Chapter 15

Insect Pest Management Under Climate Change

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Abstract Insect responses to climate change are vital for knowing the response of agroecosystems to climate change. Although numerous insect species are pests in crops, yet they also play critical roles as parasitoids and predators for other key pest species. Changes in an insect population's biochemistry, physiology, population dynamics, and biogeography may occur due to alterations in their distribution, among crop types and among the growing seasons . The response of an insect population to a quickly changing climate may also be inconsistent when insects have to interact with diverse competitors, parasitoids, and predators, and impose variable costs at a no. of life stages. The overall influence is on food production systems

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which can be already at acute risk from the influences of climate change. A significant limitation in improving crop production is the massive yield loss due to diseases, insect pests, and weeds all around the world. An unwise application of pesticides on crops has produced resistance among the insects and other pests and caused a severe effect on the economy of any country. This condition demands the need to endorse the idea of integrated pest management (IPM) among the farmers. IPM techniques are highly environment-sensitive that depend on the reasonable blend of physical, social, and biochemical control strategies utilized to control the pests, to minimize the economic loss and hazardous impact on the environment.

Keywords Climate change scenario · Pest outbreak · Insect pest management · IPM

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15.1 Introduction

The increasing global warming highlights the need for a comprehensive understanding of its results (Smith et al. 2015). Variations due to anthropogenic activities, in precipitation, increasing rate of severe meteorological events, the melting of ice-caps, and expanding ocean levels are very significant (Nicholls and Cazenave 2010; Maclean and Wilson 2011). Alongside the damaging impacts of climate change, the increasing temperature and carbon dioxide (CO_2) cons. may raise the rate of photosynthesis in medium to higher latitude areas thus improving agricultural production (McMahon et al. 2010; Asseng et al. 2015). While higher CO_2 conc. may bring a more significant increase in photosynthetic rate, it might decrease the quality of foliage as the concentration of defensive compounds in plants is increased. The increase in C-N proportion may influence C3 plants more as compared to C4 plants. Variations in vegetation characteristics influence the insects associated with them as well as affect the competitiveness between plants, the rate of plant infections, and higher order interactions of predation and parasitism. Accordingly, the impacts of climate change will proliferate all through food webs (Hoekman 2010).

Crop domestication started approximately a thousand years ago; usually, farmers have been plagued by huge numbers of pathogens (we shall call these pests later on) causing starvation and social disturbance (Woods 2011). Exemplary models are the 1840s Irish potato starvation brought about by oomycetes (*Phytophthora infestans)* and the 1943 Great Bengal famine because of fungi *(Helminthosporium oryzae)* (Strange and Scott 2005). Somewhere in the range of 10% and 16% of yield is lost due to pests (Chakraborty and Newton 2011). The multifarious crop pests (parasites, microscopic organisms, infections, viroids, oomycetes, bugs, and nematodes) keep on growing through the development and spread of new pathotypes (Fisher et al. 2012). Newly developed strains of the rusts *Puccinia graminis* and *Puccinia striiformis* are among the most harmful and quickly spreading pathogens (Singh et al. 2011; Cooke et al. 2012). The greater part of every single rising infection of plants is spread by introduction. Climate is the second most significant factor (Anderson et al. 2004). For instance, fusarium head blight of wheat has reappeared in the USA, supported by a warm, wet climate at anthesis. Warm conditions stimulate the insect pest's herbivory at higher scopes, principally through expanded winter endurance (Bale et al. 2002), as found in mountain pine creepy bugs (Dendroctonus ponderosae) episodes in the US Pacific Northwest. The impacts of climate are reliant on both host and pest reactions. For instance, dry season pressure can diminish plant obstruction as reported by Ansar et al. (1994), Mauch-Mani and Mauch (2005), Ali et al. (2014a), however disease likelihood is lower in dry conditions.

The impact of climate on crop infection has prompted hypothesis about the impacts of anthropogenic climate change on worldwide food security (Gregory et al. 2009). Projections are complicated by the collaborating impacts of expanding environmental CO_2 conc., changing climatic systems, frequency of severe climate events, and contrasting reactions of the plant and its competitors (Shaw and Osborne 2011). Variation in species abundance and variety because of climate change may bring about a decrease in the viability of IPM approach as described by Dhaliwal et al. (2010), Ewald et al. (2015).

