

**“Study on the management of major insect  
pests of brinjal (*Solanum melongena* L.)  
through botanicals and bio-pesticides”**

**THESIS**

*Submitted to*

**Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur**

**In partial fulfillment of the requirements  
for the Degree of**

**MASTER OF SCIENCE**

*In*

**AGRICULTURE**

**(Entomology)**

*By*

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**2020**

## CERTIFICATE - I

This is to certify that the thesis entitled, “**Study on the management of major insect pests of brinjal (*Solanum melongena* L.) through botanicals and bio-pesticides**” submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (Ag) in Agriculture (Entomology)** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Ms. S.ABIRAMI** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.

All the assistance and help received during the course of the investigation has been acknowledged by him.

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## CERTIFICATE - II

This is to certify that the thesis entitled “**Study on the management of major insect pests of brinjal (*Solanum melongena* L.) through botanicals and bio-pesticides**” submitted by **Ms. S.ABIRAMI** to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in Agriculture** in the **Department of Entomology** has been, after evaluation, approved by the External Examiner and by the Student’s Advisory Committee after an oral examination on the same.

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## Acknowledgement

I express my deep sense of gratitude to Dr. M.K. Nayak, Assistant Professor, Department of Entomology, JNKVV, College of Agriculture, Tikamgarh and the Chairman of my Advisory Committee for his dexterous guidance, incessant encouragement, constructive criticism and sympathetic attitude during the entire period of this investigation and preparation of this enterprise of scientific utility.

I am greatly indebted to Dr. A.K. Sarawgi, (Agril. Economics and Farm Mgt.) Dean, College of Agriculture, Tikamgarh, Dr. R.S. Marabi Assistant Professor (Entomology), Dr. D.S. Tomar, Associate Professor (Plant Pathology) and Dr. Umesh Singh, Assistant Professor (Department of Agricultural Statistics) for their advice and help during the course of the present investigation.

I am very much thankful to Dr. P.K. Bisen, Hon'ble Vice-Chancellor, JNKVV, Jabalpur, Dr. D. Khare, Dean, Faculty of Agriculture, Dr. Abhishek Shukla, Director of Instructions, JNKVV and Dr. P.K. Mishra Director of Research Services JNKVV Jabalpur for providing facilities and encouragement for the research work.

I am immensely thankful to my friends Ajay Prasanth, Kavitha, Rashmi, Dharatri, Shalini, Jyosthna, Shivani, Vinitha, Ravi Shankar, Hariom, Manoj, Manikandan and my seniors Sanjay, Alka, Vaishali, Khushboo, Mehak, Sreenivas and my loving juniors Naveen, Deepika who have inspired me in all respects and have given me their valuable time and energy at various stages of this work.

This work would have been rather impossible without the moral support and constant inspiration of my respected and beloved father Shri N.Shanmugam and mother Smt. N.Rajagarani and my lovely brother S.Pragadeesh whose affection, patience, constant inspiration, blessings and care throughout my life enabled me in my ascent to the present accomplishment. I acknowledge very heartily the contributions of all my wee wishers whose name due to paucity of space not mentioned here.

My sincere thanks to Dr. S. Arivudainambi, Professor of Entomology, Faculty of Agriculture, Annamalai University, Dr. V. Selvanarayanan, Professor of Entomology, Faculty of Agriculture, Annamalai University and Dr. M. Pazhanisamy, Assistant Professor of Entomology, Faculty of Agriculture, Annamalai University for inspiring me.

Above all, my humble and whole hearted prostration to Lord Muruga, Lord Krishna & Lord Shiva for their blessings.

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Dated:06.08.2020

**S.Abirami**

## List of Contents

<b>Chapter number</b>	<b>Title</b>	<b>Page</b>
1.	Introduction	1-3
2.	Review of Literature	4-14
3.	Materials and Methods	15-25
4.	Results	26-85
5.	Discussion	86-92
6.	Summary, Conclusions and Suggestions for further work	93-97
6.1	Summary	93-95
6.2	Conclusions	95-96
6.3	Suggestions for further work	96-97
7.	Bibliography	98-103
8.	Appendices	104

## List of Tables

Table number	Title	Page
3.1	Weekly meteorological observation during <i>kharif</i> season (July -December) 2019 at Tikamgarh (M.P.)	17
3.2	Treatment details	21
3.3	The skeleton of the analysis of variance	23
4.1	Seasonal incidence of major insect pests on brinjal at weekly interval, during the crop growth period ( <i>Kharif</i> 2019-2020)	27
4.2	Correlations were observed between insect pests of brinjal and weather factors.	29
4.3	Table 4.3 Efficacy of botanicals and bio-pesticides in the management of whitefly, <i>Bemisia tabaci</i> during 1 <sup>st</sup> spray	34
4.4	Table 4.4 Efficacy of botanicals and bio-pesticides in the management of whitefly, <i>Bemisia tabaci</i> during 2 <sup>nd</sup> spray.	38
4.5	Efficacy of botanicals and bio-pesticides in the management of whitefly, <i>Bemisia tabaci</i> 3 <sup>rd</sup> spray.	42
4.6	Efficacy of botanicals and bio-pesticides in the management of jassid, <i>Amrasca biguttula biguttula</i> during 1 <sup>st</sup> spray.	46
4.7	Efficacy of botanicals and bio-pesticides in the management of jassid, <i>Amrasca biguttula biguttula</i> during 2 <sup>nd</sup> spray	50
4.8	Efficacy of botanicals and bio-pesticides in the management of jassid, <i>Amrasca biguttula biguttula</i> during 3 <sup>rd</sup> spray	54
4.9	Efficacy of botanicals and bio-pesticides in the management of shoot and fruit borer, <i>Leucinodes orbonalis</i> during 1 <sup>st</sup> spray.	58
4.10	Efficacy of botanicals and bio-pesticides in the management of shoot and fruit borer, <i>Leucinodes orbonalis</i> during 2 <sup>nd</sup> spray.	62

<b>Table number</b>	<b>Title</b>	<b>Page</b>
4.11	Efficacy of botanicals and bio-pesticides in the management of shoot and fruit borer, <i>Leucinodes orbonalis</i> during 3 <sup>rd</sup> spray	66
4.12	Pooled Mean of 1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> spray (Whitefly and Jassid)	69
4.13	Pooled Mean of 1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> spray ( <i>L. orbonalis</i> )	71
4.14	Effect of bio-pesticidal treatments on fruit infestation percentage at different pickings against <i>L.orbonalis</i>	78
4.15	Yield of brinjal in different bio- pesticial treatment during <i>Kharif</i> 2019-20.	80
4.16	Economics of different biopesticides on pest complex of brinjal during <i>Kharif</i> 2019-20.	84
4.17	Cost of botanicals and bio-pesticides	84

## List of Figures

Figure Number	Title	Page
1	Weekly meteorological observation during <i>kharif</i> season 2019-20 at Tikamgarh (M.P.)	18
2	Layout of the experimental field	22
3	Incidence of sucking pests on brinjal at Tikamgarh during <i>kharif</i> 2019-20	28
4	Incidence of shoot and fruit borer on brinjal at Tikamgarh during <i>kharif</i> 2019-20	28
5	Efficacy of botanicals and biopesticides in the management of whitefly, <i>Bemisia tabaci</i> (1 <sup>st</sup> spray)	35
6	Efficacy of botanicals and biopesticides in the management of whitefly, <i>Bemisia tabaci</i> (2 <sup>nd</sup> spray)	39
7	Efficacy of botanicals and biopesticides in the management of whitefly, <i>Bemisia tabaci</i> (3 <sup>rd</sup> spray)	43
8	Efficacy of botanicals and biopesticides in the management of jassid, <i>Amrasca biguttula biguttula</i> (1 <sup>st</sup> spray)	47
9	Efficacy of botanicals and biopesticides in the management of jassid, <i>Amrasca biguttula biguttula</i> (2 <sup>nd</sup> spray)	51
10	Efficacy of botanicals and biopesticides in the management of jassid, <i>Amrasca biguttula biguttula</i> (3 <sup>rd</sup> spray)	55
11	Efficacy of botanicals and biopesticides in the management of shoot and fruit borer, <i>Leucinodes orbonalis</i> (1 <sup>st</sup> spray)	59
12	Efficacy of botanicals and biopesticides in the management of shoot and fruit borer, <i>Leucinodes orbonalis</i> (2 <sup>nd</sup> spray)	63
13	Efficacy of botanicals and biopesticides in the management of shoot and fruit borer, <i>Leucinodes orbonalis</i> (3 <sup>rd</sup> spray)	67

<b>Figure Number</b>	<b>Title</b>	<b>Page</b>
14	Efficacy of botanicals and biopesticides in the management of whitefly, <i>Bemisia tabaci</i> (1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> spray)	70
15	Efficacy of botanicals and biopesticides in the management of jassid, <i>Amrasca biguttula biguttula</i> (1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> spray)	70
16	Efficacy of botanicals and biopesticides in the management of shoot and fruit borer, <i>Leucinodes orbonalis</i> (1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> spray)	71
17	Effect of bio-pesticidal treatments on fruit infestation percentage at different pickings against <i>L.orbonalis</i>	79
18	Yield of brinjal in different bio- pesticial treatment during <i>Kharif</i> 2019-20	81
19	Economics of treatments	85

## List of Symbols

S.N.	Symbol	Abbreviation	Description
1	%		Per cent
2	°C		Degrees Celsius
3	@		At the rate of
4	:		Colon
5		g	Gram
6		Mg	Milligram
7		µg	Microgram
8		MT	Metric Tonnes
9		ha	Hectare
10		<i>et al.</i>	Co-workers
11		mm	Millimetre
12		<i>Viz.</i>	Wide list
13		EC	Emulsifiable concentrate
14		SL	Soluble liquid
15		SG	Soluble Granules
16		SC	Soluble Concentrate
17		ml	Millilitre
18		a.i.	Active ingredient
19		q	Quintal
20		l	Litre
21		ppm	Parts per million
22		cm	Centimetre
23		m <sup>2</sup>	Metre square
24		N	Nitrogen
25		P	Phosphorus
26		O	Oxygen
27		K	Potassium
28		m	Metre
29		H	Hour
30		RH	Relative humidity
31		DBS	Days before spraying
32		DAS	Days after spraying
33		SMW	Standard Meteorological Week

## INTRODUCTION

Brinjal, *Solanum melongena* (L.) is also known as eggplant, belongs to family Solanaceae. The eggplant is a delicate, tropical perennial plant often cultivated as a tender or half hardy annual in temperate climates. The fruit shape varies from oblong, ovoid, long or round cylindrical. The mature fruit color varies from purple, purple black, white green, yellowish and green with white / light green stripes, variegated types of purple with white stripes or even mixture of three colors. As a member of the genus *Solanum*, it is related to tomato and potato. The composition of brinjal per 100 g of edible portion contains 24 calories, 92.7 per cent moisture content, 4 per cent carbohydrates, 1.4 g protein, 0.3 g fat, 1.3 g dietary fibre, 18 mg oxalic acid, 18 mg calcium, 15 mg magnesium, 47 mg phosphorus, 0.38 mg iron, 3.0 mg sodium, 0.12 mg copper, 2.0 mg potassium, 44 mg sulphur, 52.0 mg chlorine, 0.74 µg beta carotene, 0.11 mg riboflavin, 12 mg vitamin C, 0.04 mg vitamin A and vitamin B (Gopalan *et al.*, 2007). Due to its nutritive value, consisting of minerals like iron, phosphorous, calcium and vitamins like A, B and C, unripe fruits are used primarily as vegetable in the country. The fruit of brinjal is a tremendous cholesterol controller. The flavonoid nasunin, an antioxidant and occurrence of free radical scavenger protects the cell membrane from injury.

In India, during 2017, brinjal is cultivated in about 733 thousand hectares with production and productivity of 12510 thousand MT and 18.5 MT ha<sup>-1</sup>, respectively. In Madhya Pradesh brinjal is cultivated in about 50.57 thousand hectares with production and productivity of 918.78 thousand MT and 18.17 MT ha<sup>-1</sup>, respectively (Anonymous, 2017). India is its centre of origin and diversity (Vavilov 1951; Bhaduri 1951).

The major constraint of low productivity of brinjal is due to damage of number of insect pests. Among the insect pests shoot and fruit borer *Leucinodes orbonalis* (Guenee), epilachna beetle *Epilachna vigintioctopunctata* (Fabricius), jassids *Amrasca biguttula biguttula* (Ishida) and whitefly *Bemisia tabaci* (Gennadius) are considered to have economic importance. However, brinjal shoot and fruit borer is considered as the major insect pest of brinjal in Asia as it causes serious damage especially during the fruiting stage. The shoot

and fruit borer has a specific nature of feeding. After hatching, the tiny larvae bore in the growing tips of young shoots during vegetative stage of the crop. Yellowing and wilting of the affected shoots are the common symptom of attack (Hedge *et al.*, 2009). During flowering and fruiting stage, the larva prefers flower buds and young fruits. It bores into the young fruits by making a very small hole around the calyx. Thereafter, it completes its larval stage within the developing fruits and the mature larvae come out from the fruit for pupation. It inflicts yield loss as high as 85–90% (Misra 2008; Jagginavar *et al.*, 2009; Chakraborti and Sarkar 2011).

Among sucking insect pests, jassids and whitefly cause damage from the initial stage of the crop growth. Both nymph and adult of the sucking insects suck the cell sap by congregating on the lower surface of the leaves and lower down the vigorous growth of the plants. The loss caused by sucking pests varies from 10-15 percent depending on the intensity of infestation (Chatterjee *et al.* 2018).

A number of chemical insecticides have been reported to be effective against these pests (Singh and Nath, 2007; Gautam *et al.*, 2008 and Tiwari *et al.*, 2011), but they are regarded as ecologically unacceptable. Brinjal crop is harvested at regular intervals and the use of toxic pesticides is not advisable. Repeated use of broad spectrum synthetic chemicals also results in environmental contamination, bioaccumulation and bio-magnification of toxic residues and disturbance in ecological balance (Dadmal *et al.*, 2004). Sole dependence on several broad spectrum insecticides for the control of these pests has led to insecticidal resistance, resurgence of minor pests and destruction of natural enemies. Use of bio-control agents and plant products like *Beauveria bassiana*, *Metarrhizium anisopliae*, neem and karanj are safe and non-hazardous tactic for the management of insect pests. To evolve the effective management strategy, it is pertinent to study the abiotic factors of environment in relation to insect pest population. Suitable understanding of the seasonal incidence of insect pests is important due to variation in the weather conditions and changing insect pests scenario on the crop. Therefore, the aim is to reduce the population levels with the control tactics which are environmental friendly.

Use of biopesticides, botanicals, vermicompost and indigenous products etc., may provide alternative solutions to chemical application for management of brinjal pest thereby increasing the income of farmers and saving the environment for future generation of man and his animals. In the light of the available information, the present studies were therefore undertaken on the management of major insect pests of brinjal (*Solanum melongena* L.) through botanicals and bio-pesticides with the following objectives.

1. To record the seasonal incidence of major insect pests of brinjal and their correlation with weather parameters.
2. To evaluate the efficacy of botanicals and biopesticides against major insect pests of brinjal.
3. To work out the economics of the management of major insect pests of brinjal.

## REVIEW OF LITERATURE

### 2.1 Seasonal incidence of major insect pests of brinjal and their correlation with weather parameters

Chandrakumar *et al.* (2008) studied the seasonal occurrence of major insect pests of brinjal. It revealed that aphid *Aphis gossypii* Glover attained two peaks during 2<sup>nd</sup> week of December and January. Leafhopper, *Amrasca devastans* Distant attained peak during 4<sup>th</sup> week of December. Whitefly, *Bemisia tabaci* Genn. attained peak during 3<sup>rd</sup> week of December. Sucking pests (aphid, leafhopper and whitefly) showed negative correlation with maximum temperature and rainfall. Maximum per cent leaf damage by ash weevil *Myloccerus spp.* and epilachna beetle *Henosepilachna vigintioctopunctata* was noticed during 3<sup>rd</sup> and 4<sup>th</sup> weeks of December and showed positive correlation with maximum temperature. Brinjal shoot and fruit borer *Leucinodes orbonalis* infestation was maximum during 1<sup>st</sup> and 4<sup>th</sup> weeks of December.

Gosh and Senapati (2009) found that *L. orbonalis* was active during summer and the rainy season, particularly during May – August and caused 49.5 – 81.0 % damage to fruits. Peak infestation (81.0 % fruit damage) was noticed in the first week of June (22<sup>nd</sup> standard week), when the mean temperature, mean relative humidity and weekly rainfall were 27.8°C, 79.2 % and 81.2 mm respectively. The pest became less active during winter months particularly in December – January. Borer infestation showed a significant positive correlation (P=0.05) with maximum and mean temperature, minimum and mean relative humidity and rainfall, whereas with maximum relative humidity the correlation was negative but non-significant.

Varma *et al.* (2009) determined the population of brinjal shoot and fruit borer, *Leucinodes orbonalis* for two consecutive years. It was observed that maximum population of brinjal shoot and fruit borer, *Leucinodes orbonalis* in 5<sup>th</sup> and 2<sup>nd</sup> week of December during 1<sup>st</sup> and 2<sup>nd</sup> year respectively. It showed positive correlation with maximum relative humidity, rainfall and wind speed during 1<sup>st</sup> year and with maximum relative humidity and sunshine hours in 2<sup>nd</sup> year. The

damaged fruit and fruit weigh loss varied from 3.76 to 45.45 per cent and 3.00 to 67.71 per cent in 1<sup>st</sup> year and 5.71 to 44.26 per cent and 3.00 to 51.33 per cent in 2<sup>nd</sup> year.

Shukla and Khatri (2010) recorded the results of two consecutive years and revealed that the adult population of *Leucinodes orbonalis* increased considerably in the month of October and November and decreased in subsequent weeks of December. The maximum temperature and abundance of moth showed a positive correlation ( $r = 0.319$ ) during both the years.

Shaikh and Patel (2013) noticed that the population of jassid and whitefly ranged between 1.47 to 7.93 and 1.52 to 8.50 per leaf with an average of 4.89 and 5.02, respectively. The highest peak of jassid (7.93/leaf) and whitefly (8.50/leaf) were noticed during 4<sup>th</sup> week of December. Jassid and whitefly population significantly positively correlated with bright sunshine hours (0.67993\*\* and 0.67417\*\*). However, both these pests were significantly negatively correlated with rainfall (-0.61506\*\* and -0.62344\*\*), maximum temperature (-0.65722\*\* and -0.67008\*\*), minimum temperature (-0.88218\*\* and -0.88260\*\*), mean temperature (-0.82756\*\* and -0.83224\*\*), evening relative humidity (-0.72706\*\* and -0.71820\*\*), mean relative humidity (-0.64429\*\* and -0.63292\*\*), morning vapour pressure (-0.85966\*\* and -0.86899\*\*), evening vapour pressure (-0.88671\*\* and -0.89079\*\*), mean vapour pressure (-0.88170\*\* and -0.88873\*\*), mean vapour pressure deficit (-0.39953\* and -0.41124\*) and wind speed (-0.64083\*\* and -0.62054\*\*), respectively.

Omprakash *et al.* (2014) studied the influence of abiotic factors on the seasonal incidence of major sucking peasts of brinjal, whitefly (*Bemisia tabaci*) and leaf hopper (*Amrasca devastans*). The incidence of whitefly population started from first week after transplanting and peak incidence was observed during final week of October and decreased gradually up to crop maturity. The leaf hopper incidence was also observed during first week after transplanting and population reached peak in fourth week of October. Both whitefly and leaf hopper had a non-significant association with abiotic factors like maximum and minimum temperatures, relative humidity and rainfall.

Kaur *et al.* ((2014) concluded that the maximum mean larval population (10 larvae/90 plants) of *L. orbonalis* was observed at 40<sup>th</sup> standard week whereas the lowest mean population (0.0/90 plants) was recorded in 48<sup>th</sup> standard week. Therefore, it showed that the caterpillar populations were significantly positively correlated with temperature and significantly negatively correlated with % RH.

Dahatonde *et al.* (2014) reported that the incidence of jassid (*Amrasca biguttula biguttula* Ishida) started from November (3.20 jassids/three leaves) and reached to a peak level (22.46 jassids/three leaves) during December, whereas whitefly (*Bemisia tabaci* Gennadius) started from November (7.27 whiteflies/three leaves) and reached to a peak level (25.73 whiteflies/three leaves) during January. Among various weather parameters, maximum, minimum and average temperature had highly significant negative influence on jassid and whitefly population.

Deole (2015) studied the seasonal incidence of jassid, whitefly and shoot and fruit borer on brinjal crop. The activity of both jassid and whitefly was initiated in the first week of April with mean density of 4.33 hoppers and 6.33 whiteflies per plant. It was associated with 35.94°C (maximum) and 20.78°C (minimum) temperatures and maximum relative humidity around 75 %. The peak activity of these insects was observed during first week of May when the day and night temperatures fluctuated between 25°C and 40°C and relative humidity around 55 %. The correlation studies between jassid and whitefly and different weather parameters revealed no significant effect of ambient weather on the population fluctuations of these insects. Shoot and fruit borer incidence was first observed on brinjal fruits during first week of April with peak activity of 66.66 % in May first week when day and night temperatures varied from 20°C to 40°C and maximum relative humidity around 60 %. The correlation studies between % fruit damage by fruit borer and ambient weather revealed a significantly negative relationship with minimum temperature and significantly positive relationship with maximum relative humidity.

Indirakumar *et al.* (2016) conducted an experiment on the effect of abiotic factors on the seasonal incidence of major insect pests was observed on brinjal crop. The incidence of leaf hopper (*Amrasca biguttula biguttula*) was

maximum during December, 52<sup>nd</sup> Standard Week (SW) and minimum during March (12<sup>th</sup> SW). The incidence of white fly (*Bemisia tabaci*) was maximum during January (2<sup>nd</sup> SW) and lowest in March (12<sup>th</sup> SW). Both these insects showed significant negative correlation with both maximum and minimum temperature and wind speed while a positive correlation was revealed with mean relative humidity and total rainfall. The incidence of shoot and fruit borer, *Leucinodes orbonalis* Guenee was observed during Nov. – Dec. with peak infestation during February (6<sup>th</sup> and 7<sup>th</sup> SW). The per cent shoot damage was positively correlated with both maximum and minimum temperature, rainfall and wind speed while negatively correlated with mean relative humidity. While per cent fruit infestation revealed a non significant positive correlation with maximum and minimum temperature, rainfall and wind speed exhibited negative correlation with mean relative humidity.

Anwar *et al.* (2017) revealed that all the weather parameters had a significant ( $P < 0.05$ ) effect on population of *L. orbonalis*. The average change in pest population ranged from 62.39 to 78.98% during 2011 and 57.82 to 82.49% during 2012 due to weather parameters. Results also showed that mean maximum temperature had a significant positive correlation with population of *L. orbonalis* but non-significant positive correlation with mean minimum temperature and maximum relative humidity. Similarly a negative correlation with mean minimum relative humidity and total rainfall was recorded during both the years.

Javed *et al.* (2017) reported that among the various abiotic factors, maximum temperature showed highly significant positive correlation ( $r = 0.77$ ) and sunshine hours ( $r = 0.61$ ) showed significant positive correlation with the leaf hopper population. In case of aphid population, maximum temperature showed significant positive correlation ( $r = 0.70$ ), rainfall showed highly significant negative correlation ( $r = -0.74$ ) and relative humidity evening ( $r = -0.59$ ) showed significant negative correlation with aphid population.

Borah and Saikia (2018) observed that four *viz.*, brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guen.), epilachna beetle *Henosepilachna vigintioctopunctata* (F.), aphid *Aphis gossypii* Glover and leaf hopper *Amrasca biguttula biguttula* Ishida were the major pest whereas aphid *Myzus persicae* (Sulzer), whitefly, *Bemisia tabaci* (Guen.), flea beetle, *Monolepta signata* Oliv.,

leaf roller, *Antoba (Eublemma) olivacea* (Walker), semilooper, *Plusia spp.* Were found as minor pests. Among these brinjal shoot and fruit borer was the dominant one.

Raidu *et al.* (2018) concluded that the peak shoot infestation was in second week of October (78%) on initiation of fruiting stage thereafter the population observed was in decline trend, peak fruit infestation was in first week of November (63%) by brinjal shoot and fruit borer, *Leucinodes orbonalis* whereas the peak infestation of whitefly (13.52 adults / 3 leaves) and jassids (7.71 adults / 3 leaves) was observed during third week of November. After that, the population declined with advent of winter season. The rainfall and relative humidity had significant positive correlation with infestation of whitefly and jassids. Temperature was negatively correlated with whitefly and jassids infestation and shoot and fruit infestation was positively correlated with maximum temperature and mean temperature.

Chatterjee *et al.* (2018) recorded the population of sucking pest of brinjal on May sown and July sown crop. The highest leaf hopper population was recorded in 44<sup>th</sup> and 49<sup>th</sup> standard week (SW) of May sown and July sown crop respectively. Aphid population was observed highest in 35<sup>th</sup> SW for May sown brinjal and for July sown brinjal the peak population was recorded on 51<sup>st</sup> SW. Aphid was found to be negatively correlated with temperature when it is sown in July. The white fly population reached its peak in 35<sup>th</sup> and 49<sup>th</sup> SW respectively for May and July sown crops and found to be negatively correlated with temperature and rainfall.

Nishad *et al.* (2018) stated that initial population of brinjal shoot and fruit borer (2.73%) was recorded during 38<sup>th</sup> standard week (5<sup>th</sup> week after transplanting) on the other hand maximum number of per cent infestation of *L. orbonalis* (19.36%) was recorded during 47<sup>th</sup> standard week (14<sup>th</sup> week after transplanting).

## 2.2 Efficacy of botanicals and biopesticides against major insect pests of brinjal

Gautam *et al* (2008) determined the comparative efficacy of insecticides, biopesticides and botanicals against *Leucinodes orbonalis*. Among botanicals, neemarin and achook were significantly on par and effective by 78.5 and 77.6% followed by bioneem 69.6%, respectively in reducing shoot infestation over control. Biopesticides, however, register 60.8% and 59.6% reduction in shoot infestation in case of dipel and biolep, respectively. Neemarin and achook were significantly on par and registered 9.2 and 10.6% yield loss, respectively followed by bioneem 14.6%.

Gosh and Senapati (2009) evaluated some insecticides on the field for control of *Leucinodes orbonalis*. It revealed that avermectin (Vertimec 1.9 EC; 0.5ml/l) was the most effective in suppressing dead heart caused by the pest, closely followed by *Beauveria bassiana* (Biorin 10<sup>7</sup> conidia / ml; 1ml/l) and *Bacillus thuringiensis* Berliner (Biolep 5×10<sup>7</sup> spores/ml; 1g/l). Significantly lower levels of fruit damage were recorded in avermectin treatment, closely followed by DDVP (0.05%) (Nuvan 76 SL; 2ml/3l) when compared with the untreated control. The other insecticides evaluated, including a neem formulation (Neemactin 0.15 EC; 2.5ml/l) and malathion (0.05%) (Malathion 50 EC; 1.0ml/l), were less effective. None of the insecticides evaluated produced satisfactory results against *Leucinodes orbonalis*.

