MATERIAL AND METHODS
III. MATERIAL AND METHODS

The studies on the present investigations were carried out at the Vasantdada farm and Manjari Farm of Vasantdada Sugar Institute (VSI), Manjari (Bk.), Tal. Haveli, Dist. Pune during the winter and summer season of 2005-06, 2006-07 and 2007-08.

3.1 SURVEY AND IDENTIFICATION OF VARIOUS PESTS OF SUGAR BEET

Experimental details

All preparatory tillage operations were carried out for the preparation of soil to good tilth for the cultivation of sugar beet crop. The experimental plots were laid out as per Randomised Block Design (RBD) with three replications. The five sugar beet varieties, Posada (Indus), Dorotea (Cauvery), HI-0064 (Shubhra), IISR Comp-1, and LS-6 were used for sowing. Sowing the sugar beet seed in the field was done by marking with the help of marker (20 cm wooden stick) to maintain the spacing 50 cms between in row to row and 20 cms between plant to plant. The sowing was done by dibbling method and the sowing date was 14.12.2004 (Farm Block No.A-14), 28.11.2005 (Farm Block No. B-17) and 06.12.2006 (Farm Block No. B-16) for winter crop, while it was 20.04.2005 (Farm Block No.-A12), 02.06.2006 (Farm Block No.B-7) and 01.06.2007(Farm Block No. B-5) for summer crop during 2004-05, 2005-06 and 2006-07, respectively. The sowing was done by putting two seeds at each hill on middle of the ridge in ridge and furrow method. Total plot size was 20 m² with 8 rows of 5 m in length.

Gap filling and thinning was done at 30 days after sowing for maintaining the equal plant population per plot. One healthy plant per hill was kept by thinning. Recommended doses of fertilizer i.e. 120:60:60 Kg NPK/ha was applied, while basal dose of 60:60:60 Kg
NPK/ha and remaining 60 Kg N was applied as a top dressing after four weeks after sowing. Timely weeding operations were carried out. Crop was irrigated 7-8 times each season. Studies on survey of sugar beet pests are done in the operational area of two experimental farm of VSI, during winter season at a Vasantdada Farm and summer season at a Manjari Farm.

MATERIAL REQUIRED

The sugar beet crop was cultivated at Vasantdada and Manjari Farm and the survey of the sugar beet pests was carried out in this crop. Swipping insect collection nets, aspirators, wide mouth plastic insect collection bottles, camlin hair brush, muslin cloth, lens, etc. were used for the collection of insect pests of sugar beet crop. The collected specimen were killed in an insect killing bottle and brought to the laboratory for identification and further studies.

Observations

• The observation on pests stages infesting to sugar beet crop (leaves and beets) are recorded at weekly interval till harvest of the crop.

• Five plants were selected for recording the pests observations at random from each of 20 m² plot. The plant parts viz. leaf, beet root and surrounding soil were observed for the existence of pest stages and the damage made. The pest stages were collected in insect collection bottles with the help of camlin brush. The live pests stages were brought to the laboratory and reared in a laboratory. The adult stages were preserved in the insect collection boxes and specimens were sent to the identification to the Zoological Survey of India, Western Region, Akurdi, Pune.

• The pest stages were grouped according to their damage to various plant various parts and their feeding habit.

• The incidence and intensity of insect pests was recorded at fortnightly interval till harvest of the crop.
• Damaged beet roots due to rodents were also recorded in each plot.

3.2 STUDIES ON THE BIOLOGY, LIFE CYCLE AND BEHAVIOR OF S. litura IN LABORATORY

The egg masses of Spodoptera litura were collected from sugar beet field on May for two years 2007 and 2008 at Vasantdada Sugar Institute, farm, Manjari (Bk), Pune and lateron as per requirement, time to time.

Material required
1. Insect collecting bottles
2. Black cloth
3. Camel hair brush
4. Micrometry
5. Research microscope
6. Fresh green leaves of sugar beet for feeding to the larvae for rearing
7. Rubber band, etc.

Field collected egg masses of S. litura, laid on lower surface of sugar beet leaves nearer to ground level, were collected and brought to the laboratory. The egg masses were kept on a moist blotting paper in plastic bottles having a wide mouth of each bottle and bottle mouth was closed with a muslin cloth. After hatching, the larvae fed with a fresh sugar beet leaves and leaves were changed twice in a day. After the formation of the pupae, they were collected and kept in a separate plastic container having a moist soil at the bottom of a container to avoid the desiccation. The adult moths comes out from the pupae were separated. A pair of male and female moth was kept in a separate plastic container with a muslin cloth at the wide open end. The adult moths were fed with a 5% honey solution through suspended cotton swab. The green paper strips were placed in the container to facilitate the egg laying. The experiment was replicated ten times. The room
temperature was maintained at 23 – 26 °C and 65-70 % Relative humidity during the study period and the observations on biology were recorded.

