

## Insect pests of sugarcane in Andhra Pradesh: Current status and integrated management

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### Abstract

Sugarcane is a long duration crop and is prone to be attacked by several insect pests. According to an estimate, sugarcane production declines by 20-25 percent due to insect pests. In India, sugarcane is infested by about 228 insect pests. Nearly 15 insect pests are causing significant losses to the quality and quantity of sugarcane. Among the pest groups of sugarcane, borers are the most important followed by soil pests, sucking pests, and defoliators. In Andhra Pradesh, the major sugarcane pests include early shoot borer, internode borer, and scale insect whereas sporadic pests which appear irregularly but can be damaging include mealybugs, whitefly, termites, white grubs and minor pests, which are less frequent and typically cause limited damage, include fall armyworm, root borer, top borer, *Pyrilla*, woolly aphid & grasshopper, non-insect pests like sugarcane mite /web mite and rodents. Several factors have contributed to the persistent pest build-up, including high daytime temperatures combined with low relative humidity; irregular irrigation schedules with long intervals during the early stages of crop growth, making them more susceptible; non-availability of resistant cultivars, limiting options for effective pest management; neglected ratooning practices, improper or inadequate usage of pesticides and chemicals. These combined factors have resulted in sustained pest problems across the Andhra Pradesh. To maintain the pest population at minimum level, integrated pest management is the only way to manage the pests and sustainable production in sugarcane. In this paper, the current pest scenario and their management in sugarcane agroecosystem were outlined in detail.

**Keywords:** Sugarcane borers, sucking pests, soil insects, Integrated management

### Introduction

India is the world's second-largest producer of sugarcane (18.18 percent) and sugar (15.81 percent) after Brazil (Yadav and Yadav 2018) [38]. The rapid expansion of sugarcane cultivation to meet the requirements of the sugar industry led to large tracts of monocultures in both tropics and subtropics, the two agroclimatic regions of the India from sugarcane. In subtropical India, the adverse climate characterized by seasonal extremities which supports moderate crop growth but high pest abundance. In contrast, the moderate climate in tropical India favours good crop growth but low pest levels (Easwaramoorthy 1986) [13]. In India, sugarcane is infested by about 228 insect pests (David and Nandagopal 1986) [10]. Nearly 15 insect pests cause heavy losses to an extent of 20% reduction in sugarcane output and a 15% reduction in sugar recovery (Avasthy 1977) [1]. Sugarcane borers are an important constraint to cane yield and sugar recovery in India. Among the eight moth borers known to occur in the country, only four are economically more important-namely the early shoot borer (ESB) - *Chilo infuscatellus* Snellen, inter node borer (INB) - *Chilo sacchariphagus indicus* (Kapur), top shoot borer (TSB) - *Scirpophaga excerptalis* Walker and stalk borer (STB) - *Chilo auricilius* Dudgeon (Sithanantham *et al.* 2013) [31].

During the surveys, it was observed that several established pests began proliferating in a region-specific manner in the recent past. Pests such as early shoot borer with a nationwide distribution have largely remained under control, except for occasional spurts under extremely favorable weather conditions in Andhra Pradesh. Interestingly, the pest was found to have dropped below the damaging levels over the last couple of decades in some parts of the Northern India. The internode borer, *C. sacchariphagus indicus* has become a major issue due to its transformation from a truly

internode borer to a meristem feeder, resulting in the loss of canes instead of internodes in the southern states of India. Different species of white grubs and rats are becoming a major threat to sugarcane cultivation in the vast tracts of sugarcane monocultures without any diversity or alternative food sources (Srikanth 2012) [34].

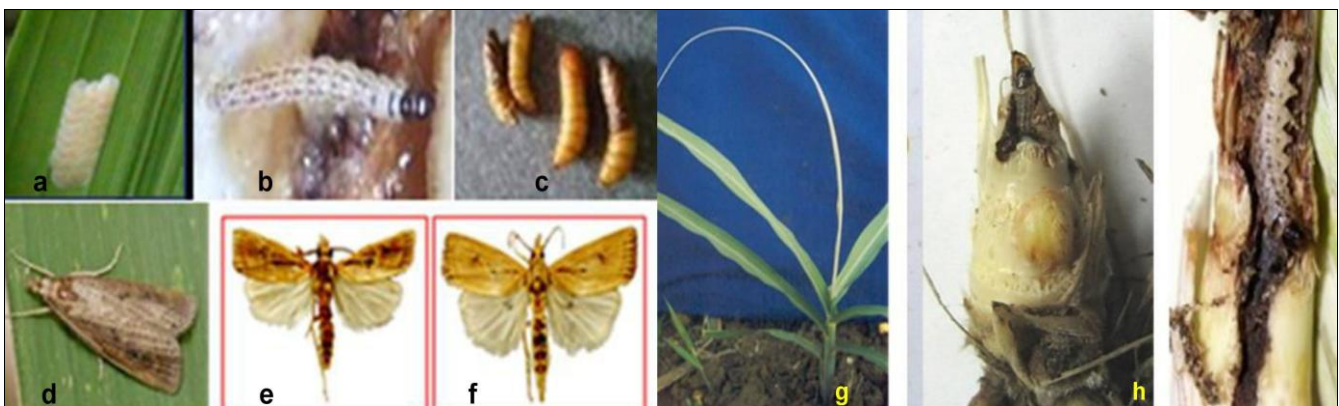
In recent years, an invasive pest, fall armyworm was introduced from other countries also found to be infested on sugarcane (Srikanth *et al.* 2018; Bhavani *et al.* 2019) [5, 36]. Thus, sugarcane is vulnerable to invasion and establishment of pests from the other region if they are introduced through movement of seed or by some other mode. The same holds good for invasive pests from neighboring sugarcane growing countries. Disturbances in the crop habitat locally often led to an increase in the populations of occasional pests and such localized outbreaks in a severe form have been noticed for sucking pests such as *Pyrilla*, scale insect, mealy bug, whitefly, sugarcane aphid, sugarcane mite and web mite. The current situation, the detailed description of major insect pests and integrated management techniques that can be utilized to control the pests of sugarcane in the field are outlined hereunder.

### Early shoot borer, *Chilo infuscatellus* Snellen (Lepidoptera: Crambidae)

Early shoot borer (ESB), *Chilo infuscatellus* Snellen is the major pest in Andhra Pradesh especially in rainfed sugarcane and continues throughout the crop growth period by infesting the internodes immediately after cane formation due to staggered plantings in South Indian states especially in Andhra Pradesh. ESB infests the crop in early stages as shoot borer and as internode borer after internode formation. The borer larvae bore into shoot usually at ground level and feed on growing point resulting in a 'dead heart' in 1-3-month-old crop which can be easily pulled out and emits

offensive smell (Fig. 1g). It often bores into the tops of grown-up or mature canes in the sugarcane tracts of humid coastal Andhra Pradesh State, southern India, behaving as a 'late shoot borer'. Climatic factors and non-availability of suitable young crops play a role in such altered feeding behavior of *C. infuscatellus*. Infestation by early shoot borer was found high in rainfed sugarcane. The infestation was found to range from 15.5% to 60.5% of the shoots produced and a maximum of 90% clumps have been affected in the North Coastal Zone of Andhra Pradesh. The loss in sugar production due to this pest is estimated to be 13-20%. The maximum loss in yield due to this borer was found to be 42.5% (Prasad Rao *et al.* 1991) [25]. All commercial varieties were equally susceptible to the early shoot borer, when the dead hearts were 15%, the reduction in yield was only half a ton per hectare. When the number of dead hearts increased to 30% the average loss in cane yield was about 7 tonnes/ha (Patil and Hapase 1981, Bhavani *et al.*, 2025) [7, 24].

