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Review Article

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Scenario of climate change impact on insect pests in India

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ABSTRACT
The climate change has been intensified the risk of climate dependent crop production. Increase in temperature can reduce crop duration, increase crop respiration rates, alter photosynthesis process and affect the survival and proliferation of pest populations. The importance of climate and weather events to the distribution of insects and their population dynamics has long been recognized. Insects are poikilothermic in nature and are directly under the control of temperature for their growth. The duration of insect life cycle is altered under increased temperature and elevated carbon dioxide concentrations resulting in variable number of generations per year. The elevated carbon dioxide concentrations are mediated through enhanced photosynthesis in plants for phytophagous insects' growth and development. Several insect pests, that were important in the past or the minor pests are likely to become more devastating with global warming and climate change. Insect pests cause an estimated annual loss of 13.6% globally and 23.3% in India. Losses due to insect pests are likely to increase as a result of change in crop diversity and climate change. An increase of 0.4ºC average surface temperature over past century in India has led to crop insect pests losses increase from 3.0% during the pre-green revolution period to 50% during the post-green revolution period. The changes of insect pests losses has been increased up to 32%. Considerable knowledge is available on the effects of weather and climatic events on insect pests in India. But concerned to the impact of climate change on insect pests studies are in lag phase. A major portion of the cultivated areas of India covered under rainfed. The rainfed agriculture is directly reciprocal to the climate. So, any changes in the state of climate may cause crop failure due to biotic and abiotic stresses of climatic vagaries. Therefore, detailed study of the climate change scenario, its impact on insect pest management and formulation of coping strategies are of paramount importance to reduce the risk of crop failure. This paper attempt to analyse the review of reported studies on the scenario of climate change impact on insect pests in India to reduce the risk of strategy for effective insect pest management.
Keywords: Climate change, Insect pests, Impact, Scenario, India.

INTRODUCTION

The prominent cause of climate change is the man induced global warming due to emission of greenhouse gases in the atmosphere. The global average surface temperature has increased by approximately 0.6ºC over the past century and further it will be increased by 1.4–5.8ºC over the end of 21 century. It has manifested in terms of events like melting glaciers, rising sea levels, extreme weathers and floods. The impact of climate change affects the natural resources like, land, water and forests. These could lead to impacts on fresh water availability, oceanic acidification, food production, flooding of coastal areas and increased burden of vector borne and water borne diseases associated with extreme weather events. The consistent impact of climate change may threaten livelihood activities, which are mostly based on agriculture providing food security. Climate change has been posed a significant threat to agriculture. Climate is the primary determinant of agricultural productivity. The climate change has been intensified the risk of climate dependent crop production. Increase in temperature can reduce crop duration, increase crop respiration rates, alter photosynthesis process and affect the survival and proliferation of pest populations. (NAPCC, 2008; Kannan, 2009; Dhaliwal *et al*., 2011; NATCOM, 2012; Ninan and Bedamatta, 2012; Adhinarayanan, 2013; Rattani, 2018; IPCC, 2022).

The importance of climate and weather events to the distribution of insects and their population dynamics has long been recognized. Insects are poikilothermic in nature and are directly under the control of temperature for their growth. The duration of insect life cycle is altered under increased temperature and elevated carbon dioxide concentrations resulting in variable number of generations per year. The elevated carbon dioxide concentrations are mediated through enhanced photosynthesis in plants for phytophagous insects' growth and development. So, any changes in the state of climate may cause crop failure due to biotic and abiotic

stresses of climatic vagaries. Several insect pests, that were important in the past or the minor pests are likely to become more devastating with global warming and climate change. Overwintering of insect pests will increase as a result of climate change producing larger spring population as a base for a build-up in numbers in the following seasons. Many insect species, that will move to newer areas as invasive pests due to climate change. The legume pod borers (*Helecoverpa armigera* and *Maruca vitrata)* presently confined to tropical climates in Asia, Africa and Latin America are most likely to move to northern Europe and North America over the next 50 years as a result of global warming and climate change is now become the classical example. (Bale *et al*., 2002; Benedict, 2003; Rao *et al*., 2010; Sharma, 2014; Sharma, 2016; IPCC, 2022).

