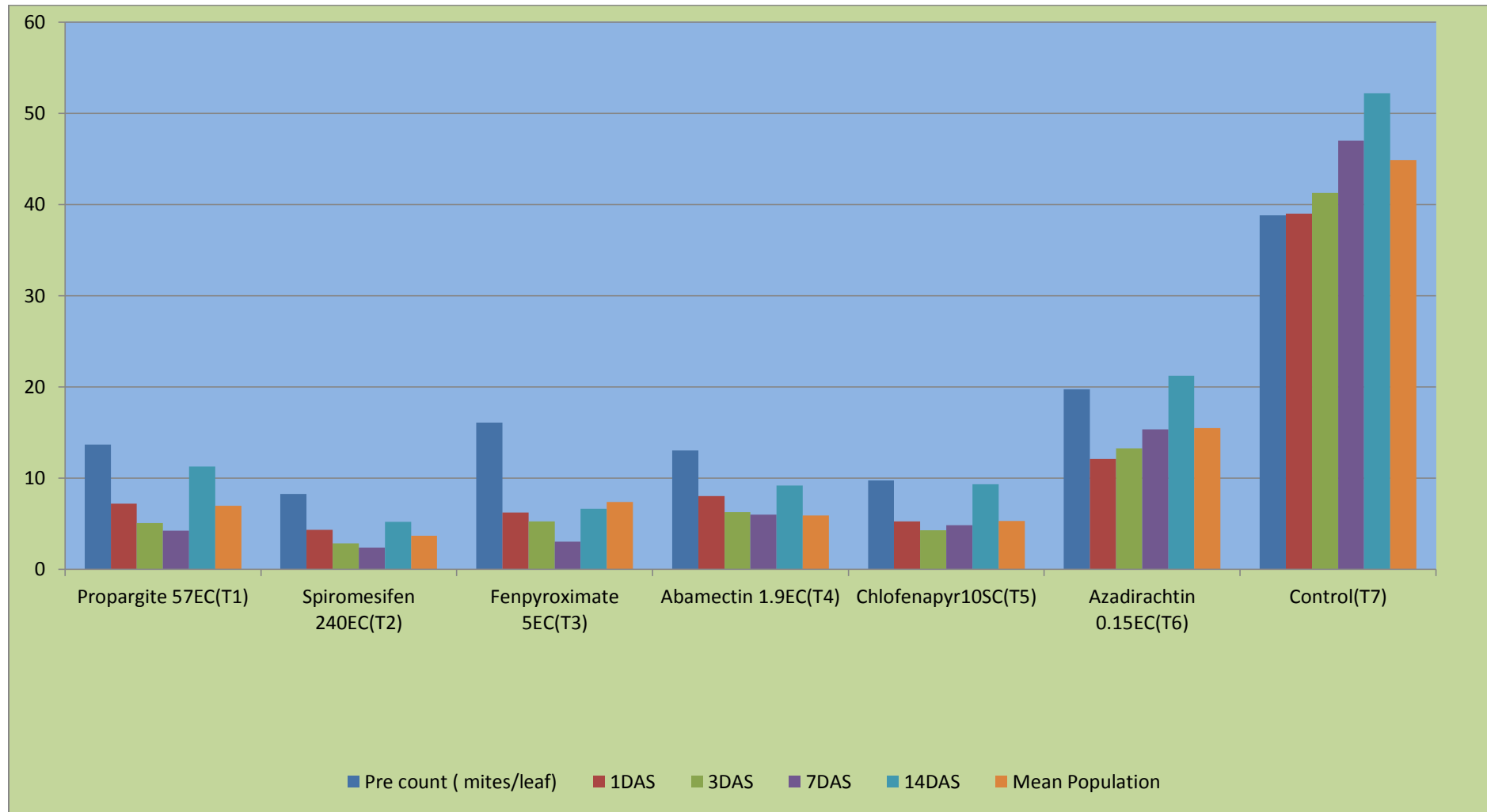


Fig.10: Field efficacy of different acaricides against phytophagous mites on brinjal crop (First spray)

The highest mean number of mites activity was observed in azadirachtin plots at 15.49 mites/leaf, followed by fenpyroximate treated plot at 7.39 mites/leaf, and the least number of mites on average was observed in Spiromesifen plots at 3.69 mites/leaf, followed by chlofenapyr treated plot at 5.29 mites/leaf, as compared to control plots at 44.87 mites/leaf.

The highest percent reduction over control was observed in plots treated with spiromesifen on par with chlofenpyr followed by abamectin, viz., 85.09 %, 83.02 %, and 79.03 %, respectively. The lowest percent reduction over control was observed in plots treated with azadirachtin at 64.92 %, followed by fenpyroximate at 69.06 %

