Invasion of the Fall Armyworm

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Fall armyworm (*Spodoptera frugiperda*) is a common pest in the Western Hemisphere affecting many commercial crops, most importantly maize. This voracious Lepidoptera (grouping of insects that includes butterflies and moths) was first detected in Central and Western Africa in 2016 and has quickly spread throughout the continent. Fall armyworms thrive in tropical and sub-tropical climates but also spread to colder areas after overwintering in areas without severe freezes. Adult moths spread quickly via strong winds (Capinera 2005).

Figure 5. Fall armyworm larva. *Source: Russ Ottens, University of Georgia, Bugwood.org Creative Commons Attribution License*

Thousands of hectares of cropland have been affected in Togo, Nigeria, Ghana, Malawi, Zambia, Namibia, Mozambique, Uganda, Zimbabwe, and Western Kenya and Tanzania (Organic Farmer 2017 (http://www.theorganicfarmer.org/Articles/how-control-fall-armyworms-using-organic-methods)). Field corn and sweet corn account for most of the economically significant losses, but sorghum, cotton, millet, peanut, rice, soybean, sugarcane, and wheat are susceptible, thus affecting both incomes and food security. The situation is so dire for smallholder farmers in Malawi that President Mutharika declared a state of disaster (https://malawi24.com/2017/12/17/malawi-declared-state-national-disaster-due-armyworm/) and mobilized government agencies to assist farmers and subsidize pesticides. Crops in Malawi most affected are maize, sorghum, and millet (Mumbere and Mtuwa 2017).

As adult moths disperse, females lay eggs on crop foliage. The eggs hatch in only two or three days. The larvae burrow into foliage (especially buds and new growth), corn silks and ears, and stalks (Figure 7). Larvae feed for approximately 14 days, drop to the ground, burrow 2-8 cm into the soil, then start their pupal stage. The adult moth emerges after 8 or 9 days, thus starting the cycle again. This short life cycle (25 days total) allows for several generations per crop cycle, leading to immense damage throughout the growing season (Capinera 2005).

Figure 6. Fall armyworm adult (moth). *Source: Lyle Buss, University of Florida, Bugwood.org Creative Commons Attribution License*

Fall armyworms resemble other species of armyworms and corn earworm (*Helicoverpa zea*), but are distinguishable by coloration and markings. The moths have a 30-40 mm wingspan and are dark grey with mottled spots on the wings (Figure 6) (Organic Farmer 2017). Mature larvae can vary in color from tan to green to black, but have three white or yellow hairlines running down the back with darker stripes on the sides (see Figure 5). They are not rough to the touch, lacking the small spines of corn earworms. The pupae hide in the soil in a 20-30 mm cocoon (Capinera 2005).

Figure 7. Fall armyworm in maize. *Source: Charles Bonaventure*

Synthetic insecticides are most commonly used for fall armyworm management in large-scale mono-crops in the US, including organophosphates and carbamates. Due to multiple generations and continuous crop damage, spraying schedules tend to be long and expensive. Over the years, fall armyworms have also shown resistance to some of these insecticides. This growing resistance and the health risks to humans, non-target insects, and animal populations led to the development of several organic and biological controls (Yu 1991, Capinera 2005).

Neem-based pesticides and pyrethrum are natural chemical options (Organic Farmer 2017). Applications of the bacteria *Bacillus thuringiensis* (Bt), the fungi *Beauveria bassiana*, and various Baculoviruses impair feeding or reproductive functions of larvae (FAO

2018). Parasitic wasps and flies can be released into fields to interrupt the life cycle. Naturally occurring predators include beetles, earwigs, soldier bugs, and many bird species; to promote natural predators, avoid spraying wide spectrum insecticides that can negatively affect them (Capinera 2005).

From the Frontlines

Dan McGrath is an independent consulting entomologist, and a retired professor from Oregon State University. Over the past couple of years, he has worked for several organizations including USAID. He told us, “Since 2016, my focus has been on fall armyworm in Africa. I happened to be in West Africa shortly after the fall armyworm landed on the continent (and blew up). As the insect has spread throughout Africa (about 40 countries), I have moved along with it, sharing what we learned during the earlier stages of the outbreak.”

Dan shared some information about fall armyworm (FAW) in an e-mail list. Excerpts are below, shared with his permission:

“My primary focus is the introduction of two concepts, 1) the untreated control, and 2) the power of replication. The challenge of fall armyworm is that it is complex. Foliar damage is dramatic, but depending on the timing, it may or may not result in significant yield loss. A well-timed tropical rainstorm kills small worms and can clean up a problem. As a result of the complexity of the insect/maize interaction, a lot of false positive results are spread among the small-holder farmers. Part of the NGO community is so dedicated to low-input, organic agriculture that they run with these false positives and encourage smallholder farmers to spend thousands of hours on control methods that may not be worth their time.

