

**BIO-EFFICACY OF**  
*Bacillus thuringiensis* (Berliner)  
**FORMULATIONS AGAINST**  
*Earias vittella* (Fabricius)  
**ON OKRA**

*A THESIS SUBMITTED TO THE*

**MAHATMA PHULE KRISHI VIDYAPEETH,  
RAHURI-413 722. DIST. AHMEDNAGAR,  
(MAHARASHTRA STATE, INDIA)**

*IN  
PARTIAL FULFILMENT OF THE  
REQUIREMENTS FOR THE DEGREE  
OF*

**MASTER OF SCIENCE (AGRICULTURE)**

*IN*

**AGRICULTURAL ENTOMOLOGY**

*BY*

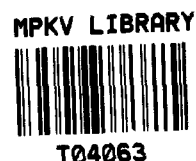
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B.Sc. (Agri)**

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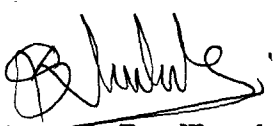
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### CANDIDATE'S DECLARATION

I hereby declare that the thesis entitled "BIO-EFFICACY OF *Bacillus thuringiensis* (Berliner) FORMULATIONS AGAINST *Earias vittella* (Fabricius) ON OKRA", or any part thereof has not been submitted by me or any other person to any other University or Institute for Degree or Diploma.

Place : Pune

  
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### CERTIFICATE

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

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Place : Pune

Dated : - 6 JAN 1997

Tendulkar A V.  
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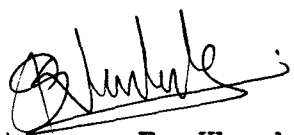
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Place : Pune  
Date : 24.12.96

  
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## CONTENTS

|                                                                                         |         |     |
|-----------------------------------------------------------------------------------------|---------|-----|
| CANDIDATE'S DECLARATION                                                                 | .. .. . | 111 |
| CERTIFICATES                                                                            |         |     |
| RESEARCH GUIDE                                                                          | .. .. . | iv  |
| ASSOCIATE DEAN                                                                          | .. .. . | v   |
| ACKNOWLEDGEMENTS                                                                        | .. .. . | vi  |
| LIST OF TABLES AND FIGURES                                                              | .. .. . | x   |
| ABSTRACT                                                                                | .. .. . | xi  |
| 1. INTRODUCTION                                                                         | .. .. . | 1   |
| 2. REVIEW OF LITERATURE                                                                 | .. .. . | 5   |
| 2.1 EFFICACY OF <i>B. t.</i> AGAINST LEPIDOPTEROUS<br>PESTS UNDER LABORATORY CONDITIONS | .. .. . | 7   |
| 2.2 EFFICACY OF <i>B. t.</i> AGAINST LEPIDOPTEROUS<br>PESTS UNDER FIELD CONDITIONS      | .. .. . | 13  |
| 3. MATERIAL AND METHODS                                                                 | .. .. . | 18  |
| 3.1 LABORATORY STUDIES ON EFFICACY OF<br><i>B. t.</i> AGAINST <i>E. vittella</i>        | .. .. . | 18  |
| 3.1.1 Rearing of Test Insect                                                            | .. .. . | 18  |
| 3.1.2 Exposure of Test Insect<br>to <i>B. t.</i> Products                               | .. .. . | 19  |
| 3.1.3 Reading the Assay                                                                 | .. .. . | 20  |
| 3.1.4 Analysis of Data                                                                  | .. .. . | 20  |
| 3.2. EFFICACY OF COMMERCIAL PRODUCTS OF<br><i>B. t.</i> UNDER FIELD CONDITIONS          | .. .. . | 21  |
| 3.2.1 Experimental Details                                                              | .. .. . | 21  |
| 3.2.2 Preparation and Application<br>of Spray Suspension                                | .. .. . | 22  |

|       |                                                                                                                                         |    |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------|----|
| 3.2.3 | Method of Recording Observations ..                                                                                                     | 22 |
| 3.2.4 | Analysis of Data .. .. .                                                                                                                | 24 |
| 4.    | RESULTS .. .. .                                                                                                                         | 25 |
| 4.1   | EFFICACY OF DIFFERENT FORMULATED PRODUCTS<br>OF <i>B.t.</i> VARIETIES AGAINST <i>E. vittella</i> UNDER<br>LABORATORY CONDITIONS .. .. . | 25 |
| 4.2   | EFFICACY OF DIFFERENT FORMULATED PRODUCTS<br>OF <i>B.t.</i> VARIETIES AGAINST <i>E. vittella</i> UNDER<br>FIELD CONDITIONS .. .. .      | 31 |
| 4.2.a | Season : <i>Kharif</i> 1994 .. .. .                                                                                                     | 31 |
| 4.2.b | Season : <i>Kharif</i> 1995 .. .. .                                                                                                     | 35 |
| 4.2.c | Season : <i>Summer</i> 1995 .. .. .                                                                                                     | 41 |
| 5.    | DISCUSSION .. .. .                                                                                                                      | 47 |
| 5.1   | LABORATORY STUDIES ON EFFICACY OF DIFFERENT<br>FORMULATED PRODUCTS OF <i>B.t.</i> VARIETIES AGAINST<br>THE TEST INSECT .. .. .          | 47 |
| 5.2   | EFFICACY OF DIFFERENT FORMULATED PRODUCTS OF<br><i>B.t.</i> VARIETIES UNDER FIELD CONDITIONS ..                                         | 51 |
| 5.3   | EFFECT OF DIFFERENT FORMULATED PRODUCTS OF<br><i>B.t.</i> VARIETIES ON YIELD OF MARKETABLE FRUITS                                       | 53 |
| 6.    | SUMMARY AND CONCLUSIONS .. .. .                                                                                                         | 56 |
| 6.1   | EFFICACY OF DIFFERENT FORMULATED PRODUCTS OF<br><i>B.t.</i> VARIETIES UNDER LABORATORY CONDITIONS                                       | 56 |
| 6.2   | EFFICACY OF DIFFERENT FORMULATED PRODUCTS OF<br><i>B.t.</i> VARIETIES UNDER FIELD CONDITIONS ..                                         | 57 |
| 6.3   | CONCLUSIONS .. .. .                                                                                                                     | 58 |
|       | LITERATURE CITED .. .. .                                                                                                                | 60 |
|       | APPENDIX-I : WEATHER DATA .. .. .                                                                                                       | 69 |
|       | VITA .. .. .                                                                                                                            | 72 |

## LIST OF TABLES AND FIGURES

| Table No. | Caption                                                                                                                                                                     | Page No. |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 1.        | TREATMENT DETAILS OF LABORATORY AND FIELD TRIALS AGAINST <i>E. vittella</i> ON OKRA .. ..                                                                                   | 23       |
| 2.        | LABORATORY TESTING OF DIFFERENT FORMULATED PRODUCTS OF <i>B.t.</i> VARIETIES AGAINST <i>E. vittella</i>                                                                     | 26       |
| 3.        | BIOEFFICACY OF DIFFERENT FORMULATED PRODUCTS OF <i>B.t.</i> VARIETIES AGAINST <i>E. vittella</i> UNDER FIELD CONDITIONS (Season : <i>Kharif</i> 1994) ..                    | 32       |
| 4.        | BIOEFFICACY OF DIFFERENT FORMULATED PRODUCTS OF <i>B.t.</i> VARIETIES AGAINST <i>E. vittella</i> UNDER FIELD CONDITIONS (Season : <i>Kharif</i> 1995) ..                    | 36       |
| 5.        | BIOEFFICACY OF DIFFERENT FORMULATED PRODUCTS OF <i>B.t.</i> VARIETIES AGAINST <i>E. vittella</i> UNDER FIELD CONDITIONS (POOLED MEAN : <i>Kharif</i> 1994 and 1995) .. .. . | 40       |
| 6.        | BIOEFFICACY OF DIFFERENT FORMULATED PRODUCTS OF <i>B.t.</i> VARIETIES AGAINST <i>E. vittella</i> UNDER FIELD CONDITIONS (Season : Summer 1995) ..                           | 42       |

| Figure No. | Caption                                                                                                   | Page No. |
|------------|-----------------------------------------------------------------------------------------------------------|----------|
| 1.         | LOG TIME - PROBIT KILL REGRESSION LINES FOR FIRST INSTAR LARVAE OF <i>E. vittella</i> (LT <sub>50</sub> ) | 27 & 28  |

T-4063

## ABSTRACT

BIO-EFFICACY OF *Bacillus thuringiensis* (Berliner)  
FORMULATIONS AGAINST *Earias vittella* (Fabricius)  
ON OKRA

by

SATAPPA BHAMBAR KHARBADE

A candidate for the degree of  
MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL ENTOMOLOGY

COLLEGE OF AGRICULTURE, PUNE-5

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RESEARCH GUIDE  
DISCIPLINE

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Dr. A.G. CHANDELE  
AGRICULTURAL ENTOMOLOGY

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The present studies were carried out to find out the relative bioefficacy of different formulated products of *Bacillus thuringiensis* varieties viz., *kurstaki*, *thuringiensis*, *kurstaki* X *aizwai* and *aizwai* against *Earias vittella* (Fabricius) on okra under laboratory and field conditions during *Kharif* 1994, *Kharif* 1995 and *Summer* 1995 at Agril. Entomology Section, College of Agriculture, Pune.

The observations on biology of the pest, LT<sub>50</sub> and per cent fruit damage and yield of marketable fruits of okra were recorded. The *B.t.* products tested were Dipel 8 L, Delfin WG, Biolep WP, Bioasp WP, Halt WP formulations of *B.t.* var. *kurstaki*, Agree WP *B.t.* var. *kurstaki* X *aizwai*, Biotox WP *B.t.* var. *thuringiensis* and Centari WG *B.t.* var. *aizwai*.

Studies carried out under laboratory condition revealed that the formulations of *B.t.* var. *kurstaki* viz., Dipel 8 L (LT<sub>50</sub> 24.71 hrs.), Delfin WG (LT<sub>50</sub> 29.07 hrs.) and Halt WP (LT<sub>50</sub> 29.92 hrs.) were observed to be more effective followed by the formulations of *B.t.* var. *thuringiensis*, Biotox WP (LT<sub>50</sub> 31.25 hrs.), *B.t.* var. *kurstaki* X *aizwai* Agree WP (LT<sub>50</sub> 37.06 hrs.), *B.t.* var. *aizwai* Centari WG (LT<sub>50</sub> 42.20 hrs.). The larval mortality starts from 12 hrs after the treatment and reached to its peak at 60 hrs after the treatment. The corrected mortality and LT<sub>50</sub> value indicating similar trend of efficacy.

Under field conditions, *B.t.* var. *kurstaki* was found to be more effective when per cent fruit damage and yield of marketable fruits of okra <sup>were</sup> taken into consideration. While, *B.t.* var. *thuringiensis* was moderately effective followed by *B.t.* var. *kurstaki* X *aizwai* and *B.t.* var. *aizwai*. The average yield of marketable fruits of okra during the year 1994-1995 as influenced by different *B.t.* treatments ranged from 60 to 76.56 q/ha as against 35.15 to 49.15 q/ha in untreated plots. While, per cent fruit damage ranged from 11.90 to 24.90 per cent as against 42.14 per cent in untreated control. All *B.t.* treatments <sup>were</sup> observed to be significantly superior over control.

The present findings are indicative for the incorporation of *B.t.* <sup>varieties</sup> in development of Integrated Pest Management for *E. vittella*.

Chapter Opener Page

# **INTRODUCTION**

## 1. INTRODUCTION

Okra *Abelmoschus esculentus* (Linn.) [Moench], which is also commonly known as Bhendi, is one of the largely cultivated fruit vegetables grown all over the country. It occupies an area of about 6,000 hectares in the State of Maharashtra (Anonymous, 1991). Okra fruits are rich in vitamin 'A' and 'C' and proteins and preferred by all the people because of its high nutritive value and taste. It has large Indian markets and good scope for export (60% share).

Successful production of this crop is hampered due to incidence of many pests. About twenty pests have been recorded on this crop (Butani and Verma, 1978). Amongst these, shoot and fruit borer, *Earias vittella* (Fabricius) [Noctuidae : Lepidoptera] is of endemic nature and causes direct loss in the yield of marketable fruits. This pest causes 88 to 100 per cent fruit damage (Radke and Undirwade, 1981). The first instar larva is the most vulnerable stage in the case of this pest. The adults usually lay eggs on flower buds, shoots and fruits and tiny larvae soon after hatching roam about on the plant surface for half an hour and then start boring. The larvae attack the shoots initially and cause drying. After fruit formation, larvae also attack the tender fruits and feed internally. As a result of their feeding, fruits get deformed fetching less price in the market.

T-4063

To control the pest, farmers use many insecticide sprays in a cropping season. Such insecticide sprays brought on their wake a large number of problems. Various chemical insecticides effective for the control of this pest are bound to leave undesirable toxic residues on the fresh leaves and fruits destined for human consumption. The shorter interval between the pluckings of fruits poses the residue hazards to the consumers when chemical insecticides are used and has also led to killing of natural enemies of the pests resulting in their resurgence and development of resistance. Thus, routine insecticide application would harm the delicate balance between insect pests and their natural enemies besides increasing cost of control measures. Therefore, alternative to this method of pest control was sought using biological insecticides non-toxic to warm blooded animals, leave harmless residues and relatively safe for beneficial insects.

Microbial insecticides particularly those derived from *Bacillus thuringiensis* (Berliner) offer great promise for pest management. It is one of the microbial pesticides under use in many Biological Control Programmes throughout the World. In early 1950s, the use of bacterium *B. thuringiensis* resumed the interest in Europe and America and late 1950s, the *B.t.* was commercially produced. Of late, there has been growing emphasis on use of *B.t.* in India.

*B. thuringiensis* is highly effective against certain lepidopterous pests, yet they do not harm humans, beneficial insects and other non-target organisms. Commercialization of more effective strains of *B. thuringiensis* and genetic engineering of the genes for *B. thuringiensis* toxins into crop plants and plant-colonizing bacteria form an important component of Integrated Pest Management.

As a result of restriction on the usages of chemical pesticides, microbial control agents are receiving a great deal of consideration. The insecticidal action of *B. thuringiensis* have been tested against a wide variety of lepidopterous pests. Taylor (1974) reported that it was effective against a mixed population of okra leaf and fruit infesting lepidopterous larvae. Similarly, Krishnaiah *et al.* (1981) and Kadam (1993) also reported effective control of *E. vittella* by using different formulations of *B. thuringiensis*.

*B.t.* is a desirable agent for insect pest control and ideal for use in developing countries because of its low production cost and lack of toxicity to non-target organisms. Over the last decade research activity into the molecular and genetic make-up of *B.t.* has intensified, leading to additions of numerous *B.t.* strains/formulations with different insecticidal spectra.

Considering the above aspects, the present investigations were undertaken with a view to find out :

1. The  $LT_{50}$  of different products of *B.t.* varieties against *Earias vittella* (Fabricius).
2. Relative bioefficacy of different products of *B.t.* varieties under field conditions against *E. vittella*.

Chapter Opener Page

**REVIEW OF**  
**LITERATURE**

## 2. REVIEW OF LITERATURE

*Bacillus thuringiensis* is naturally occurring crystalliferous, spore forming, rod-shaped, gram-positive bacteria. The potential of *B.t.* for biological pest control was first recognised by Berliner (1915). Since then, it received considerable attention of the researchers. To date, it is the most successful eco-friendly bioinsecticide and estimated to account for 80-90 per cent of all biological pest control agents sold worldwide. Nevertheless, *B.t.* not yet made much impact and only account for 1-2 per cent share of the total insecticide market. In future, the market share of *B.t.* is expected to reach 5-10 per cent by the year 2000 and sales of *B.t.* products estimated to rise at least 20 per cent per annum in the next few years (Rigby, 1991).

