EFFICACY OF ORGANIC PRODUCTS AGAINST MAJOR INSECT PESTS OF BRINJAL

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
in partial fulfillment of the requirements
for the Degree of

MASTER OF SCIENCE
IN
AGRICULTURE
(AGRICULTURAL ENTOMOLOGY)

By

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Enrolment Number - LL/2513 **2015**

DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the thesis entitled **"EFFICACY OF ORGANIC PRODUCTS AGAINST MAJOR INSECT PESTS OF BRINJAL"** or part thereof has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis / publication of any University or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

Place: Nagpur
Date: 08/06/2015

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CERTIFICATE

This is to certify that thesis entitled **"EFFICACY OF ORGANIC PRODUCTS AGAINST MAJOR INSECT PESTS OF BRINJAL"** submitted in partial fulfilment of the requirement for the degree of **"Master of Science in Agriculture (Agricultural Entomology)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **Rathod Krishnamurti Baburao** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

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Acknowledgements

It is by the lavish and boundless blessing of the almighty that, I have been able to complete my studies successfully hitherto and present this humble piece of work, for which I am eternally indebted.

Fervently and modestly, I extol the genuine cooperation, inspiration and affection offered to me by the Chairman of advisory committee, Shri. R. W. Gawande, Professor and Head, section of Entomology, College of Agriculture, Nagpur in completing the research work in time and successfully. The present work bears the impression of his concrete suggestions and guidance meticulous attention to details.

I humbly place on record my respect and gratitude to Dr. R. O. Deotale, Associate professor of Entomology, Dr. M. J. Patil, Associate Professor of Plant Pathology, and Dr. V. U. Raut, Associate professor of Horticulture, members of my advisory committee, College of Agriculture, Nagpur for constant motivation rendered at all stages of this endeavor and my study period.

I am very much grateful to earlier Associate Dean, Dr. V. S. Gonge, College of Agriculture, Nagpur and to existing Associate Dean, Dr. V. S. Kharche, College of Agriculture, Nagpur for providing the necessary facilities in accomplishing the course of present studies.

I am grateful to our beloved Professor and chairman of my advisory committee, Shri. R. W. Gawande, for his care, affection and guidance throughout my M.Sc. programme, particularly in hard times and made section, a homely place for the students. I record my profound thanks to Dr. V. J. Tambe, Associate Professor of Entomology, Shri. V. N. Nandanwar Assistant Professor of Entomology and Shri. N. V. Lavhe Assistant Professor of Entomology for their moral support and timely help in successful completion of my course.

I am pleased to express my sincere thanks to Shri. D. N. Phulbhoge, Shri. Masurkar, Smt. Venubai, Smt Vithabai, Smt Bebibai, Shri. Vijubhau, Shri. Arvindbhau and other field staff of Entomology Section for their contribution and cooperation in my research work.

It's an immense pleasure to express great, heartfelt respect to my beloved Teachers, who have guided me, all the way to reach up to this level and to whom I dedicate my thesis, for their help, motivation and encouragement.

I am humbly and whole heartedly thankful to entire faculty members of Section of Entomology, College of Agriculture, Nagpur who impaired me the great wealth of timely advice and support.

Diction is not enough to express my unbound gratitude and affection to my beloved father Shri. Rathod B. S. and to my mother Smt. Gunabai, for bringing me up in the best of ways, for rendering me the best of education, for nurturing in me the best of ideals and for helping me to see the best of times. There is no match to the love I have towards my brother Arjun Rathod to whom I live for.

It's my pleasure to mention my best friends Sushil Sarkate, Nivruti Chinak, Satish Kayande, Vaibhav Giri, Milind, Sumedh, Honnaya, Mritunjay, Priyanka, Tabasum, Prakash, and Swapnil for their co-operation during my PG studies and thesis work.

In explicable is my sense of affection to all my dear senior and junior friends, specially to Rahul Punewar Sir, Vilas Chavan sir, Ravi Chavan Sir, Vishwanath Sir, Ajinkya Nirkhee and all the great souls who helped me keep my composure and for being there when I needed them the most.

Everyone is not mentioned, but no one is forgotten.

Place: Nagpur
Date : 08/06/2015

(RATHOD KRISHNAMURTI BABURAO)

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(D) Abbreviations

%	:	Per cent
/	:	Per
^0C	:	Degree Celsius
@	:	at the rate
a.i.	:	Active ingredient
CD	:	Critical difference
cm	:	Centimeter
Conc.	:	Concentration
DAS	:	Days after spraying
DAT	:	Days after transplanting
et al.	:	et allia (and associates)
Eve.	:	Evening
FAO	:	Food and Agricultural organisation
Fig.	:	Figure
g	:	gram
GCK	:	Garlic Chilli Kerosene extract
Ha^{-1}	:	Per hectare
i.e.	:	that is
IPM	:	Integrated Pest Management
K	:	Potassium
Kg.	:	Kilogram
Kg/ha	:	Kilogram per hectare
Lit.	:	Liter
m	:	Meter
Max.	:	Maximum
Met	:	Meteorological
Min.	:	Minimum
Ml/l	:	Milliliter per litre
Mm	:	Millimeter
Mor.	:	Morning
MT	:	Metric tonnes
MT/ha	:	Metric tonnes per ha

N	:	Nitrogen
No	:	Number
NSE	:	Neem seed extract
NSKE	:	Neem seed kernel extract
P	:	Phosphorus
Qtl.	:	Quintal
R.H.	:	Relative Humidity
RDF	:	Recommended dose of fertilizer
q/ha	:	Quintal per hectare
Rs.	:	Rupees
Rs./ha	:	Rupees per hectare
SE (m)	:	Standard error of mean
Sig.	:	Significant
t/ha	:	Tonnes per hectare
Temp.	:	Temperature
Tr.	:	Treatment
Unpub.	:	Unpublished
viz.,	:	Namely

(E) THESIS ABSTRACT

a)	Title of the thesis	:	**"EFFICACY OF ORGANIC PRODUCTS AGAINST MAJOR INSECT PESTS OF BRINJAL"**
b)	Full name of student	:	RATHOD KRISHNAMURTI BABURAO
c)	Name and address of Major Advisor	:	Shri. R. W. Gawande Professor and Head, section of Entomology, College of Agriculture, Nagpur.
d)	Degree to be awarded	:	M.Sc. (Agriculture)
e)	Year of award of degree	:	2015
f)	Major subject	:	Agricultural Entomology
g)	Total number of pages in the thesis	:	55
h)	Number of words in the abstract	:	312
i)	Signature of the student	:	
j)	Signature, Name and address of forwarding authority	:	

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ABSTRACT

Experiment on the efficacy of organic products against major insect pests of brinjal, their effect on natural enemies, yield and economics of different treatments was carried out at Insectary field of Entomology section, College of Agriculture, Nagpur during kharif season of 2014-15. The experiment was laid out in randomized block design (RBD) with eight treatments and three replications. Studies on the efficacy of organic products against major insect pests of brinjal revealed that, lowest infestation (shoot, fruit and sucking pests like aphids, jassids and whiteflies) and highest yield was observed in the treatment cypermethrin 25 EC (T_7) at 0.003% (153.64 q/ha).

Amongst all the organic treatments neem oil 4 per cent (T_5) and NSKE 5% (T_6) were more effective in reducing the infestation (shoot, fruit and sucking pests like aphids, jassids and whiteflies) and recorded yield of 143.73 and 141.64 q/ha and both the treatments were at par with each other. The next promising organic treatments were of agniastra 3% (T_3) and bramhastra 3% (T_2) with 131.23 and 129.29 q/ha yield and were on par with each other followed by neemastra 3% (T_1) and jivamrut 3% (T_4) which recorded 120.33 and 117.85 fruit yield and were also found to be at par with each other.

All the organic products used were completely safe to the natural enemies i.e. coccinellides (1.95 to 3.04/plant), spiders (1.35 to 2.33/plant) and *Chrysopa* (1.02 to 1.80/plant) in brinjal ecosystem as compared to cypermethrin 25 EC (T_7), in which lowest population of coccinellides (0.92/plant), spiders (0.68/plant) and *Chrysopa* (0.51 /plant) was recorded.

Considering the cost of the inputs and the overall returns through yield, it was revealed that, amongst all the organic treatments NSKE 5% (T_6) was more economical in terms of cost benefit economics (6.26) followed by the treatment of bramhastra 3% (5.29), neemastra 3% (5.12), agniastra 3% (4.34), neem oil 4% (2.73) and jivamrut 3% (1.80).

Chapter I

INTRODUCTION

1.1 Background information

Brinjal is one of the important vegetable grown in most of the countries in the world. India is the second largest producer of Brinjal after china. Brinjal is known as egg plant, which is very important common man's vegetable in India. It is often described as a poor man's vegetable because it is popular amongst small-scale farmers and low income consumers. It contains high per centage of nutrition, high water content and is a very good source of fiber, calcium, phosphorus, folate and vitamins B and C. Also used in *ayurvedic* medicine for curing diabetes, hypertension and obesity. In addition, dried brinjal shoots are used as fuel in rural areas. Brinjal has embedded itself deeply into the Indian culture.

A wide range of insect pests attack brinjal including sucking pests like leaf hoppers (*Amrasca species*), white fly (*Bemisia tababci*) and shoot and fruit borer (*Leucinodes orbonalis*), the losses due to pests had been reported up to 50 per cent (Sinha and Nath 2012).

In India brinjal shoot and fruit borer has country wide distribution and has been categorized as the most destructive and most serious pest causing huge losses in India. The larvae bore into the tender shoots in the early stage resulting in drooping shoots, which are readily visible in the infested field. At the later stage, caterpillars bore into flower buds and fruits, rendering the fruit unfit for consumption and marketing, resulting in the direct yield losses. The pest has been reported to inflict losses to the tune of 20.7-60.0 per cent in Tamil Nadu, 70 per cent in Andhra Pradesh, 80 per cent in Gujarat and 41 per cent in Himachal Pradesh (Anil and Sharma 2010).

Farmers of Asian countries in most cases solely depend on insecticides for the management of the pests. Such reliance on insecticides has created many problems such as very frequent

application of insecticides, excessive residues on market vegetables that concern general consumer health and the environment, pesticide resistance, trade implications, poisoning, hazards to non-target organisms, increased production costs etc. (Alam et al. 2003). To overcome insecticidal complications, the present experiment was done at insectary field, college of Agriculture, Nagpur.

Brinjal or eggplant (*Solanum melongena* L.) is an important solanaceous crop of subtropics and tropics. Brinjal has been cultivated in India for the last 4,000 years and is often thought of as a Mediterranean or Mid-Eastern vegetable. The brinjal is of much importance in the warm areas of Far East, being grown extensively in India, Bangladesh, Pakistan, China and the Philippines. It is also popular in Central, South and South East Asia, some parts of Africa and Central America (Gurubban, 1977). It is native of India and is grown throughout the country (Choudhary, 1970). In India, it is one of the most common, popular and principal vegetable crops grown throughout the country except higher altitudes. It is a versatile crop adapted to different agro-climatic regions and can be grown throughout the year. It is a perennial but grown commercially as an annual crop. A number of cultivars are grown in India and the consumer's preference being dependent upon fruit colour, size and shape.

Brinjal fruit (unripe) is primarily consumed as cooked vegetable in various ways and dried plants are used as fuel in rural areas. It is low in calories and fats, contains mostly water, some protein, fibre and carbohydrates. It is a good source of minerals and vitamins and is rich in total water soluble sugars, free reducing sugars, amide proteins among other nutrients. It has been reported that on an average, the oblong-fruited eggplant cultivars are rich in total soluble sugars, whereas, the long-fruited cultivars contain a higher content of free reducing sugars, anthocyanin, phenols, glycoalkaloids (such as solasodine), dry matter, and amide proteins (Bajaj et al., 1979). It is also used as raw material in pickle making and dehydration industries and is an excellent remedy for those suffering from liver complaints. It

is used in ayurvedic medicine for curing diabetes and also as a good appetizer. It is good aphrodisiac, cardio tonic, laxative, mutant and reliever of inflammation.

The global area under brinjal cultivation has been estimated as 18.11 million hectares with total production of brinjal fruit of about 46.68 million MTs with an average productivity of 25.77 t/ha (FAO, 2011). After China, India is second largest producer of vegetable in the world. Yet, the consumption of vegetable is much lower than the recommendation i.e. 275 gram/day/capita (Hansraj, 2000). In India, brinjal was cultivated during the year 2012 in *Kharif, Rabi* and summer seasons on an area of 704.96 thousand hectares with a production of 12994.77 thousand MT and productivity of 18.43 MT/ha (National Horticulture Board, Govt. of India, 2012).

In India, brinjal is grown throughout the year in almost all parts of the country except in higher altitudes and liked by both poor and rich. It is a major vegetable crop of the plains (Premanatha et al., 1987). The major brinjal growing states in India are Andhra Pradesh, Karnataka, West Bengal, Tamil Nadu, Maharashtra, Orissa, Uttar Pradesh, Bihar and Rajasthan. In Maharashtra, brinjal crop occupied the area of 26 thousand hectare with the production of 588 thousand MTs and productivity of 22.62 MT/ha during the year 2012 (National Horticulture Board, Govt. of India, 2012).

1.2 Importance of study

As Brinjal is a consumable commodity, the effect of residue of pesticide in Brinjal is harmful to human health. In this context, botanicals are being considered as environmentally safe, selective, biodegradable, economical and renewable alternative for use in IPM programmers. Botanicals are natural plants products and may be grown by the planters with minimum cost and extracted by indigenous methods. Biopesticides are secondary metabolites, which includes alkaloids, terpenoids, phenolics, and minor secondary chemicals. It is estimated that as many as 2121 plants species have been reported to

posses pest control properties. Botanicals like neem, ghora neem, mahogany, karanj, tobacco, dhatura, castor, marigold, chrysanthemum and wild sunflower many other may be grown by planter with minimum expense.

Brinjal is grown on nearly 680,000 hectares, Production 12,973,000 MT in India 2012-2013, making the country the second largest producer after China with a 25 per cent world production share. It is an important cash crop for more than 1.4 million small, marginal and resource-less farmers. Brinjal, being a hardy crop that yields well even under drought conditions, is grown in almost all parts of the country. Major brinjal producing states includes: West Bengal (23% production share), Orissa (17%), Andhra Pradesh (13%), Gujarat (11%), Bihar (10%), Madhya Pradesh and Maharashtra (5% each). In India 2010-2013, the national average productivity of brinjal was recorded around 17.5 tons per hectare. (Source: Indian Horticulture Database-2013).

Though brinjal is a summer crop, it is being grown throughout the year under irrigated condition. Hence, it is subjected to attack by number of insect pests right from nursery stage to till harvesting (Regupathy et al., 1997). Among the insect pests infesting brinjal, the brinjal shoot and fruit borer, *L. orbonalis* is considered the main constraint as it damages the crop throughout the year. This pest is reported from all brinjal growing areas of the world including Germany, Burma, USA, Srilanka and India. It is known to damage shoot and fruit of brinjal in all stages of its growth. The yield loss due to the pest is to the extent of 70-92 per cent (Reddy and Srinivasa, 2004).

In early stage of the crop growth, larva bores into the shoots resulting in drooping, withering and drying of the affected shoots. During the reproductive stage, tiny larva bores into the flower buds and fruits, the bored hole are invariably plugged with excreta. The infested fruits become unfit for consumption due to loss of quality and lose their market value. It was also reported that there will be reduction in vitamin

C content to an extent of 68 per cent in the infested fruits (Hemi, 1955).

The utilization of organic products and botanicals in the management of brinjal shoot and fruit borer is lagging. Little work has been done so far, hence keeping the above points in view; the present experiment was taken up with following objectives.

1.3 Objectives of study

1. To study the efficacy of organic products against major insect pests of brinjal.
2. To record the population of natural enemies.
3. To work out the economics of different treatments.

