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A review on pink stem borer, *Sesamia inferens* Walker: A threat to cereals

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Abstract
Cereals are the edible seeds or grains of the grass family, Gramineae. A number of cereals are grown in different countries including rice, wheat, maize, rye, oats, barley, triticale, millet and sorghum. Cereals are staple foods and are important sources of nutrients in both developed and developing countries. Cereals and cereal products are an important source of energy, carbohydrate, protein and fibre as well as containing a range of micronutrients such as vitamin E, some of the B vitamins, magnesium and zinc. Due to the insect pests there were severe damage into seed yield as well as seed quality during various crop stages. Among different species of insects attacking cereals, stem borers are most damaging insects. Pink stem borer *Sesamia inferens* assumed major pest status in recent time in cereals and has known to cause dead hearts, earheds and reduction in yield losses. The grain yield losses due to *S. inferens* in maize cultivars vary from 25.7 to 78.9%. The authors tried here to collect the information about taxonomic position, distribution, host range and crop losses, seasonal abundance, nature of the damage as well as control measures including IPM strategies.

Keywords: Cereals, pink stem borer, *Sesamia inferens*

1. Introduction
Pink stem borer *Sesamia inferens* Walker (Lepidoptera: Noctuidae) is a polyphagous pest attacking various graminaceous crops like sorghum, pearl millet, finger millet, wheat [30,48], rice [5, 23], oats, barley, sugarcane and some grasses [38]. It is the serious pests of almost all the cereals by attacking the crops at various stages and causing severe damage and yield losses. It is also referred as "Goolabi tanna chhedak" and "khod kid" in north India and Maharashtra, respectively [21]. In Gujarat locally known as "Gulabi gaabhmarani eyal" [32]. It is also known by names such as Gramineous stem borer, The Asiatic pink stem borer, Pink borer, Pink rice stem borer, Ragi stem borer, Purple borer, Purple stem borer or Purplish stem borer.
In India, The pink stem borer was recorded for the first time in maize by Fletcher [12] from Madras. Later on from Mysore this pest was found feeding on finger millet [24] and also reported in wheat by Patel [33]. *S. inferens* was a minor pest of rice crop in Punjab causing severe damage in the fields [41]. This pest was found in Gujarat infesting irrigated wheat [16]. Pest of rice, which later migrated to other graminaceous crops [34] Later on, it began to emerge as a serious pest in wheat [26, 36] as well, as rice- wheat [46, 47] being a major cropping system [11]. Now it is a well-established pest in the rice-wheat rotation in North western plains of India [50]. Recently it was also reported in unirrigated wheat in Gujarat [3].

1.1 Taxonomic position
Pink stem borers are the principal members of genus Sesamia belonging to the order Lepidoptera, Family Noctuidae and Subfamily Acronytinae [25]. It was classified under the genus Leucania until 1856 [39] but in 1884 it was brought under the genus Sesamia [22]. Leucania inferens and Nonagria inferens were its synonym [8, 27].

1.2 Distribution
The pink stem borer occurs in India, Pakistan, Bangladesh, Burma, China, Sri Lanka, Malaysia, Taiwan, Japan, Indonesia and Philippines [31, 51]. In India, it was also reported in Andhra Pradesh, Karnataka, Tamil Nadu, Madhya Pradesh, Maharashtra, Orissa, West Bengal, Bihar, Assam, Uttar Pradesh, Delhi and Punjab as a serious pest of cereal crops [45]. This pest was found infesting irrigated wheat [16] and unirrigated wheat [3] in Gujarat.

