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Review Paper

Insect pests of cereal crops in India: New emerging and outbreaks: a review

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ABSTRACT

Cereals have an important place in the area, production and dietary composition of the world. During current agriculture, insect-pests are being influenced to such an extent that their distribution and host range are changing dynamically, resulting in the appearance of new insect-pests. Pink stem borer (*Sesamia inferens* Walker) on rice, wheat and finger millet; cutworm (*Mythimna separata* Walker), swarming caterpillar (*Spodoptera mauritia* Boisduval) and black bugs on rice; aphid complex on wheat; sugarcane leafhopper (*Pyrilla perpusilla* Walker) on wheat, oats, sorghum and pearl millet; *Helicoverpa armigera* on wheat, sorghum and small millets are some examples of pests emerging in different parts of India. Outbreaks of brown plant hopper (*Nilaparvata lugens* Stål) have recently occurred on rice in Odisha, Telangana and Kerala. Many insect-pests are also introduced into country or new regions of the country, either through natural dispersal as invasive species, or due to quarantine irregularities at the national or international levels. Fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), is an invasive pest in India, marked its first appearance during May 2018 on maize in Karnataka. FAW continues to spread to new areas, moving towards east and north India. It also infests rice, sorghum, sugarcane and pearl millet. Therefore, it is very important to keep track of new pests that are emerging or have emerged in recent times so that one can be prepared to deal with them in the future. This review presents an overview of newly emerging and invasive insect-pests of cereal crops like rice, wheat, barley, oat, maize, sorghum, pearl millet and small millets in the country in the recent past.

Keywords: Cereals, emerging insects, fall armyworm, invasive species, millets

Cereals form a major part of human diet across the world and India is the second largest producer of rice, wheat and other cereals. During 2021-22, India produced 129.47, 107.74 and 51.10 million tonnes of rice, wheat and coarse cereals (https://static.pib.gov.in). Rice and wheat as the fine cereals are the main sources of nutrition for billions of Indians. Coarse cereals include maize, barley, oats and millets. Millet is a collective term referring to a number of small-seeded annual grasses that are cultivated as grain crops, primarily on marginal lands in dry areas in temperate, subtropical and tropical regions. Millets are classified as major millets (sorghum, pearl millet and finger millet), minor millets (foxtail millet, proso millet, kodo millet, barnyard millet, little millet, *etc*.) and pseudo millets (buck-wheat and amaranth). Millets are rich sources of nutrients, non-glutinous, non-allergenic, non-acid-forming foods and also contain bioactive compounds of pharmaceutical value. Ministry of Agriculture and Farmers Welfare (Government of India) recognized the importance of millets and declared 2018 as the "National Year of Millets" to boost production of the millets (Nutri-Cereals). Government of India had proposed to United Nations for declaring 2023 as International Year of Millets (IYOM). The proposal of India was supported by 72 countries and United Nation's General Assembly (UNGA) declared 2023 as "International Year of Millets" on 5th March, 2021. Now, Government

of India has decided to celebrate IYOM, 2023 to make it peoples' movement so that the Indian millets, recipes, value added products are accepted globally.

Agricultural crops suffer huge yield losses due to biotic stresses, in which insects play a major role as a yield limiting factor. The annual yield loss of agricultural crops in India due to attack by various insect-pests is 15.7 percent, causing an annual loss of US$ 36 billion (Dhaliwal *et al*., 2015). After the Green Revolution in the country, insect-related losses in cereal crops were recorded at 21.3 percent, an increase of 15.9 percent compared to losses in the pre-Green Revolution period. A pest reported from a field on a particular crop, showing a substantial increase in its population and the potential to cause economic damage over a period of time is called an emerging pest (Hill, 1997). Due to numerous factors, the population distribution and host plant species of many insect-pests are changing dynamically, resulting in the upsurges of new insect-pests. Several factors are responsible for insect-pest build-up over time and space such as injudicious use of pesticides, climate change, global warming, aberrant weather, resistant pest populations, invasive pests, biotype development, changing cropping patterns, human interventions, *etc*. Insect pests with minor status acquire dominant proportions due to increased adaptive abilities due to mutational changes for survival. In India, the changing insect-pest scenario had been well documented across the crops and agroecological regions (Dhaliwal and Koul, 2010; Mandeep and Pradeep, 2018; Kumar *et al*., 2021). Paradigm changes have also been reported from time to time in the insect pests of cereal crops (Kishore, 2005; Krishnaiah and Varma, 2011; Prakash *et al*., 2014; Jena *et al*., 2018). Agricultural crops are also vulnerable to threats from exotic pests that may purposefully or accidentally enter new regions of the country or country in addition to natural dispersal. Fall army worm has been wreaking havoc in maize fields across the country recently (Tippannavar *et al*., 2019). Changing scenario, outbreaks and invasion of insect-pests on cereal crops have not previously been reviewed in such detail. Therefore, this article has been written, which deals with the newly emerging and invasive insect-pests of cereal crops in India.