**Egg**

The eggs were observed carefully for their size, shape, colour, number of eggs laid per female and their appearance under 10X microscope. Change in the colour of eggs during hatching period was observed, daily. The observations on preoviposition and incubation period were recorded.

**Larva**

The number of larvae emerged from egg mass were counted manually and hatching percentage was calculated. The emerged larvae were transferred to a wide mouth plastic jar with a muslin cloth at the open end. Fresh sugar beet leaves were fed to the larvae, twice a day. The ten larvae were observed for biological observations in one replication and the experiment was replicated thrice. The micrometric observations viz. length, breadth (mm) of larvæ were recorded under 10 x microscope on the scale having least count of 0.25. The micrometric observations were recorded at every day interval throughout the larval period. The time required for completing each larval instar and the total larval period was also recorded with the larval development.

**Pupa**

The pupae were kept in a moist soil in separate bottles for emergence of adults. The micrometric observations viz. length and breadth of pupa were recorded. Pupal duration was observed.

**Adult**

After emergence of adults, sexual dimorphism was observed. Male and female adults were separated and kept in a separate bottle. The duration of male and female adult was observed. The original photographs of all the stages were snapped in the laboratory.
3.3 RECORD OF THE NATURAL ENEMIES OF *S. litura* IN SUGAR BEET FIELDS.

*Spodoptera litura* is an important polyphagous pest infesting many agricultural crops. The swarming population and voracious feeding of pest larvae have intensified the problem. It is highly essential to have a natural control over this pest in field. It is primly necessary to know the different natural enemies of *Spodoptera litura* in the sugar beet ecosystem and to find out the potential indigenous natural enemies that can be multiplied and released for the control of the pest, an experiment was conducted to record the natural enemies of *S. litura* in sugar beet field.

Experimental details

All preparatory tillage operations were carried out for the preparation of soil to good tilth for cultivation of sugar beet crop. The experimental plots were laid out as per Randomised Block Design (RBD) with three replications. The five sugar beet varieties viz. Posada (Indus), Dorotea (Cauvery), HI-0064 (Shubhra), IISR Comp-1 and LS-6 were used for sowing. Marking was done by marker (20 cm wooden stick) for sowing the sugar beet seed in the field to maintain the spacing of 50 cms in between row to row and 20 cms between plant to plant. The sowing was done by dibbling method and the sowing date was 14.12.2004 (Farm Block No.A-14), 28.11.2005 (Farm Block No.B- 17) and 06.12.2006 (Farm Block No.B- 16) for winter crop, while it was 20.04.2005 (Farm Block No.-A12), 02.06.2006 (Farm Block No.B-7) and 01.06.2007(Farm Block No. B-5) for summer crop during 2005-06, 2006-07 and 2007-08, respectively. The sowing was done by putting two seeds per hill. Total plot size was 20 m² with an 8 rows of 5 m length.

Gap filling and thinning was done at 30 days after sowing for maintaining the equal plant population per plot. One healthy plant per
hill was kept by thinning. Recommended doses of fertilizers i.e. 120:60:60 Kg NPK/ha was applied, while basal dose of 60:60:60 Kg NPK/ha and remaining 60 Kg N was applied as a top dressing four weeks after sowing. Timely weeding operations were carried out. Crop was irrigated 7-8 times in each season. Records of natural enemies of *S. litura* in sugar beet field are done in the operational area of two experimental farm of VSI, during winter season at Vasantdada Farm and summer season at Manjari Farm.

**MATERIAL REQUIRED**

The sugar beet crop was cultivated at Vasantdada and Manjari Farm and the survey of natural enemies of sugar beet pests was carried out. Swiping nets, Aspirators, Wide mouth plastic insect collection bottles, camlin hairbrush, muslin cloth, lens, etc. are the materials used for the collection of parasites/predators, etc.

**Observations**

- The observation on pests stages infesting to sugar beet crop (leaves and beets) were recorded at fortnightly interval. In each plot, randomly selected five sugar beet plants were observed for pest stages and entomopathogens, parasites, predators etc. infesting the pest stages.

- Life stages of *S. litura* infested with predators and parasites were collected from field and brought to the laboratory. The parasites emerged from life stages of *Spodoptera* were collected and identified. The predators stages collected from the fields were also reared in the laboratory till the growth of adult. The adult stages of the predators were identified, recorded and reviewed.

- A cadaver and naturally dead larvae found infested by microbial agents were also collected and brought to the laboratory. The entomopathogens infesting to the *S. litura* was multiplied, identified and recorded.
Avian natural enemies of *S. litura* were observed at morning and evening hours during the peak infestation of *S. litura*.

### 3.4 Seasonal Incidence of *S. litura* in Various Sugar Beet Varieties.

Resistant varieties are one of the tools in pests management. The resistance source can be found out by screening the various varieties and genotypes against various pests. The seasonal incidence of the pest in various varieties can also help in sourcing out the resistant material, too. The experiment was carried out to know the seasonal incidence of *S. litura* on various genotypes of sugar beet in winter and summer season.

