C. Chattopadhyay and D. Prasad (eds),
Dynamics of Crop Protection and Climate Change

Insect Pest Management in Climate Change 5

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Climate is an important determinant of the abundance and distribution of biological species. The climate has profound effects on population of invertebrate pests like insects, mites, and others species; and affects their development, reproduction, and dispersal (Sutherst 1991). Climate change is expected to have significant impacts on the distribution, phenology, and abundance of many species over the next few decades. Change in the global climate may, thus, affect the crop yields, incidence of pests, and economic costs of agricultural production. The rising CO_2 concentrations may not only have a variety of direct effects on plants, but may also have indirect effects on herbivores and their natural enemies. The climate change impacts on insects may include shifts in species distributions with shift in geographic ranges to higher latitudes and elevations, changes in phenology with life cycles beginning earlier in spring and continuing later in autumn, increase in population growth rates and number of generations, change in migratory behaviour, alteration in crop-pest synchrony and natural enemy-pest interaction, and changes in interspecific interactions (Sutherst 1991; Hughes 2002; Walther *et al*. 2002; Root *et al*. 2003). Changes in community structure and extinction of some species are also expected (Thomas *et al*. 2004). Climate change may alter the interactions between insect pests and their host plants (Bale *et al*. 2002; Sharma 2010). Plant-herbivore interactions are of particular significance because of their agricultural importance as well as their potential to affect ecosystem nutrient and carbon fluxes (Frost and Hunter 2004). The relative abundance of different insect species may change rapidly owing to climate change, and those unable to withstand the stress may be lost in the near future (Jump and Penuelas 2005; Thomas *et al*. 2004).

Extreme weather events such as intense rainstorms, wind, or high temperatures also affect survival of insect populations. For species to survive changing climates, they must either adapt *in situ (place)* to new conditions or shift their distributions in pursuit of more favourable ones. Many insects have large population sizes and short generation times; and their phenology, fecundity, survival, selection, and habitat use can respond rapidly to climate change. These changes to insect life history may in turn produce rapid changes in abundance and distribution. Due to recent climate change, widespread, generalist species at their cool range margins have expanded their distribution ranges, whereas ranges of localized, habitat-specialist species and those at their warm margins have narrowed (Hill *et al*. 2002; Konvicka *et al*. 2003). Changes in rainfall pattern also have implications for insect survival. It is being predicted that frequency of rainfall would decrease, but its intensity would increase. This may lead to floods on one hand and long dry spells on the other. More intense rainfall as project under climate change may thus, reduce incidence of small pests on crops. Aphid population on barley was negatively related to january mean minimum temperature and february total rainfall (Chander 1998; Chander *et al*. 2003).

Pest management has potential to provide eco-friendly sustainable solution to obnoxious pest problems. However, the relative efficacy of pest management components such as, host-plant resistance, bio-pesticides, natural enemies, and synthetic chemicals are liable to change as a result of global warming (Sharma 2010). It, therefore, becomes important to assess climate change impact on insect populations and adopt suitable pest management adaptations for their effective management.

Climate Change Impacts on Crop Pests

Climate change will have both direct as well as indirect effects on insect populations. Temperature is the major factor in global climate change that directly affects insect development, reproduction, and survival. Although the insect responses to global climate change vary, the effect of global warming in general has been predicted to increase intensity of herbivore pressure on plants. Climate change will also affect insects indirectly through their host plants.

Direct Effects of Climate Change on Insects

- **Expansion of Habitat Range** Any increase in temperature is bound to influence the distribution of insect populations. Climatic warming will allow the majority of temperate insect species to extend their ranges to higher latitudes and altitudes. It is predicted that 1°C temperature increase would extend distribution of species 200 km northwards or 140 m upwards in altitude (Parry and Carter 1989). Four butterfly species became extinct at the southern margins of their distribution ranges at low elevation and inhabited high altitudes with a mean increase in elevation of 41 m between pre-1970 and 1999 in Great Britain (Hill *et al*. 2002). Likewise, average elevation for 15 butterfly species increased significantly between 1950 and 2001 in the Czech Republic with a mean upward shift of 60 m (Konvicka *et al*. 2003). There is a need to regularly observe activity of pests in different regions in terms of timing, population size, and habitat ranges for drawing any meaningful conclusions.

Few Pages are not available

through (a) temperature increase and altered rainfall pattern, and (b) changes in morphological and physiological characteristics in crop plants (Coakley *et al.* 1999). An increase in probability of intense rainfall could result in increased pesticide wash-off and reduced pest control. In contrast, increased metabolic rate at higher temperature could result in faster uptake by plants and higher toxicity to pests. Likewise, increased thickness of epicuticular wax layer under high CO_2 could result in slower or reduced uptake by host, while increased canopy size may hinder proper spray coverage and lead to a dilution of the active ingredient in the host tissue. The rates of pesticide application thus have to be modified according to new situations. Granular formulations may prove more effective as these are less liable to be washed by rainfall. Reliable medium-range weather forecast can help in predicting rainfall and avoid pesticide application under imminent rainy conditions. Likewise, regular monitoring can help in undertaking control interventions at right time, thereby, helping in managing small population levels easily and effectively. Properly timed pesticide application and application coinciding with egg hatching prove more effective than many ill-timed applications. Likewise, proper placement of pesticide is also equally important to ensure its efficacy against pests. In case of rice plant hoppers, pesticide application needs to be targeted at plant stems, because foliar spray on canopy proves of little or of no use.

Conclusion

Climate change is imminent, and it has started showing its effect on organisms and insects, which are of no exception for it. Climate change will also impinge upon efficacy of pest management components. It thus, becomes very important to assess climate change impact on insects and pest management components and adopt appropriate mitigation and adaptation measures to sustain agricultural productivity. Simulation models have been used for several applications in the area of pest management, which helped to increase the efficiency of field research greatly. These will be of even greater relevance in new emerging research areas such as climate change impacts on pests and crop yield, impacts of transgenics on environment, pest risk analysis for sanitary and phytosanitary requirements, and pest forecasting.

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