Emerging and invasive insect species on cereal crops: Crop-wise detailed status of emerging and invasive insect pests of cereal crops in India is mentioned hereunder.

Rice: With the introduction of new cultivars, practicing of different cultivation systems and concomitant changes in rice-based cropping systems, some insect-pests previously considered minor pests have now gained the status of pests of regional significance. With the expansion of rice cultivation, especially fragrant rice varieties in non-traditional areas such as north-western parts of India and hilly regions, the incidence of pink stem borer, *Sesamia inferens* (Walker), and white stem borer, *Scirpophaga innotata* (Walker), has increased. The pink stem borer is especially prominent in the reproductive stage of the crop in north-west India. In the southern state of Kerala and in the hills of the northern region, the white stem borer has become dominant (Jena *et al*., 2018).

The brown planthopper (BPH), *Nilaparvata lugens* (Stål) (Fig. 1), a minor pest until the mid-sixties, assumed the status of the most destructive pest in the 1970s. The first serious epidemic of BPH occurred in 1973 on half a million hectares, resulting in 10-70 percent grain yield losses worth $12 million.

a **b**

Fig. 1: Brown plant hopper: a. infested plants b. hopperburn symptom (PC: Dr. Rohit Rana, Shamli Maa Shakumbhari University Saharanpur)

Since then, a series of BPH outbreaks have been reported in Karnataka (1975 and 1985), Krishna and Godavari deltas of Andhra Pradesh (1976-1983) and Telangana (1980), Madhya Pradesh and Odisha (1976), Tamil Nadu (1977 and 1982). The intensity of the occurrence gradually decreased during 1983-1986 and it remained almost unremarkable until 1999. This was attributed to the development of resistant/tolerant varieties and different groups of insecticides. But, despite all these developments, BPH again became a threat during 2000-2005 in the southern and eastern states of the country. Later, it became more aggressive in the northern states by 2010 (Rath *et al*., 2020; Jena *et al*., 2018).

Another planthopper i.e., white-backed planthopper (WBPH), *Sogatella furcifera* (Horváth), upsurged in the early nineties. Virulent biotypes have developed due to the planting of resistant varieties with a single gene conferring high levels of resistance. Frequent incidence of planthoppers was observed in voluntary summer rice crop and even in nursery. During *Kharif* 2005, planthopper populations were critical in Gangavathi (30000ha), Kampli (25000ha) and Koppal (10000ha) areas of Siruguppa and Mandya region (2000 ha) in Bhadra and Kaveri command of Karnataka. A mixed population of both BPH and WBPH was observed in Cauvery Command. During *Kharif* 2006, outbreaks of BPH were reported from Telangana region of Andhra Pradesh and Uttara Kannada region of Karnataka (Krishnaiah and Varma, 2011). During *Kharif* 2008, there was a severe infestation of these hoppers in about 120,000 hectares in Punjab and Haryana. They have been regular pests in East and West Godavari districts of Andhra Pradesh, and Bellary and Sindanur areas of Karnataka and Burdwan district of West Bengal during *Kharif* 2009-12 (Prakash *et al*., 2014). Once considered seasonal pests, later these planthoppers began to occur in significance proportions throughout the year. Outbreaks of BPH and WBPH have raised serious concern recently and these have spread rapidly to new non-traditional areas of Punjab, Haryana, parts of Uttar Pradesh. WBPH as a pest gained immense importance in both lowland and upland areas, especially where rice varieties resistant to BPH are cultivated (Krishnaiah and Varma, 2011). BPH infestation has destroyed 180,000 hectares of rice crop in 15 out of 30 districts of Odisha in 2017. Unprecedented heavy rains between November 14 and 18, 2017 caused further losses to farmers due to premature harvesting. This pest has also destroyed more than 1,000 ha of the paddy crop in four districts of Telangana *viz*., Karimnagar, Jagtial, Peddapalli and Sircilla. About 200,000 hectares of paddy area has been damaged in nine districts of Odisha including Koraput, Nuapada and Bargarh by BPH attack during *Kharif* 2021. Hybrid rice, high density planting, high urea and ammonium content in fertilizers, high use of pesticides and congenial environment, all favoured a rapid build-up of BPH populations. Rainfall also profoundly affects BPH build-up by creating favourable high humidity at the base of the crop. Spurious insecticides being used proved ineffective in controlling BPH, which firstly wilted the green crops and then turned them to rust. To prevent further spread of the pest, the farmers burnt their crops, but was not successful at all. Recently during *Kharif* 2022, BPH has shown its notable infestation in Kuttanad region of Kerala.

