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RESEARCH ARTICLE

Shifting Pest Paradigms in Indian Crops: A Comprehensive Review of Emerging Threats

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ABSTRACT

Sustainable crop production directly relates to the insect repercussions in future climates. In recent times, it has been essential to look over the changes in the pest scenario as the categories of pests may shift. Such deviations in the pest status are due to multiple factors *viz*., increased temperature, rise in Co_2 levels, etc. This is well-witnessed in a wide array of crops. Changes in these factors favour the pest species depending on their ecology. Monitoring the climate and pest population is vital for understanding the effect of climate change on insect pests. Therefore, the forecasting and prediction models must be adjusted considering the evolving circumstances. This review examines these changes in key crops, including pearl millet, maize, okra, cotton, tomato, chilli, cassava, mango and coconut. Significant pest shifts include the replacement of stem borer and shoot fly by fall armyworm in maize and the rise of sucking pests in *Bt* cotton. New invasive pests such as *Tuta absoluta* in tomato and *Thrips parvispinus* in chilly underscore the shifting pest landscape. The review highlights the importance of monitoring pest populations and advocates for integrated pest management (IPM) strategies, the development of resistant varieties and conservation of natural enemies to mitigate economic losses.

Key Words: *Changing scenario; Insect pests; Cotton; Maize; Okra; Pearl Millet.*

INTRODUCTION

Since the onset of the green revolution in India, there has been a constant increase in the number of insect pests and non-insect pests like mites and nematodes and their pest status has shifted concurrently. Climate change, genotype change, loss of biodiversity, excessive fertilizer application, unwise use of pesticides, lack of natural enemies and prevailing favourable microclimatic weather conditions have all contributed to changes in the pest scenario (Rathee and Dalal, 2018).

In nature, the status of pests keeps changing year after year. The major pest will become minor and vice versa. Sometimes alien/invasive pests may cause havoc and establish them as major pests. Several new pest populations or already known minor pests were increasing significantly over time, which caused economic damage. Such deviations in the pest status were noticed in various crops. Hence, it is critical to keep an eye on the appearance and abundance of pests because their habitat might shift quickly.

For example, Stem borer and shoot fly were replaced by fall armyworm and earhead worm in pearl millet. *Chilo partellus* is replaced by S. *frugiperda* in maize and before the introduction of *Bt* crops, the bollworms are the major pests and after their introduction, the sucking pests become a major pest. In Karnataka, Tamil Nadu, Maharashtra and Andhra Pradesh, the green mirid bug, *Creontiades biseratense* (Distant), has become a major pest in cotton (Udikeri *et al*., 2012). In Northern India, mites belonging to Eriophyiidae and Tetranychidae families have become a major pest in bean, jalapeno, cotton, cucurbits, okra, apple, ber, citrus and mango (Singh and Raghuraman, 2011). In Northeastern India, the invasive pest so-called tomato

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pinworm, *Tuta absoluta* become a major pest in tomato (Azad Thakur *et al*., 2012). In chilli, the invasive thrips, *Thrips parvispinus* also referred to as tobacco thrips or Western thrips become a pest of concern with quarantine importance. In cassava, the invasives *viz*., the spiralling whitefly *Aleurodicus dispersus* Russell, papaya mealybug *Paracoccus marginatus* Williams & Granara de Willink, Madeira mealybug *Phenacoccus madeirensis* Green, cassava mealybugs *Phenacoccus manihoti* Matile-Ferrero and *Phenacoccus herreni* Cox & Williams are regarded as the potential pests. In mango, pests including mealybugs, thrips, mites, leaf webbers, stem borers and scales which were once thought to be minor or secondary pests have recently become major pests (Jayanthi *et al*., 2014). In coconut, the eriophyid mite *Aceria guerreronis* Keifer become an emerging threat resulting in an economic loss for the coconut industry. Thus, it is important to examine current changes in the pest situation.