The adult is pale greyish brown in colour with black dots near the coastal margin of the forewings and with white hind wings (Fig. 1d-f). Flat scale like eggs are laid in 3-5 rows on the lower surface of leaves in masses of 4-100. Freshly laid eggs are transparent, which later turn creamy white and are glued firmly on the surface of the leaf (Fig. 1a). The masses are slightly overlapping like tiles and hatches in 4-6 days. The larva is dirty white with five dark violet longitudinal stripes and dark brown head with a duration of 16-30 days (Fig. 1b). It is a five striped borer like stalk borer and its prolegs have incomplete crochet arrangement. Newly hatched larvae wander for about a few hours and reach the base of the stem by crawling or hanging by a silken thread. The larva generally enters in between the first leaf sheath and stem and feeds on the soft inner tissues of the sheath like a leaf miner for a few days. After that, the larvae bore into stalk and kill the growing point ((Fig. 1g-h).



**Fig 1:** Life stages of *C. infuscatellus*: (a) Egg mass (b) Larva (c) Pupae (d) Adult moth (e) Male (f) Female  
Damage symptoms of ESB: (g) Deadheart (h) ESB larva inside the shoot

Early shoot borer attacks the young shoots of 4-10 weeks and produces dead heart symptoms. Pulling these dead hearts comes out easily (Fig. 1g). The base of the dead heart gets rotten and emits an offensive smell. The shoot borer caterpillar is migratory in habit and after killing one shoot it migrates to another. A single caterpillar may destroy three or four shoots before it pupates. Shoot borer infestation is high during the pre-monsoon period (April-June) when the ambient temperature is high with low relative humidity. Days comparatively warm throughout favoured proliferation of early shoot borer. Borer activity decreases rapidly due to the onset of monsoon. Pupation takes place within the tunnel (1c). Caterpillar before pupating makes a large exit hole in the stem and blocks the opening with silken discs.

### Management

- Planting in deep trenches (40 cm wide and 20 cm deep).
- Early planting coupled with frequent light irrigations in the formative phase of the crop.
- Spreading the cane trash in between rows on the 3<sup>rd</sup> day after planting 3t/ha.
- Application of carbofuran 3G (33 kg/ha) or fipronil 0.3G (25 kg/ha) or chlorantraniliprole 0.4G (20 kg/ha) mixed with sand (2:1) in the furrows at planting.
- Setting up pheromone traps at 5/ha for monitoring or 25/ha for mass trapping of adult moths with ESB lure change at 21 days.
- Field release of *Trichogramma chilonis* at 50,000/ha commencing from 30 days after planting four times at weekly intervals from January to May.

- Growing of intercrops *viz.*, greengram, blackgram, cowpea and soybean or coriander.
- Remove and destroy dead hearts.
- Light earthing-up at 45 days after planting helps to reduce the incidence.
- Application of granulosis virus with high volume spray (500 LE/ha) into whorls of the plant commencing from 30 days after planting for two times at 15 days interval.
- Need based spray of chlorpyrifos (2.5 ml/L) or monocrotophos (1.6 ml/L) or acephate (1g/L) at 4<sup>th</sup>, 6<sup>th</sup> and 9<sup>th</sup> weeks after planting.
- Spray of chlorantraniliprole 18.5 SC (0.3 ml/L) at 30 and 60 days after planting under severe infestation.

### Internode borer, *Chilo sacchariphagus indicus* Kapur (Lepidoptera: Crambidae)

It is a major pest of sugarcane in south India. The internode borer (*Chilo sacchariphagus indicus*) makes a modest beginning in April *i.e.*, soon after internode formation and its activity continues till harvest. The infestation of the borer goes on progressively increasing with the growth of the crop reaching maximum during the month of September-October when the crop is 7-8 months old. The larvae bore into the internodes and enter the stem, feed on inner tissues and the frass is pushed out to the exterior. Entrance hole is usually plugged with excreta (Fig. 2a-d). Its feeding makes the tissues red. A single larva may attack several nodes. The damaged internodes constricted, shortened, got hardened and crushing of these becomes difficult (Fig. 2b). The

damage due to internode borer infestation results in both yield and factory loss.

Its infestation ranged from 5.8 to 62% on cane basis and 5.0 to 15.0% on internode basis depending on variety and season (David *et al.* 1979) [11]. Internode borer produced higher levels of bore hole damage than dead hearts (Fig. 2a); the borer also caused different patterns of internode and spindle damage, with or without the involvement of meristem (Srikanth and Kurup 2011) [35]. The borer is more active during the June-July months. Factors favouring high population build-up of this borer are lodging, drought, high dose of nitrogen and presence of large number of water shoots.

The biology of internode borer indicated the presence of

four overlapping generations in a year. The moths are small, straw coloured, fore wings have a marginal dark line, and hind wings are white (Fig. 2h). The moths lay eggs in clusters in 2-3 parallel rows on both sides of the leaves on the mid rib and parallel to the midrib. Freshly laid eggs are oval, flat shiny and waxy white in colour (Fig. 2e). The caterpillar has a white body with four violet stripes on the dorsum of larva and brown head (Fig. 2f). The larva in the prepupal stage comes out of the tunnel and selects a semi dry leaf sheath, spins a silken cocoon in about 10-18 hours and rests aside. Freshly formed pupa is light brown in colour, becoming dark brown after 6-7 days (Fig. 2g). Males are smaller than females. The pupal period ranges from 7-10 days (David 1987) [9, 12].



**Fig 2:** Damage symptoms of *C. sacchariphagus indicus*: (a) Infested cane with bored nodes (b) Sprouting of the buds below the infested nodes (c) Entrance hole plugged with excreta and (d) Reddening of the inner tissue; Life stages (e) Egg (f) Larva (g) Pupa (h) Adult

Chemical insecticides are not effective against internode borer due to the canopy structure and tall growing nature of the sugarcane crop, which limits the application of the pesticides in foliar. Further, as the borer pests remain concealed within the sugarcane stem, the success of chemical insecticides in containing the incidence is low. Therefore, different control methods are being employed to overcome this complex situation in which integrated pest management is the most desired approach. The mass trapping of internode borer moths using pheromone traps in combination with other non-insecticidal methods as an integrated approach reduces the infestation levels of internode borer (Sithanatham *et al.* 2014; Bhavani *et al.* 2016, Bhavani *et al.* 2025) [7, 18, 32].

### 1. Management

- Avoid high dose of nitrogen.
- Draining off water in low-lying areas.
- Use of synthetic pheromones in Delta traps 5 /ha for monitoring or 25 traps/ ha for mass trapping of adult moths commencing from the internode formation stage of the crop with lure change in 45 days interval.
- Field release of egg parasitoid, *Trichogramma chilonis* (50,000/ha) at 7-10 days intervals from 120 days after planting until a month before harvest.
- Detrashing of the crop with a view to destroying the

larvae and pupae attached with the leaf sheaths.

- Removal of water shoots on eighth/ ninth months.
- Spray of chlorpyrifos (2.5 ml/L) or monocrotophos (1.6 ml/L) or acephate (1.0 g/L) twice at 15 days interval during June-July months after detrashing to kill the larvae and pupae attached with the leaf sheaths.