Leaf folder, previously a pest of minor importance, attained the status of major pest by 2005 with the introduction of high-yielding varieties across the country, especially in areas of high fertilizer use (Prakash *et al*., 2014; Jena *et al*., 2018). Four species of leaf folder *viz*., *Cnaphalocrocis medinalis* (Guenee), *Marasmia patnalis* (Bradl), *M. exigua* (Butl), *Brachmia arotraea* (Meyr), of which *C. medinalis* (Fig. 2) is the dominant and widespread species (Krishnaiah and Varma, 2011). The first outbreak of leaf folder occurred in Haryana during 1985, resulting in extensive damage. Later on, leaf folder spread to all rice growing areas. The Cauvery delta region observed more than 65 percent damage due to leaf folder outbreak during August and October, mainly on TKM 9 and ADT 43 varieties in Tamil Nadu during 2006. Leaf folder damage was moderate to severe in entire Punjab during 2007 (Krishnaiah and Varma, 2011). In recent years, leaf folder has become prevalent and increased incidences have been observed in many states of the country. An outbreak of leaf folder was observed on Lalat variety of rice during *Kharif* 2008 at Central Rice Research Institute, Cuttack, Odisha (Rath *et al*., 2020). The use of high levels of nitrogen and cloudy weather with little sunlight favours this pest build-up. The use of insecticides in the early stages of crop growth generally results in more adverse effects. Low level of damage is compensated but damage at post booting stage leads to heavy loss in yield.

The cutworm or ear cutting caterpillar, *Mythimna separata* Walker, is becoming a serious pest in several rice growing areas in coastal Andhra Pradesh and eastern states (Prakash *et al*. 2014; Jena *et al*., 2018). During *Kharif* 2007, an outbreak of this pest occurred in Pudukkottai and Pattukottai of Tamil Nadu in 200 to 300 hectares of crop near harvest. Though its occurrence is sporadic, it causes heavy losses during outbreaks. In some areas of Pusa, Bihar during 2007, outbreak of this pest was witnessed in about 33 percent of high yielding varieties and the incidence was as high as 45 to 65 percent (Krishnaiah and Varma, 2011). Recently severe damage to 30,000 hectares of paddy crop was reported in Assam (Rath *et al*., 2020).

a **b**

Fig. 2: Rice leaf folder (*Cnaphalocrocis medinalis*): a. damaging symptom b. larva (PC: Dr. Rohit Rana, Shamli Maa Shakumbhari University Saharanpur)

Swarming caterpillar, *Spodoptera mauritia* Boisduval has been reported to have emerged as a pest on paddy crop in India (Jena *et al*., 2018; Kumar *et al*., 2021). Irrigated or rain-fed lowland rice is more prone to this pest because of its favourable crop conditions, especially water (Jena *et al*., 2018). It also poses a threat in hilly or forested croplands, which generally belong to a range of upland ecosystems. Severe outbreaks of swarming caterpillar on paddy have been reported from Maharashtra (2001), and West Bengal and Orissa (2005). It affected an area of 5000 ha in Nuapara district and parts of Bolangir, Bargarh and Sambalpur districts of Orissa during *Kharif* 2007 mainly due to drought for a period of 15 to 20 days after early rain (Krishnaiah and Varma, 2011). Similarly, it has acquired the status of major pest in Bihar and Jharkhand during *Kharif* 2007-09, 2012, 2013 and has destroyed the paddy crop at early stage in many areas (Prakash *et. al*., 2014). Although, it gains serious proportions occasionally, severe damage has been reported in 30, 000ha in Assam (Krishnaiah and Varma, 2011). Two species of swarming caterpillar, *S. mauritia* and *S. litura* (Fabricius) are found on paddy crop in Assam. *Spodoptera mauritia* is a sporadic pest that attacks paddy and certain types of grasses while the latter is a regular pest and attacks castor, okra, tomato, crucifers, *Colocasia* and other crops besides paddy. Swarming caterpillar affected an area of over 500 hectares in Lakhmipur district of Assam during *Kharif* 2016. Heavy rains during the months of June-July followed by a dry spell and then showers in a few weeks is ideal weather for the build-up of this pest.

