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Effect of Climate Change on Insect Biodiversity

Pushpa Choudhary[1] and Arti Sharma[2]

[1]Department of Entomology, College of Agriculture, Jodhpur, Agriculture University, Jodhpur 342 304

[2]Department of Entomology, Shri Karan Narendra College of Agriculture, Jobner, Shri Karan Narendra Agriculture University, Jobner, 303 328

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Abstract

The scientific community around the world has focused its attention on climate change, which is arguably the most significant global change. Agriculture production is likely to be impacted by changes in pest activity brought on by climate change in a number of ways. Pest populations that are out of control will stress crop plants and raise the possibility of crop failure, lowering harvest yield and/or quality. Furthermore, as climate change advances, crop damage from pests will exacerbate and interact with plant stress brought on by the direct impacts of changes in temperature, precipitation, and carbon dioxide levels on crops. The possible effects of changing climate on insects could result in their outbreaks, migration, change in biodiversity, species extinction, change in host shift, and emergence of new pests or biotypes. Due to the climate change, there is an increase in number of insect pest population, out breaks of insects, increased number of generations and development of resistant biotypes. This would definitely increase the damage caused by the insect to decrease the crop yields, increase the cost on crop protection and thereby affect the economy. Possible effects of elevating temperatures, CO_2 and precipitation on insects have been discussed in this chapter.

Introduction

Climate change plays a significant role in determining species distribution and abundance. It is concerned with everyone since it posess potential threat to environment and agricultural productivity and production throughout the world. It is defined as a change in climate over time, either as a result of natural variability or as a result of human activity, according to the Intergovernmental Panel on Climate Change (IPCC, 2001). According to the IPCC, human activity is primarily responsible for the majority of the observed global warming over the past 50 years. The rise in global climate temperature is the result of the enhanced greenhouse effect that is caused due to the increased levels of greenhouse gasses like Carbon

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dioxide, Chlorofluorocarbon, Methane and Nitrous oxide in the atmosphere. The phenomenon of climate change can be defined as a long-term change in environmental variables such as temperature, humidity and precipitation. Global food production is in danger as a result of rising temperatures, increased levels of CO_2, other harmful gases and irregular rainfall. Climate change will also result in increased problems of insect transmitted diseases. These changes will have major implications for crop protection and food security, particularly in the developing countries, where the need to increase and sustain food production is most urgent. Long-term monitoring of population levels and insect behaviour, particularly in identifiably sensitive regions, may provide some of the first indications of a biological response to climate change.

As in agriculture, the normal physiological processes of plants, such as photosynthesis, respiration, transpiration, nutrient uptake, mineral balance, ionic exchange etc., can be affected by climate change. Additionally, climate change can affect crop production by altering the population and behaviour of pests and pathogens. Climate factors like temperature, humidity, precipitation, and others influence the growth, development, and proliferation of organisms like bacteria, fungi, viruses, and insects. The population of pests is also anticipated to change as a result of climate change.

The climatic change impacts on pests may include:

1. Changes in insect pest diversity and abundance
2. Changes in insect pest geographic distribution
3. More insects that overwinter.
4. Rapid population growth and no. of generations
5. Introduction of alternative hosts plants
6. Changes in host plant resistance
7. Increased risk of invasive pest species
8. Emergence and dissemination of insect transmitted diseases
9. Changes in synchrony between insect pests and their host crops

All of these effects have a direct impact on agriculture and food security, and they have created fresh difficulties for pest management. Some of the earliest signs of a biological response to climate change may come from long-term monitoring of population levels and insect behaviour, especially in clearly sensitive areas.

Temperature

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Temperature is identified as dominant abiotic factor directly affects herbivorous insects. Insects are cold blooded organisms (poikilothermic). The temperature of their bodies is approximately the same as that of the environment. Therefore, temperature is probably the single most important environmental factor influencing insect behaviour, distribution, development, survival and reproduction. The most popular method for predicting the life stages of insects is to use the accumulated degree days from a base temperature and biofix point. According to estimates, insects may go through one to five extra life cycles per season for every 20°C rise in temperature.

The increase in temperature associated with climatic change, would have a variety of complex effects on crop pest insect populations, including-

- **a)** Geographic range expansion
- **b)** Increased overwintering
- **c)** Population growth rate changes
- **d)** An increase in the number of generations
- **e)** An extension of the development season
- **f)** Changes in crop pest synchrony
- **g)** Changes in interspecific interactions
- **h)** An increased risk of migrant pest invasions
- **i)** The introduction of alternative hosts and overwintering hosts.

Increased level of CO_2

One of the most studied aspects of climate change is the effect of increasing concentrations of CO_2 on plants. Plants consist primarily of carbon and elevated CO_2 levels allow them to grow more rapidly because they can assimilate carbon more quickly. Greenhouse growers have known for years, and they use CO_2 to promote plant growth. Similar to this, scientists initially believed that increasing CO_2 would be a solution for the world's food supply because it increases the photosynthetic rates of the majority of crop plants (LaMarche et al., 1984). In addition to enhanced growth, many crop plants become more drought-tolerant due to CO2 enrichment. This is because openings in the leaves (stomata) that let CO2 in and also let water vapor out. If there is high CO_2 concentration in the vicinity of leaf then the stomata need not open as much. It was suggested that under conditions of elevated CO_2, plants will produce better yields even when conditions are harsh (LaMarche et al., 1984). One reason for this is

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that insects also eat more when plants are grown under elevated levels of CO_2 to compensate their low nutritional quality. Insect sometimes feed more on leaves that have lowered nitrogen content in order to obtain sufficient nitrogen for their metabolism. Increased carbon to nitrogen ratios (C: N) in plant tissue resulting from increased CO_2 levels may slow insect development and increase the length of life stages vulnerable to attack by parasitoids.

