Article ID 240203043

IPM Adaptations Under Climate Change

Vidya Madhuri E.[1]*, Rupali J.S.[1], Sai Pooja N.[2] and Rajna S.[1]
[1]Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi- 110012
[2]Department of Entomology, International Crop Research Institute for the Semi-Arid Tropics, Hyderabad-502324
*Corresponding Author: evidyamadhuri@gmail.com

Abstract

Climate change poses a formidable threat to ecosystems and agricultural systems worldwide, affecting various facets of life on Earth. In particular, insects, which constitute a significant portion of the global animal kingdom, face profound impacts due to climate change, with implications extending to agricultural pest management. This paper explores the direct and indirect effects of climate change on agricultural insect pests and evaluates the adaptations required in Integrated Pest Management (IPM) practices to mitigate these effects. Direct effects include alterations in habitat range, over-wintering success, migrating behavior, interspecific interactions, and population growth rates of insects. Indirect effects through host plants involve changes in insect physiology and behavior due to increased CO2 levels and temperature. The paper discusses how IPM components such as host-plant resistance, biological control, cultural control, and chemical control are susceptible to climate change and proposes adaptation strategies to sustain their effectiveness. These strategies include breeding climate-resilient crop varieties, altering sowing dates, rescheduling crop calendars, GIS-based risk mapping of crop pests, and screening pesticides with novel modes of action. Additionally, future research directions and policy considerations for combating pest problems under climate change regimes are outlined. Despite the complexity and uncertainty surrounding climate change, understanding its impacts on insect pests and developing adaptive pest management strategies are imperative for safeguarding agricultural productivity and food security in the face of changing environmental conditions.

Introduction

Climate change is one of the global threats that is been facing by living organisms on earth in recent past decades. It's been a matter of concern to human mankind in the coming future. Almost all the living fauna on earth is being affected by changing climate, plants and insects are no exception. Insects account for three-fourths of the global animal kingdom, and the worst effects of global climate change have been seen in insects most often. The major share of agricultural pests are insects, changes in the life of insects related to agriculture ultimately make changes in both crop protection and crop production aspects in a negative sense.

Pest management has the potential to provide an 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 is liable to change as a result of global warming/climate change. It, therefore, becomes important to assess climate change's impact on insect populations and adopt suitable pest management adaptations for their effective management. IPM (Integrated Pest Management) came to the scenario of pest management in the 1970s, however, the initiation took place around before the 1960s and has been most successfully practicing by farmers in many countries. The changing climate necessitates the adaptations in present ongoing IPM practices like host plant resistance, cultural control, biological control, chemical control, etc.,

Effect of climate change on agricultural insect pests:

Direct effects of climate change on insects,

- Expansion of habitat range
- Changes in over-wintering success
- Change in migrating behaviour
- Changes in interspecific interactions
- Changes in population growth rates

Indirect effect through host plants,

- Effect of increased CO2
- Effect of increased temperature

Adaptations in pest management components/IPM tools

Host-plant resistance, biological control, cultural control, and chemical control are the major pillars of the IPM. These components are likely to be affected by climatic change and thus need appropriate modifications to sustain their effectiveness.

Host plant resistance: Breakdown of temperature-sensitive resistance under increased temperature regimes may lead to the more rapid evolution of pest biotypes. Sorghum varieties that were resistant to sorghum midge, *Stenodiplosis sorghicola* (Coq.) in India became susceptible to the pest under high humidity and moderate temperatures in Africa (Sharma et al., 1999). With global warming and increased water stress, tropical countries like India might face the problem of higher yield losses in sorghum due to the breakdown of resistance against the midge and spotted stem borer *Chilo partellus*.

Biological control: Biodiversity is very important for the abundance of insect pests and their natural enemies. It thus calls for increasing functional diversity in agro-ecosystems that are prone to climate change so as to improve their resilience and reduce pest-induced yield losses. Hosts might pass through vulnerable life stages faster at higher temperatures, reducing the time available for parasitism, thereby giving a setback to the survival and multiplication of parasitoids (Gutierrez, 2008). There is thus a need to breed temperature tolerant natural enemies of pests. An increase in the time of herbivore development due to changes in plant nutrition can make herbivore prey more susceptible to predation because of the ample opportunity available to predators. Fungi such as *Metarhizium anisopliae*, *Beauveria bassiana*, Baculovirus, nuclear polyhedrosis virus (NPV), cytoplasmic virus, and bacteria like B.t have great potential for development as microbial control agents. Because of their selectivity and minimal environmental impact, microbial control agents will be ideal components of integrated pest management programs under climate change.

Cultural control: Global climate change would cause alteration in sowing dates of crops, which may alter host-pest synchrony. There is a need to explore changes in pest-host interaction under agronomic management adaptations. *Helicoverpa armigera* and Bemisia 10 tabaci are late-season pests of cotton and by sowing till mid-May, crops can escape damage from these pests. Early sowing can be used to minimize pod borer, *H. armigera* damage to chickpea in North India, BPH damage in rice, and mustard aphid damage in Brassica crops.