Rice earhead bug or gundhi bug has become a major problem in rice production since the early 2000s in the north-eastern states, especially Manipur. Earhead bug is a major pest of the upland paddy ecosystem (Rath *et al*., 2020). Three species of earhead bug *viz*., *Leptocorisa oratorius* (Fabricius), *L. acuta* (Thunberg) and *L. pseudolepida* Ahmad are found on rice crop in India (Krishnaiah and Varma, 2011). It appeared in severe proportions during 2007 in the Konkan region of Maharashtra and parts of the hilly areas of Dharampur, Vansda, Ahwa and Dang districts of Gujarat (Krishnaiah and Varma, 2011).

Rice hispa, *Dicladispa armigera* (Olivier), had emerged as a major pest in West Bengal, Himachal Pradesh, Assam and north-eastern Indian states by 2005 (Jena *et al*., 2018; Rath *et al*., 2020). In 2007, it was found to be severe in Khawala, Trind and Dhanotu villages of Kangra district of Himachal Pradesh, causing a 34.3 percent reduction in yield (Krishnaiah and Varma, 2011). During the first week of September 2008, an outbreak of hispa was reported in Bainsia, Ballav and Ambabati grampanchayat of Gondia block of Dhenkanal District, Odisha. An area of about 1300 ha was affected, covered by varieties such as Annapurna, Pooja, Swarna and Lalat. In addition to climatic factors, the influence of surrounding vast marshlands and un-weeded fields may have contributed to hispa outbreak in that area (Rath *et al*., 2020).

During 2007, there was a severe outbreak of caseworm, *Nymphula depunctalis* Guenée, in more than 2000 hectares of Sali rice in Jorhat, Sivasagar, Golaghat, Nagaon, Lakhimpur, Dhemaji and Karimganj districts of Assam following flood, resulting in 20 to 90 percent crop loss. Moderate to heavy attack of caseworm was also reported during 2007 especially in Patna and Nalanda districts of Bihar (Krishnaiah and Varma, 2011). This pest is a major problem in lowland rice ecology where water level increases to more than 30 cm and water stagnation is a major problem during the rainy season (Jena *et al*., 2018).

In Tamil Nadu, black bugs, *Scotinophora lurida* (Burmeister) and *S. coarctata* (F.) were observed to be particularly severe in hybrid rice. It is a common pest during the vegetative stage of the crop in rainfed and irrigated wetland environments, especially in poorly drained areas and prefers densely planted areas. It is also emerging as an important pest on rice crop in Gujarat (Krishnaiah and Varma, 2011; Jena *et al*., 2018).

The rice gall midge, *Orseolia oryzae* (Wood-Mason) has been found to cause severe damage in new areas like Bihar and the north-eastern state of Manipur, besides the traditional areas of Odisha, Madhya Pradesh, Andhra Pradesh and Kerala (Jena *et al*., 2018). The mealy bug, *Brevennia rehi* (Lindinger), a pest common in upland and dryland cultivated areas, has recently become an important pest of upland rice in West Bengal and Odisha (Jena *et al*., 2018; Rath *et al*., 2020). In Kerala, blue beetle [*Leptispa pygmaea* (Baly)] has emerged as an important defoliator since 2010 (Krishnaiah and Varma, 2011; Jena *et al*., 2018). The rice thrips, *Stenchaetothrips biformis* (Bagnall), has become a significant pest in rainfed rice during seedling stage or within a fortnight of sowing or in early transplanted crop (Jena *et al*., 2018). The root aphid, *Tetraneura nigriabdominalis* (Sasaki), has emerged as an important pest in upland rice (Jena *et al*., 2018). White grub, *Holotrichia* spp., has emerged as a major pest in the hilly regions of Uttarakhand (Rath *et al*., 2020). Termites seriously affect aerobic rice cultivation in light soils and under marginal rainfall and drought conditions (Jena *et al*., 2018).

