SUMMARY AND CONCLUSION
V. SUMMARY AND CONCLUSION

5.1 SURVEY AND IDENTIFICATION OF VARIOUS PESTS OF SUGAR BEET

The survey revealed that 12 major pests are noticed to infest the sugar beet crop. Among these, seven are leaf feeders, one is leaf miner, three are sucking pests including red spider mites and rodents as a subterranean root feeder. Out of seven leaf feeders recorded, the lepidopteron pests are most predominant and among the noctuids *Spodoptera litura*, *Spodoptera exigua* and one crambidae, *Spoladea recurvalis* are most destructive in sugar beet crop at Pune location in Maharashtra State. One lepidopteran pest, *Spilosoma obliqua*, two colepteran pests i. e. *Ceutorhynchus* spp. weevil and *Cassida viridis* and a grass hopper are the pests of occasional occurrence and minor in importance. Among the sucking pests observed, thrips, *Scirtothrips dorsalis* Stevens and red spider mite, *Tetranychus urticae* are most severe in incidence. Serpentine leaf miner, *Liriomyza* spp. is sporadic in occurrence, however, with the increase in area under sugar beet crop, can be a serious status in a near future. At crop mature stage, the rodents infestation has assumes the serious damage at Pune location.

5.2 STUDIES ON BIOLOGY, LIFE CYCLE AND BEHAVIOR OF *S. litura* IN LABORATORY

Each female has laid 1000 to 2000 eggs during the life span. Incubation period is 3-4 days. Newly hatched larva is pale green in colour with dark black head having the tiny black spots on the first abdominal segment. The larvae feeds gregariously on the leaves and second instar completes in a two days. Larval duration is 20 days which is completed in a six instars. Pupa is yellowish-green in colour and afterwards, turn to greenish-brown and finally become the dark brown. Pupal stage complete in 8 to 9 days. Adults are brownish-yellow in colour. Head is projected
downwards with two dark compound eyes. Wings span is about 36 to 37 mm. Moth lives for 3-4 days. Life cycle is completed in 24 – 47 days with incubation, larval and pupal periods of 3 to 4, 10 to 30 and 8 to 9 days. The overlapping of broods and all the stages of the pest are observed.

5.3 RECORD OF THE NATURAL ENEMIES OF S. litura IN SUGAR BEET FIELDS

Survey of the natural enemies of the sugar beet pests revealed that the 13 different natural enemies are naturally controlling the sugar beet pests at Pune location. Among these, the hymenopteran braconid parasitoid, *Bracon spp* was predominant in the fields severely affected by *Spodoptera litura*. *C. sexmacuiata* Fab., are abundantly observed in the field, while another coccinellids, *Scymnus sp* and a neuropteran, *Chrysoperla carnea* Stephen are sporadic in nature. Occurrence of cadavers of green muscardine fungus, *Metarhizium anisopliae* was ample in a rainy season with suitable relative humidity and atmospheric temperature. Among the avian natural enemies, seven major species *viz.* *Acridotheres tristis* (Linnaeus), *P. domesticus*, *Vanellus indicus* (Boddaert), *C. splendens*, *Centropus sinensis* (Stephens), *Pycnonotus cafer* (Linnaeus), *Eudynamys scolopacea* (Linnaeus), from six families and others had shown their presence.

5.4 SEASONAL INCIDENCE OF S. litura IN VARIOUS SUGAR BEET VARIETIES

All the 61 sugar beet varieties screened for their reaction against *Spodoptera litura* recorded the pest infestation with varying severity during winter season of 2005-06 to 2006-07. Infestation of pests starts due to favorable increasing temperature in March. It was peak in the month of April. The incidence of *S. litura* was observed firstly at 120 and 95 days after sowing for first and second year, respectively. Incidence of *Spodoptera*
remained upto harvest and after defoliating it also feeds on exposed beet roots by making the holes.

Sugar beet varieties, IN-06, IN-07, IN-08, IN-10 and Dorotea have recorded over the season $S. litura$ incidence less than 2 larvae/plant while, sugar beet varieties LKC-11, LKC-HB, IN-01, IN-03, IN-04, IN-11, R-06, IN-09, IN-12, IN-15, IN-16 and Posada recorded the maximum incidence of more than three larvae/plant during 2004-05 and 2005-06.

Sugar beet varieties, IN-12, IN-06, LK-8, LKC-95, IN-03, LKC-11, SYT-5, SYT-8 and SYT-16 recorded minimum mean larval population of $S. litura$ per plant was less than one during 2005-06 season.