Mandal *et al.* (2010) recorded the efficacy of different doses of NSKE and insecticides against whitefly (*Bemisia tabaci*) and shoot and fruit borer (*Leucinodes orbonalis*). The treatments were NSKE @ 5g a.i/ha, NSKE @ 2.5g a.i/ha, NSKE @ 1.25g a.i/ha, commercial neem @ 0.2g a.i/ha. Among them NSKE @ 5g a.i/ha was found to be the most effective treatment in minimizing the whitefly population (56.25% reduction) and shoot and fruit borer population (25.64% reduction). The maximum yield was also recorded in NSKE @ 5g a.i/ha.

Islam *et al.* (2011) conducted research to investigate the combined efficacy of neem and *Beauveria bassiana* against whitefly, *Bemisia tabaci*. Neem was applied as soil drench and *B. bassiana* was applied to foliage. Three concentrations of Azadirachtin EC- 0.25, 0.5 and 1.0%; and three concentrations of *B. bassiana*-  $10^6$ ,  $10^7$  and  $10^8$  conidia/ml were used for investigation. The results demonstrate that maximum nymph mortality (92.3%) occurred when 1.0% neem was combined with  $10^8$  conidia/ml of *B. bassiana*. The highest (14.3) mortality ratio (N/Bb; mortality caused by neem/mortality caused by *B. bassiana*) occurred when 1.0% neem was combined with  $10^6$  conidia/ml of *B. bassiana*; and the lowest mortality ratio (5.7) occurred when 0.25% neem was combined with  $10^8$  conidia/ml of *B. bassiana*. The results showed that neem was compatible with *B. bassiana*; and suggest that soil application of neem along with foliar application of *B. bassiana* might be useful for the control of *B. tabaci*.

Sharma *et al.* (2012) conducted experiment to evaluate the potential of two botanicals *viz*, ozoneem and neem seed kernel extract (NSKE) and three chemical insecticides *viz*, imidacloprid, alphamathrin, chlorpyrifos 50% EC + cypermethrin 5% EC against *Leucinodes orbonalis*.

The results revealed that chlorpyrifos + cypermethrin @ 0.01% (a.i) was found to be the most economical, resulting in minimum shoot (2.15%) and fruit (12.95%) infestation respectively, followed by alphamathrin @ 0.01% a.i. with a highest marketable yield of 87.77 q ha<sup>-1</sup>. Maximum marketable yield was received from the treatment with alphamathrin, but due to high costs involved in the use of this chemical, it took second place. NSKE @ 5 ml/l recorded a maximum of shoot (3.91%) and fruit (24.49%) infestation, respectively.

Mathur *et al.* (2012) studied the efficacy of plant products *viz.*, neem oil (2%), iluppai oil (2%), pungam oil (2%), combination of iluppai and pungam (1 : 1) and microbial formulations *viz.*, entomopathogenic fungi, *Beauveria bassiana* and *Verticillium lecanii* against the brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee. The results revealed that newer plant products *i.e.* oils of iluppai and pungam were at par with standard check endosulfan and were found to be significantly superior than microbial formulations and also showed better efficiency than neem oil in the suppression of brinjal shoot and fruit borer infestation with significant insecticidal property. The

yield data also revealed that the maximum yield of marketable fruits was obtained using iluppai oil (202.75 q/ha) ; the percent gain over control was least with *V. lecanii* followed by *B. bassiana*, neem oil, combination of iluppai and pungam oil, pungam oil, iluppai oil (77.8%), and maximum with endosulfan (83.3%). The results thus suggest that newer plant products such as oils of iluppai and pungam are promising botanicals in the integrated pest management strategy against brinjal shoot and fruit borer.

Pareet and Basavangoud (2012) determined the efficacy of biopesticides and insecticides. It was found that emamectin benzoate 5 SG @ 0.2ml/l and spinosad 45 SC @ 0.1 ml/l were found to be most effective in reducing shoot infestation (14.6%, 16.9%) and fruit infestation (9.0%, 10.9%), respectively. Highest marketable fruit yield was recorded in emamectin benzoate 158.51q ha<sup>-1</sup> and spinosad 153.51q ha<sup>-1</sup>.

Efficacy of five insecticides viz., spiromesifen (100g a.i. ha<sup>-1</sup>), chlorantraniliprole (20g a.i. ha<sup>-1</sup>), novaluron (75g a.i. ha<sup>-1</sup>), flubendamide (25g a.i. ha<sup>-1</sup>) and carbosulfan EC (250g a.i. ha<sup>-1</sup>) were studied against insect pests of brinjal. It revealed that all insecticides were effective against leaf hoppers and whiteflies (Singh and Nath, 2012).

Nayak *et al.* (2013) reported the efficacy of biopesticides viz. *Bt* (Halt), *Beauveria bassiana* (Myco-Jaal 10% EC) and *Metarhizium anisopliae* (Multiplex *Metarhizium* dust) and botanicals such as crude neem oil, NSKE and two neem oil formulations such as multilineem (*Azadirachtin* 300 ppm) and Neemacin (*Azadirachtin* 1500 ppm) against the brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. Results revealed that foliar application of *Bt* @ 2g/l of water recorded lowest shoot and fruit damage by the borer insect as well as highest marketable yield followed by NSKE (5%) while other treatments in order of their efficacy were Neemarin, Multineem and crude neem oil. The fungal biopesticides viz. Myco-Jaal and Multiplex *Metarhizium* dust proved least effective against this noxious pest.

Gowrish *et al.* (2015) studied the efficacy of *Metarhizium anisopliae* and *Beauveria bassiana* (talc formulation @ 5g / l), *M. anisopliae* and *B. bassiana*

(potato dextrose broth @  $10^7$  spores / ml), *Bt* formulation @ 1 ml/l, spinosad 45 SC @ 0.4 ml/l, azadirachtin 1 % @ 2ml/l and malathion 50 EC @ 2ml/l against *Leucinodes orbonalis*, *Epilachna vigintioctopunctata*, *Antoba olivacea* and *Selepa docilis*. Spinosad 45 SC was found to be effective in reducing shoot and fruit infestation by *L. orbonalis*. Azadirachtin 1% was found to be most effective in controlling leaf infestation by *E. vigintioctopunctata*. *Bt* formulation was highly effective for early larval instars of *A. olivacea*. However, for later instars, malathion 50 EC was found to be effective. Azadirachtin 1 % was found to be highly effective against *S. docilis*.

Singh and Sachan (2015) determined the comparative efficacy of *Bacillus thuringiensis*, *Beauveria bassiana*, neemarin (neem oil), neemarin- *Bt-Bb*, *Bt-Bb-Bt*, spinosad 45 SC and chlorpyrifos 20 EC against shoot and fruit borer, *Leucinodes orbonalis* in brinjal. Application of spinosad 45 SC @ 200ml ha<sup>-1</sup> was the most effective treatment in reducing the shoot and fruit damage and it was followed by chlorpyrifos 20 EC @ 1l ha<sup>-1</sup> and neemarin @ 3l ha<sup>-1</sup>.

Patel *et al.* (2015) reported the efficacy of different biopesticides against brinjal pest complex. It was found that *Passilomyces fumosoresus* @ 1l ha<sup>-1</sup> was the most effective as it recorded lowest infestation of all recorded pests followed by *Beauveria bassiana* @ 1l ha<sup>-1</sup>. Highest fruit yield was registered in *Passilomyces fumosoresus* @ 1l/ha (85.06 q ha<sup>-1</sup>), followed by *Beauveria bassiana* @ 1l/ha (80.05 ha<sup>-1</sup>), highest net profit was registered in *Passilomyces fumosoresus* @ 1l/ha (Rs. 21672/ha) with highest cost benefit ratio in *Passilomyces fumosoresus* @ 1l/ha (1:6.53).

Ali *et al.* (2016) evaluated the efficacy of biopesticides in relation to imidacloprid 20 SL against sucking pests of brinjal. The biopesticides were not superior over imidacloprid 20 SL which had 96.12% control, however Neem extract had 82.60%, Tobacco extract had 75.95% and Eucalyptus extract had 73.93% control on whitefly and on jassid, chemical control imidacloprid 20% SL showed highest effect of 77.90% followed by Neem extract with 55.95%, Tobacco extract with 53.38% and Eucalyptus extract with 53.99%.

Patra *et al.* (2016) conducted experiments to evaluate some biopesticides and newly introduced insecticides against shoot and fruit borer of

brinjal. The treatments were azadirachtin 1 EC, karanjin 2 EC, anonin 1 EC, *Bacillus thuringiensis* (Bt), emamectin benzoate 5 SG, flubendiamide 480 SC, chlorantraniliprole 18.5 SC, chlorpyrifos 20 EC. Results showed that chlorantraniliprole 18.5 SC had 2.46 % shoot infestation which was statistically at par with flubendiamide 480 SC which had 3.08 % and emamectin benzoate 5 SG which had 3.76 % shoot infestation. The overall mean fruit infestation was also minimum in chlorantraniliprole 18.5 SC (5.76%) and flubendiamide 480 SC (5.93 %) treated plots. The results indicated that highest marketable yield was recorded in chlorantraniliprole 18.5 EC treated plots (155.01q ha<sup>-1</sup>) followed by flubendiamide 480 SC (149.50 q ha<sup>-1</sup>), emamectin benzoate 5 SG (134.24 q ha<sup>-1</sup>) and chlorpyrifos 20 EC (125.43 q ha<sup>-1</sup>). Among the biopesticides, highest mean marketable yield was recorded in *Bacillus thuringiensis* treated plots (114.45 q ha<sup>-1</sup>) followed by azadirachtin (101.11 q ha<sup>-1</sup>).

Ali *et al.* (2017) conducted experiment to examine the efficacy of different bio-pesticides against major sucking pests on brinjal. The results revealed that against white fly, the first spray of Neem extract showed highest reduction percent (82.60%) followed by Tobacco extract (75.95%), Datura extract (73.93%), and lowest for untreated control (11.07%); while in the second spray also Neem extract showed highest effect against white fly (67.53%); followed by Tobacco extract (56.43%), Datura extract (42.25%), and least by untreated plot (5.49%) while on jassid, Neem extract showed highest effect (55.95%) as observed during 1st spray, followed by Tobacco extract (53.38%), Datura extract (63.11%) and untreated control (8.00%), while after second spray also Neem extract showed highest reduction percent (68.73%) followed by Tobacco extract (55.72%), Datura extract (50.66%) and the lowest was resulted by untreated control (13.90%). Neem extract showed its superiority in effect to combat sucking insect pests studied in brinjal, followed by, Tobacco extract, Datura extract and untreated control remained the least.

Dehariya *et al.* (2018) evaluated the performance of some botanical products against the sucking pest of brinjal. The treatment included Triazophos 40 E.C. 0.04%, Neem oil 1 %, Achook 5 %, NSKE 5%, Karanj oil 1%, Eucalyptus oil 1%. The results revealed that Triazophos 40 E.C. 0.04% was significantly superior over all the botanical treatments. Highest healthy fruits yield

(24.76q ha<sup>-1</sup>) was recorded in the treatment of Triazophos 40E.C. 0.04% followed by the treatment of neem oil 1% (20.54 q ha<sup>-1</sup> healthy fruits), and both the treatments were statistically at par yields comparing to remaining treatments.

Kunbhar *et al.* (2018) conducted experiments to evaluate the impact of neem *Azadirachta indica*, tobacco *Nicotina tabbaciun*, trooh *Citrullus colocynthus*, Movanto (Spirotetramat) against sucking insect pests of brinjal. All the botanical pesticides especially neem showed potential to cause population reduction of aphids, whitefly, jassid and thrips. Trooh also showed significant mortality of aphid and thrips, whereas tobacco caused more mortality of whitefly and jassid. Comparatively neem showed less persistency in comparison to trooh and tobacco as mostly pest populations started rebuilding after 72 hours of its application.

Singh *et al.* (2018) concluded that among the various insecticides evaluated against brinjal shoot and fruit borer (*L. orbonalis*), Emamectin benzoate 5 SG @ 12.5g a.i./ha treated plots showed lowest infestation and gave higher fruit yield (253.12q/ha) followed by Flubendiamide 480 SC (249.33 q/ha) and Novaluron 10 EC (243.63q/ha). Among the biopesticide NSKE 5% was most effective followed by *Bacillus thuringensis*, *Verticellium lecanii* and *Beauveria bassiana* in controlling brinjal shoot and fruit borer (*L. orbonalis*). The highest cost benefit ratio was obtained from NSKE 5% (1:24.40). It was followed by Indoxacarb 14.5 SC (1:24.13) and Emamectin benzoate 5 SG (1:24.03) which were also economical than other treatments.

## **MATERIAL AND METHODS**

The experiment entitled, "Study on the management of major insect pests of brinjal (*Solanum melongena* L.) through botanicals and biopesticides" was carried out during *kharif* season of 2019-20 at JNKVV, Research farm, College of Agriculture, Tikamgarh (M.P.). The materials deployed and the methods followed during the course of this study have been described in this chapter. In accordance with the objectives, the studies were divided into three sections as detailed below.

1. To record the seasonal incidence of major insect pests of brinjal and their correlation with weather parameters.
2. To evaluate the efficacy of botanicals and biopesticides against major insect pests of brinjal.
3. To work out the economics of the management of major insect pests of brinjal.

### **3.1 Geographical location**

The field experiment was conducted at Research Farm, Jawaharlal Nehru Krishi Vishwa Vidyalaya, College of Agriculture, Tikamgarh (M.P.) which is situated at 24' 43° North latitude and 78' 49° East longitude at an altitude of 358 meter mean sea level.

### **3.2 Climate**

Tikamgarh district lies in the Bundelkhand Zone (Agro-climatic Zone-VIII). It is situated in the north-eastern part of Madhya Pradesh at 24' 43° North latitude and 78' 49° East longitude at an altitude of 358 meter mean sea level. It has sub-tropical climate characterized by hot dry summers and cool dry winter. The average maximum temperature during the month of May–June varies between 43.0 to 45.0°C, while the average minimum temperature varies between 3.0 to 4.5°C during December-January, which is the coldest months of the year.

### **3.3 Rainfall**

The average annual rainfall of this region is about 1000 mm which is mostly received between June to September and a little rainfall (90 mm) is also obtained during October to May. The average humidity of the tract is about 70 per cent.

### **3.4 Soil of the experimental field**

Soil of the experimental site was medium in organic carbon and nitrogen, high in phosphorus, medium in potassium and neutral in the action.

### **3.5 Meteorological observations**

The meteorological data prevailed during crop season (*kharif* 2019-20) was recorded at the Meteorological Observatory located at Farm, College of Agriculture, Tikamgarh (M.P.) and presented in Table 1 and depicted in Fig. 1.

#### **Weather condition during the crop season:**

The weather condition during the course of studies from 2019 to 2020 is presented in table 3.1.

### **3.6 To record the seasonal incidence of major insect pests of brinjal and their correlation with weather parameters.**

#### **3.6.1 Nursery raising**

Seeds of brinjal variety Kashi Sandesh were sown on raised nursery with row to row distance of 10 cm on July 15, 2019.

#### **3.6.2 Preparation of the field**

The experimental field was ploughed twice with the help of tractor mounted disc harrow. The field was ensured with the fine tilth.

#### **3.6.3 Transplanting of seedling**

Twenty five days old seedlings of brinjal were planted on August 09, 2019 in a plot size of 10 X 10 m<sup>2</sup>. The spacing between row to row and plant to plant was kept 80 cm. Light irrigation was provided after transplanting for better establishment of seedlings. All the agronomical practices, except the package recommended for insect pests management were adopted to raise a good crop.

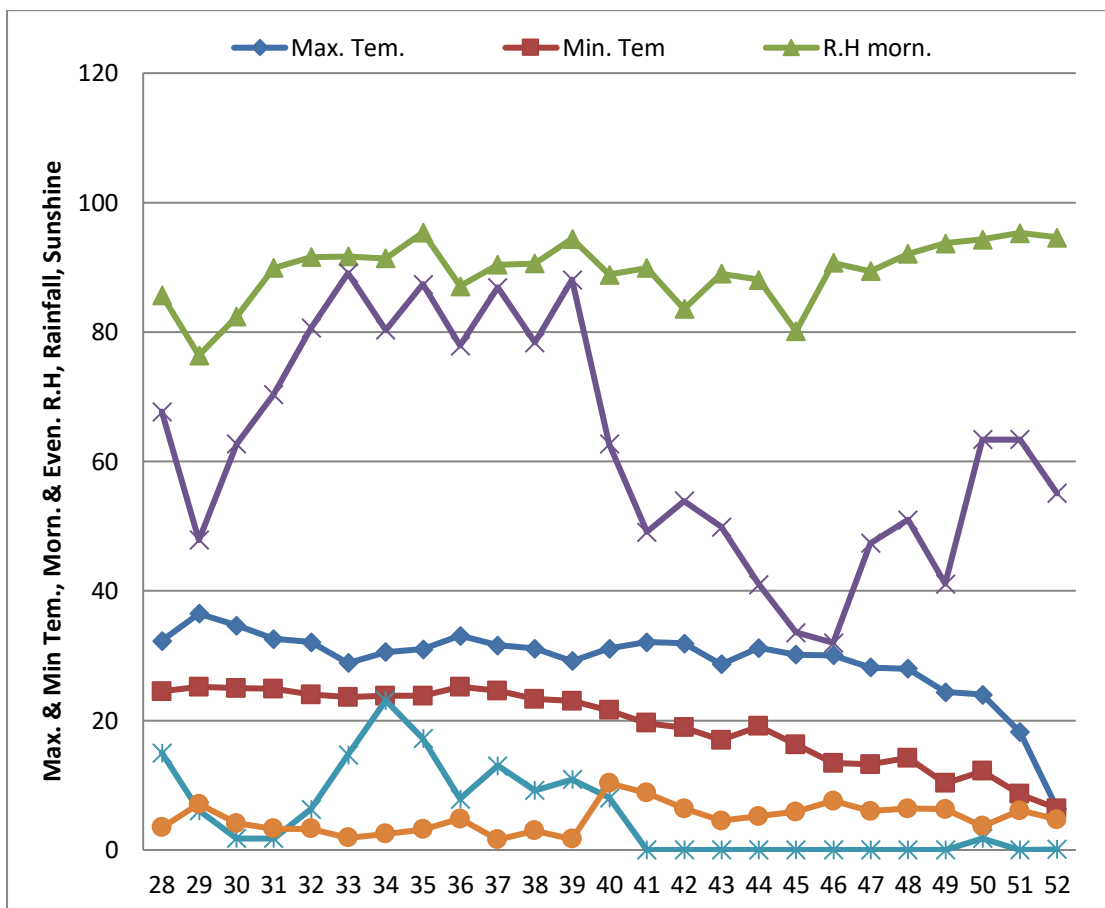
#### **3.6.4 Fertilizer application**

The recommended dose of fertilizers such as N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O (180:80:80) were applied for crop production. The half dose of nitrogen and full dose of phosphorus and potash were applied as basal at the time of last ploughing while remaining dose of nitrogen was top dressed 30 days after transplanting.

**Table 1: Weekly meteorological observation during *Kharif* season (July - December) 2019 at Tikamgarh (M.P.)**

Date	Standard Meteorological Week	Temperature(°C)		Relative humidity (morning)	Relative Humidity (evening)	Rain-Fall (mm)	Sunshine (hr.)
		Maximum	Minimum				
8-14 July 19	28	32.3	24.5	85.7	67.7	15.0	3.5
15-21 July 19	29	36.5	25.2	76.4	47.9	6.1	7.1
22-28 July 19	30	34.7	25.0	82.4	62.7	1.8	4.1
29-4 Aug. 19	31	32.6	24.9	89.9	70.4	1.8	3.3
5-11 Aug. 19	32	32.1	24.0	91.6	80.6	6.3	3.3
12-18 Aug. 19	33	28.9	23.6	91.7	89.1	14.7	1.9
19-25 Aug. 19	34	30.6	23.8	91.4	80.3	23.1	2.5
26-1 Sep. 19	35	31.0	23.8	95.4	87.4	17.2	3.2
2-8 Sep. 19	36	33.1	25.2	87.1	77.9	7.9	4.8
9-15 Sep. 19	37	31.6	24.6	90.4	86.9	13.0	1.6
16-22 Sep. 19	38	31.1	23.3	90.6	78.4	9.2	3.0
23-29 Sep. 19	39	29.2	23.0	94.4	88.1	10.9	1.7
30-6 Oct. 19	40	31.1	21.6	88.9	62.7	8.1	10.3
7-13 Oct. 19	41	32.1	19.6	89.9	49.1	0.0	8.8
14-20 Oct. 19	42	31.9	18.9	83.6	53.9	0.0	6.4
21-27 Oct. 19	43	28.7	17.0	89.0	49.9	0.0	4.5
28-3 Nov. 19	44	31.2	19.1	88.1	41.0	0.0	5.2
4-10 Nov. 19	45	30.2	16.3	80.1	33.6	0.0	5.9
11-17 Nov. 19	46	30.1	13.4	90.7	32.0	0.0	7.6
18-24 Nov. 19	47	28.2	13.2	89.4	47.4	0.0	6.0
25-1 Dec.19	48	28.0	14.2	92.1	51.0	0.0	6.4
2-8 Dec. 19	49	24.4	10.3	93.7	41.1	0.0	6.3
9-15 Dec.19	50	24.0	12.2	94.3	63.4	1.8	3.7
16-22 Dec. 19	51	18.2	8.6	95.3	63.4	0.0	6.1
23-29 Dec. 19	52	6.4	6.4	94.6	55.1	0.1	4.7

**Source: Department of Meteorology College of Agriculture Tikamgarh.**



**Fig 1 : Weekly meteorological observation during *kharif* season 2019-20 at Tikamgarh (M.P.)**

### **3.6.5 Weeding**

First weeding was done at 15 days after transplanting with the help of Khurpi and second weeding was done when the crop was 60 days old.

### **3.6.6 Irrigation**

The experiment field was kept moist by providing necessary irrigation in order to render the suitable crop growth.

### **3.6.7. Experimental details**

The experimental plot consists of 12 rows of plants and each row consists of 12 plants with 80 × 80 cm row to row and plant to plant spacing. The experimental plot consists of total 144 plants.

#### **Observation :**

Observations on the incidence of major insect pests were recorded from the first appearance of the pest and it was continued till maturity of the crop at weekly intervals and data were correlated with meteorological parameters.

**Jassid :** Observation on jassid were recorded (adult) on 3 leaves each from upper, middle and lower plant canopy of randomly selected 25 plants at weekly intervals.

**Whitefly :** Observation on whitefly were recorded (adult) on 3 leaves each from upper, middle and lower plant canopy of randomly selected 25 plants at weekly intervals.

**Shoot and fruit borer :** Incidence of shoot and fruit borer were recorded at weekly interval during vegetative stage. The withered or drooped stem depicted the initiation of shoot infestation. Thereafter its incidence was noticed by each fruit picking on randomly selected twenty five plants. The numbers of healthy and damaged fruits of twenty five randomly selected plants were counted at each picking. The seasonal fluctuation in the activity of shoot and fruit borer was observed by recording percentage of infested fruits at each picking.

### 3.6.8 Statistical analysis

The seasonal incidence of pests with abiotic factors, were correlated on the basis of following formula :

$$r = \frac{\Sigma XY - n\bar{X}\bar{Y}}{\sqrt{(\Sigma X^2 - n\bar{X}^2) \times (\Sigma Y^2 - n\bar{Y}^2)}}$$

where,

X = Mean of first factor

Y= Mean of second factor

n = Total no. of observations

r = Correlation coefficient

After correlating significant and non-significant findings, t-test value n-2 degrees of freedom were calculated on the following formula:

$$t = \frac{r \sqrt{n} - 2}{\sqrt{1 - r^2}}$$

## 3.7. To evaluate the efficacy of botanicals and biopesticides against major insect pests of brinjal.

### 3.7.1 Design and layout

The experiment was laid out in a Randomized block design (RBD) with nine different treatments including one untreated check. Each treatment was replicated thrice. Each plot is measured 12m<sup>2</sup> (4m×3m). The total number of plots were 27. Each plot consists of 3 rows with 5 plants at spacing of 80 × 80 cm. Each plot was separated from each other by bunds. Drainage as well as irrigation facilities were adequately provided to the experimental plot for necessary irrigation and drainage. The treatment details are given in table 3.2.

### 3.7.2 Method of observation

All the treatments were sprayed at an interval of 15 days between each spray by using high volume knapsack sprayer @ 500 liters of spray solution per ha

to determine the efficacy against major insect pests of brinjal. The first spray was done at ETL level. The treatments were sprayed thrice.

