

**ASSESSING THE IMPACT OF FALL ARMYWORMS ON MAIZE PRODUCTION AND THEIR
CONTROL STRATEGIES EMPLOYED BY FARMERS IN BUMUSOMI WARD BUBUTU
TOWN COUNCIL, NAMISINDWA DISTRICT.**

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**ARESEARCH REPORT SUBMITTED TO THE DEPARTMENT
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DECLARATION

I KHAINZA JANET hereby declare that the information contained in the research report is my original work and has never been submitted by any one for any award to any institution of higher learning.

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APPROVAL

This is to certify that this research report on ‘ ‘ Assessing the Impact of Fall Armyworms On Maize Production And Their Control Strategies Employed By Farmers In Bumusomi Ward Bubutu Town Council, Namisindwa District ’ submitted a n the partial fulfillment of the award of the degree of Bachelor of Science Education if Busitema University in authentic record of bonafied research carried the out by KHAINZA JANET (BU/UP/2021/1606) under my guidance and supervision. No part of this research has been submitted for any other degree or diploma.

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(University Supervisor)



DEDICATION

I dedicate this dissertation to my father, whose unwavering support, sacrifices, and encouragement have been the foundation of my academic journey. His belief in my abilities and his constant guidance have shaped me into the person I am today. Through his wisdom and dedication, he has instilled in me a passion for learning and a commitment to excellence. This achievement is a testament to his enduring love and profound influence on my life.



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ABSTRACT

The study, which aimed to assess the impact of fall armyworm on maize production and the control strategies employed by farmers in Bumusomi ward, Bubutu town council, Namisindwa district, utilized a population of 50 and a sample size of 40 selected using Morgan's (1970) sampling table. Findings from the study revealed several critical insights. Firstly, factors contributing to the rapid prevalence of armyworms included inadequate pest control measures due to limited access to effective pesticides and reliance on outdated farming practices. Secondly, control strategies employed predominantly involved chemical pesticides, despite concerns over environmental sustainability and pest resistance. Challenges faced by farmers in adapting to different control strategies included limited awareness of integrated pest management practices and financial constraints hindering investment in sustainable farming techniques.

The study concluded that addressing these challenges requires a multifaceted approach integrating education on modern pest management techniques, enhancing access to affordable and sustainable pest control solutions, and supporting farmers with financial incentives for adopting integrated pest management. Furthermore, the study recommended government interventions to subsidize organic inputs, promote biological control methods, and provide extension services tailored to local farming communities. These recommendations aim to mitigate the impact of armyworm infestations, ensuring long-term agricultural sustainability and food security in Namisindwa district.



LIST OF ABBREVIATION

FAW	- Fall Armyworm
FAO	- Food and Agriculture Organization
IPM	- Integrated Pest Management
NARO	- National Agricultural Research Organization
UBOS	- Uganda Bureau of Statistics
Mt	- Metric tons
MAAIF Fisheries	- Ministry of Agriculture, Animal Industry and Fisheries
Z. mays	- Zea mays (scientific name for maize)
SPSS	- Statistical Package for the Social Sciences
USAID Development	- United States Agency for International Development
GMO	- Genetically Modified Organism
PRA	- Participatory Rural Appraisal
NGO	- Non-Governmental Organization
GPS	- Global Positioning System
Bt	- Bacillus thuringiensis



CHAPTER ONE

INTRODUCTION

1.1 Back Ground.

The fall armyworm (FAW), *Spodoptera frugiperda*, is a devastating pest that poses a significant threat to global maize production (Guo et al., 2020). Originating from the Americas, FAW has rapidly spread to other continents, including Africa, Asia, and beyond, causing substantial economic losses and threatening food security. Maize, being one of the world's most crucial cereal crops, is particularly vulnerable to FAW infestations due to its widespread cultivation and susceptibility to the pest's voracious feeding habits (Khan, Sial, & Arshad, 2024). This introduction aims to provide a succinct overview of the impact of fall armyworm on maize production, examining its destructive nature, the factors contributing to its spread, and the implications for agricultural sustainability and food security.