**Experimental Details**

All preparatory tillage operations were carried out to bring the soil in a good tilth. The experimental plots were laid out as per Randomised Block Design (RBD) with three replications in medium black soil. Marking was done by a marker (20 cm wooden stick) for sowing the sugar beet seed in the field to maintain the spacing of 50 cms between row to row and 20 cms between plant to plant. Dibbling of two seeds per hill was done. Total plot size was 20 m² with 8 rows of 5 m in length. Gap filling and thinning was done at a time at 30 days after sowing of sugar beet for maintaining the equal plant population in each plot. One healthy plant per hill was kept by thinning. Recommended doses of fertilizers i.e. 120:60:60 Kg NPK/ha was applied. The basal dose of 60:60:60 Kg NPK/ha was applied before sowing and remaining 60 Kg N was applied as a top dressing after four weeks after sowing. Timely weeding operations were carried out. Crop was irrigated 7-8 times in the season. Seasonal incidence of *S. litura* in various sugar beet varieties are carried out in the operational area of two experimental farm of VSI.
3.4.1 Screening of sugar beet varieties and seasonal incidence of *S. litura* in winter season of 2005 with 24 varieties.

Sowing was done on 30 November, 2005 in winter season with twenty four varieties i.e. LKS-10, LKC-11, LKC-2000, LKC-HB, R-06, and Syngenta varieties (IN-01, IN-02, IN-03, IN-04, IN-05, IN-06, IN-07, IN-08, IN-09, IN-10, IN-11, IN-12, IN-13, IN-14, IN-15, IN-16, Shubhra, Cauvery and Indus) at farm block No. B – 17 and harvested on 30.05.2006.

3.4.2 Screening of sugar beet varieties and seasonal incidence of *S. litura* in winter season of 2006 with 34 varieties.

During second year trial sowing was done on 29 November, 2006 with thirty four varieties i.e. LKS-10, LKC-11, LKC-2000, LKC-HB, R-06, LKC-95, LK-4, LK-7, LK-8, LK-27, Rasoul, Shirin, Zorghan, 7112, 436 and 16 Syngenta varieties (IN-01, IN-02, IN-03, IN-04, IN-05, IN-06, IN-07, IN-08, IN-09, IN-10, IN-11, IN-12, IN-13, IN-14, IN-15, IN-16), Shubhra (Standard check), LS - 6 (Standard check) and IISR Comp - 1 (Standard check) and harvested on 28.05.2007.

3.4.3 Screening of sugar beet varieties and seasonal incidence of *S. litura* in winter season of 2006 with 28 varieties.


**Observations :**

- The incidence and intensity of *S. litura* were recorded at fortnightly interval during first year and weekly interval during second year, till harvest of the crop.
• Five plants were selected at randomly from each of 20 m² plot and observations were taken on aerial part of the plant for recording *S. litura* larval population.

• Spraying of *SI* NPV against *S. litura* (1 lit/ha) was taken to protect the plants from severe damage at 142 and 164 days after sowing for first year and at 95 DAS and 110 DAS for second year, to avoid the very severe incidence of the pest, otherwise not a single plant can be available for recording the observations.

### 3.5 NATURE AND EXTENT OF DAMAGE CAUSED BY MAJOR PESTS IN SUGAR BEET

Assessment of the nature and extent of damage caused by the major pest *S. litura* in sugar beet was carried out in the experimental farm of VSI.

**Experimental details**

The experimental plots were laid out as per Randomised Block Design (RBD) with a three replications. Marking was done by a marker (20 cm wooden stick) to maintain the 50 cms spacing in between row to row and 20 cms between plant to plant for sowing the sugar beet seed in the field. In a winter season, sowing was done by dibbling method on 15.12.2004 (Farm Block No.A-14) and 28.11.2005 (Farm Block No.B-17) with the use of IISR Comp – 1 and Posada varieties for first and second year, respectively. In a summer season, sowing was done 20.04.2005 (Farm Block No.-A12) and 02.06.2006 with Posada and HI 0064 varieties for first and second year, respectively by putting two seeds per hill. Total plot size was 20 m² with an 8 rows of 5 m in length.

Gap filling and thinning was done on same time at 30 days after sowing for maintaining the equal plant population per plot. One healthy plant per hill was kept by thinning. Recommended doses of fertilizers i.e. 120:60:60 Kg NPK/ha was applied. The basal dose of 60:60:60 Kg NPK/ha was applied before sowing and remaining 60 Kg N was applied
as a top dressing at four weeks after sowing. Timely weeding operations were carried out. Crop was irrigated 7-8 times in the season.

3.5.1 Nature of damage caused by a major pest, *S. litura*

Nature of damage caused by *S. litura* was observed visually from germination of the crop to harvest on different stages of plant and various parts of the plant i.e. leaves, petiole and roots.