The present study was comparable with Patel and Patel, 2017 who showed most efficient treatments for mites were fenazaquin 0.01% and spiromesifen 0.02%. Using spiromesifen 0.02% (37.91 tonnes/ha) and fenazaquin 0.01% (36.95 tonnes/ha) resulted in better fruit yields. Fenazaquin recorded the lowest percentage of preventable losses at 0.01% (2.52%), followed by diafenthiuron at 0.05% (11.76%). The treatment of spiromesifen 0.02% had the highest net realisation (1, 01,240/ha), proceeded by fenazaquin 0.01% (97,140/ha) and diafenthiuron 0.05% (78,540/ha). Kavya *et al.*, 2015 tested different acaricide for *T. urticae* control. Within three days of application, propargite (0.78 mites/leaf) and spiromesifen (1.05 mites/leaf) considerably reduced the overall mite population more than other acaricides, and this will result in a proportional increase in fruit output. They also mentioned predatory mite population was safe on plots treated with buprofezin, spiromesifen, and HMO. They reported the most effective compounds recorded more than 85% reductions on moving stages of *T. urticae* on cowpea were abamectin (91.91%), milbemectin (91.01 %), Ortus (90.65 %), and S-1283 (90.57%), 2,4- diphenyloxazoline (89.7%). The present study was supported by the mortality caused by spiromesifen is on par with abamectin. They both falls under same class of insecticide. Roopa, 2005 revealed spiromesifen (0.024%), difenthiuron (0.075%), and dicofol (0.046%) outperformed the other pesticides in the study when it came to killing spider mites at all stages, while dimethoate (0.05%), endosulfan (0.07%), methyl demeton (0.025%), monocrotophos (0.036%), and phosalone (0.07%) were ineffective. They also observed that Spiromesifen and difenthiuron had the highest fruit yields, with respective yields of 240.74 and 248.97 q/ha during the second season trial and 176.33 and 163.99 q/ha during the third season trial.

**Table 12: Field efficacy of different acaricides against phytophagous mites on brinjal (2<sup>nd</sup> spray)**

S. No	Treatment Details	Before Spraying (Pre count mites/leaf)	After Spraying(DAS) (mites/leaf)					Percent reduction over control
			1	3	7	14	Mean	
1	Propargite 57%EC	13.02 (3.87)	7.21 (2.87)	5.04 (2.46)	4.23 (2.29)	11.27 (3.50)	6.94 (2.82)	75.96 (60.95)
2	Spiromesifen 240%SC	8.24 (3.35)	4.34 (2.31)	2.85 (1.96)	2.36 (1.83)	5.21 (2.49)	3.69 (2.17)	85.09 (67.69)
3	Fenpyroximate5% EC	16.09 (4.13)	6.24 (2.69)	5.26 (2.50)	3.01 (2.00)	6.63 (2.76)	7.39 (2.90)	69.06 (56.27)
4	Abamectin 1.9%EC	09.75 (3.20)	8.01 (3.00)	6.27 (2.70)	6.00 (2.65)	9.26 (3.20)	5.91 (2.63)	79.03 (62.83)
5	Chlofenapyr10%SC	13.66 (3.70)	5.24 (2.50)	4.26 (2.29)	4.82 (2.41)	9.32 (3.21)	5.29 (2.51)	83.02 (65.27)
6	Azadirachtin0.15%EC	19.72 (4.44)	12.12 (3.62)	13.25 (3.77)	15.36 (4.04)	21.24 (4.72)	15.49 (4.06)	64.92 (53.73)
7	Control	34.83 (5.90)	39.01 (6.33)	41.25 (6.50)	47.02 (6.93)	52.20 (7.29)	44.87 (6.77)	-
	CD (0.05)	0.35		0.25	0.33	0.23	0.24	2.40
	SE. m(±)	0.11		0.07	0.12	0.08	0.07	0.75
	CV	8.06		9.01	7.38	8.74	10.36	6.47

**Note 1:** \* Figures were transformed by square root transformation and the original values are given in the parenthesis.

**Note 2:** \*\* Figures were transformed by arcsine transformation and the original values are given in the parenthesis.