### Top borer, *Scirpophaga excerptalis* Walker (Lepidoptera: Crambidae)

It is a major pest of sugarcane in sub-tropical India. It completes five generations (broods) a year. The first brood adult (moth) appears in February, second brood moth appears in April, the third brood in June, the fourth brood in August and the fifth in September. Amongst the borers of sugarcane, the moths of top borer are relatively easy to identify due to their silvery white colour which is distinctly different from straw-coloured moths of other borers (Fig. 3a-c). Females have a tuft of crimson red/orange or buff colour anal hairs (Fig. 3c). Moths are nocturnal. However, top borer moths are often observed in the morning hours clinging on crown leaves of sugarcane. As day progresses moths take shelter in whorls/ leaf sheath of sugarcane. Eggs are laid parallel to the mid rib mainly on the underside of younger crown leaves (Fig. 3d). Attack of top borer was heavy in crops planted during July-August and October-November (Agarwal and Ramanujam 1964) [2, 3].



**Fig 3:** Life stages of *S. excerptalis*: (a)Adult moth (b) Male (c) Female (d) Egg mass (e) Larvae (f) Pupae; Damage symptoms: (g) Shot holes on crown leaves (h) Bunchy top (i) Reddish midrib tunnel on the crown leaf (j) Slender deadheart (k) Larva feeding in top shoot

The First two broods of this pest attack young plants. In subsequent generations, the pest attacks the terminal portion of the cane, causing bunchy-top (Fig.3h). Maximum damage occurs during the third and fourth generations, resulting in plant mortality and complete yield loss. The pest is active during February to October (Singh *et al.* 1980) [30]. Egg masses are covered with orange tuft of anal hairs (Fig. 3d). A female can lay 46-216 eggs. Eggs were laid on both sides of leaves near and away from midrib. Egg mass size varied from 12mm x 1.5 - 5mm and was arranged in two to five rows of various shapes. Incubation period is 7-10 days. After hatching, the fragile first instar larvae crawl actively on the leaves and bore into the mid-rib from the lower side of inner leaves of crown. Five instars of stalk borer were found to occur during August - September and six instars during summer and winter (Sardana 1998) [27]. The larvae tunnel through the cane goes downwards and reaches towards the rind to make an exit hole and after making the exit hole closes it with the cut portion of rind. Behind the exit hole it also produces several silken discs for self-protection

Tunnelling through the mid-rib larva finally reaches the inner core of the crown and then enters the central core making holes through the unfolded leaves. These leaves show larval damage as shot holes on unfolding (Fig. 3g). The mid-rib tunnel initially remains white and later turns reddish (Fig. 3i). The presence of the reddish mid-rib tunnel on the crown leaf indicates top-borer infestation. Larva eats away from the growing point and thus a slender dead heart is formed (Fig. 3j). As a result of the fourth brood attack side shoots develop and give an appearance of bunchy top (Fig. 3h). Second instar and onwards larvae are pale white to creamy, sluggish with atrophied legs (Fig. 3e). Pupa is cylindrical in shape and pale yellow in colour (Fig. 3f). Pupation takes place in the cane and pupal period lasts for about a week (7-10 days). The average life cycle is completed in 54-60 days (Mukunthan, 1985) [23].

### Management

- Installation of sex pheromone traps for monitoring and mass trapping of top borer moths,
- Collection and destruction of egg mass and dead hearts during the second brood period.
- Application of carbofuran 3G (33 kg/ha) or Fipronil 0.3G (25 kg /ha) in June (on the appearance of top borer moths as observed in traps). A light irrigation should be given after application of granular insecticide, if soil moisture is limited.

- Releases of *Trichogramma japonicum* (50,000 /ha) at 7-10 days interval from July to check 4<sup>th</sup> and 5<sup>th</sup> broods.

### Root borer, *Polyocha depressella* Swinhoe (Lepidoptera: Pyralidae)

It is a minor pest of sugarcane. The root borer attacks sugarcane in the early stages when the crop is 2-4 months old and causes damage throughout the year. Dead hearts are produced in the young crop which, though they resemble shoot borer, cannot be pulled out. The dead heart does not emit any offensive smell and often one or two leaves adjacent to the central leaf whorl also dry up. There is only one entry hole near the base of the shoot. In early April, the newly hatched larvae crawled down and bore into the base of young plants about 2.5" below ground level resulting in drying of the central spindle in about 17 days and the entire plant in 37-43 days. After July, the larvae attack side tillers more frequently than the main or mature side shoots making one to seven holes in the internodes below ground level and sometimes disperse from one shoot to another. Although they are called root borers, they rarely bore into the root. Only that part of the stem which is below the ground level is attacked by this pest (Fig. 4f). The damage caused to cane crops is mainly done by caterpillars. Caterpillars, after hatching, crawl down the plant and enter the soil to bore into the plant tissue below the soil surface (Fig. 4f-i). Drying up on inner whorl of leaves and formation of dead hearts are the common symptoms of the attack of this pest.

Pest attack in the later stages lead to yellowing of leaves in the post-monsoon period and this yellowing is due to the obstruction of free flow of nutrients from roots to leaves. On average 5-15% of the cane crop is attacked by this pest. It causes reduction in weight by 10%. The sucrose content is also lowered by only about 0.5%. Among the five generations examined in April, May, June, July and September, larvae of the first generation killed all shoots attacked but those of the last generation had no apparent effect on the weight of the cane. The root borer can reduce stalk weight, juice quality, and sugar recovery.

In severe cases, it can lead to a "root-borer-wilt complex" infestation (Fig. 4j). Studies during 1990-91 showed that reduction in weight of canes infested only with the borer averaged up to 4% whereas weight loss in canes infested with the borer and infected with root rot fungus *Fusarium* averaged 36.7-62.5% (Sardana 1993) [26]. No significant reduction in cane weight and juice quality in later stages of the crop growth due to root borer attack alone. However,

wilt and root borer-wilt complex together affected cane yield and quality significantly (Sardana *et al.* 2000) [28].

Moths emerge during the early morning hours, and mating occurs in the early hours of night. The adult moth measures about 25 mm in wingspan. The female moths lay eggs singly on the leaves along the midrib and rarely on the stem or in the soil (Fig.4a-b). The number of eggs laid by a female varies between 180-280. The neonate larva crawls to the base of the stem and enters by making a single hole at or just below the ground level. The larva feeds in an irregular semi-circular pattern (Fig.4h-i). The larval period lasts for 4-7 days but during the crop season it may extend up to 28-32 days. Fully grown caterpillars are white in colour, relatively active and

measures 2-5 cm in length (Fig. 4g). The larvae of the fifth brood hibernate in the stubble of the sugar cane plants during mid-November to early December. A hibernating larva can survive for 200 or more days. Pupation occurs inside the stem at or below the soil surface, generally in the early stages of plant growth. Prior to pupation, the larva cuts an opening to the exterior and constructs a silken tube up to the surface of the soil in line with the tunnel to ensure easy emergence of the adult and pupates 4 cm below the ground level. High temperature and low humidity accelerate the multiplication rate of the pest. The life span of male moth is 3-10 days and that of female is 10-15 days. Three to five generations per year. The root borer prefers temperatures of 31–34°C and high humidity.



**Fig 4:** Life stages of *P. depressella*: (a-b) Egg (c) Larva (d) Pupa (e) Adult; Damage symptoms of root borer: (f) Grown up larvae (g) Larvae inside the cane (h) Pupa inside the cane (i) Damaged canes (j) Damaged cane infected with wilt disease

### Management

- Deep ploughing and destruction of stubbles by burning or flooding.
- Deep harvesting of crops intended to be ratooned.
- Destruction of weeds in and around cane field as weeds harbour the pest.
- Removal of dry leaves from the canes.
- Removal and destruction of late shoots at the time of harvesting.
- Spray of monocrotophos (1.6ml/L) fortnightly during July to September is quite effective in controlling this pest.
- Intercropping sugarcane with blackgram and cowpea.
- Use of light traps to collect moths at regular intervals beginning early in the season.
- Avoidance of ratoons in farms with severe infestation
- Uprooting and destruction of infested plants in the early stages.
- Water management through frequent light to medium irrigation.
- Release of *Trichogramma chilonis* (50,000/ha) in a sequential manner from early stages of crop on an area-wide basis.
- Need based application of fipronil 0.3G (25 kg/ha) at the time of planting.

