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The Fall Armyworm Threatens Zimbabwe's Food Security

Since the beginning of recorded human history, most civilizations have controlled pest populations to protect the integrity of their agriculture. Such widespread practices continue today and while pests do not pose imminent danger to the food security of developed countries, they present a grave threat to the food security of developing countries. Zimbabwe, a landlocked developing country located in southern Africa, relies heavily on agriculture for trade and to feed its population. A recently discovered pest, the Fall Armyworm (FAW) has caused devastation to Zimbabwe's largest crops and, if left unchecked, endangers its food security. As Martin Kropff, director general at the Center of International Maize and Wheat Improvement Center (CIMMYT) explains, "The potential impact of the fall armyworm as a major food security and economic risk for African nations cannot be overstated" (CIMMYT, 2018, para. 8).

Zimbabwe gained independence in 1980. Its current population is 16,846,595 and the majority of inhabitants live in rural areas. Over two-thirds of Zimbabwe's population lives in poverty (Borgen, 2018). A typical rural household consists of a husband, wife, children and extended family members. The life expectancy is only 59 years (Borgen, 2018). Most homes are composed of mud and sun-dried bricks with thatched roofing. Men will often leave their village to find work, which results in over two-thirds of rural dwellings headed by women who will cook, care for the home, and often work locally for extra income (Skweyiya, 2016).

Living conditions for most families pose multiple challenges. Most rural families do not have tap water and half of the rural population does not have access to clean water or toilets. Families often do not have reliable access to electricity. Most of the roads in rural areas are unpaved. The education system is unreliable and many schools have closed as a result of widespread poverty. Children are often put to work at a young age. Zimbabwe has no national health care system and 90% of the population has no access to health aid. The average monthly wage is $253, with only 10-20% of Zimbabwe's population having formal work (Everyculture, 2018).

In rural areas of Zimbabwe, communities will often be supported by locally produced agriculture (Skweyiva, 2016). The principal food source for a typical family is maize. Maize is often ground into flour and cooked into a thick porridge. Climate conditions are mostly sub-tropical, with one rainy season between November and March. Rainfall is typically inconsistent, with only 37% of the country receiving rainfall considered adequate for agriculture. This can create serious droughts which have led to soil erosion and decreased agricultural production (FAO, 2018). Zimbabwe is considered a low-income food deficit country. Malnutrition is a growing concern with over one-fourth of children under age five suffering from chronic malnutrition.

Agriculture in Zimbabwe is a very important part of the economy, providing employment for approximately two-thirds of the population. Approximately half of the country's exports are of agricultural origin (Skweyiva, 2016). Zimbabwe has many agricultural resources, but less than ten percent of the country is cultivated. Major communal crops produced in Zimbabwe are corn, sugar, and maize. Maize is one of the most influential crops with almost 80% of the population directly involved in its production. Although women participate in the agricultural production, their male counterparts control the industry (Everyculture, 2018). Zimbabwe was once considered the breadbasket of southern Africa due to its strong agricultural sector. However, political crises, controversial land reforms, and recurrent droughts have resulted in an underperforming agricultural sector. Due to these challenges, farmers have been struggling to exist (Everyculture, 2018). Because of its current fragile economic state, any additional burden to the Zimbabwean agriculture can be devastating.

The FAW is a caterpillar with a voracious appetite that threatens the food security of Zimbabwe. The FAW is named for its ability to march and eat its way through a crop, causing a significant amount of damage in a short period of time. The FAW (Spodoptera frugiperda) is a species in the order of Lepidotera and is the larval life stage of the fall army moth. The scientific name is derived from frugiperda, which is Latin for *lost fruit* and named for its ability to destroy crops. The fact that the FAW has the ability to breed quickly and migrate fast makes controlling this pest difficult. The entire life cycle of the FAW is between 35 and 61 days. Due to the fragile state of agriculture in Zimbabwe, the FAW poses a severe threat to various crops and overall food security (Briggs, 2018).