Agricultural research is receiving more attention as the desire to reduce yield loss from biotic and abiotic factors grows. With this in mind, the review discusses the changing pest situation in the Indian ecosystems of pearl millet, maize, okra, cotton, tomato, chilli, cassava, mango and coconut along with the percentage increase in pest infestation over the past few years and the likelihood that these pests will become major or key pests shortly, causing significant economic losses for both agriculture and horticulture.

Changing pest status in various crops

1. Pearl millet

In India, pearl millet is cultivated on more than 8 million hectares, ranking third after rice and wheat. Besides being a staple food for humans, it is also a valuable source of fodder for livestock (Yadav *et al*., 2016). In this crop, the incidence of insect pests and diseases is not up to a great extent but sometimes the infestation by white grubs or grasshoppers causes substantial loss in the crop. The chemical management measures are costlier and unpopular; therefore, farmers do not adopt them (Kumar *et al*., 2010). Till 2018, the stem borer, *Chilo partellus* and the shoot fly *Atherigona* spp greatly affected the quality and productivity of pearl millet. The occurrence of fall armyworm *Spodoptera frugiperda* on pearl millet and sorghum was noticed in October 2018. The damage was up to the extent of 30 per cent in pearl millet and 70 per cent in sorghum. The pest is gradually spreading to other millets also (Venkateswarlu *et al*., 2018). Similarly, a heavy incidence of earhead worm, *Helicoverpa armigera* was noticed on the pearl millet during flowering as well as in the milking stage in the Anand district of Gujarat. Due to the infestation of *H. armigera* in pearl millet, the flowering and ear heading stages are heavily damaged. The pearl millet showed a reduction in grain formation and yield of the crop as compared to earlier years as per the farmer's view. During the summer season, the heavy infestation of *H. armigera* in the pearl millet in almost all the areas of Borsad taluka of Anand district showed habitat and behavioural change of *H. armigera* (Dabhi, 2018). Thus, earlier stem borer and shoot fly were the major pests but now fall armyworm and earhead worm are the emerging insect pests of pearl millet.

2. Maize

Maize has wider adaptability under varied agro-climatic conditions and is known as the queen of cereals. After rice and wheat, maize is the third most important food crop in India. In 2010-11, it was grown on 8.7 million hectares (80% of the total area), mainly during the *Kharif* season (Parihar *et al*., 2011). A total of twenty-four insect pests *viz*., sorghum earhead worm *Stenachroia elongella*, shoot fly *Atherigona soccata*, cutworm *Agrotis* spp, oriental armyworm *Mythimna* sp, Bihar hairy caterpillar *Spilosoma obliqua*, Maize Webworm *Marasmia trapezalis*, green stink bug *Nezara virudula*, shoot bug *Peregrinus maidis*, leaf-footed bugs *Cletus* sp, aphids *Rhopalosiphum maidis*, white leaf hopper *Cofana unimaculata*, Green leaf hopper *Nephotettix* spp, leaf beetles *Monolepta signata*, weevil *Sitophilus zeamais*, Ash weevil *Myllocerus* sp, grasshopper *Atractomorpha crenulata* and *Hieroglyphus banian* were recorded in maize. Among these, stem borer (*C. partellus*), cob borer (*S. elongella*) and shoot fly (*Atherigona soccata*) were found to be major pests and crop damage by these major pests were 8.5 and 21.75 per cent by shoot fly, 15.67 and 13.45 per cent by stem borer and 11.95 and 6.5 per cent by cob borer during 2010 and 2011, respectively (Patra *et al*., 2013). Before mid-2018, the stem borer *C. partellus* and *S. inferens* and shoot fly *Atherigona* spp. were regular pests in maize-growing areas posing challenges in maize production (Kumar *et al*., 2018). The fall armyworm, *S. frugiperda* is a well-known pestiferous insect with strong dispersion capacity, a broad host range and high fecundity. In 2018, the fall armyworm on maize was reported in

various districts of Karnataka, India (Sharanabasappa *et al*., 2018). The recent invasion of *S. frugiperda* has transformed the pest situation and is now a major pest of maize in India (Suby *et al*., 2020). Thus now *C. partellus* is replaced by *S. frugiperda* and this invasive pest became a major pest of maize.

