Fall Armyworm Outbreak in Zambia: Responses, Impact on Maize Production and Food Security

by

Stephen Kabwe, Christabel Chengo-Chabwela, and Kabaso Mulenga

Technical Paper 6
January 2018

Indaba Agricultural Policy Research Institute (IAPRI)
Lusaka, Zambia
Downloadable at: http://www.iapri.org.zm
and http://www.aec.msu.edu/
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Kabwe and Chengo-Chabwela are Research Associate and Outreach Specialist while Mulenga was at the time of the assessment a Research Assistant of Indaba Agricultural Policy Research Institute Respectively.
ACKNOWLEDGEMENTS

The Indaba Agricultural Policy Research Institute (IAPRI) is a non-profit company limited by guarantee and collaboratively works with public and private stakeholders. IAPRI exists to carry out agricultural policy research and outreach, serving the agricultural sector in Zambia so as to contribute to sustainable pro-poor agricultural development.

We wish to acknowledge the financial and substantive support of the Swedish International Development Agency (SIDA), and the United States Agency for International Development (USAID) in Lusaka. We further would like to acknowledge the technical and capacity building support from Michigan State University (MSU) and its researchers and Patricia Johannes for editing and formatting assistance.

Any views expressed or remaining errors are solely the responsibility of the authors.

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EXECUTIVE SUMMARY

In November and early December in 2016, Zambia experienced an outbreak of the Fall Army Worm (FAW) that affected districts in almost all the provinces. Once pest was identified, The President of the Republic of Zambia, His Excellency Edgar Lungu declared the outbreak as a national disaster. This prompted the quick mobilization of resources to control the pest and the Ministry of Agriculture (MoA) and Disaster Management and Mitigation Unit (DMMU) were tasked to coordinate resource mobilization and implementation of control measures.

In order to understand the implications the FAW outbreak had on Zambia’s Food Security and Trade, regarding the most affected crop (maize), IAPRI carried out an assessment of the FAW outbreak to evaluate the response and identify key lessons for future response. The assessment was carried out between 28th January and 10th February 2017.

The fieldwork was revealing, drawing out several key findings from this outbreak, notably:

- Lack of effective early warning systems, and misidentification in the differentiation of FAW and stalk borers by some field officials. This led farmers to delay in understanding the potential threat the yield was facing;
- Government’s response was reactive rather than proactive; hence, resource mobilization is always a challenge. Logistics to effectively distribute pest controls were a challenge, including getting chemicals and equipment to farmers. Also, sufficient chemicals and equipment were not available to distribute to all the farmers that were affected;
- Shortages were compounded by the decision to offer free treatment chemicals; some farmers that could have purchased insecticides on the open market did not, leading to further delays treating the outbreak; and
- Shortages and poor education led some farmers to take drastic measures—using detergents as insecticide, often destroying whole harvest.

Despite these challenges, the government deserves credit for timely response, which ultimately contained the outbreak and ensured Zambia’s food security. IAPRI estimated that the outbreak could have reduced maize outputs by around 40 metric-tons, an amount that was expected to be more than offset by the good rains experienced this year.

This was good news for Zambia in the short term, but in the long-term Zambia needs to acknowledge that the FAW is a chronic pest and prepare itself for future outbreaks. In addition, the FAW can be hosted by about 79 other crops in the absence of maize, which has been found to be its preferred host crop. Hence, going forward, containing the pest will require concerted efforts from all key stakeholders.

Based on the findings of the fieldwork and a literature review of successful practice in other countries to help mitigate against the risk of future outbreaks the government should take some urgent steps:

- Strengthen the early warning systems—improve the capacity of district officers and maintain clear reporting channels to central agencies (MoA and the International Red Locust Control Organization (IRL-C)).
- Ensure the timely disbursement of operational funds, which will ensure that field staff have funds before the start of season to operate early warning systems and interact with farmers in advance of the growing season.
- Strengthen the entomology section of the MoA—there is urgent need for more entomology staff and capital injection to construct state of the art laboratories to
improve research and identification. This will complement and improve on the current efforts being undertaken by Zambia Research Institute (ZARI)

- Introduction, re introduction, and strengthening of plant clinics. The introduction and strengthening of plant clinics at district level by ZARI should be strengthened and encouraged to spread to other districts
- Encourage farmers on e-vouchers to redeem pesticides, as the e-voucher offers opportunities to support farmers to tackle pests via purchasing chemicals, rather than just fertilizer.
- Promote crop rotation and encourage field hygiene, which will disturb the life cycle of the pest and reduce the risk of regular outbreaks.