1.4 Scope and limitations

Insecticidal control is one of the common means of controlling major insect pests in brinjal crop and many of the insecticides applied are not effective in the satisfactory control of these pests. Over use of chemical insecticides has left considerable toxic residues in the brinjal fruits. The global demand for pesticide residue free crops has increased the interest in using eco-friendly plant products for pest control, which are easily biodegradable and leaves no harmful toxic residues besides conserves natural enemies.

The use of organic products in the management of major insect pests of brinjal will be able to produce toxic free fruits and our Indian farmers can export their brinjal fruits to foreign markets and they can able to get good returns.

Many of us are unaware about many locally available indigenous products and plant products which can be used in controlling major insect pests of brinjal and also one big limitation is that, these organic products, which are used to control major insect pests in brinjal, may not show sudden results in single application as compared to that of chemical insecticides. Hence, it has to be used frequently or in combination with other plant products.

Yet there is a wide scope for using organic products in controlling major insect pests of brinjal, these organic products should be added in IPM practices of brinjal productions as one of the major tool or component.

1.5 Hypothesis

Vijayalakshmi et al. (1996) reported the effectiveness of garlic extract in combination with other extracts like neem, chilli, ginger, tobacco, cow urine (with soap solution) against *H. armigera* and *S. litura* upto 13 days of spray in tomato.

Raja et al. (1998) were conducted studies on the effect of neem products on brinjal shoot and fruit borer *L. orbonalis*. Among the different neem products, neem oil 4% recorded less fruit damage (9.07%) and higher yield (24.48 t/ha), NSKE 5% was on par with it.

Chakraborti (2000) who reported that neem based treatments like spraying of neem oil and NSKE were found safer to natural enemies and were on par with untreated check in brinjal ecosystem.

Singh (2000) evaluated effect of neem products (neem cake, neem oil and a neem-based insecticide) along with conventional insecticide against brinjal shoot and fruit borer, *L. orbonalis* for two years. The results revealed that, the foliar spray of neem oil with basal application of neem cake reduced the incidence of borer and increased the yield. The pest incidence and yield recorded in neem oil treated plots were on par with neem products but not much more profitable than chemical insecticides.

Rosaih (2001b) evaluated different botanicals against pest complex of brinjal. The results revealed that, NSKE 5% recorded least shoot damage (15.61%) and fruit damage (35.60%) and this was followed by neemazal 0.5% with 16.1 and 25.51 per cent shoot and fruit damage.

Chapter II

REVIEW OF LITERATURE

A retrospection of literature pertaining to utilization of organic products combinations procured by local farmers like neemastra, bramhastra, agniastra, jivamrut, neem oil and NSKE and also works done by scientists for the management of major insect pests of brinjal and other related crops are presented here under.

2.1 Efficacy of organic products against *L. orbonalis*

A review pertaining to the utilization of organic products for the management of *L. orbonalis* are presented here under.

2.1.1 Efficacy of organic products against *L. orbonalis* in brinjal ecosystem

Raja et al. (1998) were conducted studies on the effect of neem products on brinjal shoot and fruit borer *L. orbonalis*. Among the different neem products, neem oil 4% recorded less fruit damage (9.07%) and higher yield (24.48 t/ha), NSKE 5% was on par with it.

Sangappa (1999) conducted an experiment to test the ecofriendly treatments against brinjal shoot and fruit borer *L. orbonalis*. NSKE 5% recorded less fruit damage of 21.06 per cent and highest yield (141.53 q/ha) among the ecofriendly treatments.

Singh (2000) evaluated effect of neem products (neem cake, neem oil and a neem-based insecticide) along with conventional insecticide against brinjal shoot and fruit borer, *L. orbonalis* for two years. The results revealed that, the foliar spray of neem oil with basal application of neem cake reduced the incidence of borer and increased the yield. The pest incidence and yield recorded in neem oil treated plots were on par with neem products but not much more profitable than chemical insecticides.

Anonymous (2001) from Indian Institute of Horticultural Research (IIHR) conducted an experiment on the control of brinjal shoot and fruit borer *L.orbonalis* and found that, NSKE 5% was effective.

Reddy and Srinivasa (2001) conducted an experiment for the management of brinjal shoot and fruit borer *L. orbonalis* using different plant extracts, pongamia oil 2% recorded less fruit damage 11.40 per cent and highest yield (39.66 q/ha). This was followed by leaf extract of *Vitex negundo* L.

Rosaih (2001b) evaluated different botanicals against pest complex of brinjal. NSKE 5% recorded least shoot damage (15.61%) and fruit damage (35.60%) and this was followed by Neemazal 0.5% with 16.1 and 25.51 per cent shoot and fruit damage.

Singh (2003) reported the control of brinjal shoot and fruit borer with combination of plant products and insecticides. Among the different treatments tested, basal application of neem cake @ 20 q/ha + foliar spray of quinolphos 0.05% was effective in reducing the fruit borer incidence (20.63%) and increased the yield (82.59 q/ha) as compared to control (27.7 q/ha). However, foliar spray of neem oil 3% + basal application of neem cake @ 20 q/ha was on par with it.

Belina et al. (2005) indicated that, cow-five (Panchagavya) can be used against foliage feeders, especially by increasing the dose to 5% or more and by spraying at shorter intervals for better results. Cow-five did not appear to have any effect on caterpillars that bore deep into the plant tissue e.g. *L. orbonalis* even endosulfan 0.07% also failed to reduce the borer attack significantly indicates that, *L. orbonalis* is very difficult to control at higher dose of cow-five but will probably be able to deter *L. orbonalis* moths from oviposition because of its characteristic odour.

Yadav and Sharma (2005) studied the comparative efficacy of bioagents, neem products and malathion against brinjal shoot and fruit

borer, *Leucinodes orbonalis*. The results showed that, the bioagents and neem products were not superior to the malathion 50 EC (0.05%). However, *Bacillus thuringiensis* subsp. *kurstaki* (Dipel 8 L at 2.5 ml/l water) provided sufficient control of the pest. Nimbicidine, neem seed kernel extract, neem seed kernel solution and *Trichogramma chilonis* were statistically superior over control, but were less effective than malathion and *Bacillus thuringiensis* subsp. *kurstaki*, in suppressing the infestation.

Kalawate and Dethe (2005 and 2006) conducted experiment on bioefficacy study of biorational insecticides on brinjal. They observed, bioefficacy of spinosad (56.25, 72 and 90 g a.i. per ha) and emamectin benzoate (5, 6.25 and 12.5 g a.i. per ha) in comparison to cypermethrin (50 g a.i. per ha) and self formulated neem seed extract (5%). Field experiments were undertaken for two cropping seasons during *Kharif* 2005 and summer 2006. From the study it was found that spinosad was found to be the most effective against brinjal shoot and fruit borer. Although corresponding yield recorded in cypermethrin (check treatment) was higher (16.30 and 21.01 t/ha) but was not significantly differ than that noticed in spinosad and emamectin benzoate.

Murugesan and Murugesh (2009) were evaluated ten plant products like *Azadirachta indica* leaf extract @ 5%, *Calotropis gigantea* leaf extract @ 5%, *Lantana camera* leaf extract @ 5%, neem cake extract @ 5%, neem oil @ 2%, Nimbicidine @ 2 ml/l, *Pongamia glabra* leaf extract @ 5%, *Prosopis juliflora* leaf extract @ 5%, *Vitex negundo* leaf extract @ 5%, and garlic (*Allium sativum*) extract @ 5% *Vitex negundo* leaf extract @ 5% , and garlic (*Allium sativum* Linn.) extract @ 5% against *Leucinodes orbonalis*. Among the plant products, neem oil was the best treatment both in *Kharif* (60.20%) and *Rabi* (59.91%) followed by nimbicidine (57.42%). Neem cake extract (51.97%) and *C. gigantea* (51.34%) were also quite effective in *Kharif* crop reducing fruit damage by more than 50 per cent. Botanicals are moderate in their efficacy in reducing the fruit borer damage in brinjal.

Pareet and Basavanagoud (2009) in their field trials with ten combinations of organic amendments and plant extracts which were evaluated against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. and sucking pest in brinjal crop ecosystem reported that, the basal application of neem cake at 0.5 t per ha+50% RDF followed by foliar application of four different indigenous materials viz., neem seed kernel extract 5%, vermiwash 2%, garlic chilli extract 3%, fermented botanical spray 20% were found to be more effective in reducing per cent infestation.

Mane and Kulkarni (2010) were conducted field experiment to evaluate the bio-efficacy of various neem products against shoot and fruit borer on brinjal. Among the ten treatments, endosulfan 0.05% was the most effective treatment. It was followed by other treatments viz., nimbicidine 0.5% (T_4), NSKE 5% (T_8) and bioneem 0.3% (T_3) which recorded 17.65, 20.40 and 23.02% infestation, respectively. All the treatments were significantly superior over control.

Tayde and Sobita (2010) studied the efficacy of spinosad and neem products against shoot and fruit borer (*Leucinodes orbonalis*) of brinjal (*Solanum melongena*) which revealed that, spinosad 45 SC @ 0.01% was found most effective and showed (9.84%) shoot infestation. Amongst neem products NSKE 5% was found to be superior in terms of efficacy and yield.

Magar (2011) studied on management of *L. orbonalis* through neem products and found that, neem oil @ 5% and neem oil @ 2% recorded shoot infestation to the extent of 14.72 and 19.54 per cent at 7 days after spraying and 15.92 and 21.53 per cent at 14 days after spraying.

Mathur et al. (2012) conducted studies to evaluate the efficacy of plant products viz., neem oil (2%), iluppai oil (2%), pungam oil (2%), combination of iluppai and pungam (1:1). The results thus suggest that,

newer plant products such as oils of iluppai and pungum are promising botanicals in the IPM strategy against *Leucinodes orbonalis* Guen.

Kumar et al. (2013) conducted experiment on efficacy of botanicals with organic manures and fertilizers on brinjal pests. The results showed that, Vermicompost was significantly more effective as regards to fruit borer infestation. NSKE 5% extract proved to be the most effective against fruit borer. Neemgold (*Azadirachtin*) 5 ml/l, *Pongamia glabra* 5% leaf extract and *Annona aquamosa* 5% leaf extract also were effective in reducing the fruit borer incidence. *Murraya koenigi* 5% extract and chilli-garlic 5% extract were less effective. Significantly highest marketable yield was obtained in neemgold (*Azadirachtin*) 5 ml/l followed by NSKE 5%.

2.1.2 Efficacy of organic products against fruit borers of other solanaceous vegetable crops

Rajashri et al. (1991) tested four neem formulations *viz.,* neem oil, neemgaurd, repelin and biosol and some synthetic insecticides against chilli fruit borers, *H. armigera* and *S. litura.* These neem products gave 48.50 to 64.35 per cent reduction in fruit damage over control but were inferior to synthetic insecticides and showed moderate efficacy.

Vijayalakshmi et al. (1996) reported the effectiveness of garlic extract in combination with other extracts like neem, chilli, ginger, tobacco, cow urine (with soap solution) against *H. armigera* and *S. litura* upto 13 days of spray in tomato.

Kasyapa (1998) reported from that chilli + garlic extract and NSKE spray were common practices followed by local farmers of Medhak district of Andhra Pradesh for pest management.

Shivaprakasam (1998) tested NSKE 5% and neem oil 2% along with NPV (Nucleo Polyhadrous Virus) and insecticides for the management of tomato fruit borer, *H. armigera.* NSKE 5% and neem

oil 2% were moderately effective by recording 21 and 20 per cent fruit damage.

Shivaramu (1999) studied the effect of botanicals and biological pesticides on *H. armigera* in chilli. Among the plant products, NSKE 5%, neem oil 5 ml/l and achook 5 ml/l were found to be on par with each other recording 9.77, 12.99 and 9.60 per cent fruit damage, respectively.

Krishnamoorthy and Krishnakumar (2001) conducted field experiment to study the effect of plant products on tomato fruit borer *H. armigera*. Different treatments tested included soil application of neem cake 250 kg/ha, neem seed powder extract 7%, neem oil, pongamia oil, neem soap + pongamia soap all at 1%. Among the different treatments tested soil application of neem cake 250 kg/ha reduced the fruit borer incidence to 13.21 per cent as compared to 33.23 per cent in untreated control.

Ukey and Sarode (2001) reported that, seedling dip in NSE (neem seed extract) 5% before transplanting and spraying of NSE 5% in alternation with monocrotophos 0.05% in field was effective against chilli fruit borer, *H. armigera* by recording least fruit damage of 5.79 per cent followed by spraying of NSE 5% alone (7.73%). Other indigenous methods like spraying of cow urine 5%, cow dung suspension 5% and turmeric 5% in alternation with monocrotophos were moderately effective.

Mallapur (2005) evaluated indigenous materials like nimbicidine 5 ml/l, GCK (garlic chilli kerosene extract) 0.5%, nimbicidine 2.5 ml/l, GCK alone (0.5 and 1.0%), turmeric + cow urine 25%, parthenium extract 17% and cow urine 17% for the management of chilli pests. Among the different treatments, GCK 5% + nimbicidine 2.5 ml/l recorded less per centage of fruit damage due to fruit borer, *H. armigera* and highest yield (11.3 q/ha).

2.1.3 Efficacy of organic products against *Lepidopteron borers* in other crop ecosystems

Malik and Lal (1989) reported the efficacy of neem oil cake and fertilizer mixtures against okra fruit borer *Erias vittella* Fab. and *Earias insulana* Basd. Application of neem oil cake with fertilizer showed fruitful results. Application of sadabahar + neem oil cake 5 kg per plant was quite effective in reducing the fruit borer incidence (18%) with higher fruit yield (1863 kg/ha).

Sadwarte and Sarode (1997) reported that, the combination of cow dung and cow urine with half dose of insecticides observed to have moderate impact on *H. armigera* on pigeon pea, while NSKE + half dose of insecticide was the most effective treatment, while sole application of cow dung and cow urine were ineffective.

Bharathi (2005) reported that, among different combinations of Panchagavya with plant products, Panchagavya (3%) with NSKE (5%) and Panchagavya (3%) with *V. Negundo* (5%) recorded high feeding detterency. After 48 hrs of treatment, sole treatment of Panchagavya at different concentrations recorded significantly less antifeedent property by third instar larva of *S. litura*.

Efficacy of organic products against sucking pests

A reviews regarding to the efficacy of organic products against sucking pests are presented here under.

2.2.1 Efficacy of organic products against sucking pests in brinjal ecosystem

Rosaih (2001a) evaluated different botanicals against pest complex of brinjal and reported that, neem oil 0.5% was significantly superior in reducing the whitefly population in brinjal.

Venkatesh et al. (2004) studied the influence of application of five organic manures viz. neem cake, pongamia cake, castor cake (all at

1.0 t/ha), farmyard manure and vermicompost (10.0 t/ha) alone and in combination with chemical fertilizer on whitefly and leaf hopper in brinjal. Amongst the cakes, neem cake was the most effective. Significantly higher yield (40.3 q/ha) was obtained from neem cake treated plots followed by vermicompost and castor cake treated plots.

Varma et al. (2010) conducted experiment on efficacy of some indigenous plant products for management of the aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) infesting brinjal. The results revealed that, the chlorpyriphos (0.05%) against *Aphis gossypii* Glover infesting brinjal. The treatments reduced the populations of aphids significantly. NSKE recorded 51.92 and 54.07 per cent reduction of population in the two experiments followed by Chilli + Garlic with 47.11 and 48.77 per cent reduction and Calotropis with 45.24 and 46.38 per cent reduction were on par and they were also on par with Chlorpyriphos which gave 60.42 per cent and 62.25% reduction.

Raza et al. (2014) the experiment was carried out at the farmer's field to evaluate the efficacy of botanical pesticides in comparison to synthetic insecticide against major sucking insect pests of brinjal. The overall results of 4 sprays showed that, neem oil (61.04%) and neem kernel powder (57.99%). Jassid population was reduced by neem oil (61.54%) and neem kernel powder (59.79%). Similarly, aphid population was reduced by neem oil (66.51%) and neem kernel powder (61.49%).