**Note 3:** Sampling methods – 6 leaves per plant; 5 plants per plot

**Note 4:** The entire table data was two weeks of average data

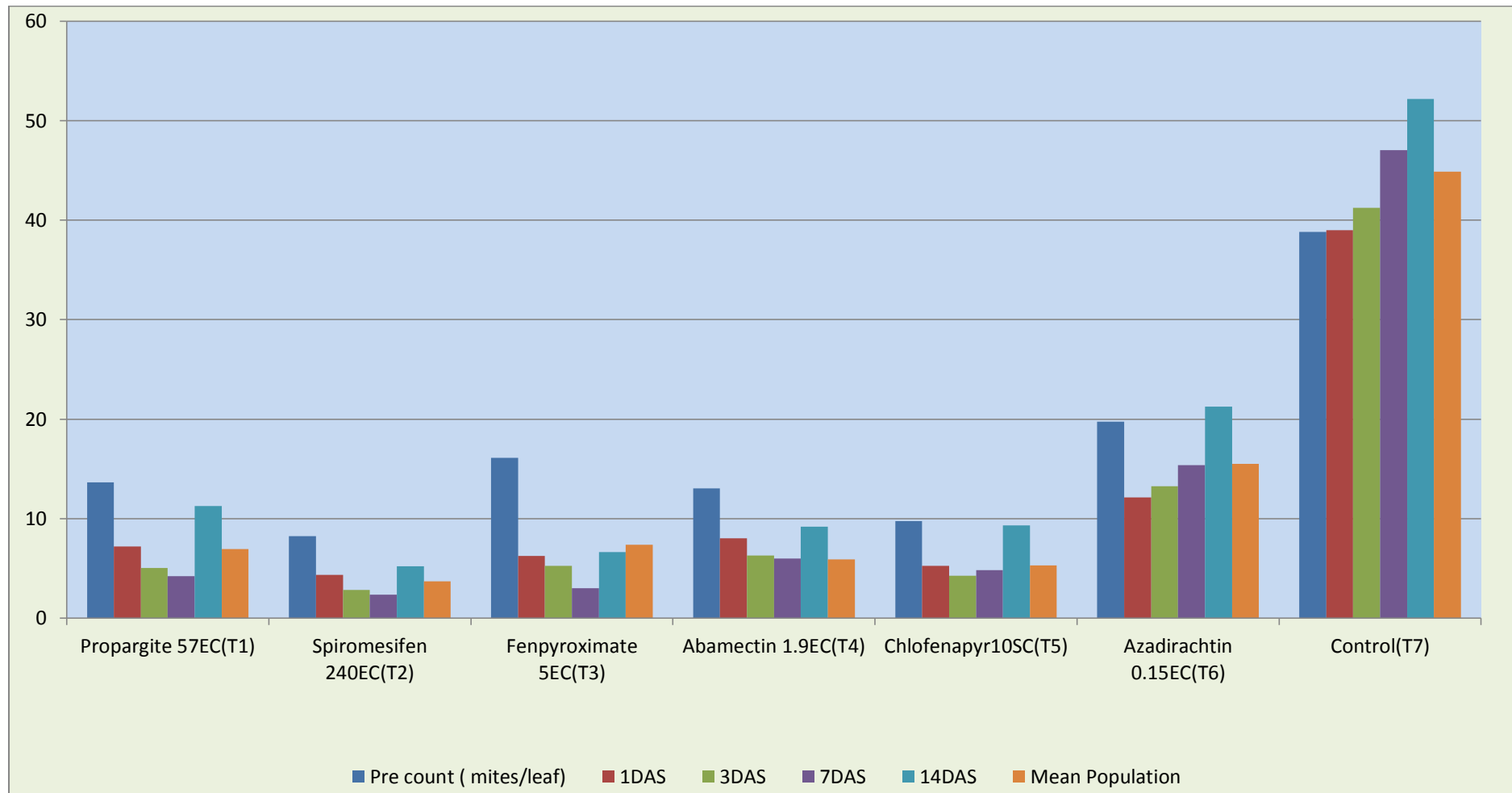


Fig. 11: Field efficacy of different acaricides against phytophagous mites on brinjal crop (2<sup>nd</sup> spray)

### 4.3.3 Pooled over two sprays

Overall pooled data (Table 13 and Fig.12) for the two sprays showed that spiromesifen 240 EC was much more effective than the other treatments at reducing the population of the mite *T. urticae*, followed by chlorfenapyr 10EC. These two treatments showed the mite incidence to be much lower (4.78 to 5.92 mites/2.5cm<sup>2</sup> leaf area).

However, it was also determined that propargite 57EC and abamectin 1.9 EC were the next best treatments. Fenpyroximate 5EC was shown to be moderately effective in treating brinjal mites, with a 10.52 mite count per 2.5 cm<sup>2</sup> of leaf area. Moreover, the azadirachtin-treated plot recorded fewer mites per 2.5 cm<sup>2</sup> of leaf area (21.27) than the control plot (39.46mites/2.5cm<sup>2</sup> leaf area).

The current study's observation of spiromesifen's excellent effectiveness against brinjal mite is consistent with those reported by Roopa (2005), Reddy *et al.* (2014), Varghese and Mathew (2013), and Kavitha *et al.* (2006).

According to Reddy *et al.* (2014), under laboratory and greenhouse conditions, the acaricide spiromesifen 0.02% recorded a greater mortality of the cucumber mite, *T. urticae*. According to Varghese and Mathew's (2013) report, spiromesifen 45 SC @ 100 g a.i./ha was successful in lowering the number of chilli mites.

According to Kavitha *et al.* (2006), spiromesifen at 120 g a.i./ha was found to be more effective at controlling the chilli mite.

Table13 : Effect of different acaricides against brinjal mite, *T. urticae* after two sprays

Treatments	*Number of mites/ leaf ( 2.5cm <sup>2</sup> leaf area)		
	1 <sup>st</sup> spray	2 <sup>nd</sup> spray	Pooled
<b>Propargite 57%EC</b>	9.76 (3.17)	6.94 (2.82)	8.35 (3.05)
<b>Spiromesifen240%EC</b>	5.94 (2.63)	3.69 (2.17)	4.86 (2.41)
<b>Fenpyroximate 5%EC</b>	13.66 (3.28)	7.39 (2.90)	10.52 (3.39)
<b>Abamectin 1.9%EC</b>	9.02 (3.17)	5.91 (2.63)	7.45 (2.89)
<b>Chlofenapyr10%SC</b>	6.55 (2.75)	5.29 (2.51)	5.92 (2.13)
<b>Azadirachtin 0.15%EC</b>	16.80 (4.22)	15.49 (4.06)	16.15 (4.02)
<b>Control</b>	34.06 (5.92)	44.87 (6.77)	39.46 (5.76)
S.Em(±)	0.23	0.25	
C.D at 5%	0.25	0.33	
CV(%)	7.60	7.80	

\* Figures were transformed by square root transformation.

CD- Critical difference

#### **4.3.4 Fruit Yield**

After two sprays, the yield of brinjal fruits was calculated, and the results showed that the maximum output (12.91 tonnes/ha) was significantly higher than the control plot when the fruit was harvested from the plots treated with spiromesifen 240EC and found to be 90.20% higher than the control. Abamectin 1.9EC was the next-highest compound which gave 8.84 tonnes/ha after chlofenapyr 10SC (10.80 tonnes/ha). The plots sprayed with propargite 57% EC and fenpyroximate 5% EC yielded more than the control plot (5.81 and 4.15 tonnes/ha, respectively).

The azadirachtin 0.15% EC treatment increased the fruits yield by 2.9 tonnes per hectare over the the control plot.