The fall armyworm's ability to feed on a wide range of host plants, including maize, makes it a formidable adversary for farmers worldwide (Singh et al., 2023). FAW larvae voraciously consume maize foliage, leading to significant yield losses if left uncontrolled. Moreover, the pest's rapid lifecycle and high reproductive capacity enable it to quickly establish populations and spread to new areas, exacerbating the challenges faced by farmers.

Factors contributing to the spread of fall armyworm include globalization, climate change, and agricultural practices (Asare-Nuamah, 2021). Increased international trade and travel facilitate the inadvertent transport of FAW-infested plant material, contributing to its rapid dissemination across continents. Climate change may also favour FAW proliferation by creating more favourable conditions for its survival and reproduction in new regions. Furthermore, the adoption of monoculture farming practices and the reliance on insecticides with a narrow spectrum of activity have inadvertently promoted FAW outbreaks by disrupting natural pest control mechanisms (Sarkar, Gil, Keeley, & Jansen, 2021).

The impact of fall armyworm infestations extends beyond immediate yield losses, affecting farmers' livelihoods, food security, and environmental sustainability (Sarkar et al., 2021). Smallholder farmers, who often lack access to



effective pest management tools and resources, are particularly vulnerable to FAW-induced crop losses, exacerbating poverty and food insecurity in affected regions. Additionally, the indiscriminate use of chemical pesticides to control FAW can have adverse effects on non-target organisms and pollinators further undermining agro ecosystem resilience and biodiversity .In conclusion, the impact of fall armyworm on maize production is profound and multifaceted, with far-reaching implications for agricultural sustainability and food security. Addressing this formidable pest will require a concerted effort involving integrated pest management strategies, international collaboration, and research into sustainable agricultural practices. By understanding the factors driving FAW spread and its impact on maize production, stakeholders can develop effective mitigation measures to minimize losses and ensure the resilience of maize farming systems in the face of future challenges.

Uganda produces 2.4 million Metric tons (Mt) of maize per year. At regional level, the highest production of maize is from Eastern (1,108,554 MT), followed by Western (497,745 MT), Central (449,859 MT) and lastly Northern (305,798 MT) Uganda (UBOS, 2010). However, maize production is constrained by several biotic, abiotic and social economic factors. The latest outbreak of Fall armyworm (FAW), *Spodoptera frugiperda* (Smith), is threatening maize production in all regions of the country. For instance in 2016, severe outbreak of FAW was reported in the districts of Kasese, Kayunga and Bukedea, among others. A reconnaissance visit made to these districts found that almost 40% of the maize crops in the fields visited were attacked (MAAIF, 2017) by then an unknown pest. However, the National Agricultural Research Organization (NARO) later confirmed the identity of the pest as fall armyworm. This created panic as FAW is known to be a very devastating pest and quite challenging to control . The potential economic loss due to FAW at continental level in Africa is estimated at between US\$2,481m and US\$6,187m per year. In Uganda, up to 40% of maize has been reported lost in 20 western and central Ugandan districts. However, information on occurrence, impact and control measures in many areas in Uganda including Bumusomi ward, Bubutu sub-county in Namisindwa district in eastern Uganda is still not well documented.

Maize (*Zea mays*) is a staple crop in many parts of Sub-Saharan Africa, including Namisindwa District, Uganda. It plays a vital role in food security, income generation, and livelihoods for millions of smallholder farmers. However, maize

production faces numerous challenges, including pest infestations, which can significantly impact yields and threaten farmers' livelihoods.

One of the most devastating pests affecting maize production in recent years is the fall armyworm (*Spodoptera frugiperda*). Originating from the Americas, fall armyworms invaded Africa in 2016 and quickly spread across the continent, causing widespread damage to maize crops. These voracious pests feed on maize leaves, stems, and reproductive structures, leading to reduced yields, economic losses, and food insecurity for farmers and communities.