Precipitation

Distribution and frequency of rainfall may also affect the incidence of pests directly as well as through changes in humidity levels. It is being predicted that under the climate change, frequency of rainfall would decline while its intensity would increase. This would lead to heavy showers and floods on one hand and drought spells on the other. Under such situations, incidence of small pests such as aphids, jassids, whiteflies, mites, etc. on crops may be reduced as these get washed away by the heavy rains (Pathak et al., 2012). The deviation of rainfall during monsoon and November and its relationship with level of *Helicoverpa armigera* damage severity showed higher November rainfall favoured higher infestation.

Impact of Climate Change on Pollinators and Pollination

Insects play vital role in providing various ecosystem services. One of the very important is pollination as they are excellent pollinators for many of the economically important crops. Approximately 73 per cent of the world is cultivated crops are pollinated by bees, 19 per cent by flies, 6.5 per cent by bats, 5 per cent by wasps, 5 per cent by beetles, 4 per cent by birds, and 4 per cent by butterflies and moths (Abrol, 2009). The pollinators in turn benefit by obtaining floral resources such as nectar, pollen or both. This mutualism has evolved over centuries and been helping both natural terrestrial ecosystems as well as man-made agro-ecosystems. Thus, the entomophiles pollination is a fundamental process essential for the production of about one-third of the world human food. Climate change, an emerging global phenomenon, with a potential to affect every component of agricultural ecosystems, is reported to impact insect pollinators at various levels, including their pollination efficiency. According to Millennium Ecosystem Assessment report 2005, pollination is one of the 15 major ecosystem services currently under threat from mounting pressures exerted by growing population, depleting natural resource base and global climate change. Earlier studies have clearly shown that the population abundance, geographic range and pollination activities of important pollinator species like bees, moths and butterflies are declining considerably with changing climate. The climatic factors like temperature and water availability have been found to affect profoundly the critical events like flowering, pollination and fruiting in the life cycle of plants.

Impact of Climate Change on the Pest Management Strategies

a) **Breakdown of host plant resistance: -** Host plant resistance is one of the most environmentally friendly components for managing harmful insect-pests of crops where in the plant can lessen the damage caused by insect-pests through various mechanisms like antixenosis, antibiosis and tolerance. Expression of the host plant resistance is greatly influenced by environmental factors like temperature, sunlight, soil moisture, air pollution, etc. Changes in these climatic factors may alter the interactions between insect pests and their host plants. Under stressful environment, plant becomes more susceptible to attack by insect pests because of weakening of their own defensive system resulting in pest outbreaks and more crop damage. With global temperature rise and increased water stress, tropical countries like India may face the problem of severe yield loss in sorghum due to breakdown of resistance against midge *Stenodiplosis sorghicola* and spotted stem borer, *Chilo partellus* (Sharma et al., 2005).

b) **Transgenic crop: -** In recent advancement of integrated pest management, insect resistant transgenics expressing the *Bacillus thuringiensis* (Bt) insecticidal protein (delta-endotoxin) were developed. However, these transgenic plants showed a reduction in the level of toxin protein during periods of high temperature, elevated CO2 levels, or drought, leading to decreased resistance to insect pests.

c) **Natural enemies: -** Relationships between insect pests and their natural enemies will change as a result of global warming, resulting in both increases and decreases in the status of individual pest species. Changes in temperature will also alter the timing of diurnal activity patterns of different groups of insects and changes in interspecific interactions could also alter the effectiveness of natural enemies for pest management. Quantifying the effect of climate change on the activity and effectiveness of natural enemies for pest management will be a major concern in future pest management programs. The majority of insects are benign to agro-ecosystems, and there is considerable evidence to suggest that this is due to population control through interspecific interactions among insect pests and their natural enemies' pathogens, parasites, and predators.

d) **Biopesticides and Synthetic Insecticides**: - There will be an increased variability in insect damage as a result of climate change. Higher temperatures will make dry seasons drier, and conversely, may increase the amount and intensity of rainfall, making wet seasons wetter than at present. Current sensitivities on environmental pollution, human health hazards and, pest resurgence are a consequence of improper use of synthetic insecticides. Natural plant products, entomopathogenic viruses, fungi, bacteria, nematodes, and synthetic pesticides are highly sensitive to the environment. Temperature is a major factor affecting insecticide toxicity either positive or negative and, thus, efficacy. The response relationship between temperature and efficacy has been found to vary depending on the mode of action of an insecticide, target species, method of application, and quantity of insecticide ingested or contacted. Increased temperature will increase the activity of some of the insecticides.

References

Abrol, D.P. (2009). Plant-pollinatorinteractions inthe context of climate change - an endangered mutualism. Journal of Palynology, 45:1-25.

IPCC (2001). Climate Change (2001). Impacts, Adaptation, and Vulnerability. Cambridge University Press, Cambridge, UK, p. 1032.

LaMarche, V.C., Grabyll, D.A., Fritts, H.C. and Rose, M.R. (1984). Increasing atmospheric carbon dioxide: Tree ring evidence for growth enhancement in natural vegetation. Sci. 22: 5-21.

Pathak, H. Aggarwal, P.K. and Singh, S.D. (2012). Climate Change Impact, Adaptation and Mitigation in griculture: Methodology for Assessment and Application Division of Environmental Sciences, Indian Agricultural Research Institute New Delhi, pp 111-130.

Sharma, H.C., Dhillon, M.K., Kibuka, J., Mukuru, S.Z. (2005). Plant defense responses to sorghum spotted stem borer, Chilo partellus under irrigated and drought conditions. Int. Sorghum Millets News. 46: 49-52.