### Pink borer, *Sesamia inferens* Walker (Lepidoptera: Noctuidae)

The pink borer, *Sesamia inferens* is a minor pest. It attacks rice, sugarcane, maize, wheat, ragi, finger millet, sorghum, bajra, pearl millet, barley and grasses. The economic impact of *S. inferens* in India was mainly restricted to maize, rice, ragi, finger millet and sorghum. However, more recent studies reported up to 19.0% infestation of sugarcane with

57.31 and 36.45% reduction in cane weight and brix, respectively. It infests the crop in a borer complex, with *Chilo infuscatellus*, as early shoot borer in month of March to June but it has been observed infesting different sugarcane varieties from first week of August to third week of September as internode borer (Choudhary and Shrivastava 2007) [8]. Newly hatched larvae take shelter in between stem and leaf sheath and mines into epidermal layers of leaf-sheath (Fig. 5f). Later third instar larvae bore and enter in the middle of the stalk and extruding plenty of wet frass (Fig. 5h). The central whorl of the leaves is cut off and dries up forming a dead heart. On pulling out, dead hearts emit a foul odour. Borer larvae have rarely been observed in grown-up canes. Besides this, the larvae also feed in the whorls of young canes during the month of June and produce oblong holes (Fig. 5e) in developing unfolded leaves (Mahesh *et al.* 2013) [20].

There are two types of infestation- Primary and Secondary were observed. Primary attack remains confined to the late formed tillers or the top portion of a cane (Fig. 5f-h) and is the larvae feed gregariously, while the secondary infestation is caused by grown-up larvae in the solitary phase. Tunnel made by the larva inside the internode is straight and only two holes, entrance and exit are usually observed on the rind. During December to April, about 20 percent shot of the ratoon and 10 per cent of the plant crops are generally destroyed every year (Kumar and Karla 1965) [19].

The adult moth is light brown in colour, with dark brown streaks on the fore wings and white hind wings. The female lays about 150 creamy-white and hemispherical eggs that are arranged in two or three rows between the leaf sheath and the stem of the host plant (Fig. 5a). Egg period 7 days. The fully-grown larvae measures about 25 mm and is pale yellow with a purple-pink tinge and a reddish-brown head

(Fig. 5b). The larval period is 25 days but in cold months it may be extended to 75 days. Pupation occurs in the larval tunnel in the stem, and the adult emerges in 12 days (Fig. 5c-d). One generation may take 6-7 weeks. The life cycle is

completed in 45-75 days. There are 4-6 generations per year. The pink borer existence was found between December to April while its peaks were in April/ May and in August (Mannan *et al* 1999) <sup>[21]</sup>.



**Fig 5:** Life stages of *S. excerptalis*: (A) Egg mass (B) Larva (C) Pupae (D) Adults; Damage symptoms: (E) Oblong holes in unfolded leaves (F) Infestation on top portion of the cane (G) Entrance hole plugged with wet frass

### Management

- Release egg parasitoids: *Telenomus* sp., *Trichogramma chilonis*; Larval parasitoids: *Apanteles flavipes*, *Bracon hebetor*; Pupal parasitoid: *Tetrastichus ayyari*
- Soil application of carbofuran 3G (33 kg/ha) or fipronil 0.3G (25kg/ha) or cartap hydrochloride 4G (20 kg/ha) at the time of planting of the crop.

### Whitefly, *Aleurolobus barodensis* Maskell (Hemiptera: Aleyrodidae)

It is a major pest and sporadic pest in tropical India but occasionally assumes a serious form and causes heavy losses especially in water-logged conditions. The adults are active tiny insects with a pale body, black eyes and two pairs of nearly white wings. They measure about 3 mm in length. Nymphs and adults suck the cell sap from the underside of the leaves which as a result turn yellow and ultimately dry, affecting the vigour of the crop and yield (Fig. 6a). Due to the injury to leaf tissues and on account of the coverage of leaf surface with mealy secretion, the metabolic activities of the plant are upset, which adversely affects sugar formation. Besides, excretion of honeydew encourages the development of a black fungus which affects photosynthesis (Agarwal and Siddiqi 1964) <sup>[2, 3]</sup>.

Eggs are deposited in rows side by side near the midrib of leaves and attached to the leaf by a short filament (Fig. 6b). The eggs hatch in 8-10 days. The nymphs complete their development in 15-30 days after passing through four instars (Fig. 6c). The pupal stage lasts for 10-11 days (Fig. 6d). The life cycle is completed in 5-6 weeks and pests complete 9 generations in a year (Hamid Mohamood 1955) <sup>[16]</sup>.

### Management

- Clipping off and destroying the early infested leaves prevents further spread of the pest.
- Removal of infested leaves + spray of malathion @ 2 ml or dimethoate (1.7 ml/L) or monocrotophos (1.6 ml/L) or imidacloprid (0.25 ml/L) along with 2% urea or
- Application of neem-based pesticide, azadirachtin 1500 ppm (5 ml/ L) on under side of the leaves.
- Apply the recommended dose of nitrogen and avoid excessive use of nitrogenous fertilizers.

- Conserve nymphal parasitoids viz., *Azotus delhiensis*, *Encarsia isacci*.
- Encourage predators viz., *Chilocorus nigritus*, *Scymnus nubilus*.
- Provision of adequate drainage facilities.
- Heavy rainfall washes out the pest.
- Ratooning is to be avoided in low lying areas prone for water logging.
- Spray of chlorpyrifos (2.5 ml/L) or imidacloprid (0.25ml/L) on lower side of the leaves.

### Sugarcane leafhopper, *Pyrilla perpusilla* Walker (Hemiptera: Lophopidae)

It is a major pest of sugarcane crop in sub-tropical India and breeds throughout the year, but the incidence is at the peak from April to August. The adults are straw hoppers with two pairs of wings, folded like a pointed beak which is quite readily visible (Fig. 6h). Eggs are laid in cluster typically on the underside of sugarcane leaves near the midrib covered with a white waxy thread like material secreted by the female (Fig. 6f). Newly hatched nymphs are milky white in colour with a pair of characteristic anal processes or filaments covered by wax (Fig. 6g). Both nymphs and adults suck the cell sap from the under surface of leaves which as a result lose turgidity, begin to wither and ultimately get dried under severe conditions (Fig. 6i-j). Due to feeding the sucrose percentage of juice and development of cane is adversely affected. Besides sucking the sap, these insects secrete honeydew like substance that spreads on the leaves, on which a black fungus (sooty mold) develops, that adversely affects the photosynthesis and ultimately the yield of canes. Since sucrose content is reduced, the quality of jaggery is drastically affected. Failure of monsoon, cloudy weather, waterlogged conditions, late activity of parasite, *Fulgoracia (Epiricania) melanoleuca* favour rapid multiplication of the pest. Temperature and humid conditions in summer, low rainfall or long dry intervals during monsoon months combined with sudden changes in atmospheric humidity, affecting the parasite activity. Heavy dose of nitrogen results in population explosion of *Pyrilla* to epidemic proportions.

