THE BANANA STEM WEEVIL *ODOIPORUS LONGICOLLIS*

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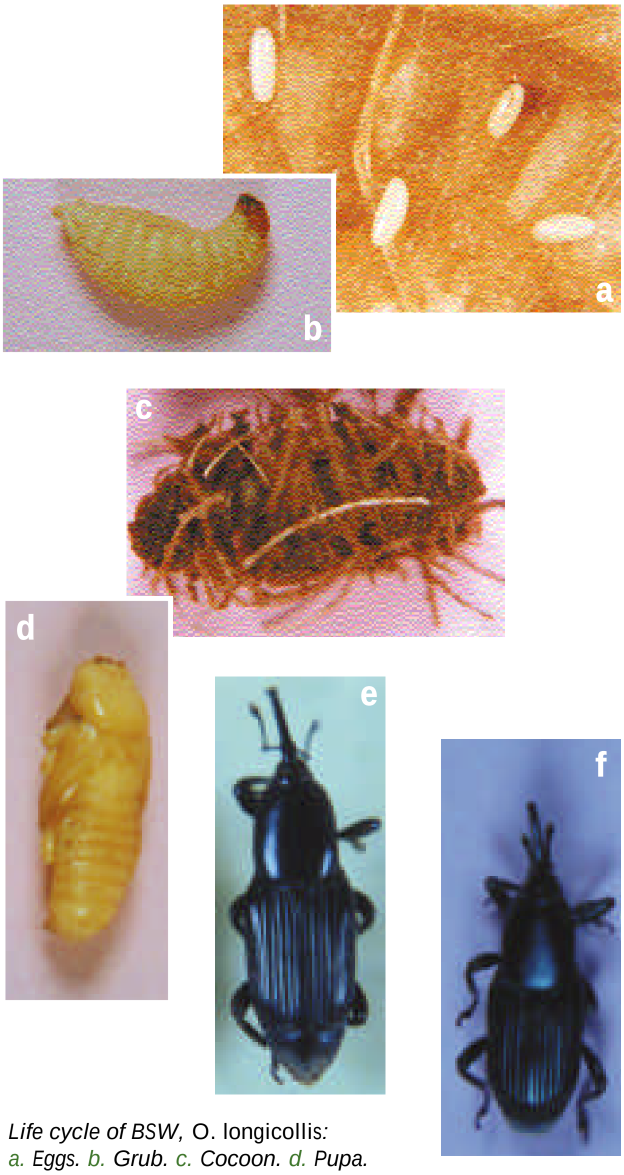

Life cycle of BSW, O. longicollis*:*
a. Eggs. b. Grub. c. Cocoon. d. Pupa.
e. Female. f. Male.

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Biology and life cycle

The banana stem weevil (BSW) or banana pseudostem borer, *Odoiporus longicollis* Oliver (Coleoptera: Curculionidae) is one of the most important pests of bananas and plantains. The adult weevils are black-coloured and measure 23-39 mm. Red-coloured morphs of the BSW are also encountered in certain banana-growing areas of India. Based on mating studies, it has been concluded that the colour difference is not due to sexual dimorphism but is a phenomenon of non-sex limited variation and of sympatry (Dutt and Maiti 1972). The weevils are predominantly nocturnal in habit, although during cloudy days and cooler months they may fly during the daytime. They often confine themselves within the pseudostem and in the decomposing tissues of harvested pseudostems. All life stages of the weevil are present throughout the year in the infested plant. Adults are strong fliers and in this way, move from plant to plant.

The BSW has a long life span and many adults live for a year. The sex ratio of adults encountered in banana gardens is 1:1.17 (male:female) (Dutt and Maiti 1972). The sensory structures present on the rostrum of the weevils provide a key for sex differentiation (Nahif *et al*. 2000). The pre-oviposition period is 15-30 days and the adult weevils mate throughout the day and night. The mean number of eggs laid by a female following a single mating is nine eggs at the rate of one egg per day. Gravid females lay yellowish white, elliptical eggs by inserting the ovipositors through ovipositional slits cut by the rostrum on the outer epidermal layer of the leaf sheath of the pseudostem down to the air chambers. Oviposition takes place only in the leaf sheaths. The number of eggs deposited is considerably reduced as the number of weevils increases, indicating the existence of a spacing pheromone, epideictic compounds which act as a deterrent to conspecific females (Ranjith and Lalitha 2001).

