Chapter

Stem Borers of Cereal Crops in Africa and Their Management

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Abstract

The economic importance of the stem borer in Africa results in their severe damage that affect directly cereal yield factors such as the density of fertile tillers and the number of effective panicles. The objective of this paper is to describe and discuss the management options of the main prevalent stem borer of cereal crops in Africa. Host plant resistance, cultural practices, biological control and reasoning chemical control are among the most encouraging options. Integrated pest management combining several compatible methods was highlighted as the most sustainable control option. This paper will served as support for the current research on cereal crops but also as relevant prospect document for entomologists and breeders from across the world.

Keywords: IPM, environment friendly, yield loss, biocontrol, cultural practices

1. Introduction

Stem borers constitute the most widely distributed and injurious group of insect pests of cereal crops. They are commonly known to be one of the limiting factors of cereal production worldwide. They are present in field throughout the crop growing stage from seedling to maturity. The stem borers found on cereal crops in Africa are mainly lepidopterans and dipterans. Cereal crops such as rice, sorghum, maize, sugarcane and pearl millet suffer from the attack of stem borers. The larval stage constitutes the most damaging developmental stage of the pest. They are concealed inside the stem where they feed on the internal cavity of the plant making them very difficult to control. Stem borers cause severe damage on plant stems particularly the destruction of the central leaves (dead-heart) and the drying of the panicle (white head). Their attack leads to significant yield losses. According to [1], the most serious pests of cereal crops in Africa include stem borers. The severity of damage depends not only on the species and density of the pest but also on the phenology stage of the crops. Yield losses of about 10 and 100% due to stem borer have been recorded in rice fields [2].

To control these pests, various strategies have been practiced. These include cultural practices, host plant resistance, habitat management, biocontrol and the use of synthetic pesticides. Each management method has some advantages and limitation regarding its impact on environment, human health and its economic costs and sustainability. Nowadays, the integrated management, combining two or several of these management methods appears to be the most effective and sustainable option.

This chapter comprises two main sections. The first section gives an overview of the main stem borers and their host range in Africa and the second section describes the various management options used to control stem borers and discusses the advantage and limitation of each method while exploring option of combining multiple methods to sustainably mitigate the effect of the stem borer on stakeholder farmers in Africa. This chapter will support the current research on the sustainable management of stem borers attacking cereal crops and will contribute to increase their productivity in Africa.

2. Overview of the main stem borers of cereal crops in Africa

Several stem borers species have been reported to cause severe damage on various cereals crop in Africa.

