CHAPTER 06

Low-Cost Agronomic Practices and Landscape Management Approaches to Control FAW

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1. Introduction

In addition to host plant resistance, biological control, and judicious application of chemical pesticides, a number of low-cost cultural practices and landscape management options can be implemented as part of an effective Integrated Pest Management (IPM) strategy against Fall Armyworm (FAW). Such approaches can be particularly relevant to smallholders who lack financial resources to purchase improved seed, pesticides, or other relatively expensive agricultural inputs (Wyckhuys and O'Neil 2010; Stevenson *et al*. 2012).

While there is a range of experience applying cultural and landscape management practices to control other pests in Africa (Martin *et al*. 2016;, Pumariño *et al.* 2015;, Stevenson *et al*. 2012), there is still considerable uncertainty about how effective such approaches will be against FAW, and these knowledge gaps require additional research. Many of the measures recommended in this chapter therefore represent general agroecological best practices for pest control – though where indicated, emerging evidence suggests efficacy against FAW in Africa, particularly for the "Push-Pull" intercropping approaches.

This chapter will focus on cultural and landscape management practices suitable for maize-based farming systems common in most parts of sub-Saharan Africa, with additional reference to agroforestry interventions.

1.1. Principles of Agroecological Control

Agroecological approaches apply knowledge about the complex interactions between organisms and their environment to suggest management options that reduce the frequency and intensity of pest infestation and minimize the damage inflicted by pests on crops. In the context of FAW control in Africa, such approaches typically focus on farmers' cultural practices or landscape management options that achieve the following:

Improve plant health to better withstand pest attack. Increasing plant health, for example through improved soil management and crop nutrition, can ensure that plants develop well before pest damage significantly affects yield-defining components (*e.g.*, leaf area). Healthy plants can also invest more in defense (Chapin 1991), thereby increasing the likelihood of escaping serious damage.

Figure 1. Diverse landscapes provide shelter and perches for preying birds, parasites, and predators that can potentially mitigate the damage by FAW (Source: Frédéric Baudron, CIMMYT).

Optimize timing of crop planting and rotations to escape pest pressure. Manipulating the timing of host plant development relative to pest presence (*e.g.*, early planting, crop rotations). Such approaches work by creating asynchrony between the pest and critical crop growth stages.

Create sustainable local ecosystems that are inhospitable to the pest and attractive to its predators and parasitoids. Intercropping or crop rotations with crops that are not preferred by the pest can help repel FAW. Some intercrops, particularly those producing natural insecticides (*e.g., Tephrosia*) or repugnant semiochemicals (*e.g., Desmodium*), repel the adult female moths, reducing the number of eggs laid on host plants. Conversely, creation of sustainable ecosystems (*e.g.*, through surface crop residue retention) that attract and conserve natural enemies of FAW, including generalist predators (*e.g.*, spiders, ants, or birds) and parasitoids, can contribute to enhanced pest predation and parasitism

that controls FAW populations. In particular, increasing habitat diversity at the landscape scale (*e.g.*, through the preservation or cultivation of patches of natural vegetation, tree cover, or hedgerows) can increase the abundance of insectivorous birds and bats. The effect of these voracious and highly mobile pest predators depends on the availability of suitable habitat within the field (*e.g.,* suitable perches or roost sites) and across the broader landscape (Figure 1).

The benefits of cultural and landscape management approaches often arise from the interplay of ecological factors across a range of spatial scales – from plot to field to farm to landscape – that disrupt and control the pest at multiple stages throughout its life cycle (Veres *et al.* 2013; Martin *et al.* 2016) (Figure 2). For example, cultural practices such as intercropping, companion cropping, conservation agriculture, and agroforestry may simultaneously improve the health of the crop, provide shelter and alternative food sources for natural enemies, and reduce the ability of FAW larvae to move between host plants.

Cultural and ecological management options are highly compatible with host plant resistance and biological control approaches. Indeed, laboratory experiments have demonstrated that evolution of insect resistance to pest-control measures can be delayed or prevented in the presence of natural enemies (Liu *et al.* 2014). However, indiscriminate spraying of toxic pesticides often adversely affects these natural enemies, reducing benefits from biocontrol (Meagher *et al*. 2016) and potentially increasing the population of secondary pests (Tscharntke *et al*. 2016).