However, as highlighted above, the FAW is likely to be endemic to Zambia regardless of these recommended measures. To mitigate against the potential consequences over the longer term, this report concludes that the government and farmers should seek to follow international best practices to tackle the pest, including developing pest resistant seed varieties (including transgenic varieties of corn used in South America) and extending the reach of extension officers by building accommodation in farming camps among other strategies.

Our findings show that rapid action by government averted a significant crisis for Zambia’s food security during the 2016/17 farming season yield. The authors hope that the recommendations set out will improve Zambia’s ability to identify any future threat from the FAW early enough and enable the government to act in a better coordinated and more efficient manner.
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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bt</td>
<td>Bacillus thuringiensis</td>
</tr>
<tr>
<td>CIMMYT</td>
<td>Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)</td>
</tr>
<tr>
<td>DMMU</td>
<td>Disaster Management and Mitigation Unit</td>
</tr>
<tr>
<td>GM</td>
<td>Genetically Modified</td>
</tr>
<tr>
<td>GMO</td>
<td>Genetically Modified Organism</td>
</tr>
<tr>
<td>FAW</td>
<td>Fall Army Worm</td>
</tr>
<tr>
<td>ha</td>
<td>hectare</td>
</tr>
<tr>
<td>IAPRI</td>
<td>Indaba Agricultural Policy Research Institute</td>
</tr>
<tr>
<td>IRLO-CSA</td>
<td>International Red Locust Control Organization for Central and Southern Africa</td>
</tr>
<tr>
<td>Kg</td>
<td>kilogram</td>
</tr>
<tr>
<td>mt</td>
<td>metric ton</td>
</tr>
<tr>
<td>MoA</td>
<td>Ministry of Agriculture</td>
</tr>
<tr>
<td>PACO</td>
<td>Provincial Agricultural Coordinator</td>
</tr>
<tr>
<td>ZARI</td>
<td>Zambia Agricultural Research Institute</td>
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</tbody>
</table>
1. INTRODUCTION

In November and early December of 2016, Zambia experienced an outbreak of the FAW which affected various districts in almost all the provinces (Figure 1). According to Disaster Management and Mitigation Unit (DMMU), the first provinces to report were Copperbelt, Central, Lusaka, and Luapula. In all these areas, the pest mostly affected maize fields, though it can also affect other crops such as sorghum, millet, cotton and, soybeans among others.

Literature shows that the outbreak, if not contained could have a devastating impact on crop production and export trade of the grain (Goergen et al. 2016). The pest is considered chronic (Flanders, Ball, and Cobb 2011) which means that it reoccurs nearly every season in infested areas.

In order to understand the implications of the FAW on food security and trade, IAPRI carried out an assessment survey between 28th January and 10th February 2017. Specifically, the assessment focused on the following:

a) How wide spread the outbreak was;

b) Response by government and stakeholders;

c) Who was affected, small or/and commercial farmers;

d) Extent of infestation on crops other than maize; and

e) Possible impact on food security and on export of maize grain.

The assessment was done in Central Province covering Chibombo and Kabwe districts, Copperbelt Province Covering Ndola, Kitwe, Luanshya, Masiti, Mpongwe, Chingola, Mufulira, and Chililabombwe districts, Lusaka Province covering Chongwe and Rufunsa, and Eastern Province covering Nyimba, Petauke, Sinda, Katete, Chipata, Chidiza, and Lundazi districts. The choice of most of the districts was necessitated by the reported extent of infestation (DMMU 2017). The information was obtained through discussions with key informants such as Ministry of Agriculture (MoA) field officials and smallholder farmers.