*B.t.* varieties containing various strains exhibited different insecticidal activity spectra and insect species differed in their susceptibility to particular strain while strains differed in their pathogenicity to a particular insect species. This triggered studies to identify more potent strains than those currently used in commercially available products. As commercial importance of *B.t.* increased, different isolates were discovered. To date, 34 serovars are known including 27 antigenic groups and 7 sub-groups (de Barjac and Frachon, 1990). Various *B.t.* varieties viz.,

*kurstaki*, *thuringiensis*, *berliner*, *aizwai*, *entomocidus*, *endobacterin*, *gallaridae*, *sotto*, etc. are available in various formulations.

The mode of action of *B.t.* has been worked out with certain detail by Berliner (1915) and Mattes (1927) in Mediterranean flour moth, *Anagasta kuehniella* (Zeller). Upon ingestion, *B.t.* spores/crystals get dissolved at high pH in the larval midgut. Protoxins generated by enzymatic hydrolysis in the midgut; the toxins act directly on the membranes of midgut epithelium cells by binding of toxins to putative receptor sites on midgut cells causing gradual increase in membrane permeability followed by swelling and lysis of the cells. Intoxication is associated with immediate feeding inhibition; leakage of ions from gut to haemolymph causes ionic imbalance in the haemolymph; in some species, this ionic imbalance is sufficient to cause paralysis and death; in other species, changes in gut and haemolymph conditions permits vegetative propagation of *B.t.* within the insect, resulting in a septicemia, which contributes to or causes death.

After commercial exploitation of *B.t.*, different varieties and formulations were used against number of lepidopterous pests under field and laboratory conditions. Therefore, voluminous literature on its efficacy against lepidopterous pests is available. But the literature pertaining to the use of *B.t.* for the control of *Earias vittella*

(Fabricius) on okra is meagre. Thus, literature available on other lepidopterous pests have been reviewed and presented in this chapter.

## 2.1 EFFICACY OF *B.t.* AGAINST LEPIDOPTEROUS PESTS UNDER LABORATORY CONDITIONS

McConnell and Cutkomp (1954) observed cent per cent mortality with suspension containing 1.5 million spores/ml of *B.t.* spray to the first instar larvae of European corn borer, *Ostrinia nubilalis* (Hbn.) and 50 per cent mortality at 1 million and 25 per cent to 0.5 million spores/ml of spray.

Tanada (1956) found that sprays with 0.25 g *B.t.* per gallon gave complete mortality of *Pieris rapae* (Linn.) and *Trichoplusia ni* (Hbn.) within 2 to 4 days. Mortality to the extent of 70-80 per cent was obtained in *Heliothis virescence* (F.) within 4 to 5 days by Chamberline and Dutky (1958) by using HD-135 and HD-133-6 cultures of *B.t.*. Laboratory experiments conducted by Hall and Dunn (1958) revealed that 0.25 to 2 g powder of *B.t.* containing 100 billion spore/g gave 28 to 100 per cent mortality in several leaf chewing insects. Complete mortality was, however, obtained in the *Plutella maculipennis* (Curt.) by Menn (1960) using *B.t.* at the rate of  $47 \times 10^5$  spores  $100 \text{ ml}^{-1}$ . Venkatraman et al. (1962) observed cent per cent mortality of *Epilachna ocellata* (Redp.) and *Athalia proxima* (Klung.) with  $70 \times 10^7$  and  $30 \times 10^7$  spores/g within 24 hours and mortality

to the extent of 80 per cent in *Corcyra cephalonica* (Staint.) after 3 days with  $75 \times 10^7$  spores/g and *Schistocera gregaria* (Forsk.) required high concentration to get 90 per cent mortality within 3-6 days. However, 88.89 per cent mortality of 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> instar larvae of *Achoea janata* (Linn.) within 76 hours were obtained with Thuricide dust containing  $30 \times 10^9$  spores/g by Kulshreshtha *et al.* (1965). Studies carried out by Gaimmarco *et al.* (1966) revealed that aqueous suspension of *B.t.* containing  $1 \times 10^8$  spores/g gave complete mortality of 4<sup>th</sup> and 5<sup>th</sup> instar larvae of *Prays citri* (Mill.) in laboratory conditions. Ramakrishnan and Pant (1967) noticed mortality of *Earias fabia* (Stoll.) larvae within 30 hours after ingestion when Thuricide (3 billion viable spores) treated seeds of lady's finger seeds were fed to 7 to 8 days old larvae. In case of *Helicoverpa armigera* (Hub.) studies, Doust and Roome (1974) revealed that minimum time for mortality using *B.t.* (Bitrol BTB-183) was four days. Joseph and Gerald B.C. (1974) evaluated commercial preparation of *B.t.* viz., Dipel, Thuricide, Bactospeine for the control of *Heliothis* spp on cotton, at the rate of 1 to 2 lb/acre. Dipel produced higher mortality of caged larvae than other preparations of *B.t.*

✓ Taylor (1974) in Nigeria, evaluated Dipel at the rate of 0.5, 1.0 and 1.5 lb/acre against lepidopterous pests of okra. Laboratory bioassay test showed that the suspension

of Dipel caused at least 90 per cent mortality in the leaf-roller, *Sylepta derogata* (Fallen) larvae within 48 hrs. Over 50 per cent mortality was achieved after 24 hrs at all concentrations tested and 100 per cent mortality with 1.0 and 1.5 lb/acre in 48 and 60 hrs, respectively. Dabi *et al.* (1979) tested *B.t.* products viz., Dipel HD-1 using different doses against *H. armigera* on gram and found an application of  $12 \times 10^9$  IU ha<sup>-1</sup> against 3<sup>rd</sup> instar and  $16 \times 10^9$  IU ha<sup>-1</sup> against 5<sup>th</sup> instar to be the most effective within 96 hrs after treatment.

Screening of 29 cultures of *B.t.* belonging to fourteen serotypes against *H. armigera* by Salama *et al.* (1981) revealed that 100 per cent mortality was obtained with two cultures of serotypes 3a, 3b *B.t.* var. *kurstaki* (HD-1 and HD-73), whereas some cultures of serotype *B.t.* var. *aizwai* gave activity reaching 90 per cent and 86 per cent for HD-133 and HD-135, respectively. Studies on pathogenicity of *B.t.* by Deshpande and Ramakrishnan (1982) against *A. janata* indicated that *B.t.* var. *kurstaki* was most pathogenic being 1.5 and 3.8 times more toxic than *B.t.* var. *gallariae* and *berliner*. The LT<sub>50</sub> values were 41.9, 36.3 and 75.6 hrs, respectively.

Mowad *et al.* (1982) tested potency of Dipel in comparison to Bactospeine, using *Earias insulana* Boisduval on bhendi as test insect by fruit dip method. Dipel was observed to be the most effective (LC<sub>50</sub> = 0.0675 per cent or  $10.8 \times 10^3$

IU/ml) than Bactospeine ( $LC_{50} = 0.1$  per cent or  $16.5 \times 10^3$  IU/ml) giving 0 to 25 and 0 to 1.25 per cent malformed population of the pest.

Sastrosiswojo and Nuswantara (1986) reported a period of 3 days to cause 95 per cent mortality of 3<sup>rd</sup> instar larvae of *Plutella xylostella* (Linn.) after treatment with 500 ppm *B.t.* (Bactospeine).

Jaquet *et al.* (1987) studied the insecticidal activity of the delta-endotoxin of 14 *B.t.* strains belonging to 12 sub-species against *H. virescens* by conducting bioassay with freshly hatched 1<sup>st</sup> instar larvae on artificial diet and reported that the most toxic crystals were produced by strain 4430 (*B.t.* var. *Kenya*) and 4443 (*B.t.* var. *kurstaki*). They, further, observed that pre-dissolution of crystal greatly improved the activity of a number of delta-endotoxins. Thus, the studies indicated that bacterium as well as insect species contribute significantly to the specificity of insecticidal activity. Similarly, Kulkarni and Amonkar (1988) tested different concentrations of *B.t.* var. *Kenya* (ISPC-1 and ISPC-7 isolates) and *B.t.* var. *kurstaki* (ISPC-4) in the dose range of  $10^5$ - $10^9$  spores  $ml^{-1}$  against 1<sup>st</sup> to 4<sup>th</sup> instar larvae of *H. armigera*. The results indicated that all the three pathogens showed high toxicity to the 1<sup>st</sup> instar larvae, but ISPC-1 gave quicker mortality than other.  $LT_{50}$  values were 4.5 (ISPC-1), 6.2 (ISPC-4) and 6.7 (ISPC-7) days, respectively.

Justin et al. (1988) studied the infectivity of 8 subspecies of *B.t.* to 3<sup>rd</sup> instar larvae of *P. xylostella* by feeding them on cauliflower leaves dipped in suspension containing  $10^7$  spores ml<sup>-1</sup> and reported that *B.t.* var. *kurstaki* (Bactospeine) was the most toxic (LT<sub>50</sub> = 21.90 hrs) followed by *B.t.* var. *thuringiensis* (LT<sub>50</sub> = 22.60 hrs) and *B.t.* var. *kurstaki* (laboratory culture) with LT<sub>50</sub> of 23.15 hrs.

Studies conducted by Khalique et al. (1989) using Bactospeine (*B.t.* subsp. *thuringiensis*) and HDIS 1980 (*B.t.* subsp. *kurstaki*) against 1<sup>st</sup> and 3<sup>rd</sup> instar larvae of *H. armigera* revealed LC<sub>50</sub> values for *B.t.* var. *thuringiensis* as 63.52 and 177.60 IU ml<sup>-1</sup> and for *B.t.* var. *kurstaki* as 56.16 and 126.40 IU ml<sup>-1</sup> for 1<sup>st</sup> and 3<sup>rd</sup> instar larvae, respectively after seven days exposure.

Navon and Klein (1990) evaluated *B.t.* var. *kurstaki*, *B.t.* var. *thuringiensis* and *B.t.* var. *aizwai* at the rate of 4 ug/g of each against *E. insulana* on cotton. Laboratory bioassay test showed that *B.t.* var. *kurstaki* was found to be superior showing 100 per cent larval mortality over *B.t.* var. *thuringiensis* and *B.t.* var. *aizwai* in which 85.7 and 70.4 per cent larval mortality was recorded, respectively.

Studies by Mane (1993) revealed that minimum time for mortality of *H. armigera* was 2 days of testing on treated

diet and maximum mortality was 95 per cent in case of Delfin and 80 per cent with Dipel. In case of *P. xylostella* mortality started 12 hours after treatment and within 36 hours mortality reached almost 100 per cent.

Chandele and Mane (1994) carried out bioassay of *B.t.* against *Plutella xylostella* (Linn.) and reported that the LC<sub>95</sub> value of Agree 50 WP *B.t.* var. *k X a* was 0.103 per cent.

Mathur et al. (1994) evaluated three commercial formulations of *B. thuringiensis* Berliner viz., Dipel wettable powder containing  $25 \times 10^9$  viable spores/g of the final product of *B. thuringiensis* var. *kurstaki* (serotype 3a, b strain HD-1), Thuricide HP wettable powder containing  $30 \times 10^6$  viable spores of *B. thuringiensis* var. *kurstaki* (serotype 3a, b strain HD-1) per g of final product and Bactospeine containing  $1 \times 10^8$  spores of *B. thuringiensis* (serotype 1/g of final product) for their pathogenicity against black hairy caterpillar, *Pericallia ricini* (Fabricius). The LT<sub>50</sub> values of different preparations of *B. thuringiensis* against 3<sup>rd</sup> instar larvae of *P. ricini*, were reported to be only 71.78 hrs in case of Dipel at 0.5 per cent concentration, whereas the same concentration Bactospeine had the maximum LT<sub>50</sub> value of 240 hrs and Thuricide HP showed intermediary with LT<sub>50</sub> value as 155 hrs.

## 2.2 EFFICACY OF *B. t.* AGAINST LEPIDOPTEROUS PESTS UNDER FIELD CONDITIONS

Studies by Bullock<sup>and Dulmage H.T.</sup> (1969) revealed that only 10 to 40 per cent infestation in cotton bolls with *Pectinophora gossypiella* (Saunders) when it was treated with 1 to 2 quarts of microbial insecticides as against 80 per cent in the untreated fields. Similarly, Popava (1971) reported effective control of the pest on cotton with Entobakterin in Bulgaria.

In a preliminary test, Roome (1971) obtained good control of *H. armigera* on sorghum in Botswana with *B. thuringiensis* at  $2.78 \times 10^8$  spores ml<sup>-1</sup>. In another field trial conducted against the pest on tomato in Jordan, Kabur and Sane (1971) obtained significantly better control with 2.5 per cent wettable powder of Dipel than other treatments.

Studies by Taylor (1974) under field and laboratory conditions revealed that Dipel at the rate of 0.5 to 1 lb/acre is a suitable alternative for the control of *E. insulana* along with the other lepidopterous pests of okra. Similarly, Krishnaiah *et al.* (1981) evaluated formulations of *B. t.* for the control of major lepidopterous pests of okra, cabbage, egg plant (brinjal) and trailing beans. On okra, weekly sprays of Dipel at 0.5 Kg/ha reduced fruit infestation of *E. vittella* and effectively controlled the pest reducing 14.98 per cent fruit borer damage as against 24.22 per cent in untreated control.

Abul Nasir *et al.* (1983) recorded 42 to 45 per cent reduction in the infestation of spotted bollworm and pink bollworm using *B.t.* serotypes I and II on cotton as against 34 per cent reduction in insecticide leptophos. Hosny *et al.* (1983) in laboratory and field experiments revealed that Bactospeine, Dipel, Thuricide ABG-6105 each containing 16,000 IU/mg gave better control of the cotton leaf worm, *Spodoptera littoralis* (Boisd).

*B. thuringiensis* has also been studied extensively against *Plutella xylostella* (L.) under field conditions. In field trials on cabbage in Malaysia, Indonesia and Australia and on cabbage and cauliflower in India, Thuricide HP (*B.t.* var. *kurstaki*) has been shown to give good control of the pest (Brunner and Stevens, 1986). Nawrocka (1986) reported that out of Dipel, Thuricide HP, Bactospeine-PM 600 and Entobacterin tested against *P. xylostella*, Dipel and Thuricide HP (at 0.5 to 3 Kg ha<sup>-1</sup>) gave best control, causing 100 per cent mortality of the caterpillars. Sastrodihardjo (1986) reported better effectiveness of all strains of *B.t.* var. *aizwai* against *P. xylostella*. Tkach and Chaplagia (1986) found that a sprays of Dendrobacillin (30 million spores/g) at 2 per cent in 400 litre liquid/ha applied from ground against hatching 2<sup>nd</sup> generation larvae of *P. xylostella* gave 92 per cent control and when the same was applied in 100 litre from helicopter against 3<sup>rd</sup> generation, it gave 85 per cent control.

Studies carried out at Taiwan indicated that two strains of *B.t.* (HD-1 and H 3a, 3b) at 0.5 to 1.5 Kg/ha, gave satisfactory control of *P. xylostella* and also increased yields significantly (Anonymous, 1987).