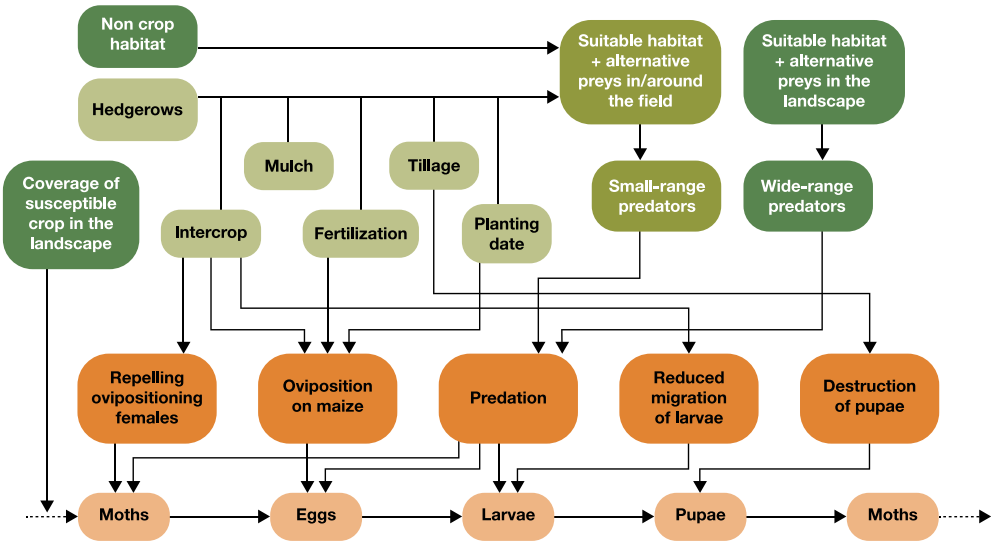

Figure 2. Cultural and landscape management approaches implemented at various spatial scales interact to help control FAW throughout the pest's life cycle. (Source: Frédéric Baudron, CIMMYT).

1.2. Cultural Practices and Landscape Management Approaches in an African Smallholder Context

Although agroecological concepts broadly inform any IPM approach to pest management, they can be particularly relevant in the design and implementation of low-cost management approaches for smallholder farmers in particular, because such farmers may not have access or financial capital to purchase pesticides, improved seed, or other relatively costly inputs on which the chemical-control or host-plant-resistance elements of an IPM approach are typically based. Because most of these cultural and landscape management practices rely on labor rather than financial capital, they may be more accessible for smallholders.

At the plot, field, and farm scale, cultural interventions are typically implemented by smallholder farmers, ideally with guidance from extensionists, development implementing partners, or other knowledgeable experts. Although individual farmers and practitioners may also implement landscape-level interventions, landscape-scale approaches typically also require involvement of communities, governments, or other organizing bodies to coordinate action across a sufficient scale to achieve impact on pest populations.

2. Cultural and Landscape Management Options

2.1. Recommended Practices to Control FAW

Based on a review of available evidence, the following low-cost cultural practices and landscape management options are currently recommended for control of FAW. With the exception of the "Push-Pull" approach, for which experimental evidence exists to suggest efficacy against FAW in an African context (Section 2.1.1), many of these measures represent generic best crop and landscape management practices for pest control, and have not been specifically validated for FAW in Africa (Section 2.1.2). It is also worth noting that, while these approaches are highlighted due to their low financial cost, in many cases they may require a substantial investment of labor to implement, and are therefore not completely without cost.

2.1.1. "Push-Pull" Companion Cropping

In the "Push-Pull" companion cropping strategy, farmers protect cereal crops from pest damage by intercropping them with pest-repellent ("push") plant species (*e.g., Desmodium* spp.), surrounded by a border pest-attractive trap ("pull") plant species [usually grasses such as napier grass (*Pennisetum purpureum* Schumach.) or *Brachiaria* spp.] (Table 1). In one recent study conducted across East Africa, farmers who fully implemented the Push-Pull approach reduced FAW infestation and crop damage by up to 86%, with a 2.7-fold increase in yield relative to neighboring fields that did not implement the approach (Midega *et al.* 2018) (Figure 3). Though implementing Push-Pull requires initial financial costs to establish the companion plants, costs gradually reduce in subsequent seasons. Furthermore, beyond controlling FAW and other stemborer pests, Push-Pull has also been reported to reduce *Striga* infestation, increase nitrogen and soil humidity, and most importantly, provide a suitable environment for the proliferation of predators and parasitoids of FAW (Khan *et al*. 2010). However, achieving the benefits of the Push-Pull approach depends heavily on proper establishment and management of the companion plants, and is therefore highly knowledge and labor intensive.