3.5.2 Artificial defoliation and losses in sugar beet yield and juice quality attributes

Accurate estimates of yield losses are seldom possible in field trials. Artificial defoliation was done for simulating the pest damage and to estimate the losses in sugar and beet root yield. Experiment was carried in a winter season of 2004-05 and 2005-06 and a summer season of 2005. Defoliation was done at once at 150 days after sowing during the first year winter season, while it was done twice at 120 and 135 days after sowing in a second year winter and summer season. Defoliation was done by hand cutting.

**Treatments**: Ten

- T1- 0-10 per cent defoliation
- T2- 10.1-20 per cent defoliation
- T3- 20.1-30 per cent defoliation
- T4- 30.1-40 per cent defoliation
- T5- 40.1-50 per cent defoliation
- T6- 50.1-60 per cent defoliation
- T7- 60.1-70 per cent defoliation
- T8- 70.1-80 per cent defoliation
- T9- 80.1-90 per cent defoliation
- T10- 90.1-100 per cent defoliation
Observations

- At harvest, randomly five beet roots per plot were harvested and collected for juice analysis.
- Weight of beet roots/plot was taken.
- Quality attributes – Brix (%), purity of juice (%) and pol (%) of juice and pulp of five beet roots/plot were recorded.
- Juice analysis was done by following Cold Extraction method (Le – Docte, 1927)

SUGAR BEET ANALYSIS - COLD EXTRACTION METHOD

Juice analysis and sampling of sugar beet

The following material is required for juice analysis and sampling of sugar beet

1. Instruments: Cossette maker, Refractometer (Brix meter), Juice maker, Digital weighing balance. Glass wares: Beakers, Conical flasks, Funnel etc.


3. Chemicals: Stock solution (Lead monoxide, Neutral lead acetate), Distilled water.

Procedure of stock solution

- Neutral lead acetate of 430 gm was dissolved in D/W and added 130 gm of activated lead monoxide after complete dissolution of lead acetate and made final volume 1000 ml in a volumetric flask.
- Standard stock solution was kept in water bath at 60°C for ½ hrs for complete dissolution.
- Above solution was filtered through Whatmann’s filter paper No. 1.
- 25 ml standard stock solution was taken and made the final volume in 1000 ml D/W for working stock solution.

Procedure for sampling and juice analysis of sugar beet

- Five sugar beets were collected randomly from each plot and tagged.
- Beetroots were weighed and washed with water.
Beetroots were cut into four pieces with the help of knife for crushing in cossets maker. (Plate 3)

Brix per cent was recorded from extracted juice with the help of digital Brix Refractometer.

The 26 gm of cossets and 177.0 ml working stock of lead acetate were added in heavy duty mixture and grinded this mixture for one minute. The grinded mixture was filtered through Whatman filter paper No.1.

Pol per cent was recorded by using Polarimeter.

3.6 FIELD EVALUATION OF BIO CONTROL AGENTS AND CHEMICAL INSECTICIDES AGAINST S. litura IN SUGAR BEET

Bio control agents are the natural important tools in keeping the pests under check. Some of the potential natural enemies can be multiplied and evaluated for their performance in controlling the pests. An experiment was conducted to evaluate the bio control agents in the sugar beet field. The some chemical insecticides, which are helpful to the farmers as an immediate weapon against the voracious pests were evaluated. Various chemical insecticides, which are available in the market, and some of them, which are already proved promising in control of Spodoptera litura in other crops, were tested for their efficacy.

MATERIAL REQUIRED

The material like wooden sticks, boards, knapsack sprayer, adjuvant (sticker), bird perches, pheromone traps, insecticides, biocontrol agents etc. were used while conducting the experiments.

Experimental details

All the preparatory tillage operations were carried out to bring the soil in a good tilth. The experimental plots were laid out as per Randomised Block Design (RBD) with the three replications. Marking was done by marker (20 cm wooden stick) for sowing the sugar beet seed in the field and to maintain the spacing of 50 cms between row to
Plate 1

Healthy Sugar Beet Crop

Sugar Beet Plant

Mature Beet Root
LIFE CYCLE OF *Spodoptera exigua* Hub.
SPECIAL EQUIPMENTS FOR EXTRACTION OF JUICE FROM BEET ROOTS

Heavy Duty Mixer

Cossette Maker
row and 20 cms lateron plant to plant Soil type is medium black and total plot size was 20 m² with the 8 rows of 5 m in length.

Gap filling and thinning was done at a same time at 30 days after sowing for maintaining the equal plant population per plot. One healthy plant per hill was kept by thinning. Recommended doses of fertilizers i.e. 120:60:60 Kg NPK/ha was applied. The basal dose of 60:60:60 Kg NPK/ha was applied before sowing and remaining 60 Kg N was applied as top dressing at four weeks after sowing. Timely weeding operations were carried out. Crop was irrigated 7-8 times in the season, as per requirement.