Eggs are cream in colour and cylindrical in shape with rounded ends. Typically, eggs are 3.14 mm in length and 1.1 mm in diameter. The incubation period ranges from 3 to 8 days. The emerging larvae are fleshy, yellowish white and apodous. The larvae feed on tissues of the succulent sheath by tunnelling extensively and may reach as far as the true stem. If larvae emerge during the advanced pre-flowering stage of the plant, the ascending flower bud and the peduncle inside the pseudostem can be eaten and damaged, resulting in non-emergence of the flower bud which decays inside the pseudostem

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(Padmanaban *et al.* 2001). In severely infested plantations, more than 20% plants do not flower due to this reason. The depth of the tunnels made by the larvae range between 8 to 10 cm. The tunnels are widespread and may go as high as the fruit peduncle or to the lowermost collar region near the rhizome. The larvae pass through five instars. The fifth instar larvae enters a non-feeding pre-pupal stage and constructs a cocoon by winding short pieces of fibrous materials of the sheath around its body. The pupa is exarate and present inside the cocoon. The developmental rates are highly dependent on climatic factors with the duration of the life stages longer in the winter season than in the summer. Under laboratory conditions the duration from egg to adult stage is 44 days.

Symptoms

Adult BSW are attracted by the volatiles released by the banana plants. Infestation of the weevil normally starts in 5-month-old plants. Early symptoms of the infestation are the presence of small pinhead-sized holes on the stem, fibrous extrusions from bases of leaf petioles, adult weevils and exudation of a gummy substance from the holes on the pseudostem. During the advanced stages of infestation, the stem, when split open, exhibits extensive tunnelling both in the leaf sheath and in the true stem. Rotting occurs due to secondary infection of pathogens and a foul odour is emitted. When the true stem and peduncle are tunnelled after flowering, the fruits do not develop properly, presenting a dehydrated condition with premature ripening of the bunch itself.

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Banana stem broken near the crown region due to BSW infestation.

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Symptoms of BSW infestation (exudation of gum and tunnelling).

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Adult stem weevil and grub feeding on leaf sheath.

Stem weevil infestation interferes with the translocation of nutrients and water, retards growth and development and increases susceptibility to wind lodging, which is more commonly associated with nematode infestation. Weakening of the stem by larval tunnelling may result in breakage by wind or inability to bear the weight of the maturing bunch. It is estimated that the stem weevil causes 10-90% yield loss depending on the growth stage of the crop and management efficiency. The severity of the loss is greater when infestation occurs at the early vegetative stage (5 months old).

Distribution

The BSW is believed to have originated in South and South East Asia, which is also the centre of origin of the present day bananas and plantains. This insect is found in India, China, Malaysia, Indonesia and Thailand and is a key pest of bananas and plantains, posing a great threat to banana production systems in these countries (Valmayor *et al*. 1994). Pest density may vary from field to field. The weevil prefers plantains and highland bananas, particularly 'Pome' types. Total crop failure will result in farms where the weevils are not managed efficiently. Such crop failures are not uncommon in banana production systems in India.

Control methods

Measures to curb BSW damage vary widely depending upon the type of banana production systems practised. Large plantations resort to regular application of chemical insecticides to control the weevil. Resource-limited marginal farmers cultivating banana as a subsistence crop are unable to undertake chemical pesticide interventions on a regular basis. In this situation, cultural control strategies assume greater significance due to their ease of application and their compatibility with other methods of control. Natural enemies including arthropods, entomopathogenic nematodes and entomopathogens have great potential to reduce the population of the weevils in severely infested gardens. Screening *Musa* germplasm for resistance to BSW has the potential to identify the source of resistance genes that could be used in plant breeding programmes.

Chemical control

Control of BSW is an elusive and complex problem as the life cycle of the pest may be completed within the pseudostem. Application of organochlorine insecticides is no longer carried out due to the possible development of insecticide resistant weevil strains and environmental concerns. Currently stem injection of a systemic organophosphorus compound (e.g. monocrotophos) is extensively used in controlling the pest. As well as stem injection, other insecticide application methods may be used, such as swabbing along with surfactants, swabbing with mud slurry containing the candidate insecticide, spraying and fumigation of the spaces between the leaf sheaths in the pseudostem. Fumigation of banana plants using Celphos (aluminium phosphide tablets), especially during the vegetative phase is phytotoxic and should be discouraged.

Cultural control

Field sanitation is imperative in the control of this pest. Dried old leaves must be removed to allow the detection of early symptoms of weevil infestation and to increase the efficacy of chemical application. Suckers should be pruned periodically and infested pseudostems must be removed from the field and destroyed. Banana stumps kept in the field after harvest must be removed and destroyed as they serve as weevil refuges and breeding sites. Investigations made at the National Research Centre for Banana (NRCB) in India have indicated that traps could be efficiently used to monitor and reduce the adult weevil population. Among the disc-on-stump and longitudinal split pseudostem traps, the disc-on-stump traps with higher exudations of plant fluids have been found to be more effective. However, in general, banana corm weevil outnumbered the BSW in the traps (Padmanaban *et al.*, unpublished). Use of pheromones to trap and destroy weevil populations is under investigation at NRCB.