This result is consistent with Roopa's earlier study from 2005, which found that the highest fruit yields were obtained with spiromesifen 0.02% and diafenthiuron 0.05%, which gave, respectively, 240.74 and 248.97 q/ha during the second and 176.33 and 163.99 q/ha during the third season trials that the highest fruit yields were achieved with spiromesifen 0.02% and diafenthiuron 0.05%, which gave, respectively, 240.74 and 248.97 q/ha during the second and 176.33 and 163.99 q/ha during the third season trials.

This finding is in conformity with the earlier report of Roopa (2005), who reported that maximum fruit yield was recorded in spiromesifen 0.02% and diafenthiuron 0.05% gave 240.74 and 248.97 q/ha during second and 176.33 and 163.99 q/ha during third season trial, respectively.

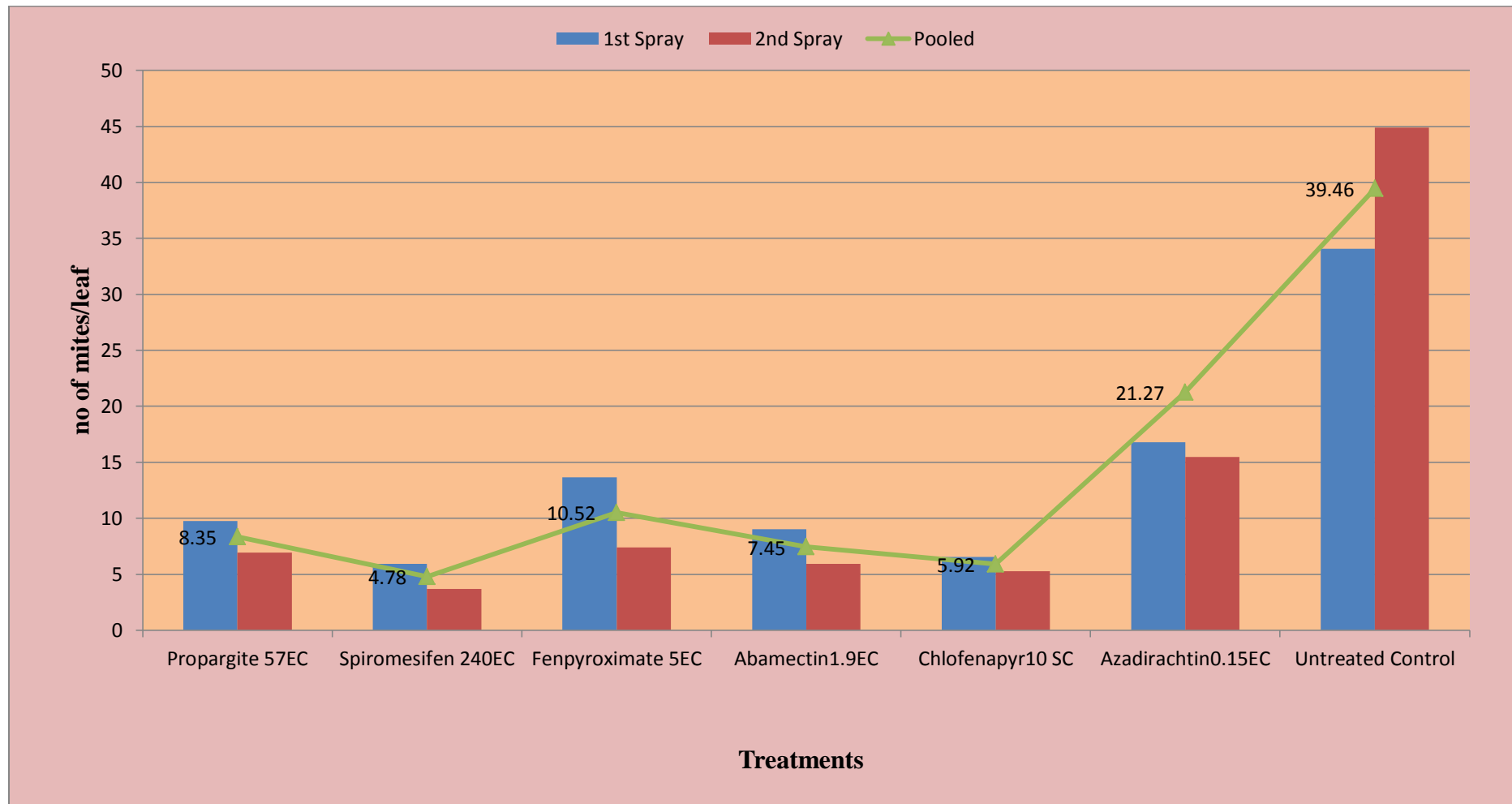


Fig. 12: Effect of different acaricides against brinjal mite, *T. urticae* after two sprays

**Table 14: Effect of different acaricides on brinjal fruit yield during crop period 2022.**

Treatment	Acaricides	Dose (ml /ha)	Fruit yield (t/ha)	Yield increase over control ( t/ ha)	% increase over control
T1	Propargite 57%EC	1000	20.11	5.81	40.6
T2	Spiromesifen240%EC	400	27.21	12.91	90.2
T3	Fenpyroximate5%EC	500	18.45	4.15	29.0
T4	Abamectin1.9% EC	400	23.14	8.84	61.8
T5	Chlofenapyr10%EC	750	25.10	10.80	75.52
T6	Azadirachtin0.15%EC	2500	17.20	2.9	20.27
T7	Control	-	14.30	-	

#### 4.3.3. Determination of Incremental Benefit - Cost Ratio

The benefit – cost ratio was significantly influenced by different acaricides treated brinjal while the interaction of these treatments on brinjal was statically traceable 00 (Table 15 and Fig. 12 ). Among the treatments, values ranged from 1.13 : 1 to 5.34 :1. The maximum benefit-cost ratio was recorded with Spiromesifen treated brinjal plots at 5.34:1, followed by Chlofenpyr treated plots at 4.47:1. The lowest cost-benefit ratio was observed in Azadirachtin treated plot at 1.13:1, followed by Fenpyroximate at 1.82: 1.