Although only first observed in September 2016, the FAW has now been reported in all provinces of Zimbabwe (Briggs, 2018). Scientists think that it may have reached the continent through imported produce. Once established, adult moths can fly long distances and spread quickly. Maize is the primary crop of Zimbabwe and also a favorite crop of the FAW. The impact of the FAW on maize crop is damaging because the FAW eat the leaves and its reproductive parts destroying future crops. Lack of resources to battle the resilient FAW, coupled with the fact that maize is a major crop in Zimbabwe, places the country in a vulnerable position. FAW destroyed approximately 20 percent of the country's maize crop in 2017. The trend of FAW damage appears to be increasing. The Centre for Agriculture and Biosciences International (CABI) warned that FAW could cause maize crop losses between $76 million and $191 million (Tsiko, 2018). Since small rural farms contribute toward 80% of maize production in Zimbabwe, this group is particularly vulnerable to the damages of the FAW. Lack of education about the FAW and funding may further increase this trend. Zimbabwe's Agricultural Deputy has used field officers to educate farmers about the FAW, but most of the farms affected by the pests did not take the recommended actions to control them (Tsiko, 2018).

Because of its potential to create both agricultural and economic devastation, solutions to the FAW problem are urgently needed. A viable solution in controlling the damage from the FAW will require a multifaceted approach which may include: education of farmers, use of biological control agents/natural predators, pesticide application, and genetic modification of plants.

The education of farmers is critical in controlling the FAW population. Teaching farmers to distinguish the FAW from other worms is important. Once farmers identify the eggs and larva of the FAW, they can begin treatment and notify the appropriate agencies. Early detection will allow for early intervention to help minimize damages. It is helpful if farmers understand the FAW life cycle and reproduction habits. For example, how and where females lay their eggs can help farmers target the time and location of their treatments. Recently, the UN Food and Agriculture Organization (FAO) created a comprehensive guide to better educate farmers. "The guide builds on the experiences of farmers and researchers from the Americas who have been dealing with the pest for centuries as well as on new technology and lessons learned so far in Africa. It gives African farmers and frontline agricultural workers the practical advice they need to tackle FAW head-on," according to Maria Helena Semedo, FAO Deputy Director-General (FAO, 2018b, para. 6).

Biological control agents can help control the spread of the FAW. Studies have shown that FAW suffers up to 56 percent mortality from insects that eat its eggs or larvae (FAO, 2018b). Control of FAWs with biological control agents can include entomopathogenic nematodes (i.e., parasitic organisms that grow on or in insects), predatory bugs, and parasitic organisms. An example of a parasitic organism is the Trichogromma wasp, which will parasitize any newly laid FAW eggs by inserting its own eggs inside of FAW eggs, killing them before they enter the plant-eating larval stage (deLourdes, 2015). There are many benefits of using biological control agents. One benefit is that biological control agents are usually specific for the pest population they are being used to control. This is unlike other methods such as pesticides that may have unintended consequences of destroying both the pest population as well as beneficial organisms. Another advantage is that biological agents are usually self-sustaining and require minimal additional work (Bale, 2008). Biological agents tend to be cost effective since there is little additional cost once they are placed in the environment. Despite the many benefits, there are some disadvantages to biological agents. First, the biological agent may not adapt well to the environment due to various conditions including weather. Second, the use of pesticides may pose a threat to the biologic agent. Furthermore, biological agents tend to take a long time to become established in the new environment. Finally, although less expensive in the long run, the initial startup costs can be expensive (Bale, 2008).

Pesticide application is another option. Most maize farmers in Africa do not apply pesticides to their maize. The cost of production and the prices received by most small maize farmers does not make the use of pesticides economically practical. There are additional issues with pesticides even when they are economically feasible. The use of pesticides can be ineffective, may eliminate natural enemies of FAW, and can cause health and environmental risks. Furthermore, the FAW has developed some resistance to pesticides (Fatoretto, 2017).

Genetic modification of plants is a newer option for combating the FAW. Genetically modified organisms (GMOs) are living organisms whose genetic material have been artificially manipulated in a laboratory through genetic engineering. GMO has been used to combat the FAW in plants such as maize. Genetically modifying plants such as maize can make their outer shell more resistant to the FAW and even make the shell impenetrable by the FAW teeth. Another example is genetically modified BT (Bacillus Thuringiensis) maize. This maize is effective against the FAW because the BT is a poisonous protein to the FAW (Amadala, 2018). GMO can also make plants such as maize resistant to various pesticides. Although initially appearing beneficial, further evaluation reveals that this could lead to an increased use of pesticides in these crops which can have negative consequences. For example, studies have shown that the consumption of GM pesticide resistant maize can lead to toxic pesticide from the maize in the blood of pregnant women and their unborn fetuses (Aris, 2011). Another problem of GM plants is cross contamination. Cross contamination of nearby plants with pollen from GM crops could transfer certain genes from one plant type to another (Bawa, 2013). The above findings may limit the ability to use GMO and not meet all the needs of the Zimbabwe population. The genetic modification of crops has significant potential but must be used cautiously while understanding the potential risks. Further studies into this new promising technology are required.

