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Shamik Dey
Department of Agricultural Entomology, Bidhan Chandra Krishi Vishwavidyalaya, Mohanpur, Nadia, West Bengal, India

Corresponding Author:
Shamik Dey
Department of Agricultural Entomology, Bidhan Chandra Krishi Vishwavidyalaya, Mohanpur, Nadia, West Bengal, India

Stem borers, an important yield reducing insect pest complex of rice in India: A review

Shamik Dey

Abstract
Paddy stem borers have been considered as one of the most destructive insect pests causing significant yield loss globally. Majority of them belongs to the family Pyralidae and Noctuidae under the order Lepidoptera. The larval stage is the only feeding stage cause substantial damage by boring the stem portion. Infestation typically characterized by the presence of "Dead heart" and "White Ear Head". From tropical condition, *Scirpophaga incertulas*, *Scirpophaga innotata*, *Chilo suppressalis*, *Chilo polychrysus* and *Sesamia inferens* have been received major attention for causing huge yield loss in Gramineous crop specially Paddy.

Keywords: Dead-heart, paddy, white-ear-head, yield

Introduction
The rice stem borers (SBs) having wide distribution in almost all the rice growing countries of the world constitute an economically important group of pests [24]. Most of them belong to family Pyralidae and Noctuidae of the order Lepidoptera and very few species belong to Diopsidae of the order Diptera. Pyralids are one of the most successful borer groups usually exhibit a high degree of host plant specificity. The noctuid borers on the other hand are polyphagous and cause economic loss occasionally. Twenty-four common species of rice stem borers were recorded all over the rice growing countries in the world [12, 26, 28]. In Asian countries, where 90% of the world's rice is grown and consumed, the most prevalent species are yellow stem borer (YSB), *Scirpophaga incertulas* Walker; stripped stem borer (SSB), *Chilo suppressalis* Walker; white stem borer (WSB), *Scirpophaga innotata* Walker; dark headed striped borer (DHSB), *Chilo polychrysus* Meyr; golden fringed stem borer (GFSB), *Chilo auricilius* Dudg and pink stem borer (PSB), *Sesamia inferens* Walker [13, 12].

Important species of rice stem borers
In Asian countries including India about 20 species of rice stem borers have been reported but only 5 species viz. *Scirpophaga incertulas* (Walker), *Scirpophaga innotata* (Walker), *Chilo suppressalis* (Walker), *Chilo polychrysus* (Meyr) and *Sesamia inferens* (Walker) are most important [7, 28]. White Stem Borer, *Scirpophaga innotata* mostly confined to Indonesia (excluding Sumatra), southern Philippines and Northern Australia [3]. Studies on *Scirpophaga innotata* in Pakistan reported coexistence of *Scirpophaga incertulas* and *Scirpophaga innotata* i.e. the outbreak years of the former species were actually those in which the later species was not abundant and vice-versa [14] and further mentioned of its occurrence and damage from India [2]. The average of 25 years of data revealed that in Punjab province of Pakistan 94% of the borers belonged to *Scirpophaga* spp. and *Sesamia* spp. population was only 6% [21, 11]
In India, thirteen species of rice stem borers have been reported infesting rice stem (Table: 1.) but only five borer species viz. *Scirpophaga incertulas*, *Scirpophaga innotata*, *Chilo suppressalis*, *Chilo polychrysus* and *Sesamia inferens* are predominant [25, 28]. A few other species viz. *Chilo auricilius*, *Chilo partellus* and *Scirpophaga novella* have got localized distribution. Some rare species like *Ancylolomia chrysographella* Koll., *Scirpophaga gilviberbis* Zell. and *Maliarpha separatella* Ragon are also reported to infest rice from India [28].

Table 1: Rice stem borers reported from different states in India

Sl. No.	Scientific name	Common name
1	*Ancylolomia chrysographella* Koll	Angled grass moth
2	*Chilo auricilius* Dudgeon	Rice stalk borer
3	*Chilo infascatellus* Snellen	Yellow top borer
4	*Chilo partellus* Swinhoe	Spotted stalk borer
5	***Chilo polychrysus* Meyr	Dark headed striped borer
6	***Chilo suppressalis* Walker	Spotted stem borer
7	*Maliarpha separatella* Ragon	African white stem borer
8	***Scirpophaga incertulas* Walker	Yellow stem borer
9	***Scirpophaga innotata* Walker	White stem borer
10	*Scirpophaga gilviberbis* Zeller	------
11	*Scirpophaga nivella* Fabricius	White rice borer
12	***Sesamia inference* Walker	Pink stem borer
13	*Sesamia uniformis* Dudgeon	Stem borer

(** Pre dominant stem borers reported from rice crop)

Stem borers in different rice ecologies

Rice can be grown in different ecological condition and cropping sequences throughout the globe which can be categorized into following systems [14]. Abundance of stem borers varies significantly under different cropping sequences or ecological conditions. It is prerequisite to understand the species composition and also the pest status of the stem borers so that control measures can be planned accordingly [5, 6].