A large scale field programme implemented in Egypt assessed the potential of several *B.t.* formulations against pests on cotton plants. The efficacy level of baits based on *B.t.* against *Agrotis ipsilon* (Rott.) and spray application against *S. littoralis*, *P. gossypiella* and *E. insulana* were highly encouraging (Salama and Morris, 1993).

Kadam (1993) evaluated *B.t.* formulations viz., Albit and Bactospeine at the concentrations of 0.0045 per cent ( $15.75 \times 10^3$  IU/ml) and 0.006 per cent ( $21 \times 10^3$  IU/ml) against *E. vittella* on bhendi showing 11.41 to 16.34 per cent fruit injury as against 36.67 per cent in untreated control, while yield of marketable fruits of bhendi was recorded as 65.64 to 70.67 q/ha as against 46.16 q/ha in untreated control.

Mane (1993) studied the efficacy of Dipel 8 L and Delfin WG against *H. armigera* and *P. xylostella*. The results indicated that Dipel 8 L and Delfin WG at 0.4 per cent of each gave better control of *H. armigera*, while 0.1 per cent of each gave better control of *P. xylostella*.

Studies by Broza and Sneh (1994) revealed that *B.t.* preparations viz., Dipel and Bio-T were highly effective

against *Crysodeixus (Plusia) chalcites* Esper, *H. armigera* and the potato tuber worm *Phthorimaea operculella* (Zeller) in tomato fields when applied at the rate of 16,000 IU/mg and 4,000 ml/ha, respectively.

Panchbhavi and Sundhindra (1994) evaluated different preparations of *B.t.* serovar *kurstaki* viz., Halt (Wock biological 01) and Dipel against *H. armigera* on cotton. The results indicated that Halt and Dipel at the rate of 1.5 Kg and 1.0 litre of each per ha gave 25.75 and 27.30 per cent larval mortality and 58.52 and 58.16 per cent damage to fruiting bodies, respectively.

Kulkarni et al. (1995) found that Delfin at the rate of 0.5 Kg/ha and Halt 1 Kg/ha gave better control of *P. xylostella* on cabbage and were equally effective showing the damage score of 0.15 per cent and 1.37 per cent, respectively. Pawar and Gunjal (1995) evaluated Dipel and Halt at the rate of 1,000 gm/ha against lepidopterous pod borers of pigeonpea. The results indicated that Dipel and Halt were equally effective showing 7.74 per cent and 7.18 per cent pod damage, respectively.

Similarly, Mastoli et al. (1995) studied the efficacy of bioinsecticides against bollworm complex of cotton under field conditions. The results showed that all *B.t.* treatments were significantly superior over the control. *B.t.*

$10^8$  spores/ml gave 19.83 per cent boll damage, 15.09 per cent locule damage, 8.18 per cent bad kapas and 17.46 q/ha yield. While, in untreated control 45.38 per cent boll damage, 29.7 per cent locule damage, 34.92 per cent bad kapas and 12.27 q/ha yield.

Chapter Opener Page

## **MATERIAL AND METHODS**

### 3. MATERIAL AND METHODS

The present studies were undertaken with a view to find out relative efficacy of different formulated products of *Bacillus thuringiensis* (Berliner) against the okra shoot and fruit borer, *Earias vittella* (Fabricius). Experiments were carried out under laboratory as well as field conditions at Agril. Entomology Section, College of Agriculture, Pune during the year 1994-95.

#### 3.1 LABORATORY STUDIES ON EFFICACY OF *B.t.* AGAINST *E. vittella*

##### 3.1.1 Rearing of Test Insect

For conducting various laboratory trials, supply of physiologically homogenous larvae was essential and hence mass rearing of *E. vittella* was carried out in the laboratory. Mass rearing technique for test insect employed was on the lines of Ratan Lal and Dhall (1965).

*E. vittella* infested okra fruits were collected from the field and kept in rearing cages having a layer of soil (2 cm depth) for pupation. The pupae were then collected from time to time and kept separately in glass vials. These vials were transferred to BOD incubator ( $27 \pm 1^{\circ}\text{C}$ ) for adult emergence.

The moths were transferred to glass jar (25 X 20 cm) in which 4 to 5 fresh okra fruits were kept for oviposition.

Cotton swab dipped in 5 per cent honey solution was kept hanging in the jar which was covered with muslin cloth. The eggs laid on okra fruits as well as muslin cloth were collected and kept in conical flask which was covered with black paper to prevent the escape of larvae. The flask containing eggs were placed in incubator ( $27 \pm 1^{\circ}\text{C}$ ). Newly hatched larvae were collected with the help of fine camel hair brush and placed on the pieces of okra fruits in petri-dishes. Total 5 larvae were released on each piece. Such petri-dishes were then placed in incubator ( $27 \pm 1^{\circ}\text{C}$ ). The food was changed after every 48 hrs and fresh pieces of okra fruits were given until pupation. The pupae were then removed and transferred to glass vials which were kept in incubator for the emergence of adults. The moths were again transferred to glass jar for egg laying as mentioned earlier. In this way, mass rearing of *E. vittella* was done throughout the course of laboratory investigations.

### 3.1.2 Exposure of Test Insect to *B.t.* Products

After hatching, the larvae were found to roam and feed on surface of okra fruits for about 8 to 10 hrs prior to entry in the fruits. Hence newly hatched larvae were used as test insect for the present investigations. Requisite quantity of *B.t.* formulations (Table 1) along with sticker (0.1 per cent) were mixed with water and okra fruits were dipped in each suspension. These okra fruits were dried

under the fan at medium speed and on each fruit 5 larvae were released. Three fruits with 15 larvae were kept separately in each petri-dish considering one replication. There were three replications for each of the treatments. These petri-dishes were kept in BOD incubator ( $27 \pm 1^\circ\text{C}$ ).

### 3.1.3 Reading the Assay

Observations on larval mortality were recorded at 12 hrs interval for 60 hrs and data on larval mortality were recorded. After 12 hrs of treatment the fruits were opened and larval mortality were recorded. Moribund larvae were considered as dead. The surviving larvae were transferred on the pieces of okra fruits for further observations. The data on time required for mortality were recorded. For compensating the mortality observed in control, the mortalities due to treatment were corrected by using formula suggested by Abbott (1925).

Formula :

$$Pt = \frac{Po - Pc}{100 - Pc} \times 100$$

Where,

Pt = Corrected per cent mortality  
 Po = Observed mortality in treatment  
 Pc = Observed mortality in check

### 3.1.4 Analysis of Data

The data on larval mortality of test insect and time required for mortality were subjected to probit analysis

(Finney, 1971) and  $LT_{50}$  values were calculated.

### 3.2 EFFICACY OF COMMERCIAL PRODUCTS OF *B.t.* UNDER FIELD CONDITIONS

In order to study the relative performance of different formulated products of *B.t.* against *E. vittella* on okra under field conditions statistically designed field experiments were laid out at the farm of Agril. Entomology section, College of Agriculture, Pune during *Kharif* 1994 and *Kharif* and *Summer* 1995. The treatment details are given in Table 1.

#### 3.2.1 Experimental Details

- a. Experimental design : Randomized block design
- b. Replications : Three
- c. Plot size
  - i. Gross : 3 X 3.5 m
  - ii. Net : 2.5 X 3 m
- d. Plant distance : 30 X 15 cm
- e. Variety : Pusa sawani
- f. Seasons :
  - i. *Kharif* 1994
    - Date of sowing : 23-6-1994
    - Dates of spraying: 9-8-1994, 20-8-1994, 3-9-1994 and 14-9-1994
    - Dates of plucking: 13-8-1994, 18-8-1994, 24-8-1994, 29-8-1994, 7-9-1994, 12-9-1994, 18-9-1994 and 23-9-1994

ii. *Kharif* 1995

Date of sowing : 30-6-1995  
 Dates of spraying: 16-8-1995, 26-8-1995, 6-9-1995  
 and 17-9-1995  
 Dates of plucking: 20-8-1995, 25-8-1995, 30-8-1995  
 4-9-1995, 10-9-1995, 15-9-1995,  
 21-9-1995 and 26-9-1995

iii. *Summer* 1995

Date of sowing : 15-2-1995  
 Dates of spraying: 2-4-1995, 13-4-1995, 24-4-1995  
 and 5-5-1995  
 Dates of plucking: 6-4-1995, 11-4-1995, 17-4-1995,  
 22-4-1995, 28-4-1995, 3-5-1995,  
 9-5-1995 and 14-5-1995

### 3.2.2 Preparation and Application of Spray Suspension

The quantity of spray material required for treating the crop in a plot was found out by spraying water alone with hand compression sprayer. Then, quantity of *B.t.* formulations required for preparing the spray fluids of different *B.t.* formulations were worked out and mixed in water. Sandovit was added as sticker at the rate of 2 ml  $l^{-1}$ . Spraying was carried out in the late afternoon with knapsack sprayer, as tender shoots and fruits are the main feeding sites of test insect. Thorough coverage of these plant parts was ensured.

### 3.2.3 Method of Recording Observations

The data were recorded on number of healthy and infested fruits and yield of marketable fruits per plot at each plucking.

Table 1. TREATMENT DETAILS OF LABORATORY AND FIELD TRIALS  
AGAINST *E. vittella* ON OKRA

| Sr. No. | Name of formulated product | <i>B. t.</i> variety                                 | Sero-type | IU/mg      | Dose <sub>1</sub><br>litre <sup>-1</sup> | Manufacturer                               |
|---------|----------------------------|------------------------------------------------------|-----------|------------|------------------------------------------|--------------------------------------------|
| 1.      | Dipel 8 L                  | <i>B. t.</i> var. <i>kurstaki</i>                    | 3a,3b     | 17,600 IU  | 1.5 ml                                   | Lupin Agro-chemicals (I) Pvt. Ltd., Mumbai |
| 2.      | Delfin WG                  | <i>B. t.</i> var. <i>kurstaki</i>                    | 3a,3b     | 53,000(SU) | 2.0 g                                    | Sandoz (I) Ltd., Hyderabad                 |
| 3.      | Biolep WP                  | <i>B. t.</i> var. <i>kurstaki</i> -I                 | H-3a,3b   | 3000 IU    | 2.0 g                                    | Biotech International Ltd., New Delhi      |
| 4.      | Bioasp WP                  | <i>B. t.</i> var. <i>kurstaki</i> -II                | H-3a,3b   | 3000 IU    | 2.0 g                                    | Biotech International Ltd., New Delhi      |
| 5.      | Halt WP                    | <i>B. t.</i> var. <i>kurstaki</i>                    | 3a,3b,3c  | 55,000(SU) | 2.00 g                                   | Wockhardt Ltd. Bombay                      |
| 6.      | Agree WP                   | <i>B. t.</i> var. <i>kurstaki</i><br>X <i>aizwai</i> | GC-91     | *          | 2.00 g                                   | Hindustan Ciba Geigy Ltd., Bombay          |
| 7.      | Biotox WP                  | <i>B. t.</i> var. <i>thuringiensis</i>               | H-1       | 1,500 IU   | 2.00 g                                   | Biotech International Ltd., New Delhi      |
| 8.      | Centari WG                 | <i>B. t.</i> var. <i>aizwai</i>                      | *         | 15,000 IU  | 2.00 g                                   | Lupin Laboratories Ltd., New Delhi         |

\* Not available  
IU = International Units  
SU = Spodoptera Units

#### **3.2.4 Analysis of Data**

Taking into consideration healthy and infested fruits, the per cent fruit damage was worked out. The data on per cent fruit damage and yield of marketable fruits were subjected to statistical analysis.

Chapter Opener Page

## RESULTS

## 4. RESULTS

Results of the laboratory and field experiments carried out to test the efficacy of different formulated products of *Bacillus thuringiensis* (Berliner) viz., Dipel 8 L B.t. k, Delfin B.t. k, Biolep B.t. k, Halt B.t. k, Agree B.t. k X a, Biotox B.t. t and Centari B.t. a against the larvae of *E. vittella* on okra are presented in this chapter.

### 4.1 EFFICACY OF DIFFERENT FORMULATED PRODUCTS OF *B.t.* VARIETIES AGAINST *E. vittella* UNDER LABORATORY CONDITIONS

The observations on larval mortality obtained at 12, 24, 36, 48 and 60 hrs after treatment were subjected to statistical analysis. Corrected mortality percentages were worked out by using Abbott's formula. The data were further processed for probit analysis to get regression equation. LT<sub>50</sub> values obtained for different products along with aforesaid details are given in Table 2. Graphical presentation of Log Time and Probit Kill is illustrated in Figure 1 and 2.

It could be seen from the data (Table 2) that highest larval mortality of 23.08, 38.47, 76.92, 92.30 and 100 per cent were recorded for 12, 24, 36, 48 and 60 hrs after the treatments, respectively with Dipel B.t. k, whereas Centari B.t. a recorded the least larval mortality of 7.70, 15.39, 38.47, 69.23 and 76.92 per cent for 12, 24, 36, 48 and 60 hrs of treatment, respectively.

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Table 2. LABORATORY TESTING OF DIFFERENT FORMULATED PRODUCTS OF *B.t.* VARIETIES AGAINST *E. vittella*

| Sr. Treatment No.                | Dose (litre <sup>-1</sup> ) | Corrected per cent mortality of larvae of <i>E. vittela</i> |       |       |       |        |                           |                     |                         |                 |
|----------------------------------|-----------------------------|-------------------------------------------------------------|-------|-------|-------|--------|---------------------------|---------------------|-------------------------|-----------------|
|                                  |                             | Hours after treatment                                       |       |       |       |        | Regression equation       | Heterogeneity at 5% | LT <sub>50</sub> (hrs.) | Fiducial limits |
|                                  |                             | 12                                                          | 24    | 36    | 48    | 60     |                           |                     |                         |                 |
| 1. Dipel 8 L<br><i>B.t. k</i>    | 1.5 ml                      | 23.08                                                       | 38.47 | 76.92 | 92.30 | 100.00 | y = 4.0600 In(x) + 8.7752 | 2.8464              | 24.71                   | 18.65<br>32.30  |
| 2. Delfin WG<br><i>B.t. k</i>    | 2.0 g                       | 15.39                                                       | 30.77 | 69.23 | 84.62 | 100.00 | y = 4.3178 In(x) + 9.9546 | 1.5043              | 29.07                   | 23.09<br>36.58  |
| 3. Biolep WP<br><i>B.t. k</i>    | 2.0 g                       | 7.70                                                        | 23.08 | 46.15 | 69.23 | 84.62  | y = 3.9700 In(x) + 9.2244 | 0.4884              | 38.28                   | 30.55<br>47.97  |
| 4. Bioasp WP<br><i>B.t. k</i>    | 2.0 g                       | 7.70                                                        | 15.39 | 43.85 | 69.23 | 84.62  | y = 4.4883 In(x) +11.1069 | 0.4184              | 38.77                   | 31.62<br>46.77  |
| 5. Halt WP<br><i>B.t. k</i>      | 2.0 g                       | 15.39                                                       | 30.77 | 61.54 | 84.61 | 100.00 | y = 4.2761 In(x) + 9.8641 | 2.0713              | 29.92                   | 23.87<br>37.49  |
| 6. Agree WP<br><i>B.t. k X a</i> | 2.0 g                       | 7.70                                                        | 23.08 | 46.15 | 76.92 | 84.61  | y = 4.1638 In(x) + 9.8605 | 0.8631              | 37.06                   | 29.84<br>46.01  |
| 7. Biotox WP<br><i>B.t. t</i>    | 2.0 g                       | 15.39                                                       | 30.77 | 61.54 | 76.92 | 92.30  | y = 3.5800 In(x) + 7.5116 | 0.2910              | 31.25                   | 23.66<br>40.34  |
| 8. Centari WG<br><i>B.t. a</i>   | 2.0 g                       | 7.70                                                        | 15.39 | 38.47 | 69.23 | 76.92  | y = 4.0657 In(x) + 9.7480 | 0.9130              | 42.20                   | 34.20<br>52.56  |

