

Case Study

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Effect of Climate Change on Insect Behaviour

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ABSTRACT

Global warming is a great concern throughout the world. The ill effects of global warming like change in climate, temperature, rainfall, humidity, level of carbon di-oxide has been found to have both positive and negative effects on insects, which in turn reduces the effectiveness of crop protection measures. This creates the need for global warming to be taken as an important criterion in Entomology. Being poikilothermic in nature insects are greatly affected by changing temperature. Insect will experience additional life cycles with rapid growth rate. As a result of changes in the population dynamics including distribution and migration the reliability on current insect pest ETL will be reduced. Increased insect pests outbreak will affect agricultural production. Research on basic biology of insect, population dynamics and behavior patterns should be focused to ascertain the effect of global warming on insect behavior.

Keywords

Global warming,
Climate change,
Insect pests

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Introduction

Generally global warming refers to an increase in average global temperatures. Climate change has been recognized globally as the most impending and pressing critical issue affecting mankind survival. The fifth assessment report (AR5) by the `Intergovernmental Panel on Climate Change` (IPCC) reported that each of past three decades has been successively warmer at the Earth's surface and the decade of 2000's has been the warmest. The globally averaged

combined land and ocean data as calculated by a linear trend, showed a warming of 0.85(0.65-1.06) °C over the period 1880 to 2012 (IPCC 2013). The major cause of climate change is increase in the concentration of greenhouse gases (GHG) viz., carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (NO₂) as a result of human activities from pre-industrial era. These gases keep the earth warm and cause global warming or green house effect. Global warming is caused by natural as well as human activities. There are number of natural

factors responsible for climate change. Some of the most prominent are volcanoes, ocean currents, forest fire etc. Among human activities, emissions of green house gases, industrialization, deforestation, fuel burning, etc are most important factor contributing towards global warming. It is not new that global warming can affect agriculture through their direct and indirect effects on the crops, soils, livestock and pests. Changed climatic conditions will also change the current crop pest scenario.

Effects of increased temperature on insects

Insects are cold-blooded organisms - the temperature of their bodies is approximately the same as that of the environment. The effect of rising temperature on insect can be direct, through the influence of climatic factors on the insects' physiology and behavior or indirect, as mediated by host plants, competitors or natural enemies (Thomson *et al.*, 2010). Therefore, temperature is probably the single most important environmental factor influencing insect behaviour, distribution, development, survival and reproduction. Some researchers believe that the effect of temperature on insects largely overwhelms the effects of other environmental factors (Bale *et al.*, 2002). It has been estimated that with an increase of 2oC temperature, insects might experience one to five additional life-cycles per season (Yamamura and Kiritani 1998). Based on evidence developed by studying the fossil record some researchers conclude that the diversity of insect species and the intensity of their feeding have increased historically with increasing temperature. At higher temperatures, aphids have been shown to be less responsive to the aphid alarm pheromone they release when under attack by insect predators and parasitoids – resulting in the potential for greater predation (Awmack *et al.*, 1997). Climate change will have a

major effect on geographic distribution of insect pests and low temperatures are often more important than high temperatures in determining geographical distribution of insect-pests. Increasing temperatures may result in a greater ability to overwinter in insect species limited by low temperatures at higher latitudes, extending their geographical range (EPA, 1989; Hill and Dymock, 1989), and sudden outbreaks of insect pests can wipe out certain crop species, and also encourage the invasion by exotic species (Kannan and James, 2009). Increased temperature has resulted in increased northward migration of some insects, insect development rate and oviposition, potential for insect outbreaks, invasive species introductions and insect extinctions. Global warming has lead to earlier infestation by *Helicoverpa zea* in North America (EPA, 1989), and *H. armigera* in North India (Sharma *et al.*, 2010), resulting in increased crop loss. Rising temperatures are likely to result in availability of new niches for insect-pests. Temperature has a strong influence on the viability and incubation period of *H. armigera* eggs (Dhillon and Sharma, 2007).

Case study

Spruce bark beetle

2.4 to 3.8^o rise in temperature due to climate change resulted in Spatio - temporal changes in the life cycle of bark beetle. It resulted in the formation of viable population leading to heavy damage to crops (Anna Maria Jonsson *et al.*, 2009)

Impact of rising CO₂ levels on insects

Elevated CO₂ levels are likely to influence the crop physiology through increased photosynthetic activity. This would, in turn, affect insects indirectly through the changes of plants and vegetation in quantity as well as

in quality. Global warming may be attributed for *Helicoverpa armigera* to attain the pest status of vegetables and recent outbreaks of rice bugs and fruit bugs in Japan (Kiritani 2005). Elevated CO₂ concentration increases food consumption by caterpillars, reproduction of aphids while it decreases insect development rates, response to alarm pheromones by aphids, parasitism and effectiveness of transgenics developed with *Bacillus thuringiensis* (Das *et al.*, 2011).

Case study

Influence of elevated CO₂ on gram pod borer

Alteration of food quality of chickpea due to elevated CO₂ stimulates the growth of pod borer which leads to increased food consumption, gain in larval weight, more faecal matter production, increased pupal weight and total larval duration. (Abdul Khadar *et al.*, 2014).

Impact of precipitation on insects

High humidity favours the development of some insects Eg: Aphids. Thrips and White flies are sensitive to heavy precipitation and are removed and killed by heavy rains. Out breaks of *Amsacta moorei* is directly related to heavy and frequent rain (Saini *et al.*, 2010).