Observations on the efficacy of treatments were recorded one day before the treatment and after 3, 7 and 10 days of first ,second spray and third spray respectively

**Table 3.2 Treatment details:**

S.No	Treatment	Dose ( ml / ha)
T <sub>1</sub>	Neem oil 1%	3000
T <sub>2</sub>	Karanj oil 1%	3000
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	1000
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	1000
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3000-1000- 3000
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	3000-1000-3000
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	3000-1000-3000
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	3000 -1000-3000
T <sub>9</sub>	Untreated control	---

*Bb- Beauveria bassiana; Ma- Metarrhizium anisopliae*

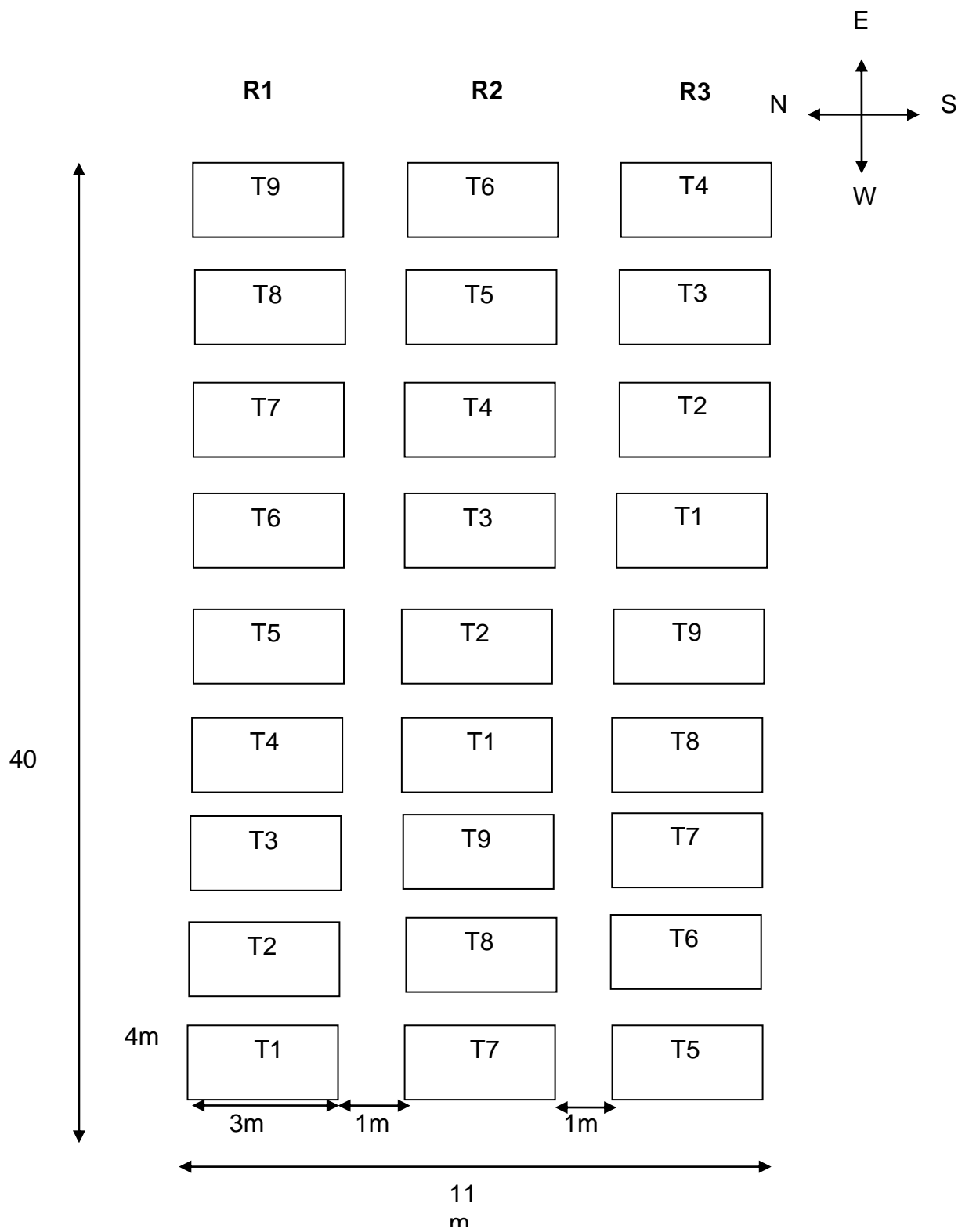
The other input pertains to agronomic practices were same as described in earlier chapter (3.6).

### 3.7.2 Method of observation

All the treatments were sprayed at an interval of 15 days between each spray by using high volume knapsack sprayer @ 500 liters of spray solution per ha to determine the efficacy against major insect pests of brinjal. The first spray was done at ETL level. The treatments were sprayed thrice.

Observations on the efficacy of treatments were recorded one day before the treatment and after 3, 7 and 10 days of first ,second spray and third spray respectively.

1. Pre treatment observation on incidence of insect pests of brinjal was recorded one day before treatment.
2. Post treatment observations were recorded at 3, 7 and 10 days after spraying.



**Fig 2: Layout of the experimental field**

3. Observation on jassid were recorded (adult) on 3 leaves each from upper, middle and lower plant canopy of randomly selected 5 plants in each plot.
4. Observation on whitefly were recorded (adult) on 3 leaves each from upper, middle and lower plant canopy of randomly selected 5 plants in each plot.
5. Observations on shoot and fruit borer population were recorded on five randomly selected plants in each plot at each picking. The number of healthy and damaged fruits were counted and weighted separately.

### 3.7.3 Statistical analysis

The data obtained were analyzed statistically after using appropriate transformation. The percentage data were processed under Arcsine transformation before statistical analysis.

Percentage of fruit damage and yield (q/ha) were calculated on the basis of following formula.

$$\text{Per cent fruit damage} = \frac{\text{weight of damaged fruits}}{\text{Total weight of fruits (healthy + damaged)}} \times 100$$

The sucking pest data obtained were converted into square root transformation, by using the formula ( $\sqrt{x} + 0.5$ ). This transformed data was then analyzed by the method of analysis of variance as described by Gomez and Gomez (1984). The “F” test was used at 5 per cent level of significance.

Critical difference (CD) values were analyzed at 5 per cent level of significance. The skeleton of analysis of variance and formula used for various estimations are given in table: 3.3.

**Table 3.3: The skeleton of the analysis of variance**

Source of variation	DF	SS	MSS	F cal	F tab	S.E	CD 5%
Replication (R)	(R-1)						
Treatment (T)	(T-1)						
Error (E)	(R-1)(T-1)						
Total	RT-1						

The following formulae were used for standard error, critical difference and coefficient of variance estimations.

$$(a) \text{ S.Em } \pm = \frac{\sqrt{EMS}}{R}$$

$$(b) \text{ C.D. } = \text{ S.Em } \times \sqrt{2} \times t \text{ (D.F. at 5\%)}$$

Where,

R = Number of Replications,                      D.F = Degrees of Freedom

T = Number of Treatments,                      S.S. = Sum of Square

C.D. = Critical Difference,                      GM = Grand Mean

M.S.S= Mean Sum of Square,                      EMS = Error Mean Square

S.Em  $\pm$  = Standard Error of means

### **3.8 To work out the economics of the management of major insect pests of brinjal.**

With a view to ascertain the effect of different botanical and chemical insecticides on the yield, the harvested fruits of brinjal were weighed separately from net plot area in each treatment. The yield was then converted on hectare basis. The percent increase in yield over control was calculated by using the following formula given by Khosla (1977):

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

**Where,**

T= Yield of respective treatments (kg/ha)

C= Yield of control (kg/ha)

#### **3.8.1 Assessment of benefit cost ratio**

Incremental Cost Benefit Ratio (ICBR) was also worked out to compare the economics of different insecticidal treatments.

For benefit cost analysis, record of costs incurred in each treatment and that of control were maintained. It was to be noted here that expenses incurred referred to those only on pest management i.e. cost of insecticides and labour charges for insecticide spraying. The price and expenses of the harvested crop of each treatment and that of control were also calculated at the then existing market rate. Thereafter, Benefit cost ratio (B: C ratio) was calculated by the

estimation of different pest management cost by adjusting with the control condition i.e.

B: C ratio = Adjusted net return (Rs/ha)

Cost of pest management (Rs/ha).

Where,

Adjusted net return = Net return from individual treated plot  
(Rs/ha) – Cost of pest management (Rs/ha)

Cost of pest management

(Rs/ha) = Cost of insecticide + Labour charges per hectare.

## RESULTS

In the present investigation entitled, “Study on the management of major insect pests of brinjal (*Solanum melongena* L.) through botanicals and biopesticides” experiments were conducted during *Kharif*, 2019 at J.N.K.V.V., College of Agriculture, Tikamgarh (M.P.). Results of experiments were critically evaluated and statistically analyzed as per method suggested by Snedecor and Cochran (1967) as given in this chapter.

The results obtained in the present study are presented in this chapter under following head.

1. To record the seasonal incidence of major insect pests of brinjal and their correlation with weather parameters.
2. To evaluate the efficacy of botanicals and biopesticides against major insect pests of brinjal.
3. To work out the economics of the management of major insect pests of brinjal.

### **4.1 Seasonal incidence of major insect pests of brinjal and their correlation with weather parameters**

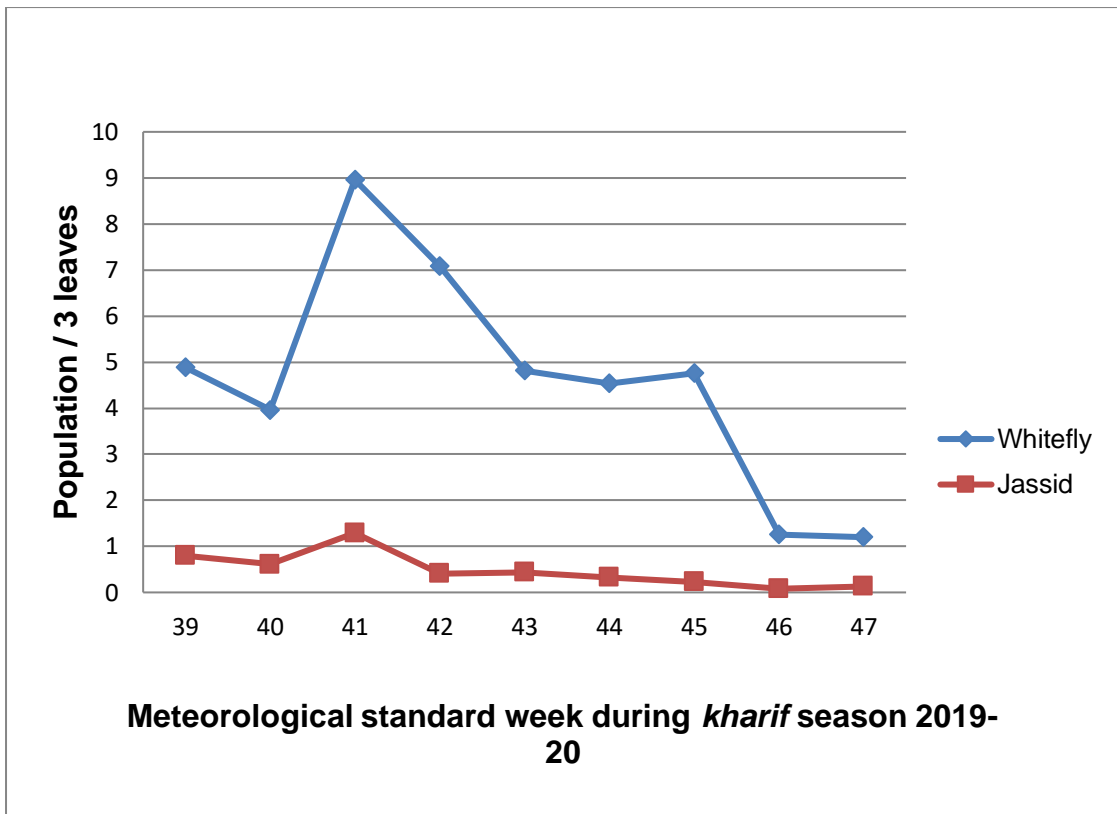
The data on intensity and population fluctuation of major insect pests on Kashi sandesh variety of brinjal, along with prevailing weather conditions during *kharif* season 2019-20 were recorded in field and the data recorded is presented in Table 4.1, Fig 3 and Fig 4.

Jassid (*Amrasca biguttula biguttula*), whitefly (*Bemisia tabaci*) and brinjal shoot and fruit borer (*Leucinodes orbonalis*) were recorded during the crop growth period.

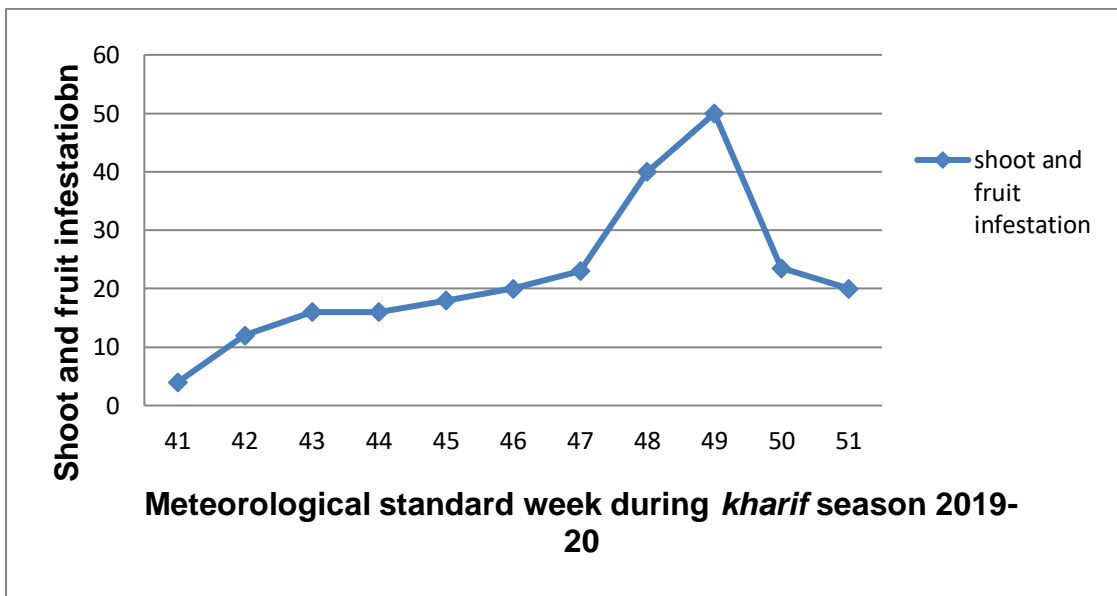
**Table 4.1: Seasonal incidence of major insect pests on brinjal at weekly interval, during the crop growth period (*Kharif* 2019-2020)**

S.M. Week	Period		Whitefly population/ 3 leaves	Jassid population / 3 leaves	Shoot / fruit infestation (%)
	From	To			
39	23 Sep. 2019	29 Sep. 2019	4.89	0.80	0.00
40	30 Sep. 2019	06 Oct 2019	3.96	0.61	0.00
41	07 Oct. 2019	13 Oct. 2019	8.96	1.29	4.00 (s)
42	14 Oct. 2019	20 Oct. 2019	7.08	0.41	12.00 (s)
43	21 Oct. 2019	27 Oct. 2019	4.82	0.44	16.00 (s)
44	28 Oct. 2019	03 Nov. 2019	4.54	0.33	16.00 (s)
45	04 Nov. 2019	10 Nov. 2019	4.76	0.23	18.00 (s)
46	11 Nov. 2019	17 Nov. 2019	1.26	0.08	20.00 (s)
47	18 Nov. 2019	24 Nov. 2019	1.20	0.13	23.00 (f)
48	25 Nov. 2019	01 Dec. 2019	0.00	0.00	40.00 (f)
49	02 Dec. 2019	08 Dec. 2019	0.00	0.00	50.00 (f)
50	09 Dec. 2019	15 Dec. 2019	0.00	0.00	23.50 (f)
51	16 Dec. 2019	22 Dec. 2019	0.00	0.00	20.00 (f)

**(s) : shoot infestation; (f) : fruit infestation**



**Fig 3 : Incidence of sucking pests on brinjal at Tikamgarh during *kharif* 2019-20**



**Fig 4 : Incidence of shoot and fruit borer on brinjal at Tikamgarh during *kharif* 2019-20**

### Correlation studies:

**Table: 4.2 Correlations were observed between insect pests of brinjal and weather factors.**

Insect pests	Temperature(°C)		Relative humidity (%)		Rainfall (mm)	Sunshine hours (hrs)
	Max.	Min.	Morning	Evening		
	Correlation coefficient	Correlation coefficient	Correlation coefficient	Correlation coefficient		
<b>Whitefly</b>	0.73*	0.79*	-0.56*	0.05	0.15	0.15
<b>Jassid</b>	0.59*	0.79*	-0.15	0.31	0.41	0.18
<b>Shoot and fruit borer</b>	-0.47	-0.77*	0.24	-0.44	-0.56*	-0.08
<b>*Significant at 5% level</b>						

#### 4.1.1 Whitefly, *Bemisia tabaci* (Hemiptera : Aleyrodidae)

The population of whitefly ranged between 1.20 to 8.96 / 3 leaves during September to December months (Table 4.1). Periodical observations, on the incidence of sucking insect pests of brinjal on the crop, revealed that the nymphs and adults of whitefly appeared in the last week of September (39<sup>th</sup> standard week). Initially the population of nymphs and adults of whitefly was 4.89 / 3 leaves. The highest whitefly population (8.96/ 3 leaves) was noticed during second week of October (41<sup>st</sup> standard week); during this period, maximum (32.10°C) and minimum (19.60°C) temperatures, morning (89.90%) and evening (49.10%) relative humidity, rainfall (0.00ml) and bright sunshine hours (8.80 hrs/day) prevailed. Thereafter, the population gradually decreased reaching 1.2 whitefly / 3 leaves during third week of November (47<sup>th</sup> standard week). During this week, maximum (28.20°C) and minimum (13.20°C) temperatures, morning (89.40%) and evening (47.40%) relative humidity, rainfall (0.00 ml) and bright sunshine hours (6.00hrs/day) prevailed.

### **Correlation studies:**

Correlation studies revealed that maximum temperature and minimum temperature exhibited significantly positive correlation ( $r= 0.73, 0.79$  respectively) with whitefly population. Morning relative humidity exhibited significantly negative correlation ( $r= -0.56$ ).

Whereas evening relative humidity, rainfall and sunshine hours were observed positive correlation ( $r= 0.05, 0.15, 0.15$  respectively) with whitefly population but to the non – significant level.

#### **4.1.2 Jassid, *Amrasca biguttula biguttula* (Hemiptera : Cicadellidae)**

The population of jassid ranged between 0.80 to 1.29 / 3 leaves during September to November months (Table 4.1). The first appearance of jassid was recorded during the last week of September (39<sup>th</sup> standard week) with the population of 0.8 / 3 leaves, which reached at its peak during the second week of October (41<sup>th</sup> standard week) with the population of 1.29 / 3 leaves. During the peak period of jassid population maximum (32.10°C) and minimum (19.60°C) temperatures, morning (89.90%) and evening (49.10%) relative humidity, rainfall (0.00ml) and bright sunshine hours (8.80 hrs/day) prevailed. Thereafter, the population gradually decreased reaching 0.13 jassid / 3 leaves during third week of November (47<sup>th</sup> standard week). During this week, maximum (28.20°C) and minimum (13.20°C) temperatures, morning (89.40%) and evening (47.40%) relative humidity, rainfall (0.00 ml) and bright sunshine hours (6.00hrs/day) prevailed. The population fluctuated during the different weeks.

### **Correlation studies:**

Correlation studies revealed that maximum temperature and minimum temperature exhibited significantly positive correlation ( $r=0.59, 0.79$  respectively) with jassid population.

Whereas morning relative humidity was negatively correlated ( $r=-0.15$ ) while evening relative humidity, rainfall and sunshine hours were observed positive correlation ( $r= 0.31, 0.41, 0.18$  respectively) with jassid population but to the non- significant level.

#### **4.1.3 Brinjal shoot and fruit borer, *Leucinodes orbonalis* (Lepidoptera : Crambidae)**

The infestation of shoot and fruit borer was observed in the second week of October (41<sup>st</sup> standard week) with 4.00% shoot infestation. During this period, maximum and minimum temperature were 32.10°C and 19.60°C, respectively, and morning and evening relative humidity were 89.90% and 49.10% respectively with 8.80 hrs of sunshine. Then the infestation gradually increased and reached its peak during the second week of November (46<sup>th</sup> standard week) with 20.00% shoot infestation. During this period, maximum and minimum temperature were 30.10°C and 13.40°C, respectively, and morning and evening relative humidity were 90.70% and 32.00% respectively with 7.60 hrs of sunshine. The fruit infestation was high during the fourth week of November (48<sup>th</sup> standard week) with 50% fruit infestation. During this period, maximum and minimum temperature were 28.00°C and 14.20°C, respectively, and morning and evening relative humidity were 92.10% and 51.00% respectively with 6.40 hrs of sunshine. Thereafter the fruit infestation gradually declined to 20% during the third week of December (51<sup>th</sup> standard week).

#### **Correlation studies:**

Correlation studies revealed that minimum temperature and rainfall exhibited significant negative correlation ( $r = -0.77, -0.56$ ) with shoot and fruit borer population.

Whereas morning relative humidity observed positive correlation ( $r = 0.24$ ) with shoot and fruit borer population while maximum temperature, evening relative humidity and sunshine hours were observed negative correlation ( $r = -0.47, -0.44, -0.08$  respectively) with shoot and fruit borer population but to non – significant level.

## **4.2 Efficacy of botanicals and bio-pesticides against major insect pests of brinjal**

To evaluate the efficacy of treatments on major insect pests of brinjal, foliar sprays were given thrice - first at ETL level, second was 15 days after first spray and third was 15 days after second spray. Observations on the nymph and adult population of whitefly and jassid, shoot infestation of shoot and fruit borer were recorded 1 day before spray and 3, 7 and 10 days after each spray. Fruit infestation of shoot and fruit borer was recorded during each picking.

### **4.2.1 Effect of different treatments on population of whitefly, *Bemisia tabaci*.**

#### **First spray**

##### **Pre-treatment observations:**

The data revealed that the whitefly population varied from 6.07 – 7.50 whitefly/ 3 leaves in different treatments including untreated control and the differences among the treatments were not statistically significant denoting that the whitefly population was more or less uniformly distributed in the field.

##### **Post treatment observations:**

##### **Population at 3 days after first spray**

Data presented in the table 4.3 showed that at three days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of whitefly as compared to control (6.93/ 3 leaves) (T<sub>9</sub>). The lowest (2.73 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (2.80 / 3 leaves), Neem oil – *Bb* – Neem oil 1% (T<sub>5</sub>) (3.30/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (3.50/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (3.87/ 3 leaves), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (4.03/ 3 leaves), Karanj oil 1% (T<sub>2</sub>) (4.13/ 3 leaves) and Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (4.37/ 3 leaves). The treatments Neem oil 1% (T<sub>1</sub>) and Neem oil –*Ma* –Neem oil 1% (T<sub>6</sub>) were at par and significantly superior over other treatments.

### **Population at 7 days after first spray**

Data presented in the table 4.3 showed that at seven days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of whitefly as compared to control (7.67/ 3 leaves) (T<sub>9</sub>). The lowest (3.20 / 3leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) (3.33 / 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (3.47/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (4.10/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (4.17/ 3 leaves), Karanj oil 1% (T<sub>2</sub>) (4.33/ 3 leaves), Karanj oil – *Ma* –Karanj oil 1% (T<sub>8</sub>) (4.40/ 3 leaves) and Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (4.43/ 3 leaves). The treatment Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

### **Population at 10 days after first spray**

Data presented in the table 4.3 showed that at ten days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of whitefly as compared to control (8.10/ 3 leaves) (T<sub>9</sub>). The lowest (4.00/ 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) (4.20/ 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (4.70/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (4.73/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (4.80/ 3 leaves), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (5.13/ 3 leaves), Karanj oil 1% (T<sub>2</sub>) (5.20/ 3 leaves) and Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (5.23/ 3 leaves). The treatments Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

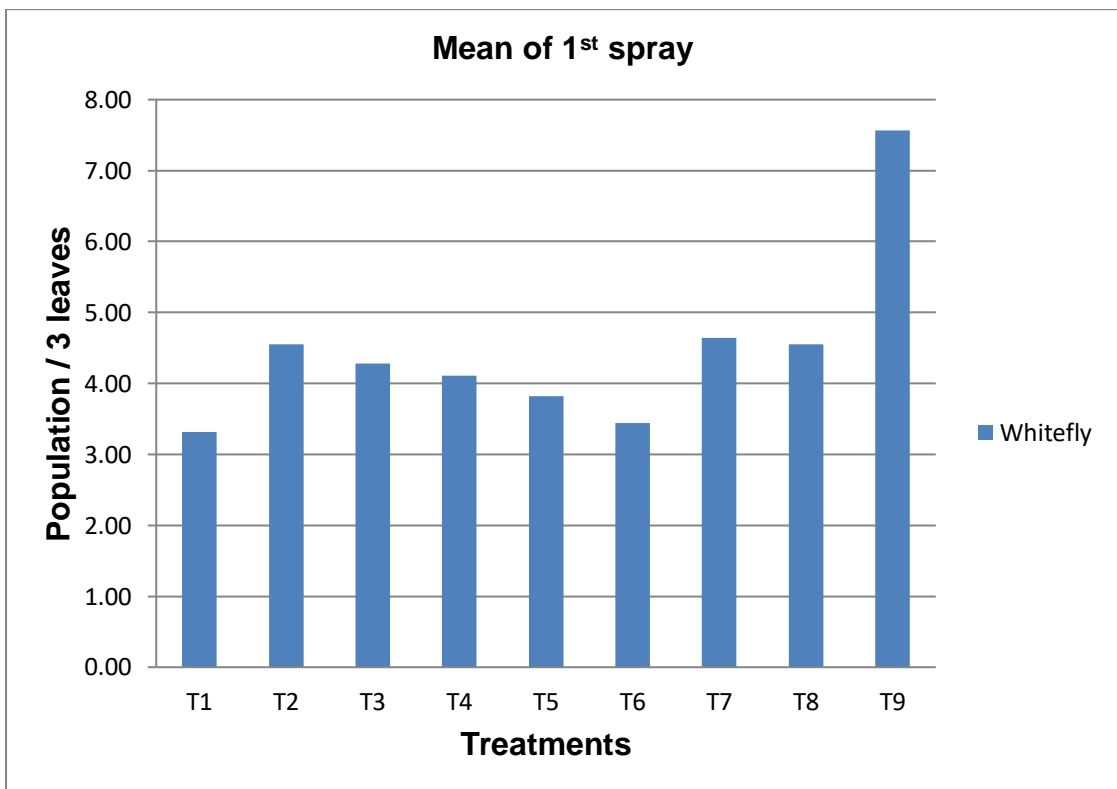
### **Overall mean**

On the basis of mean of overall observations all the biopesticidal treatments significantly reduced the population of whitefly as compared to control (7.57/ 3 leaves). Among the treatments Neem oil 1% (T<sub>1</sub>) was found to be the most effective (3.31/ 3 leaves) which was significantly better than Neem oil – *Bb* – Neem oil 1% (T<sub>5</sub>) (3.82/ 3 leaves ), *Metarrhizium anisopliae* (T<sub>4</sub>) (4.11/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (4.28/ 3 leaves), Karanj oil 1% (T<sub>2</sub>) (4.56/ 3 leaves), Karanj oil –*Ma* – Karanj oil 1% (T<sub>8</sub>) (4.56/ 3 leaves) and Karanj oil – *Bb* –Karanj oil 1% (T<sub>7</sub>) (4.64/ 3 leaves) but at par with Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) (3.44/ 3 leaves).