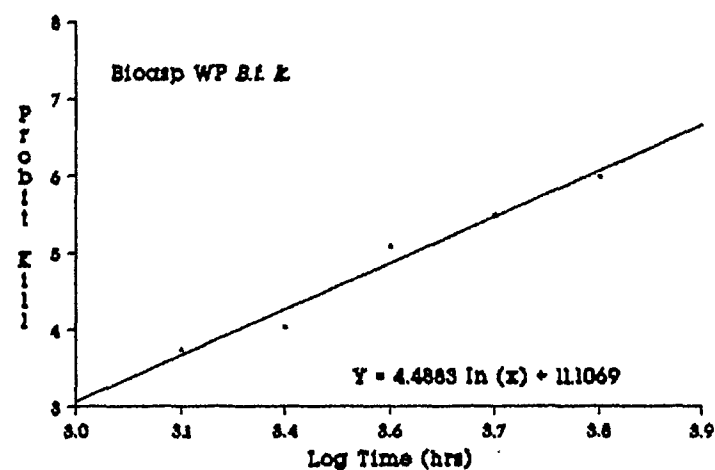
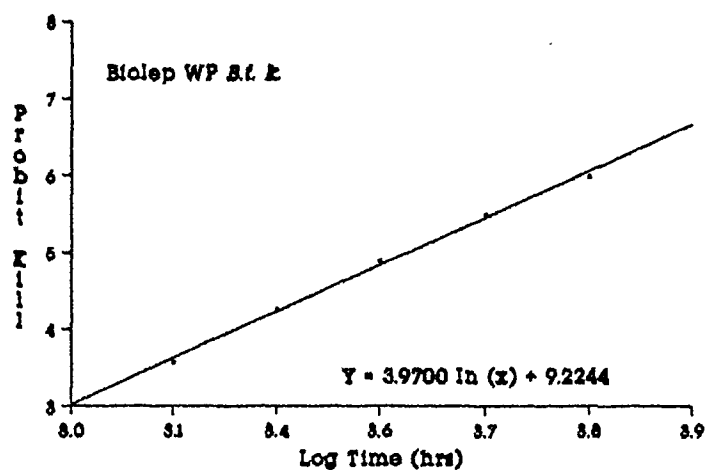
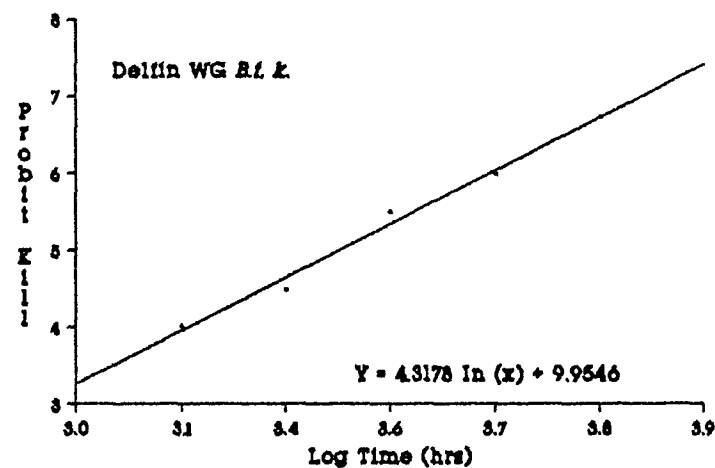
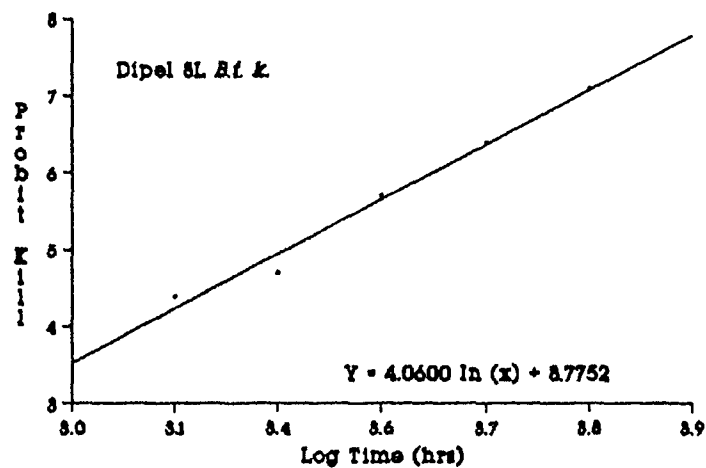


FIG.1 : LOG TIME - PROBIT KILL REGRESSION LINES FOR B.t. PRODUCTS AGAINST FIRST INSTAR LARVAE OF *E. vittella* (LT50)

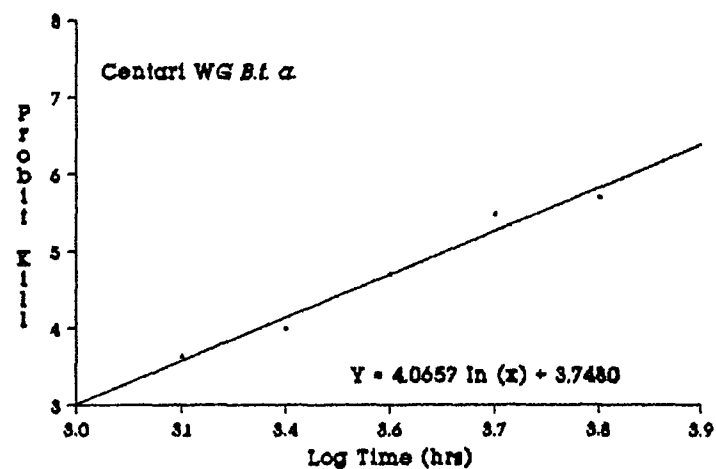
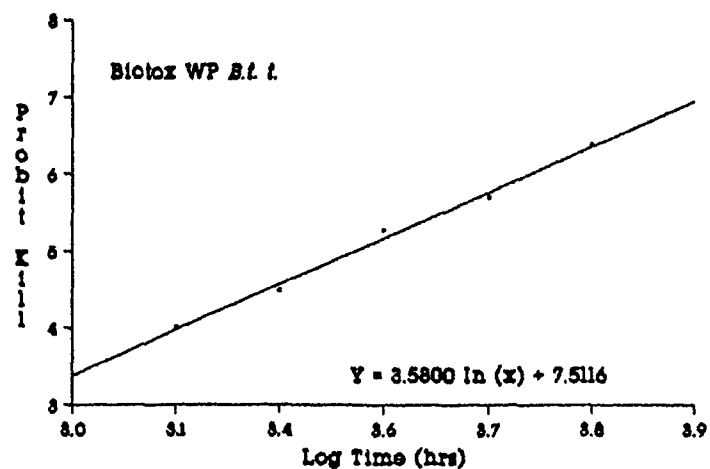
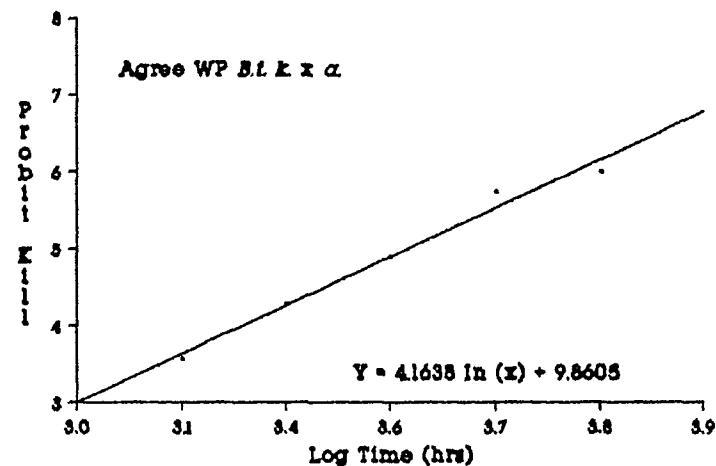
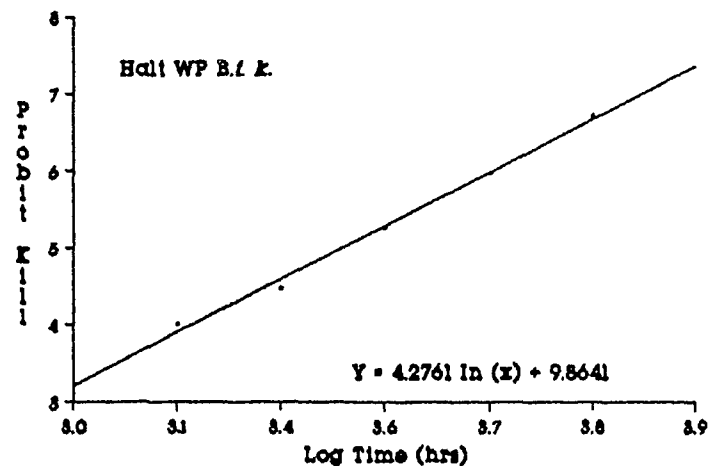


FIG.2 : LOG TIME - PROBIT KILL REGRESSION LINES FOR *B.t.* PRODUCTS AGAINST FIRST INSTAR LARVAE OF *E. vittella*. (LT50)

After 12 hrs of treatment, various formulations of *B.t.* var. *kurstaki* gave 7.70 to 23.08 per cent larval mortality, whereas Biotox *B.t.* *t* and Centari *B.t.* *a* recorded 15.39 and 7.70 per cent larval mortality, respectively.

After 24 hrs of treatment, the highest larval mortality of 38.47 per cent was recorded with Dipel *B.t.* *k* and least larval mortality of 15.39 per cent was recorded in the treatments with Bioasp *B.t.* *k* and Centari *B.t.* *a*. Whereas larval mortality of 30.77 per cent was recorded in treatments with Biotox *B.t.* *t*. While, rest of the treatments of *B.t.* *k* viz., Delfin, Biolep and Halt gave 30.77, 28.08 and 30.77 per cent larval mortality, respectively and 23.08 per cent larval mortality was recorded with Agree *B.t.* *k X a*.

After 36 hrs of treatment, the highest larval mortality of 76.92 per cent was recorded in the treatment with Dipel *B.t.* *k* and least larval mortality of 38.47 per cent was recorded with Centari *B.t.* *a*. While, 69.23, 46.15, 46.15, 43.85, 61.54 and 61.54 per cent larval mortality was recorded in treatments with Delfin *B.t.* *k*, Agree *B.t.* *k X a*, Biolep *B.t.* *k*, Bioasp *B.t.* *k*, Halt *B.t.* *k* and Biotox *B.t.* *t*.

After 48 hrs of treatment, the highest larval mortality of 92.30 per cent was recorded in the treatment with Dipel *B.t.* *k*, whereas 76.92 per cent larval mortality was recorded with Biotox *B.t.* *t* and 69.23 per cent mortality with

Centari *B.t. a*. While, rest of the treatments of *B.t. k* viz., Delfin, Biolep, Bioasp, Halt gave 84.62, 69.23, 69.23, 84.61 per cent larval mortality, respectively and 76.92 per cent larval mortality was recorded with Agree *B.t. k X a*.

After 60 hrs of treatment, 100 per cent larval mortality was recorded with Dipel *B.t. k*, Delfin *B.t. k* and Halt *B.t. k*. While, least larval mortality of 76.92 per cent was recorded in the treatment with Centari *B.t. a*. The formulation Biotox of *B.t. t* gave 92.30 per cent larval mortality. Whereas, rest of the formulations of *B.t. k* viz., Biolep, Bioasp gave 84.62 per cent larval mortality. While, 84.61 per cent larval mortality was recorded with Agree *B.t. k X a*.

It is also evident from the Table 2 that the Dipel *B.t. k* recorded the least LT<sub>50</sub> value of 24.71 hrs. Whereas, the highest LT<sub>50</sub> value of 42.20 hrs was observed with Centari *B.t. a*. The estimated LT<sub>50</sub> values of 29.07, 38.28, 38.77 and 29.92 hrs were observed with the different formulations of *B.t. k* viz., Delfin, Biolep, Bioasp and Halt, respectively and Agree formulation of *B.t. k X a* recorded LT<sub>50</sub> value of 37.06 hrs. Whereas, Biotox *B.t. t* has LT<sub>50</sub> value of 31.25 hrs. On the basis of fiducial limits, there were no significant differences among the various formulations of *B.t.* varieties i.e. *B.t. k*, *B.t. t* and *B.t. k X a*. However, *B.t. a* with the



formulation of Centari WG recorded high values of upper (52.56 hrs) and lower (34.20 hrs) fiducial limits.

The interspecific comparison of different formulated products of *B.t.* varieties indicated higher efficacy of *B.t.* var. *kurstaki* and *B.t.* var. *thuringiensis* against *E. vittella* as compared to *B.t.* var. *kurstaki* X *aizwai* and *B.t.* var. *aizwai*.

#### 4.2 EFFICACY OF DIFFERENT FORMULATED PRODUCTS OF *B.t.* VARIETIES UNDER FIELD CONDITIONS

Efficacy of different formulated products of *B.t.* varieties were tested in *Kharif* 1994, *Kharif* 1995 and *Summer* 1995 for the control of *E. vittella* on okra. The statistical analysis of the experimental data regarding efficacy of *B.t.* products viz., Dipel 8 L, Delfin WG, Biolep WP, Bioasp WP, Halt WP formulations of *B.t.* var. *kurstaki*, Agree WP formulation of *B.t. kurstaki* X *aizwai*, Biotox WP formulation of *B.t.* var. *thuringiensis* and Centari WG formulation of *B.t.* var. *aizwai* against *E. vittella* is presented in Tables 3 to 6.

##### 4.2.a Season : *Kharif* 1994

It could be seen from the Table 3 that all treatments were significantly superior over control, when per cent fruit damage per plot on 4 and 9 days after the treatment were taken into consideration.