Chemical control: Climate change could affect the efficacy of crop protection chemicals through (a) changes in temperature and rainfall patterns, and (b) morphological and physiological changes in crop plants (Coakley et al., 1999). An increase in the probability of intense rainfall could result in increased pesticide wash-off and reduced pest control. In contrast, the increased metabolic rate at higher temperatures could result in faster uptake by plants and higher toxicity to pests. Likewise, increased thickness of the epicuticular wax layer under high CO2 could result in slower or reduced uptake by the 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. A reliable medium-range weather forecast can help in predicting rainfall and avoiding 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, application coinciding with egg hatching, proves more effective than many ill-timed applications. Likewise, the proper placement of pesticides is also equally important to ensure their efficacy against pests. In the case of rice planthoppers, pesticide application needs to be targeted at plant stems, because foliar spray on canopy proves of little or no use.

Specific adaptation strategies in IPM practices in the view of climate change are mentioned here,

1. Breeding climate-resilient varieties

To minimize the impacts of climate and other environmental changes, it will be crucial to breed new varieties for improved resistance to abiotic and biotic stresses. Considering the late onset and/ or shorter duration of winter, there is a chance of delaying and shortening the growing seasons for certain Rabi/ cold season crops. Hence, we should concentrate on breeding varieties suitable for late planting and those that can sustain adverse climatic conditions and pest and disease incidences.

2. Alternation in sowing dates of crops

Global climate change would cause alternation in sowing dates of crops which alter host-pest synchrony. There is a need to explore changes in host plant interaction under early, normal and late sown conditions in order to recommend optimum sowing dates for reduced pest pressure and increased yield.

3. Rescheduling of crop calendars

As such, certain effective cultural practices like crop rotation and planting dates will be less or noneffective in controlling crop pests with a changing climate. Hence there is a need to change the crop calendars according to the changing crop environment. The growers of the crops have to change insect management strategies in accordance with the projected changes in pest incidence and the extent of crop losses in view of the changing climate.

4. GIS-based risk mapping of crop pests

Geographic Information System (GIS) is an enabling technology for entomologists, which helps in relating insect-pest outbreaks to biographic and physiographic features of the landscape, hence can best be utilized in area-wide pest management programs. How climatic changes will affect the development, incidence, and population dynamics of insect pests can be studied through GIS by predicting and mapping trends of potential changes in the geographical distribution of agro-ecological hotspots and future areas of pest risk.

5. Screening of pesticides with a novel mode of actions

It has been reported that the application of neonicotinoid insecticides for controlling sucking pests induces salicylic acid-associated plant defense responses which enhance plant vigour and abiotic stress tolerance, independent of their insecticidal action. This gives an insight into investigating the role of insecticides in enhancing stress tolerance in plants. Such more compounds need to be identified for use in future crop pest management.

In addition to the strategies discussed above, we need to decide the future line of research and devise policies for combating the pest problems under climate change regimes. Some of these are

- Evolve temperature tolerance strains of natural enemies
- Development of Weather and pest forecasting models
- Developing early warning systems/decision support systems
- Awareness regarding impacts of climate change
- Adoption of mitigation and adaptation measures
- Sensitization of stakeholders about climate change and its impacts
- Farmers' participatory research for enhancing adaptive capacity
- Promotion of resource conservation technologies

Conclusion

Dealing with the climate change is a really tedious task owing to its complexity, uncertainty, unpredictability, and differential impacts over time and place. Understanding abiotic stress responses in crop plants, insect pests, and their natural enemies is an important and challenging topic ahead in agricultural research. Impacts of climate change on crop production mediated through changes in populations of serious insect pests need to be given careful attention for planning and devising adaptation and mitigation strategies for future pest management programmes.

References

Gvozdenac, S., Dedić, B., Mikić, S., Ovuka, J., & Miladinović, D. (2022). Impact of climate change on integrated pest management strategies. *Climate Change and Agriculture:*

Perspectives, Sustainability and Resilience, 311-372.

Karlsson Green, K., Stenberg, J. A., & Lankinen, Å. (2020). Making sense of Integrated Pest Management (IPM) in the light of evolution. *Evolutionary Applications*, *13*(8), 1791-1805.

Nihal, R. (2020). Global Climate change and its impact on integrated pest management. *Agro Econ. Int. J*, *7*(2), 133-137.

Skendžić, S., Zovko, M., Živković, I. P., Lešić, V., & Lemić, D. (2021). The impact of climate change on agricultural insect pests. *Insects*, *12*(5), 440.

Subedi, B., Poudel, A., & Aryal, S. (2023). The impact of climate change on insect pest biology and ecology: Implications for pest management strategies, crop production, and food security. *Journal of Agriculture and Food Research*, *14*, 100733.

* * * * * * * *