**Table 4.3 Efficacy of botanicals and bio-pesticides in the management of whitefly, *Bemisia tabaci* during 1<sup>st</sup> spray.**

Tr. No	Treatments	Dose/ha (ml)	Mean population / 3 leaves during 1 <sup>st</sup> spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Mean
T <sub>1</sub>	Neem oil 1%	3000	6.77 (2.70)	2.73 (1.78)	3.20 (1.92)	4.00 (2.12)	3.31 (1.94)
T <sub>2</sub>	Karanj oil 1%	3000	7.47 (2.81)	4.13 (2.15)	4.33 (2.20)	5.20 (2.39)	4.56 (2.25)
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	1000	7.50 (2.82)	3.87 (2.09)	4.17 (2.16)	4.80 (2.30)	4.28 (2.18)
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	1000	7.00 (2.73)	3.50 (2.00)	4.10 (2.14)	4.73 (2.28)	4.11 (2.14)
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3000-1000-3000	7.27 (2.78)	3.30 (1.95)	3.47 (1.99)	4.70 (2.28)	3.82 (2.07)
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	3000-1000-3000	6.93 (2.72)	2.80 (1.80)	3.33 (1.96)	4.20 (2.17)	3.44 (1.98)
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	3000-1000-3000	6.67 (2.67)	4.37 (2.20)	4.43 (2.22)	5.13 (2.37)	4.64 (2.27)
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	3000-1000-3000	6.53 (2.65)	4.03 (2.13)	4.40 (2.21)	5.23 (2.39)	4.56 (2.25)
T <sub>9</sub>	Untreated control	---	6.07 (2.56)	6.93 (2.72)	7.67 (2.86)	8.10 (2.93)	7.57 (2.84)
	<b>S.E.m ±</b>		<b>0.10</b>	<b>0.08</b>	<b>0.03</b>	<b>0.04</b>	<b>0.05</b>
	<b>C.D at 5%</b>		<b>N.S</b>	<b>0.25</b>	<b>0.08</b>	<b>0.13</b>	<b>0.15</b>

**Figs. in parentheses are in  $\sqrt{(x+0.5)}$  transformed values; DBS- Days before spraying; DAS- Days after spraying**



**Fig 5 : Efficacy of botanicals and biopesticides in the management of whitefly, *Bemisia tabaci* (1<sup>st</sup> spray)**

#### **4.2.2 Effect of different treatments on population of whitefly, *Bemisia tabaci*.**

##### **Second spray**

###### **Pre-treatment observations:**

The data revealed that the whitefly population varied from 6.07 – 8.47 whitefly/ 3 leaves in different treatments including untreated control and the differences among the treatments were not statistically significant denoting that the whitefly population was more or less uniformly distributed in the field.

###### **Post treatment observations:**

###### **Population at 3 days after second spray**

Data presented in the table 4.4 showed that at three days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of whitefly as compared to control (9.07/ 3 leaves) (T<sub>9</sub>). The lowest (2.63 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (2.77 / 3 leaves), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (3.03/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (3.23/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (3.33/ 3 leaves), Karanj oil –*Ba* –Karanj oil (T<sub>7</sub>) (3.37/ 3 leaves), Neem oil –*Ba* –Neem oil (T<sub>5</sub>) (3.40/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (3.65/ 3 leaves). The treatments Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

###### **Population at 7 days after second spray**

Data presented in the table 4.4 showed that at seven days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of whitefly as compared to control (9.23/ 3 leaves) (T<sub>9</sub>). The lowest (2.67 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (2.83 / 3 leaves), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (3.10/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (3.33/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (3.43/ 3 leaves), Karanj oil –*Ba* –Karanj oil (T<sub>7</sub>) (3.53/ 3 leaves), Neem oil –*Ba* –Neem oil (T<sub>5</sub>) (3.57/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (3.83/plant). The treatment Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

### **Population at 10 days after second spray**

Data presented in the table 4.4 showed that at ten days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of whitefly as compared to control (9.47/ 3 leaves) (T<sub>9</sub>). The lowest (3.23 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (3.57 / 3 leaves), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (3.87/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (3.97/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (4.23/ 3 leaves), Karanj oil –*Ba* –Karanj oil (T<sub>7</sub>) (4.27/ 3 leaves), Karanj oil 1% (T<sub>2</sub>) (4.33/ 3 leaves) and Neem oil –*Ba* –Neem oil (T<sub>5</sub>) (4.37/ 3 leaves). The treatments Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

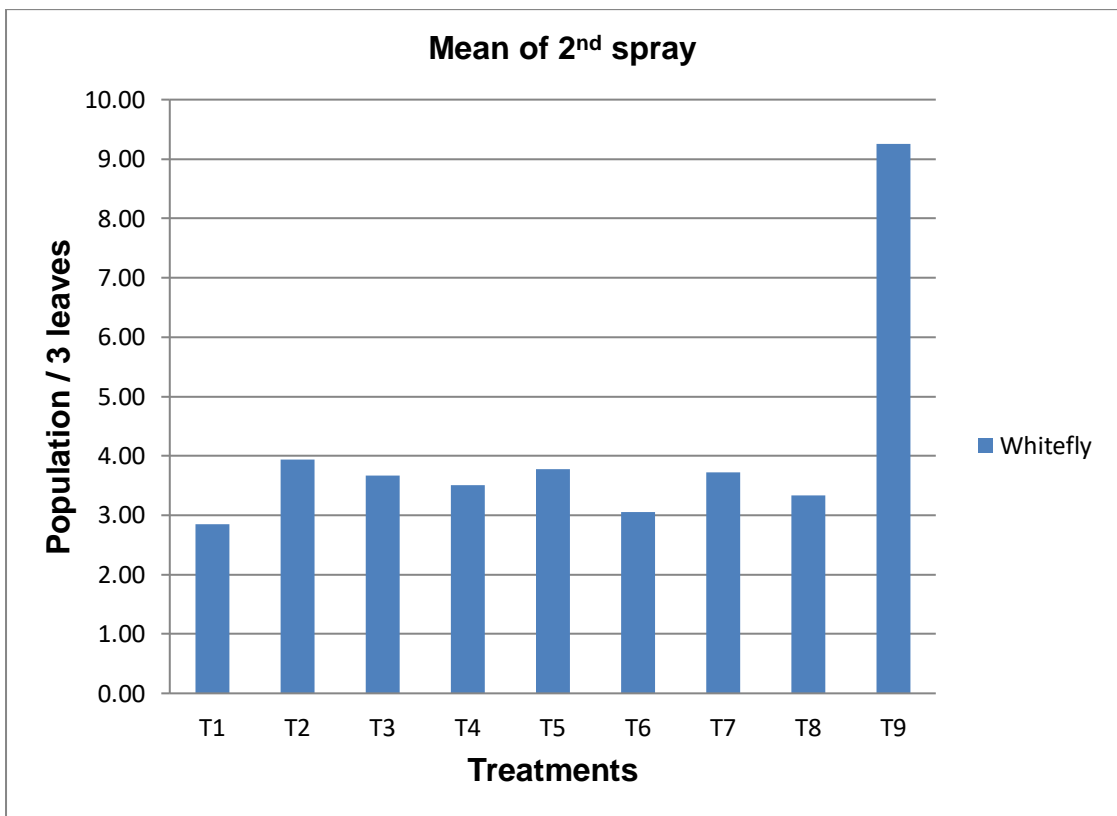
### **Overall mean**

On the basis of mean of overall observations all the biopesticidal treatments significantly reduced the population of whitefly as compared to control (9.26/ 3 leaves). Among the treatments Neem oil 1% (T<sub>1</sub>) was found to be the most effective (2.84/ 3 leaves) which was significantly better than Neem oil –*Ma* – Neem oil (T<sub>6</sub>) (3.06/ 3 leaves), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (3.33/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (3.51/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (3.67/ 3 leaves), Karanj oil –*Ba* –Karanj oil (T<sub>7</sub>) (3.72/ 3 leaves), Neem oil –*Ba* –Neem oil (T<sub>5</sub>) (3.78/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (3.94/ 3 leaves).

**Table 4.4 Efficacy of botanicals and bio-pesticides in the management of whitefly, *Bemisia tabaci* during 2<sup>nd</sup> spray.**

Tr. No	Treatments	Dose/ha (ml)	Mean population / 3 leaves during 2 <sup>nd</sup> spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Mean
T <sub>1</sub>	Neem oil 1%	3000	6.17 (2.58)	2.63 (1.77)	2.67 (1.78)	3.23 (1.93)	2.84 (1.83)
T <sub>2</sub>	Karanj oil 1%	3000	6.47 (2.62)	3.65 (2.04)	3.83 (2.08)	4.33 (2.20)	3.94 (2.11)
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	1000	6.80 (2.70)	3.33 (1.96)	3.43 (1.98)	4.23 (2.18)	3.67 (2.04)
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	1000	6.73 (2.69)	3.23 (1.93)	3.33 (1.96)	3.97 (2.11)	3.51 (2.00)
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3000-1000-3000	6.40 (2.63)	3.40 (1.97)	3.57 (2.02)	4.37 (2.20)	3.78 (2.06)
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	3000-1000-3000	6.33 (2.61)	2.77 (1.81)	2.83 (1.82)	3.57 (2.02)	3.06 (1.88)
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	3000-1000-3000	6.27 (2.60)	3.37 (1.97)	3.53 (2.01)	4.27 (1.18)	3.72 (2.05)
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	3000-1000-3000	6.07 (2.56)	3.03 (1.88)	3.10 (1.90)	3.87 (2.09)	3.33 (1.96)
T <sub>9</sub>	Untreated control	---	8.47 (2.99)	9.07 (3.09)	9.23 (3.12)	9.47 (3.16)	9.26 (3.12)
	<b>S.E.m ±</b>		<b>0.09</b>	<b>0.04</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>
	<b>C.D at 5%</b>		<b>N.S</b>	<b>0.11</b>	<b>0.09</b>	<b>0.10</b>	<b>0.10</b>

**Figs. in parentheses are in  $\sqrt{(x+0.5)}$  transformed values; DBS- Days before spraying; DAS- Days after spraying**



**Fig 6: Efficacy of botanicals and biopesticides in the management of whitefly, *Bemisia tabaci* (2<sup>nd</sup> spray)**

### 4.2.3 Effect of different treatments on nymph and adult population of whitefly, *Bemisia tabaci*.

#### Third spray

##### Pre-treatment observations:

The data revealed that the whitefly population varied from 4.00 – 6.67 whitefly/ 3 leaves in different treatments including untreated control and the differences among the treatments were not statistically significant denoting that the whitefly population was more or less uniformly distributed in the field.

##### Post treatment observations:

##### Population at 3 days after third spray

Data presented in the table 4.5 showed that at three days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of whitefly as compared to control (7.67/ 3 leaves) (T<sub>9</sub>). The lowest (0.90 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* Neem oil 1% (T<sub>6</sub>) (1.00 / 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (1.20/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (1.37./ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (1.47/ 3 leaves), Karanj oil 1% (T<sub>2</sub>) (1.65/ 3 leaves), Karanj oil – *Ma* –Karanj oil 1% (T<sub>8</sub>) (1.67/ 3 leaves) and Karanj oil –*Bb* – Karanj oil 1% (T<sub>7</sub>) (1.70/ 3 leaves). The treatments Neem oil 1% (T<sub>1</sub>) and Neem oil – *Ma* Neem oil 1% (T<sub>6</sub>) were at par and significantly superior over other treatments.

##### Population at 7 days after third spray

Data presented in the table 4.5 showed that at seven days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of whitefly as compared to control (9.33/ 3 leaves) (T<sub>9</sub>). The lowest (1.13 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* Neem oil 1% (T<sub>6</sub>) (1.20 / 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (1.37/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (1.55/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (1.77/ 3 leaves), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (1.80/ 3 leaves), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (1.90/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (2.10/ 3 leaves). The treatment Neem oil 1% (T<sub>1</sub>) and Neem oil – *Ma* Neem oil 1% (T<sub>6</sub>) were at par and significantly superior over other treatments.

### **Population at 10 days after third spray**

Data presented in the table 4.5 showed that at ten days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of whitefly as compared to control (11.67/ 3 leaves) (T<sub>9</sub>). The lowest (1.33 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* Neem oil 1% (T<sub>6</sub>) (1.43 / 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (1.50/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (1.70/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (1.83/ 3 leaves), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (2.17/ 3 leaves), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (2.30/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (2.43/ 3 leaves). The treatment Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

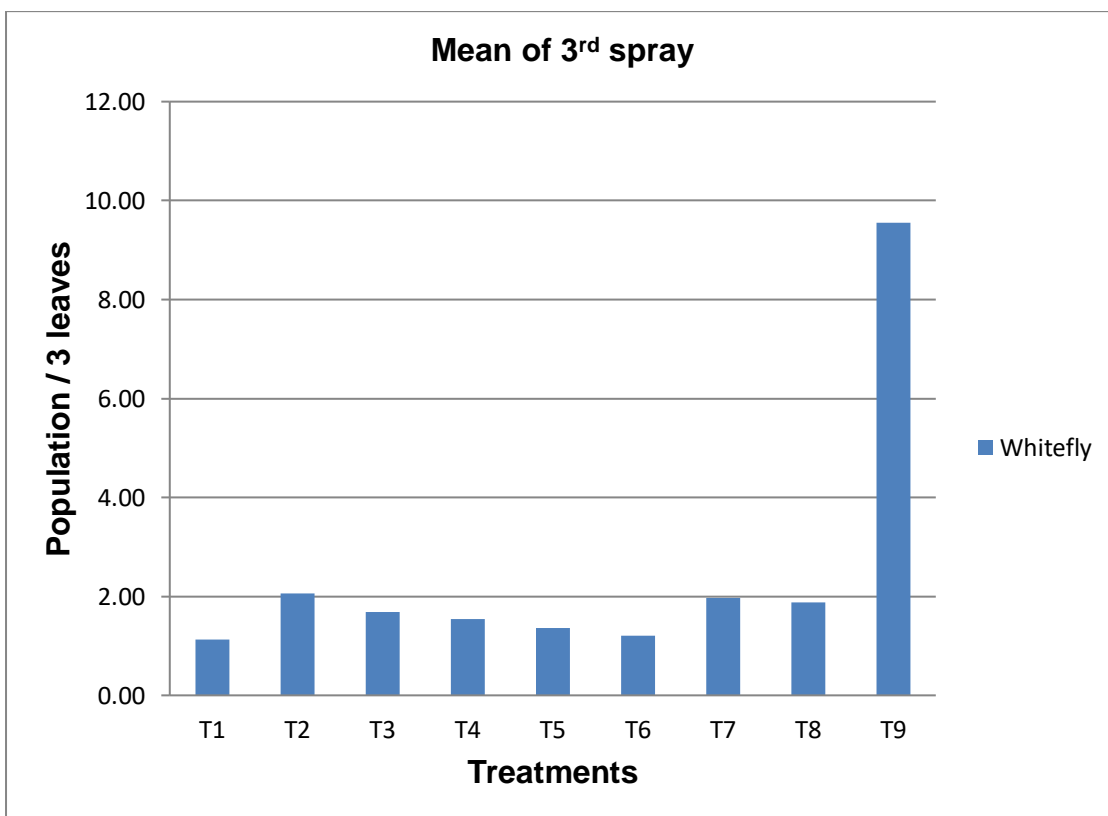
### **Overall mean**

On the basis of mean of overall observations all the biopesticidal treatments significantly reduced the population of whitefly as compared to control (9.56/ 3 leaves). Among the treatments Neem oil 1% (T<sub>1</sub>) was found to have the lowest population (1.12/ 3 leaves) which was followed by Neem oil – *Ma* Neem oil 1% (T<sub>6</sub>) (1.21 / 3 leaves), Neem oil – *Bb* – Neem oil 1% (T<sub>5</sub>) (1.36/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (1.54/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (1.69/ 3 leaves), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (1.88/ 3 leaves), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (1.97/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (2.06/ 3leaves). The treatment Neem oil 1% (T<sub>1</sub>) and Neem oil – *Ma* Neem oil 1% (T<sub>6</sub>) were at par and significantly superior over other treatments.

**Table 4.5 Efficacy of botanicals and bio-pesticides in the management of whitefly, *Bemisia tabaci* 3<sup>rd</sup> spray.**

Tr. No	Treatments	Dose/ha (ml)	Mean population / 3 leaves during 3 <sup>rd</sup> spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Mean
T <sub>1</sub>	Neem oil 1%	3000	4.00 (2.12)	0.90 (1.18)	1.13 (1.28)	1.33 (1.35)	1.12 (1.27)
T <sub>2</sub>	Karanj oil 1%	3000	4.80 (2.30)	1.65 (1.47)	2.10 (1.61)	2.43 (1.71)	2.06 (1.60)
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	1000	4.63 (2.26)	1.47 (1.40)	1.77 (1.51)	1.83 (1.53)	1.69 (1.48)
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	1000	4.50 (2.23)	1.37 (1.37)	1.55 (1.43)	1.70 (1.48)	1.54 (1.43)
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3000-1000-3000	4.33 (2.20)	1.20 (1.30)	1.37 (1.37)	1.50 (1.41)	1.36 (1.36)
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	3000-1000-3000	4.12 (2.15)	1.00 (1.22)	1.20 (1.30)	1.43 (1.39)	1.21 (1.31)
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	3000-1000-3000	5.07 (2.36)	1.70 (1.48)	1.90 (1.55)	2.30 (1.67)	1.97 (1.57)
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	3000-1000-3000	4.93 (2.33)	1.67 (1.47)	1.80 (1.52)	2.17 (1.63)	1.88 (1.54)
T <sub>9</sub>	Untreated control	---	6.67 (2.65)	7.67 (2.85)	9.33 (3.13)	11.67 (3.49)	9.56 (3.16)
	<b>S.E.m ±</b>		<b>0.11</b>	<b>0.05</b>	<b>0.03</b>	<b>0.02</b>	<b>0.03</b>
	<b>C.D at 5%</b>		<b>N.S</b>	<b>0.15</b>	<b>0.09</b>	<b>0.06</b>	<b>0.10</b>

**Figs. in parentheses are in  $\sqrt{(x+0.5)}$  transformed values; DBS- Days before spraying; DAS- Days after spraying**



**Fig 7: Efficacy of botanicals and biopesticides in the management of whitefly, *Bemisia tabaci* (3<sup>rd</sup> spray)**

#### **4.2.4 Effect of different treatments on population of jassid, *Amrasca biguttula biguttula*.**

##### **First spray**

###### **Pre-treatment observations:**

The data revealed that the jassid population varied from 1.93 – 3.17 jassid/ 3 leaves in different treatments including untreated control and the differences among the treatments were not statistically significant denoting that the jassid population was more or less uniformly distributed in the field.

###### **Post treatment observations:**

##### **Population at 3 days after first spray**

Data presented in the table 4.6 showed that at three days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of jassid as compared to control (3.27/ 3 leaves) (T<sub>9</sub>). The lowest (0.19 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) (0.33 / 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (0.60/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.63/ 3 leaves), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (0.73/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (0.83/ 3 leaves),Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (0.93/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (1.17/ 3 leaves). The treatments Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

##### **Population at 7 days after first spray**

Data presented in the table 4.6 showed that at seven days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of jassid as compared to control (3.43/ 3 leaves) (T<sub>9</sub>). The lowest (0.33 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) (0.46 / 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (0.70/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.83/ 3 leaves), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (0.93/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (0.96/ 3 leaves), Karanj oil 1% (T<sub>2</sub>) (1.25/ 3 leaves) and Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (1.37/ 3 leaves). The treatment Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

### **Population at 10 days after first spray**

Data presented in the table 4.6 showed that at ten days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of jassid as compared to control (3.60/ 3 leaves) (T<sub>9</sub>). The lowest (0.53 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) (0.60 / 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (0.80/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.90/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (1.03/ 3 leaves), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (1.23/ 3 leaves), Karanj oil 1% (T<sub>2</sub>) (1.45/ 3 leaves) and Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (1.50/ 3 leaves). The treatments Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

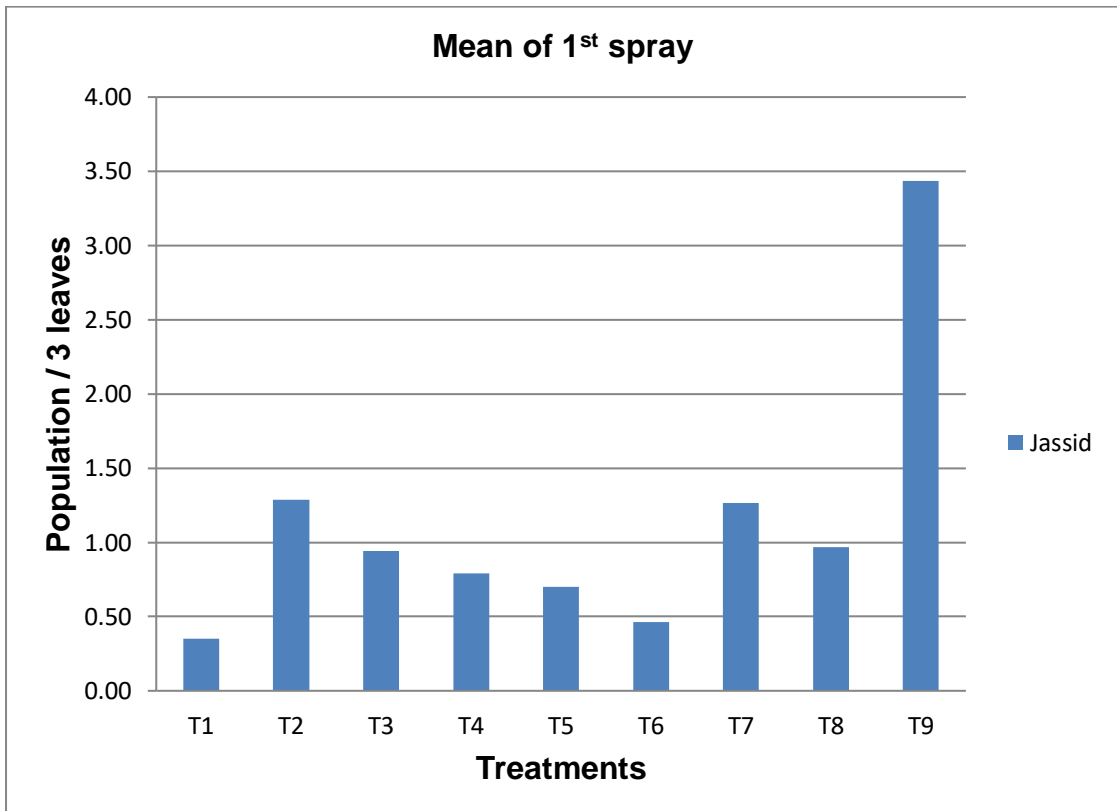
### **Overall mean**

On the basis of mean of overall observations all the biopesticidal treatments significantly reduced the population of jassid as compared to control (3.43/ 3 leaves). Among the treatments Neem oil 1% (T<sub>1</sub>) was found to be the most effective (0.35/ 3 leaves) which was significantly better than Neem oil – *Ma* – Neem oil 1% (T<sub>6</sub>) (0.46 / 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (0.70/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.79/plant), *Beauveria bassiana* (T<sub>3</sub>) (0.94/ 3 leaves), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (0.97/ 3 leaves), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (1.27/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (1.29/ 3 leaves).

**Table 4.6 Efficacy of botanicals and bio-pesticides in the management of jassid, *Amrasca biguttula biguttula* during 1<sup>st</sup> spray.**

Tr. No	Treatments	Dose/ha (ml)	Mean population / 3 leaves during 1 <sup>st</sup> spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Mean
T <sub>1</sub>	Neem oil 1%	3000	1.93 (1.56)	0.19 (0.83)	0.33 (0.91)	0.53 (1.02)	0.35 (0.92)
T <sub>2</sub>	Karanj oil 1%	3000	2.83 (1.82)	1.17 (1.29)	1.25 (1.32)	1.45 (1.40)	1.29 (1.34)
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	1000	2.67 (1.78)	0.83 (1.15)	0.96 (1.21)	1.03 (1.24)	0.94 (1.20)
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	1000	2.47 (1.72)	0.63 (1.06)	0.83 (1.15)	0.90 (1.18)	0.79 (1.13)
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3000-1000-3000	2.33 (1.67)	0.60 (1.05)	0.70 (1.10)	0.80 (1.14)	0.70 (1.09)
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	3000-1000-3000	2.13 (1.62)	0.33 (0.91)	0.46 (0.98)	0.60 (1.05)	0.46 (0.98)
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	3000-1000-3000	2.87 (1.83)	0.93 (1.20)	1.37 (1.37)	1.50 (1.41)	1.27 (1.33)
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	3000-1000-3000	3.00 (1.87)	0.73 (1.11)	0.93 (1.20)	1.23 (1.22)	0.97 (1.21)
T <sub>9</sub>	Untreated control	---	3.17 (1.91)	3.27 (1.94)	3.43 (1.98)	3.60 (2.02)	3.43 (1.98)
	<b>S.E.m ±</b>		<b>0.08</b>	<b>0.02</b>	<b>0.02</b>	<b>0.01</b>	<b>0.02</b>
	<b>C.D at 5%</b>		<b>N.S</b>	<b>0.06</b>	<b>0.07</b>	<b>0.03</b>	<b>0.05</b>

**Figs. in parentheses are in  $\sqrt{(x+0.5)}$  transformed values; DBS- Days before spraying; DAS- Days after spraying**



**Fig 8: Efficacy of botanicals and biopesticides in the management of jassid, *Amrasca biguttula biguttula* (1<sup>st</sup> spray)**

#### **4.2.5 Effect of different treatments on population of jassid, *Amrasca biguttula biguttula*.**

##### **Second spray**

###### **Pre-treatment observations:**

The data revealed that the jassid population varied from 1.80 – 3.67 jassid/ 3 leaves in different treatments including untreated control and the differences among the treatments were not statistically significant denoting that the jassid population was more or less uniformly distributed in the field.