3.6.1 Evaluation of management practices for *S. litura* in sugar beet

Trial was conducted in three winter and two summer season. The experimental plots were laid out as per Randomised Block Design (RBD) with the three replications.

**Treatment Details**

Eleven (Application as per pest incidence noticed and no any control practices in untreated plot)

- **T1-** 0.1% chlorpyriphos, 20EC (spray)
- **T2-** 0.05% quinalphos, 25EC (spray)
- **T3-** Phorate 10G @ 1kg a.i./ha (soil application)
- **T4-** 0.008 \% imidacloprid 17.8 SL (spray)
- **T5-** Carbofuran 3G @ 1kg a.i./ha (soil application)
- **T6-** 0.15% Cartap hydrochloride 50 SP (spray)
- **T7-** Azadiractin 3000 ppm, 5 ml / lit. of water (spray)
- **T8-** Release of an egg parasite *T. chilonis* Ishii @ 50000/ ha
- **T9-** Placement of Pheromone Traps @ 5 traps/ha (change of lures every 15 days) against *S. litura* male adults
- **T10-** SNPV @ 1 x 10⁹ POBs/ml (500ml/ha) (Spray)
- **T11-** Control (Untreated)
3.6.1.1 Winter crop, 2004-05
Sowing was done on 14.12.2004 with a variety Posada (Indus). All the treatments were tested against S. litura except Pheromone traps and SI NPV during this season. Crop was harvested after six month age on 15.06.05. Treatments were applied twice at 111 days after sowing (06.04.2005) and 15 days after first application.

3.6.1.2 Summer crop, 2005
Sowing was done on 12.04.2005 with two varieties Posada (Indus) and IISR Comp -1. All the treatments were included against S. litura except pheromone traps and SI NPV treatment. Treatments were applied at 22 days after sowing (12.05.2005) due to severe infestation. A single observation of mean larval population could possible at 10 days after treatment. Due to heavy rainfall and stagnation of water, all the beetroots were rotten and hence harvesting was not possible.

3.6.1.3 Winter crop, 2005-06
Sowing was done on 28.11.2005 with a variety Posada (Indus) <VSI farm Block No. B-17. All the treatments were studied tested against S. litura. Placement of Pheromone traps @ 5/ha and spraying of SI NP @ 1 x 10^9 POBs/ml (500ml/ha) were additionally included from the season with other treatments. Treatments were applied at 135 day after sowing (28.05.2006). Crop was harvested after six month after sowing i.e. 28.05.2006.

3.6.1.4 Summer crop, 2006
Sowing was done on 02.06.2006 with a variety Dorotea (Cauver at VSI research farm block No. B -7. Treatments were applied at 8 days after sowing (21.08.2006) at once. Crop was harvested at s months age of crop i.e. on 18.12.2006.
3.6.1.5 Winter crop, 2006-07

Sowing was done on 06.12.2006 with a variety HI 0064 (Shubhra) at VSI farm Block No. B-16. Treatments were applied at 121 days after sowing (06.04.2007). Crop was harvested after six month of crop age i.e. 26.05.2007.

Observations

- The observations of S. *litura* infesting to sugar beet crop (leaves and beet roots) were recorded at weekly interval till harvest of the crop.
- Five plants from each of 20 m² plot were selected at randomly for recording the larval population of *S. litura* and observations were taken on aerial part of the plant.
- Plant population count was taken before harvesting.
- At harvest, randomly five beet roots per plot were harvested and collected for juice analysis.
  - Weight of beet roots/plot was taken
  - Quality attributes – Brix (%), purity of juice (%) and pol (%) of juice and pulp of five beet roots /plot were recorded.
  - Juice analysis was done by Cold Extraction method (as mentioned above 5.2)

3.6.2 Evaluation of a suitable bio-control measures against *S. litura* Fb., a major pest of sugar beet

Recommended control measures against *S. litura* in other crops were tested with the various concentrations in sugar beet crop for evaluating the effective dose. In all the seasons, Posada variety was used for the trials. The experimental plots were laid out as per Randomised Block Design (RBD) with the five replications. Trials were
conducted in two winter and one summer season at VSI research farm. Sowing was done on 30.11.2005, 30.05.06 and harvested after six months of crop age i.e. on 30.05.2006, 18.12.2006 during winter and summer season of first year, respectively, while sowing was done on 07.12.2006 and harvested on 26.05.2007 during a winter season of second year.

3.6.2.1 Role of farm yard manure (FYM) in build up of *S. litura* population
Well decomposed FYM was applied before sowing of sugar beet in a plot.

