CONCLUSION

8. CONCLUSION

Pesticides play an important role in the control of pests in common agri-fields and thus improve the growth and productivity. Insect-pest management has assumed tremendous importance in the developed and developing countries. But at the same time, the indiscriminate use of pesticides has led to toxicities in animals and humans. This selected acridid species is easily identified by the following characters of tegmina with a patch of densely placed transverse nervures at the parting of the radial veins and post ocular band well marked. Azadirachtin (AZT) has a potential use as botanical pesticides in insect-pest management. The present studies infer that pesticides intoxication may induce oxidative stress (OS) more in lower organism. However, the effect of sub-chronic exposure of pesticides on livestock leading to OS requires further evaluation at molecular level. After an acute exposure, the risk assessment should be performed to quantify the exposure of humans to that particular contamination. For a sustained or chronic exposure, the risk assessment is important at community level with a focus on its long-term ecological and environmental impact. Based on the findings it can be concluded that beside antifeedant property, the toxic effects of AZT may be synergized or antagonized and can be acute or chronic or gender specific/sex dimorphic by generating reactive oxygen species (ROS) in insects. The most serious effects involve changes in behaviour, nutritional-indices and antioxidant status that can affect diversity, community structure and even loss of this ecologically important species. Bio-accumulation and its magnification of pesticides/toxicant in the food cycle have the most deleterious effects on the ecological system and that may also impair the agricultural productivity. A large number of communities world-wide consume different types of insects including grasshopper as the source of high protein-source food. So, pesticides toxicities in lower organisms has also detrimental effects on human health. Hence, ecological effects are of serious concern in regulating use of pesti-

cides for sustainable agriculture practices. The neurotoxic effects of AZT are due to oxidative pathway due to excessive production of ROS. Sex dimorphic pattern of AZT function via OS has been noticed in the current experimental species. Previous studies have been done on Coleoptera species but limited reports are available in Orthoptera. The present results may be regarded as the foundation for further studies on other orthopteran-pests using such pesticides. However, an extensive research work should be undertaken on AZT for its better utilization in sustainable agriculture practices. In conclusion, the survival and fitness of a species is determined by its fecundity and reproducibility. The oxidative-antioxidative balance in both sexes is of great interests in maintaining its gene-pool and existence/participation of other representatives of the particular ecological niche. The interpretation of these results will be more complete after further investigation of more biochemical and molecular determinants in this or other species. The current study represents the first report dealing with the sex and age dependent impairment of enzyme activities by AZT on the enzyme activities in the species-specific gonads and juvenile tissue of an acridid. The present study reveals that OS marker and antioxidant enzymes activity in testis as well as tissues are to some extent influenced by AZT exposure. Most farmers are not aware of the environment hazards caused by the inappropriate handling of pesticides. Awareness attempts need to be undertaken on use of environment measures among farmers while handling pesticides. Farmers need to be encouraged to reduce if not eliminate the use of pesticides with the introduction of incentives to help them shift from synthetic pesticides to bio-pesticides as well as organic farming.

9. FUTURE DIRECTIONS

The present investigation made an effort to explore the toxic impacts of azadirachtin (AZT) on a non-target/beneficial organism *Spathosternum prasiniferum prasiniferum*. This study explored significant aspects of AZT toxicity in short-horned-grasshopper but needs to address further on some under explored issues in future. These include the following:

1. Abnormal behaviour of restlessness, sudden quick and jerky movements in adults need to be correlated with altered neuro-muscular coordination in the body. The molecular mechanism and the factors behind the reactive oxygen species (ROS) mediated cellular stress in *S. pr. prasiniferum* also need to be explored.
2. Azadirachtin was found to induce structural deformities in adult insects. But detailed investigation on some signalling pathways like Hedgehog pathway, Notch signalling pathway and epidermal growth factor (EGF) receptor pathways which are involved during organ development should be studied. Simultaneously, impact of AZT on master gene expression should be monitored.
3. Azadirachtin was seen to reduce efficiency of conversion of digested-food (ECD) and efficiency of conversion of ingested-food (ECI) in adult. But detailed investigation of hormonal regulation on nutritional-indices should be explored.
4. There was higher cellular mortality by toxicity in some vital organs like brain, haemolymph, gut and gonad of male and juvenile tissue of this species. The molecular cascade driving mass-cellular mortality (caspase-dependent) should be studied in detail.
5. This study indicated immunotoxic potential of AZT in the form higher lipid peroxidation (LPO) in haemolymph of this species. But, effect of AZT on some important parameters like haemocytes count, haemocytes mortality, phagocytic ac-

tivity of plasmatocytes and encapsulation activity of lamellocytes need to be studied to address immunotoxicity in coming days.

6. Azadirachtin induced ROS production within the cellular environment. The inference was drawn through study of some indirect parameters like superoxide-dismutase (SOD), catalase (CAT), malondialdehyde (MDA) and non-protein-soluble-thiols (NPSH) contents. The direct quantification of ROS was not undertaken in this study. Therefore, hydroxyl radical ($^{\cdot}OH\bullet$), semi-quinone ($\bullet Q^{-}$), superoxide anion radical ($O_2\bullet^{-}$), singlet oxygen ($^1O_2$), nitric oxide ($NO\bullet$), peroxynitrite anion ($ONOO^{-}$), peroxide ion (O_2^{2-}), alkoxy radical ($RO\bullet$), peroxy radical ($ROO\bullet$), alkyl hydroperoxide/organic peroxide (ROOH), hydrogen peroxide (H_2O_2), perhydroxy radical (HO_2) etc. might be measured directly in near future. Involvement of reactive nitrogen species (RNS) should also be investigated.
7. Azadirachtin was found to be effective against acridid-pest population and hence, should be standardized to obtain effective results against its chronic toxicity. Other than AZT, botanical pesticides could be used for pilot studies to explore their toxic potential against wild Orthoptera: Acridoidea.