3. Okra

India is the largest producer of okra. Although okra holds larger areas under cultivation in India, productivity remains low. Insect pests are one of the major direct causes of yield reduction and low productivity. Nearly 72 insect pests attack okra (Mandal *et al*., 2006). Among these insect pests, shoot and fruit borers, *Earias vittella*, aphids *Aphis gossypii* Glover, leafhopper *Amrasca devastans* and *Bemisia tabaci* are quite serious. Shoot and fruit borer, *E. vitella* is the most damaging pest of okra as young larva bores into tender shoots in the early vegetative growth of plants (Dhaker *et al*., 2017). Apart from these pests Mealy bug, *Phenacoccus solenopsis*, Fruit borer, *H. armigera* and Stem fly, *Ophiomyia phaseoli* extended their host range towards okra (Sathiah *et al*., 2021). Due to the injudicious amount of pesticides used against phytophagous mites, they quickly developed resistance and the two-spotted spider mite, *Tetranychus urticae* Koch, became the major phytophagous mite in okra (Sathiah *et al*., 2021).

4. Cotton

In India, cotton contributes to the livelihoods of 95 million people. India is also the only country where all four cultivated varieties are grown. In the past, Asiatic cotton cultivars (Gossypium arboreum and *Gossypium herbaceum*) were only cultivated in India. The development of high-yielding upland cotton varieties (Gossypium hirsutum) and hybrid cotton varieties has led to the replacement of traditionally low-yielding and low-quality Asiatic cotton varieties (Blaise and Kranthi, 2019). Till 2000 the American bollworm *Helicoverpa armigera,* pink bollworm *Pectinophora gossypiella*, spotted bollworm *Earias vittella,* leaf-eating caterpillar *Spodoptera litura* and the whitefly *Bemisia tabaci* are major pests of cotton. The first genetically modified cotton crop with cry genes from the bacteria *Bacillus thuringiensis* was officially launched in India in 2002. Bollgard II with Cry1AC and Cry2AB (double-gene technology) was released in mid-2006. These genes encode proteins that defend the cotton plant from the bollworms. After this introduction of *Bt* cotton, the quantities of pesticides required decreased significantly. But soon after, the sucking insects became a major problem. After 2006 Mealybugs started destroying cotton and reduced yields by up to 40-50 per cent in affected fields (Compendium of Cotton Mealybugs, 2011). To combat the problem farmers started prophylactic spraying of pesticides which leads to the resurgence and resistance of the sucking pests. Similarly in 2015, a whitefly outbreak caused havoc and destroyed the *Bt* cotton crop in Punjab and Haryana (Kranthi, 2015). On the other hand, the resistance of pink bollworm *P. gossypiella* to Boll guard 1 with the Cry1AC gene was reported in Gujarat, India (Karihaloo and Kumar, 2009). In India, pink bollworms became resistant to *Bt* cotton after 7 years due to the use of illegal *Bt* cotton seeds with low doses of *Bt* protein and non-compliance with the refuge strategy (Huang *et al*., 2011). The field resistance in pink bollworms to Cry1Ac and Cry1Ab is also reported in India (Naik *et al*., 2020). Thus, before the introduction of *Bt* crops, the bollworms are the major pests and after their introduction, the sucking pests become a major pest and due to the resistance development pink bollworm is still holding its position as a major pest.