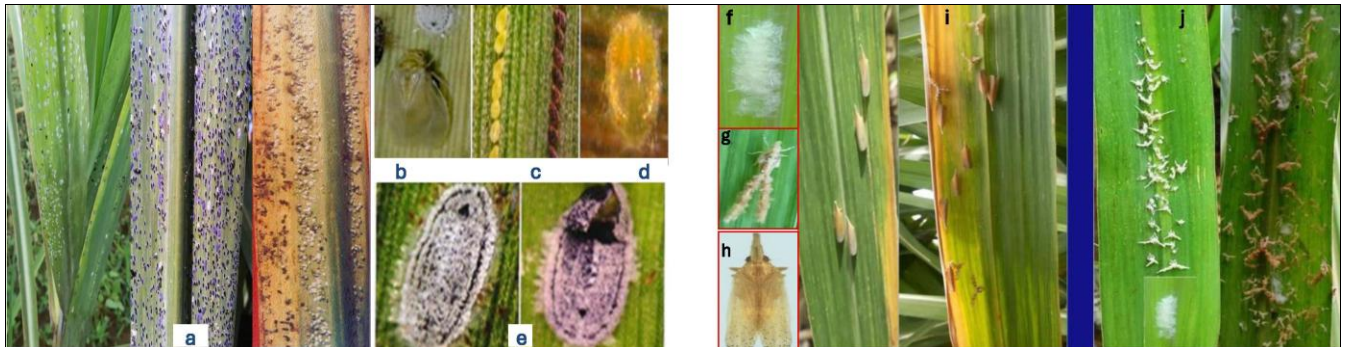
The pale greenish yellow eggs are laid on the lower surface of the leaves and between the detached leaf sheath and the stem, the eggs are covered with white cottony waxy filaments (Fig. 6f). The incubation period lasts for 7 to 14

days under warm conditions while in winter it continues up to 30 to 40 days. The nymphs become adult hoppers within 50 to 60 days. There are about 5 instars, and the life cycle is completed in about 60 days in summer and 120 days in winter. Depending upon the weather conditions, 3 to 5 generations are completed in a year. Besides sugarcane crop, it also feeds on jowar, maize, bajra and barley crops.

**Management**

- Mechanical methods such as collection and destruction of eggs masses help to minimize the pest incidence.
- Disposal of cane trash.
- Detrashing of 5 to 6 lower leaves on which generally eggs are laid.

- Avoid excessive use of nitrogenous fertilizers.
- Set up light trap.
- Release cocoons @ 5000/ha or egg masses @ 500000 eggs/ha of *Fulgoracia (Epiricania) melanoleuca* parasite for effective control of *Pyrilla*. After the establishment of parasites, insecticide should not be used.
- Avoid trash burning to prevent destruction of hibernating above parasite eggs on dry leaves.
- Use of *Metarhizium anisoplaea* and *Aspergillus flavous* against this pest.
- If biocontrol is not undertaken, spray dimethoate (1.7 ml/L) or monocrotophos (1.6 ml/L) as soon as the incidence is noticed.



**Fig 6:** (a) Whitefly infestation on underside of the leaves; Life stages of *A. barodensis*: (b) Adult (c) Eggs (d) Nymph (e) Puparia; Life stages of *Pyrilla*: (f) Egg mass (g) Nymph (h) Adult; Damage symptoms of *Pyrilla*: (i-h) Adults & nymphs feeding on underside of the leaves

**Sugarcane white woolly aphid: *Ceratovacuna lanigera* Zehntner (Hemiptera: Pemphigidae)**

It is one of the major pests in sugarcane growing areas. Nymphs are yellowish or greenish yellowish in colour (Fig. 7a-b). They moult four times and become adults. Adults are black in colour, having two pairs of transparent wings and two cornicles on last abdominal segment (Fig.7c). Nymphs and adults suck the sap from leaves and excreted honey dew like substance on which black sooty mold

developed (Fig.7g). Yellowish spot developed on leaves, leaves edges dries and complete leaves dried (Fig. 7d-f). Stunted growth of the plant and yield losses up to 26 per cent. On single leaf, 8000 aphids are seen. Older sugarcane damages more. Each female produces 15-35 nymphs in one day, up to 217 in her lifetime, causing rapid multiplication. Nymphal period 6-22 days. Adult period 32-57 days. Total life cycle is completed within 30 days (Venugopala Rao *et al.* 2004) [36].



**Fig 7:** Life stages of *C. lanigera*: (a-c) Nymphs & adults on underside of the leaves; Damage symptoms : (d-f) White woolly coated colonies on underside of the leaves (g) Sooty mold on upper side of the leaves

**Management**

- Use pest free seed material for planting.
- Set treatment with chlorpyrifos 20EC (2.5 ml/L) for 15 minutes or with imidacloprid 600FS (1 ml/L) for 5 minutes.
- Avoid late application of nitrogenous fertilizer and excessive irrigation.
- Avoid transportation of infested leaves.

- Avoid ratooning, if the plant crop is heavily infested with woolly aphid.
- Adoption of paired/wider row planting & provision of proper drainage.
- Removal and burning of affected leaves & wrapping and propping of canes.
- Monitoring of the pest through yellow traps.

- Field release of *Chrysoperla carnea* at 2500 eggs/ha or *Dipha aphidivora* at 1000 larva /ha or *Micromus* spp. at 2500 larva/ha or Syrphid fly at 2500 larva/ha.
- Spray of monocrotophos (1.6 ml/L) or dimethoate (1.7ml/L) or chlorpyriphos (2.5 ml/L) or acephate (1g/L) directing the spray fluid towards the under surface of leaves.

### Mites

#### 1. Sugarcane mite, *Oligonychus indicus* Hirst. (Acarina: Tetranychidae)

The adults of *O. indicus* settle on the lower surface of the leaves (Fig. 8a). Weave out fine webs and form several colonies. They feed on lower surface of the leaves (Fig. 8a). As a result of feeding the injured surface of the leaf exhibits characteristic red spots (Fig. 8a). High temperatures and low humidity are favourable for the buildup of the pest. The pest activity starts in April on the crop and continues up to June when the monsoon sets in.

#### 2. Web mite, *Schizotetranychus krungthepensis* Naing & Auger (Acarina: Tetranychidae)

The web mite, *Schizotetranychus krungthepensis* belongs to the 8th group of *Schizotetranychus* (Flechtmann 2012) [15]. It was first reported on *Saccharum officinarum* in Thailand during 2014. The colonies are formed only on the surface of the leaves in 6-8 rows, parallel to the mid rib. The mite feeds by scraping the epidermis and sucking the sap, generally on the under surface of leaves resulting in white patches (Fig. 8b). The webs are thin and semi-transparent in the beginning and become whitish subsequently. The adult females are yellowish green in colour with two pairs of maculae. Eggs are white translucent, becoming yellow with age. This species produces web-nests on the under-surface of the leaves.

### Management

Removal and destruction of infested leaves Removal and destruction of grass on the bunds. Spray the sugarcane crop and grasses with wettable sulphur @ 3g/L or dimethoate @ 1.7 ml per litre of water at 15 days interval starting from the appearance of the pest. Adoption of balanced nutrition. Frequent irrigations in the pre-monsoon period reduce *O. indicus* infestation.