Extension materials including videos, radio storylines, brochures, and farmer training materials have been developed in multiple languages to support dissemination of the Push-Pull approach, and are available at www.push-pull.net.

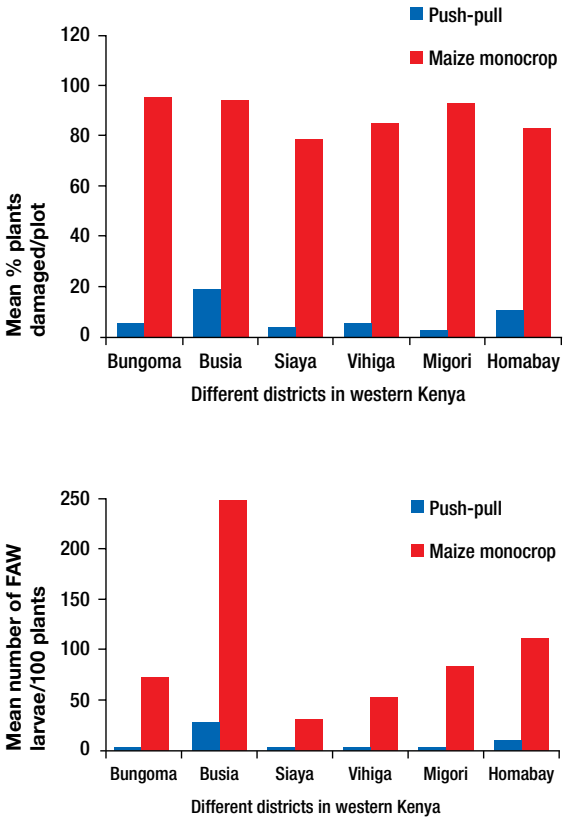

Figure 3. Effect of Push-Pull technology on FAW. (Source: Midega *et al.* 2018)

2.1.2. General Best Practices for Cultural Control and Landscape Management

In addition to the Push-Pull companion cropping strategy cited above, a number of other cultural and landscape management practices have demonstrated some degree of success in managing insect pest populations in various agricultural systems. Ongoing and future research will be necessary to determine the specific efficacy of these approaches against FAW within the African context, and thus provide clearer guidance regarding the relative benefit of smallholders' investment of money and/or labor to implement these approaches. However, current evidence is adequate to recommend them as general best practices (Table 1).

In some cases these approaches may be undertaken directly by individual smallholders, ideally with technical guidance from extensionists, agro-dealers, or other experts. In other cases – particularly for landscape-scale interventions – the approaches suggested here require coordinated action at the village or community level, or even by policymakers, in order to achieve sufficient scale to impact pest populations.

Table 1. Recommended cultural and landscape management options for control of FAW in Africa.

Method	Description	Effectiveness	Financial cost	Relevant actors	Scientific evidence and further information
Planting at the recommended/ optimal time	Do not delay planting. Take advantage of planting with the first effective rains, as FAW populations build up later in the crop season.	Evidence from research with other maize stem borers shows that early/timely planting has higher chances of escaping pest infestation, compared to delayed planting.	Low	Extensionists, farmers	Gebre-Amlak *et al.* (1989); Van den Berg and Van Rensburg (1991)
Plant nutrition	Adequate nutrient supply through mineral fertilizer, use of fertilizer trees and nitrogen-fixing legume crops, organic manures, or compost support healthy plant growth.	Good fertilization reduces plant damage by increasing plant health and defenses against pests, but damage may increase with excessive nitrogen application.	Medium: if additional input purchase is required	Extensionists, farmers, agro-dealers	Altieri and Nicholls (2003); Morales *et al.* (2001); Rossi *et al.* (1987)
Intercropping with compatible companion crops or fertilizer trees	Plant additional crops in strips, rows, or stations between the main crop (e.g., pigeonpea, cassava, sweet potatoes, cowpea, beans, pumpkins, or fertilizer trees [*e.g.*, *Tephrosia, Gliricidia,* or *Faidherbia albida*]) (Figure 4).	Likely to be more effective either when non-host plants are used (e.g., cassava or fertilizer trees) or when crop diversity may interrupt egg laying, and can increase the diversity of beneficial organisms including natural enemies of the pest. For example, *Tephrosia* is a source of natural insecticides and may reduce egg laying.	Low: often a traditional practice.	Extensionists, farmers, plant nurseries	Pichersky and Gershenzon (2002); Landis *et al.* (2000); Coolman and Hoyt (1993)
Conservation agriculture (CA)	Combined use of no-tillage, residue retention, and rotation increases and diversifies biological activity of macro-(spider, beetles, ants), meso-(fungi), and microfauna (bacteria). These practices also lead to improvement of soil health, which contributes to more vigorous growth of the crop.	Effective, if all principles of CA are applied and continued for some time. Unlike other pests, FAW cannot be controlled by burning of crop residues. **Note:** CA can reduce plant access to nitrogen if this is limiting, which might reduce the health and vigor of plants and increase pest attack rates. This can be avoided by addition of fertilizer or by intercropping with fertilizer trees (e.g., CA with agroforestry).	Medium: some specific tools and inputs may be required for establishing effective CA systems.	Extensionists, farmers, agro-dealers	All (1988); Tillman *et al.* (2004); Rivers *et al.* (2016)