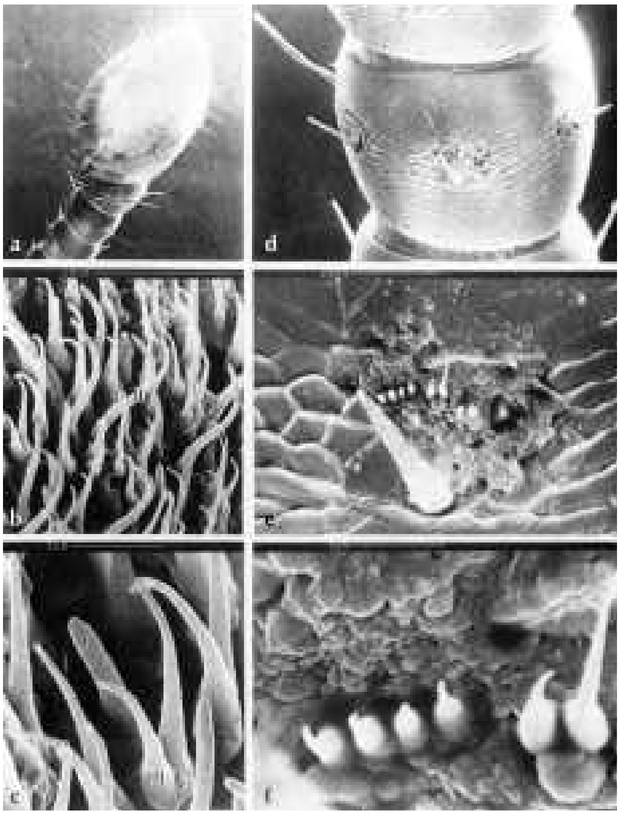
Biological control

Research on biological control of BSW is inadequate and research reports are scanty. Two species of earwigs feeding on larvae and pupae are reported from China. There is a report of an acarid mite parasitizing larvae and adults. Release of an ectoparasitic mite, *Uropodia* sp. on adult BSW had been tried for its control with limited success.

Metarhizium anisopliae, an entomopathogenic fungus, effected more than 90% mortality under laboratory conditions. Fungal pathogens such as *Fusarium solani*, *Mucor heimalis*, *Aspergillus niger* and *Scopulariopsis brevicaulis* have also been isolated from field populations of the BSW. Although these entomopathogenic fungi caused more than 90% mortality in the laboratory, there is a long way to go before they can be used in the field, as the safety of these fungi to non-target organisms is still to be tested and efficient mass production systems and application methods need to be devised. Entomopathogenic nematodes are yet to be isolated from BSW endemic areas.

Host plant resistance

Host plant resistance may offer a long-term solution to the problem. Screening trials and surveys to determine the resistance to BSW need further work although it appears that the pest, with the aid of a host of sensory structures



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Sensory structures: SEM micrographs of antenna of adult O. longicollis.
a. Antennae with hairsensilla. b. Sensilla type II. c. Sensilla type I and sensilla type III with forked structure. d. Antennal segment with sensilla. e. Section of antennal segment with sensilla type I and sensilla type II. f. Sensilla type II: variant with conspicuously swollen base tapering gradually towards the tip, known as "pick & ringel" (magnification).

located on the antennal tip and mouthparts, exhibits a high degree of host plant preference. Resistance to BSW seems to depend on the morphological and anatomical characteristics of the banana leaf sheath along with the interaction of the chemicals present in plant sap, thus suggesting a combination of antixenosis and antibiosis mechanisms. Through field screening of 212 banana accessions of various genomes, Charles *et al.* (1996) identified 27 accessions that exhibited tolerance to the pest. At NRCB, laboratory screening of 119 accessions led to the identification of a high degree of resistance in *Musa balbisiana* clones, such as Bhimkol, Athiakol, Elavazhai and Sawai. In general, plantains are the most preferred host.

Research needs

There are many gaps in the knowledge of the BSW that require further investigation. For example, population dynamics and bionomics of the pest are not well understood and studies on yield loss due to the BSW are incomplete. The effect of different banana production systems on BSW populations must also be studied and economic threshold levels should be estimated for the BSW in these different production systems.

Non-chemical methods of pest control, such as trapping, merit more attention. Similarly, surveys for natural enemies of the pest must be intensified to identify and isolate potential parasites, predators and pathogens. Delivery systems for entomopathogens must also be standardized and field trials must be conducted to identify cost-efficient systems. Semiochemicals such as pheromones and kairomones must be isolated, identified and tested as one of the components of an IPM strategy.

Screening trials currently utilize a number of different methodologies to identify resistant clones. Screening methodologies require further refinement and more attention must be paid to identify resistant and tolerant genotypes, as host plant resistance is the only viable long-term control strategy. The different mechanisms of resistance must be studied in detail in order to gain the necessary knowledge for determining the selection criteria for utilization of resistance sources in breeding strategies, which could thus be made more cost-efficient and less time-consuming.

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