This report sets out the key lessons from IAPRI’s fieldwork, makes an assessment of the possible risk to Zambia’s food security, and sets out some policy recommendations to reduce the risk of a serious outbreak going forward.

Figure 1. Population Density of Farmers Affected by Armyworms as of January 7, 2017

2. FIELD ASSESSMENT

2.1. Outbreak of Fall Armyworms

The first report of an outbreak of the FAW was reported on the Copperbelt, Central, Lusaka, and Luapula Provinces in late November to early December, 2016. Other provinces such as Eastern, Western, and Southern also reported the presence of the pest. However, it was not severe. It was also reported that farmers who grew irrigated winter maize in Ndola District observed the pest in June and July in their maize fields, however, regarded the pest as the usual stalk borer and the cases were not reported to the MoA. The challenge which some of the MoA officials and farmers had was the misidentification of the fall armyworm to the maize stalk borer in terms of eating habits. However, that challenge was resolved after some samples of the pests from Copperbelt Province were taken to the International Red Locust Control Organization for Central and Southern Africa (IRLO_CSA) in Ndola while samples from Lusaka and surrounding areas were taken to Zambia Research Institute (ZARI) in Chilanga for scientific identification. Both institutions identified the pest as the FAW.

Despite the identification of the pest by IRLO_CSA and ZARI, the IAPRI assessment team found that some field agricultural officials and farmers were still referring to the FAW as a stalk borer. This clearly showed that the pest was not fully known by some field agricultural officials.

Key lesson for the future: The MoA working in collaboration with ZARI and IRLO_CSA must take a lead in sensitizing the field extension officers about the distinctive features and habits of the FAW and how different they are from the stalk borer and the Africa armyworm. Informational Educational Communications materials such as pamphlets, posters, and brochures should be developed and distributed to all the districts offices and there is need for mass media sensitization campaigns.

2.2. Response by Government and Other Stakeholders

After the FAW outbreak was reported, the government responded to control the pest with His Excellency the President of the Republic of Zambia Mr. Edgar Lungu declaring it as a national disaster. The President went further to direct the MoA and the DMMU to coordinate the response to fight the outbreak of fall armyworms. In that vein, the DMMU in collaboration with MoA procured chemicals, safety suits, and also early maturing maize varieties and dispatched these requisites to all the Provincial Agricultural Coordinators for distribution to the affected smallholder farmers. The early maturing maize seed varieties were also provided to farmers whose fields were attacked beyond control for replanting. The main chemicals that were distributed were Cypermethrin and Lambda. All the distributed chemicals were none-systemic pesticides.\(^1\) The Central Government announced on radio that free chemicals were being provided through the district offices and encouraged the farmer’s to access the chemicals.

However, field assessment indicated that they were some challenges in the way the exercise was conducted and key informants highlighted the following:

i. Logistics: All the field personnel talked to highlighted logistical challenges, which included aspects of untimely release of usual operational funds as budgeted in the national budget, lack of transport (motor bikes, and vehicles), and insufficient

\(^1\) These are pesticides that kill pests when they come in contact with the pests.
equipment such as sprayers and protective clothing. Field staff also indicated that operational funds should come at the time when farmers are less active in the field and most cases less than budgeted. This is supported by the study done by Kuteya et al. (2016) which looked in-depth analysis of budget. This situation makes extension officers immobile and unable in some cases to attend to farmers’ needs during critical periods of agriculture. Lack of transport especially for extension officers was also another limiting factor affecting effective and efficient provision of extension services to the farmers by the extension officers. Because of this, the field officials indicated that during the outbreak of the FAW, the resources were not enough to allow the extension officers to monitor the effectiveness of the operation.

ii. Nonfunctional pest early warning system: The stakeholders in the field felt that the government was reactive and not proactive because the pest early warning system was not operational due to lack of pheromone traps and hormones and even in some areas where the traps were available.