1. Rice-Wheat cropping sequence

Rice-Wheat cropping system is the largest rice-based cropping system in India. Seven species of stem borers viz. *Scirpophaga incertulas*, *Scirpophaga innotata*, *Chilo polychrysus*, *Chilo suppressalis*, *Chilo auricillius*, *Chilo partellus* and *Sesamia inference* have been reported to infest rice under rice-wheat cropping system [4]. Among them *Scirpophaga incertulas* and *Scirpophaga innotata* are considered as monophagous and *Chilo polychrysus*, *Chilo suppressalis*, *Chilo auricillius*, *Chilo partellus* and *Sesamia inference* are strictly polyphagous in nature [20]. Emergence of adult of *S. incertulas*, *S. innotata* and *S. inference* has been drastically reduced due to cultural practices of wheat crop [14]. On the other hand, extreme arid to dry sub humid climate covering states, *Scirpophaga incertulas* is the major constraint for rice and *Sesamia inference* for wheat cultivation [34].

2. Rice-Maize cropping sequence

The maize stalk borer, *Chilo partellus* is a serious pest in rice maize cropping system and yellow stem borer, *Scirpophaga incertulas* has been found as second most important [9, 24].

3. Rice-Sugarcane cropping sequence

Rice stalk borer, *Chilo auricilius* and pink stem borer, *Sesamia inference* are serious stem borer pests in rice sugarcane cropping system followed by yellow stem borer [24].

4. Rice-Sorghum cropping sequence

Spotted stem borer, *Chilo partellus* is considered as most dominant yield reducing pest followed by yellow stem borer [24].

5. Rice-Rice cropping sequence

Occurrence of different stem borers in diverse Rice-rice sequences are as follows:

5.1 Rainfed upland rice: In rainfed upland rice *Scirpophaga incertulas*, *Scirpophaga innotata*, *Chilo polychrysus*, *Chilo suppressalis* have been reported severely causing considerable yield loss [27-29].

5.2 Irrigated rice: In irrigated rice, a number of pests have been recorded so far but among them Yellow stem borer (*Scirpophaga incertulas*) was dominant and other stem borer species viz. *Chilo polychrysus*, *Chilo suppressalis*, *Chilo auricillius* have benn found as occasional pest [27-29].

5.3 Shallow rainfed lowland rice: This rice ecology is very much prone to attack of yellow stem borer than any other lepidopteran insect pests [27, 28].

Agro-ecological condition and factors causing abundance of stem borers

Incidence of stem borer complex have been reported from all the rice ecosystems viz. upland, medium land, low land, rainfed and irrigated conditions but low land and irrigated rice grown in both summer and wet seasons are mostly succumbed to stem borer damage [30, 31, 23]. The agro-ecological conditions where semi deep water (50-100 cm water level) and deep-water (more than 100 cm water level) rice are cultivated provide favorable conditions for stem borers particularly in Yellow stem borer (YSB) in heading stage of the crop [1] [32]. In general, stem borers are polyvoltine but number of indivisiual, body length, brood length mostly depend on weather parameters and the cropping pattern. They are warm weather loving creature but maximum temperature range (35 ºC-39 ºC) is fatal causing highest larval mortality [9, 21]. The maximum larval mortality has been observed in the month of July due to higher temperature of irrigation water [15].

Damage symptoms caused by rice stem borers.

Dead heart and White ear head are two important characteristics features produced by the attack of stem borers. In addition, a number of symptoms in sequences usually recorded during attack of stem borers are as under:

Larvae initiate their attack by boring the inner portion of leaf sheath and cause longitudinal yellowish white or whitish discolored patches at the feeding site and it causes in wilting and drying of leaf blades [26, 8]. Feeding of apical parts of the plant from the base cause tunneling of the stem. As a result, central leaf whorl turns brown, fail to open and dries, while lower leaves may still look green and healthy and the affected tillers do not bear the effective tillers and panicles. This condition known as “Dead heart” [26, 16]. Dead heart symptom ultimately leads to formation of “White ear head” which cause largely erected panicles with empty grains. Larval feeding at early booting stage can cause empty panicles which causes more than 70% yield loss [34, 6].

Damage potential and yield loss

Considerable yield loss is also inflicted due to larval feeding within the stem without severing the growth plant parts. The stem borers induced yield loss have been assessed to range from 30-70% in outbreak years and 2-20% in non-outbreak years in Bangladesh, 3-95% in India as against 33% in Malaysia and up to 95% in Indonesia [19, 17]. An estimate made at Central Rice Research Institute, suggests that every 1% increase in yellow stem borer damage registered a loss of 0.28% at the vegetative stage and 0.62% at the heading stage [18]. In India losses caused by stem borers have been estimated to range from 3-95% and their incidence is more severe in the double or triple cropping areas and also the coastal saline rice tracts [10]. In deep-water rice about 40% stems have been reported to be damaged by stem borers resulting in 20-40% grain yield loss and increase in 1% yield loss in deep water rice is attributed to each 2% damaged stem at harvesting stage [5]. On an average 27% grain yield loss has been estimated in semi-deep-water rice due to stem borer infestation in heading stage and for every 1% increase in white head incidence the grain yield loss was 29-49 kg/ha in different varieties [32]. Further it has been reported that each 1% stem damage resulted in reduction of 0.01 to 0.016 g grain yield/panicle and 0.1 to 0.16% total yield loss [32].

Conclusion

Paddy stem borers are very common in all rice ecosystems though they vary in species in different rice ecologies. They have the potentiality to cause huge yield loss in paddy as well as other Gramineous crops. Proper precautions should be taken to manage this insect pest which is prerequisite to obtain higher crop productivity**.**

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