2.2.2 Efficacy of organic products against sucking pests of other solanaceous vegetable crops

Malagatti (2011) studied on biorational management against sucking pests of chilli and found that, the treatments neem oil 1% and NSE 1% were effective to control aphid population and recorded 55.79 and 46.79 per cent population reduction.

Gundannavar and Giraddi (2013) conducted field experiment on effect of organic soil amendments on the activity of sucking pests of

chilli. Experiment was carried out under field condition at main agricultural research station, university of agricultural sciences, Dharwad to evaluate efficacy of different organic amendments superimposed with neem based pesticides against chilli sucking pests. Among different treatments, split application of neem cake @ 125 kg/ha + vermicompost @ 625 kg/ha at transplanting and 50 days later NSKE spray interventions later was found to be the most effective treatment.

2.2.3 Efficacy of organic products against sucking pests in other crop ecosystems

Amer et al. (1999) comparative efficacy of insecticides for the control of insect pest complex of cotton (*Gossypium hirsutum* L.) the result revealed that, Polytrin- C (curacron + cypermethrin) 440 EC was effective as it cause 84.04 and 86.52 per cent population reduction of jassid and whitefly respectively in cotton ecosystem.

Rao (2002) conducted a field trial on the influence of fertilizers and organic manures on the groundnut insect pests viz., leaf hoppers and aphids. The organically manured treatments viz., farmyard manure, neem cake and vermicompost recorded lowest pest population compared to fertilized treatment.

2.3 Impact of organic products on natural enemies

A review pertaining to the impact of organic products on natural enemies in brinjal ecosystem are presented here under.

Guddewar et al. (1994) reported that, the extract of neem seed kernel was safer than synthetic insecticides to *C. septumpunctata*. The order of safety was neem seed kernel extract, endosulfan, quinalphos malathion and monocrotophos.

Patil et al. (1997) evaluated some plant products viz., *Parthenium hysterophorus, Vitex negundo, Vincarosea, Calotropis*

gigantea, *Lantana camera*, *Argemona Mexicana* and *Tujaoccidentalis*. at 2% concentration each on different stages of *C. carnea* along with polytrin and profenofos. They recorded significantly high egg hatchability and less larval and adult mortality of *C. carnea* due to botanicals compared to insecticides.

Kaethner (1999) reported that, neem seed extract and neem oil were harmless to the egg and larvae of *Chrysoperla carnea* and *Coccinella septumpunctata*.

Chakraborti (2000) reported that, neem based treatments like spraying of neem oil and NSKE were found safer to natural enemies and were on par with untreated check in brinjal ecosystem.

Rosaih (2001a) reported that, spiders in all botanicals treatments were almost equal to untreated control (1.87 spiders/plant) as compared to monocrotophos (0.41 spiders/plants). These results reveal the safety of botanicals to natural enemies compared to synthetic insecticides after 10 days of spray in brinjal.

Rosaih (2001b) reported that, among the predatory population in okra ecosystem, spiders, chrysopids, *Apanteles* sp and coccinellides were most predominant and there was no significant difference in the population of these predators in different plant products. This clearly indicated increased activity of natural enemies in plots treated with botanical insecticides.

Mollah et al. (2009) toxic effect of some insecticides on predatory lady bird beetles (coleoptera: coccinellidae) in country bean (Lablab purpureus l.) field. The study was carried out in the Entomology Research field at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during 2009. Amongst the insecticides, fenvalerate 5 EC @ 1.0 ml/l water, cypermethrin 10 EC @ 1.0 ml/l water and deltamethrin 2.5 EC @ 1.0 ml/l water found highly toxic to lady bird beetle resulting 33.78, 31.76 and 28.42% mortality, respectively. Whereas, neem oil (fresh) @ 2.5 ml/l water, neem oil

(stored) @ 2.5 ml/l water and emamectin benzoate 5 SG @ 1.0 gram per liter water found least toxic to lady bird beetles confirming 9.37, 17.45 and 19.04 % mortality respectively.

Thulasiram et al. (*Kharif* 2012 and *Rabi* 2013) effect of bifenthrien 8 SC on the population of spiders in okra ecosystem was evaluated with the help of two supervised field experiments conducted during *Kharif* 2012 and *Rabi* 2013 at Eastern farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Pondicherry. The results showed that, the overall mean population of spiders was higher in the untreated check (4.62/plant) while cypermethrin 10 EC @ 70 g a.i. per ha recorded 1.02 and 0.92/plant in *Kharif* and *Rabi*.

Chapter III

MATERIAL AND METHODS

The field experiment on "Efficacy of organic products against major insect pests of brinjal" was conducted at Insectary premises of Entomology section, College of Agriculture, Nagpur during *Kharif* season of 2014-15. Details of materials used and the methods adopted during these studies are described here under.

3.1 Materials required

For conducting the experiment, organic products like neem leaves, water, gomutra and indigenous cow dung for preparation of neemastra; gomutra, neem leaves, karanj leaves, castor leaves, papaya leaves and dhatura leaves for preparation of bramhastra; gomutra, tobacco leaves, green chillies, garlic and neem leaves for preparation of agniastra; water, indigenous cow dung, gul (Jaggery), besan (except soyabean), gomutra and bund soil for preparation of jivamrut; neem oil, neem seed kernel, water, wooden plank, muslin cloth and detergent powder for preparation of NSKE, brinjal seeds (var. Harit), agricultural implements, inorganic fertilizers, measuring cylinder, buckets, mortar and pestle, labels, pegs, threads, polythene bags, wooden plank, muslin cloth and electrical balance were used. These materials were provided by Entomology section, College of Agriculture, Nagpur during the present study.

3.2 Methods adopted

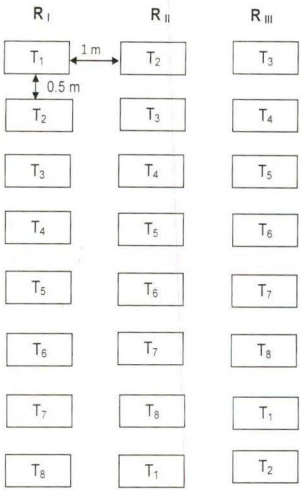
A field experiment was carried out at insectary premises of Entomology Section, College of Agriculture, Nagpur using brinjal variety Harit during *Kharif* season of 2014-15 to evaluate the efficacy of organic products against major insect pests of brinjal with three replications in randomized block design (RBD) with a gross plot size of 3.75 x 3 m. The transplanting was done on 23rd August 2014.

Spacing maintained was 75 x 60 cm between rows and plants. The treatment details were as followed.

3.2.1 Details of experiment

1. Name of crop	: (Brinjal) *Solanum melongena L.*
2. Family	: Solanaceae
3. Variety	: Harit
4. Experimental Design	: Randomised Block Design (RBD)
5. No. of Replication	: 03
6. No. of Treatments	: 08
7. Total plots	: 24
8. Plot size	
a) Gross	: 3.75 X 3 m
b) Net	: 3 X 2.40 m
9. Spacing	
a) Row to Row	: 75 cm
b) Plant to Plant	: 60 cm
10. Inter Replication Spacing	: 1 m
11. Inter Plot Spacing	: 0.5 m
12. Row per Plot	: 05
13. Plant per Row	: 05
14. Total no. Of plant/plot	: 25
15. Method of sowing	: Transplanting
16. Date of sowing	: 23/08/2014
17. Fertilizer dosage	: 60:50:00 NPK Kg/ha
18. Irrigation	: As per requirement.

Plan of Layout:



T_1	Neemastra	3 %
T_2	Bramhastra	3 %
T_3	Agniastra	3 %
T_4	Jivamrut	3 %
T_5	Neem oil	4 %
T_6	NSKE	5 %
T_7	Cypermethrin 25 EC	0.0
T_8	Control (water spray)	----

Fig. 1: Plan of Layout

3.2.2 Treatment details

Table 1. Details of organic products tested against major insect pests of brinjal

Treatment No.	Treatments	Concentration
T1	Neemastra	3%
T2	Bramhastra	3%
T3	Agniastra	3%
T4	Jivamrut	3%
T5	Neem oil	4%
T6	Neem seed kernel extract	5%
T7	Cypermethrin 25 EC	0.003%
T8	Control (water spray)	

The organic products evaluated include organic manures, and plant products. All the organic products were prepared at Insectary premises of Entomology section, College of Agriculture, Nagpur. Only neem oil was purchased. Chemical fertilizers were also applied, but only 50% of nitrogen was applied at the time of transplanting and the remaining 50% was applied as top dressing six weeks after transplanting. Fertilizer was applied by ring method, where a ring was formed around the seedling, the fertilizer was applied in ring and soil was covered.

3.3 Preparation of Organic Products

3.3.1 Neemastra: Grind 5 kg neem leaves and mix in 100 liter water. Add 5 liter gomutra + 0.5 kg indigenous cow dung. Stir well, sieve well. Use after 24 hrs.

3.3.2 Bramhastra: Take 10 liter gomutra, add to it 3 kg neem leaves + 2 kg karanj leaves + 2 kg castor leaves + 2 kg papaya leaves + 2 kg dhatura leaves. Boil properly. Cool for 48 hrs. 3 liter of this solution in 100 liter water to be sprayed for foliage feeders.

3.3.3 Agniastra: Take 10 liter gomutra add 1 kg tobacco leaves + 1 kg grinded green chillies + 0.5 kg garlic + add 5 kg neem leaves. Boil solution and cool for 48 hrs. Spray in 3 liter/100 liter of water for fruit borer.

3.3.4 Jivamrut: Take 200 liter water + 10 kg cowdung of indigenous cow + 1 kg gul (Jaggery) + 2 kg besan (except soyabean) + 5 liter gomutra + 100 gm bund soil. Mix all. Keep in shade for 72 hrs. Stir in morning and evening for 2 minutes. The solution of 4 to 7 days used for spraying.

3.3.5 Neem seed kernel extract

- Take required quantity of Neem seed kernel (5 kg).
- Grind the kernels gently to powder it.
- Soak it overnight in 10 liters of water.
- Stir with wooden plank in the morning till solution becomes milky white.
- Filter through double layer of muslin cloth and made the volume to 100 liters.
- Add 1% detergent (Make a paste of the detergent and then mix it in the spray solution).
- Mix the spray solution well and use.

First spray was given at 30 days after transplanting and remaining three sprays were given subsequently at 15 days intervals.

Plate 1: General view of experimental field

Plate 2: Preparation of organic products spray solutions

3.4 Cultural practices

3.4.1 Preparatory tillage

During summer the soil was thoroughly prepared by ploughing followed by two harrowing. The field was cleaned by picking stubbles of previous crop. The experimental plots were laid out as per the statistical design (figure 1).

3.4.2 Preparation of nursery

The seeds were sown on raised bed to raise the seedlings in nursery. Regular irrigation and weeding were done before transplanting of seedlings to the main field.

3.4.3 Transplanting and gap filling

The seedlings were transplanted on 23rd August 2014. The gap filling was done on 8th September 2014 to maintain the plant population, keeping one plant per hill.

3.4.4 Application of fertilizers

Application of fertilizer was done at the rate of 60:50:00 NPK kg/ha. Half dose of nitrogen and full dose of phosphorus were given at the time of transplanting on 23rd August 2014. The remaining half dose of nitrogen was applied one month after transplanting. Fertilizers were applied by ring method in the form of urea and single super phosphate.

3.4.5 Hoeing and weeding

Timely hoeing and weeding operation were carried out to conserve soil moisture and to remove weeds as and when needed.

3.4.6 Protective irrigation

Though the crop was sown in the *Kharif* season. Three protective irrigations were given during dry spell.

Plate 3: Ready to use organic products for spraying

Plate 4: Spraying of organic products spray solutions to plants

3.5 Method of recording observations

3.5.1 Shoot

Observations were recorded on the number of infested shoots in each plot a day before first spray and 7 and 14 days after each spraying on five randomly selected plants from each plot. The cumulative per cent shoot damage is worked out using the formula.

$$\text{Per cent shoot damage} = \frac{\text{Number of infested shoots}}{\text{Total number of shoots}} \times 100$$

3.5.2 Fruit

Observations were recorded on the number of infested fruits and number of marketable fruits on five randomly selected plants from each plot picking wise. The per cent fruit damage is worked out using the formula.

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

Observations were also recorded on the basis of weight of infested fruits and weight of marketable fruits on five randomly selected plants from each plot picking wise. The per cent fruit damage is worked out using the formula.

$$\text{Per cent fruit damage} = \frac{\text{Weight of damaged fruits}}{\text{Weight of total fruits}} \times 100$$

The per cent shoot and fruit damage was transformed into angular values and the data were subjected to statistical analysis.

The fruits were harvested from each plot separately and yield per plot on each picking was recorded. Totally six pickings were done. Total yield was calculated by adding yield of each picking. The per plot

yield was converted to quintals per hectare and the data were subjected to the statistical analysis.

3.5.3 Sucking pests

To evaluate efficacy of organic products against sucking pests in brinjal ecosystem, the observations on sucking pests were taken in all treatments. The population count of aphids, jassids and whiteflies were recorded on five randomly selected plants in each plots 7 and 14 days after each spraying. The data were subjected to arcsine transformation before statistical analysis.

$$\% \text{ reduction} = \frac{\text{Pre-treat. observation} - \text{Post treat. observation}}{\text{Pre-treatment observation}} \times 100$$

3.5.4 Natural enemies

To assess efficacy of organic products against the natural enemies in brinjal ecosystem, the natural enemies count was taken in all treatments. The population count of coccinellides, *Chrysopa* and spiders were recorded on five randomly selected plants in each plots 7 and 14 days after each spraying. The data were subjected to square root transformation before statistical analysis.

3.6 Harvesting of brinjal fruits

In all eight pickings were undertaken on following dates:

First picking	: 11/11/2014
Second picking	: 26/11/2014
Third picking	: 12/12/2014
Fourth picking	: 29/12/2014
Fifth picking	: 15/01/2015
Sixth picking	: 27/01/2015

3.7 Yield of brinjal fruits

In order to compare effect of different treatments the yield data was collected from each of the net plot and thus worked out in the form of quintal per hectare.

3.8 Statistical analysis

The data recorded in different treatments were subjected to statistical analysis after suitable transformation by following standard procedures of R. B. D. experiment (Gomez and Gomez, 1984).

3.9 Meteorological observations

The meteorological observations on temperature (maximum and minimum), humidity (morning and evening), rainfall and rainy days during the experimental periods are given in Appendix.

Chapter IV

RESULTS AND DISCUSSION

In recent years with the increased awareness about the harmful effects of pesticides, organic products have attracted the attention of scientists and farmers for the management of brinjal pests to have toxic free sustained vegetable production.

Over use of pesticides has led to the outbreak of pests and destruction of natural enemies. It has also led to the development of resistance, environmental pollution followed by substantial erosion of net income. Further, farmers failed to get difference in yield between sprayed and non-sprayed plots (Ranga Rao and Weightman (1993). So, organic plant protection farming has emerged as an alternate farming system to overcome all these problems.

Therefore, keeping this view in mind the experiment was conducted during *Kharif* season of 2014-2015 in Insectary premises of Entomology section, College of Agriculture, Nagpur to know the efficacy of organic products against major insect pests and natural enemies of brinjal with following objectives.

1. To study the efficacy of organic products against major insect pests of brinjal.
2. To record the population of natural enemies.
3. To work out the economics of different treatments.

4.1 Observations and interpretation of data on shoot infestation

The treatments were initiated immediately at the start of infestation (i.e. 30 DAT). Four applications of treatments were given during the period of experimentation at 15 days interval. The pretreatment observations on shoot infestation were recorded 24 hrs before first spraying and the subsequent post treatment observations were recorded 7 and 14 days after each treatment application.

Egg

Larva

Pupa

Male Adult

Female Adult

Plate 5: Life stages of brinjal shoot and fruit borer

The data thus generated was subjected to statistical analysis. The inferences drawn are discussed in the light of available literature reported by different research workers which is as under.