5.5 NATURE AND EXTENT OF DAMAGE CAUSED BY MAJOR PESTS

5.5.1 Nature of damage caused by a major pest, $S. litura$

Among the 13 pests recorded to infests the sugar beet crop at Pune location, sugar beet army worm, $Spodoptera litura$ is major pest causing severe damage. During the early stage of crop growth, the larva acts as a cutworm and feeds on new emerging plants. Damage to germinated seedlings has affects the plant population at harvest and sugar yield reduction has noticed. Larvae prefers to feed mainly on older leaves. A first and second instar larva has mostly damages the single leaf by gregarious in nature. After second instar, larvae become more voracious and chew the leaf lamina either partially or completely. Due to the abundance population of $Spodoptera$ the complete defoliation of the crop is occurred. In the epidemic, whole crop suffers severely within a 3-4 days period. After defoliation, the full-grown larvae also feed on the beet roots. The injury made by a $Spodoptera$ larva to beet roots also acts as an entry point for the pathogens and beet root can be easily affected by root rot diseases causing a tremendous damage.
5.5.2 Artificial defoliation and losses in sugar beet yield and juice quality attributes

The losses caused due to defoliating pests were simulated by various levels of defoliation of leaves and estimated for reducing the cost of crop protection in sugar beet (Var. Posada, HI 0064 and IISR Comp -1) during winter season, 2004-05 and winter and summer season, 2005-06 at Vasantdada Sugar Institute, Pune (India). Beet root yield, pol and juice purity has not reduced significantly due to defoliation up to 70%, while the maximum yield reduction noticed in 90.1-100% defoliation with a reduction in pol and juice purity, when defoliation done twice at 120 and 135 days after sowing. During severe defoliation, up to 90.1-100%, the beet root yield up to 15.38 t/ha was obtained with minimum of 11.37% pol and 62.08% juice purity. Weight of beet root was remained unaffected up to 70%.

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

5.6.1 Evaluation of management practices for S. litura in sugar beet

The efficacy of neonicotinoid, nereistoxin analogue, organophosphate, carbamate insecticides, neem derivatives and an egg parasite, Trichogramma chilonis Ishii. were studied for the control of S. litura Fab. in sugar beet (Var. Posada and HI 0064) during winter season (sowing in Nov., December and harvesting at 6 months of crop age) in 2004-05 to 2006-07 at Vasantdada Sugar Institute, Pune (India). The pooled and statistical significant data indicated that the spraying of quinalphos 25EC @ 0.05% recorded the maximum (97.27%) reduction of Spodoptera larvae followed by chlorpyriphos 20EC @ 0.1% (94.17%). Imidacloprid 17.8 SL @ 0.008% also gave 80.24 per cent reduction in larval population. Release of parasitoids, T. chilonis @ 50000/ha and spraying of Azadiractin 3000 ppm (5 ml/lit) gave 89.71 and 89.39% reduction of larval population of Spodoptera and found effective to combat the sugar beet pests. Granular insecticides were noticed ineffective. Placement of 5 pheromone traps/ha
(Change of lure at once i.e. 15 days after placement) to attract male adults of *Spodoptera* and spraying of 500ml/ha SINPV @ 1 x 10⁹ POBs /ml also gave low population, 5.64 and 3.31 larvae/plant in over the season, respectively. Spraying of quinalphos (0.05%) yielded maximum of 75.54t/ha beet root followed by chlorpyriphos (0.1%) and imidacloprid spraying with 70.33 and 71.51 t/ha. The treatment, quinalphos, chlorpyriphos and imidacloprid have proved the most economical with ICBR ratio of 1.63, 1.57 and 1.56, respectively. Azadiractin and *Trichogramma* releases have given more beet root yield than control.

In a summer season, spraying of 0.08% Imidacloprid 17.8 SL was noticed most effective by considering the *Spodoptera litura* larval population, 0.73/plant in a over the season, beet root yield of 20.33 t/ha, pol (11.93%), and spraying of 0.05% quinalphos noticed second best treatment with 0.65 larva/plant, beet root yield of 24.00t/ha, pol (11.93%). However, placement of 5 pheromone traps/ha (Change of lure at once i.e. 15 days after placement) to attract male adults of *Spodoptera* and spraying of 500ml/ha SINPV @ 1 x 10⁹ POBs /ml also gave low population, 0.99 and 0.87 larva/plant in the season, respectively. The combination of bio-control treatments noticed as effective as inorganic insecticidal treatments.

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

Application of FYM @ 20 t/ha recorded the minimum of 1.7 and 4.0 larvae/plant of *S. litura* with a sugar beet yield of 65.28 and 25.00 t/ha during winter 2005-06 and 2006-07 and summer 2006.