iii. Over publicized announcement of free chemical by the government: This approach made work for the agricultural officers at province and districts offices very difficult because farmers and non-farmers streamed to the districts offices to collect the chemicals. Furthermore, the pronouncement led to farmers capable of purchasing chemicals opt not to purchase but of access to the free chemicals. One of the farmers from Fitobaula camp of Luanshya District, said “Tekuti inshite umuti watushishi pantu ba government balilanda pa mulabasa ati balishita umuti watushishi, balepela umuti uyu ukupitala kuli ba agriculture” meaning I can’t buy chemicals for the pest because the government has said that they have already procured enough chemicals and are distributing through the MoA district offices.

iv. Alternatives to chemicals used by farmers: Some farmers, who did not have enough resources and failed to access free chemicals from MoA, resorted to using alternative methods of controlling the pest. Some farmers indicated using Boom and MAQ detergent washing soap, while others indicated that they were using the ash and sand. Considering that the Boom and MAQ detergent washing soap were not chemicals for pest, it burned the crop.

v. Makeshifts laboratories for fall armyworms and African armyworms: Both ZARI and IR1_CO had (still have) makeshifts laboratories. This is a challenge as it was not an efficient way for the scientists to work.

vi. The chemicals, safety working suits, and knapsack sprayers distributed to almost all of the districts were not enough to supply the population of farmers that were affected.

Despite these challenges, the government should be praised for its rapid response given the late detection of the fall armyworm outbreak. An earlier diagnosis of the problem and more proactive result could have helped tackle the outbreak of the pest and would have eased the significant logistical challenge of an emergency response. For example, early diagnosis would enable extra chemicals to be imported and distributed in timely manner, ensuring that all farmers who were not able to purchase the chemicals access them, whilst also leaving chemicals available to purchase on the open market.

2.2.1. Key Lesson for the Future

a) Firstly, timely disbursement of operational funds as budgeted to the MoA by the Ministry of Finance during the period when extension officers are needed by the farmers is critical. This would improve the provision of effective and efficient
extension services to the farmers by agricultural extension officers during the crop production period. In the case of pest outbreaks, such as the fall armyworms, the extension officers would be able to carry out sensitizations and offer needed advice to farmers effectively and efficiently before the central government emergency support is provided if need be.

b) Secondly, Zambia needs to develop well-functioning pest early warning systems. This will enable the government to be proactive in responding and controlling forecasted pest outbreaks. A well-functioning early warning system requires that the institutions mandated to do such works are well funded; officers in the field should have the correct and adequate equipment such as pheromone traps and a timely supply of pheromone hormones. (Figure 2)

c) Thirdly, the entomology sections of ZARI of the MoA and the IRL-CO needs well-functioning state on the art laboratories that can enable scientists to execute their work in an efficient and timely manner. Currently the institutions operate makeshift laboratories (Figure 3).

d) Finally, the e-voucher presents an opportunity to enable farmers to proactively tackle pests, including the armyworm, as it allows farmers to purchase chemicals in addition to seed and fertilizers (Kuteya and Chapoto 2017). Agro dealers should be encouraged to stock these chemicals and farmers encouraged to diversify their purchases to ensure they purchase them in the event of future outbreaks.

Figure 2. Pheromone Traps and African Armyworm Pheromone Hormones in 2012

Figure 3. Culturing of the FAW at ZARI Using a Provisional Lab and Equipment
2.3. Who Was Affected—Small and/or Commercial Farmers?

Reports on the FAW outbreak initially came from small and medium scale farmers rather than the commercial farmers and small and medium scale farmers were the worst affected with the outbreak. This can be attributed to the fact that commercial farms approach farming as a business and therefore, the response to an outbreak of the pest like that is quite different with small-scale farmers. So the commercial farms that saw the presence of the FAW and immediately moved in swiftly to control the pest and did not wait for government action. There is a clear knowledge gap between commercial and small-scale farmers, particularly regarding pest identification and pest control techniques, for example, the majority of small-scale farmers think that maize is normally not attacked by pests so take limited preventative action.

2.3.1. Key Lesson for the Future

Small-scale farmers need to adapt best practice and approach farming as a business. Specifically, they need to be trained on pest knowledge and how to control the pests so they respond swiftly and appropriately to future outbreaks.