Treatments details,
- T1- FYM application @ 10 t/ha
- T2- FYM application @ 15 t/ha
- T3- FYM application @ 20 t/ha
- T4- FYM application @ 25 t/ha
- T5- FYM application @ 30 t/ha
- T6- Control (Untreated)- No FYM application

3.6.2.2 Hand collection and destruction of stages of *S. litura*

*S. litura* egg masses, larvae were collected by hands and destructed manually in a kerosenised water. Treatments were applied at 135 and 80 days after sowing in a winter and a summer season, respectively during first year, while it was applied 121 days after sowing in a second year winter season, when pest incidence observed as per economic injury level.

Treatments details-
- T1- Collection and destruction of pest stages at 2 days interval
- T2- Collection and destruction of pest stages at 3 days interval
- T3- Collection and destruction of pest stages at 4 days interval
- T4- Collection and destruction of pest stages at 5 days interval
T5- Collection and destruction of pest stages at 6 days interval
T6- Control (Untreated) – No collection of pest stages.

3.6.2.3 Placement of heaps of grasses and it’s effect on *Spodoptera* population

Weeds removed from the same field during weeding were kept in small heaps at five randomly selected spots in each plot and removed on second day of it’s placement and destroyed the larvae of *Spodoptera*, those observed beneath the heaps. Treatments were applied thrice starting at 135 and 80 days after sowing for winter and summer season, respectively during first year, while it was applied 121 days after sowing in winter season of second year, when pest incidence was observed.

Treatments details

T1- Placement of heaps of grasses at 2 days interval
T2- Placement of heaps of grasses at 3 days interval
T3- Placement of heaps of grasses at 4 days interval
T4- Placement of heaps of grasses at 5 days interval
T5- Placement of heaps of grasses at 6 days interval
T6- Control (Untreated) – No placements of heaps

3.6.2.4 Use of bird perches for reducing the *S. littura* population

'I' shaped wooden bird perches with 60 cms. length were erected in field, when pest incidence starts at 135 and 80 days after sowing in winter and summer season, respectively, during first year while it was applied 121 days after sowing in winter season of second year. Number of birds sitting on bird perches and their species were recorded in total 15 days during severe incidence at morning and evening hours.

Treatments details

T1- Placement of 5 bird perches per hectare
T2- Placement of 10 bird perches per hectare
T3- Placement of 15 bird perches per hectare
3.6.2.5 Use of pheromone traps in control of Spodoptera

Sleeve pheromone traps were installed in a sugar beet field by keeping its height above 30 cms of the crop, when the pest incidence observed. Lures in trap were changed at 15 days interval. Trapped S. litura male adults were counted continuous 15 days during peak infestation and after change of lures.

Treatments detail
T1- Placement of 5 pheromone traps per hectare
T2- Placement of 10 pheromone traps per hectare
T3- Placement of 15 pheromone traps per hectare
T4- Placement of 20 pheromone traps per hectare
T5- Placement of 25 pheromone traps per hectare
T6- Control (Untreated)- no placement of pheromone trap

3.6.2.6 Efficacy of Paecilomyces ($1 \times 10^8$ CFU/ml) on population build up of Spodoptera

Drenching of Paecilomyces ($1 \times 10^8$ CFU/ml) was done in two time with the Knapsack sprayer by removing it’s nozzle at 135 and 80 days after sowing in a winter and summer season, respectively, during first year, while it was applied 121 days after sowing in a winter season of second year. Total 1000 lit. water used per hectare for drenching.

Treatments details
T1- Drenching of Paecilomyces ($2 \times 10^{11}$ CFU/ml) @ 2 Kg/ha
T2- Drenching of Paecilomyces ($3 \times 10^{11}$ CFU/ml) @ 3 Kg/ha
T3- Drenching of Paecilomyces ($4 \times 10^{11}$ CFU/ml) @ 4 Kg/ha
T4- Drenching of Paecilomyces ($5 \times 10^{11}$ CFU/ml) @ 5 Kg/ha
T5- Drenching of Paecilomyces ($6 \times 10^{11}$ CFU/ml) @ 6 Kg/ha
T6- Control (Untreated) – only water spray.
3.6.2.7 Effect of an egg parasitoid, *Trichogramma chilonis* Ishii release in reducing the *S. litura* population

The VSI's Trichocard having an egg parasitoid of *T. chilonis* were stapled below the leaves in two installments at 15 days interval at 135 and 80 days after sowing in a winter and summer season, respectively, during first year, while it was applied 121 days after sowing in a winter season of second year, when incidence of *S. litura* noticed.

Treatments details

- **T1** - Release of *T. chilonis* parasitized eggs @ 25000 /ha
- **T2** - Release of *T. chilonis* parasitized eggs @ 50000 /ha
- **T3** - Release of *T. chilonis* parasitized eggs @ 75000 /ha
- **T4** - Release of *T. chilonis* parasitized eggs @ 100000 /ha
- **T5** - Release of *T. chilonis* parasitized eggs @ 150000 /ha
- **T6** - Control (Untreated) – No release of parasitoids.