### Aphids

#### 1. Sugarcane aphid, *Melanaphis sacchari* Zehnter (Hemiptera: Aphididae)

It is a minor pest generally observed on senescent leaves of grown-up crops during May to December. Nymphs are yellow in colour, while adults, which are generally yellow, turn purple when crowded (Fig. 8c). Head and spiracular plates pale. The aphid does not multiply well on sugarcane. The winged forms are responsible for the widespread transmission of viral diseases in sugarcane. The monsoon wind helps in the dispersal of aphids. It is a vector of persistent viruses viz., sugarcane yellow leaf, and sugarcane mosaic viruses. Sugarcane yellow leaf virus (ScYLV), Polorovirus, Luteoviridae, is one of the main viruses that infect sugarcane worldwide is transmitted by the aphid *Melanaphis sacchari* in a persistent, circulative manner (Schenck and Lehrer 2000; Viswanathan 2021) [29,38].

Sorghum and Maize are the preferred hosts. It prefers grasses like *Echinochloa colona* Link, generally growing around channels as an alternative host. Nymphs are yellow in colour, while adults, which are generally yellow, turn purple when crowded. Head and spiracular plates pale. The monsoon wind helps in the dispersal of aphids.

#### 2. Rusty plum aphid, *Hysteroneura setariae* Thomas (Hemiptera: Aphididae)

The aphid species is known to infest 82 plant species in about 40 genera mostly belonging to plant family Poaceae including Rice, Sugarcane, Corn, Wheat and other plants.

It occurs on young sugarcane crop for up to three months. It is brown in colour, process very long, cornicles dark and slightly long, hind wing was only one oblique vein instead of the usual two, cauda has two pairs of hairs (Fig. 8d). This aphid does not multiply well on sugarcane the winged forms which alight on many plants are responsible for the widespread transmission of the mosaic disease (Alexander 1987) [4]. These aphids acquire and transmit the sugarcane mosaic virus in a rapid, non-persistent manner during their feeding probes on infected plants.

### Management

Spray of dimethoate (1.7 ml/L) or monocrotophos (1.6 ml/L) or acephate (1g/L). Conservation of the coccinellid and neuropteran predators in sugarcane ecosystem, which naturally keep the pest under check.



Fig 8: (a) *O. indicus* infested leaves with reddish patches; b) Damage symptoms of web mite; (c) Sugarcane aphid (d) Rusty plum aphid

#### Grasshopper, *Hieroglyphus banian* F. (Orthoptera: Acrididae)

Grasshopper damage in sugarcane is being observed in certain pockets of India. The hoppers of the first and second

instar of *H. banian* are gregarious in nature and feed for about a week on *Cynodon dactylon* grass. In the third stage, they migrate to sugarcane and continue to feed on leaves. Leaf margins are seen with irregular wavy feeding

symptoms. In severe cases, complete defoliation takes place leaving only the mid rib (Fig. 9b).

Adults are green with three transverse dark lines on the prothorax (Fig. 9a). Adults commence mating in the 1st week of August. Eggs are laid one day after mating. The oviposition period varies from 80-150 minutes. The eggs per egg pod vary from 68-99. The eggs are yellowish brown and undergo diapause for 10-11 months. The eggs may remain viable for 10 years. Eggs hatch in the following year after commencement of rain. There are totally six moults. The total nymphal period lasts for 48-81 days. Alternative hosts are Rice, sorghum, bajra and other millets.

#### Fall armyworm (FAW), *Spodoptera frugiperda* J. E. Smith (Lepidoptera: Noctuidae)

After its first appearance on maize in different south Indian states, this pest was observed on sugarcane in some districts of Tamil Nadu during 2018 (Srikanth *et al.* 2018) [33] and in Andhra Pradesh during 2019 (Bhavani *et al.* 2019) [5]. The incidence of FAW was noticed on 20 to 60 days old sugarcane crop. Other than sugarcane, it was also reported on maize, sorghum, bajra and ragi in different districts of Andhra Pradesh during August-November 2018.

Leaves of infested sugarcane exhibited skeletonization, irregular holes, windowing, and margin feeding on both mother shoots and tillers. In some plants, the central shoot was nibbled by mature larvae, and the spindle was often sheared, although meristem damage was not observed. Severe infestations were characterized by mature larvae hidden in the whorl, accompanied by large quantities of fresh fecal pellets and dry frass on older leaves (Srikanth *et al.*, 2018) [36]. Early instars of FAW scrape chlorophyll, producing silvery transparent patches, while later instars cause extensive windowing and frass accumulation in whorls (Fig. 10c-d). The total life cycle on sugarcane ranged from 30-36 days during March-April (Bhavani *et al.*, 2019) [5].



**Fig 9:** (a) Grasshopper, *H. banian* adult (b) Damaged leaves; Fall armyworm damage symptoms (c-d); Life stages of *S. frugiperda* (e) Egg mass (f) Larvae (g) Pupae

#### Mealybugs (Hemiptera: Pseudococcidae)

Mealybugs are widespread throughout the sugarcane growing tracts of India but rarely attain major pest status. According to an earlier estimate, 30 species are known to attack sugarcane in the world. Of these, *Saccharicoccus sacchari*, *Kiritshenkella sacchari* are widely distributed in Andhra Pradesh. Nymphs and adults suck the sap from leaves, nodes and internodes of canes. Severe infestation results in yellowing of leaves, stunting of canes and poor germination. Loss of sap may kill the young shoots or result in a marked setback in cane growth ultimately leading to total drying of the crop. Persistent residues of wax, honey

Eggs are laid in masses on the inner side of the whorl and the upper leaf surface, arranged in layers (Fig. 9e). They are dome-shaped, brownish yellow, and loosely covered with pale yellow frass. Early instar larvae are greenish with black dorsal hairs and a black head, while later instars have a dull grey body, dark grey head, and white subdorsal and lateral lines (Fig. 9f). Mature larvae possess a characteristic inverted 'Y' mark on the head capsule and distinct black spots, arranged squarely on the eighth and trapezoidally on the ninth abdominal segment. The incubation period is 2-3 days, followed by six larval instars lasting 13-14 days. During the prepupal stage, larvae cease feeding and turn dark greenish grey to brown. The total life cycle ranges from 30-34 days in males and 32-36 days in females during March-April. Pupae are reddish brown and formed in soil or leaf folds (Fig. 9g). Adults show clear sexual dimorphism: males have grey-brown forewings with a triangular white apical patch and central spot, while females exhibit uniformly mottled grey-brown forewings. Hind wings are silvery white with a narrow dark border in both sexes (Bhavani *et al.* 2019) [5].

#### Mangement

- Soil application of fipronil 0.3G (25kg/ha) or chlorantraniliprole 0.4G (20kg/ha) at the time of planting will avoid the infestation of FAW in the early stage of the crop.
- Early application of azadirachtin or neem oil 1500ppm (5 ml/L) to prevent oviposition and larval feeding.
- Removal of weeds in and around the sugarcane fields.
- Spray of chlorpyrifos (2.5ml/L) or monocrotophos (1.6 ml/L) after noticing the incidence of FAW (>5%) in the early stage of the crop ensuring that the spray fluid is directed to the whorls.
- Need based spray of chlorantraniliprole at 0.3 ml/L under severe infestation.

dew and sooty mould indicate past colonization. Severe infestation reduces sucrose, brix, purity and available sugar content significantly.

#### 1. Pink mealybug, *Saccharicoccus sacchari* Cockerell

Mealybug is one of the important pests of sugarcane in the state, but sporadic in occurrence and may cause heavy losses especially under drought conditions. Adults and Nymphs of mealy bugs are soft bodied, light-coloured oval creatures and found in large numbers near the nodes, covered over by a mealy white secretion of waxy powder (Fig.10 a-b). Both nymphs and adults remain under the leaf

and continuously suck the cell sap from the cane stalks as a result, the growth is retarded, and the sucrose content of the cane juice is reduced. Excretion of honey dew encourages development of black sooty mould, which affects photosynthesis. Mealy bug also acts as vectors of "Motlling, Spike and Mosaic diseases of sugarcane. Severe infestation of *S. sacchari* reduced sucrose content by 24.1% and brix by 16.2%.