According to the Patel and Patel, 2017experiment, fenazaquin 0.01% and spiromesifen 0.02% were the most successful pesticides against the mite *T. urticae* for improved crop protection in brinjal, which led to a larger fruit yield and higher net profits. Same as our cost benefit ratio they also obtained highest incremental cost-benefit ratio (ICBR) in fenazaquin 0.01% (1:27.84) and spiromesifen 0.02% (1:24.70). However, spiromesifen 0.02% also proved to be the most effective against *T. urticae* and recorded the highest fruit yield with the highest net realisation. The economics of several insecticides revealed that spiromesifen 0.02% treatment yielded the highest net realisation (1, 01,240/ha), proceeded by fenazaquin 0.01% (97,140/ha) and diafenthiuron 0.05% (78,540/ha).

**Table 15: Economics of different treatments evaluated for efficacy against Brinjal tetranychid mites, Tetranychus urticae during 2022**

Treatment	Dose (ml/ha)	Cost of insecticide(Rs/ha)	Labour cost per person	Cost of one spray (Rs/ha)	No. of spray	Total Protection cost (Rs/ha)	Cost of cultivation (Rs/ha)	Total cost of production (Rs/ha)	Yield (t/ha)	Additional yield (t/ha)	Additional income (Rs/ha)	Net Additional income (Rs/ha)	B:C Ratio
Propargite57EC	1000	1080	336	1752	2	3504	42000	45504	20.11	5.81	116200	112696	2.47:1
Spiromesifen240EC	400	1993	336	2665	2	5320	42000	47320	27.21	12.91	258200	252880	5.34:1
Fenpyroximate 5EC	500	450	336	1122	2	2244	42000	44244	18.45	4.15	83000	80756	1.82:1
Abamectin1.9EC	400	2956	336	3628	2	7256	42000	49256	23.14	8.84	176800	169544	3.44:1
Chlofenapyr10	750	2475	336	3147	2	6294	42000	48294	25.10	10.80	216000	171756	4.47:1
Azadirachtin	2500	1750	336	2422	2	4844	42000	46844	17.20	2.90	58000	53156	1.13:1
Control	-	-	-	-	-	-	42000	-	14.30	-	-	-	-

**Note 1:** Brinjal per kg 20 Rs; labour cost 336per day; 2 labours per spray; Cost of cultivation excluding protection – 42000 Rs/ha