Current sensitivities on environmental contamination, human health risks, and pest resurgence are a result of inappropriate utilization of manufactured pest sprays (Sharma 2016). A few naturally and organically based items are utilized as eco-friendly items. A significant number of these strategies for pest management are profoundly sensitive to nature. Increment in temperatures and UV radiation, and abatement in relative humidity may reduce a large number of these control strategies to be incapable as mentioned by Sharp et al. (1986) and Niziolek et al. (2012). Consequently, there is a need to create proper procedures for pest control that will be successful under circumstances of a worldwide temperature change in the future. Host-plant resistance, biopesticides, regular adversaries, and agronomic practices offer a possibly feasible alternative for IPM. However, the overall viability of a significant number of these control measures is probably going to change because of climate change (Ali et al. 2019).

15.2 Effects of Climate Change on Insect/Pest

In agriculture, pest outbreaks occur by a number of variables as well as insect-pest biology, synchronization of resources in host-plant, and natural competition among species (Letourneau 2012). These components are completely affected by climate. Increments in temperature, GHGs (particularly CO_2), and precipitation because of worldwide climate change will without a doubt keep on worsening many insect-pest issues in cereal and other crops. Shifting, prior spring excursions of aphids in European countries (Hulle et al. 2010), disruption of the occurrence patterns of the multivoltine tea tortrix moth in Japan (Nelson et al. 2013), and prior appearance of the potato leafhopper over the USA particularly in hotter years have all been due to change in climatic conditions (Baker et al. 2015). Eigenbrode et al. (2015) described that there are different manners by which pests may straightforwardly react to climate change (Fig. 15.1). Abiotic environments are influenced by different structures such as rocks, topsoil, landscape, and plant canopy. Biotic environments are influenced by nearby organisms, such as common herbivores insect, which are mostly influenced by change in leaves surface's temperature and humidity by opening of stomata (Akram et al. 2019; Zahoor et al. 2019). Both abiotic and biotic environments can be influenced to some extent by organisms to find their most favorable climate and make it difficult to predict the change in climate (Gia and Andrew 2015; Akram et al. 2018a, b).

Behavioral adaptation to climate change by insects is not fully studied but is a critical aspect of an insect's response to climate change (Andrew et al. 2013). Population abundances of pests, beneficial insects, competitors, and symbionts may go through substantive changes with a changing climate. For example, if a pest species is released from competitive interactions, its abundance may increase with a changing climate and it may become more invasive and impact on a wider number

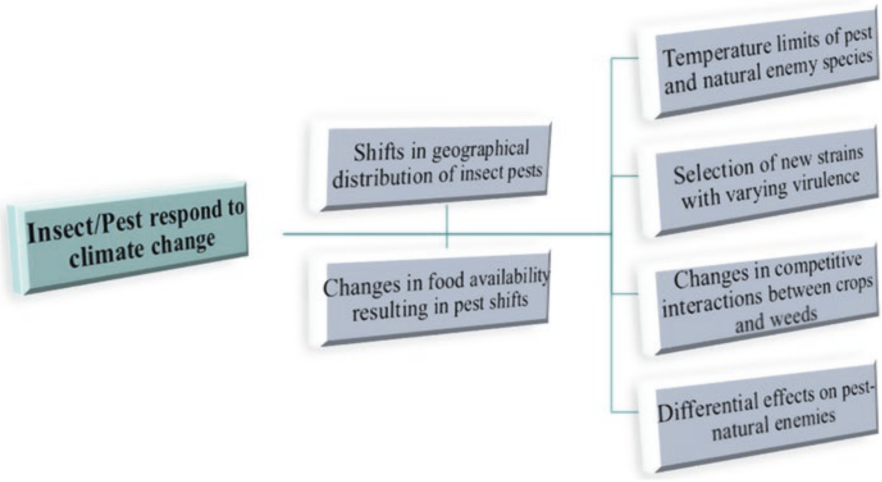

Fig. 15.1 Various ways in which pest directly respond to climate change

of species within its realized niche (Bolnick et al. 2010). If crops are planted in a new environment to keep within their climatic envelope (Nasim et al. 2016, 2018), then natural enemy and pest species may show different responses, as outlined by Gilman et al. (2010) for native species along a climatic gradient (Nasim et al. 2011, 2012).