Hand collection of the pest stages at four days interval recorded the minimum 1.20 larvae/plant over the season with a maximum yield of 73.79 t/ha in winter 2005-06 and 2006-07. While during Summer 2006, hand collection of the pest stages at four days interval recorded mean larval population of 1.40 /plant with a 24.33t/ha sugar beet yield.
Placement of heaps of grasses at 4 to 5 days interval found effective in reduction of *S. litura* population and recorded the minimum incidence of 1.0 and 2.60 larvae/plant over the season with a maximum yield of 65.38 and 25.33 t/ha during winter 2005-06 and 2006-07 and summer 2006.

Placement of bird perches @ 25/ha helps in effective reduction of *Spodoptera litura* larval incidence with minimum of 1.20 mean larvae/plant over the season with a beet root yield of 67.62 t/ha during winter 2005-06 and 2006-07. While during summer 2006 the minimum pest incidence of 3.50 larvae/plant in the season with maximum of 28 t/ha beet root yield was observed in sugar beet plot with a placement of 10 bird perches/ha.

During winter 2005-06 to 2006-07, the placement of pheromone traps @ 25/ha, trapped mean 19.49 male adults of *S. litura* /day and proved the best with a minimum (0.97 larva/plant) *S. litura* incidence over the season with a maximum (76.33 t/ha) yield. Similar treatment also found effective in a summer, 2006 and showed minimum (4.53 larvae/plant) larval population over the season with a beet yield of 25.33 t/ha with a mean trapping of 2.25 male adults of *S. litura* /day.

Lowest *S. litura* incidence (1.0 and 2.83 larvae/plant) over the season and maximum (24 and 77.06 t/ha) sugar beet yield was recorded in a winter 2005-06 and 2006-07 and summer 2006 with a drenching of *Pacilomyces* @ 5 kg/ha.

Release of *T. chilonis* @ 100000/ha in two installments found the best with a minimum larval population of 1.37/plant and maximum yield of 73.66 t/ha during 2005-06 and 2006-07 and 0.55 larva/plant with a maximum yield of 22.50 t/ha over the season in summer, 2006.

Maximum yield (68.23 t/ha) and minimum pest incidence (0.4 larva/plant) was recorded in a release of *C. carnae* @ 1500 larvae/ha in two installments during winter 2005-06 and 2006-07, while it was 25.00 t/ha and 1.30 larvae/ plant in summer, 2006.
Spraying of Bt. 650 gm/ha observed most effective with the lowest (0.80) larval population per plant over the season and a maximum beet root yield of 69.24 t/ha during winter 2005-06 and 2006-07. In summer, 2006 the pest incidence of 0.20 larva/plant with a beet root yield of 25.33 t/ha was obtained.

The minimum incidence of S. littoralis (1.53 larvae/plant) over the season and a maximum yield (73.21 t/ha) was obtained with the spraying of SI NPV @ 600 ml/ha during winter 2005-06 and 2006-07, while spraying of SI NPV @ 500 ml/ha found effective with the pest population of 1.0 larva/plant and a maximum yield of 24.33 t/ha in a summer 2006.

Application of Lannate 40 SP @ 25 gm/ha baiting has recorded the minimum larval population of 0.90 larva/plant of Spodoptera over the season with a maximum beet root yield of 61.86 t/ha during winter 2005-06 and 2006-07, while it was 0.60 larva/plant over the season with a maximum beet yield of 26.00 t/ha during summer 2006.

5.7 STANDARDIZATION OF THE IPM MODULE FOR THE CONTROL OF S. littura IN SUGAR BEET

Considering the significant low larval population of Spodoptera litura, maximum beet root yield of 67.54 t/ha with 14.17% pol and maximum ICBR of 1:1.57, the BIPM package found most effective in reducing Spodoptera incidence as compared to farmers practice in a winter season sown sugar beet crop. Similar trend was also noticed in a summer season and no larval population was observed at 15 days after treatment. Although, cultural control and existing package noticed is the second best effective, considering the low pest population and maximum ICBR of 1:1.61 however, it may risky to relay solely on this package singlely to control the divesting pest like Spodoptera litura.

On the basis of the results obtained from the present research work during 2004-05 to 2007-08, the IPM Module is prepared and presented for the effective control of Spodoptera litura in sugar beet crop for Pune location, Maharashtra. This BIPM package will also be effective.
throughout the Maharashtra and at Indian conditions with the fewer modifications to control of *Spodoptera* in sugar beet crop.