Table 3. BIOEFFICACY OF DIFFERENT FORMULATED PRODUCTS OF *B.t.* VARIETIES AGAINST *E. vittella* UNDER FIELD CONDITIONS (Season : Kharif 1994)

| Treatment                | Precount  | Per cent fruit damage days after treatment |         |                       |         |                       |         |                       |         |         |         | Yield<br>(q/ha) |
|--------------------------|-----------|--------------------------------------------|---------|-----------------------|---------|-----------------------|---------|-----------------------|---------|---------|---------|-----------------|
|                          |           | 1 <sup>st</sup> spray                      |         | 2 <sup>nd</sup> spray |         | 3 <sup>rd</sup> spray |         | 4 <sup>th</sup> spray |         | Mean    |         |                 |
|                          |           | 4 DAT                                      | 9 DAT   | 4 DAT                 | 9 DAT   | 4 DAT                 | 9 DAT   | 4 DAT                 | 9 DAT   | 4 DAT   | 9 DAT   |                 |
| Dipel 8 L                | 11.87     | 11.72                                      | 11.37   | 10.97                 | 10.13   | 7.96                  | 6.32    | 11.89                 | 10.97   | 10.64   | 9.70    | 84.36           |
| <i>B.t. k</i>            | (20.18) * | (20.00)                                    | (19.73) | (19.37)               | (18.53) | (16.43)               | (14.54) | (20.18)               | (19.37) | (19.00) | (18.15) |                 |
| Delfin WG                | 12.98     | 12.31                                      | 11.98   | 11.25                 | 10.95   | 8.98                  | 6.76    | 12.72                 | 12.03   | 11.32   | 10.21   | 82.96           |
| <i>B.t. k</i>            | (21.13)   | (20.53)                                    | (20.27) | (19.64)               | (19.37) | (17.46)               | (15.12) | (20.88)               | (20.27) | (19.64) | (18.63) |                 |
| Biolep WP                | 13.46     | 14.13                                      | 13.69   | 13.14                 | 11.62   | 10.89                 | 8.97    | 16.92                 | 15.73   | 13.77   | 12.50   | 73.49           |
| <i>B.t. k</i>            | (21.56)   | (22.06)                                    | (21.72) | (21.22)               | (19.91) | (19.28)               | (17.46) | (24.27)               | (23.34) | (21.81) | (20.70) |                 |
| Bioasp WP                | 12.50     | 15.12                                      | 14.58   | 14.09                 | 12.98   | 11.41                 | 10.67   | 17.23                 | 16.43   | 14.46   | 13.67   | 71.82           |
| <i>B.t. k</i>            | (20.70)   | (22.87)                                    | (22.46) | (22.06)               | (21.13) | (19.73)               | (19.09) | (24.50)               | (23.89) | (22.38) | (21.72) |                 |
| Halt WP                  | 13.18     | 12.87                                      | 12.31   | 11.83                 | 11.26   | 9.38                  | 6.98    | 13.96                 | 12.14   | 12.01   | 10.67   | 81.25           |
| <i>B.t. k</i>            | (21.30)   | (21.05)                                    | (20.53) | (20.09)               | (19.64) | (17.85)               | (15.34) | (21.97)               | (20.36) | (20.27) | (19.09) |                 |
| Agree WP                 | 13.77     | 15.77                                      | 14.73   | 14.27                 | 13.64   | 11.82                 | 10.73   | 17.83                 | 16.98   | 14.92   | 14.02   | 70.21           |
| <i>B.t. k</i> X <i>a</i> | (21.81)   | (23.42)                                    | (22.55) | (22.22)               | (21.64) | (20.09)               | (19.09) | (24.95)               | (24.35) | (22.41) | (21.97) |                 |
| Biotox WP                | 14.21     | 13.21                                      | 13.17   | 12.62                 | 11.53   | 9.87                  | 7.24    | 15.38                 | 14.16   | 12.77   | 11.53   | 79.96           |
| <i>B.t. t</i>            | (22.14)   | (21.30)                                    | (21.30) | (20.79)               | (19.82) | (18.34)               | (15.68) | (23.11)               | (22.14) | (20.96) | (19.82) |                 |
| Centari WG               | 12.83     | 17.49                                      | 17.12   | 16.93                 | 15.78   | 13.73                 | 12.86   | 18.96                 | 18.12   | 16.78   | 15.97   | 68.43           |
| <i>B.t. a</i>            | (20.96)   | (24.73)                                    | (24.43) | (24.27)               | (23.42) | (21.72)               | (21.05) | (25.84)               | (25.18) | (24.20) | (23.50) |                 |
| Control                  | 11.81     | 25.88                                      | 25.41   | 30.83                 | 32.78   | 33.92                 | 35.25   | 38.78                 | 41.01   | 32.35   | 33.61   | 49.15           |
|                          | (20.09)   | (30.59)                                    | (30.26) | (33.71)               | (34.94) | (35.61)               | (36.45) | (38.53)               | (39.82) | (34.70) | (35.43) |                 |
| S.E. $\pm$               | 0.91      | 0.97                                       | 0.78    | 0.82                  | 0.77    | 0.70                  | 0.98    | 0.78                  | 0.82    | 0.44    | 0.50    | 1.69            |
| C.D. at 5%               | N.S.      | 2.91                                       | 2.34    | 2.46                  | 2.31    | 2.10                  | 2.94    | 2.34                  | 2.46    | 1.32    | 1.50    | 5.07            |

DAT = Days After Treatment.

\*Figures in parentheses are arcsin values.

After 4 days of the 1<sup>st</sup> spray, significantly least fruit damage i.e. 11.72 per cent was recorded in the treatment with Dipel *B.t. k*, which was at par with Delfin *B.t. k*, Halt *B.t. k*, Biotox *B.t. t* and Biolep *B.t. k* resulting in 12.31, 12.87, 13.21 and 14.13 per cent fruit damage, respectively. This was followed by Bioasp *B.t. k* and Agree *B.t. k X a* with 15.12 and 15.77 per cent fruit damage, respectively. While, in the treatment with Centari formulation of *B.t. var. aizwai* highest fruit damage of 17.49 per cent was noticed. Similar trend of efficacy of *B.t.* products was noticed on 9 days after the treatment.

After 4 days of the 2<sup>nd</sup> spray, the per cent fruit damage recorded in treatments with different formulations of *B.t. var. kurstaki* viz., Dipel, Delfin, Biolep, Bioasp and Halt was 10.97, 11.25, 13.14, 14.09 and 11.83 per cent, respectively. While, Agree *B.t. k X a* and Biotox *B.t. t* resulted in 14.27 and 12.62 per cent fruit damage, respectively. The maximum per cent of fruit damage was recorded in the treatment with Centari. Similar trend was noticed on 9 days after the treatment.

After 4 and 9 days of the 3<sup>rd</sup> spray, significantly minimum fruit damage was recorded with different treatments over the control. On 4 days after the treatment, least fruit damage of 7.96 per cent was recorded with Dipel *B.t. k* and was at par with Delfin *B.t. k*, Halt *B.t. k* and Biotox *B.t. t* with

8.98, 9.38 and 9.87 per cent fruit damage, respectively which was followed by Biolep *B.t. k*, Bioasp *B.t. k*, Agree *B.t. k* and Centari *B.t. a* giving 10.89, 11.41, 11.82 and 13.73 per cent fruit damage, respectively. On 9 days after treatment, 6.32 per cent fruit damage was observed in Dipel *B.t. k*, which was at par with Delfin *B.t. k*, Halt *B.t. k*, Biotox *B.t. t* and Biolep *B.t. k* showing 6.76, 6.98, 7.25, 8.97 per cent fruit damage, respectively. This was followed by Agree *B.t. k* and Centari *B.t. a* in which 10.73 and 12.86 per cent fruit damage was recorded, respectively.

After 4 days of the 4<sup>th</sup> spray, 11.89 per cent fruit damage was recorded in Dipel *B.t. k* which was at par with Delfin *B.t. k*, Halt *B.t. k* indicating 12.72 and 13.96 per cent fruit damage, respectively. This was followed by Biotox *B.t. t*, Biolep *B.t. k*, Agree *B.t. k X a*, Centari *B.t. a*, Bioasp *B.t. a* in which 15.38, 16.92, 17.23, 17.83, 18.96 per cent fruit damage was observed, respectively. Similar trend of efficacy of *B.t.* products was noticed on 9 days after treatment.

It is also observed from the Table 3 that average mean of per cent fruit damage in *Kharif* 1994 with different formulations of *B.t.* var. *kurstaki* viz., Dipel, Delfin, Biolep, Bioasp and Halt on 4 days after treatment was 10.64, 11.32, 13.77, 14.46 and 12.01 per cent, respectively. Whereas, 14.92 and 14.16 per cent fruit damage was recorded in treatments of Agree *B.t. k X a* and Biotox *B.t. t*. The maximum

fruit damage (16.78%) was observed in the treatment with Centari formulation of *B.t.* var. *aizwai*. On 9 days after treatment, 9.70 per cent fruit damage was observed in Dipel *B.t. k* which was at par with Delfin and Halt formulations of *B.t.* var. *kurstaki* with 10.21 and 10.67 per cent fruit damage, respectively. This was followed by Biotox *B.t. t*, Agree *B.t. k X a* and Centari *B.t. a* showing 11.53, 14.02 and 15.97 per cent fruit damage, respectively.

In case of yield of marketable fruits (Table 3) as influenced by different formulated products of *B.t.* varieties was ranged between 68.43 to 84.36 q/ha. The treatment with Dipel *B.t. k* was the most promising and gave highest yield (84.36 q/ha) of marketable fruits. This was followed by treatments with Delfin *B.t. k* (82.96 q/ha) and Halt *B.t. k* (81.25 q/ha). The next promising treatment was Biolep *B.t. k* (73.49 q/ha) followed by Bioasp *B.t. k* (71.82 q/ha), Agree *B.t. k X a* (70.2 q/ha) and Centari *B.t. a* (68.45 q/ha) as against in untreated control (45.15 q/ha).

#### 4.2.b Season : *Kharif* 1995

During *Kharif* 1995, same products of *B.t.* varieties were tested. Table 4 shows that after 4 days of the 1<sup>st</sup> spray, least fruit damage of 10.52 per cent was recorded in the treatment with Dipel *B.t. k*, which was at par with Delfin *B.t. k* and Halt *B.t. k* with 11.67 and 12.83 per cent fruit

Table 4. BIOEFFICACY OF DIFFERENT FORMULATED PRODUCTS OF *B.t.* VARIETIES AGAINST *E. vittella* UNDER FIELD CONDITIONS (Season : Kharif 1995)

| Treatment         | Precount | Per cent fruit damage days after treatment |         |                       |         |                       |         |                       |         |         |         | Yield<br>(q/ha) |
|-------------------|----------|--------------------------------------------|---------|-----------------------|---------|-----------------------|---------|-----------------------|---------|---------|---------|-----------------|
|                   |          | 1 <sup>st</sup> spray                      |         | 2 <sup>nd</sup> spray |         | 3 <sup>rd</sup> spray |         | 4 <sup>th</sup> spray |         | Mean    |         |                 |
|                   |          | 4 DAT                                      | 9 DAT   | 4 DAT                 | 9 DAT   | 4 DAT                 | 9 DAT   | 4 DAT                 | 9 DAT   | 4 DAT   | 9 DAT   |                 |
| Dipel 8 L         | 17.21    | 10.52                                      | 12.01   | 11.14                 | 11.45   | 13.69                 | 11.29   | 15.87                 | 12.83   | 12.81   | 11.90   | 81.44           |
| <i>B.t. k</i>     | (24.50)* | (18.91)                                    | (20.27) | (19.46)               | (19.82) | (21.72)               | (19.64) | (23.50)               | (20.96) | (20.96) | (20.18) |                 |
| Delfin WG         | 13.77    | 11.67                                      | 13.22   | 11.95                 | 12.30   | 14.27                 | 12.13   | 16.22                 | 13.78   | 13.53   | 12.86   | 79.83           |
| <i>B.t. k</i>     | (21.81)  | (20.00)                                    | (21.30) | (20.27)               | (20.53) | (22.22)               | (20.36) | (23.73)               | (21.81) | (21.64) | (21.05) |                 |
| Biolep WP         | 15.30    | 13.89                                      | 15.79   | 14.91                 | 14.25   | 16.47                 | 14.15   | 17.26                 | 15.35   | 15.63   | 14.89   | 71.69           |
| <i>B.t. k</i>     | (23.03)  | (21.89)                                    | (23.42) | (22.71)               | (22.22) | (23.97)               | (22.14) | (24.58)               | (23.11) | (23.26) | (22.71) |                 |
| Bioasp WP         | 12.19    | 14.82                                      | 16.22   | 15.22                 | 14.95   | 17.21                 | 14.90   | 18.71                 | 17.88   | 16.49   | 15.99   | 69.47           |
| <i>B.t. k</i>     | (20.44)  | (22.63)                                    | (23.73) | (22.95)               | (22.79) | (24.50)               | (22.71) | (25.62)               | (25.03) | (23.97) | (23.58) |                 |
| Halt WP           | 14.35    | 12.83                                      | 13.98   | 13.24                 | 13.19   | 14.66                 | 12.21   | 16.88                 | 14.12   | 14.40   | 13.38   | 77.63           |
| <i>B.t. k</i>     | (22.30)  | (20.96)                                    | (21.97) | (21.30)               | (21.30) | (22.55)               | (20.44) | (24.27)               | (22.06) | (22.30) | (21.06) |                 |
| Agree WP          | 14.11    | 15.72                                      | 17.31   | 15.97                 | 16.25   | 17.96                 | 16.00   | 19.21                 | 18.00   | 17.22   | 16.89   | 66.57           |
| <i>B.t. k X a</i> | (22.06)  | (23.34)                                    | (24.58) | (23.58)               | (23.81) | (25.10)               | (23.58) | (25.99)               | (25.10) | (23.73) | (24.27) |                 |
| Biotox WP         | 16.12    | 13.12                                      | 15.10   | 14.75                 | 13.29   | 15.87                 | 13.12   | 17.21                 | 15.00   | 15.24   | 14.13   | 74.35           |
| <i>B.t. t</i>     | (23.66)  | (21.22)                                    | (22.87) | (22.63)               | (21.39) | (23.50)               | (21.22) | (24.50)               | (22.79) | (22.95) | (22.05) |                 |
| Centari WG        | 12.98    | 16.46                                      | 18.22   | 17.12                 | 18.42   | 18.86                 | 17.00   | 20.69                 | 18.10   | 18.28   | 17.94   | 64.72           |
| <i>B.t. a</i>     | (21.13)  | (23.97)                                    | (25.25) | (24.43)               | (25.40) | (25.77)               | (24.35) | (27.06)               | (25.18) | (25.33) | (25.03) |                 |
| Control           | 15.92    | 26.31                                      | 28.93   | 31.97                 | 33.44   | 35.22                 | 39.96   | 41.24                 | 42.96   | 33.69   | 36.33   | 46.89           |
|                   | (23.50)  | (30.85)                                    | (35.52) | (34.45)               | (35.30) | (36.39)               | (39.23) | (39.93)               | (40.98) | (35.49) | (37.05) |                 |
| S.E. $\pm$        | 0.89     | 0.78                                       | 0.97    | 0.93                  | 1.09    | 0.99                  | 1.03    | 0.95                  | 1.15    | 0.81    | 0.97    | 1.41            |
| C.D. at 5%        | N.S.     | 2.34                                       | 2.91    | 2.79                  | 3.27    | 2.97                  | 3.09    | 2.85                  | 3.45    | 2.43    | 2.91    | 4.23            |

DAT = Days After Treatment.

\* Figures in parentheses are arcsin values.

damage, respectively. Whereas, 13.12 per cent fruit damage was recorded in the treatment with Biotox formulation of *B.t.* var. *thuringiensis* and was at par with Biolep and Bioasp formulations of *B.t.* var. *kurstaki* in which 13.89 and 14.82 per cent fruit damage was recorded, respectively. This was followed by Agree *B.t. k X a* in which 15.72 per cent fruit damage was observed. The maximum fruit damage of 16.46 per cent was recorded in the treatment with Centari *B.t. a*. Similar trend of efficacy of *B.t.* products was noticed on 9 days after the treatment.