2.4. Which Crops Were Attacked?

Literature shows that the FAW attacks an array of crops. The field crops which are frequently injured include maize, barley, cotton, oat, millet, groundnuts, rice, sorghum, sugar beet, soybean, sugarcane, tobacco, and wheat among others. Other crops sometimes attacked are apple, grape, orange, papaya, peach, strawberry, and a number of flowers (Capinera 1999). However, field assessments with various stakeholders in Zambia indicated that the attack was only reported on the maize crop and no reports of attack have been reported in other crops in all the districts the assessment team visited.

2.4.1. Key Lessons for the Future

The FAW is a chronic pest and can attack other crops beyond maize. Extension officers and all the front workers as well as farmers need to be sensitized on this recurrence of the pest in infested areas, including information that the pest attacks crops other than maize as well.

2.5. Other Challenges as Highlighted by Field Officials

2.5.1. Ratio of Extension Officers to Farmers

The ratio of extension officers to farmers was found to be too high and this had a negative effect in the timely delivery of extension services. The high ratios, coupled with lack of operational funds, made it difficult for extension officers to physically visit some farmers and distribute the chemicals and/or monitor the fight against the pest. In some cases, the zonal areas of an extension officer covered a radius of up to 80 kilometres encompassing over 1,000 farmers per one extension officer.

2.5.2. Dependency Syndrome by Farmers

Some farmers exhibited the dependency syndrome by entirely relying on free chemicals from the government even when they could afford to purchase from agro dealers. The chemicals
were readily available from agro dealers and cost an average of K80 (US$8) at the time of the survey. Since some farmers who could have managed to buy the chemicals to contain the pest on time did not, which amplified the infestation rate because the pest multiplied significantly in number due to the lack of a quick response.

2.5.3. Ineffectiveness of Some Chemicals

There were reports that some chemicals did not work effectively in eliminating the pest. This could have been due to wrong dilution because some farmers did not know the right dosage and did not have access to extension services. In some cases, the timing of the chemical application had an adverse effect on its effectiveness on the pest. For example, if a farmer sprayed the chemicals just before a rain storm or in the early morning, it was highly likely that the chemical would be washed away by the rains or get diluted by dew, thereby, making it less effective.

2.5.4. Housing Units for Extension Officers in Camps

Due to lack of adequate housing units within the camps for extension officers, some officers resorted to staying in nearby towns. Again, this situation makes it difficult for agricultural extension officers to work closely with the farmers. The outbreak of FAW reaffirmed this challenge. Some extension officers relied only on getting information via mobile phones to some farmers without actually visiting them.

2.5.5. Dual Roles of Extension Officers (FISP vs FAW)

The outbreak of the FAW coincided with the distribution of inputs under the Farmer Input Support Programme (FISP) and rolling out of the e-FISP. Some extension officers were executing dual roles both of which required their full attention. This affected how such extension officers responded to the outbreak of the FAW visa vis FISP.
3. WILL ZAMBIA BE FOOD INSECURE BECAUSE OF THE FAW ATTACK?

One important question arising from the outbreak of the FAW and IAPRI’s fieldwork is if Zambia’s food security was threatened. To assess this, IAPRI modelled the impact of the outbreak on Zambia’s maize production based on the data that was collected during the survey, information obtained by DMMU, and production figures of maize for 2015/16. Three scenarios of crop losses were modelled: a low scenario of 5% of crop loss in affected areas based on district agricultural officials’ anecdotal estimates during fieldworks, a central 10% scenario, and high 25% scenario (both as a percentage of crop lost in affected areas).

All three scenarios assumed the 2015-16 season maize production of 2.8 million metric tons in the modelling and the estimates are shown below.

- Low scenario – 5% crop loss, estimated loss based on estimates during fieldwork and allowing for the government’s intervention minimizing losses, would result in 20 metric tons of lost maize;
- Central scenario – 10% crop loss, estimated based on the area affected and before adjustments for government action, would result in 40.5 metric tons of lost maize,
- A worst case/high scenario – 25% crop loss, illustrating the worst possible case if the outbreak were not controlled, would result in 101 metric tons of lost maize.