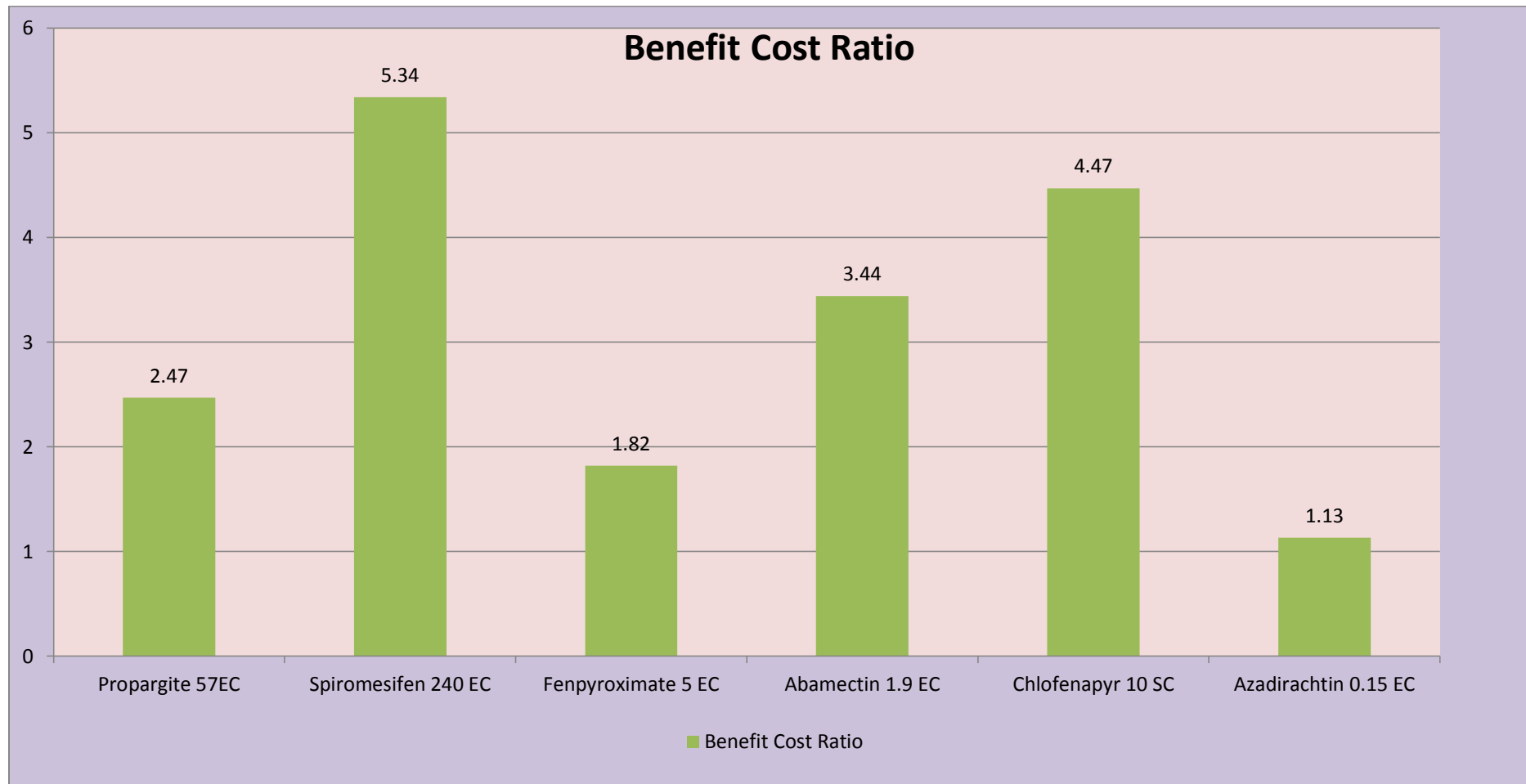


Fig. 13: Benefit cost ratio against different acaricides on brinjal crop





## **CHAPTER - VI**



## **SUMMARY AND CONCLUSION**



## SUMMARY AND CONCLUSIONS

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Brinjal (*Solanum melongena* L.), a member of the Solanaceae family and a purported native of India. It is among the most well-liked and commonly cultivated vegetable crops in both India and the rest of the world. It is a warm-season crop that needs a long, warm growth season because it is highly frost-sensitive. The ideal pH range for this crop's cultivation is 5.5 to 6.6, and the best temperature range for its successful production is 13 to 21°C. It has a high nutritional value because it is rich in minerals including calcium, magnesium, potassium, iron, phosphorus, and fatty acids as well as vitamins A, B, and C. The fruit brinjal is an excellent cholesterol-lowering food. In addition, brinjal contains significant amounts of phenolics and ascorbic acid, both of which are strong antioxidants. Even though brinjal is farmed all year round, several insect and non-insect pests attack it from the nursery stage to the fruiting stage, which lowers output and degrades the quality of brinjal fruits. Shoot and fruit borer, leaf roller, stem borer, blister beetle, spotted beetles, and other pests have been cited as the major pest of brinjal. The most infamous non-insect pests are arguably mites, which have become incredibly important in recent years due to their destructive nature particularly red spider mite, *T. urticae*.

Mites typically suck the sap from the underside of leaves producing little white specks that gradually dry and fall off. Plant development, flowering, and fruiting are negatively impacted by the diminished vigour and leaf loss. Tetranychid mites can produce a thick sheath of webbing that covers the entire plant during a severe infection. So in view of the damage caused by the mites it is important to evaluate the seasonal incidence and the management by using acaricides. The current research was carried out in a field condition on **“Survey of Major Phytophagous mites, its associated natural enemies and their management through Acaricides on Brinjal Crop during Summer Season”** during 2022. The results of the research are summarized below.

In the Samastipur district, four villages were surveyed *viz.*, Chandauli, Gopalpur Thara, Narayanpur and Harpur. Among the four villages surveyed in Samastipur district, a maximum of 26.21 tetranychid mites per leaf was observed in Harpur village. When it comes to natural enemies, Chadauli village reported the highest number of them, where five types of natural enemies were observed on each

visit. Besides, the other district covered was Muzaffarpur, where four villages, viz., Loutan, Muraul, Mirapur, and Ittha, were visited. In the district of Muzaffarpur, the tetranychid mite's occurrence trend viz., Ittha (21.20 mites/leaf) >Mirapur (19.52 mites/leaf) >Loutan (15.58 mites/leaf) >Mural (15.10 mites/leaf). In terms of natural enemies, Mural village had the highest number of natural enemies (6 types per visit).

The *T. urticae* population started recording during the 1<sup>st</sup> fortnight of January and was noticed up to the 2<sup>nd</sup> fortnight of June. The highest *T. urticae* population of 35.15 mites/ 2.5 cm<sup>2</sup> leaf area was observed during the 1<sup>st</sup> fortnight of June. In the 1<sup>st</sup> fortnight of February, the population of *T. urticae* was lowest at 5.26 mites/2.5 cm<sup>2</sup> leaf area. The data pertaining to the relationship between *T. urticae* population and weather conditions indicated that maximum and minimum temperatures had positive and significant effects ( $r = 0.744$  and  $0.783$ ) on the mite population. However, the relationship of mites with morning relative humidity was significant and negative ( $r = -0.834$ ). In the case of evening relative humidity, it shows a negative and non-significant relationship ( $-0.469$ ). Mite population, on the other hand, was not affected by rainfall ( $r = -0.0162$ ), which was a negative correlation.

The *A. indicus* population which varied from 0.75 to 12.23 mites/ 2.5 cm<sup>2</sup> leaf area, was first noted in the 1<sup>st</sup> fortnight of January and was observed until the 2<sup>nd</sup> fortnight of June. The maximum *A. indicus* population of 12.23 mites/ 2.5 cm<sup>2</sup> leaf area was noted during the 1<sup>st</sup> fortnight of June. The population of *A. indicus* reached its lowest point in the first fortnight of February, with 0.75 mites per 2.5cm<sup>2</sup> leaf area. The data pertaining to the relationship between *A. indicus* population and weather indicators showed that the highest and lowest temperatures had positive and significant effects ( $r = 0.715$  and  $0.733$ ) on the mite population. However, the relationship of mites with morning relative humidity was significant and negative ( $r = -0.775$ ). In the case of evening relative humidity, it shows a negative and non-significant relationship ( $-0.410$ ). Whereas, rainfall had a negative correlation and a non-significant ( $r = -0.207$ ) influence on the mite population.