###### **Post treatment observations:**

###### **Population at 3 days after second spray**

Data presented in the table 4.7 showed that at three days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of jassid as compared to control (3.77/ 3 leaves) (T<sub>9</sub>). The lowest (0.20 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (0.34 / 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.53/ 3 leaves), Neem oil – *Bb* – Neem oil (T<sub>5</sub>) (0.55/ 3 leaves), Karanj oil –*Ma* – Karanj oil (T<sub>8</sub>) (0.73/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (0.77/ 3 leaves), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (0.83/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (0.87/ 3 leaves). The treatment Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

###### **Population at 7 days after second spray**

Data presented in the table 4.7 showed that at seven days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of jassid as compared to control (4.23/ 3 leaves) (T<sub>9</sub>). The lowest (0.30 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (0.43 / 3 leaves), Neem oil – *Bb* – Neem oil (T<sub>5</sub>) (0.67/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.67/ 3 leaves), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (0.80/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (0.90/ 3 leaves), Karanj oil – *Bb* –Karanj oil (T<sub>7</sub>) (0.93/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (1.27/ 3 leaves). The treatment Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

### **Population at 10 days after second spray**

Data presented in the table 4.7 showed that at ten days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of jassid as compared to control (4.40/ 3 leaves) (T<sub>9</sub>). The lowest (0.48 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (0.58 / 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.85/ 3 leaves), Neem oil – *Bb* – Neem oil (T<sub>5</sub>) (0.87/ 3 leaves), Karanj oil –*Ma* – Karanj oil (T<sub>8</sub>) (1.00/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (1.00/ 3 leaves), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (1.10/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (1.33/ 3 leaves). The treatment Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

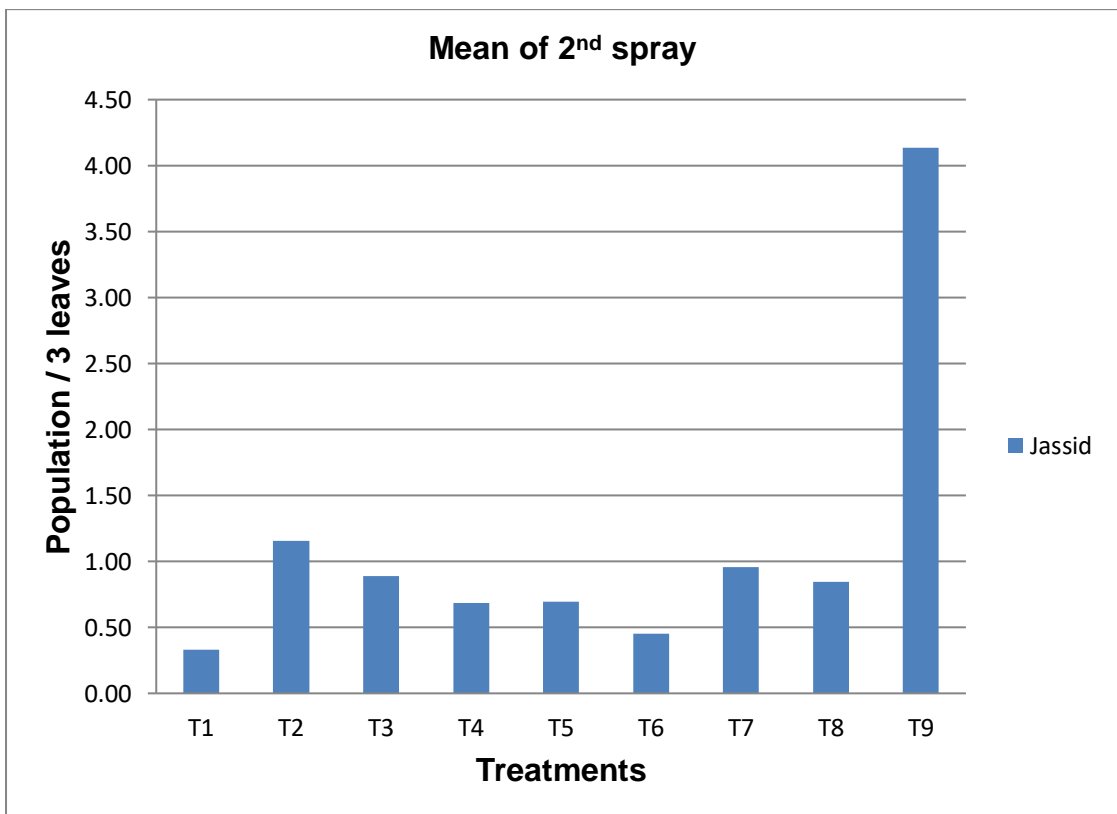
### **Overall mean**

On the basis of mean of overall observations all the biopesticidal treatments significantly reduced the population of jassid as compared to control (4.13/ 3 leaves). Among the treatments Neem oil 1% (T<sub>1</sub>) was found to be the most effective (0.33/ 3 leaves) which was significantly better than Neem oil – *Ma* – Neem oil (T<sub>6</sub>) (0.45 / 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.68/ 3 leaves), Neem oil – *Bb* – Neem oil (T<sub>5</sub>) (0.70/ 3 leaves), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (0.84/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (0.89/ 3 leaves), Karanj oil –*Bb* – Karanj oil (T<sub>7</sub>) (0.96/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (1.16/ 3 leaves).

**Table 4.7 Efficacy of botanicals and bio-pesticides in the management of jassid, *Amrasca biguttula biguttula* during 2<sup>nd</sup> spray.**

Tr. No	Treatments	Dose/ha (ml)	Mean population / plant during 2 <sup>nd</sup> spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Mean
T <sub>1</sub>	Neem oil 1%	3000	1.80 (1.51)	0.20 (0.84)	0.30 (0.90)	0.48 (0.99)	0.33 (0.91)
T <sub>2</sub>	Karanj oil 1%	3000	2.53 (1.72)	0.87 (1.17)	1.27 (1.33)	1.33 (1.35)	1.16 (1.28)
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	1000	2.47 (1.72)	0.77 (1.12)	0.90 (1.18)	1.00 (1.22)	0.89 (1.18)
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	1000	2.33 (1.68)	0.53 (1.01)	0.67 (1.08)	0.85 (1.16)	0.68 (1.08)
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3000-1000-3000	2.20 (1.63)	0.55 (1.02)	0.67 (1.08)	0.87 (1.17)	0.70 (1.09)
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	3000-1000-3000	1.97 (1.56)	0.34 (0.92)	0.43 (0.97)	0.58 (1.04)	0.45 (0.97)
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	3000-1000-3000	2.60 (1.76)	0.83 (1.15)	0.93 (1.20)	1.10 (1.26)	0.96 (1.21)
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	3000-1000-3000	2.77 (1.80)	0.73 (1.11)	0.80 (1.14)	1.00 (1.22)	0.84 (1.16)
T <sub>9</sub>	Untreated control	---	3.67 (2.04)	3.77 (2.07)	4.23 (2.18)	4.40 (2.21)	4.13 (2.15)
	<b>S.E.m ±</b>		<b>0.10</b>	<b>0.03</b>	<b>0.02</b>	<b>0.02</b>	<b>0.02</b>
	<b>C.D at 5%</b>		<b>N.S</b>	<b>0.10</b>	<b>0.07</b>	<b>0.06</b>	<b>0.08</b>

**Figs. in parentheses are in  $\sqrt{(x+0.5)}$  transformed values; DBS- Days before spraying; DAS- Days after spraying**



**Fig 9: Efficacy of botanicals and biopesticides in the management of jassid, *Amrasca biguttula biguttula* (2<sup>nd</sup> spray)**

#### **4.2.6 Effect of different treatments on population of jassid, *Amrasca biguttula biguttula*.**

##### **Third spray**

###### **Pre-treatment observations:**

The data revealed that the jassid population varied from 1.70 – 4.52 jassid/ 3 leaves in different treatments including untreated control and the differences among the treatments were not statistically significant denoting that the jassid population was more or less uniformly distributed in the field.

###### **Post treatment observations:**

##### **Population at 3 days after third spray**

Data presented in the table 4.8 showed that at three days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of jassid as compared to control (4.53/ 3 leaves) (T<sub>9</sub>). The lowest (0.17/ 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) (0.27 / 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (0.43/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.53/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (0.67/ 3 leaves), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (0.78/ 3 leaves), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (0.80/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (0.87/ 3 leaves). The treatment Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

##### **Population at 7 days after third spray**

Data presented in the table 4.8 showed that at seven days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of jassid as compared to control (4.67/ 3 leaves) (T<sub>9</sub>). The lowest (0.33 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) (0.43 / 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (0.53/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.67/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (0.77/ 3 leaves), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (0.83/ 3 leaves), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (0.85/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (0.97/ 3 leaves). The treatment Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

### **Population at 10 days after third spray**

Data presented in the table 4.8 showed that at ten days after spray, all the botanicals and bio - pesticide treatments significantly reduced the population of jassid as compared to control (4.77/ 3 leaves) (T<sub>9</sub>). The lowest (0.47 / 3 leaves) population was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) (0.58 / 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (0.73/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.80/ 3 leaves), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (0.87/ 3 leaves) and Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (0.97/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (1.00/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (1.33/ 3 leaves). The treatment Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

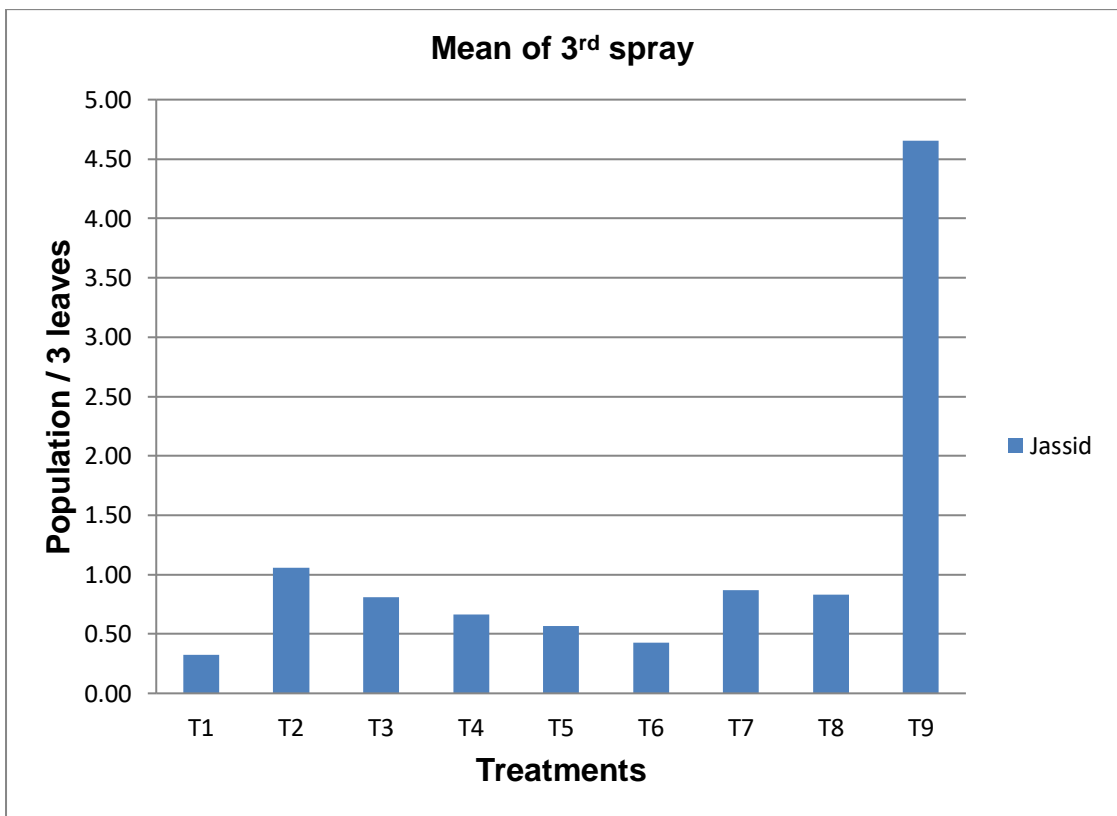
### **Overall mean**

On the basis of mean of overall observations all the biopesticidal treatments significantly reduced the population of jassid as compared to control (4.66/ 3 leaves). Among the treatments Neem oil 1% (T<sub>1</sub>) was found to be the most effective (0.32/ 3 leaves) which was significantly better than Neem oil – *Ma* – Neem oil 1% (T<sub>6</sub>) (0.43 / 3 leaves), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (0.57/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.67/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (0.81/ 3 leaves), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (0.83/ 3 leaves), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (0.87/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (1.06/ 3 leaves).

**Table 4.8 Efficacy of botanicals and bio-pesticides in the management of jassid, *Amrasca biguttula biguttula* during 3<sup>rd</sup> spray.**

Tr. No	Treatments	Dose/ha (ml)	Mean population / 3 leaves during 3 <sup>rd</sup> spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Mean
T <sub>1</sub>	Neem oil 1%	3000	1.73 (1.47)	0.17 (0.82)	0.33 (0.91)	0.47 (0.98)	0.32 (0.90)
T <sub>2</sub>	Karanj oil 1%	3000	2.37 (1.69)	0.87 (1.17)	0.97 (1.21)	1.33 (1.35)	1.06 (1.24)
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	1000	1.93 (1.55)	0.67 (1.08)	0.77 (1.13)	1.00 (1.22)	0.81 (1.14)
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	1000	2.20 (1.64)	0.53 (1.01)	0.67 (1.08)	0.80 (1.14)	0.67 (1.08)
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3000-1000-3000	2.00 (1.56)	0.43 (0.97)	0.53 (1.02)	0.73 (1.11)	0.57 (1.03)
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	3000-1000-3000	1.70 (1.48)	0.27 (0.88)	0.43 (0.97)	0.58 (1.04)	0.43 (0.96)
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	3000-1000-3000	2.40 (1.70)	0.78 (1.13)	0.85 (1.16)	0.97 (1.21)	0.87 (1.17)
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	3000-1000-3000	2.53 (1.70)	0.80 (1.24)	0.83 (1.15)	0.87 (1.17)	0.83 (1.15)
T <sub>9</sub>	Untreated control	---	4.52 (2.24)	4.53 (2.24)	4.67 (2.27)	4.77 (2.29)	4.66 (2.27)
	<b>S.E.m ±</b>		<b>0.14</b>	<b>0.02</b>	<b>0.01</b>	<b>0.02</b>	<b>0.02</b>
	<b>C.D at 5%</b>		<b>N.S</b>	<b>0.07</b>	<b>0.04</b>	<b>0.06</b>	<b>0.06</b>

**Figs. in parentheses are in  $\sqrt{(x+0.5)}$  transformed values; DBS- Days before spraying; DAS- Days after spraying**



**Fig 10: Efficacy of botanicals and biopesticides in the management of jassid, *Amrasca biguttula biguttula* (3<sup>rd</sup> spray)**

#### **4.2.7 Effect of different treatments on shoot and fruit borer, *Leucinodes orbonalis* .**

##### **First spray**

###### **Pre-treatment observations:**

The data revealed that the shoot infestation varied from 9.67 – 16.67% in different treatments including untreated control and the differences among the treatments were not statistically significant denoting that the shoot and fruit borer population was more or less uniformly distributed in the field.

###### **Post treatment observations:**

###### **At 3 days after first spray**

Data presented in the table 4.9 showed that at three days after spray, all the botanicals and bio - pesticide treatments significantly reduced the shoot infestation as compared to control (17.67%) (T<sub>9</sub>). The lowest (5.83%) infestation was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* – Neem oil 1% (T<sub>6</sub>) (7.00%), *Metarrhizium anisopliae* (T<sub>4</sub>) (8.83%), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (8.90%), *Beauveria bassiana* (T<sub>3</sub>) (10.60%), Karanj oil – *Bb* –Karanj oil 1% (T<sub>7</sub>) (11.00%), Karanj oil 1% (T<sub>2</sub>) (11.67%) and Karanj oil – *Ma* –Karanj oil 1% (T<sub>8</sub>) (12.00%). The treatments Neem oil 1% (T<sub>1</sub>), Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) and *Metarrhizium anisopliae* (T<sub>4</sub>) were at par and significantly superior over other treatments.

###### **At 7 days after first spray**

Data presented in the table 4.9 showed that at seven days after spray, all the botanicals and bio - pesticide treatments significantly reduced the shoot infestation as compared to control (18.33%) (T<sub>9</sub>). The lowest (7.00%) infestation was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* – Neem oil 1% (T<sub>6</sub>) (7.50%), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (9.17%), *Metarrhizium anisopliae* (T<sub>4</sub>) (9.60%), *Beauveria bassiana* (T<sub>3</sub>) (11.17%), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (11.67%), Karanj oil 1% (T<sub>2</sub>) (12.00%) and Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (12.33%). The treatments Neem oil 1% (T<sub>1</sub>) and Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) were at par and significantly superior over other treatments.

### **At 10 days after first spray**

Data presented in the table 4.9 showed that at ten days after spray, all the botanicals and bio - pesticide treatments significantly reduced the shoot infestation as compared to control (19.00%) (T<sub>9</sub>). The lowest (7.33%) infestation was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* – Neem oil 1% (T<sub>6</sub>) (7.73%), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (9.50%), *Metarrhizium anisopliae* (T<sub>4</sub>) (10.17%), *Beauveria bassiana* (T<sub>3</sub>) (11.67%), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (12.00%), Karanj oil 1% (T<sub>2</sub>) (12.33%) and Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (12.87%). The treatments Neem oil 1% (T<sub>1</sub>) and Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) were at par and significantly superior over other treatments.

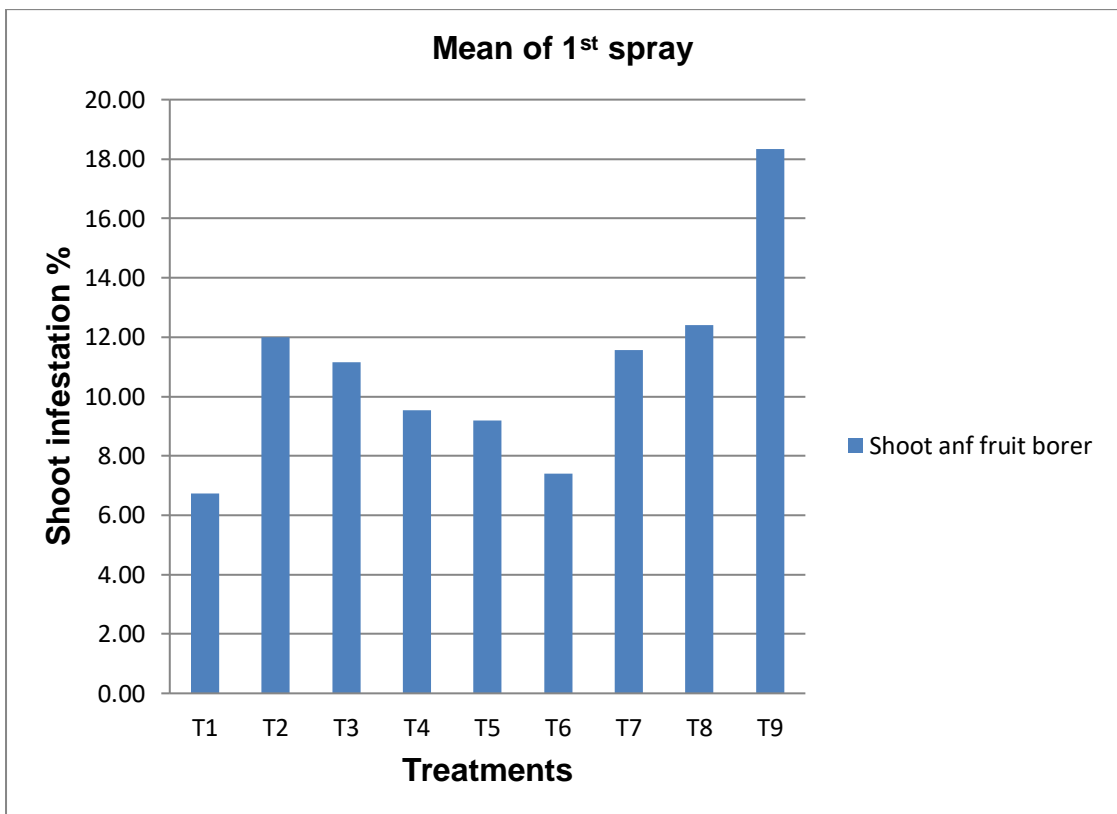
### **Overall mean**

On the basis of mean of overall observations all the biopesticidal treatments significantly reduced the shoot infestation as compared to control (18.33%). Among the treatments Neem oil 1% (T<sub>1</sub>) was found to be the most effective (6.72%) which was significantly better than Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (9.19%), *Metarrhizium anisopliae* (T<sub>4</sub>) (9.53%), *Beauveria bassiana* (T<sub>3</sub>) (11.14%), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (11.56%), Karanj oil 1% (T<sub>2</sub>) (12.00%) and Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (12.40%) but at par with Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) (7.41%).

**Table 4.9 Efficacy of botanicals and bio-pesticides in the management of shoot and fruit borer, *Leucinodes orbonalis* during 1<sup>st</sup> spray.**

Tr. No	Treatments	Dose/ha (ml)	Shoot infestation(%) during 1 <sup>st</sup> spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Mean
T <sub>1</sub>	Neem oil 1%	3000	9.67 (18.11)	5.83 (13.96)	7.00 (15.32)	7.33 (15.71)	6.72 (15.00)
T <sub>2</sub>	Karanj oil 1%	3000	14.00 (21.96)	11.67 (19.66)	12.00 (20.27)	12.33 (20.56)	12.00 (20.16)
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	1000	13.33 (16.40)	10.60 (18.99)	11.17 (19.51)	11.67 (19.97)	11.14 (19.49)
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	1000	12.00 (16.13)	8.83 (17.29)	9.60 (18.01)	10.17 (18.54)	9.53 (17.95)
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3000-1000- 3000	13.00 (20.33)	8.90 (17.33)	9.17 (17.62)	9.50 (17.95)	9.19 (17.63)
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	3000-1000- 3000	10.67 (19.05)	7.00 (15.34)	7.50 (15.89)	7.73 (16.17)	7.41 (15.79)
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	3000-1000- 3000	14.33 (22.24)	11.00 (19.29)	11.67 (19.95)	12.00 (20.23)	11.56 (19.82)
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	3000-1000- 3000	14.67 (22.30)	12.00 (20.17)	12.33 (20.56)	12.87 (21.09)	12.40 (20.58)
T <sub>9</sub>	Untreated control	---	16.67 (19.93)	17.67 (24.82)	18.33 (25.34)	19.00 (25.83)	18.33 (25.33)
	<b>S.E.m ±</b>		<b>6.15</b>	<b>1.16</b>	<b>0.55</b>	<b>0.56</b>	<b>0.76</b>
	<b>C.D at 5%</b>		<b>N.S</b>	<b>3.49</b>	<b>1.65</b>	<b>1.69</b>	<b>2.28</b>

**Figures in parentheses are angular transformed values; DBS- Days before spraying; DAS- Days after spraying**



**Fig 11: Efficacy of botanicals and biopesticides in the management of shoot and fruit borer, *Leucinodes orbonalis* (1<sup>st</sup> spray)**

#### **4.2.8 Effect of different treatments on shoot and fruit borer, *Leucinodes orbonalis*.**

##### **Second spray**

###### **Pre-treatment observations:**

The data revealed that the shoot infestation varied from 8.67 – 19.67% in different treatments including untreated control and the differences among the treatments were not statistically significant denoting that the shoot and fruit borer population was more or less uniformly distributed in the field.

###### **Post treatment observations:**

###### **At 3 days after second spray**

Data presented in the table 4.10 showed that at three days after spray, all the botanicals and bio - pesticide treatments significantly reduced the shoot infestation as compared to control (20.00%) (T<sub>9</sub>). The lowest (5.00%) infestation was observed in Neem oil 1% (T<sub>1</sub>) followed by Neem oil – *Ma* – Neem oil (T<sub>6</sub>) (6.67%), *Metarrhizium anisopliae* (T<sub>4</sub>) (8.00%), Neem oil – *Bb* – Neem oil (T<sub>5</sub>) (8.27%), Karanj oil – *Ma* – Karanj oil (T<sub>8</sub>) (8.40%), Karanj oil – *Bb* – Karanj oil (T<sub>7</sub>) (10.00%), *Beauveria bassiana* (T<sub>3</sub>) (10.17%), and Karanj oil 1% (T<sub>2</sub>) (11.33%). The treatments Neem oil 1% (T<sub>1</sub>) was significantly superior over other treatments.

###### **At 7 days after second spray**

Data presented in the table 4.10 showed that at seven days after spray, all the botanicals and bio - pesticide treatments significantly reduced the shoot infestation as compared to control (20.67%) (T<sub>9</sub>). The lowest (6.67%) infestation was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* – Neem oil (T<sub>6</sub>) (7.43%), *Metarrhizium anisopliae* (T<sub>4</sub>) (8.83%), Karanj oil – *Ma* – Karanj oil (T<sub>8</sub>) (9.20%), Neem oil – *Bb* – Neem oil (T<sub>5</sub>) (9.20%), Karanj oil – *Bb* – Karanj oil (T<sub>7</sub>) (10.73%), *Beauveria bassiana* (T<sub>3</sub>) (11.53%), and Karanj oil 1% (T<sub>2</sub>) (11.73%). The treatments Neem oil 1% (T<sub>1</sub>) and Neem oil – *Ma* – Neem oil (T<sub>6</sub>) were at par and significantly superior over other treatments.

### **At 10 days after second spray**

Data presented in the table 4.10 showed that at ten days after spray, all the botanicals and bio - pesticide treatments significantly reduced the shoot infestation as compared to control (21.00%) (T<sub>9</sub>). The lowest (7.30%) infestation was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* – Neem oil (T<sub>6</sub>) (7.97%), *Metarrhizium anisopliae* (T<sub>4</sub>) (9.67%), Karanj oil –*Ma* – Karanj oil (T<sub>8</sub>) (10.00%), Neem oil – *Bb* – Neem oil (T<sub>5</sub>) (10.03%), Karanj oil – *Bb* –Karanj oil (T<sub>7</sub>) (11.43%), *Beauveria bassiana* (T<sub>3</sub>) (11.70%), and Karanj oil 1% (T<sub>2</sub>) (12.50%). The treatments Neem oil 1% (T<sub>1</sub>), Neem oil – *Ma* – Neem oil (T<sub>6</sub>), Neem oil – *Bb* – Neem oil (T<sub>5</sub>), *Metarrhizium anisopliae* (T<sub>4</sub>) and Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) were at par and significantly superior over other treatments.

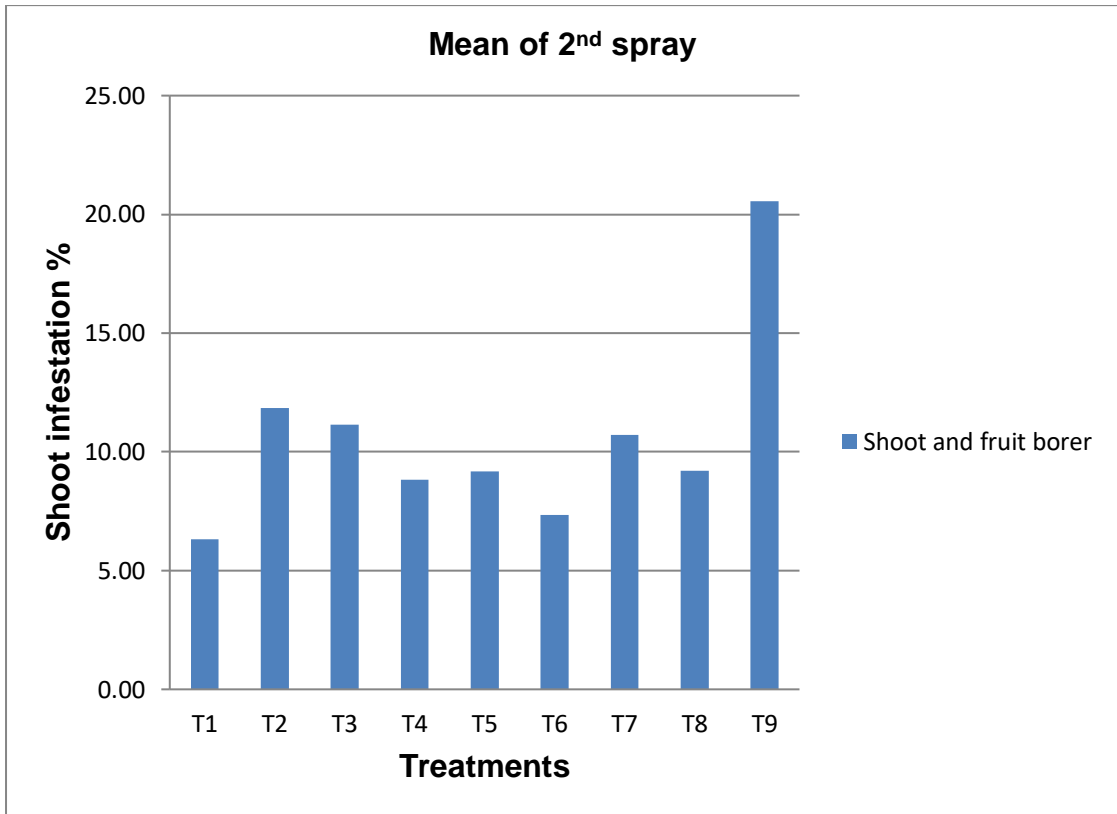
### **Overall mean**

On the basis of mean of overall observations all the biopesticidal treatments significantly reduced the shoot infestation as compared to control (20.56%). Among the treatments Neem oil 1% (T<sub>1</sub>) was found to be the most effective (6.32%) which was significantly better than *Metarrhizium anisopliae* (T<sub>4</sub>) (8.83%), Neem oil – *Bb* – Neem oil (T<sub>5</sub>) (9.17%), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (9.20%), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (10.72%), *Beauveria bassiana* (T<sub>3</sub>) (11.13%), and Karanj oil 1% (T<sub>2</sub>) (11.86%) but at par with Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (7.36%).

