

CHAPTER 6

6.0 SIGNIFICANT FINDINGS AND CONCLUSION

6.1 Significant Findings

- *Spodoptera litura* is one of the pests, which has caused detrimental damage to crops like Castor, Cotton, Maize and Cabbage in the fields of Vadodara.
- Other pests included *Helicoverpa armigera*, *Scirpophaga incertulas*, *Chilo partellus*, *Chilo infuscatellus*, *Leucinodes orbonalis*, *Plutella xylostella*, *Earias vitelli*, *Scirpophaga auriflua*, *Percallia ricini*, Aphids- *Aphis gossypii*, *Lypaphis erysimi*, *Aphis craccivora*, Hoppers- *Nilaparvata lugens*, *Sogatella furcifera* (Table 3).
- There were broadly four ways implemented by farmers for controlling the insect pests: Biological methods, Mechanical, Cultural and Chemical methods.
- Unfortunately, Chemical methods were followed by 80% of the farmers.
- Biological methods included: Biorationals, Bioproducts, Biofertilizers.
- Bio-rationales like pheromone traps and lures (Heli-lure, Earias-lure, Spodo-lure, Lucin-lure Scirpo- lure). These pheromone traps were supplied by many leading whole-sellers in Vadodara, like Agriland Biotech Pvt Ltd, Pest Control India Pvt Ltd, Elevon Enterprise India.
- Mechanical methods used were Handpicking in the fields of Dabhoi, Chhani mainly for foliage feeding insects like beetles, bugs and also for lepidopteran pests like *Spodoptera litura*, *Helicoverpa armigera*, *Earias insulana*, *Leucinodes orbonalis*. In the fields of Savli and Timbi, mulching sheets were used for the control of Aphids, Beetles, Leaf miners and *Thrips sp.* These methods used were eco-friendly, but less effective in controlling insect pests.

- Cultural methods like Crop rotation (Rice rotated with legumes and Cabbage, cauliflower rotated with Chickpea, Potato), was adopted in Ankleshwar, Gujarat. Moreover, intercropping of different varieties of crops i.e intercropping of cowpea and maize, intercropping of Castor in Banana was implemented in Varnama (15kms from Vadodara).
- In the areas of Waghodiya taluka and Chhani, neem oil based bio-pesticides were used by 5 farmers out of 20 for the control of *S.litura*. But detrimental loss was incurred by these 5 farmers, due to damage of the pest in Castor and cotton at 3-4 leaf stage.
- Chemical methods included application of insecticides to control devastating damage caused by *S.litura* in Cotton and Castor.
- The major insecticides used for controlling *S.litura* were Cypermethrin 25EC, Novaluron 10EC, Indoxacarb 15.8EC, Spinosad 45SC, Chlorantraniliprole 18.5SC, Cyantraniliprole 10OD, Emamectin Benzoate 5SG, Flubendiamide 480SC, Chlorpyrifos 20EC, Thiodicarb 75 WP, Chlorfenpyr 10SC (EC: Emulsifiable Concentrate, OD: Oil Dispersion, SC: Suspension Concentrate, SG: Suspension Granules, WP: Wettable Powder).
- Major insecticides belonging to Organophosphates, Carbamates and Synthetic Pyrethroids were used in Savli, Chhani, Waghodiya, Dabhoi, Varnama and Timbi.
- The insecticide resistance studies were carried out in laboratory conditions using four insecticides: Spinosad 45SC(Tracer®, Bayer Industries), Cypermethrin 25EC(Auzar®, Biosatdt Industries, Chlorpyrifos 20EC (Dursban®, Dow Agrosiences and Chlorantraniliprole 18.5 SC (Coragen® 20SC, FMC India Pvt limited). Commercial formulations of these were procured from the pesticide shops in Chhani and Dabhoi districts.
- The rearing of *S.litura* was successful on artificial diet (Siddiqui, K. H., & Debjani, 2002) by maintaining the optimum conditions of temperature ($26\pm 2^{\circ}\text{C}$) and humidity (60-65%RH).