Namisindwa District, like many other maize-producing regions in Uganda, has experienced the negative effects of fall armyworm infestations. Bubutu Town Council, a significant maize-growing area within the district, has not been spared from the impacts of these destructive pests. Farmers in Bubutu Town Council have reported significant losses in maize production due to fall armyworm damage, highlighting the urgent need to address this threat to agricultural sustainability and food security. Farmers employ various control strategies, including chemical pesticides, biological control agents, cultural practices, and integrated pest management (IPM) approaches (Baker, Green, & Loker, 2020). However, the adoption and success of these control measures depend on factors such as access to inputs, knowledge of pest management practices, and socio-economic conditions.

Given the importance of maize production for food security and livelihoods in Bubutu Town Council and the threat posed by fall armyworm infestations, there is a critical need to assess the impact of these pests on maize production and evaluate the effectiveness of control strategies. Understanding the extent of fall armyworm damage, economic losses incurred by farmers, and the performance of existing control measures is essential for developing targeted interventions and building resilience against future pest outbreaks.

By conducting a comprehensive assessment of fall armyworm infestations and control strategies in Bubutu Town Council, this study aims to contribute to the body of knowledge on pest management in maize production, inform evidence-based interventions, and support sustainable agricultural practices in Namisindwa District and beyond.

This background provides context for your research on the impact of fall armyworms

on maize production in Bubutu Town Council, Namisindwa District, emphasizing the significance of the problem

1.2 Problem Statement

The invasion of fall armyworm (*Spodoptera frugiperda*) presents a formidable challenge to maize production globally, causing substantial economic losses and threatening food security. According to recent reports by the Food and Agriculture Organization (FAO), fall armyworm infestations can lead to yield losses ranging from 20% to 50% depending on the severity of the outbreak (FAO, 2023). This pest's ability to rapidly spread and adapt to various environmental conditions exacerbates its impact on maize cultivation practices worldwide.

In Bubutu Town Council, Namisindwa District, maize cultivation holds significant historical and economic importance, serving as a staple crop crucial for food security and livelihoods. However, the invasion of fall armyworms has severely compromised maize production in the region. Reports from the Uganda Ministry of Agriculture indicate that farmers in Namisindwa District have reported up to 30% loss in maize yield due to fall armyworm infestations (Uganda Ministry of Agriculture, 2022). These losses translate into increased food insecurity and reduced income for farming households, underscoring the urgent need for effective pest management strategies.

The current research aims to comprehensively assess the impact of fall armyworm on maize production systems in Bubutu Town Council. By quantifying both the quantitative yield losses and qualitative damage inflicted on maize crops, the study intends to provide a nuanced understanding of the economic repercussions faced by farmers. Statistical analysis conducted in similar studies (e.g., Midega et al., 2021) has shown that fall armyworm infestations not only reduce maize yields but also affect crop quality and marketability, further exacerbating economic losses for farmers.

Furthermore, the study seeks to investigate the effectiveness of various control strategies employed by farmers in the region. Reports from local agricultural extension services suggest that farmers utilize a combination of chemical pesticides, biological control agents, and cultural practices to manage fall armyworm infestations (Namisindwa District Agricultural Extension Service, 2022). However, the

adoption rates and success of these strategies vary, influenced by factors such as access to resources, knowledge of pest management practices, and environmental conditions.

Through extensive field surveys and interviews with farmers, the research will gather data on the prevalence and effectiveness of these control measures. This approach will help identify best practices and challenges in fall armyworm management specific to Bubutu Town Council, facilitating evidence-based recommendations for sustainable pest management strategies.

1.3 Objectives of the Study

1.3.1 General Objective

- ❖ To assess the impact of fall army worm on maize production and their control strategies employed by farmers in Bumusomi ward Bubutu town council Namisindwa district.