The coccinellids population started recording during the 1<sup>st</sup> fortnight of January and was noticed up to the 2<sup>nd</sup> fortnight of June. The highest coccinellids population of 12.09 coccinellids/ 5 plants was noticed during the 2<sup>nd</sup> fortnight of April. In the 2<sup>nd</sup> fortnight of January, the population of coccinellids was lowest at 1.75 coccinellids/5 plants. The results indicated that maximum temperatures had a positive

and significant effects ( $r = 0.694$ ) while minimum temperature had positive and non-significant effect (0.486) on the coccinellid population. However, the correlation between morning and evening relative humidity and mites was significant and negative ( $r = -0.638$  and  $r = -0.790$ ). Whereas rainfall had a negative correlation and a non-significant ( $r = -0.432$ ) influence on the coccinellid population.

The green lace wing population which varied from 0.00 to 7.55 green lace wings/ 5 plants, was first noted in the 2<sup>nd</sup> fortnight of January and was observed until the 2<sup>nd</sup> fortnight of June. The maximum green lace wings population of 7.55 green lace wings/ 5 plants was captured during the 2<sup>nd</sup> fortnight of April. The population of green lace wing reached its lowest point in the 2<sup>nd</sup> fortnight of January, with 1.02 green lacewing per 5 plants. The data pertaining to the relationship between green lace wing population and weather parameters indicated that maximum temperatures had positive and significant effects ( $r = 0.670$ ) on the green lace wing population. On the other hand, minimum temperature shows a positive and non-significant ( $r = 0.427$ ) relationship with green lace wings. However, the relationship of mites with evening relative humidity was significant and negative ( $r = -0.839$ ). In the case of morning relative humidity, it shows a negative and non-significant relationship ( $-0.535$ ) whereas rainfall had a negative correlation and a non-significant ( $r = -0.420$ ) influence on the mite population.

Data pertaining to the efficacy of various insecticides after the first spray results indicated that at one day after spray (1 DAS), Spiromesifen treated plot recorded the lowest number of mites (7.32 mites/leaf). On the other hand, the highest number of active mites was present in Azadirachtin treated plots at 17.27 mites/leaf. At 3 DAS the lowest number of mites 4.21 mites per leaf was found in chlofenapyr treated plot and at 7 DAS, the lowest number of mites was found in spiromesifen treated plots at 3.89 mites/leaf. The highest number of mites was found in Azadirachtin treated plots at 15.15 mites/leaf. At 14 DAS, the lowest number of active mites was observed in Spiromesifen treated plot at 8.24 mites/leaf, whereas the highest number of active mites was observed in Azadirachtin treated plots at 19.72 mites/leaf. The highest mean number of mites activity was observed in Azadirachtin treated plots at 16.80 mites/leaf, and the fewest amount of mites activity was observed in Spiromesifen treated plot at 5.94 mites/leaf. The greatest percent reduction compared to the control was observed in plots treated with Spiromesifen on par with

Chlofenpyr and Abamectin, viz., 88.60 %, 88.00 %, and 85.75 %, respectively. The lowest per cent reduction over control was noticed in plots treated with Azadirachtin at 57.25 %.

Information on the effectiveness of various pesticides after the second spray results indicated that at one day after spray (1 DAS), Spiromesifen treated plot recorded the lowest number of mites (4.34 mites/leaf). On the other hand, the highest number of active mites was present in Azadirachtin treated plots at 12.12 mites/leaf. At three days after spray (3 DAS), the lowest number of mites was found in Spiromesifen treated plots at 2.85 mites/leaf, while the highest number of mites was found in Azadirachtin treated plots at 13.25 mites/leaf. At seven days after spray (7 DAS), Spiromesifen treated plots had the fewest mites (2.36 mites/leaf), while Azadirachtin treated plots had the most mites (15.36 mites/leaf). At 14 days after spray (14 DAS), the lowest number of active mites was observed in Spiromesifen treated plots at 5.21 mites/leaf, whereas the highest number of active mites was observed in Azadirachtin treated plots at 21.24 mites/leaf. The highest mean number of mites activity was observed in Azadirachtin plots at 15.49 mites/leaf, and the lowest number of mites activity was observed in Spiromesifen plots at 3.69 mites/leaf. The highest percent reduction over control was observed in plots treated with Spiromesifen (85.09%). The lowest per cent reduction over control was observed in plots treated with Azadirachtin at 64.92 %.

From the overall data of fruit yield and acaricides efficacy of all treatments, it is revealed that the lowest mean population and maximum fruit yield was found in Spiromesifen( 4.86mites/ leaf and 12.91t/ha) treated plot which was at par with Chlofenapyr(5.92mites/ leaf and 10.80t/ha). Among the remaining treatments Abamectin 97.45 mites/ leaf found the next superior followed by propargite (8.35 mites/ leaf and 5.81t/ha) and fenpyroximate (10.52 mites/leaf and 4.15t/ha). Azadirachtin (16.15mite/ leaf and 2.9t/ha) showed inferior to the above mentioned acaricides but significantly superior to the untreated control.

On the basis of incremental benefit- cost ratio, spriomesifen treated found the highest which was at par with chlofenapyr treated plot.