Case study

Brown Plant Hopper

The abundance of BPH without precipitation is found to be normal. With an increase in 10% precipitation more than normal it is abundant. But with an increase in 10% precipitation and temperature of 1⁰C successively it has been found to multiply enormously. Global warming has lead to the increased risk and abundance of invasive pest such as *Aceria gerreronis*, *Aleurodicus*

disperses, *Paracoccus marginatus*, *Ceratovacuna lanigerum*.

Effect of global warming on insect biology

The life span of Japanese beetle, *Popillia japonica* a major pest of soybean, is prolonged by 8.25% when fed on foliages developed under elevated CO₂. Also females fed on such foliages laid approximately twice as many eggs as compared to females fed on foliages grown under normal ambient conditions. Life cycle of *Aphis gossypii* Glover ranges from 20-22 days at 10-25 0C, but at 300C it will take only 6-9 days to complete the life cycle. In the cricket, *Gryllus texensis*, 6 days of elevated temperatures resulted in increased egg laying, faster egg development and greater mass gain. Global climate change is projected to increase temperature of the upper soil (0–5 cm) by 1.6– 3.4 °C by 2100, which is likely to have several effects on soil insects such as *Sitona spp*, root weevils that are important in lentil in West Asia. Higher temperatures could speed up egg development, resulting in more than one generation per year of the pest (Scott *et al.*, 2010).

Effect on parasitism

Studies suggest that higher temperatures increase the probability of parasitoid killed by the host. Parasitism of the caterpillar *Spodoptera littoralis* by the parasitoid *Microplitis rufiventris* is less at 27°C (80.6°F) than at 20°C (68°F) (Thomas and Blanford 2003). Natural enemies of the spruce budworm, *Choristoneura fumiferana*, are less effective at higher temperatures (Harrington *et al.*, 2001). Temperature not only affects the rate of insect development, but also has a profound effect on fecundity and sex ratio of parasitoids (Dhillon and Sharma 2008, 2009). Oriental armyworm, *Mythimna separate* population increases during extended periods of drought (which is detrimental to the natural

enemies), followed by heavy rainfall because of the adverse effects of drought on the activity and abundance of natural enemies of this pest (Sharma *et al.*, 2002).

Effect of climate change on expression of resistance to insect-pests

Host plant resistance to insects is one of the most environmental friendly components of pest management. However, climate change may alter the interactions between the insect-pests and their host plants (Bale *et al.*, 2002; Sharma *et al.*, 2010). Climate change may result in breakdown of resistance to certain insect pests. Sorghum varieties exhibiting resistance to sorghum midge, *Stenodiplosis sorghicola* in India become susceptible to this pest under high humidity and moderate temperatures (Sharma *et al.*, 1999). Chemical composition of some plant species changes in direct response to biotic and abiotic stresses as a result, their tissues become less suitable for growth and survival of insect-pests (Sharma 2002).

Effect on insect pheromones

Pheromones are utilized by insects for several purposes, including alarm signalling and sexual communication. It was found that when CO₂ was elevated, aphids *Chaitophorus stevensis* did not disperse readily, but when O₃ was elevated, aphids exhibited an extreme dispersal response. The researchers think this escape behavior may explain the larger aphid populations observed under enriched O₃ conditions (Edward *et al.*, 2004).

Effect on insect coloration

Insect coloration is the phenomenon of adoption to maintain the heat. Scientists have noticed that warming climate is changing ladybugs of the coast of Netherlands from black to red. Red reflects more energy hence

ladybugs stay cool. The difference between red and black in ladybugs is only one protein, so as far as genetic adaptations concerns, it's an easy switch.

Effect of climate change on effectiveness of transgenic plants

Interestingly, such changes have important implications for the use of certain transgenic plants that are resistant to insects. It was observed that growing these transgenic plants in elevated carbon dioxide resulted in a nearly 25 per cent reduction of the expression of these proteins. This reduction allowed beet armyworms, *Spodoptera exigua* to survive on these plants, which would likely lead to the rapid selection of pest populations resistant to these proteins.

Climate change may affect our strategies for pest management

The relationship between the crop protection costs and the resulting benefits will change as results of global warming and climate change. Global warming will also reduce the effectiveness of host plant resistance, transgenic plants, natural enemies, biopesticides, and synthetic chemicals for pest management (Sharma, 2010). Casteel *et al.*, (2009) reported that global warming could cause another deleterious effect in the form of deactivation of some genes responsible for the production of volatile substances that are used by plants to attract the natural enemies of the herbivorous insects. Increased temperature and UV radiation and low relative humidity may render many of these control tactics to be less effective, and therefore, there is a need to:

Understand the changes in expression of resistance to insect-pests, and identify stable sources of resistance, and pyramid the resistance genes in commercial cultivars.

Study the effects of global warming on the efficacy of transgenic crops in pest management.

Assess the efficacy of various pest management technologies under diverse environmental conditions, and develop appropriate strategies for pest management to mitigate the effects of climate change.

In conclusion, global warming is the international problem. Agricultural business is likely to suffer losses in long run due to climate change and new emerging pest scenario. Hence pest management tactics are to be improved according to the prevailing condition. Productive insects and natural enemies are affected to a greater extent. So, resistant strains are to be developed. IPM principles will be required to be followed more strictly in the future scenario of global warming. Reduction in use of pesticides will also help in reducing carbon emissions. Historical data should be taken into consideration while formulating the experiments and standardization of protocols. Further research has to be carried out to manipulate the effects with a focus to improve the effectiveness of crop protection practises.

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