Overall, the brown plant hopper has been showing up in outbreaks at different times in different parts of the country. Along with this, pink stem borer and white stem borer are emerging as pests in north-western parts. Recently ear cutting caterpillar and swarming caterpillar have posed a serious threat to rice in Assam.

Wheat, barley and oat: Compared to other cereal crops, these crops are less prone to insect pest attack. Wheat aphid [*Sitobion avenae* F. and *Rhopalosiphum maidis* (Fitch)] was identified as an emerging pest of wheat in Kangra district of Himachal Pradesh during 2010-2012 (Sharma *et al*., 2012). An increased incidence of the aphid complex, comprising of *S. avenae*, *R. maidis* and *Schizaphis graminum* (Rondani) has been observed on wheat, barley and oats (Rathee and Dalal, 2018; Kumar *et al*., 2021). Aphid attack on wheat crop was also noted in Mansa, Bathinda, Kapurthala, Pathankot Amritsar, Jalandhar and other districts of Punjab during 2018-2020.

Sugarcane leafhopper, *Pyrilla perpusilla* Walker, is a major sucking pest of sugarcane. A range of crops are known to be alternate hosts of this pest include maize, pearl millet, sudan grass, guinea grass, oats, wheat and barley in Punjab and North India. Recently, heavy infestation of this pest was observed on wheat and oats in Sarguja District of Chhattisgarh (Jeer *et al*., 2019). The incidence started after harvesting of sugarcane crop and peak activity was observed during February to April. The pink stem borer, *Sesamia inferens* (Walker) (Fig. 3), is emerging as an important pest of wheat and a serious threat to the successful cultivation of wheat in north-western plains of India likely to be posed (Singh, 2012; Baladhiya *et al*., 2018). Changes in environment and tillage practices under the widely adopted rice-wheat cropping system led to the build-up of pink stem borer populations. Another lepidopteran pest, *Helicoverpa armigera* (Hübner) may be of serious concern for wheat cultivation as heavy infestation was first reported in April 2002 at the Haryana Agricultural University in Hisar, Haryana (Sharma *et al*., 2003). Armyworm and pink stem borer infestations in Sangrur district of Punjab have affected wheat crop spread over 2,500 acres in 2019. This problem has been caused by sowing wheat without burning the paddy straw. Several villages of Depalpur tehsil in Madhya Pradesh have marked the outbreak of tobacco caterpillars in wheat crop since last two years. Outbreak has been observed at the ear formation stage and more on Tejas variety as compared to Lok-1.

a **b**

Fig. 3: Pink stem borer on wheat: a. Infested plants b. damage caused by larva (Singh, 2012)

Overall, pink stem borer, aphid complex and armyworm are the emerging pests on wheat, barley and oats especially in northern regions of the country.

Maize: Fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith), is an invasive pest in India (Fig. 4). This pest marked its first appearance in India during May 2018, causing severe damage to maize in Karnataka (Sharanabasappa *et al*., 2018). It is native to tropical and subtropical regions of America and has invaded Africa, first detected in central and western Africa in early 2016 and in late 2016 and 2017 in parts of southern, eastern and northern Africa. FAW continues to spread to new areas, moving towards east and north India. Serious incidences of FAW have been registered from almost all maize growing Indian states (Babu *et al*., 2019; Balla *et al*., 2019; Navik *et al*., 2021; Vinay *et al*., 2022). FAW mainly targets maize crop in India but being a polyphagous pest, it is also found to infest rice, sorghum, sugarcane and pearl millet crops (Chormule *et al*., 2019; Bhavani *et al*., 2019; Venkateswarlu *et al*., 2018; Ali *et al*., 2018). The damage incidence of FAW on maize was recorded as 22.13–46.83 percent with damage severity 0 to 4.9 on the 0 to 9 scale (Navik *et al*., 2021). However, FAW prefers sweet corn over maize, jowar and sugarcane (Chormule *et al*., 2019). The voracious feeding behaviour of FAW larvae poses a threat to food security if its activity is left unchecked. This new invasive pest is spreading rapidly; FAW adult moths are highly migratory, capable of traveling up to 500 km in a season to search for oviposition sites and capable of flying over 100 km per night. It is a potential threat to agricultural crop production as well as to the Indian economy. Occurrence of FAW on bajra and sorghum was first noticed in Andhra Pradesh during October, 2018 (Venkateswarlu *et al*., 2018). Similarly, its occurrence on paddy crop type Arize 6444, Pranava mansuri and Pioneer has been reported for the first time in Nawada and Gaya districts of Magadh division of Bihar (Ali *et al*., 2018).