4.1.1 Cumulative mean per cent infestation of shoots due to *L. orbonalis* after four sprayings

The data presented in Table 2 and depicted in fig. 2 regarding infestation on shoots revealed that all the treatments were significantly superior in suppressing shoot infestation of brinjal shoot and fruit borer over control after four sprayings. The performance of individual treatment in reducing per cent shoot infestation was compared on the basis of cumulative mean per cent shoot infestation.

After application of four sprays at 15 days interval, the cumulative data on shoot infestation indicated that, the treatment cypermethrin 25 EC (T_7) @ 0.003% was significantly superior over all the organic product treatments and recorded 14.03 per cent shoot infestation. These results are in confirmation with the findings of Deshpande (2005), who reported 13.20 per cent shoot infestation at 7 days after spraying. Kalmegh (2008) revealed that, treatment with cypermethrin (0.006%) showed minimum shoot infestation (13.99%) at 15 days after spraying.

Amongst the different organic products, the treatment neem oil (T_5) 4% and NSKE (T_6) 5% recorded 19.22 and 20.10 per cent shoot infestation and were found on par with each other. These results are in confirmation with the findings of Magar (2011) who studied on management of *L. orbonalis* through neem products and found that neem oil @ 5% and neem oil @ 2% recorded shoot infestation to the extent of 14.72 and 19.54 per cent at 7 days after spraying and 15.92 and 21.53 per cent at 14 days after spraying. Rosaih (2001b) evaluated different botanicals against pest complex of brinjal and found that NSKE 5% recorded least shoot damage (15.61%).

The next effective treatments were agniastra (T_3) 3% (contains gomutra, tobacco leaves, green chilies, garlic and neem leaves) and

Table 2: Cumulative mean per cent infestation of shoots due to *L. orbonalis* on brinjal at different intervals after four sprayings

Tr. No.	Treatments	Conc.	Before first spraying	First spraying		Second spraying		Third spraying		Fourth spraying		Cumulative mean
				7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	
T_1	Neemastra	3%	25.33 (30.22)	26.12 (30.74)	25.04 (30.02)	23.42 (28.94)	25.28 (30.18)	24.30 (29.53)	23.57 (29.05)	24.63 (29.75)	24.78 (29.85)	24.72 (29.81)
T_2	Bramhastra	3%	22.38 (28.23)	23.19 (28.79)	22.79 (28.51)	21.07 (27.32)	22.75 (28.49)	21.40 (27.55)	21.10 (27.34)	22.32 (28.19)	23.33 (28.88)	22.26 (28.15)
T_3	Agniastra	3%	26.75 (31.14)	22.54 (28.35)	22.17 (28.09)	20.24 (26.73)	22.07 (28.02)	20.67 (27.04)	20.33 (26.80)	21.76 (27.81)	22.73 (28.48)	22.14 (28.07)
T_4	Jivamrut	3%	27.08 (31.35)	26.79 (31.17)	25.49 (30.32)	24.18 (29.45)	26.03 (30.68)	25.06 (30.04)	24.41 (29.61)	23.40 (28.93)	25.50 (30.33)	25.33 (30.21)
T_5	Neem oil	4%	24.79 (29.86)	19.68 (26.34)	19.54 (26.23)	17.66 (24.85)	19.18 (25.97)	17.12 (24.44)	17.98 (25.09)	17.56 (24.78)	19.48 (26.19)	19.22 (25.97)
T_6	NSKE	5%	26.30 (30.85)	20.04 (26.59)	20.20 (26.71)	18.51 (25.48)	20.01 (26.57)	18.66 (25.60)	18.57 (25.53)	18.37 (25.38)	20.27 (26.76)	20.10 (26.61)
T_7	Cypermethrin 25 EC	0.003%	23.66 (29.10)	13.56 (21.80)	12.98 (21.12)	12.59 (20.78)	13.68 (21.70)	12.48 (20.69)	11.95 (20.22)	12.18 (20.43)	13.23 (21.33)	14.03 (21.89)
T_8	Control (water spray)	-	26.74 (30.14)	35.63 (36.65)	30.41 (33.46)	31.52 (34.16)	34.86 (36.18)	34.96 (36.25)	31.04 (33.86)	36.50 (37.17)	35.83 (36.77)	33.05 (35.07)
	'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE (m) ±		0.279	0.309	0.324	0.321	0.272	0.202	0.233	0.292	0.303	0.456
	CD at 5%		0.847	0.936	0.981	0.974	0.826	0.612	0.708	0.886	0.919	1.293

(Figures in parentheses are corresponding values of arcsine transformations)

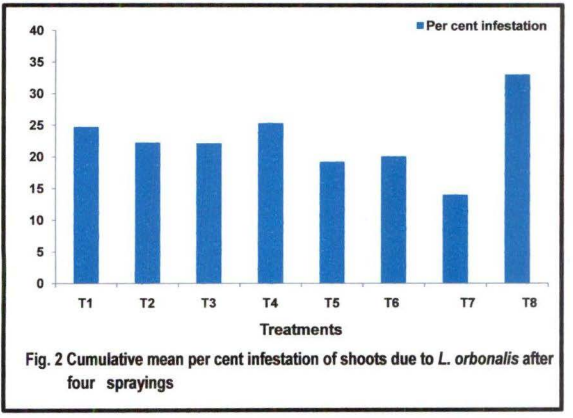


Fig. 2 Cumulative mean per cent infestation of shoots due to *L. orbonalis* after four sprayings

T_1 -	Neemastra	3%
T_2 -	Bramhastra	3%
T_3 -	Agniastra	3%
T_4 -	Jivamrut	3%
T_5 -	Neem oil	4%
T_6 -	NSKE	5%
T_7 -	Cypermethrin 25 EC	0.003%
T_8 -	Control (water spray)	

Plate 6: Infested brinjal shoot by *Leucinodes orbonalis*

Plate 7: Healthy plant

bramhastra (T_2) 3% (contains gomutra, neem leaves, karanj leaves, castor leaves, papaya leaves and dhatura leaves) found on par with each other recording 22.14 and 22.26 per cent shoot infestation. These treatments were followed by neemastra (T_1) 3% (contains neem leaves, gomutra and cow dung) and jivamrut (T_4) 3% (contains cowdung, Jaggery, besan, gomutra and bund soil) which found on par with each other by registering 24.72 and 25.33 per cent shoot infestation as compared to control (water spray), which recorded highest (33.05%) shoot infestation.

These results are in confirmation with the findings of Vijayalakshmi et al. (1996) regarding the effectiveness of garlic extract in combination with other extracts like neem, chili, ginger, tobacco, cow urine (with soap solution) against *H. armigera* and *S. litura* upto 13 days of spray in tomato.

Pareet and Basavanagoud (2009) in their field trials with ten combinations of organic amendments and plant extracts which were evaluated against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. and sucking pest in brinjal crop ecosystem reported that, the basal application of neem cake at 0.5 t per ha+50% RDF followed by foliar application of four different indigenous materials viz., neem seed kernel extract 5%, vermiwash 2%, garlic chilli extract 3%, fermented botanical spray 20% were found to be more effective in reducing per cent infestation.

4. 2 Observations and interpretation of data on number and weight basis of fruit infestation

The data presented in Table 3 and 4 regarding infestation on fruits on number and weight basis revealed that, all the treatments were significantly superior in suppressing mean per cent fruit infestation of brinjal shoot and fruit borer over control during subsequent six pickings. The performance of individual treatment in reducing per cent fruit infestation was compared on the basis of cumulative mean per cent fruit infestation.

The data thus generated were subjected to statistical analysis and the cumulative mean per cent fruit damage was worked out picking wise. The inferences drawn are discussed in the light of available literature reported by different research workers as under.

4.2.1 Cumulative mean per cent fruit infestation on number basis during subsequent pickings.

The data presented in table 3 and depicted in fig. 3 regarding with the infestation of *L. orbonalis* on fruits on number basis revealed that, all the treatments were significantly superior in reducing per cent fruit infestation over control during subsequent six pickings. The cumulative mean per cent fruit infestation observed in different treatments was varied from 12.46 per cent in cypermethrin 25 EC @ 0.003% treated plot to 35.71 per cent in control plot.

After completion of six brinjal fruit pickings, it was found that, per cent fruit damage was significantly less in the treatment cypermethrin 25 EC (T_7) @ 0.003% recorded 12.46 per cent fruit infestation. These results are in agreement with the findings of Budhvat (2011) who conducted studies on the biorational management of *L. orbonalis* Guen. on brinjal and found that cypermethrin 25 EC @ 0.0075% was effective in managing *L. orbonalis* with 12.92 per cent fruit infestation on number basis.

Amongst the different organic products neem oil (T_5) 4% and NSKE (T_6) 5% recorded significantly lower fruit damage and found on par with each other by registering 17.75 and 18.48 per cent fruit infestation. These results are in confirmation with the findings of Magar (2011), who studied on management of *L. orbonalis* through neem products and found that, neem oil @ 5% and neem oil @ 2% recorded fruit infestation to the extent of 14.85 and 17.03 per cent on number basis.

Sangappa (1999) conducted an experiment to test the ecofriendly treatments against brinjal shoot and fruit borer *L. orbonalis*.

Table 3: Cumulative mean per cent fruit infestation due to *L. orbonalis* after six pickings on number basis

Treatments		Conc.	No. of Picking						Cumulative Mean
			I	II	III	IV	V	VI	
T_1	Neemastra	3%	24.36 (29.58)	23.59 (29.06)	26.31 (30.86)	26.36 (30.89)	23.89 (29.26)	26.08 (30.71)	25.10 (30.06)
T_2	Bramhastra	3%	23.28 (28.85)	22.24 (28.14)	23.07 (28.71)	24.52 (29.68)	22.41 (28.25)	23.70 (29.13)	23.20 (28.79)
T_3	Agniastra	3%	22.88 (28.58)	21.48 (21.61)	22.30 (28.18)	23.88 (29.25)	21.81 (27.84)	22.99 (28.65)	22.56 (28.35)
T_4	Jivamrut	3%	25.07 (30.05)	24.23 (29.49)	27.07 (31.35)	27.07 (31.35)	24.31 (29.54)	26.81 (31.18)	25.76 (30.49)
T_5	Neem oil	4%	17.76 (24.93)	16.99 (24.34)	18.99 (25.84)	17.96 (25.08)	16.77 (24.18)	17.99 (25.10)	17.75 (24.91)
T_6	NSKE	5%	18.58 (25.53)	17.58 (24.79)	19.79 (26.41)	18.76 (25.67)	17.44 (24.68)	18.72 (25.64)	18.48 (25.45)
T_7	Cypermethrin 25 EC	0.003%	12.42 (20.64)	13.19 (21.29)	13.15 (21.26)	12.72 (20.89)	12.16 (20.41)	11.15 (19.51)	12.46 (20.67)
T_8	Control (water spray)	-	34.07 (35.71)	36.38 (37.10)	36.56 (37.20)	34.70 (36.09)	35.18 (36.74)	36.62 (37.24)	35.71 (36.68)
	F Test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE (m) ±		0.293	0.259	0.243	0.339	0.308	0.410	0.223
	C. D. (0.05)		0.889	0.785	0.768	1.027	0.934	1.242	0.637

(Figures in parenthesis are the arcsine transformations)

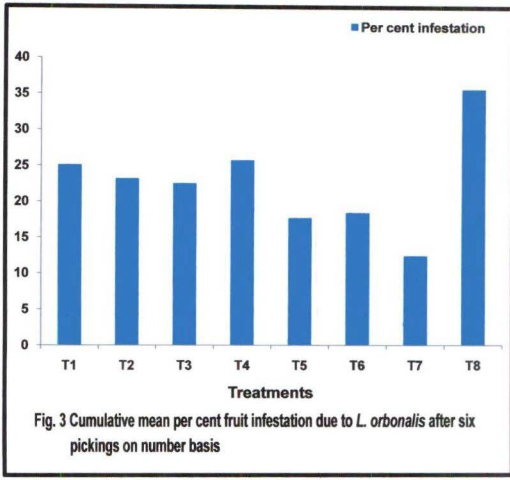


Fig. 3 Cumulative mean per cent fruit infestation due to *L. orbonalis* after six pickings on number basis

T_1 -	Neemastra	3%
T_2 -	Bramhastra	3%
T_3 -	Agniastra	3%
T_4 -	Jivamrut	3%
T_5 -	Neem oil	4%
T_6 -	NSKE	5%
T_7 -	Cypermethrin 25 EC	0.003%
T_8 -	Control (water spray)	

Plate 8: Infested brinjal fruit by *Leucinodes orbonalis*

Plate 9: Damaged brinjal fruit by *Leucinodes orbonalis*

NSKE 5% recorded less fruit damage of 21.06 per cent and highest yield (141.53 q/ha) among the ecofriendly treatments.

The next promising organic treatments were of agniastra (T_3) 3% and bramhastra (T_2) 3% which were found on par with each other with 22.56 and 23.20 per cent fruit infestation. These treatments were followed by neemastra (T_1) 3% and jivamrut (T_4) 3% which were at par with each other by recording 25.10 and 25.76 per cent fruit infestation as compared to control (water spray), registering highest (35.71) per cent infestation.

These results are in confirmation with the findings of Pareet and Basavanagoud (2009) who conducted field trials with ten combinations of organic amendments and plant extracts were evaluated against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. and sucking pests in brinjal crop ecosystem. The basal application of neem cake at 0.5 t per ha+50% RDF followed by foliar application of four different indigenous materials viz., neem seed kernel extract 5%, vermiwash 2%, garlic chilli extract 3%, fermented botanical spray 20% were found to be more effective in reducing per cent fruit infestation.

Mallapur (2005) evaluated indigenous materials like nimbicidine 5 ml/l, GCK (garlic chili kerosene extract) 0.5%, nimbicidine 2.5 ml/l, GCK alone (0.5 and 1.0%), turmeric + cow urine 25%, parthenium extract 17% and cow urine 17% for the management of chilli pests. Among the different treatments, GCK 5% + nimbicidine 2.5 ml/l recorded less percentage of fruit damage due to fruit borer, *H. armigera* and highest yield (11.3 q/ha).

Murugesan and Murugesh (2009), evaluated ten plant products like *Azadirachta indica* leaf extract @ 5%, *Calotropis gigantea* leaf extract @ 5%, *Lantana camera* leaf extract @ 5%, neem cake extract @ 5%, neem oil @ 2%, nimbicidine @ 2 ml/l, *Pongamia glabra* leaf extract @ 5%, *Prosopis juliflora* leaf extract @ 5%, *Vitex negundo* leaf extract @ 5% and garlic (*Allium sativum*) extract @ 5%

against *Leucinodes orbonalis* and found that, botanicals are moderate in their efficacy in reducing the fruit borer damage in brinjal.

4.2.2 Cumulative mean per cent fruit infestation on weight basis during subsequent pickings.

The data presented in table 4 and depicted in fig. 4 regarding infestation of fruits on weight basis revealed that, all the treatments were significantly superior in reducing per cent fruit infestation over control during subsequent six pickings. The cumulative mean per cent fruit infestation in different treatments was varied from 12.80 per cent in cypermethrin 25 EC @ 0.003% treated plot to 35.83 per cent in control plot.

After completion of six pickings, it was noticed that, per cent fruit damage was observed significantly less in the treatment cypermethrin 25 EC (T_7) @ 0.003% which recorded 12.80 per cent fruit infestation. These results corroborates with the findings of Budhvat (2011) who conducted studies on the biorational management of *L. orbonalis* Guen. on brinjal and found that, cypermethrin 25 EC @ 0.0075% was effective in restricting infestation of *L. orbonalis* to the tune of 12.13 per cent fruit damage on weight basis.

Amongst the different organic products neem oil (T_5) 4% and NSKE (T_6) 5% recorded significantly lower fruit damage and were seen at par with each other by notifying 17.89 and 18.37 per cent fruit infestation. These results are in confirmation with the findings of Magar (2011) who studied on management of *L. orbonalis* through neem products and found that, neem oil @ 5% and neem oil @ 2% recorded fruit infestation to the extent of 15.19 and 17.14 per cent on weight basis.

