

CONCLUSIONS

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- *Helopeltis theivora* is a major pest of tea plantations in India. They lay eggs endophytically and pass through five nymphal instars before molting to adult, hence hemimetabola. The percent survivability decreases with advancement of developmental stage. Total developmental period varies from 19 to 22 days in climatic condition of Terai, in northern part of West Bengal.
- The population of *H. theivora* from the central region of Terai was found to be the most tolerant against monocrotophos and cypermethrin, representing pesticides of organophosphate and synthetic pyrethroid, respectively.
- Populations of *H. theivora* from conventional plantations managed with chemical pesticides were generally more tolerant to pesticides than those from bio-organically managed ones.
- Conventional management of pests with chemical pesticides exerts directional selection pressure leading to selection of more tolerant individuals and bottlenecking of population for development of high resistance. In bio-organically managed plantations such pressure for evolution of more tolerant form of *H. theivora* is low.
- Exposure to synthetic pesticides leads to enhancement of the defence/detoxifying enzymes, general esterases and cytochrome P450 in populations of *H. theivora*. The activities of the defence enzymes were significantly higher in populations of *H. theivora* collected from conventional than from bio-organically managed plantations.
- A strong correlation of resistance ratio and the activities of general esterases and cytochrome P450 in the populations of *H. theivora* could be observed from tea plantations of Terai. The resistance ratio is dependent and is a function of the activity of the defence enzymes. The higher level of tolerance in *H. theivora* populations of conventionally managed plantations is attributed to the enhanced activity ratio of both the defence enzymes.
- There are variations in the activities of general esterases and cytochrome P450 among the populations of *H. theivora* from Terai possibly depending upon the quantum of pesticide to which they are exposed. The variation indicates the existence of heterogeneous population containing both the susceptible as well as tolerant individuals in the populations of the pest. Exposure to

inappropriately high dose of pesticides leads to selection of tolerant individuals.

- There is no statistically significant difference in the activities of defence enzyme glutathione *S*-transferases among the populations of *H. theivora* from conventionally and bio-organically managed tea plantations.
- There is a non-significant negative correlation between the glutathione *S*-transferases activity ratio and the resistance ratio in the populations of *H. theivora* in tea plantations of Terai. Resistance ratio was recorded as independent and not a function of the activity of glutathione *S*-transferases in the bug.
- Exposures to high dose of pesticide lead to artificial selection of resistant/more tolerant individuals of *H. theivora*. An increase in resistance ratio of 105 fold was observed in as early as F2 generation of the pest when exposed to LC₈₀ of monocrotophos. The enhancement of resistance ratio was found to be highly correlated with the enhancement of the activity of general esterases and cytochrome P450 to the tune of 16.5 and 9.50 fold, respectively. To the contrary, the defence enzyme glutathione *S*-transferases showed a reverse trend by decreasing the specific activity with increase in tolerance level in F2 generation.
- Artificial selection by exposure to pesticide resulted in induction of additional isozymes as revealed by the native PAGE analyses of both general esterases and cytochrome P450 in F2 generation. The observation indicated that various isozymes of defence enzymes are involved in detoxification of pesticides in *H. theivora*.
- Those isozymes that are induced in response to artificial selection are not inhibited by the pesticide that was used for selection. The observation suggested that the tolerance against the pesticide in artificially selected F2 generation is conferred by the induction of such isozymes.
- S, S, S - tributylphosphorotrithioate and piperonyl butoxide are good inhibitor of general esterases and cytochrome P450, respectively in *H. theivora*. The *in vitro* inhibition of the two defence enzymes is a function of the concentration of the inhibitors. Thus, the two inhibitors can be used as synergists at suitable concentration to improve the efficacy of pesticide for management of *H. theivora* population with higher tolerance levels.

- The titer of defence enzymes, especially the general esterases and the cytochrome P450 is directly and positively correlated with the tolerance levels in *H. theivora*. Thus, the activity level determined using microplate can act as a tool to determine and monitor the tolerance level in the pest.
- In view of the rapid development of tolerance, prophylactic and ‘no threshold’ spray of pesticides should be completely abandoned. Regular monitoring of pesticide tolerance level should be done and choice of the most effective pesticide for management of the pest under IPM is necessary.
- *Oxyopes javanus*, a lynx spider is observed as a natural predator of *H. theivora* in Terai tea plantations, which appear is a potential biocontrol agent of the pest.
- The spider perform intricate courtship dance before mating. Female lays eggs within a protective cocoon made up of silk. The cocoon containing eggs are deposited on a suitable substratum like mature tea leaves. Parental care in female spider is evident as they vigilantly guard the cocoon during egg incubation period, ranging from 13 – 30 days.
- A female *O. javanus* can lay 1 – 3 batches of eggs in her lifetime with 58 – 140 spiderlings hatching out from each batch. A very high mortality rate of about 70% is prevalent in the post-embryonic developmental stages of the spider.
- The spiderlings undergo 9 – 10 moulting before transforming into adult.
- Adult *O. javanus* are very fast runner, an adaptation required for hunting prey without spinning and laying any prey trapping webs.
- Adults of *O. javanus* survive for about 2 – 3 months.
- The spider *O. javanus* exhibit a strong ‘type II’ functional response. Females are more efficient than males in predating *H. theivora*.
- *O. javanus* did not show any self-limiting tendencies like, intra-specific cannibalism and other interferences except during post-mating period and in situation of their very high density, making them a good predator of *H. theivora*.
- The spider *O. javanus* is a generalist predator, which means unlike specialist predator, they can survive during the time of scarcity of *H. theivora* in tea plantations by feeding on alternative preys.

- *H. theivora*, a major pest of the tea plantations in Terai and the Dooars in the northern West Bengal can be largely managed if the biocontrol potential of the predatory spiders like *O. javanus* is fully realised, especially in bio-organic tea plantations.