- All the instars i.e first instar, second instar, third instar, fourth instar and fifth instar were reared carefully. Health parameters were checked regularly (Table 5).
- The whole life cycle completed in 30-33 days in the months of January-May, 28-30 days in the months of June- September, 30-32 days in the months of October- December 2017 and 2018.
- The percent hatchability and mortality were recorded for the insect pest culture that was reared in laboratory conditions. The mortality data recorded, indicated the development of resistance in pest for all the four insecticides (Table 12, Table 18, Table 24 and Table 31).
- Leaf-dip bioassays were kept for evaluating resistance developed in pest against the four insecticides, Cypermethrin 25EC, Chlorpyrifos 20EC Coragen® 20SC Spinosad 45SC. This was a five generation study on third instar larvae of *S.litura*.
- Exposure to bio-pesticide, **Spinosad** (Tracer®) for five generations indicated there was lowering down of mortality in the concentration of 1 ppm. When the live larvae were continued in the next generation, to keep the bioassay in fifth generation, mortality reduced from 46.67 to 43.33% (Table 22, Table 23). There was a swift decrease in the mortality in the otherwise susceptible. This meant that the insecticide was a potent insecticide and along with that it had the power to make the pest resistant.
- As compared to Spinosad, the resistance level developed due to **Chlorpyrifos** was higher. But this does not confirm the higher development in coming generations of the pest. Hence these studies presented the important phenomenon of resistance being developed in *Spodoptera litura* in the laboratory population in controlled conditions. Chlorpyrifos @ 0.05 ppm had a potency to develop resistance in the fifth generation as indicated by drop in mortality values from 53.33% in third generation to 50.00% in fourth generation to 46.67% in fifth generation (Table 16, Table 17).
- When the pest was exposed to **Cypermethrin** at various concentrations like 2 ppm, 1 ppm, 0.5 ppm, 0.25 ppm, 0.125 ppm and 0.0625 ppm, there was development of resistance in one of the concentrations i.e 0.5 ppm. The

onset of resistance was observed in the fifth generation, where the drop-in mortality was recorded as 46.67% (Table 10).

- Lastly the testing of **Coragen®** was done against third instar larvae of *S.litura* from third generation, the mortalities increased in all the concentrations except 1 ppm. The mortality obtained in *Spodoptera litura* for Coragen 20SC @ 1 ppm decreased from 53.33 in second generation to 46.67 in third generation (Table 27, Table 28). The fourth and fifth generation indicated again a decrease in mortalities attaining the values 40.00 and 36.67 in generation 4 and generation 5 respectively. Hence this was the most potent insecticide having a strong tendency to develop resistance in the pest (Table 29, Table 30).
- The resistance developed in *Spodoptera litura* for four insecticides were in the order: **Coragen® > Cypermethrin 25EC > Chlorpyrifos 20EC > Spinosad 45SC.**
- These results can be extrapolated to field conditions, as the whole life cycle of the pest completes in natural surroundings and there are full chances of development of resistance, if rotation of insecticides is not followed (Rotation of Organophosphates and Carbamates with biopesticides).

6.2 Conclusion

- The toxic effects of these insecticides are long lasting and they are even more dangerous than damage caused by pest.
- Rotation of less toxic insecticides with bio pesticides as well as usage of bio products must be adopted to get maximum control which will lead to high yield. This will cause less harm to the farmers as well as people consuming food ultimately.
- Insecticides sprayed in the fields are used non-judiciously by the farmers. They are not having proper knowledge about the label of the particular insecticide and symbols placed on the labels, which indicate toxicity level of the same.
- Though this is difficult to make the farmer understand, it proves to be helpful to the scientists and agriculture professionals worldwide. They can slowly educate the farmer by showing the long-term effects of such insecticides used in extensive and haphazard manner. The best alternative to this is switching to organic farming or using bio-pesticides which are having less adverse effect on environment and more positive and healthy effects on plants.
- Information regarding the correct application of pesticides and the use of advanced technologies for target delivery of pesticide, as well as intensive training on selective application of the correct pesticides at the correct time for the correct pests, should be disseminated to the user group.
- The current studies showed onset of resistance in Coragen®, Chlorpyrifos, Cypermethrin and Spinosad in different generation with varying mortality values. This must be considered as an alarming situation. Spinosad being a bio insecticide can be used in the rotation of insecticide programs.
- Hence from these studies, it is concluded that the resistance and generation turn over holds a strong relation. As the generations of pest pass by, the insecticides create a resistant effect on the pest and it then becomes robust and slowly ineffective against the same pesticides.

- The practice of using insecticides to get control of havoc caused by this pest, must be continuously monitored. If this is done, there would be progress not just on the economic front but also on the public health front.
- Lack of training, improper mixing of insecticides without knowing compatibility, illiteracy making it difficult to read the labels of pesticides, less knowledge about the rotation pattern of insecticides are all the factors which are responsible for failure of sustainable agriculture. If these points are looked upon carefully, agriculture will prove to be the strength of any country.
- Farmer awareness training programmes, flash mobs, interactive sessions with farmer are the ways and means to educate the farmer to address their issues related to pest attack, development of resistance, application of pesticides, understanding the labels for dosage of insecticides.
- With reference to the studies done so far in the area of resistance development against various insecticides, safety practices, pesticide use regulations, the correct application technologies and integrated pest management form the basis of developmental strategy for lessening exposure to harmful pesticides.