15.2.1 Climate Change Scenario and Pest Outbreak

All international organizations working on climate change are convinced that different countries would face worst effects of global climate change. Obviously, pathosystem would also be affected by this climate change. Tree decline and dieback are emerging problem in tree plantations in these areas. It started from guava and shisham decline in 90s and now similar phenomenon is observed in trees such as mango, citrus, and loquat. Though, symptoms are more or less similar but reported causal organisms differ tremendously. It includes pathogens such as *Fusarium oxysporum* and *Colletotrichum gloeosporioides*, *Phytophthora cinnamon*, *Ceratocystis fimbriata*, pathological complex include bacteria, fungi, mollicutes (Ali et al. 2014b), and *Lasiodiplodia theobromae* (Naz 2017). This confusion exists because all authors more or less worked on the etiology of disease but there is no concrete effort to corelate the occurrence of tree disease with changing climate. The unwarranted and unprecedented increase in automobile units has increased carbon footprint in the atmosphere. Tree being perennial plants suffered most by this micro-climate change. However, no interdisciplinary effort is made to tackle this menace of plant growth. Bajwa et al. (2015) pointed out that the rise in temperature and precipitation had a profound impact on blue pine (*Pinus wallichiana*) in the forest of the study area. An educated guess could be drawn that climate change made these perennials more vulnerable against pathogens against whom in past these plants were showing resistance.

Invasion of okra crop by means of lepidopterous borers, Earias vittella, and Helicoverpa armigera has been one of the present-day troubles of the farmers in African and Asian areas (Munthali and Tshegofatso 2014). The study was planned to assess an IPM (bio-in-depth) module evolved by means of selecting through in situ assessment and incorporating the simplest pest manage alternatives together with the biological and cultural strategies against okra lepidopterous borers. According to effects, maximum shoot and fruit infestations by using okra borers have been recorded in control (unsprayed) module, while minimal have been observed in IPM module. So, IPM module is suggested to the indigenous okra growers to fight infestations of E. vittella and H. armigera and different lepidopterous borers (Aziz et al. 2012; Nawaz et al. 2019).

If weather modifications result in an intensification in pest outbreaks, farmers can also respond with the aid of making use of extra pesticides to decrease the volume of pest damage (Ziska 2014; Rosenblatt and Schmitz 2014). Determining the likely influences of climate trade on pest invertebrates, and quantifying the effects of those impacts, is needed to offer advice to farmers concerning adaptive responses. Table 15.1 shows various insects and their influences on exclusive crops. Such responses may also consist of adjustments to pesticide use, improved pest tracking technologies, modifications to crop rotation sequences, and modifications to tillage and stubble retention practices. Some of those responses are inexpensive and constitute a shift towards greater sustainable pest control practices. Others are steeply priced to put into effect. For instance, shifting from one crop kind to a distinct crop type that has a decreased susceptibility to pest damage can also involve modifications to seeding and harvesting device, modifications to crop rotation practices and adjustments to buyers, and advertising and marketing of the grain. Conversely, converting to a specific crop range that permits for earlier or later sowing may additionally require only minimal changes (Sutherst et al. 2011).

15.3 Insect Pest Management to Mitigate the Effects of Climate Change

IPM rose after WWII following the acknowledgment that aimless utilization of pesticide spray would be biologically hazardous. From that point forward, it has been expressed that IPM has become the predominant yield insurance worldview (Parsa et al. 2014). Viable IPM focuses on the guideline of conveying numerous corresponding techniques for pest, weed, and infection control (Fig. 15.2). IPM has been characterized as a "choice based procedure for organizing different strategies for control of all classes of pest in a naturally and financially stable manner." This wide scope of choices considers numerous understandings of IPM (Gadanakis et al. 2015).