## Conclusions

1. In the study, two species of tetranychid mites, two species of predatory mites and seven predatory insects were recorded viz., *Tetranychus urticae*, *T. neocaedelonicus*, *Amblyseius indicus*, *A. tetranychivorous*, Coccinellids, Green lacewing, Anthocorid bugs, Mirid bugs, Scolothrips and Black ants.
2. In the Samastipur district, four villages were surveyed, of these; Harpur village had the highest number of tetranychid mites' population while Chandauli village had the most natural enemies.
3. In the district of Muzaffarpur, the tetranychid mite's occurrence trend in different villages, viz., Ittha >Mirapur >Lautan>Murai. In terms of natural enemies, Muraul village had the highest number of natural enemies (6 types per visit).
4. The *T. urticae* population started recording during the 1<sup>st</sup> fortnight of January and was noticed up to the 2<sup>nd</sup> fortnight of June. The highest *T. urticae* population was observed during the 1<sup>st</sup> fortnight of June while the lowest population was observed in the 1<sup>st</sup> fortnight of February.
5. The data pertaining to the relationship between the *T. urticae* population and weather parameters indicated that maximum and minimum temperatures had positive and significant effects on the mite population. However, the relationship of mites with morning relative humidity was significant and negative. In the case of evening relative humidity, it shows a negative and non-significant relationship. The mite population, on the other hand, was not affected by rainfall, which was a negative correlation.
6. The *A. indicus* population was first noted in the 1<sup>st</sup> fortnight of January and was observed until the 2<sup>nd</sup> fortnight of June. The maximum *A. indicus* population was recorded during the 1<sup>st</sup> fortnight of June while the first fortnight of February saw the lowest population.
7. The data pertaining to the relationship between the *A. indicus* population and weather parameters indicated that maximum and minimum temperatures had positive and significant effects on the mite population. However, the relationship of mites with morning relative humidity was significant and negative. In the case of evening relative humidity, it shows a negative and

- non-significant relationship. Whereas rainfall had a negative correlation and a non-significant influence on the mite population.
8. The coccinellid population started recording during the 1<sup>st</sup> fortnight of January and was noticed up to the 2<sup>nd</sup> fortnight of June. The highest coccinellid population was observed during the second fortnight of April, while the fewest coccinellid population was observed during the second fortnight of January.
  9. The results indicated that maximum temperatures had a positive and significant effects while minimum temperature had positive and non-significant effect on the coccinellid population. However, the correlation between morning and evening relative humidity and mites was significant and negative. Whereas rainfall had a negative correlation and a non-significant influence on the coccinellid population.
  10. The population of green lacewing was first noted in the 2<sup>nd</sup> fortnight of January and was observed until the 2<sup>nd</sup> fortnight of June. The maximum green lacewings population was noted during the 2<sup>nd</sup> fortnight of April. The population of green lacewing reached its lowest point on the 2<sup>nd</sup> fortnight of January.
  11. The data pertaining to the relationship between the green lace wing population and weather parameters indicated that maximum temperatures had positive and significant effects on the green lace wing population. On the other hand, the minimum temperature shows a positive but non-significant relationship with green lace wings. However, the relationship of mites with evening relative humidity was significant and negative. In the case of morning relative humidity, it shows a negative and non-significant relationship. Whereas rainfall had a negative correlation and a non-significant influence on the mite population.
  12. Data pertaining to the efficacy of various acaricides Chlofenapyr10SC and Spiromesifen 240EC observed the lowest number of mites. On the other hand, the most number of active mites was present in Azadirachtin 1.9EC treated plots in both the sprays.
  13. The highest per cent reduction over control was observed in plots treated with Spiromesifen and the lowest per cent reduction over control was observed in plot treated with Azadirachtin.

14. Lastly, the comparative order of acaricides against the phytophagous mite based on field efficacy, fruit yield and gross income over control were as follows:

Spiromesifen > Chlofenapyr > Abamectin > Propargite > Fenpyroximate > Azadirachtin.

**Future thrust**

- Studies are required on mite taxonomy on various Solanaceae crops.
- Extensive mite survey work is required in the Bihar region.
- The season incidence pattern of brinjal phytophagous mites in various seasons is required, and finding alternative hosts for odd-season survivability studies is also required.
- The incidence pattern of the pests should be changed at different nutritional levels. Hence, further experimentation is required.
- Climate change impact studies on brinjal pests are also mandatory
- Screening of different new molecules against brinjal mites studies is required.





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# **APPENDIX**



## APPENDIX

### Record of weather parameters during the experimental plot

Month	Fortnight	Temperature °C		Relative humidity (%)		Rainfall (mm)	Bright sunshine (hr)
		Maximum	Minimum	Morning	Evening		
January 2022	I	20.69	11.49	95.73	73.60	4.6	2.46
	II	18.70	9.38	95.56	68.56	0.00	1.77
February 2022	I	20.74	10.09	95.78	67.78	29.6	5.03
	II	25.35	12.18	92.92	55.07	0	7.73
March 2022	I	29.45	13.92	92.26	51.2	0	8.58
	II	34.14	19.86	89.37	53.31	0	6.67
April 2022	I	34.82	22.48	91.21	57.5	0	5.57
	II	36.57	21.54	83.31	46.12	0	6.68
May 2022	I	33.35	22.51	86.6	59.26	86.6	7.72
	II	33.83	23.51	86.37	63.43	39.4	6.65
June 2022	I	34.99	25.59	85.35	63.64	0	5.33
	II	34.27	24.85	89.93	68.43	75.5	4.46
July 2022	I	35.28	26.38	83.33	64.46	5.0	9.71
	II	33.67	25.35	91.00	72.00	200.3	4.7