After 4 days of the 2<sup>nd</sup> spray, 11.14 per cent fruit damage was noticed in Dipel *B.t. k* which was at par with Delfin *B.t. k* and Halt *B.t. k* with 13.22 and 13.98 per cent fruit damage, respectively. The formulation Biotox *B.t. t* showed 14.75 per cent fruit damage. This was followed by rest of the formulations of *B.t.* var. *kurstaki*, Biolep and Bioasp recording 14.91 and 15.22 per cent fruit damage, respectively. While, 15.97 per cent fruit damage was recorded in Agree *B.t. k X a*. The maximum 17.12 per cent fruit damage was noticed in the treatment with Centari formulation of *B.t.* var. *aizwai*. On 9 days after treatment, 11.45 per cent fruit damage was recorded in the treatment with Dipel *B.t. k*, which was at par with Delfin *B.t. k*, Halt *B.t. k* and Biotox *B.t. t* giving 12.30, 13.19, 13.29 per cent fruit damage, respectively. This was followed by Biolep *B.t. k*, Bioasp *B.t. k*, Agree *B.t. k X a*

in which 14.25, 14.95, 16.25 per cent fruit damage was recorded, respectively. The maximum fruit damage of 18.42 per cent was noticed in Centari *B.t. k.* among the B.t. treatments.

After 4 days of the 3<sup>rd</sup> spray, 13.69 per cent fruit damage was recorded in Dipel *B.t. k* which was at par with Delfin *B.t. k*, Halt *B.t. k*, Biotox *B.t. t* and Biolep *B.t. k* with 14.27, 14.66, 15.87, 16.47 per cent fruit damage, respectively. This was followed by Bioasp *B.t. k*, Agree *B.t. k X a* and Centari *B.t. a* in which 17.21, 17.96 and 18.86 per cent fruit damage was recorded, respectively. Similar trend of efficacy was noticed on 9 days after the treatment.

After 4 days of the 4<sup>th</sup> spray, 15.87 per cent fruit damage was recorded in Dipel *B.t. k* and was at par with Delfin *B.t. k*, Halt *B.t. k*, Biotox *B.t. t*, Biolep *B.t. k* and Bioasp *B.t. k* in which 16.22, 16.88, 17.21, 17.26, 18.71 per cent fruit damage was observed, respectively. This was followed by Agree *B.t. k X a* and Centari *B.t. a* in which 19.12 and 20.69 per cent fruit damage was noticed, respectively. On 9 days after the treatment significantly least fruit damage (12.83%) was recorded in the treatment with Dipel *B.t. k*. It was at par with Delfin *B.t. k*, Halt *B.t. k*, Biotox *B.t. t* and Biolep *B.t. k* in which 13.78, 14.12, 15.00 and 15.35 per cent fruit damage was recorded, respectively. This was followed by Bioasp *B.t. k*, Agree *B.t. k X a* and Centari *B.t. a* with 17.88, 18.00 and 18.10 per cent fruit damage, respectively.

From the Table 4, it is also evident that average mean of 4 sprays on 4 days after the treatment showed significantly minimum of 12.81 per cent fruit damage ~~was~~ in treatment with Dipel formulation of *B.t.* var. *kurstaki*, which was at par with Delfin and Halt formulations of *B.t.* var. *kurstaki* and Biotox formulation of *B.t.* var. *thuringiensis* with 13.53, 14.40 and 15.24 per cent fruit damage, respectively. This was followed by rest of the formulations of *B.t.* var. *kurstaki* viz., Biolep and Bioasp in which 15.63 and 16.49 per cent fruit damage was noticed, respectively and Agree formulations of *B.t.* var. *k X a* recorded 17.22 per cent fruit damage. While, maximum fruit damage (18.28%) was recorded in the treatment with Centari formulation of *B.t.* var. *aizwai*. Similar trend of efficacy of *B.t.* products was also noticed on 9 days after the treatment.

In case of yield of marketable fruits of okra during the season as influenced by different formulations of *B.t.* varieties, the maximum yield was obtained in the treatment with Dipel *B.t.* *k* (81.44 q/ha). This was followed by Delfin (79.83 q/ha), Halt (77.63 q/ha) formulation of *B.t.* var. *kurstaki*. The next promising treatments were Biolep *B.t.* *k* (71.69 q/ha) followed by Bioasp *B.t.* *k* (69.47 q/ha) and Agree *B.t.* *k X a* (66.57 q/ha). The minimum yield of marketable fruits was obtained in the treatment with Centari (64.72 q/ha) formulation of *B.t.* var. *aizwai* as against 46.89 q/ha in untreated control.

Table 5. BIOEFFICACY OF DIFFERENT FORMULATED PRODUCTS OF *B.t.* VARIETIES AGAINST *E. vittella* UNDER FIELD CONDITIONS (Pooled Mean : *Kharif* 1994 and 1995)

| Treatment                     | Per cent fruit damage |                  | Yield<br>(g/ha) |
|-------------------------------|-----------------------|------------------|-----------------|
|                               | 4 DAT                 | 9 DAT            |                 |
| Dipel 8 L<br><i>B.t. k</i>    | 11.73<br>(20.00) *    | 10.80<br>(19.19) | 82.90           |
| Delfin WG<br><i>B.t. k</i>    | 12.43<br>(20.62)      | 11.54<br>(19.82) | 81.40           |
| Biolep WP<br><i>B.t. k</i>    | 14.70<br>(22.50)      | 13.70<br>(24.10) | 72.59           |
| Bioasp WP<br><i>B.t. k</i>    | 15.48<br>(24.19)      | 14.83<br>(22.63) | 70.65           |
| Halt WP<br><i>B.t. k</i>      | 13.21<br>(21.30)      | 12.21<br>(20.44) | 79.44           |
| Agree WP<br><i>B.t. k X a</i> | 16.07<br>(23.66)      | 15.46<br>(23.19) | 68.39           |
| Biotox WP<br><i>B.t. t</i>    | 14.01<br>(21.97)      | 12.83<br>(21.05) | 77.16           |
| Centari WG<br><i>B.t. a</i>   | 17.53<br>(24.73)      | 16.70<br>(24.12) | 66.58           |
| Control                       | 33.02<br>(35.06)      | 34.97<br>(36.27) | 48.02           |
| S.E. $\pm$                    | 0.49                  | 0.80             | 1.42            |
| C.D. at 5%                    | 1.47                  | 2.40             | 4.26            |

DAT = Days after treatment.

\*Figures in parentheses are arcsin values.

The pooled mean of per cent fruit damage of *Kharif* 1994 and 1995 given in Table 5 revealed that on 4 days after the treatment, significantly least fruit damage of 11.73 per cent

was recorded in the treatment with Dipel *B.t. k*, which was at par with Delfin *B.t. k* and Halt *B.t. k* resulting in 12.43 and 13.12 per cent fruit damage, respectively. This was followed by Biotox *B.t. t* with 14.01 per cent fruit damage and was at par with Biolep *B.t. k*, Bioasp *B.t. k* in which 14.70 and 15.48 per cent fruit damage was recorded, respectively. In the treatment with Agree *B.t. k X a* 16.07% fruit damage was recorded. The maximum fruit damage (17.53%) per cent was recorded in the treatment with Centari *B.t. a*. On 9 days after the treatment, similar trend of efficacy of *B.t.* products was noticed.

In case of pooled yield of *Kharif* 1994 and 1995, it was observed that maximum yield was obtained in the treatment with Dipel *B.t. k* (82.90 q/ha). This was followed by Delfin *B.t. k* (81.40 q/ha), Halt *B.t. k* (79.44 q/ha), Biotox *B.t. t* (77.10 q/ha), Biolep *B.t. k* (72.59 q/ha), Bioasp *B.t. k* (70.65 q/ha) and Agree *B.t. k X a* (68.39 q/ha). Comparatively less yield was obtained in the treatment with Centari (66.58 q/ha) formulation of *B.t. var. aizwai*, whereas <sup>it was least</sup> in untreated control 48.02 q/ha.

#### 4.2.c Season : *Summer* 1995

During *Summer* 1995, same formulated products of *B.t.* variety were tested under field conditions. It could be seen from the Table 6 that after 4 days of the 1<sup>st</sup> spray,

Table 6. BIOEFFICACY OF DIFFERENT FORMULATED PRODUCTS OF *B.t.* VARIETIES AGAINST *E. vittella* UNDER FIELD CONDITIONS (Season : Summer 1995)

| Treatment         | Precount | Per cent fruit damage days after treatment |         |                       |         |                       |         |                       |         |         |         | Yield<br>(q/ha) |
|-------------------|----------|--------------------------------------------|---------|-----------------------|---------|-----------------------|---------|-----------------------|---------|---------|---------|-----------------|
|                   |          | 1 <sup>st</sup> spray                      |         | 2 <sup>nd</sup> spray |         | 3 <sup>rd</sup> spray |         | 4 <sup>th</sup> spray |         | Mean    |         |                 |
|                   |          | 4 DAT                                      | 9 DAT   | 4 DAT                 | 9 DAT   | 4 DAT                 | 9 DAT   | 4 DAT                 | 9 DAT   | 4 DAT   | 9 DAT   |                 |
| Dipel 8 L         | 18.31    | 15.33                                      | 13.33   | 16.96                 | 15.08   | 15.71                 | 13.02   | 15.33                 | 12.62   | 15.83   | 13.51   | 65.17           |
| <i>B.t. k</i>     | (23.81)* | (23.03)                                    | (21.39) | (24.35)               | (22.87) | (23.34)               | (21.13) | (23.03)               | (20.79) | (23.42) | (21.56) |                 |
| Delfin WG         | 17.12    | 15.66                                      | 13.66   | 17.47                 | 15.63   | 16.21                 | 13.41   | 15.85                 | 12.89   | 16.30   | 13.90   | 63.97           |
| <i>B.t. k</i>     | (24.43)  | (23.46)                                    | (21.64) | (24.73)               | (23.26) | (23.73)               | (21.47) | (23.50)               | (21.05) | (23.81) | (21.89) |                 |
| Biolep WP         | 22.96    | 21.00                                      | 17.16   | 22.57                 | 18.15   | 20.91                 | 17.25   | 19.86                 | 16.49   | 21.08   | 17.26   | 59.11           |
| <i>B.t. k</i>     | (28.66)  | (27.28)                                    | (24.43) | (28.38)               | (25.25) | (27.20)               | (24.58) | (26.42)               | (23.97) | (27.35) | (24.58) |                 |
| Bioasp WP         | 15.69    | 21.66                                      | 18.16   | 23.33                 | 19.55   | 20.93                 | 18.31   | 20.00                 | 17.82   | 21.48   | 18.46   | 57.98           |
| <i>B.t. k</i>     | (23.34)  | (27.69)                                    | (25.18) | (28.86)               | (26.28) | (27.20)               | (25.33) | (26.56)               | (24.92) | (27.63) | (25.48) |                 |
| Halt WP           | 17.12    | 16.66                                      | 14.16   | 18.50                 | 15.91   | 18.92                 | 13.89   | 15.92                 | 12.97   | 17.50   | 14.23   | 62.74           |
| <i>B.t. k</i>     | (24.43)  | (24.04)                                    | (22.06) | (25.48)               | (23.50) | (25.77)               | (21.89) | (23.50)               | (21.13) | (24.73) | (22.14) |                 |
| Agree WP          | 19.25    | 22.00                                      | 18.33   | 23.66                 | 19.87   | 22.20                 | 18.97   | 21.39                 | 17.93   | 22.31   | 18.78   | 56.72           |
| <i>B.t. k X a</i> | (26.06)  | (27.09)                                    | (25.33) | (29.13)               | (26.49) | (28.11)               | (25.84) | (27.56)               | (25.03) | (28.18) | (25.70) |                 |
| Biotox WP         | 18.82    | 19.29                                      | 14.16   | 20.16                 | 16.00   | 20.12                 | 14.32   | 16.12                 | 13.20   | 18.92   | 14.42   | 60.20           |
| <i>B.t. t</i>     | (27.70)  | (26.06)                                    | (22.06) | (26.71)               | (23.58) | (26.64)               | (22.22) | (23.66)               | (21.30) | (25.77) | (22.30) |                 |
| Centari WG        | 20.35    | 25.16                                      | 18.83   | 24.95                 | 20.01   | 23.85                 | 19.73   | 22.78                 | 18.12   | 24.19   | 19.17   | 53.60           |
| <i>B.t. a</i>     | (26.85)  | (30.07)                                    | (25.70) | (30.00)               | (26.56) | (29.27)               | (26.35) | (28.52)               | (25.18) | (29.47) | (25.99) |                 |
| Control           | 20.24    | 37.83                                      | 38.00   | 41.61                 | 41.41   | 42.27                 | 43.21   | 45.13                 | 46.22   | 41.71   | 42.14   | 35.15           |
|                   | (26.71)  | (37.94)                                    | (38.06) | (40.16)               | (39.87) | (40.57)               | (41.09) | (42.19)               | (42.82) | (40.22) | (40.46) |                 |
| S.E. $\pm$        | 0.64     | 1.58                                       | 1.23    | 1.18                  | 0.92    | 0.71                  | 0.75    | 0.83                  | 0.86    | 0.86    | 0.73    | 1.38            |
| C.D. at 5%        | N.S.     | 4.73                                       | 3.64    | 3.54                  | 2.75    | 2.13                  | 2.25    | 2.48                  | 2.58    | 2.19    | 2.19    | 4.14            |

DAT = Days After Treatment.

\* Figures in parentheses are arcsin values.

significantly minimum fruit damage i.e. 15.33 per cent was observed in the treatment with Dipel *B.t. k* which was at par with Delfin *B.t. k*, Halt *B.t. k* and Biotox *B.t. t* showing 15.66, 16.66 and 19.29 per cent fruit damage, respectively. This was followed by Biolep *B.t. k*, Bioasp *B.t. k* and Agree *B.t. k X a* with 21.00, 21.66 and 22.00 per cent fruit damage, respectively. While, maximum fruit damage i.e. 25.16 per cent was observed in treatment with Centari *B.t. a*. Similar trend of efficacy among different formulated products of *B.t.* varieties was noticed on 9 days after the treatment. Moreover, on 4 and 9 days after 2<sup>nd</sup> spray similar trend of efficacy also observed.

After 4 days of the 3<sup>rd</sup> spray, 15.71 per cent fruit damage was recorded in the treatment with Dipel *B.t. k*. Which was at par with Delfin *B.t. k* (16.21%). This was followed by Halt *B.t. k*, Biotox *B.t. t*, Biolep *B.t. k*, Bioasp *B.t. k* with 18.92, 20.12, 20.91 and 20.93 per cent fruit damage, respectively. In the treatment with Agree *B.t. k X a* 22.20 per cent fruit damage was observed. This treatment was at par with Centari *B.t. a* giving 23.85 per cent fruit damage. On 9 days after the treatment, significantly least fruit damage of 13.07 per cent was recorded in the treatment with Dipel *B.t. k*. It was at par with Delfin *B.t. k*, Halt *B.t. k* and Biotox *B.t. t* in which 13.41, 13.89 and 14.32 per cent fruit damage was observed, respectively. This was followed by Biolep *B.t. k*,

Bioasp *B.t. k* and Agree *B.t. k X a* in which 17.25, 18.31 and 18.97 per cent fruit damage was recorded, respectively.

After 4 days of the 4<sup>th</sup> spray, 15.33 per cent fruit damage was recorded in the treatment with Dipel *B.t. k* and was at par with Delfin *B.t. k*, Halt *B.t. k* and Biotox *B.t. t* with 15.85, 15.92 and 16.12 per cent fruit damage, respectively. This was followed by Biolep *B.t. k*, Bioasp *B.t. k* and Agree *B.t. k X a* in which 19.84, 20.00 and 21.39 per cent fruit damage was recorded, respectively. The maximum fruit damage (22.78%) was recorded in Centari *B.t. a*.