**Table 4.10 Efficacy of botanicals and bio-pesticides in the management of shoot and fruit borer, *Leucinodes orbonalis* during 2<sup>nd</sup> spray.**

Tr. No	Treatments	Dose/ha (ml)	Shoot infestation (%) during 2 <sup>nd</sup> spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Mean
T <sub>1</sub>	Neem oil 1%	3000	8.67 (17.02)	5.00 (12.88)	6.67 (14.96)	7.30 (15.67)	6.32 (14.50)
T <sub>2</sub>	Karanj oil 1%	3000	13.00 (21.13)	11.33 (19.67)	11.73 (20.03)	12.50 (20.70)	11.86 (20.13)
T <sub>3</sub>	<i>Beauveria bassiana</i> 1x 10 <sup>12</sup> spores/ml	1000	12.67 (20.66)	10.17 (18.59)	11.53 (19.85)	11.70 (19.55)	11.13 (19.33)
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1x 10 <sup>12</sup> spores/ml	1000	10.33 (18.75)	8.00 (16.41)	8.83 (17.26)	9.67 (18.11)	8.83 (17.26)
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3000-1000- 3000	11.33 (19.66)	8.27 (16.71)	9.20 (17.65)	10.03 (18.47)	9.17 (17.61)
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	3000-1000- 3000	9.67 (18.01)	6.67 (14.95)	7.43 (15.82)	7.97 (16.39)	7.36 (15.72)
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	3000-1000- 3000	13.37 (20.49)	10.00 (18.42)	10.73 (19.05)	11.43 (19.69)	10.72 (19.05)
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	3000-1000- 3000	13.17 (21.28)	8.40 (16.84)	9.20 (17.66)	10.00 (18.43)	9.20 (17.64)
T <sub>9</sub>	Untreated control	---	19.67 (25.82)	20.00 (26.57)	20.67 (27.04)	21.00 (27.27)	20.56 (26.96)
	<b>S.E.m ±</b>		<b>2.38</b>	<b>0.41</b>	<b>0.55</b>	<b>1.24</b>	<b>0.73</b>
	<b>C.D at 5%</b>		<b>N.S</b>	<b>1.22</b>	<b>1.64</b>	<b>3.72</b>	<b>2.19</b>

Figures in parentheses are angular transformed values; DBS- Days before spraying; DAS- Days after spraying



**Fig 12: Efficacy of botanicals and biopesticides in the management of shoot and fruit borer, *Leucinodes orbonalis* (2<sup>nd</sup> spray)**

#### **4.2.9 Effect of different treatments on shoot and fruit borer, *Leucinodes orbonalis*.**

##### **Third spray**

###### **Pre-treatment observations:**

The data revealed that the shoot infestation varied from 6.17 – 16.33% in different treatments including untreated control and the differences among the treatments were not statistically significant denoting that the shoot and fruit borer population was more or less uniformly distributed in the field.

###### **Post treatment observations:**

###### **At 3 days after third spray**

Data presented in the table 4.11 showed that at three days after spray, all the botanicals and bio - pesticide treatments significantly reduced the shoot infestation as compared to control (18.33%) (T<sub>9</sub>). The lowest (2.83%) infestation was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* – Neem oil 1% (T<sub>6</sub>) (3.40%), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (4.20%), *Metarrhizium anisopliae* (T<sub>4</sub>) (5.40%), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (7.50%), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (7.83%), *Beauveria bassiana* (T<sub>3</sub>) (8.47%), and Karanj oil 1% (T<sub>2</sub>) (10.43%). The treatments Neem oil 1% (T<sub>1</sub>) and Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) were at par and significantly superior over other treatments.

###### **At 7 days after third spray**

Data presented in the table 4.11 showed that at seven days after spray, all the botanicals and bio - pesticide treatments significantly reduced the shoot infestation as compared to control (20.67%) (T<sub>9</sub>). The lowest (3.37%) infestation was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* – Neem oil 1% (T<sub>6</sub>) (4.47%), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (5.50%), *Metarrhizium anisopliae* (T<sub>4</sub>) (6.00%), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (8.40%), *Beauveria bassiana* (T<sub>3</sub>) (9.33%), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (9.43%) and Karanj oil 1% (T<sub>2</sub>) (11.23%). The treatments Neem oil 1% (T<sub>1</sub>) and Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) were at par and significantly superior over other treatments.

### **At 10 days after third spray**

Data presented in the table 4.11 showed that at ten days after spray, all the botanicals and bio - pesticide treatments significantly reduced the shoot infestation as compared to control (21.33%) (T<sub>9</sub>). The lowest (4.20%) infestation was observed in Neem oil 1% (T<sub>1</sub>), followed by Neem oil – *Ma* – Neem oil 1% (T<sub>6</sub>) (5.13%), Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (6.77%), *Metarrhizium anisopliae* (T<sub>4</sub>) (7.33%), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (9.10%), *Beauveria bassiana* (T<sub>3</sub>) (10.00%), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (10.17%) and Karanj oil 1% (T<sub>2</sub>) (11.67%). The treatments Neem oil 1% (T<sub>1</sub>) and Neem oil – *Ma* –Neem oil 1% (T<sub>6</sub>) were at par and significantly superior over other treatments.

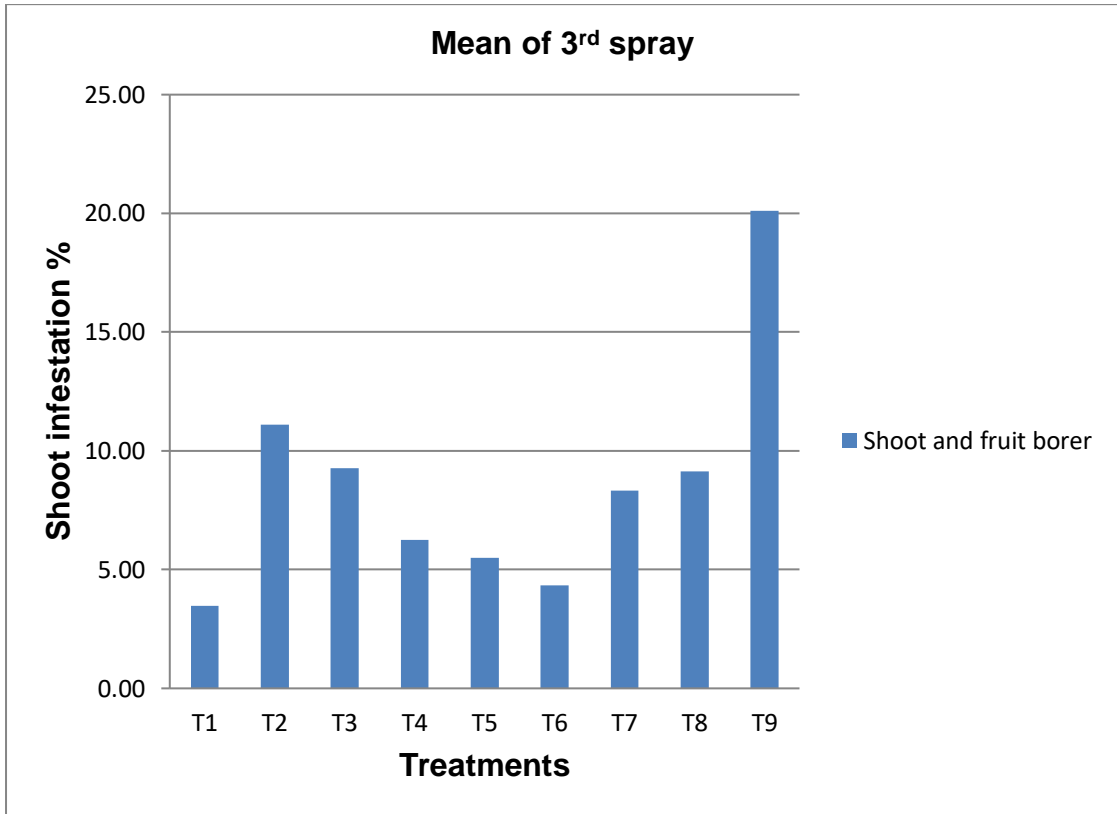
### **Overall mean**

On the basis of mean of overall observations all the biopesticidal treatments significantly reduced the shoot infestation as compared to control (20.11%). Among the treatments Neem oil 1% (T<sub>1</sub>) was found to be the most effective (3.47%) which was significantly better than Neem oil – *Bb* –Neem oil 1% (T<sub>5</sub>) (5.49%), *Metarrhizium anisopliae* (T<sub>4</sub>) (6.24%), Karanj oil –*Bb* –Karanj oil 1% (T<sub>7</sub>) (8.33%), Karanj oil –*Ma* –Karanj oil 1% (T<sub>8</sub>) (9.14%), *Beauveria bassiana* (T<sub>3</sub>) (9.27%) and Karanj oil 1% (T<sub>2</sub>) (11.11%) but at par with Neem oil – *Ma* – Neem oil 1% (T<sub>6</sub>) (4.33%).

**Table 4.11 Efficacy of botanicals and bio-pesticides in the management of shoot and fruit borer, *Leucinodes orbonalis* during 3<sup>rd</sup> spray.**

Tr. No	Treatments	Dose/ha (ml)	Shoot infestation (%) during 3 <sup>rd</sup> spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Mean
T <sub>1</sub>	Neem oil 1%	3000	6.17 (14.38)	2.83 (9.68)	3.37 (10.57)	4.20 (11.82)	3.47 (10.69)
T <sub>2</sub>	Karanj oil 1%	3000	11.67 (19.97)	10.43 (18.84)	11.23 (19.58)	11.67 (19.97)	11.11 (19.46)
T <sub>3</sub>	<i>Beauveria bassiana</i> 1x 10 <sup>12</sup> spores/ml	1000	10.40 (18.81)	8.47 (16.91)	9.33 (17.75)	10.00 (18.20)	9.27 (17.62)
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1x 10 <sup>12</sup> spores/ml	1000	8.00 (16.37)	5.40 (13.43)	6.00 (14.17)	7.33 (15.70)	6.24 (14.43)
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3000-1000-3000	7.00 (15.32)	4.20 (11.82)	5.50 (13.56)	6.77 (15.06)	5.49 (13.48)
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	3000-1000-3000	6.50 (14.76)	3.40 (10.62)	4.47 (12.19)	5.13 (13.10)	4.33 (11.97)
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	3000-1000-3000	9.00 (17.44)	7.50 (15.89)	8.40 (16.84)	9.10 (17.56)	8.33 (16.76)
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	3000-1000-3000	9.90 (18.33)	7.83 (11.24)	9.43 (17.88)	10.17 (18.59)	9.14 (17.57)
T <sub>9</sub>	Untreated control	---	16.33 (23.03)	18.33 (25.33)	20.67 (27.03)	21.33 (27.50)	20.11 (26.62)
	<b>S.E.m ±</b>		<b>1.77</b>	<b>0.38</b>	<b>0.45</b>	<b>0.79</b>	<b>0.54</b>
	<b>C.D at 5%</b>		<b>N.S</b>	<b>1.15</b>	<b>1.35</b>	<b>2.38</b>	<b>1.63</b>

Figures in parentheses are angular transformed values; DBS- Days before spraying; DAS- Days after spraying



**Fig 13: Efficacy of botanicals and biopesticides in the management of shoot and fruit borer, *Leucinodes orbonalis* (3<sup>rd</sup> spray)**

#### **Pooled Mean of 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> spray**

##### **4.2.10 Whitefly, *Bemisia tabaci***

Pooled Statistical analysis of all the three observations of 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> spray indicated that all the bio - pesticide treatments were significantly effective in reducing the population of whitefly as compared to control (8.79/ 3 leaves). Neem oil 1% (T<sub>1</sub>) proved to be effective in controlling the population of whitefly (2.43/ 3 leaves) and was significantly superior over all other treatments. Whereas efficacy of rest of the treatments was in the order of Neem oil – *Ma* – Neem oil (T<sub>6</sub>) (2.57/ 3 leaves), Neem oil – *Bb* –Neem oil (T<sub>5</sub>) (2.99/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (3.05/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (3.21 / 3 leaves), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (3.26 / 3 leaves), Karanj oil –*Bb* – Karanj oil (T<sub>7</sub>) (3.45/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (3.52 / 3 leaves).

#### **Pooled Mean of 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> spray**

##### **4.2.11 Jassid, *Amrasca biguttula biguttula***

Pooled Statistical analysis of all the three observations of 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> spray indicated that all the bio - pesticide treatments were significantly effective in reducing the population of jassid as compared to control (4.07/ 3 leaves). Neem oil 1% (T<sub>1</sub>) proved to be effective in controlling the population of jassid (0.33/ 3 leaves) and was significantly superior over all other treatments. Whereas efficacy of rest of the treatments was in the order of Neem oil – *Ma* – Neem oil (T<sub>6</sub>) (0.45/ 3 leaves), Neem oil – *Bb* –Neem oil (T<sub>5</sub>) (0.65/ 3 leaves), *Metarrhizium anisopliae* (T<sub>4</sub>) (0.71/ 3 leaves), *Beauveria bassiana* (T<sub>3</sub>) (0.88 / 3 leaves), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (0.88 / 3 leaves), Karanj oil –*Bb* – Karanj oil (T<sub>7</sub>) (1.03/ 3 leaves) and Karanj oil 1% (T<sub>2</sub>) (1.17 / 3 leaves).

#### **Pooled Mean of 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> spray**

##### **4.2.12 Shoot and fruit borer, *Leucinodes orbonalis***

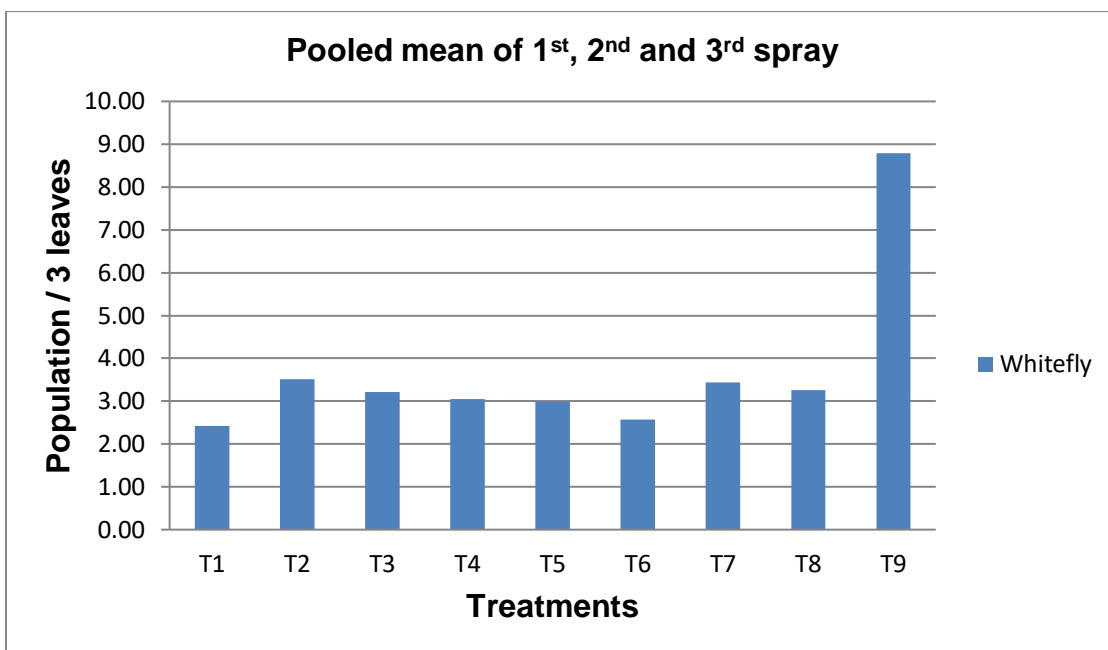
Pooled Statistical analysis of all the three observations of 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> spray indicated that all the bio - pesticide treatments were significantly effective in reducing the shoot infestation as compared to control (19.67%). Neem oil 1% (T<sub>1</sub>) proved to be effective in controlling the shoot infestation (5.80%) but was at par with Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (6.37%) and significantly superior over all other treatments. Whereas efficacy of rest of the treatments was in

the order Neem oil – *Bb* –Neem oil (T<sub>5</sub>) (7.95%), *Metarrhizium anisopliae* (T<sub>4</sub>) (8.20%), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (10.20%), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (10.25%), *Beauveria bassiana* (T<sub>3</sub>) (10.51 %) and Karanj oil 1% (T<sub>2</sub>) (11.66%).

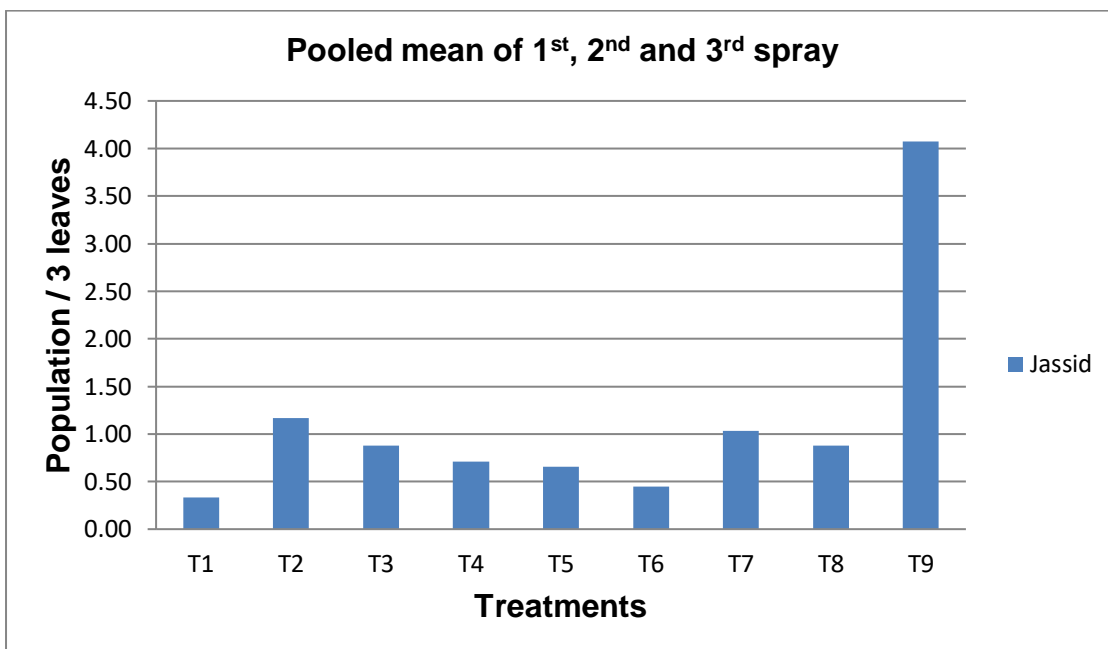
**Table 4.12 Pooled Mean of 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> spray (Whitefly and Jassid)**

Tr. No.	Treatments	Whitefly / 3 leaves			Mean	Jassid / 3 leaves			Mean
		1 <sup>st</sup> spray	2 <sup>nd</sup> spray	3 <sup>rd</sup> spray		1 <sup>st</sup> spray	2 <sup>nd</sup> spray	3 <sup>rd</sup> spray	
T <sub>1</sub>	Neem oil 1%	3.31 (1.94)	2.84 (1.83)	1.12 (1.27)	2.43 (1.68)	0.35 (0.92)	0.33 (0.91)	0.32 (0.90)	0.33 (0.91)
T <sub>2</sub>	Karanj oil 1%	4.56 (2.25)	3.94 (2.11)	2.06 (1.60)	3.52 (1.98)	1.29 (1.34)	1.16 (1.28)	1.06 (1.24)	1.17 (1.29)
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	4.28 (2.18)	3.67 (2.04)	1.69 (1.48)	3.21 (1.90)	0.94 (1.20)	0.89 (1.18)	0.81 (1.14)	0.88 (1.17)
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	4.11 (2.14)	3.51 (2.00)	1.54 (1.43)	3.05 (1.86)	0.79 (1.13)	0.68 (1.08)	0.67 (1.08)	0.71 (1.10)
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3.82 (2.07)	3.78 (2.06)	1.36 (1.36)	2.99 (1.83)	0.70 (1.09)	0.70 (1.09)	0.57 (1.03)	0.65 (1.07)
T <sub>6</sub>	Neem oil – <i>Ma</i> – Neem oil	3.44 (1.98)	3.06 (1.88)	1.21 (1.31)	2.57 (1.72)	0.46 (0.98)	0.45 (0.97)	0.43 (0.96)	0.45 (0.97)
T <sub>7</sub>	Karanj oil – <i>Bb</i> – Karanj oil	4.64 (2.27)	3.72 (2.05)	1.97 (1.57)	3.45 (1.96)	1.27 (1.33)	0.96 (1.21)	0.87 (1.17)	1.03 (1.23)
T <sub>8</sub>	Karanj oil – <i>Ma</i> – Karanj oil	4.56 (2.25)	3.33 (1.96)	1.88 (1.54)	3.26 (1.91)	0.97 (1.21)	0.84 (1.16)	0.83 (1.15)	0.88 (1.17)
T <sub>9</sub>	Untreated control	7.57 (2.84)	9.26 (3.12)	9.56 (3.16)	8.79 (3.04)	3.43 (1.98)	4.13 (2.15)	4.66 (2.27)	4.07 (2.13)
	<b>S.E.m ±</b>	0.05	0.03	0.03	0.04	0.02	0.02	0.02	0.02
	<b>C.D at 5%</b>	0.15	0.10	0.10	0.12	0.05	0.08	0.06	0.06

**Figs. in parentheses are in  $\sqrt{(x+0.5)}$  transformed values**



**Fig 14 : Efficacy of botanicals and biopesticides in the management of whitefly, *Bemisia tabaci* (1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> spray)**

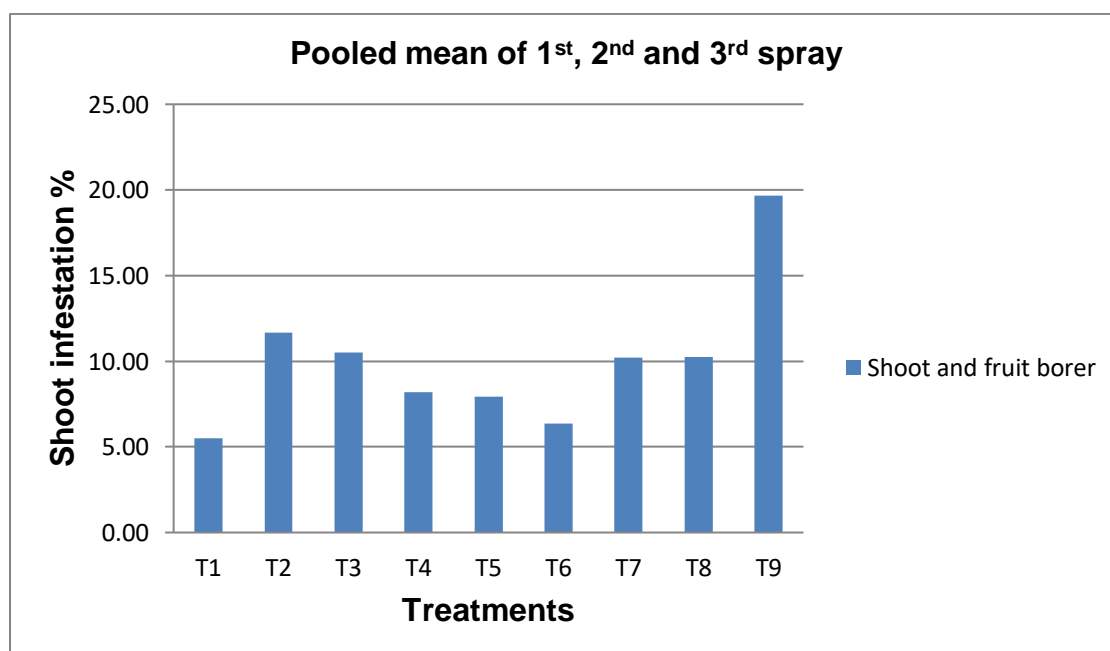


**Fig 15: Efficacy of botanicals and biopesticides in the management of jassid, *Amrasca biguttula biguttula* (1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> spray)**

**Table 4.13 Pooled Mean of 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> spray (*L. orbonalis*)**

Tr. No.	Treatments	Shoot infestation (%)			Mean
		1 <sup>st</sup> spray	2 <sup>nd</sup> spray	3 <sup>rd</sup> spray	
T <sub>1</sub>	Neem oil 1%	6.72 (15.00)	6.32 (14.50)	3.47 (10.69)	5.50 (13.40)
T <sub>2</sub>	Karanj oil 1%	12.00 (20.16)	11.86 (20.13)	11.11 (19.46)	11.66 (19.92)
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	11.14 (19.49)	11.13 (19.33)	9.27 (17.62)	10.51 (18.81)
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	9.53 (17.95)	8.83 (17.26)	6.24 (14.43)	8.20 (16.55)
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	9.19 (17.63)	9.17 (17.61)	5.49 (13.48)	7.95 (16.24)
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	7.41 (15.79)	7.36 (15.72)	4.33 (11.97)	6.37 (14.50)
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	11.56 (19.82)	10.72 (19.05)	8.33 (16.76)	10.20 (18.54)
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	12.40 (20.58)	9.20 (17.64)	9.14 (17.57)	10.25 (18.60)
T <sub>9</sub>	Untreated control	18.33 (25.33)	20.56 (26.96)	20.11 (26.62)	19.67 (26.30)
	<b>S.E.m ±</b>	0.76	0.73	0.54	0.68
	<b>C.D at 5%</b>	2.28	2.19	1.63	2.03

Figures in parentheses are angular transformed values



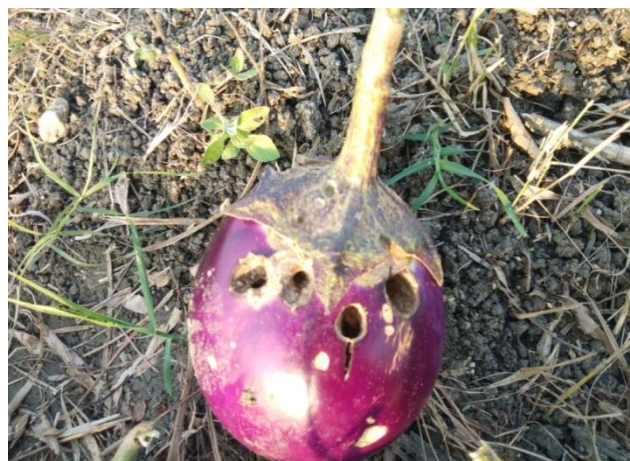
**Fig 16: Efficacy of botanicals and biopesticides in the management of shoot and fruit borer, *Leucinodes orbonalis* (1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> spray)**



**Plate 1:- General view of treatment plot of brinjal**



**Plate2 :- Dead heart symptom of shoot and fruit borer**



**Plate3 :- Bore holes on fruits**



**Plate4 :- Tunnelling inside the fruits**



**Plate5 :- Larva inside tender shoot with excreta**



**Plate6 :- Adult *L. orbonalis***

#### **4.2.13 Effect of different bio-pesticidal treatments on percent fruit infestation at different pickings**

Results of different bio-pesticidal treatments on percent fruit infestation in brinjal are presented in Table 4.13.