1.3 Host range and crop losses

It was found infesting wheat, maize, sorghum, ragi, paddy and sugarcane in South India, lemon grass in West Bengal [13], sorghum in Gujarat [20] and maize at Chhattisgarh [9]. Other host plants are Goose grass, (*Eleusine indica*), tropical cupgrass (*Eriochloa procera*), barley (*Hordeum vulgare),* saramolla grass (*Ischaemum rugosum*), citronella grass, *Cymbopogon citratus,* purple nutsedge (*Cyperus rotundus*), jungle rice (*Echinochloa colona*), barnyard grass (*Echinochloa crus-galli*), yellow foxtail (*Setaria pumila),* japanese millet (*Echinochloa frumentacea*), finger millet (*Eleusine coracana*), rice grass paspalum (*Paspalum scrobiculatum*), pearl millet (*Pennisetum glaucum),* common reed (*Phragmites australis*), sugarcane (*Saccharum officinarum*), sorghum (*Sorghum bicolor),* foxtail millet (*Setaria italica*). The grain yield losses due to *S. inferens* in maize cultivars vary from 25.7 to 78.9% [7, 45]. It causes more than 11.01% damage to the wheat [16].

1.4 Seasonal abundance

Garg [15] observed that pink stem borer hibernated in rice stubbles from end of October to March and emerged from mid – April and laid eggs on spring rice, wheat and barley in UP. In rice, it was appeared from September to beginning of April in Pakistan [2]. Deole [10] observed on highest larval population of *S. inferens* during last week of February on maize and peak activity of adult moths was found during 2nd week of March in Chandigarh. Sidar *et al*. [42] reported that *S. inferens* on maize was first appeared during third week of August (10% dead heart) and reached to its peak infestation (60% dead heart) during the third week of September. The dead heart percent showed non- significant positive correlation with maximum temperature, morning relative humidity and sun shine. Whereas negative non- significant correlation with minimum temperature, evening relative humidity and rainfall. But wind velocity showed highly significant negative correlation with a dead heart percent.

1.5 Life cycle

1.5.1 Eggs

Adult moth lay 120 - 348 eggs under leaf sheath. Eggs always laid in clusters in several rows within the cover of the leaf sheath. The eggs is creamy white in colour and semi-globular, being flattened on the dorsal surface. The egg changes to creamy white to brown, ash grey and pinkish coloration before hatching [1]. Unfertilized eggs turn dark, shrivel up and fail to develop. Siddiqui and Marwaha [45] reported that female moth lays creamy white eggs in longitudinal rows within the sheaths of bottom leaves of young plants. Singh [50] reported that maximum number of eggs were laid either at the base of the wheat plant near the soil surface or on the soil surface or in the stubbles of rice crop left in the field and not in the leaf sheath of wheat plant. The larvae hatch out in about a week.

1.5.2 Larva

The neonate larvae are dorsally pink to purplish pink in colour, lighter on the ventral side, smooth and cylindrical with a reddish-brown head is popularly known as the pink stem borer. First-instar larvae of *S. inferens* are a little larger than other stem borers and therefore take a shorter time to bore into a tiller. Final instar larvae shrink its body and stop feeding and after 12 days convert into pupae. The larval stage passes through six instars. The total larval period of about 23 - 39 days [28].

1.5.3 Pupa

Pupation took place inside the stem or in between the stem and leaves. The pupae were robust and light brown in colour with a purplish tinge on the head region. Abdominal spiracles were very prominent with slit like opening and slightly raised. The sex of the borer can easily be distinguished during this stage. Males are smaller with tapering abdomens and carry two small bumps in front of the genetalia, while the females are larger with broad abdomen and without any marking. Pupa was stout and dark brown in colour. The pupal stage lasts from 9-12 days.

1.5.4 Adult

Moths were straw coloured with a mid-longitudinal dark brown broad triangular streak. The male moth was slightly smaller than the female. Pectinate antennae found in males and filiform in females [52]. The adult female live for 6 to 8 days while the males are about 4 to 6 days. The adult male and female live for 3 to 5 and 5 to 7 days, respectively. It completes life cycle in 35 - 57 days [28]. Singh and kumar [46] observed pre - oviposition period ranged from 1.25 - 2.25 days and oviposition period ranged from 3.00 – 6.75 days of pink stem borer at Ludhiana. Four to five generations of this pest were recorded per year [45].