On 9 days after the treatment significantly minimum fruit damage of 12.62 per cent was recorded in the treatment with Dipel *B.t. k*. It was at par with Delfin *B.t. k*, Halt *B.t. k* and Biotox *B.t. t* giving 12.89, 12.97 and 13.20 per cent fruit damage, respectively. This was followed by Biolep *B.t. k*, Bioasp *B.t. k* and Agree *B.t. k X a* with 16.49, 17.82 and 17.93 per cent fruit damage, respectively. While, in the treatment with Centari *B.t. a*, the maximum fruit damage of 18.12 per cent was recorded.

The average mean of per cent fruit damage with different *B.t.* treatments on 4 days after treatment shows that the treatment with Dipel formulation of *B.t. var. kurstaki* was found to be superior throughout the season. The significantly least fruit damage of 15.83 per cent was recorded in Dipel

*B.t. k*, which was at par with Delfin and Halt formulations of *B.t. var. kurstaki* with 16.30 and 17.50 per cent fruit damage, respectively. This was followed by Biotox *B.t. t*, Biolep *B.t. k* and Bioasp *B.t. k* with, 18.92, 21.08 and 21.48 per cent fruit damage, respectively. However, treatment with Agree *B.t. k X a*, 22.31 per cent fruit damage was recorded which was at par with Centari formulation of *B.t. var. aizwai* with ~~24.19~~ 24.19 per cent fruit damage. ~~Maximum~~ Maximum is in untreated control.

On 9 days after the treatment, 13.51 per cent fruit damage was observed in Dipel *B.t. k*, which was at par with Delfin *B.t. k*, Halt *B.t. k* and Biotox *B.t. t* in which, 13.90, 14.23 and 14.42 per cent fruit damage was recorded, respectively. This was followed by Biolep *B.t. k*, Bioasp *B.t. k* and Agree *B.t. k X a* with 17.26, 18.46 and 18.78 per cent fruit damage, respectively and in Centari *B.t. a* 19.17 per cent fruit damage.

In case of average yield of marketable fruits as influenced by different *B.t.* treatments in Summer 1995, the maximum yield was obtained in the treatment with Dipel *B.t. k* (65.17 q/ha), which was followed by Delfin *B.t. k* (63.97 q/ha), Halt *B.t. k* (62.74 q/ha), Biotox *B.t. t* (60.20 q/ha), Biolep *B.t. k* (59.11 q/ha), Bioasp *B.t. k* (57.98 q/ha) and Agree *B.t. k X a* (56.72 q/ha). The lower yield of marketable fruits (53.60 q/ha) was obtained in treatment with Centari

*B.t.* a recorded 53.60 yield q/ha as against 35.15 q/ha in untreated control.

The overall results of three seasons (*Kharif* 1994, *Kharif* 1995 and *Summer* 1995) showed that among different formulated products of *B.t.* varieties tested for their efficacy against *E. vittella* on okra under field conditions, Dipel formulation of *B.t.* var. *kurstaki* was found to be the most superior over all other formulated products of *B.t.* varieties. The minimum percentage of fruit damage and maximum yield of marketable fruits were recorded in the treatment with Dipel. The performance of Dipel *B.t. k* was at par with Delfin and Halt formulations of *B.t.* var. *kurstaki* and also with Biotox formulation of *B.t.* var. *thuringiensis*. This was followed by Biolep and Bioasp formulations of *B.t.* var. *kurstaki* and Agree formulation of *B.t.* var. *kurstaki* X aizwai. While, Centari *B.t.* var. *aizwai* was found to be the least effective in which <sup>significantly higher</sup> percentage of fruit damage and ~~lower~~ yield of marketable fruits was observed.

Chapter Opener Page

## DISCUSSION

## 5. DISCUSSION

The results of the experiments conducted to test the relative efficacy of different formulated products of *B. thuringiensis* varieties against okra shoot and fruit borer, *E. vittella* are discussed in this chapter.

### 5.1 LABORATORY STUDIES ON EFFICACY OF DIFFERENT FORMULATED PRODUCTS OF *B.t.* VARIETIES AGAINST THE TEST INSECT

During the course of present investigation, different *B.t.* products viz., Dipel 8 L *B.t. k*, Delfin WG *B.t. k*, Biolep WP *B.t. k*, Bioasp WP *B.t. k*, Halt WP *B.t. k*, Agree WP *B.t. k* X a, Biotox WP *B.t. t* and Centari WG *B.t. a* were tested for their relative efficacy against one-day-old 1<sup>st</sup> instar larvae of the test insect under laboratory conditions.

From the review of literature, it is revealed that very little work is carried on the efficacy of *B.t.* against this pest particularly on *E. vittella* of okra. While, literature on LT<sub>50</sub> is not available. Hence, it is difficult to compare the findings with those of earlier workers. So attempts are made to use the relevant literature on efficacy of *B.t.* against other lepidopterous pests as component for studying the efficacy of *B.t.* against the test insect.

Among the *B.t.* products tested in laboratory experiment, Dipel 8 L *B.t. k* was observed to be the most toxic to

the test insect. Its LT<sub>50</sub> value was 24.71 hrs and cent per cent mortality of the larvae was observed at 60 hrs after the treatment.

Delfin WG and Halt WP formulations of *B.t.* var. *kurstaki* observed to be next effective *B.t.* products showing their LT<sub>50</sub> values 29.07 hrs and 29.92 hrs, respectively and recorded mortality 100 per cent of each at 60 hrs after the treatment. This was followed by Biotox WP (LT<sub>50</sub> 31.25 hrs and 92.30 per cent mortality) formulation of *B.t.* var. *thuringiensis* and Agree WP (LT<sub>50</sub> 37.06 hrs and 84.61 per cent mortality) formulation of *B.t. k X a*, Biolep WP and Bioasp WP formulations of *B.t.* var. *kurstaki* are equally effective in their efficacy showing LT<sub>50</sub> values 38.28 and 38.77 hrs and 84.62 per cent larval mortality of each.

While, Centari WG formulation of *B.t.* var. *aizawai* was found to be the least effective as compared to other *B.t.* formulations. The LT<sub>50</sub> values of Centari was 42.20 hrs and 76.92 per cent mortality at 60 hrs after the treatment.

Ramakrishnan and Pant (1967) also noticed mortality of *Earias fabia* (Stoll) larvae in case of Thuricide *B.t. k* within 30 hrs after ingestion.

In case of *E. insulana* on cotton, similar results of efficacy were recorded by Navon and Klein (1990). They observed that *B.t.* var. *kurstaki* was superior showing 100 per

cent mortality over *B.t.* var. *thuringiensis* and *B.t.* var. *aizawai* which recorded 85.7 and 70.4 per cent larval mortality, respectively.

Taylor (1974) used Dipel *B.t. k* against *S. derogata* on okra. Laboratory bioassay test showed that the suspension of Dipel at levels equivalent to 0.5 to 1 and 1.5 lb/acre caused at least 90 per cent mortality within 48 hrs. Over 50 per cent mortality was achieved after 24 hrs at all the concentrations tested and 100 per cent mortality with 1.0 and 1.5 lb/acre in 48 and 60 hrs, respectively.

Whereas, in case of *H. armigera*, LT<sub>50</sub> values recorded by Kulkarni and Amonkar (1988) was 4.5 days with ISPC-1 *B.t.* var. *kenyae*, 6.2 days with ISPC-4 *B.t.* var. *kurstaki* and 6.7 days with ISPC-7 *B.t.* var. *kenyae*. Dabi *et al.* (1979) had recorded 100 per cent mortality at 90 hrs of post-treatment for 3<sup>rd</sup> instar larvae of *H. armigera* with Dipel HD-1 strain of *B.t.* var. *kurstaki*. Mane (1993) recorded that minimum time for mortality of *H. armigera* larvae was 2 days and even after 7 days of feeding on treated diet, the maximum mortality was 95 per cent in case of Delfin WG *B.t. k* and 80 per cent with dipel 8 L *B.t. k*. While, in case of *P. xylostella*, it was noticed that the mortality started 12 hrs after treatment and within 36 hrs, mortality recorded almost 100 per cent. Justin *et al.* (1988) had reported observations on LT<sub>50</sub> in respect of *P. xylostella* on cauliflower leaves, who got 50 per

cent mortality with *B.t.* var. *kurstaki* (Bactospeine), *B.t.* var. *thuringiensis* and *B.t.* var. *kurstaki* (laboratory culture) as 21.90, 22.60 and 23.15 hrs, respectively. However, Sastrosiswojo and Nuswantara (1986) reported a period of 3 days to cause 94.97 per cent mortality of 3<sup>rd</sup> instar larvae after treatment with 500 ppm *B.t.*

During the present investigations, it was observed that the mortality started 12 hrs after the treatment and 76.92 to 100 per cent mortality was recorded at 60 hrs after the treatment with different formulated products of *B.t.* varieties.

The results of the laboratory studies of present investigations in light of LT<sub>50</sub> and relative efficacy of different formulated products of *B.t.* varieties indicated that number of factors viz., insect host, *B.t.* variety and serotype, strain and type of formulation have great influence on the activity of *B.t.* products against a particular insect host and hence, it is difficult to compare and correlate the findings of two different investigations. However, the laboratory results of the present investigations gave a positive indication and expected effectiveness of different formulated products of *B.t.* varieties against the shoot and fruit borer, *E. vittella* on okra. The interspecific comparison of different formulated products of *B.t.* varieties showed that formulated products of *B.t.* var. *kurstaki* and *B.t.* var.

T-4063

*thuringiensis* found to be the most superior showing higher efficacy against the test insect as compared to *B.t.* var. *kurstaki* X *aizwai* and *B.t.* var. *aizwai*.

## 5.2 EFFICACY OF DIFFERENT FORMULATED PRODUCTS OF *B.t.* VARIETIES UNDER FIELD CONDITIONS

The results of field experiments carried out during *Kharif* 1994 and 1995 and *Summer* 1995 to test the efficacy of different formulated products of *B.t.* varieties against *E. vittella* revealed that Dipel 8 L formulation of *B.t.* var. *kurstaki* was the most effective treatment showing average per cent fruit damage on 4 and 9 days after treatment to be 10.64 and 9.70 per cent in *Kharif* 1994 and 12.81 and 11.90 per cent in *Kharif* 1995, respectively.

While, the pooled mean of both season shows 11.73 and 10.80 per cent fruit damage on 4 and 9 days after treatment, respectively. However, this treatment was at par with Delfin WG (12.43 and 11.54%) and Halt WP (13.21 and 12.21%) formulations of *B.t.* var. *kurstaki*. This was followed by Biotox WP (14.01 and 12.83%) formulation of *B.t.* var. *thuringiensis*, Biolep WP (14.70 and 13.70%) and Bioasp WP (15.48 and 14.83%) formulations of *B.t.* var. *kurstaki* and Agree WP (16.07 and 15.46%) formulation of *B.t.* var. *kurstaki* X *aizwai* and Centari WG (17.53 and 16.70%) formulation of *B.t.* var. *aizwai*. Whereas, 33.02 and 34.97 per cent fruit damage noticed in untreated control on 4 and 9 days after treatment, respectively.

Similarly during Summer 1995, Dipel 8 L *B.t. k* again emerged as the most effective treatment in which 15.83 and 13.15 per cent fruit damage on 4 and 9 days after treatment was noticed, respectively. This treatment was at par with Delfin WG *B.t. k* (16.30 and 13.90%), Halt WP *B.t. k* (17.50 and 14.23%) and Biotox WP *B.t. t* (18.92 and 14.42%). This was followed by Biolep WP *B.t. k* (21.08 and 17.28%), Bioasp WP *B.t. k* (21.48 and 18.46%) and Centari WG *B.t. a* (24.19 and 19.17%). While, in untreated control 41.71 and 42.14 per cent fruit damage recorded on 4 and 9 days after treatment, respectively.

Krishnaiah *et al.* (1981) reported that application of weekly sprays of Dipel *B.t. var. kurstaki* at 0.5 Kg/ha gave 14.98 per cent fruit damage as against 24.22 per cent in untreated control. Similarly, Kadam (1993) found 11.41 to 16.34 per cent fruit damage in Albit *B.t. var. kurstaki* and Bactospine *B.t. var. Berliner* treatments as against 36.67 per cent in untreated control. Taylor (1974) reported good control of *E. insulana* by using Dipel *B.t. var. kurstaki* at the rate of 0.5 to 1 lb/acre along with other lepidopterous pests of okra.

In case of spotted and pink bollworm on cotton, Abul Nasir <sup>*et al.*</sup> (1983) had recorded 42 to 45 per cent reduction in infestation by using *B.t. serotype I and II*. Whereas, in case of *H. armigera* on cotton, Panchbhavi and Sudhindra (1994) had

recorded 25.75 and 27.30 per cent larval mortality and 58.52 and 58.16 per cent fruit damage by using Halt and Dipel of *B.t.* var. *k* at the rate of 1.5 kg and 1 l of each per ha, respectively.

Studies carried out by Pawar and Gunjal (1995) showed that Dipel and Halt formulations of *B.t.* var. *kurstaki* are equally effective in controlling pigeonpea pod borers showing 7.74 and 7.18 per cent pod damage, respectively. While, in case of *P. xylostella* on cabbage, Kulkarni et al. (1995) reported that by using Delfin and Halt *B.t. k* at the rate of 1 kg/ha showed the damage score of 0.15 and 1.37 per cent, respectively.

Thus, all *B.t.* treatments are significantly superior over control during *Kharif* 1994, *Kharif* 1995 and *Summer* 1995. The interspecific comparison of different formulated products of *B.t.* during the above seasons revealed that formulated products of *B.t.* var. *kurstaki* and *B.t.* var. *thuringiensis* are found to be more effective in which less per cent of fruit damage was observed as compared to *B.t. kurstaki* X *aizwai* and *B.t.* var. *aizwai*.

### 5.3 EFFECT OF DIFFERENT FORMULATED PRODUCTS OF *B.t.* VARIETIES ON YIELD OF MARKETABLE FRUITS

The pooled mean of yield of marketable fruits (Table 5) of okra as influenced by different formulated

products of *B.t.* was between 66.58 to 82.90 q/ha during Kharif 1994 and 1995. The treatment with Dipel 8 L formulation of *B.t.* var. *kurstaki* was found to be the most promising and gave highest yield of marketable fruits (82.90 q/ha). It was at par with Delfin WG (81.40 q/ha) and Halt WP (79.44 q/ha) formulations of *B.t.* var. *kurstaki*. This was followed by Biotox WP (77.16 q/ha) formulation of *B.t.* var. *thuringiensis*, Biolep WP (72.59 q/ha), Bioasp WP (70.65 q/ha) formulations of *B.t.* var. *kurstaki*, Agree WP (68.39 q/ha) formulation of *B.t.* var. *kurstaki* X *aizwai* and Centari WG (66.58 q/ha) formulation of *B.t.* var. *aizwai*. While, 48.02 q/ha yield of marketable fruits was obtained in untreated control.

During Summer 1995 Dipel 8 L *B.t.* *k* (65.17 q/ha) again emerged as the most promising treatment and was at par with Delfin WG *B.t.* *k* (63.97 q/ha) and Halt WP *B.t.* *k* (62.74 q/ha). This was followed by Biotox WP *B.t.* *t* (60.20 q/ha), Biolep WP *B.t.* *k* (59.11 q/ha), Bioasp WP *B.t.* *k* (57.98 q/ha), Agree WG *B.t.* *k* X *a* (56.72 q/ha). While, less yield of marketable fruits was obtained in treatment with Centari WG *B.t.* *k* X *a* (53.60 q/ha) as against 35.15 q/ha yield of marketable fruits in untreated control.