“We are setting farmers up with pheromone traps and instructing them on how to assess risk of crop damage (field scouting) and coupling these activities with simple paired comparisons replicated across several farms. In other words, they take four sticks and some string and cordon off an area where they do not apply the soapy water, where they do not pluck worms by hand, and compare the yield at the end of the season.

“I recommend that you take a hard look at the push-pull planting systems, originally designed for maize stalk borer. Organic activists insist the same system works with fall armyworm. This needs more rigorous testing. It may be a good approach for smallholders, but we need to be sure that it is worth the labor and the costs. Just because smallholders do not deal in "cash" for their inputs, does not mean that their labor is without value.

“We have some lab results for botanicals that need field testing [Neem, *Azadirachta indica*, was one of the most effective in the lab]. There are certified organic materials that work, including *Bacillus thuringiensis*. Multiple applications are required.

“First message: Don't panic. We are in the middle of a plague. All plagues come to an end. Plagues result when insect pest populations first arrive, following a series of weather events, and ahead of the diseases and natural enemies that would normally regulate their populations.

“West Africa is entering into its third year of the FAW plague. There are signs and growing evidence that the plague is beginning to subside. The insect diseases and natural enemies of the African armyworm (*Spodoptera exempta*) are beginning to switch over onto the recently arrived fall armyworm.

"In East Africa, they are entering into the second year of the plague. Generally, the second year is the worst. The FAW population has become established, but the regulation of the population has just gotten started. In time, FAW will settle down. When it does, there will be high pressure years and low pressure years, just like the African armyworm. Tell the growers that in time, things will settle down."

A promising control strategy for fall armyworm and several other pests is a push-pull intercropping technique in which crops that naturally repulse or discourage pests are intermixed with the main crop, while a crop attractive to pests is planted outside the crop field. An effective push-pull companion cropping system for maize uses *Desmodium intortum*, commonly named greenleaf desmodium, planted in the corn rows as a short, climbing legume (Figure 8). Like other legumes, desmodium plants fix nitrogen with the help of bacteria in their roots (which may improve maize yields). Desmodium can be used for forage and fodder, along with maize stalk crop residues after harvest. *Desmodium intortum* emits a chemical that repels several caterpillar species, including fall armyworm (Midega *et al*. 2010, 2018).

The "pull" part of the strategy utilizes fodder grass species, often vetiver (*Chrysopogon zizanioides*) or *Brachiaria* spp., as a border crop around the maize field to attract the adult moths. The moths lay eggs on the trap crop, but the larvae's survival rate is low on vetiver grass (Berg *et al.* 2003), resulting in decreased populations. This strategy has been found to reduce larvae by over 80% per maize plant, and to increase maize grain production up to 2.7 times the production of mono-cropped maize (Midega *et al.* 2018).

Figure 8. *Desmodium intortum* intercropped with maize. *Source: Holly Sobetski*

Improved maize harvest is only partially attributable to decreased fall armyworm damage and reduced populations of other caterpillar species. The push-pull system also reduces striga (*Striga hermonthica*) weed infestation, and improves soil health through nitrogen fixation, increased soil organic matter, and erosion control. Desmodium seems to exude an allelopathic chemical that weakens striga (Khan *et al.* 2002, Midega *et al.* 2010).

Additional costs and challenges must also be considered. Total labor costs are higher in the intercropped push-pull system due to additional planting and weeding time, and seed cost and lack of seed availability can exclude some farmers. However, total revenue may exceed the initial investment, especially when the benefit of increased livestock forage is considered. Subsidies and extension services need to be inclusive so that farmers of all incomes and farm sizes are given appropriate, in-context training and resources (Midega *et al.* 2010).

The challenges facing farm families threatened by crop losses from fall armyworm and multiple other pests are escalating across Africa. FAO offers a mobile app called the *Fall Armyworm Monitoring and Early Warning system (http://aptantech.com/2018/03/to-control-an-armyworm-destroying-maize-in-africas-farms-fao-unveils-mobile-app/)* to identify, report the level of infestation, and map the spread of this destructive insect, as well as to describe its natural enemies and the measures that are most effective in managing it." ECHO resources on Integrated Pest Management can be found here (http://edn.link/6fxy42).

An excellent worksheet on fall armyworm identification and scouting protocols (http://edn.link/faw) can also be found at ECHOcommunity. This worksheet was created by Neil Rowe-Miller and Putso Nyathi with Mennonite Central Committee (http://edn.link/faw), through their partnership with Canadian Foodgrains Bank (https://foodgrainsbank.ca/) promoting conservation agriculture in East and Southern Africa.

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