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Table 1. Recommended cultural and landscape management options for control of FAW in Africa.

Method	Description	Effectiveness	Financial cost	Relevant actors	Scientific evidence and further information
Increased groundcover	Cover crops like mucuna, lablab beans, jack bean, sunnhemp, etc., contribute to plant species diversity that enhances biological activities and provides shelter for natural enemies (spiders, beetles, ants).	Use of a range of cover crops can be effective as trap crops, as repellent crops that interrupt egg laying and larval development, and as shelter for natural enemies.	Medium: availability of seed and suitability of the cover crops.	Extensionists, farmers, communities, policymakers (landscape scale)	Altieri *et al.* (2012); Bugg *et al.* (1991); Hoballah *et al.* (2004); Ratnadass *et al.* (2011); Meagher *et al.* (2004); Wyckhuys and O'Neil (2007)
Hedgerows and live fences	Complex cropping systems influence interactions of biota and increase effectiveness of parasitoids. Provides extra-field diversity and habitats for natural enemies to proliferate and contribute to control of the pest (birds, spiders, ants) Planting of live fences or hedgerows, maintenance of uncultivated areas, reduced weeding in part or all of the crop, planting of other crops or fruit trees in neighboring fields.	Fields close to hedgerows are usually less infested with pest due to biological control agents (birds) activities.	Medium to high: extra land may be required for establishing hedgerows.	Extensionists, farmers, communities (landscape scale)	Veres *et al.* (2013); Landis *et al.* (2000); Martin *et al.* (2016); Marino and Landis (1996); Wyckhuys and O'Neil (2007)
Enhance agroforestry systems at landscape level	Plant trees/shrubs between maize especially neem, *Tephrosia, Gliricidia, Faidherbia albida*, etc., to enhance diversity for natural enemies (beneficial insects and birds).	Long-term intervention to create biodiversity and biological pest control – can be very effective once trees are established.	Medium: land needs to be shared with main crops.	Extensionists, farmers, policymakers, communities (landscape scale)	Wyckhuys and O'Neil (2006); Wyckhuys and O'Neil (2007); Hay-Roe *et al.* (2016); Ratnadass *et. al.* (2011)

Note: Table adapted from CABI Evidence Note (2017).

Figure 4. Potential intercropping options for mitigating FAW damage. (Source: Christian Thierfelder, CIMMYT).

2.2. Practices that Need Further Research Evidence

The following practices need further research evidence before they can be widely recommended for management of FAW in Africa, especially in the smallholder context:

- **Application of sugar water to maize foliage.** Though in some cases this practice has been recommended, efficacy, practicality at scale, and cost have to be established.
- **Placement of ash/sand/soil/chili powder in maize whorls.** Though all of these practices are being tried by some smallholders in Africa, additional research evidence is required on the efficacy and scalability, as well as the mechanism behind their possible effect on FAW.
- **Deep tillage.** Tillage can kill pupae in the soil. However, soils are normally tilled before FAW arrives in a field; tilling may therefore cause more harm than good, by reducing biological activity and increasing soil degradation while contributing relatively little to FAW control due to asynchronous timing of the intervention with the pest population cycle. Its effect is therefore inconclusive and should be investigated further.