5. Tomato

Tomatoes are one of the most important vegetable crops, grown worldwide. This crop is affected by a wide range of pests and diseases resulting in a significant yield loss in terms of both quantity and quality. Fruit borers, whiteflies, thrips, mealy bugs and serpentine leaf miners are the major pests that severely reduce farmers' productivity. Thrips and fruit borers were recorded as the primary pests in the past. Pinworm is becoming a bigger issue nowadays. The South American tomato pinworm, *Tuta absoluta* (Meyrick), has recently been reinstated as *Phthorimaea absoluta* by Chang and Metz (2021) a new invasive pest resulting in yield loss ranging from 30 per cent to 100 per cent due to inappropriate IPM techniques and the indiscriminate use of synthetic insecticides. Tomato pinworm infestations have been more frequent recently. There have been reports of *T. absoluta* from various regions of India all year long. However, the quantity varies depending on the location (Sridhar *et al*., 2015; Sharma and Omkar 2017, Nitin *et al*., 2017). A significant yield loss may potentially surpass 100 per cent if the pest is not adequately managed (IRAC,

2009). In India, it was first documented in Karnataka by Sridhar *et al*. (2014) on tomatoes. *T. absoluta* will be prevalent all around the year in India due to changes in the climatic circumstances. Hence, depending only on synthetic chemical management techniques is ineffectual. Integrated pest management is the thorough approach to eliminating this pest.

6. Chilli

Chilli is an important cash crop. In India, it is widely cultivated in Andhra Pradesh, Karnataka, Maharashtra, Odisha, Tamil Nadu, etc. Insects are the primary cause of crop loss. They started to damage the plants in its early stages of development. Fruit borers, aphids, mites and thrips are the major insect pests inflicting serious damage. *Scirtothrips dorsalis* is the most prolific sucking pest in chilli. According to Bauer and Sheih (2000), whitefly *(Bemisia tabaci* Gennadius) was found to be a persistent pest in chilli. Losses inflicted by the insect pests ranged from 50 to 90 per cent (Nelson and Natrajan, 1994) and sucking pests ranged from 30 to 50 per cent (Varadharajan, 1994). Changes in pesticide use, climate change and changes in agricultural production patterns favour the emergence of invasive flower thrips, *Thrips parvispinus* (Karny) in chilli causing 50 to 80 per cent loss and becoming a major pest issue. In areas of Andhra Pradesh, Telangana and Karnataka that grow chillies, there have been reports of infestations of this invasive pest that inflict major damage during the *Rabi* season. It was first reported in Bengaluru, India by Tyagi *et al*. (2015) on *Carica papaya* L. (Caricaceae). Subsequent reports on *Brugmansia sp.* (Solanaceae) and *Dahlia rosea* Cav. (Asteraceae) were recorded (Rachana *et al*., 2018; Roselin *et al*., 2021). *T. parvispinus*, become a prominent pest in a wide range of agricultural and horticultural crops (Rachana and Varatharajan 2017).

7. Cassava

Cassava is a starchy crop widely cultivated in Andhra Pradesh, Kerala, Tamil Nadu, etc. Numerous pests such as whiteflies, cassava scale and variegated grasshoppers damage roots and leaves, degrade planting material quality and reduce market values. The cassava whitefly, *Bemisia tabaci* was earlier regarded as the primary pest which acts as a vector in mosaic disease. In 2020, a new invasive pest was discovered: the cassava mealybug or *Phenacoccus manihoti*. The environmental factors *viz*., low humidity, high fecundity, drought-like circumstances and a short life cycle, are contributing to the current outbreak of CMB, an invasive pest of cassava that has become substantial (ICAR-NBAIR, 2020). *P. manihoti* is an Indian pest that was first identified by Joshi *et al*. (2020) in the Thrissur district of Kerala. Since then, it has spread to the districts of Salem and Namakkal in Tamil Nadu (Sampathkumar *et al*., 2021). The infestation results in 90 per cent damage. The conventional biological control involves the release of the hymenopteran parasite wasp *Anagyrus lopezi*. It is best to deploy parasitoids in several locations for effective management.