Table 15.1 Various types of insects and their impacts on differnet crops

Insect name	Scientific name	Crop (s)
American bollworm	*Helicoverpa armigera* (Hubner)	Cotton, chickpea, pigeonpea, sunflower, tomato
Whitefly	*Bemisia tabaci* (Gennadius)	Cotton, tobacco
Brown planthopper	*Nilaparvata lugens* (Stal)	Rice
Green leafhopper.	*Nephotettix* spp	Rice
Serpentine leaf	miner *Liriomyza trifolii* (Burgess)	Cotton, tomato, cucurbits, several other vegetables
Fruit fly	*Bactrocera* spp.	Fruits and vegetables
Wheat aphid	*Macrosiphum miscanthi* (Takahashi)	Wheat, barley, oats
Pink stem borer	*Sesamia inferens* (Walker)	Wheat
Gall midge	*Orseolia oryzae* (Wood-Mason)	Rice
Diamondback moth	*Plutella xylostella* (Linnaeus)	Cabbage
Hoppers Several species	Pyrilla *Pyrilla perpusilla* (Walker)	Sugarcane or rice at times
Tomato leaf Miner	*Tuta absoluta* (Meyrick)	Tomato
Coconut eriopyhid mite	*Aceria guerreronis*	Coconut
Papaya mealybug	*Paracoccus marginatus*	Papaya, cotton and mulberry
Coconut leaf Beetle	*Brontispa longissima* (Gestro)	Coconut
Coffee berry Borer	*Hypothenemus hampei* (Ferrari)	Coffee
Western flower Thrips	*Frankliniella occidentalis*	Fruits and vegetables
Serpentine leaf Miner	*Liriomyza trifolii*	Burgess Cotton, tomato and cucurbits
Mealy bugs	*Paracoccus marginatus* and *Phenacoccus solenopsis*	Field and horticultural crops
Thrips Several species	*Scirtothrips dorsalis Frankliniella, schultzei* Trybom, *Thrips tabaci* L., *Scirtothrips citri*	Groundnut, cotton and citrus
Wheat aphid	*Macrosiphum miscanthi*	Wheat, barley and oat
Rice gall midge	*Orselia oryzae*	Rice
Pink stem borer	*Sesamia inferens*	Wheat, maize and sorghum
Pyrilla	*Pyrilla perpusilla*	Sugarcane
Eucalyptus gall wasp	*Leptocybe invasa*	Eucalyptus

15.3.1 General Principles of IPM

According to the EU Framework Directive 2009/128/EC, there are eight principles of IPM (Barzman et al. 2015, Fig. 15.3).

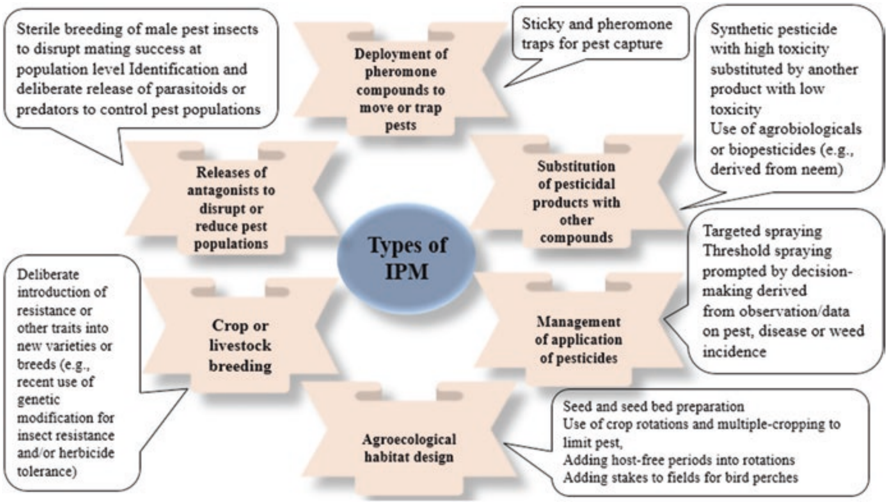

Fig. 15.2 Types of effective insect pest management

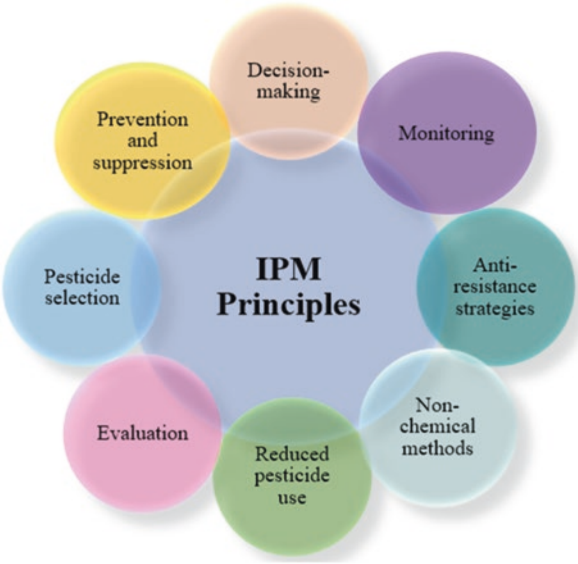

Fig. 15.3 Major principles of insect pest management

15.3.2 IPM Practices

Figure 15.4 shows four significant parts of IPM to accomplish impact results. Complete dependence on pesticides and broad utilization of synthetic concoctions for pest control is harmful to human well-being and ecological contamination.

