Popular Kheti
Volume -1, Issue-2 (April-June), 2013
Available online at www.popularkheti.com

ISSN:2321-0001

Climate Change and Insect Pests: Potential Impacts and Future Strategies

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Climate change is possibly the most significant global change event that has attracted the attention of scientific community all over the globe. Insects are poikilothermic animals and therefore they are highly sensitive to their surrounding climate particularly the temperature. 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. Possible effects of elevating temperatures, CO_2, and precipitation on insects have been discussed in this article.

Introduction

Insects are the most diverse group of animals on Earth. There are over a million described species of insect, and an estimated 6-10 million species of total (Anonymous 2013a). Worldwide, an estimated 570,000 species may go extinct by year 2100 (Anonymous 2013b). Many of insects are the pest of crops, animals, household and stored products and in terms of monetary value, the Indian agriculture currently suffers an annual loss of about Rs 8,63,884 million due to insect pests (Dhaliwal et al., 2010)

Climate change is possibly the most significant global change event that has attracted the attention of scientific community all over the globe. With the signs of climate change becoming more and more concrete with each passing year, concerns about its possible implications for various sectors of life on the Earth are also escalating. On account of its close association with climatic variables such as temperature and precipitation, agriculture is definitely the most climate-sensitive sector. Thus, the possible impact of climate change on agriculture has been the most important research topic and intensively debated in recent times. 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.

Effect of Rising Temperature on Insects

Many researchers believe that temperature effects are the most important environmental effects mediating the growth of insects. In general, temperature play important role in overall development of insect. In addition, the speed of insect dispersal through different means can be impacted. Generally, higher the temperature, the more rapidly insects develop and spread. Higher temperature decreases the time taken for

completion of life history which helps insect species to complete many generations within a short period of time. Several studies conducted over increasing altitude and latitude show that areas with cooler temperatures tend to have less species diversity and lower numbers of insects than areas with warmer temperatures (Petzoldt and Seamann, 2012). As the earth warms, those species directly restricted by temperature will be able to inflate northward in the northern hemisphere and southward in the southern hemisphere as rapidly as their dispersal mechanisms will allow (Das et al., 2011). Successful biological control may also depend on phenological coordination between the host and parasitoid, especially in the case of specialist parasitoids. If host and parasitoid populations respond differently to changes in temperature, host population suppression may be less successful (Petzoldt and Seamann, 2012).

Table 1. Impact of temperatures on insects

Increasing	Northward migration
	Migration up elevation gradient
	Insect development rate and oviposition
	Potential for insect outbreaks
	Invasive species introductions
	Insect extinctions
Decreasing	Effectiveness of insect bio-control by fungi
	Reliability of economic threshold levels
	Insect diversity in ecosystems
	Parasitism

(Source: Das et al., 2011; Parmesan, 2006; Bale et al., 2002; Thomas et al., 2004; Trumble and Butler, 2009)

Effect of Changing Precipitation on Insects

Since warmer environment has a tendency to hold more water, it results in more intense and frequent rainfalls. Small body-sized insects may be physically dislodged from the host plant by heavy rainfall, and are often more of a problem during dry seasons when the mortality factor is missing. Climate change resulting in more frequent and/or heavy rainfall would tend to suppress populations of small insects. Increase in the frequency of flooding of fields could tend to suppress some soil dwelling insect populations. Quite the opposite, drier conditions would have the opposite effect. Due to global warming, more droughts could be observed due to shift in rainfall pattern and increment in evaporation. Most fungi which are known to cause various diseases in insects (entomopathogens) depend on high relative humidity for successful epidemics, thereby reducing insect pest populations. Higher percentage of relative humidity resulting from rainfall or larger crop canopies may tend to favor fungal epidemics (Petzoldt and Seamann, 2012).

Effect of Rising CO_2 on Insects

As stated earlier, temperature has been thought to be the most important abiotic factor which can significantly affect the development of insects. The combined effect of higher temperatures and CO_2 concentration could have high subtle effects on overall growth and development of insects. Some research has shown that CO_2 effect on insect pests could occur through indirect effects on host biochemical

composition. Field studies have shown that several insect pests increase their feeding on soybeans in high CO_2 atmospheres. This is thought to be the result of insect feeding stimulation caused by increased simple sugars in the leaves of the soybean plants. Greenhouse and lab studies have shown that plants grown in high CO_2 atmosphere have a higher C:N ratio. Insects have been shown to respond this ratio by increasing their feeding in order to fulfill their metabolic needs for nitrogen (Petzoldt and Seamann, 2012).

Table 2. Effect of elevated CO_2 on insects

Increasing	Food consumption by caterpillars
	Reproduction of aphids
	Predation by lady bird beetles
	Carbon based plant defences
	Effect of foliar application of *Bacillus thuringiensis*
	Consumption and N utilization efficiency in pine saw fly and Gypsy moth
	Larval growth in pine saw fly
	Growth rate and consumption in Willow beetle
	Pupal weight in blue butterfly
	Feeding and growth rate in tobacco caterpillar
	Fecundity of aphids on cotton
Decreasing	Insect development rates
	Development and pupal weight in *Chrysanthemum* leaf miner
	Response to alarm pheromones by aphids
	Lipid concentration in small heath
	Parasitism
	Effect of transgenics to *Bacillus thuringiensis*
	Nitrogen based plant defence
	Control of grain aphids with sticky traps

(Source: Das et al., 2011; Coviella and Trumble, 2000; Chen et al., 2005; Osbrink et al., 1987; Awmack et al., 1997; Roth and Lndroth, 1995)

Effects of Climate Change on Pest Management Practices

Since insects are poikilothermic organisms, they are highly sensitive to their surrounding temperature. Increased climatic temperatures are likely to result in the need for more insecticide applications because of the likelihood of the presence of additional pest species, more generations of pests per growing season, and the earlier arrival of migratory pests. It has been shown that pyrethroid insecticides and spinosad are not as effective in killing insects at higher temperatures. Similarly, biology and life cycles of several arthropods will keep altering under change in climate that ultimately could affect many successful pest management practices including cultural control, biological control, and chemical control (Petzoldt and Seamann, 2012).

Future thrusts

In order to completely understand the effect of changing climate on insects, the efforts on time lag bio-diversity mapping in important agro-climatic regions should be undertaken. Detailed understanding of the biology and the population dynamics of major insect pests under changing climate would help in developing better and efficient pest control practices in relation to climate. Additionally, development of forewarning systems based on short as well as long term studies on population dynamics and migration pattern of insects would ultimately help in formulating robust management strategies.

Conclusion

The exact impacts of climate change on insects and pathogens are rather uncertain. However, climate change being is a gradual process will give us opportunities to modify our agricultural practices. Basics of IPM practices such as field monitoring, pest forecasting, record keeping, and choosing economically and environmentally sound control measures would helps in dealing with the effects of climate change.

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