The maize stalkborer, *Busseola fusca* (Lepidoptera: Noctuidae) is reported to be of economic importance for maize and sorghum [3] while maintaining its population on some alternative hosts. The spotted stem borer, *Chilo partellus* (Lepidoptera: Pyralidae) is considered to be one of the devastating stem borer of sorghum and maize [4, 5] and also makes severe damage on rice in some African countries (Togola, unpublished data). The African striped rice borer, *Chilo zacconius* Bleszynski (Lepidoptera: Pyralidae) is among the major rice stem borer species occurring in the humid forest and savanna zones according to Akinsola [6]. The host range comprises cultivated rice, wild rice, *Oryza longistaminata*, *Panicum* sp., and *Paspalum scrobiculatum* but it has been found also on maize [7]. Other host plants include *Pennisetum* spp., *Rottboellia cochinchinensis* (Loureiro) W.D. Clayton, *Saccharum officinarum* L and *Sorghum arundinaceum* (Desv.) Stapf. [6, 8, 9]. The pink Stem Borer *Sesamia calamistis* (Noctuidae) is generally less important than *Busseola fusca* and *Chilo partellus* as a pest of cereal crops in Africa but may be locally abundant. It attacks sorghum, maize, rice and sugarcane as main host. It can be found also on wheat and pearl millet.as secondary crop host and at less extend on wild grass such as *Pennisetum purpureum, Setaria* sp., *Rottboellia exaltata* and *Cyperus distans as alternative host* [10, 11]. The millet stem borer *Coniesta ignefusalis* Hampson (*Lepidoptera*: *Pyralidae*) is an important pest of pearl millet (*Pennisetum glaucum* (L.) especially in West Africa [12]. The damage caused by *C. ignefusalis* is estimated to 15 and 100% of crop losses annually, depending on location and season [13]. The last generation enters diapause at the beginning of the dry season and stay for 6 months the time the next growing season comes. The sugarcane stem borer *Eldana saccharina* (Pyralidae) is a stem borer of cereal crops in Africa with particular economically importance on sugarcane. In the past *E. saccharina* appeared to be of very little important pest in Africa, except on sugarcane. But it has recently increased in importance on other crops such as maize, and sorghum in several African countries [14]. Also it can attack rice. Its hosts among wild grasses are *Panicum maximum*, *Cyperus papyrus* [15], *Sorghum halepense, S. verticilliflorum and Pennisetum purpureum*. The white rice borer *Maliarpha separatella* Ragonot (Lepidoptera: Pyralidae) is an important stem-borer of rice in West Africa [16]. The larva bores into the stem from the lowest internode where it feeds on the internal tissue preventing the nutrient to rise up until the panicle. The damage caused by this stem borer is said to be unique among rice stem borers because it rarely causes deadhearts or whiteheads [7]. The symptoms of *M. separatella* damage are similar to that of the sheath rot caused by a fungus pathogen *Sarocladium oryzae*. The stem of the infested plant becomes weakened, the panicles incompletely exerted from the flag leaf and the grains incompletely filled with brown coloration. *M. separatella* is more severe in low land, irrigated and floated rice. It also attacks the wild rices *Oryza longistaminata* and *Oryza punctata* [17]. It was also reported on some wild grasses such as *Andropogon tectorum* and *Echinochloa holubii* [18]. The rice yellow stem borer *Scirpophaga spp* (Lepidoptera: Pyralidae) are among the minor rice stem borers in Africa. Several species of *Scirpophaga* exist but the most dominant in Africa is *S. melanoclista* Meyrick [7]. The stalk-eyed fly *Diopsis spp*. (Diptera: Diopsidae) is a serious pest of rice in Africa. The two main species commonly found in rice in Africa are *Diopsis thoracica* Westwood and *Diopsis apicalis* Westwood [7]. Diopsid can be found in all rice ecological zones but preferentially in humid and shady lowland [19–21] and also in irrigated rice fields [7]. Damage from Diopsid larvae is similar to the primary damage made by Lepidopteran larvae resulting to the death of the central leaf of rice plant (deadheart). Feeding by the larvae significantly reduces the tiller density, the effective panicles, the grains weight and the total yield [7] and increases the number of immature panicles. The damage level increases according to *Diopsis* density. In endemic area 60% of the tillers can be infested [22]. Finally the African rice gall midge (AfRGM), *Orseolia oryzivora* Harris and Gagné (Diptera: Cecidomyiidae) is an indigenous dipteran borer of rice that was first reported from southern Sudan in 1947 [23, 24]. The pest is now spread in more than 20 African countries where severe yield losses have been reported. The damage converted the shoot meristem into a gall. The infested plant is no longer able to develop into a floral meristem and then the reproductive potential of the plant is severely compromised [23]. Larval feeding causes severe damage to rice during the vegetative stages (seedling to panicle initiation). Heavy yield losses of 45–80% in farmers' rice crops have been recorded in some fields [25, 26].

A clear knowledge of these stem borer species and their host crop are of key importance for a sustainable management action.

3. Management of the main stem borers of cereal crops in Africa

Because of the nature of the habitat of stem borers (internal shelter), their management requires some specific control measures and actions. Various strategies exist for managing stem borers' population and damage in cereals crops. These include cultural practices, host plant resistance, biocontrol and use of synthetic pesticides.