Mane and Kulkarni (2010) conducted field experiment to evaluate the bio-efficacy of various neem products against shoot and fruit borer on brinjal. Amongst ten treatments, endosulfan 0.05% was the most effective treatment. It was followed by other treatments viz., nimbicidine 0.5% (T_4), NSKE 5% (T_8) and bioneem

Table 4: Cumulative mean per cent fruit infestation due to *L. orbonalis* after six pickings on weight basis

Treatments		Conc.	No. of Picking						Cumulative Mean
			I	II	III	IV	V	VI	
T_1	Neemastra	3%	26.03 (30.68)	25.46 (30.31)	27.42 (31.58)	25.13 (30.09)	25.09 (30.06)	25.25 (30.16)	25.73 (30.48)
T_2	Bramhastra	3%	22.20 (28.11)	23.15 (28.76)	22.07 (28.02)	23.27 (28.84)	24.39 (29.59)	23.37 (28.91)	23.07 (28.71)
T_3	Agniastra	3%	21.67 (27.75)	22.67 (28.43)	21.49 (27.62)	22.73 (28.48)	23.86 (29.24)	22.90 (28.59)	22.55 (28.35)
T_4	Jivamrut	3%	26.58 (31.03)	26.01 (30.66)	28.02 (31.96)	25.67 (30.44)	25.61 (30.40)	25.72 (30.48)	26.27 (30.83)
T_4	Neem oil	4%	17.76 (24.93)	16.99 (24.34)	17.79 (24.95)	18.64 (25.58)	17.18 (24.49)	18.99 (25.83)	17.89 (25.02)
T_5	NSKE	5%	18.28 (25.31)	17.48 (24.71)	18.88 (25.24)	19.18 (25.97)	17.68 (24.86)	19.42 (26.15)	18.37 (25.38)
T_6	Cypermethrin 25 EC	0.003%	12.82 (20.98)	13.44 (21.51)	12.46 (20.67)	12.19 (20.44)	12.44 (20.65)	13.46 (21.52)	12.80 (20.96)
T_8	Control (water spray)	-	35.50 (36.57)	36.06 (36.91)	36.06 (36.91)	34.00 (35.67)	36.18 (36.98)	37.19 (37.58)	35.83 (36.77)
	F Test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE (m) ±		0.298	0.311	0.322	0.227	0.268	0.280	0.240
	CD at 5%		0.904	0.944	0.978	0.688	0.812	0.850	0.686

(Figures in parenthesis are the arcsine transformations)

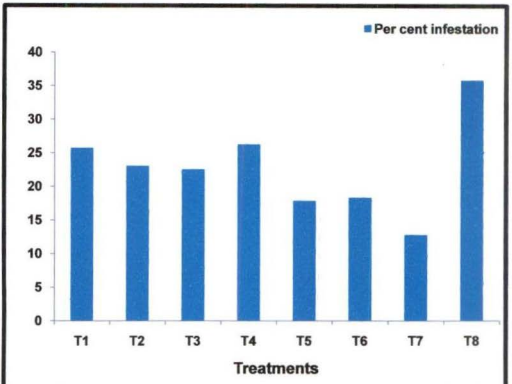


Fig. 4 Cumulative mean per cent fruit infestation due to *L. orbonalis* after six pickings on weight basis

T_1 -	Neemastra	3%
T_2 -	Bramhastra	3%
T_3 -	Agniastra	3%
T_4 -	Jivamrut	3%
T_5 -	Neem oil	4%
T_6 -	NSKE	5%
T_7 -	Cypermethrin 25 EC	0.003%
T_8 -	Control (water spray)	

0.3% (T_3) which recorded 17.65, 20.40 and 23.02% infestation, respectively. All those treatments were significantly superior over control.

The next effective organic treatments were of agniastra (T_3) 3% and bramhastra (T_2) 3% which were on par with each other recording 22.55 and 23.20 per cent fruit infestation. These were followed by neemastra (T_1) 3% and jivamrut (T_4) 3% which were also found at par with each other by registering 25.73 and 26.27 per cent fruit infestation as compared to control (water spray) recording highest per cent infestation of 35.83 .

These results are comparable with the findings of Murugesan and Murugesh (2009). They had evaluated ten plant products like *Azadirachta indica* leaf extract @ 5%, *Calotropis gigantea* leaf extract @ 5%, *Lantana camera* leaf extract @ 5%, neem cake extract @ 5%, neem oil @ 2%, Nimbicidine @ 2 ml/l, *Pongamia glabra* leaf extract @ 5%, *Prosopis juliflora* leaf extract @ 5%, *Vitex negundo* leaf extract @ 5% and garlic (*Allium sativum*) extract @ 5% against *Leucinodes orbonalis* and found that, botanicals are moderate in their efficacy in reducing the fruit borer damage in brinjal.

4. 3 Observations and interpretation of data on sucking pests

The treatments were initiated immediately at the start of infestation (i.e. 30 DAT). Four applications of treatments were given during the period of experimentation at 15 days interval. The observations on sucking pests were recorded on 7 and 14 days after each treatment application.

The data thus generated were subjected to statistical analysis. The inferences drawn are discussed in the light of available literature reported by different research workers as under.

4.3.1 Cumulative effect of different organic treatments on mean per cent reduction of aphids after four sprayings

The data presented in table 5 and depicted in fig. 5 indicated that, all the treatments were significantly superior over control (T_8: water spray) in recording per cent reduction of aphids. The cumulative mean per cent reduction of aphids after four sprayings were varied from 78.62 per cent which was observed in cypermethrin 25 EC @ 0.003% treated plot to 13.06 per cent in control plot.

The observations on per cent reduction of aphid population exhibited that, the treatment cypermethrin 25 EC (T_7) @ 0.003% recorded maximum 78.62 per cent reduction of aphid population. Our present findings are in confirmation with the reports of Kalawate and Dethe (2006) who had conducted experiment on bioefficacy of spinosad (56.25, 72 and 90 g a.i. per ha) and emamectin benzoate (5, 6.25 and 12.5 g a.i. per ha) in comparison to cypermethrin (50 g a.i. per ha) and self-formulated neem seed extract (5%) in brinjal ecosystem. From the study it was found that, cypermethrin was most effective to control aphids population but not significantly differ than that noticed in spinosad and emamectin benzoate.

Amongst the different organic products neem oil (T_5) 4% and NSKE (T_6) 5% registered significantly higher reduction of population and were on par with each other by recording 68.06 and 66.87 per cent population reduction. These results are in confirmation with the findings of Raza et al. (2014) who carried out experiment at the farmer's field to evaluate the efficacy of botanical pesticides in comparison to synthetic insecticide against major sucking insect pests on brinjal. The overall results of 4 sprays showed that, population reduction by neem oil was 66.51% followed by neem kernel powder 61.49%.

The next effective organic treatments were of bramhastra (T_2) 3% and agniastra (T_3) 3% which were at par with each other registering 57.08 and 55.55 per cent population reduction. These were followed by neemastra (T_1) 3% and jivamrut (T_4) 3% which were at par with each

Table 5: Cumulative effect of different organic treatments on mean per cent reduction of aphids at different intervals after four sprayings

Tr. No.	Treatments	Conc.	First spraying		Second spraying		Third spraying		Fourth spraying		Cumulative mean
			7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	
T_1	Neemastra	3%	53.30 (46.90)	45.51 (42.42)	51.82 (46.04)	47.18 (43.39)	51.60 (45.92)	42.99 (42.13)	48.50 (44.14)	49.68 (43.09)	48.83 (44.32)
T_2	Bramhastra	3%	60.22 (50.93)	56.66 (48.83)	58.13 (49.68)	54.57 (47.62)	57.81 (49.50)	55.16 (47.96)	55.83 (48.35)	58.25 (48.60)	57.08 (49.07)
T_3	Agniastra	3%	59.49 (50.55)	53.16 (46.81)	56.33 (48.64)	52.90 (46.66)	56.50 (48.73)	54.05 (47.32)	54.43 (47.54)	57.56 (48.23)	55.55 (48.19)
T_4	Jivamrut	3%	52.58 (46.49)	44.30 (41.72)	49.39 (44.65)	45.89 (42.64)	50.03 (45.02)	41.66 (41.36)	47.46 (43.54)	48.31 (42.30)	47.44 (43.53)
T_5	Neem oil	4%	70.91 (57.41)	68.25 (55.70)	68.64 (55.94)	67.00 (54.94)	70.42 (57.06)	63.10 (53.79)	67.49 (55.24)	68.64 (57.74)	68.06 (55.60)
T_6	NSKE	5%	68.57 (55.90)	66.41 (54.58)	67.84 (55.45)	66.70 (54.76)	68.45 (55.83)	62.27 (52.79)	67.08 (54.99)	67.63 (54.20)	66.87 (54.87)
T_7	Cypermethrin 25 EC	0.003%	80.19 (63.74)	78.11 (62.10)	78.34 (62.27)	77.45 (61.65)	80.62 (63.89)	76.68 (62.10)	78.68 (62.50)	78.85 (61.37)	78.62 (62.46)
T_8	Control (water spray)	-	16.92 (24.26)	16.40 (23.89)	11.70 (20.00)	10.20 (18.63)	10.93 (19.30)	10.40 (18.82)	15.69 (23.34)	12.19 (20.44)	13.06 (21.09)
	'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE (m) ±		1.947	2.050	2.022	2.204	2.147	1.921	1.972	2.039	0.336
	CD at 5%		5.906	6.217	6.131	6.686	6.512	5.829	5.982	6.185	1.00

(Figures in parentheses are corresponding values of arc sin transformation)

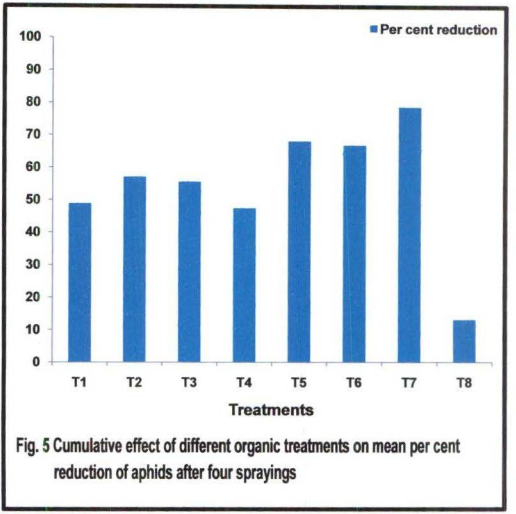


Fig. 5 Cumulative effect of different organic treatments on mean per cent reduction of aphids after four sprayings

T_1 -	Neemastra	3%
T_2 -	Bramhastra	3%
T_3 -	Agniastra	3%
T_4 -	Jivamrut	3%
T_5 -	Neem oil	4%
T_6 -	NSKE	5%
T_7 -	Cypermethrin 25 EC	0.003%
T_8 -	Control (water spray)	

Plate 10: Infestation of aphids on brinjal leaf

other recording 48.83 and 47.44 per cent population reduction as compared to control (water spray) in which lowest (13.06) per cent population reduction.

These results are in confirmation with the findings of Varma et al. (2010) who conducted experiment on efficacy of some indigenous plant products for management of the aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) infesting brinjal. The results revealed that, NSKE recorded 51.92 and 54.07 per cent reduction of population of aphids in the two experiments followed by Chilli + Garlic with 47.11 and 48.77 per cent reduction and in treatment of Calotropis 45.24 and 46.38 per cent reduction was reported and were at par with other.

4.3.2 Cumulative effect of different organic treatments on mean per cent reduction of jassids after four sprayings

The data presented in table 6 and depicted in fig. 6 indicated that, all the treatments were found significantly better over control (T_8: water spray) in recording per cent reduction of jassids. The cumulative mean per cent reduction of jassids after four sprayings was ranging from 77.94 per cent in cypermethrin 25 EC @ 0.003% treated plot to 13.30 per cent in control plot.

The data analysed after the completion of four sprays, indicated that, per cent reduction of jassid population was significantly highest in cypermethrin 25 EC (T_7) @ 0.003% and recorded 77.94 per cent population reduction. These results are in confirmation with the findings of Kalawate and Dethe (2006) who conducted studies on bioefficacy of spinosad (56.25, 72 and 90 g a.i. per ha) and emamectin benzoate (5, 6.25 and 12.5 g a.i. per ha) in comparison to cypermethrin (50 g a.i. per ha) and self-formulated neem seed extract (5%) in brinjal ecosystem. From the study it was found that, cypermethrin was most effective to control jassid population but not significantly differ than that noticed in spinosad and emamectin benzoate.

Amongst the different organic products, neem oil (T_5) 4% and NSKE (T_6) 5% recorded significantly higher reduction of population of

Table 6: Cumulative effect of different organic treatments on mean per cent reduction of jassids at different intervals after four sprayings

Tr. No.	Treatments	Conc.	First spraying		Second spraying		Third spraying		Fourth spraying		Cumulative mean
			7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	
T_1	Neemastra	3%	47.92 (43.81)	45.16 (42.22)	47.60 (43.62)	44.86 (42.05)	49.37 (44.65)	46.55 (43.02)	48.06 (43.89)	46.48 (42.98)	47.00 (43.28)
T_2	Bramhastra	3%	55.95 (48.42)	53.11 (46.78)	55.87 (48.37)	53.03 (46.74)	59.40 (50.42)	55.39 (48.09)	56.54 (48.76)	53.97 (42.27)	55.41 (48.11)
T_3	Agniastra	3%	54.81 (47.76)	51.99 (46.14)	54.64 (47.66)	51.65 (45.94)	58.51 (49.90)	54.62 (47.65)	55.44 (48.12)	52.77 (46.59)	54.30 (47.47)
T_4	Jivamrut	3%	46.79 (43.16)	44.30 (41.73)	46.89 (43.22)	43.28 (41.14)	48.66 (44.23)	45.43 (42.38)	47.31 (43.46)	45.32 (42.32)	46.00 (42.71)
T_5	Neem oil	4%	66.26 (54.49)	63.91 (53.08)	65.25 (53.88)	64.75 (53.58)	66.75 (54.78)	64.38 (53.36)	64.90 (53.67)	63.41 (52.78)	64.95 (53.70)
T_6	NSKE	5%	64.97 (53.72)	62.73 (52.38)	64.97 (53.71)	63.56 (52.87)	65.57 (54.07)	63.29 (52.71)	64.10 (53.19)	62.54 (52.26)	63.97 (53.11)
T_7	Cypermethrin 25 EC	0.003%	78.30 (62.24)	75.67 (60.44)	82.35 (65.16)	78.68 (62.50)	78.65 (62.48)	77.99 (62.02)	75.75 (60.50)	76.11 (60.74)	77.94 (62.01)
T_8	Control (water spray)	-	16.31 (23.82)	17.24 (24.54)	14.11 (22.07)	15.04 (22.82)	11.31 (19.66)	10.25 (18.67)	10.11 (18.54)	12.03 (20.29)	13.30 (21.30)
	'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE (m) ±		2.088	1.971	2.179	2.061	2.010	1.939	2.184	2.037	0.410
	CD at 5%		6.332	5.979	6.611	6.252	6.096	5.881	6.626	6.179	1.163

(Figures in parentheses are corresponding values of arc sin transformation)

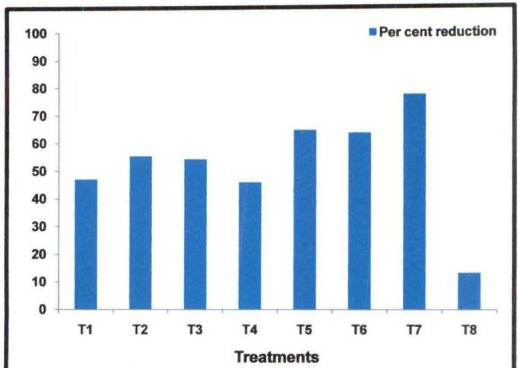


Fig. 6 Cumulative effect of different organic treatments on mean per cent reduction of jassids after four sprayings

T_1 -	Neemastra	3%
T_2 -	Bramhastra	3%
T_3 -	Agniastra	3%
T_4 -	Jivamrut	3%
T_5 -	Neem oil	4%
T_6 -	NSKE	5%
T_7 -	Cypermethrin 25 EC	0.003%
T_8 -	Control (water spray)	

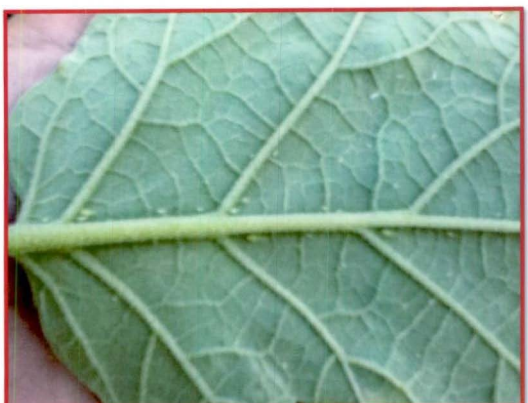


Plate 11: Infestation jassids on brinjal leaf

jassids and found on par with each other by expressing 64.95 and 63.97 per cent population reduction. These results are in confirmation with the findings of Raza et al. (2014) who carried out experiment at the farmer's field to evaluate the efficacy of botanical pesticides in comparison to synthetic insecticide against major sucking pests of brinjal. The overall results of 4 sprays showed that, population reduction of jassid due to neem oil was 61.54% followed by neem kernel powder 59.79% reduction.