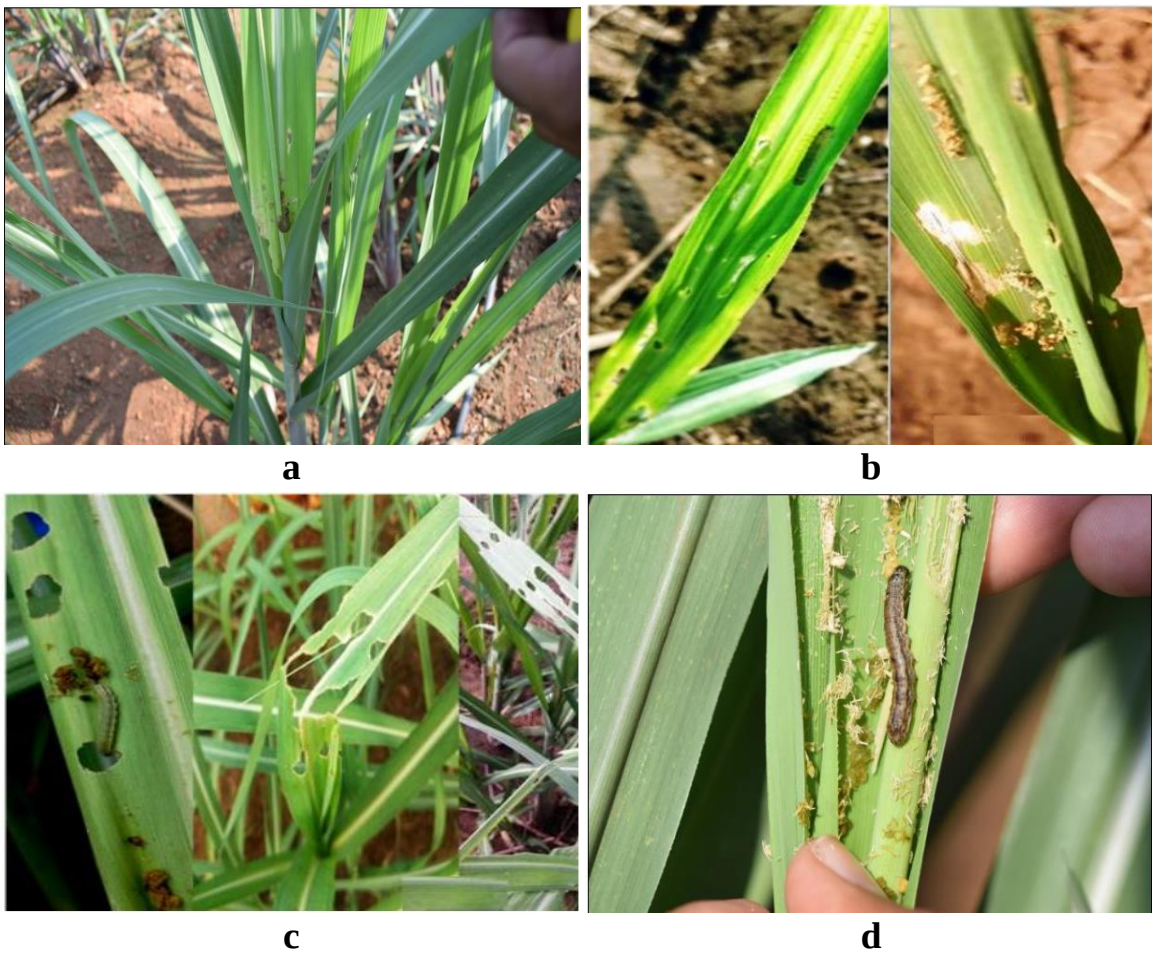

Fig. 4: Fall armyworm: a. Infested plant b. Scraping of chlorophyll by young larva c. Windows on leaf lamina caused by mature larva d. Mature larva with faecal pellets (Bhavani *et al*., 2019; Chormule *et al*., 2019)