Both nymphs and adults suck sap from the cane. The adult female is small, pinkish, has oval well segmented body females are distinctly pink with a dumb bell-shaped segmented body with white waxy coating. The older bugs are mostly seen on the lower nodes on which the leaf sheaths are loosely clasping, while crawlers are found on the upper soft tender internodes. Severe infestation results in stunted growth and yellowing of leaves. The stem gets covered with sticky honeydew, which serves as a medium for the development of black sooty mold due to the fungus *Capnodium* sp. Female lays yellowish, smooth, cylindrical eggs. Within a few hours the eggs become soft and elongated and soon the nymph emerges. Newly emerged nymphs are quite active with a pinkish transparent body (Fig.10a-b). Nymphal period 2-3 weeks. Life of adult female is 3-5 days. The entire life cycle is completed in about a month. The pest completes several generations in a year.

## 2. Yellow mealybug, *Kiritshenkella sacchari* Green

The incidence of yellow mealybug has been more predominant than pink mealybug in sugarcane over the past ten years

in Andhra Pradesh. The adult females are rather flattened and covered by a white mealy secretion. These are also gregarious in habit like the pink mealybug, measuring 2.54-4.00 mm in length with a pale yellowish or light pink colour (Fig. 10c). The antenna is six segmented, measuring 0.207 mm in length. A pair of small compound eyes is located posterior to the antennal socket. The legs are short and hairy. The oral bristles are well developed. Two pairs of spiracles, one on the mesothorax and another on the metathorax are present. Though this species commonly infests the nodal region (Fig.10d), it also has been found infesting the leaf sheaths, nodes, underground portions of the stalk and roots. This species was also reported to occur in other states like West Bengal, Tamil Nadu, Maharashtra, Karnataka and Orissa. Besides sugarcane crop, it feeds on sorghum and grass.

### Management

- The plant crop infested with mealybugs should not be ratooned.
- Selection of seed canes free from infestation of mealybugs and burning the affected canes.
- Avoid over dosage of nitrogenous fertilisers.
- Repeated ratooning may be avoided in areas prone to mealybug.
- Detrashing of lower dried leaves at 150 & 180 days after planting followed by need based spray of chlorpyrifos (2.5 ml/L) or monocrotophos (1.6 ml/L) or acephate (1 g/L) or imidacloprid (0.25 ml/L) or thiamethoxam (0.2 g/L) or or clothianidin 50 WDG (0.25 ml/L) on infested canes.



**Fig 10:** Pink mealybug (a-b) : (a) On nodal region (b) Inside the leaf sheath; Yellow mealybug(c-d): (c) Nymphs & adults on internodes (d) White waxy mass on nodal region

### Scale Insect, *Melanaspis glomerata* Green (Hemiptera: Diaspididae)

The scale insect makes its first appearance in a 5-6 months old crop after formation of few internodes. The adults are greyish black in colour, oval and slightly convex in shape. Both nymphs and adults suck the juice from the cane stalks (Fig.11). As a result, the infested canes become shriveled, the internodes are shortened and the sucrose percentage of the juice is reduced. In case of severe infestation, the entire cane is covered with the pest forming thick encrustation of the stem and ultimately the crop dries up completely. This also adversely affects the market value of the cane. The cane succumbs to the scale insect, once the crop attained maturity and the load of scale infestation reaches 5 to 6 g/cane in Co

A 8201. There were instances of scale reaching a level of 10 g of incrustation/cane in variety Co 62175 that resulted in burning of the fields. Acidity of cane juice increases because of scale insect infestation. This necessitates addition of high amounts of lime during preparation of jaggery, which makes the product black and of low market value. When juices of scale insect affected canes receive higher level of liming in the sugar factory, which results in thick scale formation in the pans requiring more cleaning. Scale insect infestation reduces germination, inhibits cane growth, reduces cane yield, percentage of juice extraction, juice quality and jaggery production. Both nymphs and adults suck the sap from cane stalks. The losses due to scale insect are estimated to be 8 to 54% in cane yield and 6.5 to

47% in sucrose in different parts of the country. Studies at Regional Agricultural Research Station, Anakapalle have indicated the losses to be 6.76% in cane yield; 4-10% in brix, 4-7% in juice sucrose, 3.5-3.9% in per cent jaggery recovery and 4.3 to 6.1% in C.C.S. percentage for every one-gram incrustation of scale per cane (Eswaramoorthy and Kurup 1987)<sup>[14]</sup>.

Drought conditions prevailing in monsoon season i.e., during the grand growth period of sugarcane crop favour build-up of scale incrustation. Normal weather factors have no influence on scale dynamics except in those heavy torrential rains, synchronizing with the emergence of the crawlers, would retard the scale multiplication by washing out the crawlers mechanically.

Heavy rain leading to inundation /submergence of fields adversely affect the scale build up. Studies on the dynamics of the scale insect in staggered planting of different commercial

varieties indicate that late plantings are met with low scale build up.

#### Management Practices

- Removal and burning of dried leaves, stubbles after the harvest of the crop.
- Selection of healthy insect free seed canes for planting.
- Dip seed cane setts for 15 minutes at planting in a suspension of dimethoate (2 ml/L) or chlorpyrifos (2.5 ml/L) or imidacloprid 600FS (1 ml/L) in 150 litres of water.
- Spray of dimethoate (1.7 ml/L) or acephate (1g/L) or imidacloprid (0.25 ml/L) or clothianidin 50 WDG (0.25 ml/L) on the infested canes after detaching the dried leaves for effective control of the pest.



**Fig 11:** Scale insect, *M. sacchari* encrustation on canes

#### Termite (White ant), *Microtermes obesi*; *Odonototermes obesus* (Isoptera: Termitidae)

They are polyphagous insects and cause damage to several cultivated crops. The pest is prevalent throughout the state. Termites are social insects. Only workers can move outside the termitaria and hence they are injurious to crops. They are whitish – yellow, flat and bodied insects (Fig. 12a). They cannot move in light and therefore, they construct a passage of mud for their movement outside and above the soil (Fig.12c-d). The workers feed on planted setts near the eye bud (Fig. 12b) and occasionally attack the root system and thus the infested plants succumb to death.

#### Management

- Locate the termitaria and destroy the queen.
- Dipping cane setts in 0.5% chlorpyrifos suspension (2ml/L) or imidacloprid 70 WS 100-150 g per 100 Litres of water.
- Application of carbofuran 3 G @ 25 kg /ha or fipronil 0.3 G @ 25 kg/ha or chlorantraniliprole 0.4G @ 20kg/ha in the furrows before planting.
- Soil drenching with chlorpyrifos @ 2.5 ml/ L after noticing the pest incidence.
- Systematic digging of termite mounds and destruction of queens. Apply 15-20 liters of chlorpyrifos 20 EC (5ml/L) per mound followed by proper levelling.

- Sett treatment with dimethoate (2.0 ml/L) or imidacloprid 600FS (1ml/L) for 15 minutes before planting.
- Apply chlorpyrifos @ 5 ml/L of water, whenever damage is noticed in standing crop.