##### **First picking**

During the first picking among these nine treatments *viz.*, Neem oil 1% (T<sub>1</sub>) (8.17%) recorded the most significant reduction in fruit infestation caused by *Leucinodes orbonalis* and was followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (10.33%), Neem oil – *Bb* –Neem oil (T<sub>5</sub>) (10.67%), *Metarrhizium anisopliae* (T<sub>4</sub>) (11.33%), *Beauveria bassiana* (T<sub>3</sub>) (11.67%), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (12%), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (14%) and Karanj oil 1% (T<sub>2</sub>) (14.33%). In the untreated plot, the infestation was the highest (23.33%).

##### **Second picking**

During second picking among the nine treatments Neem oil 1% (T<sub>1</sub>) recorded the most significant reduction in fruit infestation caused by *Leucinodes orbonalis*, with lowest fruit infestation (7.10%) followed by Neem oil – *Ma* – Neem oil (T<sub>6</sub>) (9.33%), Neem oil – *Bb* –Neem oil (T<sub>5</sub>) (9.67%) and *Metarrhizium anisopliae* (T<sub>4</sub>) (10.50%), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (10.67%), *Beauveria bassiana* (T<sub>3</sub>) (10.83 %), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (13.00%) and Karanj oil 1% (T<sub>2</sub>) (13.67%). In the untreated plot, the infestation was the highest (27.67%).

##### **Third picking**

During the observation recorded on third picking, Neem oil 1% (T<sub>1</sub>) (5.90%) recorded the most significant reduction in fruit infestation followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (8.00%), Neem oil – *Bb* –Neem oil (T<sub>5</sub>) (8.33%) and *Metarrhizium anisopliae* (T<sub>4</sub>) (9.17%), *Beauveria bassiana* (T<sub>3</sub>) (9.50 %), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (9.93%), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (11.67%) and Karanj oil 1% (T<sub>2</sub>) (11.97%). In the untreated plot, the infestation was the highest (26.33%).

#### **Fourth picking**

At fourth picking, all the treatments showed reduction over control and Neem oil 1% (T<sub>1</sub>) showing highest reduction on fruit infestation with lowest infestation of 6.00%.

#### **Fifth picking**

At fifth picking, all the treatments showed reduction over control and Neem oil 1% (T<sub>1</sub>) recorded highest reduction on fruit infestation with lowest infestation of 6.10%.

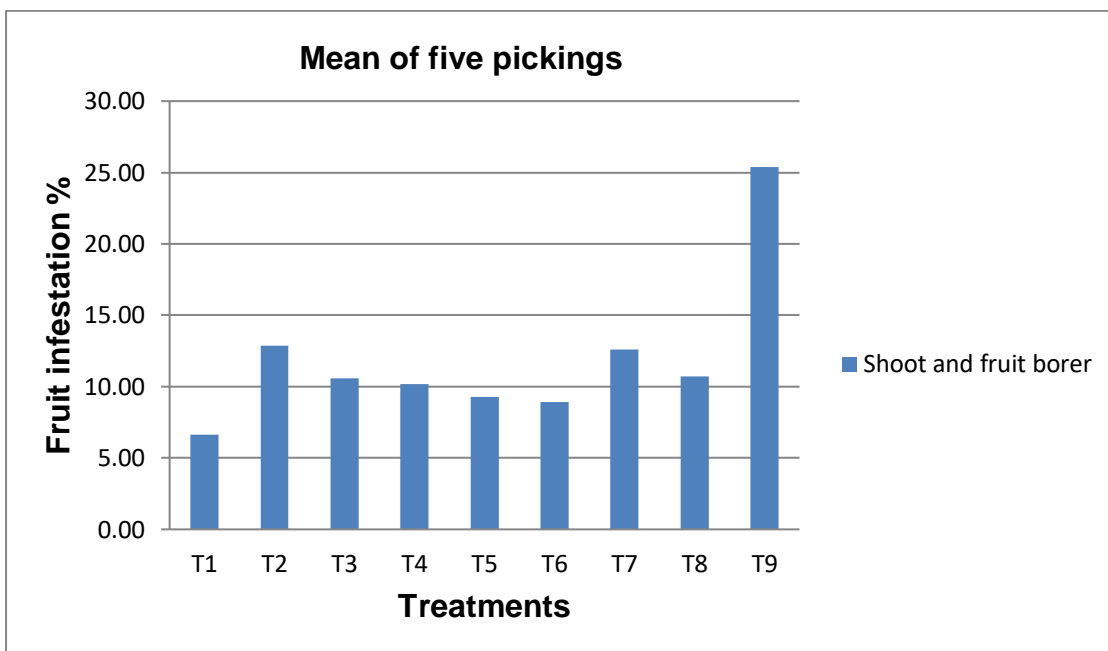
#### **Overall mean**

Overall observation on fruit infestation showed that Neem oil 1% (T<sub>1</sub>) (6.65%) has the highest reduction of fruit infestation when compared to all other treatments and was significantly superior over all other treatments. It was followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (8.93%), Neem oil – *Bb* –Neem oil (T<sub>5</sub>) (9.29%), *Metarrhizium anisopliae* (T<sub>4</sub>) (10.17%), *Beauveria bassiana* (T<sub>3</sub>) (10.60%), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (10.71%), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (12.60%), Karanj oil 1% (T<sub>2</sub>) (12.85%) and control (25.40%).

**Table 4.14 Effect of bio-pesticidal treatments on fruit infestation percentage at different pickings against *L.orbonalis***

Tr. No.	Treatments	Fruit infestation (%)					Mean
		1 <sup>st</sup> picking	2 <sup>nd</sup> picking	3 <sup>rd</sup> picking	4 <sup>th</sup> picking	5 <sup>th</sup> picking	
T <sub>1</sub>	Neem oil 1%	8.17 (16.60)	7.10 (15.43)	5.90 (14.02)	6.00 (14.18)	6.10 (14.30)	6.65 (14.90)
T <sub>2</sub>	Karanj oil 1%	14.33 (22.24)	13.67 (21.69)	11.97 (20.23)	12.00 (20.26)	12.27 (20.50)	12.85 (20.98)
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	11.67 (19.95)	10.83 (19.20)	9.50 (17.95)	10.33 (18.75)	10.67 (19.06)	10.60 (18.98)
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	11.33 (19.67)	10.50 (18.90)	9.17 (17.61)	9.67 (18.11)	10.17 (18.59)	10.17 (18.58)
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	10.67 (19.06)	9.67 (18.11)	8.33 (16.74)	8.63 (17.09)	9.17 (17.62)	9.29 (17.72)
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	10.33 (18.75)	9.33 (17.75)	8.00 (16.35)	8.23 (16.67)	8.77 (17.21)	8.93 (17.35)
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	14.00 (21.96)	13.00 (21.13)	11.67 (19.97)	12.00 (20.14)	12.33 (20.52)	12.60 (20.74)
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	12.00 (20.23)	10.67 (19.06)	9.93 (18.37)	10.17 (18.54)	10.77 (19.14)	10.71 (19.07)
T <sub>9</sub>	Untreated control	23.33 (28.88)	27.67 (31.73)	26.33 (30.87)	25.67 (30.44)	24.00 (29.33)	25.40 (30.25)
	S.E.m ±	0.57	0.54	0.68	0.77	0.41	0.60
	C.D	1.72	1.62	2.04	2.31	1.31	1.80

**Figures in parentheses are angular transformed values**



**Fig 17: Effect of bio-pesticidal treatments on fruit infestation percentage at different pickings against *L.orbonalis***

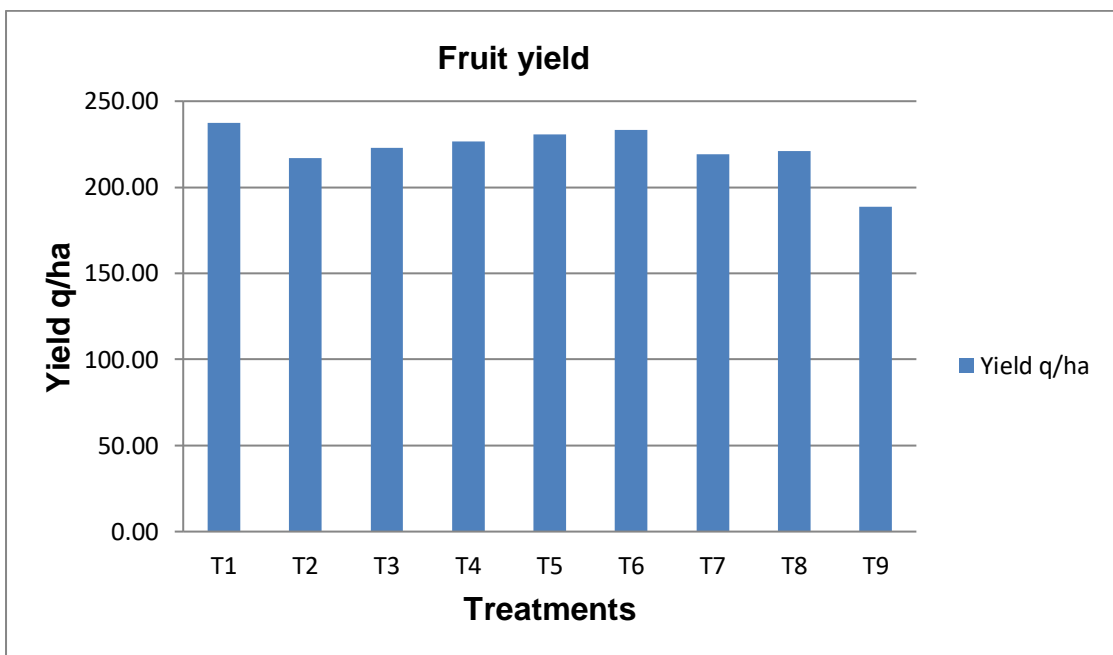
### 4.3 Economics of the management of major insect pests of brinjal

#### 4.3.1 Fruit yield:

The data on fruit yield are presented in Table 4.14. On the basis of cumulative healthy marketable fruit yield, significant differences among different treatments were observed. All the bio-pesticidal treatments were at par with each other and recorded higher fruit yields as compared to control (188.67 q / ha). Among the treatments, Neem oil 1% (T<sub>1</sub>) recorded higher healthy fruit yield (237.33 q / ha) than other treatments, followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (233.13 q/ha), Neem oil – *Bb* –Neem oil (T<sub>5</sub>) (230.53 q/ha), *Metarrhizium anisopliae* (T<sub>4</sub>) (226.47 q/ha), *Beauveria bassiana* (T<sub>3</sub>) (223.03 q/ha), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (221.10 q/ha), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (219.13 q/ha) and Karanj oil 1% (T<sub>2</sub>) (217.00 q/ha).

**Table 4.15 Yield of brinjal in different botanicals and bio-pesticidal treatments during *Kharif* 2019-20.**

Tr. No.	Treatments	Dose / ha (ml)	Fruit yield (q/ha)	% Increase in yield over control
T <sub>1</sub>	Neem oil 1%	3000	237.33	25.79
T <sub>2</sub>	Karanj oil 1%	3000	217.00	15.02
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	1000	223.03	18.21
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	1000	226.47	20.03
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3000-1000-3000	230.53	22.19
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	3000-1000-3000	233.13	23.56
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	3000-1000-3000	219.13	16.14
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	3000-1000-3000	221.10	17.19
T <sub>9</sub>	Untreated control	-	188.67	-
	S.E.m ±		7.31	-
	C.D		21.91	-



**Fig 18: Yield of brinjal in different bio-pesticidal treatment during *Kharif* 2019-20**



**Plate7 :- Harvested brinjal fruits separated treatment wise**

### **4.3.2 Economics of treatments:**

#### **Increase in yield over control:**

Among the different treatments, highest increase in fruit yield over control was registered in Neem oil 1% (T<sub>1</sub>) (48.66q / ha) followed by Neem oil – *Ma* – Neem oil (T<sub>6</sub>) (44.46q/ha), Neem oil – *Bb* –Neem oil (T<sub>5</sub>) (41.86 q/ha), *Metarrhizium anisopliae* (T<sub>4</sub>) ( 37.80 q/ha), *Beauveria bassiana* (T<sub>3</sub>) (34.36 q/ha), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) ( 32.43q/ha), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) ( 32.43q/ha) and Karanj oil 1% (T<sub>2</sub>) ( 28.33q/ha).

#### **Net profit:**

Among the different treatments, highest net profit per hectare was registered in Neem oil 1% (T<sub>1</sub>) (Rs.46860) followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (Rs.42770), Neem oil – *Bb* –Neem oil (T<sub>5</sub>) (Rs.40160), *Metarrhizium anisopliae* (T<sub>4</sub>) (Rs.36330), *Beauveria bassiana* (T<sub>3</sub>) (Rs.32860), Karanj oil – *Ma* –Karanj oil (T<sub>8</sub>) (Rs.30740), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (Rs.28760) and Karanj oil 1% (T<sub>2</sub>) (Rs.26530).

#### **Cost benefit ratio:**

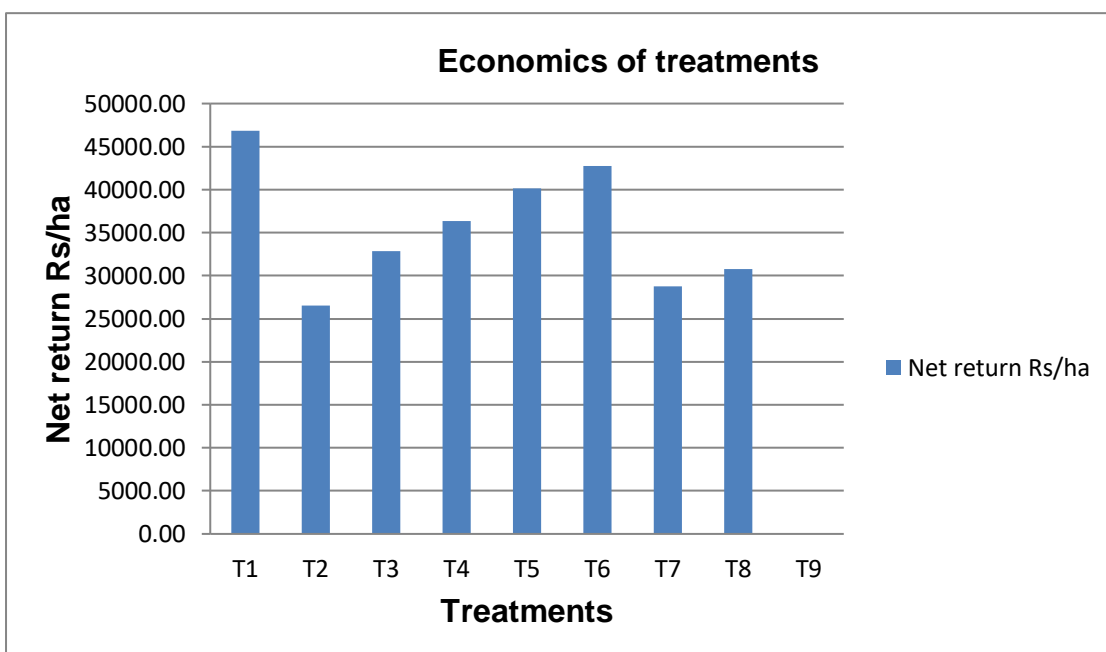
Among the different treatments, highest cost benefit ratio was registered in Neem oil 1% (T<sub>1</sub>) (1:26.03), followed by Neem oil – *Ma* –Neem oil (T<sub>6</sub>) (1:25.31), *Metarrhizium anisopliae* (T<sub>4</sub>) (1:24.71),Neem oil – *Bb* –Neem oil (T<sub>5</sub>) (1:23.62), *Beauveria bassiana* (T<sub>3</sub>) (1:21.91 ), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (1:18.19), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (1:16.92) and Karanj oil 1% (T<sub>2</sub>) (1:14.74).

**Table 4.16 Economics of different biopesticides on pest complex of brinjal during Kharif 2019-20.**

Tr. No	Treatments	Dose / ha (ml)	Additional profit (Rs/ha) @ Rs 1000 per quintal	Cost of treatments (Rs/ha)	Net profit (Rs/ha)	Cost benefit ratio
T <sub>1</sub>	Neem oil 1%	3000	48660	1800	46860	1:26.03
T <sub>2</sub>	Karanj oil 1%	3000	28330	1800	26530	1:14.74
T <sub>3</sub>	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	1000	34360	1500	32860	1:21.91
T <sub>4</sub>	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	1000	37800	1470	36330	1:24.71
T <sub>5</sub>	Neem oil – <i>Bb</i> – Neem oil	3000-1000-3000	41860	1700	40160	1:23.62
T <sub>6</sub>	Neem oil – <i>Ma</i> –Neem oil	3000-1000-3000	44460	1690	42770	1:25.31
T <sub>7</sub>	Karanj oil – <i>Bb</i> –Karanj oil	3000-1000-3000	30460	1700	28760	1:16.92
T <sub>8</sub>	Karanj oil – <i>Ma</i> –Karanj oil	3000-1000-3000	32430	1690	30740	1:18.19
T <sub>9</sub>	Untreated control	-				

**Table 4.17 Cost of botanicals and bio-pesticides:**

S. No.	Treatment	Amount Rs/lit.
1	Neem oil 1%	200
2	Karanj oil 1%	200
3	<i>Beauveria bassiana</i> 1× 10 <sup>12</sup> spores/ml	500
4	<i>Metarrhizium anisopliae</i> 1× 10 <sup>12</sup> spores/ml	490
5	Spray of insecticide / ha	500 / ha



**Fig 19: Economics of treatments**

## DISCUSSION

The results of the research entitled “Study on the management of major insect pests of brinjal (*Solanum melongena* L.) through botanicals and biopesticides” presented in the previous chapter have been discussed below.

### 5.1 Seasonal incidence of major insect pests of brinjal and their correlation with weather parameters.

#### 5.1.1 Whitefly, *Bemisia tabaci* (Hemiptera :Aleyrodidae)

The incidence of whitefly began at the last week of September (39<sup>th</sup> standard week) with a population of 4.89/ 3 leaves. The highest whitefly population (8.96/ 3 leaves) was noted at the second week of October (41<sup>st</sup> standard week) which was almost identical to the study observed by Kumari *et al.* (2016) (11.22 per leaf). Kharade *et al.* (2018) observed a maximum incidence of whitefly (14.70 whitefly/3 leaves) during the first week of October which was similar to the present study while the infection rate was higher than this study. During the peak incidence of this study, the maximum and minimum temperature were observed as 32.10°C and 19.60°C respectively with the highest relative humidity at mornings (89.90%) and the lowest relative humidity at evenings (49.10%). Bright Sunshine duration in this observed peak period was 8.80 hrs/day with no rainfall (0.00ml). The population gradually declined after the observed peak reaching 1.2 whitefly / 3 leaves during third week of November (47<sup>th</sup> standard week). The peak incidence of whitefly was observed at October in the finding of Singh *et al.* (2010) indicating a close conformity to present findings. These findings leads to a conclusion that peak incidence of whitefly may be observed at October due to the environmental conditions prevailed at that month.

Correlation studies revealed that maximum temperature and minimum temperature exhibited significantly positive correlation ( $r= 0.73, 0.79$  respectively) with whitefly population while morning relative humidity exhibited significantly negative correlation ( $r= -0.56$ ). Whereas evening relative humidity, rainfall and sunshine hours were positive correlated ( $r= 0.05, 0.15, 0.15$  respectively) with whitefly population but were non – significant.

In previous investigation significantly positive correlation of weather parameters (maximum temperature) was reported by Patel *et al.* (2015) and

Indirakumar *et al.* (2016) which are in agreement with the present results indicating that temperature acts as a factor affecting whitefly population at any place.

### **5.1.2 Jassid, *Amrasca biguttula biguttula* (Hemiptera :Cicadellidae)**

The first appearance of jassid was recorded at the last week of September (39<sup>th</sup> standard week) with a population of 0.8 / 3 leaves, which reached its peak during the second week of October (41<sup>th</sup> standard week) with a population of 1.29 / 3 leaves. Kharade *et al.* (2018) observed a peak incidence (12.46 jassids/3 leaves) during the second week of September which was fluctuating from the present study while Verma *et al.* (2020) observed a peak incidence (2.33 jassid/cage) at third week of October and Kumar *et al.* (2014) observed a peak incidence (1.26 to 1.42 jassid/leaf intensity both the years 2009 and 2010) which were in close conformity with the present study. This variation from different studies may be due to influence of fluctuating abiotic factors in different year. During the peak period of jassid population, the maximum and minimum temperature were observed as 32.10°C and 19.60°C respectively with the highest relative humidity at mornings (89.90%) and the lowest relative humidity at evenings (49.10%). Bright Sunshine duration in this observed peak period was 8.80hrs./ day with no rainfall (0.00ml).The population gradually declined reaching 0.13 jassid / 3 leaves at third week of November (47<sup>th</sup> standard week).Patial and Mehta (2008) and Singh *et al.* (2010) recorded maximum incidence of jassid during October. These are in close conformity with the findings came out from present study of the jassids incidence. These findings leads to a conclusion that peak incidence of jassids may be observed at October due to the environmental conditions prevailed at that month.

Correlation studies revealed that maximum temperature and minimum temperature were significantly positive correlated ( $r=0.59$ ,  $0.79$  respectively) with jassid population. Whereas morning relative humidity was negatively correlated ( $r=-0.15$ ) while evening relative humidity, rainfall and

sunshine hours were positively correlated ( $r= 0.31, 0.41, 0.18$  respectively) with jassid population but to the non- significant level.

The significantly positive correlation of jassid with maximum temperature are reported by Patel *et al.* (2015) as well as Shalini *et al.* (2017) which are match with the correlation data of present investigation.

### **5.1.3 Brinjal shoot and fruit borer, *Leucinodes orbonalis* (Lepidoptera :Crambidae)**

The infestation of shoot and fruit borer was observed at the second week of October (41<sup>st</sup> standard week) with 4.00% shoot infestation. Then the infestation gradually increased and reached its peak during the second week of November (46<sup>th</sup> standard week) with 20.00% shoot infestation. Latha *et al.* (2018) observed a peak incidence (30%) during October month and Sahu *et al.* (2018) observed the maximum population at second week of December which were fluctuating from this study while Shukla and Khatri (2010) observed a peak incidence at last two weeks of October month and Maru and Kumar (2018) observed a peak incidence (59.09% damaged fruits) at last week of October which were similar to this study. During the peak incidence of this study, maximum and minimum temperature were 30.10<sup>o</sup>C and 13.40<sup>o</sup>C, respectively, and morning and evening relative humidity were 90.70% and 32.00% respectively with 7.60 hrs of sunshine. The fruit infestation was high during the fourth week of November (48<sup>th</sup> standard week) with 50% fruit infestation. During this period, maximum and minimum temperature were 28.00<sup>o</sup>C and 14.20<sup>o</sup>C, respectively, and morning and evening relative humidity were 92.10% and 51.00% respectively with 6.40 hrs of sunshine. Thereafter the fruit infestation gradually declined to 20% during the third week of December (51<sup>th</sup> standard week). The present results are in agreement with the results of Shukla and Khatri (2010) and Kumar and Singh (2012) who reported the incidence of shoot and fruit borer from October to December.

Correlation studies revealed that minimum temperature and rainfall exhibited significant negative correlation ( $r= -0.77, -0.56$ ) with shoot and fruit borer population. Whereas morning relative humidity observed positive

correlation ( $r= 0.24$ ) with shoot and fruit borer population while maximum temperature, evening relative humidity and sunshine hours were observed negative correlation ( $r= -0.47, -0.44, -0.08$  respectively) with shoot and fruit borer population but to non – significant level.

In earlier findings negative correlation of minimum temperature was reported by Mondal *et al* (2014) as well as Deole (2015) and negative correlation of relative humidity (evening) was reported by Sahu *et al.* (2018) which were similar with the present investigation results.

## **5.2 Efficacy of botanicals and biopesticides against major insect pests of brinjal.**

### **5.2.1 Effect on whitefly, *Bemisia tabaci* (Hemiptera :Aleyrodidae)**

The data on overall efficacy of all the treatment over untreated control from all the three sprays imposed against whitefly during the investigation revealed that, Neem oil 1% ( $T_1$ ) was the most effective in controlling the population of whitefly (2.43/ 3 leaves) followed by Neem oil –*Ma* –Neem oil ( $T_6$ ) (2.57/ 3 leaves). The overall efficacy of different treatment over control was in the order of Neem oil 1% ( $T_1$ )>Neem oil –*Ma* –Neem oil ( $T_6$ )>Neem oil –*Bb* –Neem oil ( $T_5$ )>*Metarrhizium anisopliae*( $T_4$ )>*Beauveria bassiana*( $T_3$ )>Karanj oil –*Ma* –Karanj oil ( $T_8$ )>Karanj oil –*Bb* –Karanj oil ( $T_7$ ) >Karanj oil 1% ( $T_2$ ).

Previous findings reported by Jarwar *et al.* (2014) showed that neem oil has 73.02-80.93% reduction in whitefly population and Mochiah *et al.* (2011) findings showed that the neem oil has significant effect in controlling whitefly population are similar with the present findings. These results show that the neem oil can be used as an effective bio pesticide against whitefly.