3.6.2.8 Effect of *Chrysoperla carnea* larvae, a predator in reducing the *S. litura* population

The larvae of *Chrysoperla carnea* Stephens were taken from VSI's biocontrol lab and released in a sugar beet field in two installements as predator. The larvae were released at 135 and 80 days after sowing in a winter and summer season respectively, during first year, while they released 121 days after sowing in a winter season of second year.

Treatments details

- **T1** - Release of *C. carnea* larvae @ 25000 /ha
- **T2** - Release of *C. carnea* larvae @ 50000 /ha
- **T3** - Release of *C. carnea* larvae @ 75000 /ha
- **T4** - Release of *C. carnea* larvae @ 100000 /ha
- **T5** - Release of *C. carnea* larvae @ 150000 /ha
- **T6** - Control (Untreated)
3.6.2.9 Spraying of *Bacillus thuringiensis* (5% WP) and it’s effect on *S. litura*

Spraying of *Bacillus thuringiensis* was done with a Knapsack sprayer and total 500 lit./ha water was used for spraying. Application was done at 135 and 80 days after sowing in winter and summer season respectively, during first year while it was applied at 121 days after sowing in winter season of second year.

Treatments details
- T1- *Bacillus thuringiensis* spray @ 500 gm/ha
- T2- *Bacillus thuringiensis* spray @ 550 gm/ha
- T3- *Bacillus thuringiensis* spray @ 600 gm/ha
- T4- *Bacillus thuringiensis* spray @ 700 gm/ha
- T5- *Bacillus thuringiensis* spray @ 750 gm/ha
- T6- Control (Untreated)

3.6.2.10 Effect of spraying *SI NPV* (1 x 10⁹ POB’s) on *S. litura* population

Spraying of *SI NPV* was done with Knapsack sprayer and total 500 lit./ha water was used for spraying. Application was done at 135 and 80 days after sowing in winter and summer season respectively, during first year, while it was applied 121 days after sowing in a winter season of second year.

Treatments details
- T1- Spraying of *SI NPV* @ 300 ml/ha (3 x 10¹¹ POB’s)
- T2- Spraying of *SI NPV* @ 400 ml/ha (4 x 10¹¹ POB’s)
- T3- Spraying of *SI NPV* @ 500 ml/ha (5 x 10¹¹ POB’s)
- T4- Spraying of *SI NPV* @ 600 ml/ha (6 x 10¹¹ POB’s)
- T5- Spraying of *SI NPV* @ 700 ml/ha (7 x 10¹¹ POB’s)
- T6- Control (Untreated)
3.6.2.11 Effect of Lannate (Baiting) in reducing *S. litura* population

Lannate 40 SP bait was prepared with 975 gm of wheat husk + 25 gm mithomil (Lannate) + 100 gm jaggary in 1 lit of water. The pillets of baiting was kept underside the most infested plants at different places in a plot. Application was done at 135 and 80 days after sowing in a winter and summer season, respectively, during first year while it was applied 121 days after sowing in a winter season of a second year.

Treatments details

- T1- Lannate 40 SP baiting @ 15 gm /ha
- T2- Lannate 40 SP baiting @ 20 gm /ha
- T3- Lannate 40 SP baiting @ 25 gm /ha
- T4- Lannate 40 SP baiting @ 30 gm /ha
- T5- Lannate 40 SP baiting @ 35 gm /ha
- T6- Control (Untreated)

Observations:

- The observations of *S. litura* infesting to sugar beet crop (leaves and roots) were recorded at fortnightly interval till harvest of the crop in each experiment.
- Five plants from each of 20 m² plot were selected at randomly for recording the larval population of *S. litura* and observations were taken on aerial parts of the plant.
- Plant population count was taken before harvesting.
- At harvest, randomly five beet roots per plot were harvested and collected for juice analysis.
- Weight of beet roots/plot was taken
- Quality attributes – Brix (%), purity (%) of juice and pol (%) of juice and pulp of five beet roots /plot were recorded.
- Juice analysis was done by Cold Extraction method (as mentioned in 5.2)
3.7 STANDARDIZATION OF THE IPM MODULE FOR THE CONTROL OF S. littura IN SUGAR BEET.

It is very essential that the gregarious pest like Spodoptera needs to be managed through the integrated approach only. No any single method is cent per cent effective for control of such economically important pest therefore, the various effective control options such as mechanical, biological, chemical control needs to be formulated in a model and should be tested in the field for their effectiveness against the pest. The effective and proven control options noticed effective in the preliminary trials taken at VSI in sugar beet and on the basis of earlier work of Spodoptera in other crops were included. The mechanical, cultural, biological and chemical control were integrated as an IPM model and tested against various models including the existing farmers practice.