3.1 Preventive cultural practices

Cultural practices are considered as classic pest control methods. This method consist of manipulating the cropping systems in order (1) to avoid the meeting of crop susceptible stage with pest highest density or (2) to improve the crop growing condition or (3) to make the environment unfavorable for pest proliferation. The cultural practices have the advantage to be easy to implement with less cost. They are more convenient for smallholder farmers in developing countries [27]. Preventives cultural practices comprise a wide range of agronomic practices. These tactics need to be undertaken as first line defense measures to prevent high infestation of stem borers in cereals fields. Among the most effectives cultural practices in controlling stem borers there is cereals intercropping or strip cropping with non-host crops such as cowpea, soybeans and groundnut. Also the choice of appropriate date for planting cereals crops allows the crops to escape to critical period where the pest pressure is high [28]. The sol fertilization and field hygiene are cultural practices that reinforce the plant vigor and increase its defense system. [29, 30] demonstrated that zinc fertilization and potassium fertilization significantly decrease stem borers population in rice and increase paddy yield. Other practice such as destruction of crop residues (burning, plowing or disking) appears to be an effective cultural tactic for limiting the number of diapausing larva of stem borer. [31] demonstrated that plowing and disking crop residues destroyed 24% of the stem borers' population on sorghum and 19% of maize stem borers. Similarly, [32] reported that the destruction of sugarcane residue after harvest significantly reduced the infestation of subsequent crops by *Eldana saccharina*. Burning of crop residues was also reported to be effective against *Chilo* spp. and *Busseola fusca* as well [15]. Burning or composting old stalks before the onset of the rains is effective against *B. fusca* [13]. The management of the maize stalkborer *B. fusca* includes intercropping maize with non-hosts crops like cassava and cowpea or with a repellent plant such as silver leaf desmodium (*Desmodium uncinatum*) [33]. Others cultural practices such as destruction of alternatives host plants or ratoons, synchronized plantings, crop rotations, high cropping density, use of trap crops, good irrigation and good fertilization are good cultural tactics against the insect pests in general and stem borers in particular [27]. The use of trap crops or intercropping upland NERICA rice and maize have also been suggested as an effective method for controlling *M. separatella* in rice ecosystems in Nigeria [26]. Practices such as irrigation, planting density and dates of planting were all found to be effective as well important factors for consideration [17, 34]. According to [24], the management of the African rice gall midge take into account early and synchronized planting as rice fields planted early are less likely suffer serious damage than those planted late. Also destruction of alternative host plants such as rice ratoons, volunteers and *Oryza longistaminata* as well as the use of moderate levels of fertilizer (e.g. 60 kg/ha) prevent the build-up of AfRGM population. The same author highlighted the importance of plant spacing as close spacing provides a suitable micro-environment for the survival of the exposed life stages of AfRGM. Cleaning of the rice field especially the destruction of the wild rice are good cultural practice for managing the African striped rice borer, *C. zacconius*. The 'push-pull' method based on the intercropping of Desmodium with millet was report to effectively act as a repellent that 'pushes' the millet stem borer *C. ignefusalis* away from the millet [35]. The most useful advantage of the cultural practices is that they are compatible to all pest control measures. They represent an important component of the integrated pest management of the stems borers. The main disadvantage of the cultural practices is that they need to be continuous and collective process from field preparation to harvest. A good cultural practices field can get infested if the surrounding farmers do not apply same or no management option.

3.2 Varietal resistance

Plant resistance is the genetically inherited qualities that confer the plant ability to ward off or withstand pest attacks or recover from injury due to a pest [36, 37]. This method is the most farmer-friendly pest control option that can significantly reduce stem borer damage when supplemented with other options such as cultural or biological measures. It is most attractive as the use of insecticides is largely beyond the means of the small farmer. Considerable progress has been made in screening and breeding for host plant resistance to cereals' stem borers but only limited number of varieties have shown good level of resistance. Wiseman [38] showed that the resistant cultivar should be the base from which integrated pest management strategies arise. Rana *et al*. [39] reported that antibiotic property in sorghum plays more role in plant resistance to stem borer than ovipositional non-preference. Some plant biophysical characters such as stem hardness, leaf hairiness are important in plant resistance to stem borers. Sorghum varieties having these traits are rejected by the moths for oviposition. Pearl millet varieties such as Zongo was reported to be moderately resistant to *Coniesta ignefusalis* [40]. According to [41], hairiness of leaves and leaf sheaths were partly responsible for the differences in genotypic vulnerability to *C. ignefusalis*. Also they reported that plants with trichomes were not preferred by this pest for oviposition. [42] reported good level of resistance in the sweet sorghums BR 501, BR 504, and BR 505 to the sugarcane borer *Eldana saccharina*. [20], found good source of resistance to diopsids among upland NERCA varieties. Also, they reported that rice varieties having ability to produce new tillers to compensate the infested stems can tolerate the damage by diopsid. So far no improved rice variety was identified to be resistant to *O. oryzivora* attack but some tolerance was noted *in Oryza glaberrima* and also in some improved released rice varieties in Nigeria such as Cisadane and FARO 51 [24]. Despite limited achievement on varietal resistance to stem borer, this option remain a promising IPM component. Recent advances in biotechnology can increase the prospects of generating resistance materials and accelerate the transfer of gene for improving new genotypes.