The next promising organic treatments were of bramhastra (T_2) 3% and agniastra (T_3) 3% which were at par with each other and recorded 55.41 and 54.30 per cent population reduction. These were followed by the treatments of neemastra (T_1) 3% and jivamrut (T_4) 3% which were at par with each other registering 47.00 and 46.00 per cent population reduction as compared to control (water spray) in which lowest 13.30 per cent population reduction was observed.

In support of the results obtained regarding these organic products viz., neemastra, bramhastra, agniastra and jivamrut literature or references are not available and so could not be compared or discussed as these treatment combinations are new and used by the farmers on large scale locally and they are experimentally tested for first time in the present study.

4.3.3 Cumulative effect of different organic treatments on mean per cent reduction of whiteflies after four sprayings

The data presented in table 7 and depicted in fig. 7 indicated that, all the treatments were significantly superior over control (T_8: water spray) in recording per cent reduction of whiteflies. The cumulative mean per cent reduction of whiteflies after four sprayings were varied from 79.86 per cent in cypermethrin 25 EC @ 0.003% treated plot to 13.04 per cent in control plot.

After completion of four sprays and on the basis of cumulative mean it was found that, per cent reduction of whitefly population was significantly highest in cypermethrin 25 EC (T_7) @ 0.003% and

Table 7: Cumulative effect of different organic treatments on mean per cent reduction of whiteflies at different intervals after four sprayings

Tr. No.	Treatments	Conc.	First spraying		Second spraying		Third spraying		Fourth spraying		Cumulative mean
			7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	
T_1	Neemastra	3%	48.53 (44.16)	45.74 (42.56)	48.21 (43.98)	45.44 (42.38)	50.02 (45.01)	47.15 (43.36)	48.71 (44.26)	47.79 (43.73)	47.70 (43.68)
T_2	Bramhastra	3%	56.34 (48.64)	54.03 (47.31)	56.25 (48.59)	53.94 (47.26)	59.81 (50.66)	57.36 (49.23)	56.92 (48.98)	57.59 (49.37)	56.53 (48..75)
T_3	Agniastra	3%	55.18 (47.97)	52.84 (46.63)	54.95 (47.84)	52.39 (46.37)	58.70 (50.01)	56.18 (48.55)	55.64 (48.24)	56.34 (48.64)	55.28 (48.03)
T_4	Jivamrut	3%	47.51 (43.57)	44.32 (41.74)	47.12 (43.35)	47.34 (43.48)	48.89 (44.36)	46.18 (42.81)	47.53 (43.58)	46.49 (42.99)	46.92 (43.23)
T_5	Neem oil	4%	68.95 (56.14)	66.94 (54.90)	67.70 (55.36)	67.73 (55.38)	69.46 (56.45)	67.44 (55.21)	67.33 (55.14)	65.87 (54.25)	67.68 (55.35)
T_6	NSKE	5%	67.73 (55.39)	65.64 (54.11)	66.46 (54.61)	66.53 (54.65)	67.93 (55.51)	66.10 (54.39)	66.34 (54.55)	64.45 (53.40)	66.40 (54.57)
T_7	Cypermethrin 25 EC	0.003%	78.84 (62.61)	77.98 (62.01)	83.07 (65.71)	80.06 (63.48)	82.33 (65.15)	79.36 (62.98)	80.35 (63.69)	77.44 (61.64)	79.86 (63.41)
T_8	Control (water spray)	-	16.72 (24.13)	16.16 (23.71)	12.50 (20.71)	14.96 (22.75)	11.73 (20.03)	11.17 (19.53)	10.49 (18.90)	10.95 (19.32)	13.04 (21.13)
	'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE (m) ±		2.067	2.047	2.238	2.263	1.944	1.925	2.023	2.013	0.385
	CD at 5%		6.269	6.208	6.789	6.865	5.896	5.838	6.136	6.105	1.092

(Figures in parentheses are corresponding values of arcsine transformations)

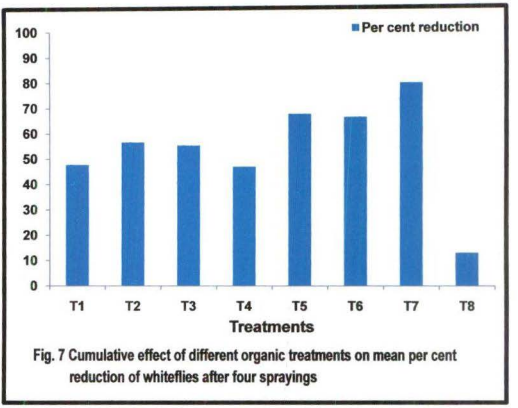


Fig. 7 Cumulative effect of different organic treatments on mean per cent reduction of whiteflies after four sprayings

T_1 -	Neemastra	3%
T_2 -	Bramhastra	3%
T_3 -	Agniastra	3%
T_4 -	Jivamrut	3%
T_5 -	Neem oil	4%
T_6 -	NSKE	5%
T_7 -	Cypermethrin 25 EC	0.003%
T_8 -	Control (water spray)	

Plate 12: Infestation of whiteflies on brinjal leaf

recorded 79.86 per cent population reduction. These results are in confirmation with the findings of Ramteke (1987) who studied insecticidal control of some important pests of brinjal and revealed that, among the different treatments cypermethrin 10 EC @ 0.007% recorded 85.53 per cent population reduction of whiteflies.

Amongst the different organic products neem oil (T_5) 4% and NSKE (T_6) 5% recorded significantly higher reduction of population and were noticed to be at par with each other recording 67.68 and 66.40 per cent population reduction. These results are in confirmation with the findings of Raza et al. (2014) who carried out experiment at the farmer's field to evaluate the efficacy of botanical pesticides in comparison to synthetic insecticide against major sucking insect pests of brinjal. The overall results of 4 sprays showed that, whitefly population was reduced by neem oil to the extent of 61.04% followed by neem kernel powder 57.99% reduction in population of whiteflies.

The next promising organic treatments were of bramhastra (T_2) 3% and agniastra (T_3) 3% which were found at par with each other and recorded 56.53 and 55.28 per cent population reduction. These were followed by neemastra (T_1) 3% and jivamrut (T_4) 3% which were also at par with each other and recorded 47.70 and 46.92 per cent population reduction as compared to control (water spray) in which lowest 13.30 per cent population reduction was observed.

In support of the results obtained regarding these organic products viz., neemastra, bramhastra, agniastra and jivamrut literature or references are not available and so could not be compared or discussed as these treatment combinations are new and locally used by the farmers on large scale and they are experimentally tested for first time in the present study.

4.4 Observations and interpretation of data on natural enemies

During the present study to assess the effect of organic products on natural enemies in brinjal ecosystem the bioagents coccinellids, *Chrysopa* and spiders were recorded on 7 and 14 days after each

treatment application. The results obtained from the experiment are presented here under.

4.4.1 Effect of different organic products on mean population of Coccinellids per plant in brinjal ecosystem

The data presented in table 8 and Fig. 8 showed that, maximum mean population of coccinellids (3.04/plant) was found in natural control and lowest i.e. 0.92/plant in cypermethrin 25 EC @ 0.003% treated plot signifying least preference to chemical insecticide.

Amongst the different organic products jivamrut (T_4) 3% recorded higher number of coccinellids (2.47/plant) followed by neemastra (T_1) 3% (2.39/plant), agniastra (T_3) 3% (2.20/plant), bramhastra (T_2) 3% (2.13/plant), NSKE (T_6) 5% (2.04/plant) and neem oil (T_5) 4% (1.95/plant).

These results are in confirmation with the findings of Guddewar et al. (1994) who reported that, the ether extracts of neem seed kernel was safer than synthetic insecticides to *C. septumpunctata*. The order of safety was neem seed kernel extract, endosulfan, quinalphos malathion and monocrotophos.

Mollah et al. (2009) showed toxic effect of some insecticides on predatory lady bird beetles (coleoptera: coccinellidae) in country bean (Lablab purpureus l.) field. The study was carried out in the Entomology Research field at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during 2009. Among the insecticides, fenvalerate 5 EC @ 1.0 ml/l water, cypermethrin 10 EC @ 1.0 ml/l water and deltamethrin 2.5 EC @ 1.0 ml/l water found highly toxic to lady bird beetle resulting 33.78, 31.76 and 28.42% mortality respectively. Whereas, neem oil (fresh) @ 2.5 ml/l water, Neem oil (stored) @ 2.5 ml/l water and emamectin benzoate 5 SG @ 1.0 gram per liter water were found to be least toxic to lady bird beetles confirming 9.37, 17.45 and 19.04% mortality, respectively.

Table 8: Effect of different organic products on mean population of Coccinellids per plant in brinjal ecosystem

Tr. No.	Treatments	Conc.	First spraying		Second spraying		Third spraying		Fourth spraying		Cumulative mean
			7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	
T_1	Neemastra	3%	2.17 (1.47)	2.45 (1.56)	2.34 (1.35)	2.55 (1.60)	2.28 (1.51)	2.53 (1.59)	2.27 (1.51)	2.56 (1.60)	2.39 (1.55)
T_2	Bramhastra	3%	1.95 (1.39)	2.19 (1.48)	1.94 (1.39)	2.19 (1.48)	2.06 (1.43)	2.33 (1.53)	2.10 (1.45)	2.31 (1.52)	2.13 (1.46)
T_3	Agniastra	3%	2.03 (1.42)	2.24 (1.50)	2.02 (1.42)	2.28 (1.51)	2.06 (1.44)	2.38 (1.54)	2.17 (1.47)	2.40 (1.55)	2.20 (1.48)
T_4	Jivamrut	3%	2.08 (1.51)	2.49 (1.58)	2.45 (1.57)	2.64 (1.63)	2.39 (1.55)	2.62 (1.62)	2.28 (1.51)	2.59 (1.61)	2.47 (1.57)
T_5	Neem oil	4%	1.83 (1.35)	2.06 (1.43)	1.79 (1.34)	2.04 (1.43)	1.84 (1.36)	2.16 (1.47)	1.78 (1.34)	2.41 (1.46)	1.95 (1.40)
T_6	NSKE	5%	1.88 (1.37)	2.10 (1.45)	1.92 (1.39)	2.14 (1.46)	1.92 (1.39)	2.23 (1.49)	1.89 (1.38)	2.21 (1.49)	2.04 (1.43)
T_7	Cypermethrin 25 EC	0.003%	0.85 (0.92)	0.95 (0.98)	0.89 (0.94)	1.00 (1.00)	0.88 (0.94)	0.99 (1.00)	0.86 (0.93)	0.97 (0.99)	0.92 (0.96)
T_8	Control (water spray)	-	2.91 (1.71)	3.21 (1.79)	2.87 (1.69)	3.16 (1.78)	2.91 (1.71)	3.21 (1.79)	2.87 (1.69)	3.15 (1.78)	3.04 (1.74)
	'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE (m) ±		0.046	0.062	0.038	0.042	0.047	0.046	0.071	0.050	0.006
	CD at 5%		0.140	0.187	0.114	0.129	0.143	0.140	0.217	0.151	0.017

(Figures in parentheses are corresponding values of square root transformations)

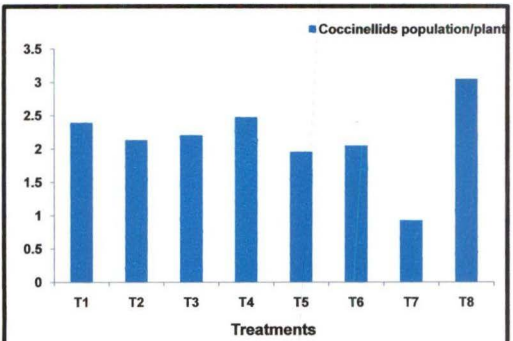


Fig. 8 Effect of different organic products on mean population of Coccinellids per plant in brinjal ecosystem

T_1 -	Neemastra	3%
T_2 -	Bramhastra	3%
T_3 -	Agniastra	3%
T_4 -	Jivamrut	3%
T_5 -	Neem oil	4%
T_6 -	NSKE	5%
T_7 -	Cypermethrin 25 EC	0.003%
T_8 -	Control (water spray)	

Kaethner (1999) reported that, neem seed extract and neem oil were harmless to the eggs and larvae of *Coccinella septumpunctata*.

Chakraborti (2000) reported that, neem based treatments like spraying of neem oil and NSKE were found safer to natural enemies and were on par with untreated check in brinjal ecosystem.

4.4.2 Effect of different organic products on mean population of Spiders per plant in brinjal ecosystem

The data presented in table 9 and Fig. 9 revealed that, maximum mean population of spiders (2.33/plant) was found in control and lowest i.e. 0.68/plant in cypermethrin 25 EC @ 0.003% treated plot signifying least preference to chemical insecticide.

Amongst the different organic products jivamrut (T_4) 3% recorded higher number of spiders (1.80/plant) followed by neemastra (T_1) 3% (1.74/plant), agniastra (T_3) 3% (1.62/plant), bramhastra (T_2) 3% (1.56/plant), NSKE (T_6) 5% (1.44/plant) and neem oil (T_5) 4% (1.35/plant) as compared to cypermethrin 25 EC (T_7).

These results are in confirmation with the findings of Rosaih (2001b) who reported that, among the predatory population in okra ecosystem, spiders, chrysopids, *Apanteles* sp and coccinellids were most predominant and there was no significant difference in the population of these predators in different plant products. This clearly indicated increased activity of natural enemies in plots treated with botanical insecticides.

Chakraborti (2000) reported that, neem based treatments like spraying of neem oil and NSKE were safer to natural enemies and were on par with untreated check in brinjal ecosystem.

Rosaih (2001a) observed that, population of spiders in all botanicals treatments were almost equal to untreated control (1.87 spiders/plant) as compared to monocrotophos (0.41 spiders/plants). These results reveal the safety of botanicals to natural enemies as compared to synthetic insecticides after 10 days of spray in brinjal.