### **5.2.2 Effect on jassid, *Amrasca biguttula biguttula* (Hemiptera :Cicadellidae)**

The data on overall efficacy of all the treatment over untreated control from all the three sprays imposed against jassid during the investigation revealed that, Neem oil 1% ( $T_1$ ) was the most effective in controlling the population of jassid

(0.33/ 3 leaves) followed by Neem oil –*Ma* –Neem oil (T<sub>6</sub>) (0.45/ 3 leaves). The overall efficacy of different treatment over control was in the order of Neem oil 1% (T<sub>1</sub>)>Neem oil –*Ma* –Neem oil (T<sub>6</sub>)>Neem oil –*Bb* –Neem oil (T<sub>5</sub>)>*Metarrhizium anisopliae*(T<sub>4</sub>)>*Beauveria bassiana*(T<sub>3</sub>)>Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) >Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>)>Karanj oil 1% (T<sub>2</sub>).

Findings by Sultana *et al.* (2012) recommended the use of bio-pesticides (neem products) in controlling the incidence of jassid on brinjal crop successfully and it was the most effective among the treatments. Kumar *et al.* (2019) and Dhillon *et al.* (2016) showed the effectiveness of neem oil for controlling jassid which is in close conformity with the present study.

### **5.2.3 Effect on brinjal shoot and fruit borer, *Leucinodes orbonalis* (Lepidoptera :Crambidae)**

#### **Shoot damage**

In the current study, it was observed that all the treatment proved their superiority over the untreated control. The data on overall efficacy of all the treatment over untreated control from all the three sprays imposed against shoot and fruit borer during the investigation revealed that, Neem oil 1% (T<sub>1</sub>) was the most effective in controlling the shoot infestation (5.80%) but was at par with Neem oil –*Ma* –Neem oil (T<sub>6</sub>) (6.37%) and significantly superior over all other treatments. The overall efficacy of different treatment over control was in the order of Neem oil 1% (T<sub>1</sub>)>Neem oil –*Ma* –Neem oil (T<sub>6</sub>)>Neem oil –*Bb* –Neem oil (T<sub>5</sub>)>*Metarrhizium anisopliae*(T<sub>4</sub>)>Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>)>Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>)>*Beauveria bassiana*(T<sub>3</sub>)>Karanj oil 1% (T<sub>2</sub>). Bhagwan and Kumar (2017) recorded minimum shoot infestation 9.83% using neem oil and Goud *et al.* (2019) reported that neem oil was effective in controlling shoot and fruit borer which were in close conformity with present studies.

#### **Fruit damage**

The result of the present investigation depicted that among the treatment Neem oil 1% (T<sub>1</sub>) (6.65%) had the highest reduction of fruit infestation followed by Neem oil –*Ma* –Neem oil (T<sub>6</sub>) (8.93%), Neem oil –*Bb* –Neem oil (T<sub>5</sub>) (9.29%),

*Metarrhizium anisopliae*(T<sub>4</sub>) (10.17%), *Beauveria bassiana*(T<sub>3</sub>) (10.60%), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (10.71%), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (12.60%), Karanj oil 1% (T<sub>2</sub>) (12.85%).

The present findings are in agreement with other previous studies including Tripura *et al.* (2017) whose study reported the highest reduction in fruit infestations (53.56%) by using neem oil; Mane and Kulkarni (2010) recorded lowest infestation (17.65%) in the treatment of nimbecidin (neem oil) against shoot and fruit borer. Likewise Murugesan and Murugesan (2009) recorded neem oil was the best treatment both in *kharif* and *rabi* with 60.20% and 59.91% reduction in fruit damage. Rakibuzzaman *et al.* (2019) recorded that the foliar application of neem oil has reduced the infestation significantly. Karkar *et al.* (2014) recorded that neem oil has effectiveness for reducing shoot and fruit infestation.

### **5.3 Economics of the management of major insect pests of brinjal**

#### **5.3.1 Fruit yield**

The result of the present investigation depicted that among the treatment the highest marketable fruit yield was obtained by using Neem oil 1% (T<sub>1</sub>) (237.33 q / ha) followed by Neem oil –*Ma* –Neem oil (T<sub>6</sub>) (233.13 q/ha), Neem oil –*Bb* –Neem oil (T<sub>5</sub>) (230.53 q/ha), *Metarrhizium anisopliae*(T<sub>4</sub>) (226.47 q/ha), *Beauveria bassiana*(T<sub>3</sub>) (223.03 q/ha), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (221.10 q/ha), Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (219.13 q/ha) and Karanj oil 1% (T<sub>2</sub>) (217.00 q/ha).

Bhagwan and Kumar (2017) reported that among the biopesticides used for treatment neem oil recorded (163.83q/ha) highest yield. Ashadul *et al.* (2014) recorded that neem has the highest yield among the treatments observed. Khan *et al.* (2017) observed an increase in yield on application of neem oil.

### 5.3.2 Net profit and Cost benefit ratio

The present findings revealed that the highest net profit per hectare was registered with Neem oil 1% (T<sub>1</sub>) (Rs.46860 ) followed by Neem oil –*Ma* –Neem oil (T<sub>6</sub>) (Rs.42770 ),Neem oil –*Bb* –Neem oil (T<sub>5</sub>) (Rs.40160), *Metarrhizium anisopliae*(T<sub>4</sub>) (Rs.36330), *Beauveria bassiana*(T<sub>3</sub>) (Rs.32860), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (Rs.30740),Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (Rs.28760) and Karanj oil 1% (T<sub>2</sub>) (Rs.26530).

The present findings also revealed that the highest benefit cost ratio was due to Neem oil 1% (T<sub>1</sub>) (1:26.03) followed by Neem oil –*Ma* –Neem oil (T<sub>6</sub>) (1:25.31),*Metarrhizium anisopliae*(T<sub>4</sub>) (1:24.71),Neem oil –*Bb* –Neem oil (T<sub>5</sub>) (1:23.62), *Beauveria bassiana* (T<sub>3</sub>) (1:21.91), Karanj oil –*Ma* –Karanj oil (T<sub>8</sub>) (1:18.19),Karanj oil –*Bb* –Karanj oil (T<sub>7</sub>) (1:16.92) and Karanj oil 1% (T<sub>2</sub>) (1:14.74).

The present findings are in agreement with Singh *et al.* (2018) who recorded the highest cost benefit ratio of 1:24.40. Likewise Dehariya *et al.* (2018) reported that the application of neem oil 1% registered the cost benefit ratio of 1:1.79 which was the most economical among the treatments. Sangma *et al.* (2019) reported that the maximum cost benefit ratio was registered in the treatment of Neem oil 2% (1:3.11) which proved as a economically valuable treatment.

## SUMMARY, CONCLUSION AND SUGGESTION FOR FURTHER WORKS

### 6.1 SUMMARY

In the present investigation entitled, "Study on the management of major insect pests of brinjal (*Solanum melongena* L.) through botanicals and biopesticides" experiments were conducted during *kharif*, 2019 at J.N.K.V.V., College of Agriculture, Tikamgarh (M.P.). The experiments were conducted with the following objectives:

1. To record the seasonal incidence of major insect pests of brinjal and their correlation with weather parameters.
2. To evaluate the efficacy of botanicals and biopesticides against major insect pests of brinjal.
3. To work out the economics for the management of major insect pests of brinjal.

#### **Seasonal incidence of major insect pests of brinjal and their correlation with weather parameters.**

During *kharif* season 2019, two sucking pest whitefly (*Bemisia tabaci*) and jassid (*Amrasca biguttula biguttula*) along with Brinjal shoot and fruit borer *Leucinodes orbonalis* were recorded as major pests on brinjal crop.

#### **Whitefly, *Bemisia tabaci* (Hemiptera :Aleyrodidae)**

The population of whitefly ranged between 1.20 to 8.96 / 3 leaves during September to December months. The nymphs and adults of whitefly first appeared in the last week of September (39<sup>th</sup> standard week). Initially the population of nymphs and adults of whitefly was 4.89 / 3 leaves. The highest whitefly population (8.96/ 3 leaves) was noticed during second week of October (41<sup>st</sup> standard week). Thereafter, the population gradually decreased reaching 1.2 whitefly / 3 leaves during third week of November (47<sup>th</sup> standard week).

Correlation studies between various abiotic factors and whitefly population revealed that maximum temperature and minimum temperature exhibited significant positive correlation besides morning relative humidity which exhibited significant negative correlation.

### **Jassid, *Amrasca biguttula biguttula* (Hemiptera :Cicadellidae)**

The population of jassid ranged between 0.80 to 1.29 / 3 leaves during September to November months. The first appearance of jassid was recorded during the last week of September (39<sup>th</sup> standard week) with the population of 0.8 / 3 leaves, which reached at its peak during the second week of October (41<sup>th</sup> standard week) with the population of 1.29 / 3 leaves. Thereafter, the population gradually decreased reaching 0.13 jassid / 3 leaves during third week of November (47<sup>th</sup> standard week).

Correlation studies between various abiotic factors and jassid population revealed that maximum temperature and minimum temperature exhibited significant positive correlation

### **Brinjal shoot and fruit borer, *Leucinodes orbonalis* (Lepidoptera :Crambidae)**

The infestation of shoot and fruit borer was observed in the second week of October (41<sup>st</sup> standard week) with 4.00% shoot infestation. Then the infestation gradually increased and reached its peak during the second week of November (46<sup>th</sup> standard week) with 20.00% shoot infestation. The fruit infestation was high during the fourth week of November (48<sup>th</sup> standard week) with 50% fruit infestation. Thereafter the fruit infestation gradually declined to 20% during the third week of December (51<sup>th</sup> standard week).

Correlation studies between various abiotic factors and shoot and fruit borer population revealed that minimum temperature and rainfall exhibited significant negative correlation.

### **Efficacy and economics of botanicals and biopesticides against major insect pests of brinjal**

1. The lowest overall mean population of whitefly (2.43/ 3 leaves) was recorded in Neem oil 1% proving to be a better treatment than other treatments against the pest.
2. The lowest overall mean population of jassid (0.33/ 3 leaves) was recorded in Neem oil 1% proving to be a better treatment than other treatments against the pest.

3. The lowest overall mean shoot infestation 5.80% was recorded in Neem oil 1% followed by Neem oil –*Ma* –Neem oil both proving to be a better treatment than other treatments against the pest.

4. The lowest overall fruit infestation 6.65% was recorded in Neem oil 1% proving to be a better treatment than other treatments against the pest.

5. Neem oil 1% recorded higher healthy fruit yield (237.33 q / ha) than other treatments, followed by Neem oil –*Ma* –Neem oil (233.13 q/ha), Neem oil –*Bb* –Neem oil (230.53 q/ha), *Metarrhizium anisopliae*(226.47 q/ha), *Beauveria bassiana*(223.03 q/ha), Karanj oil –*Ma* –Karanj oil (221.10 q/ha), Karanj oil –*Bb* –Karanj oil (219.13 q/ha) and Karanj oil 1% (217.00 q/ha). All the bio-pesticidal treatments were at par with each other and recorded higher fruit yields as compared to control (188.67 q / ha).

6. Neem oil 1% gave the maximum net profit (Rs.46860 ) followed by Neem oil –*Ma* –Neem oil (Rs.42770 ),Neem oil –*Bb* –Neem oil (Rs.40160), *Metarrhizium anisopliae* (Rs.36330), *Beauveria bassiana* (Rs.32860), Karanj oil –*Ma* –Karanj oil (Rs.30740),Karanj oil –*Bb* –Karanj oil (Rs.28760) and Karanj oil 1% (Rs.26530).

7. The maximum cost-benefit ratio was recorded in Neem oil 1% (1:26.03), followed by Neem oil –*Ma* –Neem oil (1:25.31), *Metarrhizium anisopliae* (1:24.71),Neem oil –*Bb* –Neem oil (1:23.62), *Beauveria bassiana* (1:21.91 ), Karanj oil –*Ma* –Karanj oil (1:18.19), Karanj oil –*Bb* –Karanj oil (1:16.92) and Karanj oil 1% (1:14.74).

## 6.2 CONCLUSION

Three major different species of insect pests were recorded on the brinjal crop at experimental field of Department of Entomology, College of Agriculture, Tikamgarh (M.P.) during *kharif* 2019-20 namely whitefly, jassid and shoot and fruit borer representing 2 orders i.e. Hemiptera and Lepidoptera and three families viz. Aleyrodidae, Cicadellidae and Crambidae respectively.

Whitefly and jassid were first recorded on September last week (39<sup>th</sup> standard week). The peak infestation and decline in population of both whitefly and jassid occurred during the same time. The highest population was noticed during second week of October (41<sup>st</sup> standard week). Thereafter, the population gradually decreased and reached at its lowest during third week of November (47<sup>th</sup> standard week). Correlation studies between various abiotic factors and whitefly population revealed that maximum and minimum temperature exhibited significant positive correlation besides morning relative humidity exhibited significant negative correlation. Correlation studies between various abiotic factors and jassid population revealed that maximum and minimum temperature exhibited significant positive correlation.

Shoot and fruit borer was first observed in the second week of October (41<sup>st</sup> standard week). Then the infestation gradually increased and reached its peak during the second week of November (46<sup>th</sup> standard week). The fruit infestation was high during the fourth week of November (48<sup>th</sup> standard week). Thereafter the fruit infestation gradually declined and reached at its lowest during the third week of December (51<sup>th</sup> standard week). Correlation studies between various abiotic factors and shoot and fruit borer population revealed that minimum temperature and rainfall exhibited significant negative correlation.

Among different botanicals and biopesticides against pest complex of brinjal, Neem oil 1% proved to be best treatment to minimize the population of all the major pests with the highest yield (237.33 q / ha) in brinjal crop.

### **6.3 SUGGESTION FOR FURTHER WORK**

1. In view of the changing climatic conditions, the studies on seasonal incidence of major insect pests, and testing of botanicals and biopesticides against major pest of brinjal should be carried out consecutively for 3 years in order to arrive at any concrete conclusion.
2. Climatic conditions also act a major factor affecting the effective use of biopesticides, indicating that optimum environment conditions are required for effective use of botanicals and biopesticides.

3. Further experiment of botanicals and biopesticide on various environmental conditions and locations can reveal a promising effectiveness of the experiment which can lead to replacement of other pesticide with botanicals and biopesticide.

4. Continuous usage of botanicals and biopesticide never create the condition of pesticide resistance and are also residue free. Due to these advantages botanicals and biopesticide can be a replacement for other pesticides.

5. Botanicals and biopesticide can be used along with other treatment against pests without causing damage to the plants and effectively affecting pests. This indicates that Botanical and Biopesticide can be added in any type of IPM module.

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## APPENDICES

### Anova 1 : Whitefly, *Bemisia tabaci* during 1<sup>st</sup> spray

#### Pre- treatment

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	0.17	0.02	0.77	2.59
Replication	2	0.07	0.03	1.25	3.63
Error	16	0.45	0.03		
Total	26	0.69			

### Anova 2 : Whitefly, *Bemisia tabaci* during 1<sup>st</sup> spray

#### 3 Days After Spray

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	1.87	0.23	11.50	2.59
Replication	2	0.19	0.09	4.64	3.63
Error	16	0.33	0.02		
Total	26	2.39			

**SEm± = 0.08**

**CD at 5% = 0.25**

### Anova 3 : Whitefly, *Bemisia tabaci* during 1<sup>st</sup> spray

#### 7 Days After Spray

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	1.84	0.230	114.22	2.59
Replication	2	0.01	0.003	1.55	3.63
Error	16	0.03	0.002		
Total	26	1.88			

**SEm± = 0.03**

**CD at 5% = 0.08**

**Anova 4: Whitefly, *Bemisia tabaci* during 1<sup>st</sup> spray**

**10 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	1.32	0.16	30.62	2.59
Replication	2	0.003	0.001	0.27	3.63
Error	16	0.09	0.01		
Total	26	1.41			

**SEm± = 0.04**

**CD at 5% = 0.13**

**Anova 5 : Whitefly, *Bemisia tabaci* during 2<sup>nd</sup> spray**

**Pre-treatment**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	0.42	0.05	2.12	2.59
Replication	2	0.01	0.00	0.16	3.63
Error	16	0.39	0.02		
Total	26	0.82			

**Anova 6 : Whitefly, *Bemisia tabaci* during 2<sup>nd</sup> spray**

**3 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	3.87	0.48	121.04	2.59
Replication	2	0.01	0.01	1.51	3.63
Error	16	0.06	0.004		
Total	26	3.95			

**SEm± = 0.04**

**CD at 5% = 0.11**

**Anova 7 : Whitefly, *Bemisia tabaci* during 2<sup>nd</sup> spray**

**7 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	3.91	0.49	163.60	2.59
Replication	2	0.002	0.001	0.31	3.63
Error	16	0.05	0.003		
Total	26	3.96			

**SEm± = 0.03**

**CD at 5% = 0.09**

**Anova 8 : Whitefly, *Bemisia tabaci* during 2<sup>nd</sup> spray**

**10 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	3.10	0.39	106.89	2.59
Replication	2	0.02	0.01	3.27	3.63
Error	16	0.06	0.004		
Total	26	3.18			

**SEm± = 0.03**

**CD at 5% = 0.10**

**Anova 9 : Whitefly, *Bemisia tabaci* during 3<sup>rd</sup> spray**

**Pre-treatment**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	0.59	0.07	2.19	2.59
Replication	2	0.07	0.03	0.99	3.63
Error	16	0.54	0.03		
Total	26	1.19			

**Anova 10 : Whitefly, *Bemisia tabaci* during 3<sup>rd</sup> spray**

**3 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	6.22	0.78	97.87	2.59
Replication	2	0.01	0.01	0.82	3.63
Error	16	0.13	0.01		
Total	26	6.36			

**SEm± = 0.05**

**CD at 5% = 0.15**

**Anova 11 : Whitefly, *Bemisia tabaci* during 3<sup>rd</sup> spray**

**7 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	7.92	0.99	393.19	2.59
Replication	2	0.02	0.01	3.05	3.63
Error	16	0.04	0.003		
Total	26	7.97			

**SEm± = 0.03**

**CD at 5% = 0.09**

**Anova 12 : Whitefly, *Bemisia tabaci* during 3<sup>rd</sup> spray**

**10 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	10.68	1.33	989.90	2.59
Replication	2	0.01	0.004	2.81	3.63
Error	16	0.02	0.001		
Total	26	10.71			

**SEm± = 0.02**

**CD at 5% = 0.06**

**Anova 13 : Jassid, *Amrasca biguttula biguttula* during 1<sup>st</sup> spray**

**Pre-treatment**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	0.35	0.04	2.58	2.59
Replication	2	0.04	0.02	1.30	3.63
Error	16	0.27	0.02		
Total	26	0.67			

**Anova 14 : Jassid, *Amrasca biguttula biguttula* during 1<sup>st</sup> spray**

**3 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	2.47	0.31	297.44	2.59
Replication	2	0.002	0.001	1.18	3.63
Error	16	0.02	0.001		
Total	26	2.49			

**SEm± = 0.02**

**CD at 5% = 0.06**

**Anova 15 : Jassid, *Amrasca biguttula biguttula* during 1<sup>st</sup> spray**

**7 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	2.34	0.29	187.15	2.59
Replication	2	0.002	0.001	0.64	3.63
Error	16	0.02	0.002		
Total	26	2.36			

**SEm± = 0.02**

**CD at 5% = 0.07**

**Anova 16 : Jassid, *Amrasca biguttula biguttula* during 1<sup>st</sup> spray**

**10 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	2.20	0.28	715.65	2.59
Replication	2	0.001	0.0003	0.79	3.63
Error	16	0.01	0.0004		
Total	26	2.21			

**SEm± = 0.01**

**CD at 5% = 0.03**

**Anova 17 : Jassid, *Amrasca biguttula biguttula* during 2<sup>nd</sup> spray**

**Pre-treatment**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	0.56	0.07	2.37	2.59
Replication	2	0.14	0.07	2.45	3.63
Error	16	0.47	0.03		
Total	26	1.18			

**Anova 18 : Jassid, *Amrasca biguttula biguttula* during 2<sup>nd</sup> spray**

**3 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	3.08	0.39	122.03	2.59
Replication	2	0.01	0.003	0.81	3.63
Error	16	0.05	0.003		
Total	26	3.14			

**SEm± = 0.03**

**CD at 5% = 0.10**

**Anova 19 : Jassid, *Amrasca biguttula biguttula* during 2<sup>nd</sup> spray**

**7 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	3.42	0.43	250.75	2.59
Replication	2	0.001	0.0004	0.26	3.63
Error	16	0.03	0.002		
Total	26	3.45			

**SEm± = 0.02**

**CD at 5% = 0.07**

**Anova 20 : Jassid, *Amrasca biguttula biguttula* during 2<sup>nd</sup> spray**

**10 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	3.15	0.39	386.56	2.59
Replication	2	0.0003	0.0002	0.15	3.63
Error	16	0.02	0.001		
Total	26	3.16			

**SEm± = 0.02**

**CD at 5% = 0.06**

**Anova 21 : Jassid, *Amrasca biguttula biguttula* during 3<sup>rd</sup> spray**

**Pre-treatment**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	1.29	0.16	2.56	2.59
Replication	2	0.003	0.001	0.02	3.63
Error	16	1.01	0.06		
Total	26	2.29			

**Anova 22 : Jassid, *Amrasca biguttula biguttula* during 3<sup>rd</sup> spray**

**3 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	4.32	0.54	297.25	2.59
Replication	2	0.002	0.001	0.51	3.63
Error	16	0.03	0.002		
Total	26	4.35			

**SEm± = 0.02**

**CD at 5% = 0.07**

**Anova 23 : Jassid, *Amrasca biguttula biguttula* during 3<sup>rd</sup> spray**

**7 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	4.04	0.50	749.55	2.59
Replication	2	0.004	0.002	2.78	3.63
Error	16	0.01	0.001		
Total	26	4.05			

**SEm± = 0.01**

**CD at 5% = 0.04**

**Anova 24 : Jassid, *Amrasca biguttula biguttula* during 3<sup>rd</sup> spray**

**10 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	3.75	0.47	416.74	2.59
Replication	2	0.0002	0.0001	0.11	3.63
Error	16	0.02	0.001		
Total	26	3.77			

**SEm± = 0.02**

**CD at 5% = 0.06**

**Anova 25 : Shoot and fruit borer, *Leucinodes orbonalis* during 1<sup>st</sup> spray**

**Pre-treatment**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	136.03	17.00	0.15	2.59
Replication	2	147.29	73.65	0.65	3.63
Error	16	1816.52	113.53		
Total	26	2099.85			

**Anova 26 : Shoot and fruit borer, *Leucinodes orbonalis* during 1<sup>st</sup> spray**

**3 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	235.12	29.39	7.25	2.59
Replication	2	19.14	9.57	2.36	3.63
Error	16	64.87	4.05		
Total	26	319.13			

**SEm± = 1.16**

**CD at 5% = 3.49**

**Anova 27 : Shoot and fruit borer, *Leucinodes orbonalis* during 1<sup>st</sup> spray**

**7 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	213.67	26.71	29.49	2.59
Replication	2	0.40	0.20	0.22	3.63
Error	16	14.49	0.91		
Total	26	228.56			

**SEm± = 0.55**

**CD at 5% = 1.65**

**Anova 28 : Shoot and fruit borer, *Leucinodes orbonalis* during 1<sup>st</sup> spray**

**10 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	219.37	27.42	28.88	2.59
Replication	2	2.44	1.22	1.28	3.63
Error	16	15.19	0.95		

<b>Total</b>	26	237.01			
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**SEm± = 0.56**

**CD at 5% = 1.69**

**Anova 29 : Shoot and fruit borer, *Leucinodes orbonalis* during 2<sup>nd</sup> spray**

**Pre-treatment**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
<b>Treatment</b>	8	153.27	19.16	1.12	2.59
<b>Replication</b>	2	27.20	13.60	0.80	3.63
<b>Error</b>	16	273.02	17.06		
<b>Total</b>	26	453.49			

**Anova 30 : Shoot and fruit borer, *Leucinodes orbonalis* during 2<sup>nd</sup> spray**

**3 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
<b>Treatment</b>	8	352.81	44.10	88.28	2.59
<b>Replication</b>	2	2.73	1.36	2.73	3.63
<b>Error</b>	16	7.99	0.50		
<b>Total</b>	26	363.53			

**SEm± = 0.41**

**CD at 5% = 1.22**

**Anova 31 : Shoot and fruit borer, *Leucinodes orbonalis* during 2<sup>nd</sup> spray**

**7 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
<b>Treatment</b>	8	297.44	37.18	41.63	2.59
<b>Replication</b>	2	1.48	0.74	0.83	3.63
<b>Error</b>	16	14.29	0.89		
<b>Total</b>	26	313.21			

**SEm± = 0.55**

**CD at 5% = 1.64**

**Anova 32 : Shoot and fruit borer, *Leucinodes orbonalis* during 2<sup>nd</sup> spray**

**10 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	270.45	33.81	7.32	2.59
Replication	2	2.94	1.47	0.32	3.63
Error	16	73.90	4.62		
Total	26	347.30			

**SEm± = 1.24**

**CD at 5% = 3.72**

**Anova 33 : Shoot and fruit borer, *Leucinodes orbonalis* during 3<sup>rd</sup> spray**

**Pre-treatment**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	186.99	23.37	2.47	2.59
Replication	2	18.73	9.37	0.99	3.63
Error	16	151.16	9.45		
Total	26	356.88			

**Anova 34 : Shoot and fruit borer, *Leucinodes orbonalis* during 3<sup>rd</sup> spray**

**3 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	557.44	69.68	157.69	2.59
Replication	2	2.84	1.42	3.21	3.63
Error	16	7.07	0.44		
Total	26	567.36			

**SEm± = 0.38**

**CD at 5% = 1.15**

**Anova 35 : Shoot and fruit borer, *Leucinodes orbonalis* during 3<sup>rd</sup> spray**

**7 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	575.22	71.90	118.59	2.59
Replication	2	1.05	0.52	0.87	3.63
Error	16	9.70	0.61		
Total	26	585.97			

**SEm± = 0.45**

**CD at 5% = 1.35**

**Anova 36 : Shoot and fruit borer, *Leucinodes orbonalis* during 3<sup>rd</sup> spray  
10 Days After Spray**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	505.78	63.22	33.53	2.59
Replication	2	6.93	3.46	1.84	3.63
Error	16	30.17	1.89		
Total	26	542.88			

**SEm± = 0.79**

**CD at 5% = 2.38**

**Anova 37 :Yield of brinjal in different botanicals and bio- pesticidal treatments**

Source of Variation	D.F.	S.S	MSS	Fcal	Ftab
Treatment	8	4793.26	599.16	3.74	2.59
Replication	2	29.93	14.96	0.09	3.63
Error	16	2562.52	160.16		
Total	26	7385.71			

**SEm± = 7.31**

**CD at 5% = 21.91**

# **CURRICULUM VITAE**

## Curriculum Vitae



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