**Experimental details**

The experiment was conducted in three winter and one summer season at Vasantdada and Manjari Farm. All preparatory tillage operations were carried out in a winter and summer season. The field was subsequently cleaned by picking stubbles of previous crops. The experimental plots were laid out as per Randomised Block Design (RBD) with five replications. Marking was done by a marker (20 cm wooden stick) for sowing the sugar beet seed in the field to maintain the spacing 50 cms between row to row and 20 cms between plant to plant. Soil type is medium black and total plot size was 120 m$^2$ with 16 rows of 10 m in length.

Gap filling and thinning was done on same time at 30 days after sowing for maintaining the equal plant population per plot. One healthy plant per hill was kept by thinning. Recommended doses of fertilizers i.e. 120:60:60 Kg NPK/ha was applied. The basal dose of 60:60:60 Kg NPK/ha was applied before sowing and remaining 60 Kg N was applied as a top dressing after four weeks of sowing. Timely weeding operations
were carried out. Crop was irrigated 7-8 times in the season as per requirements.

**MATERIAL REQUIRED**

The material like wooden sticks, board, knapsack sprayer, adjuvant (sticker), pheromone traps, bird perches, predator, parasitoid, insecticide etc. were used for conducting the experiments.

The standardization of IPM modules for the control of *S. litura* were conducted in four seasons with two sugar beet varieties and other details are as under,

<table>
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<th>Season</th>
<th>Variety</th>
<th>Sowing Date</th>
<th>Harvesting Date</th>
<th>Location</th>
<th>Block No.</th>
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<td>28.11.2005</td>
<td>28.05.2006</td>
<td>Vasantdada Farm</td>
<td>B-17</td>
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<td>Posada</td>
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<td>26.05.2008</td>
<td>Vasantdada Farm</td>
<td>B-18</td>
</tr>
</tbody>
</table>

**TREATMENT DETAILS:**

**T1: BIPM (Bio intensive pest management) package (Module)**

- Recommended agronomical practices
- Release of *Chrysoperla carnea* Stephan predator @ 1000/ha (3 days old larvae) once 30 days after sowing in winter seasons and 60 DAS in a summer season, as per pest occurrence.
- Release of an egg parasitoid, *Trichogramma chilonis* @ 100000 parasitoids per hectare at 110 and 125 DAS in two installments (50:50) during winter seasons and 60 DAS during a summer season.
- SI NPV spraying at 120 DAS @ [1 x 10⁹ POB/ml (500ml/ha)] in a winter seasons and 80 DAS in a summer season.
Placement of bird perches on 30 DAS @ 10/ha and continued later on in all the seasons.

Placement of pheromone traps, 10/ha at 30 DAS for monitoring and collection of male adults in all the four seasons. Change of lures at one month interval.

Lannate 40SP bait (wheat husk 975 gm + 25 gm methomyl + 100 gm jaggary in 1 lit) was applied in the soil @ 100 kg/ha, two applications from initiation of incidence of *S. litura* were made at 120 and 135 DAS in a winter seasons and 80 DAS in a summer season.

**T2: Cultural and mechanical control (Module)**
- Recommended agronomical practices
- Two deep ploughings for *Spodoptera* control during land preparation
- Thinning at one month after sowing to remove the excess plants to check the *S. litura* larval spread
- Weeding at 15 days interval for first month and later on at monthly interval
- Keeping the heaps of leaves of sugar beet and weeds for collection of *Spodoptera* larvae from 120 or 135 days after sowing at 7 days interval in a winter and 80 days after sowing in a summer season.
- *Spodoptera* pests stages collection and destruction by removal of affected leaves and from soil during weeding from 120 DAS at 7 days interval in a winter season and 80 days after sowing in a summer season.
- Intercrops such as cotton, tobacco, mustard, groundnut, sweet corn etc. were not taken in sugar beet.
- Placement of pheromone trap @ 10/ha at 30 days DAS

**T3: Existing package of practice**
- Recommended agronomical practices only.
- Spraying of Bt @ 650 gm a.i./ha + 0.03% dimethoate 30 EC at 120 DAS in a winter seasons and 80 DAS in a summer season as per pest incidence.
T4: Farmers practice

- Recommended agronomical practices only.
- Seed treatment already made with Gaucho
- Single spraying of 0.03% dimethoate, 500ml/ha at 120 DAS in a winter season and 80 DAS in a summer season as per pest incidence,

Observations

- The observations of *S. litura* infesting to sugar beet crop (leaves and roots) were recorded at weekly interval till harvest of the crop.
- Five plants from each of 20 m² plot were selected at randomly for recording the larval population of *S. litura*, and observations were recorded on aerial part of the plants.
- Plant population was recorded taken before harvesting.
- At harvest, randomly five beet roots per plot were harvested and used for juice analysis.
- Weight of beet roots/plot was taken
- Quality attributes – Brix (%), purity (%) of juice and pol (%) of juice and pulp of five beet roots /plot were recorded.
- Juice analysis was done by Cold Extraction method (as mentioned in above 5.2)
- The incremental cost benefit ratio was calculated as per the method used in MPAU, Rahuri and used whenever necessary.