1.6 Nature of damage

On hatching, pink borer larvae remain inside or behind the leaf sheath in groups and feed on the epidermal layer of the leaf sheath. The bottom most leaf sheath was the first feeding site of pink borer larvae. Due to feeding, gummy oozing with water soaked lesions appears on the affected leaf sheaths which were visible from outside in the initial stages of feeding. Subsequently, the larvae reach the central growing point by boring through the sheaths. Then feed on unopened leaves in the whorl which results in formation of oblong (elongated or oval, little bigger than pin size) holes of 2-3 mm size in parallel rows in the unfolded leaves. As the plant grows, these holes were extended and become slits and streaks. In severe cases, tunnelling of mid rib was evident on the leaf blades and plants shows ragged appearance. Infestation of the growing point of the shoot ultimately lead to drying up resulting in the formation of “dead heart” at seedling stage in cereals and “white ears” at ear head stage in wheat as well as in rice. Maximum damage to the stem was observed between first to fifth internodes. Exit holes (2-5 holes per plant) found. The stem tunnels may be horizontal (sometimes extended to other internodes) “S” shaped or circular or vertical. Dark circular ring like cuts on lower most internodes could be seen externally in the stem which may be of with excreta [40]. A number of plants may be damaged by a single caterpillar, as larvae could leave the old tunnels and prepare fresh ones [18]. Maize crop at 2 leaf stage was considered as the most critical stage for *S. inferens* infestation [35].

2. Integrated pest management

2.1 Cultural control

Godhani [16] found that Lok-1 variety of wheat showed least infestation at Junagadh. Singh [50] reported that early sown wheat crop was suffered from a higher incidence of pink stem borer as compared to timely and late sown crop in Ludhiana. Singh [49] mentioned that the pink stem borer damage was minimum in conventional tillage (0.6%) followed by zero tillage + mulch (1.0%), rotary tillage (1.2%) and zero tillage (1.4%) in wheat in Ludhiana. Nagarjuna [29] observed that

maize hybrid CP-828 as tolerant variety had lowest percent infested plants, cob damage, dead hearts, pin holes and maximum straw and grain yield in Karnataka. Sidar *et al*. [43] found HISHELL as least susceptible genotypes of maize at Raipur.

2.2 Mechanical control

Akhtar [2] in Pakistan observed trapping of pink stem borer by the light trap at 32 °C during all winter season was observed and recommended avoidance of late transplanting to hamper the incidence of pink stem borer in rice. Deole [10] observed that highest light trap catches (44 adults/ week) during 2nd week of March and in consecutive year total light trap catches (39 adults/ week) during 3rd week of March were observed.

2.3 Biological control

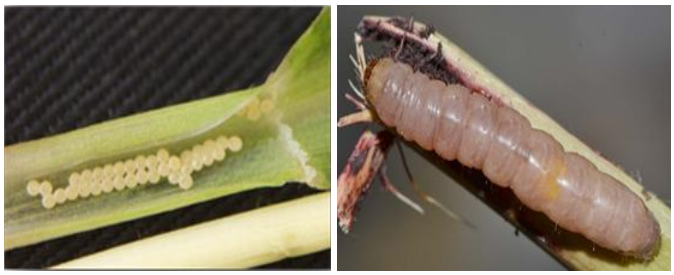
Godse and Nayak [17] observed that *S. inferens* were died within 3-5 days due to NPV application given in laboratory condition at Cuttack. Barriton [6] reported that earwig *Euborellia stali* (Dohrn) preyed on the pink stem borer larva and can consumed 20-30 young pink stem borer larvae per day. Gao *et al*. [14] in China reported that Btprotoxin Cry1ca exhibited the highest level of toxicity against *S. inferens* with LC50 of 0.30 µg/g in rice. Ramanujam *et al*. [37] noticed that among twenty eight isolates of *Beauveria bassiana* @ 1 ml / 30 larva, NBAII- Bb-1, 4, 6, 8, 11, 15, 39 and 59 isolates were found significantly higher mortality (65.99-92.59%) against *S. inferens* in Bangalore. Among the twenty seven isolates of *Metarhizium anisopliae* @ 1 ml / 30 larva, NBAII-Ma-1, 6, 10, 13, 15, 23, 25, 26, 41 and 42 isolates showed significantly higher mortality (66.25 - 100.0%) against pink stem borer under laboratory condition.