8. Mango

The mango tree is indigenous to India. It is one of the world's most important fruit crops. Insect infestations are a major barrier preventing mango cultivars from producing maximum productivity. Approximately 400 different types of insect pests are known to infest mangoes globally (Tandon and Verghese 1985; Pena *et al*., 1998). A list of mango pests found globally was created by De Laroussilhe (1980). Climate change has resulted in the emergence of new pests. Pests including mealybugs, thrips, mites, leaf webber, stem borer and others that were formerly considered to be minor or secondary have become serious problems recently (Jayanthi *et al*., 2014). The risk posed by exotic pests is growing in unison with both global trade expansion and climate change. Recently, in Karnataka (India), a soft scale known as *Fistulococcus pokfulamensis* Hodgson & Martin was discovered for the first time (Joshi *et al*., 2022). Previously, *Fistulococcus pokfulamensis* was known to infest gymnosperms in Hong Kong. In India, it has been documented to infest mango, *Vaccinium corymbosum* and *Syzigium cumini*. Joshi *et al*. (2022) issued a warning over the spread of the mango scale across India.

9. Coconut

A major crop in tropical and subtropical areas is coconut, also known as Kalpa Viruksha. The insect pests such as red palm weevils, black-headed caterpillars, rhinoceros beetles, coconut mites, etc. cause serious damage and substantial losses to coconut growers. In 2016, scientists from ICAR-NBAIR, Bengaluru reported that the extremely polyphagous invasive rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin, was found on coconut in Pollachi, Tamil Nadu. Then, the insect swiftly expanded to every district in South India that grows coconuts. The RSW is highly

polyphagous, with over 118 hosts from 43 distinct plant families, including many commercially important crops in the US (Francis *et al*., 2016). The RSW was more prevalent on the sides of national highways than in interior areas (DPPQS Survey) due to dispersion by humans, their activities and automobiles. According to an examination of meteorological data obtained from ICAR-CPCRI, Regional Station, Kayamkulam, a change in weather pattern that is evident in the deficient monsoon can be partly blamed for the abrupt increase in RSW. Due to their extreme sensitivity to the wet season, the recent monsoon deficit (>35% in Kerala) and heavy rains are the primary causes of the flare-up. The latter resulted in a drop in relative humidity of up to 7 per cent from the previous year. A temperature increase of more than 2 degrees throughout the summer is another risk factor for the growth of the insect population (ICAR-CPCRI, 2017).

Some strategies to manage emerging insect pests given by rathee and dalal (2018) are given below

- Pests' geographical distribution must be carefully tracked
- Identification, conservation and augmentation of natural enemies of insect pests
- Studying the biology and ecology of recognised insect pests and their natural antagonists in response to changing climate
- Development of cultivars resistant/tolerant to insect pests
- Judicious use of insecticides
- Developing suitable IPM programmes
- Phytosanitary laws that forbid or restrict the entry of dangerous insect pests

CONCLUSION

The evolving pest landscape in Indian agriculture necessitates continuous monitoring and adaptive management strategies. The replacement of traditional pests by invasive species in crops like maize, cotton and tomato highlights the impact of environmental and agricultural practices. Understanding these shifts is crucial for developing effective IPM measures. Regular screening is essential to detect changes early and manage them efficiently, thereby sustaining crop production. Effective pest management requires a multifaceted approach, including the use of resistant crop varieties, judicious pesticide application and integrated pest management (IPM) programs. Conservation of natural enemies and adherence to phytosanitary regulations are also vital. Addressing these challenges is key to safeguarding crop yields, ensuring sustainable agricultural practices and mitigating the economic losses caused by emerging pests. As a researcher, it is our responsibility to identify the pests in the crop ecosystem to work out the existing IPM strategies based on various parameters (crop stage, pest abundance, pest status, etc.) or as per the convenience of the farmers.

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