**INTEGRATED PEST MANAGEMENT (IPM ) PACKAGE**

- In the winter sown (October) sugar beet crop, the *Spodoptera litura* incidence starts in the month of March and at that time the sugar beet roots are matured and if, 70% sugar beet leaves are affected by *Spodoptera* still no yield loss is observed and this is experienced by the simulation trials. Therefore, winter sown sugar beet crop is good to avoid the *Spodoptera* infestation.
- Considering the low incidence of *Spodoptera*, farmers should prefer the sugar beet variety HI 0064 (Shubhra).
- Placement of bird perches @ 25/ha, one month after sowing.
- Hand collection and destruction of *Spodoptera* stages at four days interval and this operation needs to be done minimum four time during the severe incidence of the pest.
- Placement of heaps of grasses at 4 – 5 days interval and destruction of the larval stages noticed beneath the heaps of grasses during the next day morning.
- Placement of pheromone traps @ 25/ha at four month after sowing (or second fortnight of February) in a winter season and at one month after sowing during summer season. Lures can changed every 15 days interval to attract the male adults of *Spodoptera*. One or two pheromones traps can be placed from germination till fifth month of crop age for monitoring of the *Spodoptera* population.
- On the basis of collection of *Spodoptera* adult moths in the pheromone traps, the releases of *Trichogramma chilonis*, an egg parasitoid, @ 100000/ha in two installments.
- Two spraying of SI NPV @ 600ml/ha at 15 days interval in the winter season and 500 ml/ha in the summer season, when *Spodoptera* population is at initial stage.
➤ Application of Lannate 40 SP @ 25 gm/ha baiting (975 gm wheat husk + 25 gm methomyl (Lannate) + 100 gm jaggary in 1 lit. water) during the severe incidence of Spodoptera.

➤ The need base and single spraying of quinalphos 25 EC @ 0.05% (or 2 ml/lit. of water) during the severe incidence.

Cost of Integrated Pest Management Module

The cost as per the control measures practices is given as under as an example to combat the Spodoptera damage in sugar beet. The per hectare cost of Spodoptera management as per the present investigation is Rs. 3965=00 /ha and considering the severe damage by Spodoptera the cost seems to be minimum.

<table>
<thead>
<tr>
<th>Control Measure</th>
<th>Market cost (Rs.)</th>
<th>Material required/ha</th>
<th>Material cost /ha (Rs.)</th>
<th>Labour cost (Rs.)</th>
<th>Sub total (Rs.)</th>
<th>Time of application</th>
<th>Total cost (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release of T. chilonis parasitoids (one lakh/ha)</td>
<td>40/card 5 cards</td>
<td>200/-</td>
<td>-</td>
<td>200/-</td>
<td>200/-</td>
<td>Two installments at interval of 15 days</td>
<td>200/-</td>
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<tr>
<td>Placement of wooden bird perches</td>
<td>10/piece 25</td>
<td>250/-</td>
<td>75/-</td>
<td>325/-</td>
<td></td>
<td>One time</td>
<td>325/-</td>
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<tr>
<td>Making of heaps of grasses and destruction of larvae</td>
<td>- -</td>
<td>50/- each time</td>
<td>150/-</td>
<td></td>
<td>Three times at 4 days interval</td>
<td>150/-</td>
<td></td>
</tr>
<tr>
<td>Spraying of SI NPV (500ml/ha)</td>
<td>700/litre 500ml</td>
<td>350/-</td>
<td>250/-</td>
<td>600/-</td>
<td>Two times at 15 days interval</td>
<td>1200/-</td>
<td></td>
</tr>
<tr>
<td>Placement of pheromone traps @ 25/ha</td>
<td>17.34/unit 25</td>
<td>435/-</td>
<td>38/-</td>
<td>473/-</td>
<td>One time</td>
<td>473/-</td>
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<tr>
<td>Pheromone lure</td>
<td>15.11/lure 25</td>
<td>378/-</td>
<td>-</td>
<td>378/-</td>
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<td>Two lures/trap at 15 days interval</td>
<td>756/-</td>
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<tr>
<td>Methomyl 40SP @ 25gm/ha</td>
<td>1106/kg 100 gm</td>
<td>111+135 other material</td>
<td>38/-</td>
<td>284/-</td>
<td>One time</td>
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<tr>
<td>Quinalphos 25 EC</td>
<td>326.92/lit 1 lit /ha</td>
<td>327/-</td>
<td>250/-</td>
<td>577/-</td>
<td>One time</td>
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</table>

**Total cost (Rs. /ha)** 3965/-

142