3.3 Biological control measures

Biological control is the manipulation of natural enemies with the aim to maintain pest population below the economic injury level (EIL). Several organisms such as insects, fungus, virus and bacteria can be used as biocontrol agents [13, 43]. Insects based organisms acting as natural enemies are either predators (using the host as food) or parasitoids (laying their eggs in the host). Most of these insects belong to hymenoptera or diptera orders [27]. Biocontrol appears to be one of the most effective and environment friendly management option of stem borers. Indeed, stem borer's population and damage can be regulated by sustaining the action of natural enemies. This can be done through a good habitat management to favor the buildup of the population of natural enemies (spiders, wasps, ladybirds, etc.) or through mass rearing and field release of specific parasitoids to control target pest species. The success of the release of several parasitoids was reported in managing cereals stem borers in Africa. Two natural enemies of the maize stalkborer (*B. fusca*) are the larval parasitoids *Cotesia sesamiae* and *Bracon sesamiae* [31, 44]. Parasitoids such as *Tetrastichus atriclavus, Apanteles sesamiae,* and *Pediobius furvus* have been reported by [13] to be most important parasites of *B. fusca.* Similarly *Cotesia flavipes* and *Xanthopimpla stemmator* was reported to effectively control the spotted stem borer *C. partellus* [4]. The parasitoids *Cotesia sesamiae, Xanthopimpla stemmator, Trichogramma spp, etc. are cited as good biocontrol agent against the* pink Stem Borer *Sesamia calamistis* (Togola, unpublished data). The biological control of the cereal stem borers is mainly based on habitat management to sustain natural enemies including various parasitoids wasp. [45] found that that the contribution of egg parasitism is more important in controlling lepidopteran stem borers than parasitism of larvae and pupae. The African rice gall midge (AfRGM) is attacked by two parasitoids such as *Platygaster diplosisae* (Hymenoptera: Platygastridae) and *Aprostocetus procerae* (Hymenoptera: Eulophidae) that can decrease the population of the pest below the economic injury threshold in rice-production systems [25]. Several insects species such as *Cyrtorhinus viridis* (Heteroptera: Miridae), *Conocephalus longipennis* (Orthoptera: Tettigoniidae) and *Anaxipha longipennis* (Orthoptera: Gryllidae) are predators of AfRGM [24]. The effectiveness and sustainability of the biological control methods depends on the availability of the biocontrol agent at suitable density. Practices such as habitat management or avoiding the use of wide spectrum chemicals can contribute to increase the carry-over of population of natural enemies and maintain the pest population below a critical level. The main constraints of the biocontrol measures are the difficulty to find the specific biocontrol agents for targeted pest species, the complexity of the mass rearing and the complication to be explained by extension workers and to be implemented by farmers.

3.4 Chemical control

Chemical control, despite all the danger and environmental hazard, remains an important option to consider in situation where the pest population is already established. Also it can be used as IPM component to supplement varietal resistance or cultural practices. Chemical control can be achieved by applications of granules or dusts to the leaf whorl early in crop growth to kill early larval instars of *E. saccharina* [10]. Controlling *M separatella* using chemical insecticides is effective but not widely practiced because of the high costs involved [46]. As for *O. oryzivora*, chemical control can be envisaged in conditions of high infestation of rice field. In all cases, choice of selective systemic insecticides is needed to avoid adverse effects on non-target organisms and biodiversity.

3.5 Integrated pest management option

The individual control methods discussed above have their limitations and none often is sufficient to adequately control stem borer outbreaks. Hence, the integrated pest management (IPM), also known as integrated pest control (IPC) appears to be the most appropriate option for managing these pests. IPM requires the combination of several compatible and complementary practices with the aim to maintain pest populations below the economic injury level (EIL) while reducing the use of high hazardous pesticides and sustaining the action of natural enemies. Several studies have reported the success of IPM in the management of cereals' stem borers. [25] reported that varietal resistance/tolerance, cultural practices and biological control are important components of integrated management of rice stem borers. Similarly [24] found that the effective control of the African Rice Gall Midge relies on the combination of cultural practices, habitat management and moderate use of insecticide chemical. Kega [47] demonstrated that the use of resistant rice cultivars and entomopathogenic nematodes is a viable method to control *M. separatella.* Nwanze and Mueller [48] indicated that host plant resistance and cultural practices should be major components in the integrated management of sorghum stem borers. According to [49] an increase of yield can be obtained when sorghum varieties with tolerance or moderate resistance to stem borer are coupled with need-based application of pesticides. Youm et al. [41] suggested options such as early planting, destruction of crop residues and use pheromone bait traps for successful management of the millet stem borer *C. ignefusalis*. According to the conclusion from an international workshop organized by the International Institute for Semi-Arid Tropics, cultural methods and host plant resistance should be considered as the major components of the integrated management of cereals' stem borers [50]. However these practices need to be reinforced with other measures such as biological control and if necessary the use of selective systemic chemical . It is important to quote that integrated stem borer management is likely to be severely constrained by the limited capability of farmers to implement several options . For this reason it is highly important that the IPM takes into account the community farming systems and know-how.

4. Conclusion

The stem borers represent a group of insects of economic importance to cereal crops in Africa. Because of the nature of their attacks and the complexity of their biology, the success of the management options will depends on the integration of various strategies ranging from cultural practices to host plant resistance, biological control and moderate use of systemic chemical when necessary. The cultural practices and host plant resistance remains the major component of the IPM of cereal's stem borers. They can be reinforced by the biological and chemical control. The cultural practices involve farmers' engagement and cooperation. As for varietal resistance, more research action is needed to identify or develop varieties that tolerate the stem borers attack. Regarding the deployment of chemical and biocontrol options, more intensive action from extension service is need to increase the capacity of farmers so that they can engage appropriate action to limit yield losses in cereal and increase their incomes.

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