India is a vast country occupying 2.4% world geographical area sharing 16.2% of the global human population and 15% of the global livestock population. More than 60% of its population living in rural India. Agriculture is the backbone of Indian economy, that is the crucial for food and livelihood security in India. It mostly depends on onset of monsoon and its further behaviour. The cultivated fields are diverse, heterogenous and unorganised, and almost 60% are rainfed. The vulnerability of agricultural production to climate change depends not only on the physiological response of the affected plant, but also on the ability of the affected socio-economic systems of production to cope with changes in yield, as well as with changes in the frequency of droughts or floods. This scenario is more challenging, because more than 80% Indian farmers are small and marginal with poor coping capacity. Food production in India is sensitive to climate changes such as variability in monsoon rainfall and temperature changes within a season. Small changes in temperature and rainfall have significant effects on the quality of fruits, vegetables, tea, coffee, aromatic and medicinal plants, and basmati rice. An increase of 1-4 ºC, the grain yield reduced on average by 10% for each degree of temperature increased and annual wheat production could plunge by 4-5 million tons with every 1ºC rise in the temperature have been predicted in India by the end of 21 century. It has been also predicted that, 10-40% losses in crop production in India with increase in temperature 3 to 5ºC by the end of 21 century. The loss in net revenue at the farm level is estimated to range between 9% to 25% for a temperature rise of 2ºC to 3.5ºC. Insect pests cause an estimated annual loss of 13.6% globally and 23.3% in India. These crop losses due to insect pests are likely to increase as a result of changes in crop diversity and impact of climate change. (Kumar and Parikh, 2001; Benedict, 2003; Dhaliwal *et al*., 2004; NAPCC, 2008; Kumar, 2010; Ninan and Bedamatta, 2012; Ranuzzi and Srivastava, 2012; Mahato, 2014; Rao *et al*., 2019; Vanaja, 2019; Rao *et al*., 2022).

A major portion of the cultivated areas of India covered under rainfed. The rainfed agriculture is directly reciprocal to the climate. Therefore, detailed study of the climate change scenario on the basis of long-term historic weather data, its impact on yield and formulation of coping strategy are of paramount importance to reduce the risk of crop failure. Considerable knowledge is available on the effects of weather and climatic events on insect pests growth and development in India. But concerned to the impact of climate change on insect pests and their management studies are under lag phase. This paper attempt to analyse the review of reported studies on the scenario of climate change impact on insect pests and their management in India to reduce the risk of strategy for effective insect pest management.

Climate change impact on insect pests in India

Insect pests cause an estimated annual loss of 13.6% globally (Benedict, 2003) and 23.3% in India (Dhaliwal *et al*., 2004). An increase of 0.4ºC average surface temperature over past century in India has led to crop insect pests losses increase from 3.0% during the pre-green revolution period to 50% during the post-green revolution period. The changes of insect pests losses has been increased up to 32%. These losses were occurred on major crops like, Rice, Wheat, Maize, Pulses, Cotton, Sugarcane, Groundnut, Other oilseeds, and Sorghum & Millets. (Dhaliwal *et al*., 2010). Losses due to insect pests are likely to increase as a result of change in crop diversity and climate change. The sugarcane woollyaphid (*Ceratovacuna lanigera*) in Karnataka and Maharashtra and the cotton mealybug (*Phenacoccus solenopsis*) in Punjab and Haryana have been affected yield losses 30% and 30-40% for sugarcane and cotton respectively. The papaya mealybug (*Paracoccus marginatus*) in Tamil Nadu, Karnataka & Maharashtra has been affected significant yield losses for papaya. The plant hoppers (*Nilaparvata lugens* & *Sogatella furcifera*) in northern India have been affected crop failure on more than 33,000 ha area for rice (Sharma, 2016). The changes in rice insect pests losses low to severe has been inference with impact of climate change on rice insect pests scenario under eastern Uttar Pradesh conditions, while increase of 0.7º C to 1º C average surface temperature and rainfall decrease to 737 mm by 2011 (Dwivedi, 2011; SAPCCUP, 2014). The climate change has affected the number of major insect pests of rice have increase from 3 to 15 (500 times) since 1965 to 2009. Meanwhile, the rice stem borers (*Scirpophaga incertulas and Chilo suppressalis*) and rice leaf folder (*Cnaphalocrocis medinalis*) have been maintaining the major insect pest status (Krishnaiah and Varma, 2009). The prediction of insect pests incidence under climate change scenarios indicated that, the *Spodoptera litura* on groundnut and *Helicoverpa armigera* on pigeonpea were expected to have two to three additional generations during distant and very distant future climate change periods due to increased temperature across majority of locations of India (Rao *et al*., 2022).