Table 9: Effect of different organic products on mean population of Spiders per plant in brinjal ecosystem

Tr. No.	Treatments	Conc.	First spraying		Second spraying		Third spraying		Fourth spraying		Cumulative mean
			7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	
T_1	Neemastra	3%	1.63 (1.28)	1.78 (1.33)	1.68 (1.30)	1.88 (1.37)	1.71 (1.31)	1.83 (1.35)	1.67 (1.29)	1.76 (1.33)	1.74 (1.32)
T_2	Bramhastra	3%	1.47 (1.21)	1.60 (1.27)	1.51 (1.23)	1.68 (1.30)	1.51 (1.23)	1.60 (1.27)	1.47 (1.21)	1.62 (1.27)	1.56 (1.25)
T_3	Agniastra	3%	1.53 (1.24)	1.66 (1.29)	1.55 (1.24)	1.75 (1.32)	1.60 (1.27)	1.68 (1.30)	1.54 (1.24)	1.66 (1.29)	1.62 (1.27)
T_4	Jivamrut	3%	1.69 (1.20)	1.82 (1.35)	1.72 (1.31)	1.96 (1.40)	1.77 (1.33)	1.91 (1.38)	1.73 (1.31)	1.82 (1.35)	1.80 (1.34)
T_5	Neem oil	4%	1.28 (1.13)	1.38 (1.17)	1.27 (1.13)	1.44 (1.20)	1.35 (1.16)	1.37 (1.17)	1.33 (1.15)	1.43 (1.20)	1.35 (1.16)
T_6	NSKE	5%	1.35 (1.16)	1.47 (1.21)	1.38 (1.17)	1.55 (1.25)	1.43 (1.20)	1.47 (1.27)	1.38 (1.17)	1.48 (1.22)	1.44 (1.20)
T_7	Cypermethrin 25 EC	0.003%	0.61 (0.78)	0.70 (0.84)	0.64 (0.80)	0.74 (0.86)	0.64 (0.80)	0.73 (0.85)	0.62 (0.79)	0.71 (0.84)	0.68 (0.82)
T_8	Control (water spray)	-	2.13 (1.46)	2.45 (1.56)	2.15 (1.47)	2.51 (1.58)	2.22 (1.49)	2.45 (1.57)	2.28 (1.51)	2.41 (1.55)	2.33 (1.52)
	'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE (m) ±		0.074	0.042	0.040	0.043	0.047	0.093	0.043	0.064	0.004
	CD at 5%		0.224	0.126	0.122	0.130	0.144	0.281	0.130	0.195	0.011

(Figures in parentheses are corresponding values of square root transformations)

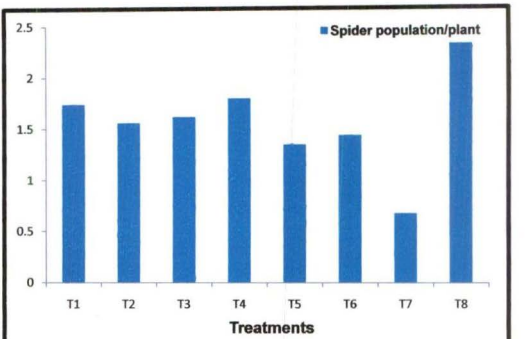


Fig. 9 Effect of different organic products on mean population of Spiders per plant in brinjal ecosystem

T_1 -	Neemastra	3%
T_2 -	Bramhastra	3%
T_3 -	Agniastra	3%
T_4 -	Jivamrut	3%
T_5 -	Neem oil	4%
T_6 -	NSKE	5%
T_7 -	Cypermethrin 25 EC	0.003%
T_8 -	Control (water spray)	

Thulasiram et al. reported the effect of bifenthrien 8 SC on the population of spiders in okra ecosystem which was evaluated with the help of two supervised field experiments conducted during *Kharif* 2012 and *Rabi* 2013 at Eastern farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Pondicherry. The results showed that, the overall mean population of spiders was higher in the untreated check (4.62/plant) while cypermethrin 10 EC @ 70 g a.i. per ha recorded 1.02 and 0.92/plant population of spiders in *Kharif* and *Rabi*.

4.4.3 Effect of different organic products on mean population of *Chrysopa* per plant in brinjal ecosystem

The data presented in table 10 and Fig. 10 revealed that, maximum mean population of *Chrysopa* i.e. 2.33/plant was found in natural control and lowest i.e. 0.68/plant in cypermethrin 25 EC @ 0.003% treated plot signifying least preference to chemical insecticide.

Amongst the different organic products jivamrut (T_4) 3% recorded more number of *Chrysopa* (1.38/plant) followed by neemastra (T_1) 3% (1.32/plant), agniastra (T_3) 3% (1.21/plant), bramhastra (T_2) 3% (1.17/plant), NSKE (T_2) 5% (1.06/plant) and neem oil (T_2) 4% (1.02/plant) as compared to cypermethrin 25 EC (T_7) @ 0.003%.

These results are in confirmation with the findings of Kaethner (1999) who reported that, neem seed extract and neem oil were harmless to the eggs and larvae of *Chrysoperla carnea*.

Rosaih (2001b) reported that, among the predatory population in okra ecosystem, spiders, chrysopids, *Apanteles* spp. and coccinellids were most predominant and there was no significant difference in the population of these predators in different plant products. This clearly indicated increased activity of natural enemies in plots treated with botanical insecticides.

Table 10: Effect of different organic products on mean population of *Chrysopa* per plant in brinjal ecosystem

Tr. No.	Treatments	Conc.	First spraying		Second spraying		Third spraying		Fourth spraying		Cumulative mean
			7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	
T_1	Neemastra	3%	1.25 (1.12)	1.35 (1.16)	1.24 (1.11)	1.44 (1.20)	1.29 (1.13)	1.39 (1.18)	1.24 (1.11)	1.41 (1.19)	1.32 (1.15)
T_2	Bramhastra	3%	1.10 (1.05)	1.21 (1.10)	1.12 (1.06)	1.21 (1.10)	1.13 (1.06)	1.28 (1.13)	1.07 (1.04)	1.22 (1.11)	1.17 (1.08)
T_3	Agniastra	3%	1.13 (1.06)	1.24 (1.12)	1.14 (1.07)	1.24 (1.11)	1.17 (1.08)	1.31 (1.14)	1.12 (1.06)	1.30 (1.14)	1.21 (1.10)
T_4	Jivamrut	3%	1.29 (1.14)	1.41 (1.19)	1.29 (1.14)	1.49 (1.22)	1.32 (1.15)	1.46 (1.21)	1.35 (1.16)	1.47 (1.21)	1.38 (1.18)
T_5	Neem oil	4%	0.94 (0.97)	1.06 (1.03)	0.97 (0.99)	1.04 (1.02)	1.02 (1.01)	1.07 (1.03)	0.95 (0.98)	1.11 (1.06)	1.02 (1.01)
T_6	NSKE	5%	0.99 (0.99)	1.09 (1.05)	1.00 (1.00)	1.08 (1.04)	1.05 (1.02)	1.14 (1.07)	0.99 (0.99)	1.14 (1.07)	1.06 (1.03)
T_7	Cypermethrin 25 EC	0.003%	0.44 (0.66)	0.55 (0.74)	0.46 (0.68)	0.58 (0.76)	0.46 (0.68)	0.58 (0.76)	0.45 (0.67)	0.56 (0.75)	0.51 (0.71)
T_8	Control (water spray)	-	1.68 (1.30)	1.88 (1.37)	1.67 (1.29)	1.92 (1.39)	1.71 (1.31)	1.89 (1.37)	1.76 (1.33)	1.87 (1.37)	1.80 (1.34)
	'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE (m) ±		0.035	0.036	0.038	0.037	0.036	0.040	0.047	0.046	0.004
	CD at 5%		0.106	0.110	0.116	0.111	0.110	0.122	0.141	0.140	0.011

(Figures in parentheses are corresponding values of square root transformations)

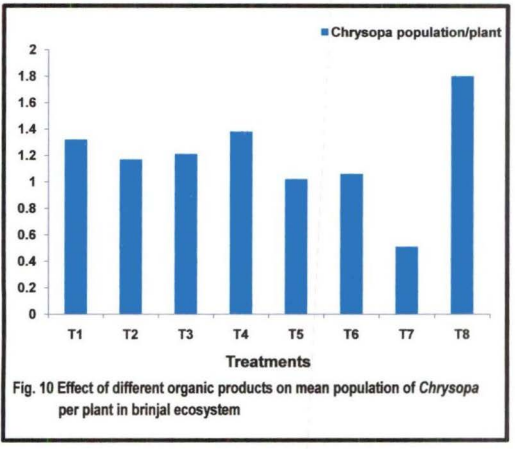


Fig. 10 Effect of different organic products on mean population of *Chrysopa* per plant in brinjal ecosystem

T_1 -	Neemastra	3%
T_2 -	Bramhastra	3%
T_3 -	Agniastra	3%
T_4 -	Jivamrut	3%
T_5 -	Neem oil	4%
T_6 -	NSKE	5%
T_7 -	Cypermethrin 25 EC	0.003%
T_8 -	Control (water spray)	

4.5 Average yield of brinjal fruits

The data presented in table 11 and Fig. 11 revealed that, all the treated plots have recorded significantly more yield of brinjal fruits as compared to control plot (110 q/ha).

In respect of yield, the treatment cypermethrin 25 EC (T_7) @ 0.003% recorded maximum yield of marketable fruits 129.69 q/ha with 98.00 per cent increased yield over control. These results are in confirmation with the yield observation reported by Budhvat (2011) who reported that, cypermethrin 25 EC @ 0.0075% recorded 236.44 q/ha yield with 104.09 per cent yield increase over control.

Amongst the different organic products neem oil (T_5) 4% and NSKE (T_6) 5% recorded significantly higher yield of marketable fruits and were on par with each other and recorded 115.64 and 112.27 q/ha with 76.55 and 71.40 per cent increased yield over control. The next promising organic treatments were of agniastra (T_3) 3% and bramhastra (T_2) 3% which were on par with each other and recorded 97.40 and 94.06 q/ha yield of marketable fruits with 48.70 and 43.60 per cent increased yield over control. These were followed by neemastra (T_1) 3% and jivamrut (T_4) 3% which recorded yield of marketable fruits accounting to 84.10 and 78.27 q/ha with 28.40 and 19.50 per cent increased yield over control. The control plot (water spray) recorded 65.50 q/ha yield i.e. lowest yield of marketable fruits.

These results are in confirmation with the findings of Raja et al. (1998) who conducted studies on the effect of neem products on brinjal shoot and fruit borer *L. orbonalis*. Among the different neem products, neem oil 4% recorded less fruit damage (9.07%) and higher yield (24.48 t/ha), NSKE 5% was on par with it.

Magar (2011) studied on management of *L. orbonalis* through neem products and found that, neem oil @ 5% and neem oil @ 2% recorded 216.88 and 197.60 q/ha with 96.00 and 78.82 per cent increase yield over control.

Table 11: Effect of different organic products on yield of brinjal fruits

Tr. No.	Treatments	Conc.	Marketable Fruit Yield q/ha.	Per cent increase over control	Infested fruit yield q/ha.	Per cent decrease over control	Gross yield q/ha.
T_1	Neemastra	3%	84.10	28.40	36.09	18.68	120.33
T_2	Bramhastra	3%	94.06	43.60	35.08	20.96	129.29
T_3	Agniastra	3%	97.40	48.70	33.68	24.11	131.23
T_4	Jivamrut	3%	78.27	19.50	39.45	11.11	117.85
T_5	Neem oil	4%	115.64	76.55	27.93	37.07	143.73
T_6	NSKE	5%	112.27	71.40	29.21	34.18	141.64
T_7	Cypermethrin 25 EC	0.003%	129.69	98.00	23.78	53.58	153.64
T_8	Control (water spray)	-	65.50		44.38	-	110.00
	'F' test		Sig.	-	Sig.	-	Sig.
	SE (m) ±		1.285	-	0.954	-	1.281
	CD at 5%		3.897	-	2.895	-	3.887

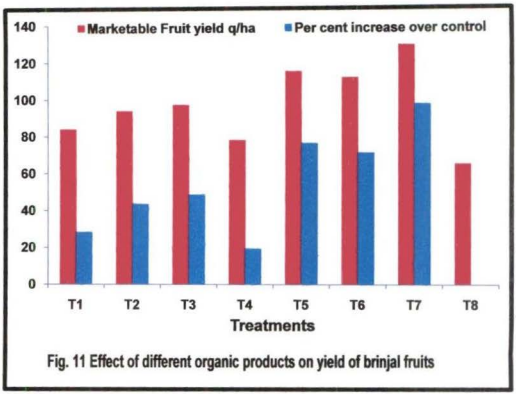


Fig. 11 Effect of different organic products on yield of brinjal fruits

T_1 -	Neemastra	3%
T_2 -	Bramhastra	3%
T_3 -	Agniastra	3%
T_4 -	Jivamrut	3%
T_5 -	Neem oil	4%
T_6 -	NSKE	5%
T_7 -	Cypermethrin 25 EC	0.003%
T_8 -	Control (water spray)	

4.5.1 Gross yield

Based on the gross yield the data presented in Table 11 exhibited that, the treatment cypermethrin 25 EC (T_7) @ 0.003% recorded (153.64 q/ha) highest gross yield. These results are in confirmation with the findings of Budhvat (2011) who conducted studies on the biorational management of *L. orbonalis* Guen. on brinjal and found that, cypermethrin 25 EC @ 0.0075% recorded 266 q/ha gross yield.

Amongst different organic products neem oil (T_5) 4% and NSKE (T_6) 5% recorded more gross yield of 143.73 and 141.64 q/ha and were statistically at par with each other. The next effective treatments were of agniastra (T_3) 3% and bramhastra (T_2) 3% which were recorded gross yield of 131.23 and 129.29 q/ha and were statistically at par with each other. These were followed by the treatments of neemastra (T_1) 3% and jivamrut (T_4) 3% which recorded gross yield of 120.33 and 117.85 q/ha and were statistically at par with each other. However, control plot (T_8) recorded (110 q/ha) lowest gross yield of brinjal fruits.

These results are in confirmation with the findings of Sangappa (1999) who conducted an experiment to test the ecofriendly organic treatments against brinjal shoot and fruit borer *L. orbonalis*. NSKE 5% recorded less fruit damage of 21.06 per cent and highest yield (141.53 q/ha) among the ecofriendly treatments.

Mallapur (2005) evaluated indigenous materials like nimbicidine 5 ml/l, GCK (garlic chilli kerosene extract) 0.5%, nimbicidine 2.5 ml/l, GCK alone (0.5 and 1.0%), turmeric + cow urine 25%, parthenium extract 17% and cow urine 17% for the management of chilli pests. Among the different treatments, GCK 5% + nimbicidine 2.5 ml/l recorded less percentage of fruit damage due to fruit borer, *H. armigera* and highest yield (11.3 q/ha).

4.5.2 Incremental cost benefit ratio (ICBR) for different treatments

The data presented in Table 12 and depicted in Fig 12 with parameters increased yield over control (q/ha) revealed that, the treatment cypermethrin 25 EC (T_7) @ 0.003% has expressed maximum ICBR to the extent of 38.92 followed by NSKE 5% (6.26). These results are in confirmation with the findings of Budhvat (2011) who conducted studies on the biorational management of *L. orbonalis* Guen. on brinjal and found that, amongst different treatments maximum ICBR (43.02) recorded from cypermethrin 25 EC @ 0.0075% treated plot, whereas ICBR recorded from NSE @ 5% was 15.99.

These treatments were followed by the treatments of bramhastra (T_2) 3% (5.29), neemastra (T_1) 3% (5.12), agniastra (T_3) 3% (4.34), neem oil (T_5) 4% (2.73) and jivamrut (T_4) 3% (1.80).

In support of the results obtained regarding these organic products viz., neemastra, bramhastra, agniastra and jivamrut literature or references are not available and so could not be compared or discussed as these treatment combinations are new and used by the farmers on large scale locally and they are experimentally tested for first time in the present study.

Considering the cost of the inputs and the overall return through yield, it was revealed that, amongst different organic treatments NSKE (T_6) 5% was more economical followed by bramhastra (T_2) 3% (contains gomutra, neem leaves, karanj leaves, castor leaves, papaya leaves and dhatura leaves), neemastra (T_1) 3% (contains neem leaves, gomutra and cow dung), agniastra (T_3) 3% (contains gomutra, tobacco leaves, green chilies, garlic and neem leaves), neem oil (T_5) 4% and jivamrut (T_4) 3% (contains cowdung, Jaggery, besan, gomutra and bund soil).