Kadam (1993) also carried out studies on efficacy of Albit *B.t.* var. *kurstaki* and Bactospeine *B.t.* var. *Berliner* against *E. vittella* during Kharif season. He reported that yield of marketable fruits of okra obtained from Albit and

Bactospeine treated plots ranged between 65.64 to 70.67 q/ha as against 46.16 q/ha in untreated control.

The range of *B.t.* treatments found to be superior in *Kharif* 1994 and 1995 were also remained constant in *Summer* 1995. The per cent fruit damage observed with *B.t.* treatments in *Summer* season was slightly more as compared to fruit damage in *Kharif* season. While, yield of marketable fruits recorded in *Kharif* season was more as compared to *Summer* season.

Chapter Opener Page

# **SUMMARY AND CONCLUSIONS**

## 6. SUMMARY AND CONCLUSIONS

The present investigations were undertaken to find out the relative bioefficacy of different formulated products of *B.t.* varieties viz., Dipel 8 L *B.t. k*, Delfin WG *B.t. k*, Biolep WP *B.t. k*, Bioasp WP *B.t. k*, Halt WP *B.t. k*, Agree *B.t. k* X a, Biotox *B.t. t* and Centari *B.t. a* against *E. vittella* on okra. The laboratory experiment to find out the LT<sub>50</sub> values and field trials to determine relative efficacy of *B.t.* products were conducted at the Agril. Entomology Section, College of Agriculture, Pune during the year 1994-95.

### 6.1 EFFICACY OF DIFFERENT FORMULATED PRODUCTS OF *B.t.* VARIETIES UNDER LABORATORY CONDITIONS

Laboratory experiments on LT<sub>50</sub> value and per cent larval mortality of *E. vittella* with different *B.t.* products were conducted by fruit dip method. Fruits were dipped in desired suspensions of *B.t.* products and dried. Then first instar larvae were released on fruits. The mortality counts were recorded for 60 hrs at every 12 hrs interval. Mortality data were corrected by formula suggested by Abbott (1925) and LT<sub>50</sub> values determined by the method given by Finney (1971).

The results indicated that among different formulated products of *B.t.* varieties tested Dipel 8 L formulation of *B.t. var. kurstaki* was found to be the most effective in which lower LT<sub>50</sub> value of 24.71 hrs and 100 per cent larval

mortality was recorded. This was followed by Delfin WG and Halt WP formulations of *B.t.* var. *kurstaki* showing LT<sub>50</sub> values 29.07 and 29.92 hrs, respectively and 100 per cent mortality in both the cases, followed by Biotox WP formulation of *B.t.* var. *thuringiensis* in which LT<sub>50</sub> value of 31.25 hrs with 92.30 per cent larval mortality was recorded, followed by Agree WP formulation *B.t.* var. *kurstaki* X *aizwai* in which LT<sub>50</sub> value of 37.06 hrs and larval mortality of 84.61 per cent recorded followed by Biolep WP and Bioasp WP formulations of *B.t.* var. *kurstaki* which are equally effective in the efficacy showing LT<sub>50</sub> values of 38.28 and 38.77 hrs., respectively with 84.62 per cent larval mortality in each. The highest LT<sub>50</sub> value of 42.20 hrs and 76.92 per cent larval mortality was recorded with Centari WG formulation of *B.t.* var. *aizwai* indicating its least effectiveness as compared to others.

## 6.2 EFFICACY OF DIFFERENT FORMULATED PRODUCTS OF *B.t.* VARIETIES UNDER FIELD CONDITIONS

Statistically designed field trials to test the relative efficacy of *B.t.* products under field conditions were conducted during the season *Kharif* 1994 and 1995 and *Summer* 1995. Four sprays were given on okra starting from 46 days old crop.

The results indicated that all the formulated products of *B.t.* were significantly superior over the control. The per cent fruit damage noticed in *B.t.* treated plots were

significantly less and yield of marketable fruits were more as compared to untreated control. During all the seasons, i.e. *Kharif* 1994 and 1995 and *Summer* 1995, Dipel 8 L formulation of *B.t.* var. *kurstaki* emerged as the most promising treatment, which was at par with Delfin WG and Halt WP formulations of *B.t.* var. *kurstaki* and Biotox WP formulation of *B.t.* var. *thuringiensis*. This was followed by Biolep WP and Bioasp WP formulations of *B.t.* var. *kurstaki*, Agree WP formulation of *B.t.* var. *kurstaki* and Centari WG formulation of *B.t.* var. *aizwai*.

### 6.3 CONCLUSIONS

The present investigations on relative efficacy of different formulated products of *B.t.* varieties viz., Dipel 8 L, Delfin WG, Halt WP, Biolep WP and Bioasp WP formulations of *B.t.* var. *kurstaki*, Biotox WP formulations of *B.t.* var. *thuringiensis* and Agree WP formulation of *B.t.* var. *kurstaki* X *aizwai* and Centari WG formulation of *B.t.* var. *aizwai* indicated effectiveness of these products against *E. vittella* on okra. Among different formulated products of *B.t.* varieties tested, it was observed that formulations of *B.t.* var. *kurstaki* was observed to be more effective against *E. vittella*. While, *B.t.* var. *thuringiensis* was moderately effective followed by *B.t.* var. *kurstaki* X *aizwai* and *B.t.* var. *aizwai*.

*Bacillus thuringiensis* because of its specificity and non-toxicity or pathogenicity to non-target animals is an

ideal biological control agent and could be used as alternative to chemical insecticides. Earlier *B.t.* "arsenal" was consisted of only one strain with few formulations. However, due to increased commercial potential new *B.t.* products based on more potent strains or strains with improved toxicity and altered specificity are entering the market. There is an urgent need to study, the effectiveness of these products, development of resistance and its mechanism under field conditions at different locations to develop anecologically sound Integrated Pest Management programme.

Chapter Opener Page

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## 7. LITERATURE CITED

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\* Originals not seen.

Chapter Opener Page

# APPENDIX- I

## WEATHER DATA

Meteorological data on Temperature, Relative Humidity and Rainfall during *Kharif* 1994

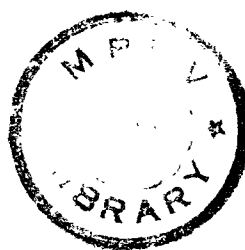
| Months    | Meteoro-<br>logical<br>weeks | Temperature<br>(°C) |       | Relative<br>humidity<br>(%) |       | Rainfall<br>(mm) |
|-----------|------------------------------|---------------------|-------|-----------------------------|-------|------------------|
|           |                              | Maxi.               | Mini. | Maxi.                       | Mini. |                  |
| June      | 23                           | 32.40               | 22.30 | 86.00                       | 57.00 | 58.30            |
|           | 24                           | 28.10               | 22.00 | 86.00                       | 74.00 | 150.20           |
|           | 25                           | 27.90               | 22.40 | 80.00                       | 71.00 | 10.60            |
|           | 26                           | 27.70               | 22.00 | 87.00                       | 77.00 | 68.00            |
| July      | 27                           | 27.10               | 21.20 | 88.00                       | 73.00 | 27.10            |
|           | 28                           | 26.30               | 21.30 | 90.00                       | 87.00 | 141.40           |
|           | 29                           | 25.80               | 21.40 | 90.00                       | 84.00 | 84.00            |
|           | 30                           | 26.80               | 21.70 | 90.00                       | 81.00 | 44.70            |
|           | 31                           | 26.90               | 21.70 | 84.00                       | 74.00 | 8.00             |
| August    | 32                           | 27.80               | 21.40 | 82.00                       | 68.00 | 2.00             |
|           | 33                           | 27.00               | 21.30 | 87.00                       | 74.00 | 16.20            |
|           | 34                           | 27.70               | 21.20 | 91.00                       | 77.00 | 18.80            |
|           | 35                           | 25.60               | 21.10 | 92.00                       | 86.00 | 82.50            |
| September | 36                           | 26.60               | 21.10 | 90.00                       | 74.00 | 28.00            |
|           | 37                           | 27.70               | 19.00 | 90.00                       | 65.00 | 5.60             |
|           | 38                           | 28.10               | 16.80 | 89.00                       | 49.00 | 0.00             |
|           | 39                           | 32.45               | 19.54 | 88.00                       | 36.00 | 0.00             |
| October   | 40                           | 32.20               | 19.90 | 90.00                       | 43.00 | 0.00             |
|           | 41                           | 32.90               | 13.40 | 71.00                       | 36.00 | 0.00             |
|           | 42                           | 30.60               | 18.70 | 90.00                       | 51.00 | 85.90            |
|           | 43                           | 30.60               | 15.90 | 91.00                       | 39.00 | 15.20            |
|           | 44                           | 29.60               | 16.90 | 90.00                       | 46.00 | 0.00             |
| November  | 45                           | 29.80               | 16.90 | 91.00                       | 44.00 | 0.00             |
|           | 46                           | 30.00               | 17.40 | 91.00                       | 46.00 | 9.10             |

**Meteorological data on Temperature, Relative Humidity and Rainfall during *Kharif* 1995**

| Months    | Meteoro-<br>logical<br>weeks | Temperature<br>(°C) |       | Relative<br>humidity<br>(%) |       | Rainfall<br>(mm) |
|-----------|------------------------------|---------------------|-------|-----------------------------|-------|------------------|
|           |                              | Maxi.               | Mini. | Maxi.                       | Mini. |                  |
| June      | 23                           | 35.90               | 23.80 | 69.00                       | 35.00 | 0.00             |
|           | 24                           | 35.00               | 23.50 | 74.00                       | 41.00 | 16.60            |
|           | 25                           | 32.40               | 23.50 | 79.00                       | 51.00 | 5.80             |
|           | 26                           | 31.50               | 24.10 | 89.00                       | 64.00 | 36.50            |
| July      | 27                           | 32.40               | 23.40 | 78.00                       | 53.00 | 1.20             |
|           | 28                           | 30.00               | 23.00 | 83.00                       | 70.00 | 34.10            |
|           | 29                           | 28.40               | 22.10 | 84.00                       | 83.00 | 112.30           |
|           | 30                           | 27.40               | 22.40 | 87.00                       | 78.00 | 36.50            |
|           | 31                           | 28.70               | 22.40 | 84.00                       | 71.00 | 19.20            |
| August    | 32                           | 28.10               | 22.00 | 86.00                       | 64.00 | 5.20             |
|           | 33                           | 29.00               | 21.50 | 83.00                       | 65.00 | 2.60             |
|           | 34                           | 30.40               | 21.40 | 85.00                       | 58.00 | 0.00             |
|           | 35                           | 29.00               | 22.00 | 87.00                       | 70.00 | 26.80            |
| September | 36                           | 27.70               | 19.20 | 90.00                       | 55.00 | 79.00            |
|           | 37                           | 29.00               | 20.80 | 92.00                       | 71.00 | 80.10            |
|           | 38                           | 29.70               | 20.40 | 86.00                       | 62.00 | 1.00             |
|           | 39                           | 29.60               | 20.70 | 90.00                       | 64.00 | 27.50            |
| October   | 40                           | 31.80               | 20.70 | 94.00                       | 58.00 | 28.10            |
|           | 41                           | 30.90               | 20.40 | 93.00                       | 57.00 | 29.30            |
|           | 42                           | 30.50               | 18.80 | 91.00                       | 53.00 | 12.80            |
|           | 43                           | 30.90               | 15.90 | 88.00                       | 40.00 | 1.40             |
| November  | 44                           | 1.30                | 12.90 | 94.00                       | 29.00 | 0.00             |
|           | 45                           | 30.20               | 11.20 | 94.00                       | 28.00 | 0.00             |
|           | 46                           | 31.10               | 12.10 | 96.00                       | 28.00 | 0.00             |

**Meteorological data on Temperature, Relative Humidity and Rainfall during *Summer* 1995**

| Months   | Meteoro-<br>logical<br>weeks | Temperature<br>(°C) |       | Relative<br>humidity<br>(%) |       | Rainfall<br>(mm) |
|----------|------------------------------|---------------------|-------|-----------------------------|-------|------------------|
|          |                              | Maxi.               | Mini. | Maxi.                       | Mini. |                  |
| January  | 1                            | 28.30               | 10.30 | 91.00                       | 41.00 | 4.00             |
|          | 2                            | 24.10               | 9.40  | 96.00                       | 41.00 | 0.00             |
|          | 3                            | 25.80               | 10.50 | 96.00                       | 46.00 | 0.00             |
|          | 4                            | 28.50               | 8.10  | 92.00                       | 24.00 | 0.00             |
|          | 5                            | 28.60               | 11.80 | 92.00                       | 36.00 | 0.00             |
| February | 6                            | 31.50               | 14.50 | 86.00                       | 34.00 | 0.00             |
|          | 7                            | 31.40               | 12.30 | 88.00                       | 25.00 | 0.00             |
|          | 8                            | 31.90               | 10.70 | 90.00                       | 22.00 | 0.00             |
|          | 9                            | 33.00               | 12.40 | 86.00                       | 23.00 | 0.00             |
| March    | 10                           | 33.00               | 13.30 | 74.00                       | 23.00 | 0.00             |
|          | 11                           | 33.60               | 16.30 | 72.00                       | 29.00 | 0.00             |
|          | 12                           | 36.00               | 18.60 | 68.00                       | 27.00 | 0.00             |
|          | 13                           | 33.60               | 15.90 | 83.00                       | 24.00 | 0.00             |
| April    | 14                           | 36.30               | 16.10 | 55.00                       | 14.00 | 0.00             |
|          | 15                           | 36.60               | 19.80 | 64.00                       | 18.00 | 0.00             |
|          | 16                           | 36.90               | 19.30 | 68.00                       | 19.00 | 9.80             |
|          | 17                           | 39.10               | 21.00 | 56.00                       | 19.00 | 0.40             |
| May      | 18                           | 37.50               | 21.40 | 69.00                       | 33.00 | 29.30            |
|          | 19                           | 35.20               | 23.70 | 69.00                       | 36.00 | 2.20             |
|          | 20                           | 33.90               | 22.50 | 68.00                       | 33.00 | 0.00             |
|          | 21                           | 35.20               | 21.70 | 75.00                       | 37.00 | 13.30            |
|          | 22                           | 37.70               | 34.50 | 65.00                       | 30.00 | 0.40             |



Chapter Opener Page

**VITA**

## VITA

SATAPPA BHAMBAR KHARBADE

A candidate for the degree  
of  
MASTER OF SCIENCE (AGRICULTURE)  
in  
AGRICULTURAL ENTOMOLOGY  
1996

**Title of Thesis** : Bio-efficacy of *Bacillus thuringiensis* (Berliner) formulations against *Earias vittella* (Fabricius) on okra

**Major field** : Agricultural Entomology

**Biographical information :**

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---- **Educational** : Passed S.S.C. from Jawaharlal Shetaki High School, Mangalwedha in June, 1987 and H.S.C. from English School Jr. College, Mangalwedha in June, 1989. Passed B.Sc. (Agriculture) from College of Agriculture, Kolhapur, under Mahatma Phule Krishi Vidyapeeth, Rahuri in June, 1993. A candidate for the degree of M.Sc. (Agriculture) in Entomology. Recipient of ASPEE Research Project Fellowship for M.Sc. (Agriculture) course for the year 1993-95.

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