The climate change has also diverse effects on natural enemies of insect pests. The abundance of natural enemies can be altered in response to changes in insect

pests population size induced by temperature and elevated carbon dioxide concentration effects on plants. The impact of climate change factors on natural enemies is more complex and critical. The decreased grub period (23%) with increased predation capacity (19%) of *Menochilus sexmaculatus* on *Aphis craccivora* at elevated carbon dioxide concentration over ambient carbon dioxide concentration indicated that, the incidence of *Aphis craccivora* will be higher with increased predation in the future climate change scenario of India (Rao *et al*., 2022).

Climate change management for insect pests in India

The adaptation, mitigation and natural resource management are basic components of remedial measures taken to combat the adverse impact of climate change. The natural resource management is a holistic approach to minimize the adverse impact of climate change by application of sustainable approach in insect pest management. To combat the adverse impact of climate change on insect pests, its urgent need to adopt climate resilient strategies and initiatives for insect pest management in India.

Strategies for climate resilient insect pest management

The potential adaptation, mitigation and natural resource management are the prominent strategies for climate resilient insect pest management. These strategies should be mostly deal with varietal improvement, production augmentation, weather forecasting application, indigenous technical knowledge and sustainable pest management. The strategies for climate resilient agriculture are the practices conducted by farmers for their farm production for minimizing the adverse effects of changing climatic conditions. These prominent strategies in the Indian context are discussed below-

1. Varietal Improvement

The adverse impact of climate change on insect pest management could be minimize with varietal improvement. The varietal improvement helps to minimize the adverse effects of seasonality on yield potential and stress resistance of crops by increasing farm income. Varietal improvement is the development of new crop varieties with higher yield potential and multiple stress resistant by strengthening germplasm improvement programmes. The improvised germplasm with multiple biotic stress resistance like, antixenosis and antibiosis, and frostbite and tolerance will be affecting yield and varietal potential status. The crops with multiple biotic stress resistance varieties seems to be good option for reducing insect pests infestation. In the most diversified ecosystem of India, the short duration crop varieties mature before peak infestation counter yield loss due to infestation induced reduction during growing period can be brought under crop improvement and their establishment. (NAAS, 2013; NMSA, 2014; SLACC, 2019; Vanaja, 2019).

2. Production Augmentation

The adverse impact of climate change on farm production could be compensated with production augmentation. The production augmentation helps to minimize the adverse effect of climate change on production potential of crops by supplement the technology induced increasing farm production. Production augmentation is the enhancing of farm production with cost-effective higher yield potential by strengthening technology induced farming system. The production augmentation practices and its associated cultivation practice modifications will be affecting higher yield potential. Technology induced farm production with higher yield potential seems to be good option for enhancing crop production to minimising the cope of climate change. The optimizing new technologies for farm production, increasing net profit and sustainable farming will be explored to introduce in the farming systems to complement and synergize the productivity and income under changing climatic conditions. (NAAS, 2013; NMSA, 2014; SLACC, 2019; Vanaja, 2019).

3. Weather Forecasting Application

The adverse impact of climate change on farm production could be minimize with application of weather forecasting. The application of weather forecasting helps to minimize the adverse effects of seasonality and climate change on farm production potential and livelihood improvement. Application of weather forecasting is the early warning systems of weather and climate for minimizing risks of climatic vagaries. The early warning systems of weather with monitor changes in farm production seasonality will be affecting higher yield potential and livelihood status. The seasonal weather forecasts and agromet advisory services seems to be good option for minimizing the cope of climatic vagaries and change. In the rich ecosystem of India, the monitoring of changes in biotic and abiotic stresses of farm production can be brought under weather forecasting by minimising the cope of changing climatic conditions. (NAAS, 2013; NMSA, 2014; SLACC, 2019; Vanaja, 2019).

4. Indigenous Technical Knowledge

The adverse impact of climate change on farm production could be minimize with application of indigenous technical knowledge in insect pest management. The application of indigenous technical knowledge in agriculture helps to minimize the adverse effects of seasonality and climate change on farm production potential and insect pest management. Indigenous technical knowledge in agriculture is the revival of traditional agriculture knowledge of scientific rationale for sustainable agriculture production. The application of traditional agriculture knowledge of scientific rationale seems to be good option for changing climatic conditions. In the rich ecosystem of India, the traditional agriculture knowledge of scientific rationale can be brought under indigenous technical knowledge for insect pest management by minimising the cope of changing climatic conditions. (NAAS, 2013; NMSA, 2014; SLACC, 2019; Vanaja, 2019).