In order to successfully implement the above-mentioned solutions, a solid distribution model must be considered. Proper farmer education is a key component in creating a strong distribution model. In Zimbabwe, farmer education has been fostered by the creation of Farmer Field Schools. These local field schools are intended to teach farmers to better identify the FAW and understand the life cycle, its reproductive patterns, and identify evidence of FAW damage to crops. Incentivizing the farmers to attend farm schools with certificates of completion and monetary rewards will help to ensure widespread attendance (FAO, 2018b). In addition to field schools, modern advances in technology, such as smart phone apps, will allow for further dissemination of information among farmers. Nuru, for example, is a talking app that allows farmers to hold their phone next to an infected plant and immediately confirm if the damage was caused by the FAW. Nuru can work offline too (FAO, 2018d). The FAO has also created an app called the Fall Armyworm Monitoring and Early Warning System (FAMEWS), which helps farmers understand how and where the FAW spreads (FAO, 2018c).

A distribution model for pesticides and biological control agents will need to include a low cost method for obtaining and monitoring these agents. The FAO will need to work closely with farmers by ensuring that these agents are affordable and being used appropriately. These agents should be easy to use and not require sophisticated machinery. Farmer Field Schools can be utilized to help educate and monitor the use and distribution of pesticides and biological control agents (FAO, 2018b).

GMO maize is currently being used in Africa but has had multiple distribution hurdles limiting its widespread use. A distribution model should create affordable GMO seeds that are accessible to small farmers. Due to the high cost, GMO seeds will likely need to be subsidized by either the FAO and/or local governments. Furthermore, field schools can be used to educate small farmers on the potential long term benefits of GMO seeds and thus hopefully promote improved compliance.

Since the economy of Zimbabwe is struggling, funding for the above may need to come from outside sources coordinated by the government and the Food and Agricultural Organization of the United Nations. Earlier this year, the Centre for Agriculture and Biosciences International (CABI) warned that without proper control measures, the FAW could cause maize yield losses estimated to be between $76 million and $191 million in Zimbabwe (Tsiko, 2018). At a joint expert and multi-stakeholder meeting that convened in Johannesburg by the Southern Africa Development Community (SADC) and the FAO, discussions focused on finding sustainable ways to manage the FAW. According to David Phiri, the FAO's Subregional Coordinator for Southern Africa, there is large need for financial resources to fund programs to cover gaps in Africa's current battle against the FAW (Nkala, 2017).

The Food and Agricultural Organization of the United Nations (FAO) would be the ideal organization to manage the above plans. The FAO has been successful in helping to eradicate the FAW in Zimbabwe due to its educational programs, financial support, and collaborative efforts with other organizations. Most recently, "The agency called for a massive scaling up on the Fall Armyworm campaign to train more than 500,000 farmers to manage the pest through Farmer Field Schools in sub-Saharan Africa" (FAO, 2018a, para. 1). Furthermore, the FAO's financial contribution for educational programs has been substantial, "To date, FAO has invested more than $9 million from its regular budget, and mobilized $12 million for its Fall Armyworm programmes" (FAO, 2018a, para. 3). The FAO is working closely with other organizations in its efforts to combat the FAW. In developing its comprehensive guide on the integrated pest management of the FAW on maize, the FAO has collaborated with multiple partners both locally and internationally. Such organizations include: International Institute of Tropical Agriculture (IITA), International Centre of Insect Physiology and Ecology (ICIPE), Lancaster University, Centre for Agriculture and Bioscience International (CABI), Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), Colegio de la Fontera Sur (ECOSUR) and the United States Department of Agriculture (USDA) (FAO, 2018b). In order to support such organizations in their fight to combat the FAW, continued research, education, and financial support is needed.

Ultimately, to control the FAW farmers will need to play a central role in implementing the above solutions with the support of Zimbabwe's government and organizations worldwide. Control of the FAW is critical in maintaining food security in Zimbabwe and the surrounding countries at risk. Through coordinated efforts, this pest can ultimately be controlled while protecting the food security of Zimbabwe and potentially the region as a whole. After reviewing the problem the FAW presents to Zimbabwe's food security it becomes clear that the solution will require not one but multiple modalities. The above solutions will not eliminate the FAW but will control its numbers and hopefully prevent it from spreading.

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