Sorghum and pearl millet: Higher incidence of sorghum midge, *Stenodiplosis sorghicola* (Coquillet), was observed on sorghum crop in Maharashtra State (Kishore, 2005). The rapid multiplication of sorghum midge by the continuous flowering from early maturing hybrids to late local varieties in the same region can be

controlled by the wide coverage of the state of Maharashtra by varieties that flowered at about the same time. The shoot fly (*Atherigona soccata* Rondani), earhead bug (*Calocoris angustatus* Lethiery) and *H. armigera* are other pests that have become serious on sorghum after the sixties. The grey weevil, *Myllocerus* spp. and *P. perpusilla* have also assumed pest status on sorghum and pearl millet. The grey weevil attacks both early and late stages of crop growth. Higher incidence of *P. perpusilla* was recorded on sorghum and pearl millet throughout the northern region of the country (Kishore, 2005). Hybrid varieties of sorghum and pearl millet are more prone to attack by *P. perpusilla* (Kishore, 1994; Kishore *et al*., 2000). A complete hopper burn was observed on some varieties of sorghum in the Indian Agricultural Research Institute, New Delhi farm. Pearl millet was found to be equally attacked by *P. perpusilla* (Kishore, 2005). Incidence of fall armyworm is spreading from maize to bajra, sorghum and other millets, which could pose a serious threat to their successful cultivation (Venkateswarlu *et al*., 2018). In the fields of Agricultural Research Station, Ananthapuramu, Andhra Pradesh, 30 percent damage was reported in bajra and 70 percent in sorghum due to FAW (Venkateswarlu *et al*., 2018).

Small millets: Small millets are a group of small-seeded cereal crops in the grass family Poaceae that includes finger millet, foxtail millet, proso millet, barnyard millet, kodo millet, little millet, teff, fonio, job's tears, guinea millet, and browntop millet. Millets are relatively less prone to insect pest damage than other cereals, however, shoot flies, stem borers, leaf-suckers, and panicle-attacking insects are considered economically important. Finger millet is the most widely grown crop in the small millet group. This crop is generally grown in tribal dominated areas (Sasmal *et al*., 2018). Pink stem borer (*Sesamia inferens* Walker), which was once an important pest of sugarcane, has now become a threat to finger millet production, especially irrigated crop during rabi season in Odisha (Sasmal *et al*., 2018).