Table 12: Incremental cost benefit ratio of different organic treatments

Tr. No.	Treatments	Conc.	Price of product for 100 lit. Spray (Rs.)	Cost of treatments		Total cost Rs/ha (A)	Yield of brinjal fruits (q/ha)	Increased yield over control (q/ha)	Increased yield over control (Rs./ha) (B)	Net gain over control Rs./ha (C) (B-A)	ICBR C/A	Rank
				Cost of spraying for 4 sprays (Rs./ha)	Labour charges and rent of sprayers (Rs.)							
1		2	3	4	5	6	7	8	9	10	11	12
T_1	Neemastra	3%	80	1600	1440	3040	84.10	18.60	18600	15560	5.12	IV
T_2	Bramhastra	3%	155	3100	1440	4540	94.06	28.56	28560	24020	5.29	III
T_3	Agniastra	3%	220	4400	1440	5840	97.40	31.19	31190	25350	4.34	V
T_4	Jivamrut	3%	156	3120	1440	4560	78.27	12.77	12770	8210	1.80	VII
T_5	Neem oil	4%	600	12000	1440	13440	115.64	50.14	50140	36700	2.73	VI
T_6	NSKE	5%	250	5000	1440	6440	112.27	46.77	46770	40330	6.26	II
T_7	Cypermethrin 25 EC	0.003%	8.4	168	1440	1608	129.69	64.19	64190	62582	38.92	I
T_8	Control (water spray)	-	-	-	1440	1440	65.50	-	-	-	-	-

Cost of inputs

- Labour 2 each for 4 sprays: Rs. 150/day/labour - 1200
- Charges of hired spray- Rs. 60/day
- Neem seed kernel - Rs. 30/Kg.
- Detergent powder - Rs. 100/Kg.
- Market rate of brinjal fruits- Rs. 1000/qtl.
- Considering 500 lit of water required for one application /ha area of the crop

Cost of organic materials required for preparing organic products

Materials	Rate/Kg (Rs.)	Materials	Rate/Kg (Rs.)	Materials	Rate/Kg (Rs.)	Materials	Rate/liter (Rs.)
Neem leaves	5	Tobacco leaves	50	Karanj leaves	5	Gomutra	10
Dhatura leaves	5	Green chillies	20	Bund soil	20	Neem oil	150
Cow Dung	10	Garlic	80	Jaggery	60		
Castor leaves	5	Papaya leaves	5	Besan	50		

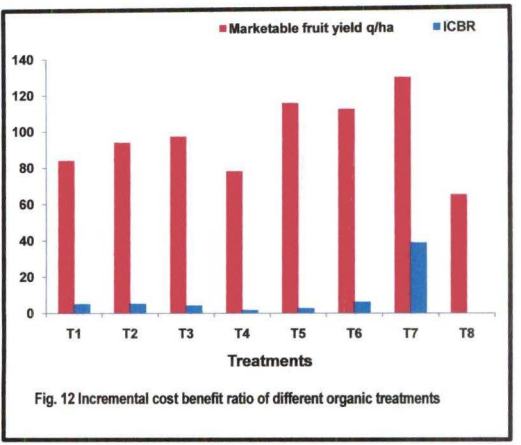


Fig. 12 Incremental cost benefit ratio of different organic treatments

T_1 -	Neemastra	3%
T_2 -	Bramhastra	3%
T_3 -	Agniastra	3%
T_4 -	Jivamrut	3%
T_5 -	Neem oil	4%
T_6 -	NSKE	5%
T_7 -	Cypermethrin 25 EC	0.003%
T_8 -	Control (water spray)	

Chapter V

SUMMARY AND CONCLUSIONS

Brinjal shoot and fruit borer (*L. orbonalis*) and sucking pests like aphid, jassid and whitefly are the major constraint in cultivation of brinjal. In spite of the several insecticides recommended, adequate management of these pests could not be achieved mostly due to indiscriminate and excessive use of insecticides over a long period of time leading to insecticide resistance along with resurgence, destruction of natural enemies and pollution disturbing balance of nature. Taking this into consideration, eco-friendly qualities of organic products such as specificity, safety and permanence, present experiment was undertaken to determine the efficacy of organic products against major insect pests of brinjal, to assess the impact of organic products on natural enemies in brinjal ecosystem and also to work out cost benefit economics.

The experiment was conducted in the Insectary premises of Entomology section, College of Agriculture, Nagpur in *Kharif* 2014-15. The experiment was laid out in Randomized Block Design with eight treatments replicated thrice. The treatments incorporated were neemastra (T_1) 3% (contains neem leaves, gomutra and cow dung), bramhastra (T_2) 3% (contains gomutra, neem leaves, karanj leaves, castor leaves, papaya leaves and dhatura leaves), agniastra (T_3) 3% (contains gomutra, tobacco leaves, green chilies, garlic and neem leaves), jivamrut (T_4) 3% (contains cowdung, Jaggery, besan, gomutra and bund soil), neem oil (T_5) 4%, NSKE (T_6) 5%, cypermethrin 25 EC (T_7) @ 0.003% and control (water spray:T_8).

Studies on the efficacy of organic products against major insect pests of brinjal revealed that, cypermethrin 25 EC (T_7) @ 0.003% (14.03%) was more effective in reducing the shoot borer incidence as compared to control plot (33.05%). Amongst different organic treatments, neem oil (T_5) 4% and NSKE (T_6) 5% were more effective

recording 19.22 and 20.10 per cent shoot infestation and were statistically on par with each other. The next promising organic treatments were of agniastra (T_3) 3% and bramhastra (T_2) 3% recording 22.14 and 22.26 per cent shoot infestation and were statistically on par with each other. These were followed by the treatments of neemastra (T_1) 3% and jivamrut (T_4) 3% with 24.72 and 25.33 per cent shoot infestation and were also found to be on par with each other.

The mean per cent fruit damage on number basis by *L. orbonalis* was lowest in cypermethrin 25 EC (T_7) @ 0.003% (12.46%) as compared to control plot (35.71%). Amongst different organic treatments, neem oil (T_5) 4% and NSKE (T_6) 5% were more effective with 17.75 and 18.48 per cent fruit infestation and were statistically at par with each other. The next promising organic treatments were agniastra (T_3) 3% and bramhastra (T_2) 3% with 22.56 and 23.20 per cent fruit infestation and were statistically on par with each other. These treatments were followed by neemastra (T_1) 3% and jivamrut (T_4) 3% registered 25.10 and 25.76 per cent fruit infestation and were statistically on par with each other.

The mean per cent fruit damage on weight basis by *L. orbonalis* was lowest in the treatment of cypermethrin 25 EC (T_7) @ 0.003% (12.80%) as compared to control plot (35.83%). Amongst different organic treatments, neem oil (T_5) 4% and NSKE (T_6) 5% were more effective with 17.89 and 18.37 per cent fruit infestation and were found statistically on par with each other. The next promising organic treatments were agniastra (T_3) 3% and bramhastra (T_2) 3% recording 22.55 and 23.07 per cent fruit infestation and were statistically at par with each other. These were followed by neemastra (T_1) 3% and jivamrut (T_4) 3% which were recorded 25.73 and 26.27 per cent fruit infestation and found to be at par with each other.

The mean per cent population reduction of aphids was highest in cypermethrin 25 EC (T_7) @ 0.003% (78.62%) as compared to control

plot (13.06%). Amongst different organic treatments, neem oil (T_5) 4% and NSKE (T_6) 5% were more effective registering 68.06 and 66.87 per cent population reduction and were statistically on par with each other. The next promising organic treatments were of bramhastra (T_2) 3% and agniastra (T_3) 3% recorded 57.08 and 55.55 per cent population reduction and were statistically at par with each other. These treatments were followed by neemastra (T_1) 3% and jivamrut (T_4) 3% with 48.83 and 47.44% population reduction and were statistically on par with each other.

The mean per cent population reduction of jassids was highest in the treatment of cypermethrin 25 EC (T_7) @ 0.003% (77.94%) as compared to control plot (13.30%). Amongst different organic treatments, neem oil (T_5) 4% and NSKE (T_6) 5% were more effective recording 64.95 and 63.97 per cent population reduction and were statistically at par with each other. The next promising organic treatments were bramhastra (T_2) 3% and agniastra (T_3) 3% with 55.41 and 54.30 per cent population reduction and were found on par with each other. These were followed by the treatments of neemastra (T_1) 3% and jivamrut (T_4) 3% recording 47.00 and 46.00 per cent population reduction and were statistically on par with each other.

The mean per cent population reduction of whiteflies was maximum in the treatment of cypermethrin 25 EC (T_7) @ 0.003% (79.86%) as compared to control plot (13.04%). Amongst different organic treatments, neem oil (T_5) 4% and NSKE (T_6) 5% were found to be more effective with 67.68 and 66.40 per cent population reduction and were statistically at par with each other. The next promising organic treatments were of bramhastra (T_2) 3% and agniastra (T_3) 3% with 56.53 and 55.28 per cent population reduction and were statistically at par with each other. These treatments were followed by neemastra (T_1) 3% and jivamrut (T_4) 3% with 47.70 and 46.92 per cent population reduction and were statistically at par with each other.

All the organic products were observed completely safe to the natural enemies i.e. coccinellids (1.95 to 3.04 per plant), spiders (1.35 to 2.33 per plant) and *Crysopa* (1.02 to 1.80 per plant) in brinjal ecosystem. Whereas, the treatment comprising of chemical insecticide i.e. cypermethrin 25 EC was found detrimental effect on natural enemies population and recorded least natural enemy population i.e., coccinellids (0.92/plant), spiders (0.68/plant) and *Crysopa* (0.51/plant).

Maximum marketable fruit yield of 129.69 q/ha was recorded in the treatment of cypermethrin 25 EC (T_7) @ 0.003%. Out of six different organic products, neem oil (T_5) 4% and NSKE (T_6) 5% recorded significantly more marketable fruit yield of 115.64 and 112.27 q/ha and were statistically on par with each other. The next promising organic treatments were of agniastra (T_3) 3% and bramhastra (T_2) 3% with marketable fruit yield of 97.40 and 94.06 q/ha and were statistically on par with each other. These treatments were followed by neemastra (T_1) 3% which recorded marketable fruit yield of 84.10 q/ha and jivamrut (T_4) 3% with marketable fruit yield of 78.27 q/ha.

On the basis of gross yield, the treatment cypermethrin 25 EC (T_7) @ 0.003% recorded (153.64 q/ha) highest gross yield. Amongst different organic products neem oil (T_5) 4% and NSKE (T_6) 5% recorded more gross yield of 143.73 and 141.64 q/ha and were statistically at par with each other. The next effective treatments were of agniastra (T_3) 3% and bramhastra (T_2) 3% which recorded gross yield of 131.23 and 129.29 q/ha and were statistically at par with each other. These were followed by the treatments of neemastra (T_1) 3% and jivamrut (T_4) 3% which recorded gross yield of 120.33 and 117.85 q/ha and were statistically at par with each other. However, control plot (T_8) recorded (110 q/ha) lowest gross yield of brinjal fruits.

Considering the cost of the inputs and the overall returns through yield, it was revealed that, the treatment of cypermethrin 25 EC (T_7) @ 0.003% was best by recording maximum ICBR to the extent of 38.92. Amongst all the organic treatments NSKE 5% (T_6) was more

economical in terms of cost benefit economics (6.26) followed by bramhastra 3% (5.29), neemastra 3% (5.12), agniastra 3% (4.34), neem oil 4% (2.73) and jivamrut 3% (1.80).

Keeping all these (above) aspects in mind, It is concluded that, amongst eight different treatments tested during the present experiment, lowest infestation (shoot, fruit and sucking pests like aphids, jassids and whiteflies) and maximum yield was observed in the treatment cypermethrin 25 EC (T_7) at 0.003% (153.64 q/ha) with ICBR of 38.92 and found superior in pest management of brinjal.

Amongst all the organic treatments neem oil 4 per cent (T_5) and NSKE 5% (T_6) were more effective in reducing the infestation (shoot, fruit and sucking pests like aphids, jassids and whiteflies) and recorded yield of 143.73 and 141.64 q/ha and both the treatments were at par with each other. The next promising organic treatments were of agniastra 3% (T_3) and bramhastra 3% (T_2) with 131.23 and 129.29 q/ha yield and were at par with each other followed by neemastra 3% (T_1) and jivamrut 3% (T_4) which recorded 120.33 and 117.85 fruit yield and were also found to be at par with each other.

All the organic products used were completely safe to the natural enemies i.e. coccinellids (1.95 to 3.04/plant), spiders (1.35 to 2.33/plant) and *Chrysopa* (1.02 to 1.80/plant) in brinjal ecosystem as compared to cypermethrin 25 EC (T_7) in which lowest population of coccinellids (0.92/plant), spiders (0.68/plant) and *Chrysopa* (0.51 /plant) was recorded.

Considering the cost of the inputs and the overall returns through yield, it was revealed that, amongst all the organic treatments NSKE 5% (T_6) was more economical in terms of cost benefit economics (6.26) followed by the treatment of bramhastra 3% (5.29), neemastra 3% (5.12), agniastra 3% (4.34), neem oil 4% (2.73) and jivamrut 3% (1.80).

Amongst all the organic treatments NSKE 5% (T_6) given best results in terms cost benefit economics (i.e. 6.26), also it shows positive effect upon population build up of natural enemies and can be used as an alternate substitute in place of chemical insecticides, which needs further testing and confirmation of results.

Chapter VI

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Signature of Student

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APPENDIX

Statement showing the weekly meteorological data for the year 2014-15 recorded at ARS, Nagpur

Date		Met Week	Temp ^{0}C		R.H. %		Total Rainfall (mm)	No. of Rainy days
			Max.	Min.	Mor.	Eve.		
02 - 08	July 14	27	35.1	26.8	61	49	19.4	03
09 - 15		28	33.7	26.4	75	59	7.4	04
16 - 22		29	28.4	24.4	84	77	22.9	04
23 – 29		30	27.1	23.2	85	73	46.2	06
30 - 05		31	31.3	25.5	78	65	68.6	05
06 - 12	Aug. 14	32	31.1	24.9	77	58	99.7	03
13 – 19		33	31.5	25.3	72	59	172.3	02
20 – 26		34	32.4	24.3	84	66	59.1	03
27 – 02		35	31.3	24.4	84	70	21.4	02
03 - 09	Sept. 14	36	28.9	24.3	84	78	21.6	05
10 – 16		37	27.9	23.7	85	73	19.8	03
17 – 23		38	32.2	24.6	77	61	241.0	01
24 – 30		39	32.1	21.9	69	44	68.4	0
01 - 07	Oct. 14	40	34.9	21.9	67	42	-	-
08 – 14		41	32.2	22.9	68	49	01.2	01
15 – 21		42	32.2	22.1	75	54	30.8	01
22 – 28		43	30.2	18.1	73	44	01.0	02
07 - 04	Nov. 14	44	31.7	16.8	67	31	-	-
05 – 11		45	31.8	17.6	59	37	-	-
12 – 18		46	31.3	20.2	60	42	-	-
19 – 25		47	30.2	12.5	50	27	-	-
26 – 02		48	30.7	13.1	59	27	-	-
03 - 09	Dec. 14	49	29.3	12.1	50	23	-	-
10 – 16		50	28.5	15.1	71	45	-	-
17 – 23		51	25.1	8.3	59	32	-	-
24 – 31		52	25.7	8.3	57	26	-	-
01 – 07	Jan. 15	01	24.8	14.0	78	52	02.4	02
08 – 14		02	26.9	7.4	58	21	-	-
15 – 21		03	26.3	9.6	53	29	-	-
22 – 28		04	28.0	14.7	71	42	-	-

Total rainfall – 903.2 mm in 47 rainy days (July 2014 to Jan. 2015)