This analysis shows that under any scenario modelled, the FAW attack is unlikely to affect the food security of the country. It is also worth noting that these are absolute loss figures, a total maize production in Zambia to up on 2015/16 given the good rains that Zambia has received, and reducing the impact of any loses in percentage terms is expected.

On the other hand, the country has over 500,000 metric tons of maize held by Food Reserve Agency and Grain Traders of Zambia and Millers Associations of Zambia, thereby, assuring food security and yet have enough grain for export. It is important to note that these losses are only indicative estimates. Full losses will be accurately computed after the 2016/17 crop forecast survey that will be carried out by the MoA and Central Statistics Office in the first and second quarter of 2017.
Table 1. Implications of Fall Armyworm Attack on Maize Food Security of Zambia

<table>
<thead>
<tr>
<th>Area planted to maize in 2015/16 (ha)</th>
<th>Anticipated output (Mt) in 2015/16</th>
<th>Area infested (ha)</th>
<th>% of area attacked against total area</th>
<th>Quantity of maize loss (Kg) based on the different scenarios as a result of the fall armyworm attacks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D =((A/C)*100)</td>
</tr>
<tr>
<td>Central</td>
<td>217,708</td>
<td>648,114</td>
<td>39,300</td>
<td>18.1</td>
</tr>
<tr>
<td>Copperbelt</td>
<td>78,875</td>
<td>236,727</td>
<td>31,040</td>
<td>39.4</td>
</tr>
<tr>
<td>Eastern</td>
<td>253,735</td>
<td>500,920</td>
<td>24,669</td>
<td>9.7</td>
</tr>
<tr>
<td>Lusaka</td>
<td>38,578</td>
<td>115,880</td>
<td>27,886</td>
<td>72.3</td>
</tr>
<tr>
<td>Luapula</td>
<td>48,354</td>
<td>148,109</td>
<td>8,639</td>
<td>17.9</td>
</tr>
<tr>
<td>Muchinga</td>
<td>72,297</td>
<td>242,546</td>
<td>383</td>
<td>0.5</td>
</tr>
<tr>
<td>Northern</td>
<td>98,030</td>
<td>264,723</td>
<td>139</td>
<td>0.1</td>
</tr>
<tr>
<td>North Western</td>
<td>67,489</td>
<td>179,855</td>
<td>1,971</td>
<td>2.9</td>
</tr>
<tr>
<td>Southern</td>
<td>213,116</td>
<td>448,187</td>
<td>10,804</td>
<td>5.1</td>
</tr>
<tr>
<td>Western</td>
<td>69,573</td>
<td>87,991</td>
<td>5,353</td>
<td>7.7</td>
</tr>
</tbody>
</table>

| Provinces                            | 1,157,755 | 2,873,052 | 150,184 | 13.0 | 20,274 | 40,549 | 101,371 |

Source: Authors.
4. CONCLUSION

The importance of understanding and controlling pests of national economic importance such as the FAW cannot be over emphasized. The outbreak posed a serious challenge for Zambia; the fact the pest went undetected for months meant that by the time it was detected the outbreak was wide spread and urgent action was needed to prevent a large-scale crop losses.

While the government deserves credit for the timely response to the outbreak, the field assessment found that some field agricultural officials misidentified the FAW as stalk borers. In addition, the early warning systems in Zambia were not fully functional and nonexistent in most cases. The government responded reactively and not proactively. The supply chain and delivery mechanisms of chemicals and equipment was incapacitated by lack of operational resources.

Considering that FAW outbreak is chronic and can be hosted by about 80 other crops besides maize, the pest will always be there, and hence, requires concerted efforts by all key stakeholders to control the outbreak and reduce severity of potential damage on crops.

The FAW outbreak experienced in Zambia is unlikely going to affect the food security of the country in 2017 because of the measures that were taken to control the pest. The pest outbreak in the maize crop was in a spotty fashion and not an entire field was attacked; the relatively good amount of rainfall the country received reduced the impact of any losses due to the pest outbreak.