5. Sustainable Insect Pest Management

The adverse impact of climate change on crop production could be minimize with sustainable pest management. The sustainable pest management helps to minimize the adverse effects of seasonality on increasing crop pests incidence by increasing farm income and quality yield. Sustainable pest management is the eco-friendly pest management with higher yield potential and cost-effective crop production by minimising adverse impact on natural resources of pest management. The improved pest management practices with efficient eco-friendly approach will be affecting quality yield potential and cost-effective status of pest management. The eco-friendly pest management with approaching natural resources of pest management seems to be good option for changing climatic conditions. In the rich ecosystem of India, the integrated pest management, biointensive pest management, ecofriendly insecticide technology and ecological engineered pest management can be brought under sustainable pest management by minimising the cope of climate change on natural resources of pest management. (NAAS, 2013; NMSA, 2014; SLACC, 2019; Vanaja, 2019).

Initiatives for climate resilient agriculture

The potential efforts by government functionaries for minimizing the cope of changing climatic conditions are the prominent initiatives for climate resilient agriculture. These initiatives should be mostly deal with varietal improvement, production augmentation, weather forecasting application, indigenous technical knowledge and sustainable pest management. The National Action Plan on Climate Change (NAPCC) of India and the National Innovations in Climate Resilient Agriculture (NICRA) project of the Indian Council of Agricultural Research (ICAR) has made excellent initiatives towards rendering Indian agriculture more resilient to climate change. These prominent initiatives are discussed below-

1. National Action Plan on Climate Change (NAPCC)

The aims to enable the country to adapt the climate change and enhance the ecological sustainability, the government of India has been launched a national strategic plan as National Action Plan on Climate Change (NAPCC) in the year 2008. The National Action Plan on Climate Change is an integration of many statutory plans. It is an amalgamation of eight missions, each of which caters to the improvement of national prospects on the threats posed by climate change and the measures proposed by India to counter them. They focus on promoting understanding of climate change, adaptation, mitigation, energy efficiency and natural resource management. The National Mission for Sustainable Agriculture (NMSA) aim is to make Indian agriculture more resilient to climate change by identifying conservation agriculture, production augmentation, crop diversification, varietal improvement, soil and water management, sustainable pest management, weather forecasting application and harnessing indigenous technical knowledge in agriculture., as well as finance and insurance mechanisms. (NAPCC, 2008, NMSA, 2014; Rattani, 2018)

2. National Innovations in Climate Resilient Agriculture (NICRA)

The aims to enhance resilience of Indian agriculture to climate change and their variability, the Indian Council of Agricultural Research (ICAR), New Delhi has been launched a national strategic research and technology demonstration network project as National Innovations in Climate Resilient Agriculture (NICRA) in the year 2011. It was formerly known as National Initiative on Climate Resilient Agriculture (NICRA). The National Innovations in Climate Resilient Agriculture is a flagship program of the Indian Council of Agricultural Research to undertake systematic long-term research on the impacts and adaptation of Indian agriculture and frontline demonstration of best practices to minimize the cope of climate change. This has been carried out in 151 vulnerable districts of the country. The National Innovations on Climate Resilient Agriculture is an integration of many village level intervention strategies. It is an amalgamation of ten intervention strategies, each of which caters to the improvement of national prospects on location specific interventions in vulnerable districts of India to enable farmers cope with current climatic variability. ten intervention strategies. (CRIDA, 2016; Prabhakar, 2019; Vanaja, 2019)

CONCLUSION

The importance of climate and weather events to the distribution of insects and their population dynamics has long been recognized. Insects are poikilothermic in nature and are directly under the control of temperature for their growth. Several insect pests, that were important in the past or the minor pests are likely to become more devastating with global warming and climate change. The adaptation, mitigation and natural resource management are basic components of remedial measures taken to combat the adverse impact of climate change. To combat the adverse impact of climate change on agriculture, its urgent need to adopt climate resilient strategies and initiatives for agriculture in India. The strategies and initiatives should be mostly deal with sustainable pest management, production augmentation, varietal improvement, weather forecasting application and harnessing indigenous technical knowledge. The National Action Plan on Climate Change (NAPCC), National Mission for Sustainable Agriculture (NMSA) and National Innovations in Climate Resilient Agriculture (NICRA) are major initiatives for climate resilient insect pest management in India.

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