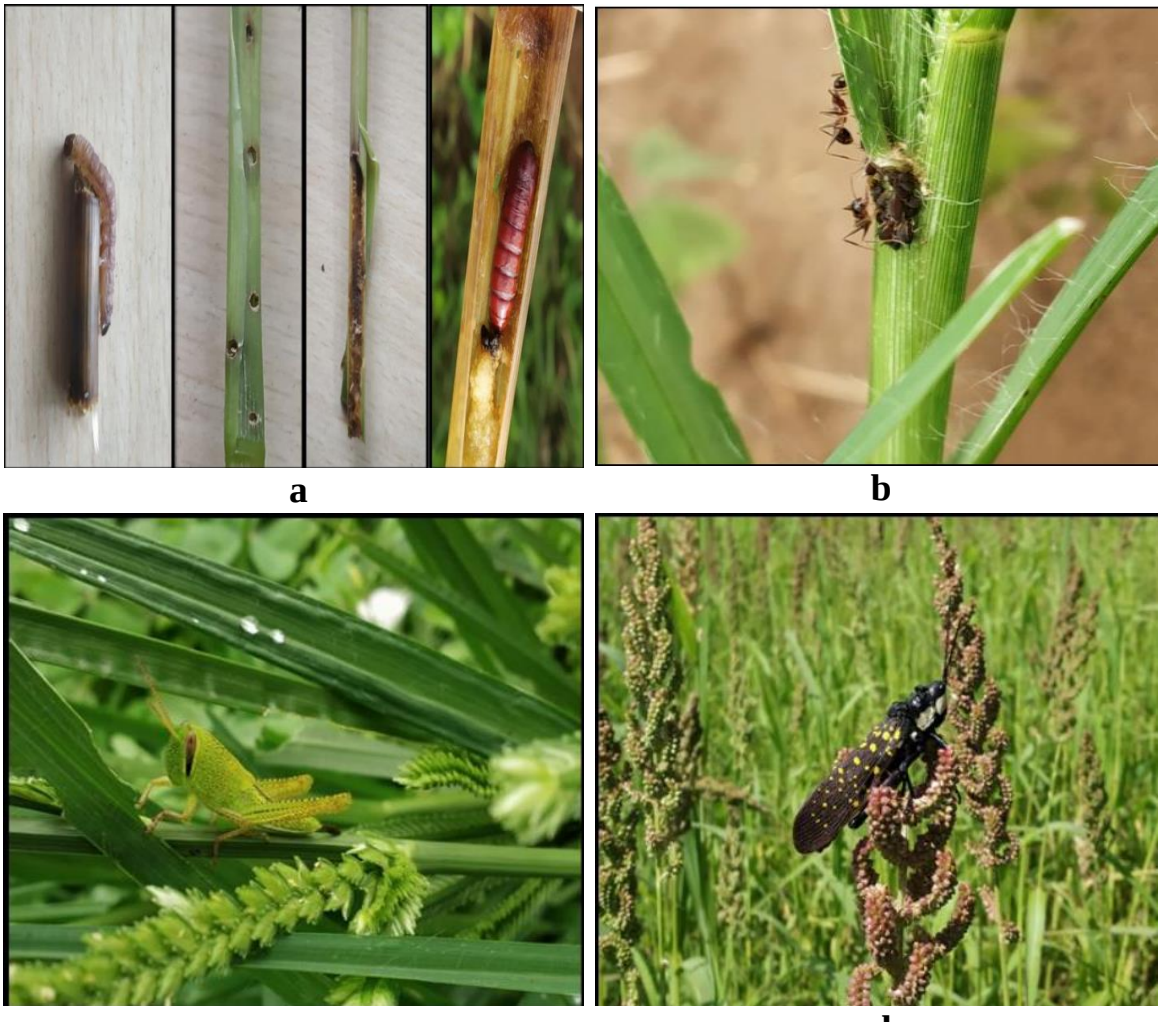

Fig. 5: Emerging insect pests on small millets: a. Stem borer (*Sesamia inferens*) b. Aphid (*Hysteroneura setariae*) c & d. Grasshoppers (Rawat *et al*., 2021)

Initiation of stem borer damage in finger millet noticed from 30 days old crop and onwards. In the central hills of Uttarakhand, finger millet and barnyard millet have recently been reported to be under serious threat of stem borer (*Sesamia inferens*), shoot fly (*Atherigona* sp.), grasshoppers (*Hieroglyphus* sp., *Cataloipus* sp.) and aphid (*Hysteroneura setariae*) (Fig. 5) (Rawat *et al*., 2021). Shoot fly is also causing a major damage on little millet and proso millet in South India (Kumar and Channaveerswami, 2015; Sathish *et al*., 2017; Kamakshi *et al*., 2021). Lately, thrips damage has been reported higher in all small millets in the rainfed area of Andhra Pradesh. A highly polyphagous pest, *Helicoverpa armigera* was found to infest finger millet, foxtail millet and barnyard millet, which may cause serious damage to these crops in near future (Kamakshi *et al*., 2021).

CONCLUSION

Since the advent of the Green Revolution in the country, cereal crops have experienced changing trends in pest infestation. Many minor insects have emerged as important pests and have caused significant yield losses at regional and national levels. Various factors such as global warming, uneven weather, changing cropping patterns and adoption of technologies alter insect abundance, distribution and pest-related losses. Pest surveys and monitoring should be done regularly across the country to get adequate information about the changing trends and outbreaks of insect pests and damages caused by them, which will facilitate general control strategies of cereal pests. The movement of planting material and seeds has increased the risk of introduction of invasive pests. These species, if not accompanied by natural enemies that keep them in check in their native range, can multiply to large proportions and cause damage to economically important plant species and crop plants. Interdisciplinary coordinated work is needed among scientists to identify invasive organisms and assess their ecological problems, environmental concerns in different ecosystems, economic losses, and control methods.

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