In this regard, the report draws out key lessons to reduce the risk of a serious outbreak in future and highlights lessons from international experience in managing the pest.
5. RECOMMENDATIONS

Based on the key lessons highlighted, the study makes the following recommendations in order to effectively prepare for possible future outbreaks of the pests and in particular fall armyworms.

5.1. Short Term Recommendations

5.1.1. Strengthening the Early Warning Systems

Early detection of various pests is cardinal in containing outbreaks and averting full-fledged pest attack. Strengthening of the early warning system can be done in two folds. Develop systems which will provide information to and enable the local community to determine the possible outbreak of pests. With the information captured at camp, empower extension officers with technologies that will enable them to send information to a central information center at research institutions such as ZARI and IRL-CO.

5.1.2. Timely Disbursement of Operational Funds

As long as operational funds are not disbursed on time and as budgeted, extension officer will not be able to effectively execute their work in determining and containing possible outbreaks of pests such as the FAW. Therefore, it is prudent that the government timely disburses operational funds as budgeted. For instance, field staff need operation funds before the start of season in order to enable them to interact with farmers on the farming activities for the coming season.

5.1.3. Strengthen the Entomology Section of the MoA

The entomology section under the department of research at ZARI under MoA in collaboration with IRL-CO is key for studying pests of economic importance in Zambia. Currently, entomology sections at ZARI and IRL-CO operate in makeshift laboratories. There is an urgent need for additional entomology staff and capital injection to construct state of the art laboratories that can enable the two institutions to work effectively and efficiently.

5.1.4. Introduce and Strengthen Plant Clinics

The creation of plant clinics in some districts by ZARI should be strengthened and encouraged to spread to other districts. Such initiatives will help farmers learn more about the health of their plants and possible pest attacks, and how to effectively respond to such attacks. For example, the use of bio pesticides, conventional pesticides, chemical handling, etc.

5.1.5. Encourage Farmers on E-vouchers to Redeem Chemicals

The introduction of an e-voucher by the government under FISP is a commended move. Because farmers who are on e-voucher can redeem for chemicals for pest control, farmers should be encouraged to do so, as well as for fertilizer and seed.
5.1.6. Promote Crop Rotation and Encourage Field Hygiene

Disturbing the life cycle of the pest is another strategy that can be used to control any pest. This can be achieved by practicing crop rotation. Therefore, farmers should be encouraged to religiously practice crop rotation and use bio pesticides such as extracts of neem tree.

5.2. Medium to Long-term Recommendation

5.2.1. Build Housing Units for Extension Officers within Camps

This will enable extension officers to reside within farmers’ catchment areas, thereby allowing them to more effectively deliver extension services. Government should, therefore, consider investing in housing infrastructure for extension officers.

5.2.2. Encourage Breeding of Maize Seed which Can Be Resistance to Pests

Literature shows that the FAW is a chronic pest, hence, there is need for seed breeders to consider to developing varieties that are pest resistant.

5.2.3. Embed Best Practice from International Experience

The FAW is a relatively new pest in Zambia and indigenous to South America. Academic literature suggests using new transgenic varieties of corn that are resistance to the armyworm as well as using biological and bio-pesticides control can improve resilience to the FAW. The government should consider how best to introduce, or test, these products in Zambia to reduce the risk from future outbreaks.
APPENDICES

A1. Background of Fall Armyworms

An armyworm may refer to any of the five types of armyworms; African armyworm (*Spodoptera exempta*) which originates from Africa, the common armyworm or true armyworm (*Mythimna unipuncta*) and the Fall armyworm (*Spodoptera frugiperda*) which originate from North and South America, the lawn armyworm (*Spodoptera mauritia*) and the oriental armyworm or Rice ear-cutting caterpillar (*Mythimna separate*) with its origins from Asia. All these armyworms are migratory in nature when they are at moth stage. This type of migration is defined as a two-way movement with some directional element, which is different from nomadism and species’ irruptions or expansions (Elliott 1999). It is a long-distance movement of several hundred kilometers and traversing international boundaries which is helped by the movement of the wind current.