2.4 Chemical control

Godhani [16] reported that fenvalrate 20 EC @ 0.0125% was highly effective against *S. inferens* (93.91%) at Junagadh. Anuradha [4] observed that seed treatment with thiamethoxam 30 FS @ 8 ml/kg recorded minimum dead heart (%) and plant infestation during *Kharif* as well as Rabi season. Deole [10] reported that spinosad 45 SC @ 160 ml/ha and chlorantraniliprole 18.5 SC @ 60 ml/ha were found to be at par and significantly effective for the control of *S. inferens* at Raipur. Sidar *et al.* [44] repored that minimum leaf injury rating of *S. inferens* was recorded in the treatment of carbofuran 3 G @ 1000 g. a.i. / ha at Raipur.

3. Conclusion

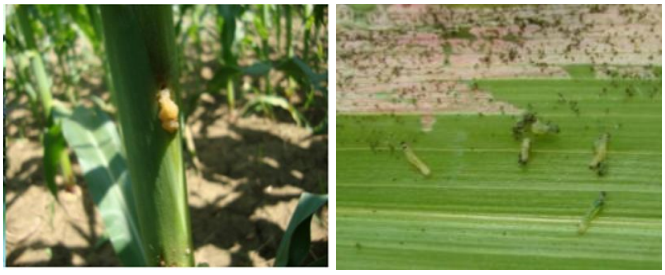
Pink stem borer is a polyphagous pest that attacks on number of cereal crops. It is shifted from sugarcane crop to rice and then other cereals so proper sanitation and tillage practices help to manage the infestation in case of rice- wheat planting. Using the different tools of Integrated Pest Management (IPM) *i.e* cultural control, mechanical control, biological control and chemical control may help to manage this new emerging pest of cereals. Proper date of sowing may helpful to escape the pest occurrence by breaking the synchronization between crop stage and pest appearance. Use of light traps as mechanical tool of IPM also helpful to catch the adults. It is very effective method also used for monitoring of the pest in the new area. In cultural methods different tillage operation may also help to manage the pest. Resistant/ tolerant varieties are more effective than chemical control as damaging stage of larvae is hidden inside the stem. Use of entomopathogenic fungi like *M. anisopliae* and *B. bassiana* @ 1 ml/ 30 larva useful to minimize this pest. Seed treatment with thiamethoxam 30 FS also helpful to reduce the dead heart percent against pink stem borer. Insecticides like spinosad 45 SC @ 160 ml/ha, fenvalrate 0.0125%, carbofuran 3G @ 1000 g. a.i./ ha and chlorantraniliprole 18.5 SC@ 60 ml/ha gave effective control of this pest.



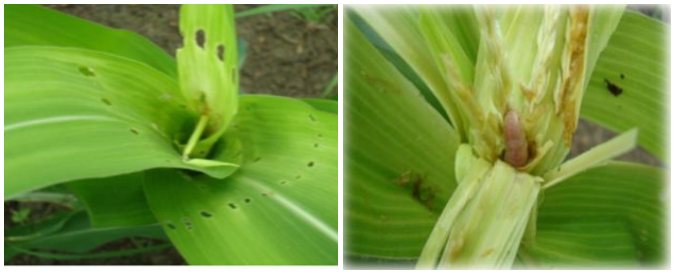
Eggs Larva

Pupa Adult

Different Stages of Pink Stem Borer



Feedingm on Epidermis Gummy Oozing



Parallel Holes Tessel Damage

Cob Damage

Damage Caused By Pink Stem Borer

Dead Hearts Symptoms

Maize Fingermillet Sorghum

White Ear

Rice Finger millet Wheat

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