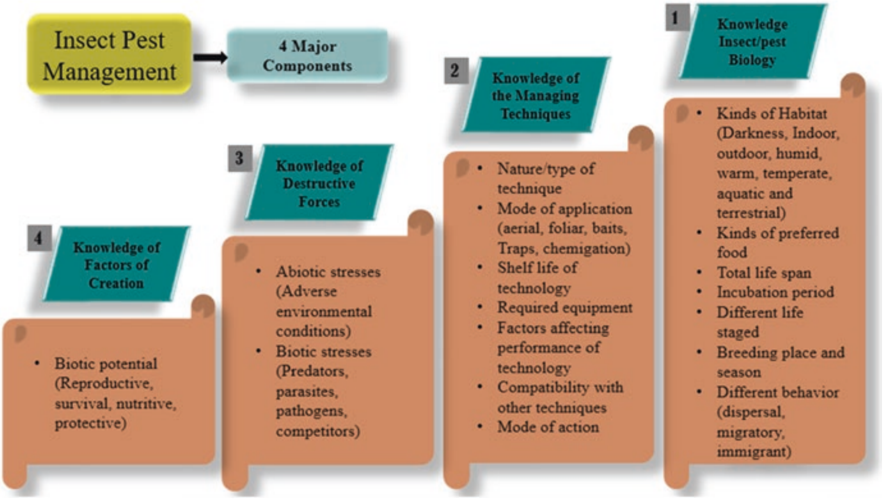

Fig. 15.4 Major components of insect pest management

15.4 Implementation of IPM Program

Effective IPM relies basically upon fundamental exploration of biological system and the comprehension of collaborations among hosts, bothers, and their normal foes. The accompanying advances ought to be taken before actualizing an IPM program (Fig 15.5).

15.5 Conclusion and Recommendations

The idea of IPM is one of a kind for the occupation of agribusiness. Entomologists with extension field staff can assume noteworthy job for moving IPM as business just at home level.

Following are some recommendations for future researchers and policymakers.

- Blend of advancements and devices, remote detecting information, Geographical Information System (GIS), Automatic Weather Stations (AWS), and internet of things (IoTs) can be utilized to advance the execution of IPM (Hussain et al. 2019, 2020).
- New age of GPS, sensors-fitted farm tool, e-tablets, and versatile applications (Plantix) could be utilized for monitoring future pest and disease threshold levels.
- Researchers can also carry out studies about converting the thoughts of farmers for the version of noninsecticidal/IPM strategies at massive level.
- In-carrier training needs to be organized for entomologists and extension area staff for distribution of new technology.

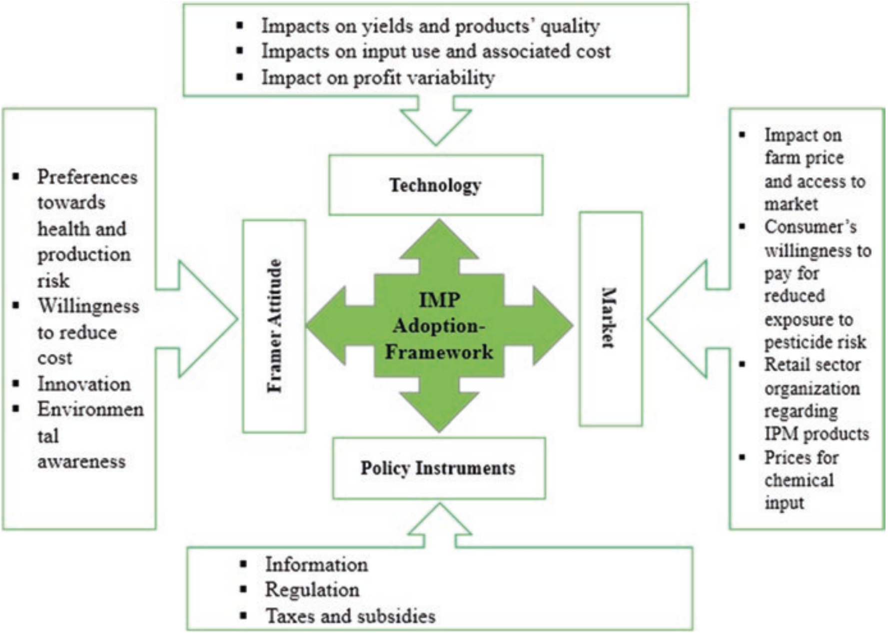

Fig. 15.5 Effective framework for insect pest management

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