The fall armyworm (*Spodoptera frugiperda*) has its origins from North and South America. It is a chronic pest nature. The larvae feeds on a variety of plants. The most common plants the pest feeds on are forage grass, maize, millet, sorghum, and wheat. It also feeds on cotton, soybeans, and most vegetable crops (Flanders, Ball, and Cobb 2011). The pest has distinctive features that make it different from other armyworms. The most prominent one is the head with dark net-like pattern and upside-down white “Y” marking. The pest is cannibalistic in nature and that is why single fully grown fall armyworms are found on a crop.

The pest is new in Africa and it was only reported on the continent in Nigeria and other West African countries in 2016 (Goergen et al. 2016). Anecdotic reports say the pest might have been brought to West African countries through trade or by the wind current across the Atlantic Ocean.

Appendix 1. Picture of a Fall Armyworm

![Fall Armyworm Identification](image)

A2. Description and Life Cycle

To fully understand the behavior and how the pest migrates, it is important to understand the life cycle of the fall armyworm.

There are four stages of the life cycle of the fall armyworms and these are moth, eggs, larva, and a pupae. For successful fertilization of eggs, mating should occur at high temperatures and low humidity’s (Hot and dry weather). This is why fall armyworm infestation is associated after long periods of drought.

Hatching of eggs is dependent on temperature and should be around 26ºC, availability of food and moisture. The eggs hatch 5-7 days after the moth lays eggs on the leaves of the host plant. The larvae feeds on leaves of the host plant. It is cannibal in nature, which means that the pest feeds on other fall armyworms which leaves only one full grown fall armyworm on the host plant. The larvae will usually take about 15-18 days before burrowing into the soil for pupating. Depending on the soil temperature, the adult moth emerges about 2 weeks after pupation.

Infestation usually occurs in very high densities following the onset of wet seasons when dry grasslands produce new growth and cereal crops are planted. The severity and extent of outbreaks are increased by extended drought followed by early season rainstorms, which concentrate egg-laying moths and provide flushes of new grass as food for newly hatched caterpillars, and dry and sunny periods during the caterpillar development, which promote survival and rapid development. It should be noted that the severity of damage to crops increases if the rain pattern is erratic.

Appendix 2. Life Cycle of a Fall Armyworm

Source: CIMMYT 2014
A3. Management of the Pest

Literatures indicate an effective way of controlling fall armyworms or any other armyworms is when the larvae is small and before they burrow deep into the funnel of plant (Bessin 2003). The control of the armyworm in countries where the pest is common (South and North America countries) is done using mainly three methods namely, chemical, use of transgenic seed varieties (Genetically Modified Organism (GMO) crops) and the biological pesticides.

A3.1. Chemical Control

This method involves the spray of chemicals as advised by the extension officers of the area. As indicated the best time of spray of chemicals and for effective results is when the larvae is small and before it burrows deep in the funnel of the crop.

A3.2. Use of Transgenic Corn Varieties

South and North American countries have adopted GMO crops and have been using the genetically modified (GM) technology to control the worms like the fall armyworms. In Brazil, GM corn was seen as an effective way of controlling fall armyworm (S. frugiperda) larvae (Frizzas et al. 2014). However, resistance of the fall armyworms to some GM protein has also been reported especially where refuge crop is not maintained (Niu 2013).

A3.3. Biological and Bio-pesticides Control

Biological control of the fall armyworms is also in place. This is where pathogens (bacteria, fungi, and virus) are introduced in order to control agricultural pests such as armyworms (Infonet Biovision 2004). The most common biological control is the use of Bacillus thuringiensis (Bt) which reduces the abundance of fall armyworm larvae in corn (Capinera 2001). On the other hand, bio-pesticides, such as extracts from plants, are also used to control the agricultural pests. The neem oil is one such example of the bio-pesticides and is widely used.

Literature shows that to effectively manage the outbreak of armyworms (fall or true worms), monitoring of fields and also the surrounding areas must be done thoroughly (Bessin 2003).
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