#### White grub (Root grub), *Holotrichia serrata* Fabr. (Coleoptera: Scarabaeidae)

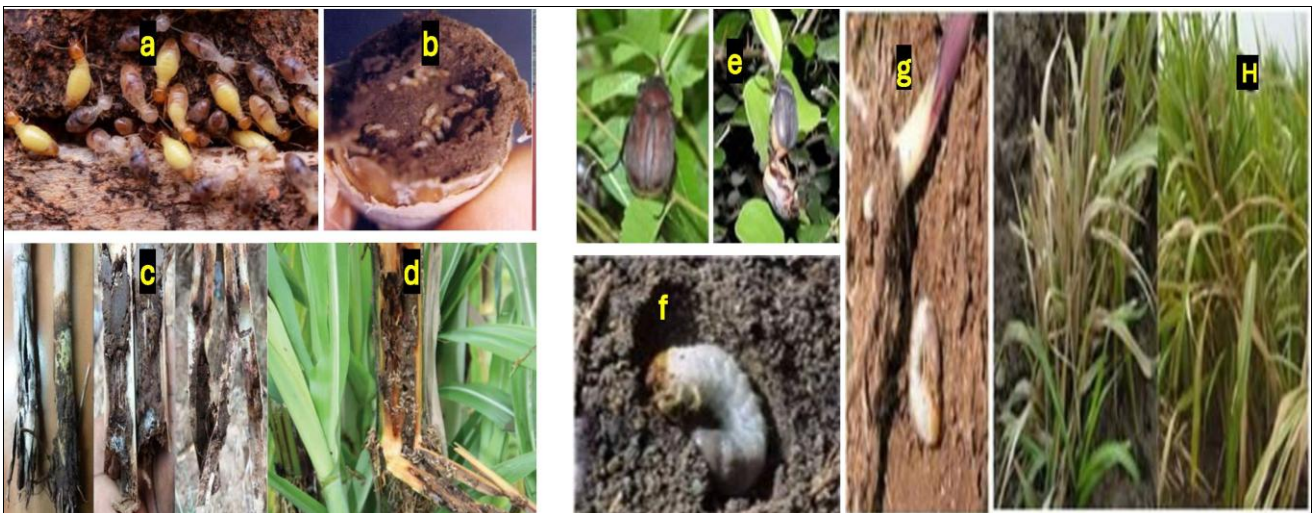
Adult beetles are stoutly built, dull brown in colour with light brown abdomen, measuring about 25 mm in length (Fig.13e). Newly hatched grubs are creamy white with dark brown head in colour. When touched they get curved to from 'C' shape (Fig. 12f). Full grown grub measures 45 to 50 mm. The grubs feed on tender roots (Fig.12g). As a result, affected plants which turn yellowish may die ultimately. The attacked plants can be easily pulled out from the soil. Affected plants exhibit withering and drying, with a single grub killing plants sequentially in one direction along the row (Fig. 12h). Adults emerge from the soil with the onset of the monsoon and feed mainly on foliage of neem, babul, ber. The adults also prefer to feed on mango, guava, fig and pomegranate. During night, eggs are laid in small earthen cells in the soil at depths of 15 to 23 cm. The incubation period is about 8 to 10 days. Grub stage lasts for about 5 to 6 months by feeding on the roots underground. The duration of pupal stage is about 11 days, and a generation is completed in a year. The adult beetles emerged

in November and remain in soil to next June. Adults are long-lived, surviving up to 90 days. It is a polyphagous pest. Grubs feed on roots of sugarcane, maize, sorghum, groundnut, paddy, chilli, cotton, tobacco, potato, pulses etc.

**Management**

- Mass collection and destruction of beetles from the branches of neem, *Acacia*, ber trees immediately after receiving summer showers or spraying with contact insecticides during late evening hours soon after the first monsoon shower reduces infestation.
- Deep ploughing after summer showers would expose the pupae and beetles to hot sun or birds may predate them. Flooding the field for 24 hours kills grub population.
- Crop rotation with paddy reduces grub population.
- Soil application of neem cake @ 500 kg/ha during field preparation, application of carbofuran 3G (33kg/ha) or fipronil 0.3G (25kg/ha) or chlorantraniliprole 0.4G (20kg/ha) in the furrows before planting the sugarcane setts and mix thoroughly in the soil or by pocketing method near sugarcane stubbles.
- Soil drenching with imidacloprid + fipronil (Lasenta 80WDG) at 125-150g/ 400 L of water at planting effectively reduces the white grub incidence.

- Drenching of chlorpyriphos 20 EC at 40 ml/15 litres of water.
- For May-June planting in endemic areas, chlorpyriphos 1.5% dust at 50 kg/ha mixed with farmyard manure or press mud to be ploughed into the soil to target first instar grub.
- Utilisation of fungal pathogens like *Metarhizium anisopliae* @ 5kg/ha or *Beauveria brongniartii* formulated with press mud, lignite or talc to be mixed with FYM or press mud and applied at  $2.5 \times 10^{12}$  spores/ha during June-July followed by irrigation. Repeated application for 4-5 years may be needed Set up light traps to attract and destroy the adults and shake the host tree during night hours and collect and destroy the adult beetles
- Dust quinalphos 5% D at 25 kg/ha or spray chlorpyriphos (2.5 ml/L) or monocrotophos (1.6 ml/L) on the host plants like neem, babul, ber when average number of beetles per tree are 20 or more in the endemic pockets after first summer rains.



**Fig 12:** Termites: (a)Workers (b-c) Infested setts (d) Mud galleries on the infested cane; Root grub: (e) Adults (f) Grub (g) Grub at root zone (h) Drying of infested shoots & canes

**Rodents, *Bandicota bengalensis* Gray (Mammalia: Muridae)**

The rats are not regular pests of sugarcane and occur occasionally. The rats feed on cane tissues in root zones and gnawing of basal internodes (Fig.13a-b) resulting in drying of canes leading to loss in cane weight and juice quality. Rats breed all year round and the gestation period is about three months. The estimated loss in yield was 532kg /ha and in sugar recovery 23 kg/ha. Early season (pre-monsoon season and monsoon) attack is more detrimental since the shoots are completely damaged. While later attack (post monsoon) causes only about 20 per cent reduction in the weight of canes. When the crops are attacked during the crushing period, greater loss in sugar recovery was observed. Rat damaged sugarcane becomes infested with

various microorganisms and other physical stresses, resulting in reduced weight and sugar recovery.

**Management**

- Manual or mechanical removal of weeds on crop field boundaries and

reduction in bund thickness and height.

- Deep tillage and ploughing of vacant land around fields to destroy burrows.
- Wrapping and propping of standing crop and judicious irrigation to minimize damage.
- Ploughing fields between crops, flood irrigation or smoking the burrows by burning cow dung cake or paddy straw drives out bandicoot rats.
- Closing or smoking the burrows a day before treatment helps to locate the active burrows in the field.
- Single dose zinc phosphide (2%) in cereal bait mixture of broken wheat grain, sugar powder and groundnut oil (96:2:2) with pre-baiting for two days.
- A single aluminum phosphide tablet to be dropped into each active burrow, small quantity of water added, and burrow sealed with wet mud.
- The single dose anticoagulant bromadiolone 0.005% bait cakes to be placed near or inside the active burrows.
- Barn owls to be encouraged by placing suitable perches at canopy height in the field.



**Fig 13:** (a) *Bandicota Bengalensis* (b) Gnawing of basal internodes

### Conclusions

The insights presented in this paper provide a foundation for developing effective and eco-safe pest management strategies to enhance sugarcane productivity, profitability, and environmental safety. Development of climate-resilient sugarcane varieties through genetic research and adaptive breeding is essential. Further research on integrated pest and disease management, integrating biological, chemical, and cultural practices, is needed to address challenges posed by changing climates. Adoption of precision agriculture tools such as drones and remote sensing can further improve early detection, monitoring, and targeted management of pest and disease outbreaks.

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