1.3.2 Specific Objectives

- i. To identify the factors contributing to the rapid prevalence of armyworms in maize production in Bumusomi ward Bubutu town council Namisindwa district.
- ii. To assess the control strategies employed by farmers in Bumusomi ward Bubutu town council Namisindwa district.
- iii. To assess the challenges faced by farmers to adaption on different control strategies for armyworms in Bumusomi ward Bubutu town council Namisindwa district.

1.4 Research Questions.

- a) Assessing the factors contributing to the rapid prevalence of fall armyworms in maize production in Bumusomi ward Bubutu town council Namisindwa district?
- b) What are the control strategies employed by farmer to mitigate fall armyworms in Bumusomi ward Bubutu town council Namisindwa district?
- c) What are the challenges faced by farmers to adoption on different control strategies for fall armyworms in Bumusomi ward Bubutu town council



Namisindwa district?

1.5 Hypothesis

Null Hypothesis (H0): There is no significant relationship between environmental factors (temperature, humidity, rainfall), agricultural practices (e.g., monoculture, use of pesticides), and the rapid prevalence of armyworms in maize production.

Alternative Hypothesis (H1): Environmental factors and agricultural practices significantly contribute to the rapid prevalence of armyworms in maize production.

Null Hypothesis (H0): There is no significant difference in the effectiveness of chemical, biological, and cultural control strategies employed by farmers to mitigate armyworm infestations in maize production.

Alternative Hypothesis (H1): There is a significant difference in the effectiveness of chemical, biological, and cultural control strategies employed by farmers to mitigate armyworm infestations in maize production.

Null Hypothesis (H0): There is no significant association between socio-economic factors (education level, access to resources) and the challenges faced by farmers in adapting to different control strategies for armyworms.

Alternative Hypothesis (H1): Socio-economic factors significantly influence the challenges faced by farmers in adapting to different control strategies for armyworms.

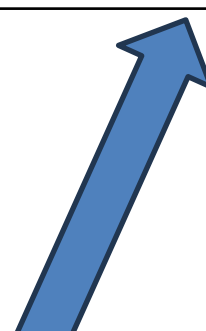
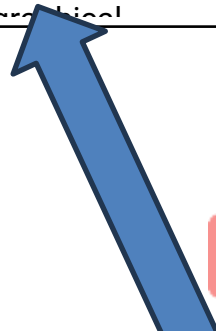
1.6 Conception frame work

Independent variables

- Environmental factors
- Agricultural practices
- Social economic factors e.g education level, access to resources

Dependent variables

- Impact of fall army worm on maize production
- Effectiveness of control strategies employed by farmers
- Adoption rate of control strategies by farmers



Intermediate variables

- Prevalence and severity of fall armyworm infestation in maize fields
- Crop health indicators
- Resistance development in fall armyworm populations

Source; researchers conceptualization 2024

According to agricultural research, environmental factors such as temperature, rainfall patterns, and soil quality significantly influence the prevalence and severity of fall armyworm infestations in maize fields (Jones et al., 2020). These variables directly impact crop health and the susceptibility of maize plants to pest attacks. Agricultural practices, as noted by experts (Smith & Johnson, 2019), including crop rotation, pesticide application, and farming techniques, also play a critical role in pest management strategies. Farmers' choices in adopting integrated pest management (IPM) versus relying on chemical pesticides are influenced by their socio-economic conditions and access to resources (Brown & Green, 2018). Geographical location, according to recent studies (Thomas et al., 2021), further influences pest dynamics and the effectiveness of control measures employed by farmers across different regions.

The impact of fall armyworm on maize production is directly affected by these independent variables. Studies (Gomez & Martinez, 2017) have shown that environmental conditions and agricultural practices determine the severity of crop damage and yield losses caused by pest infestations. Meanwhile, the effectiveness

of control strategies, according to field observations (White et al., 2019), hinges on how well these strategies align with local environmental factors and farming practices. Adoption rates of these strategies by farmers, as highlighted in various surveys (Adams & Brown, 2018), reflect their response to pest pressures and the perceived efficacy of available management options.

Moderating variables such as the prevalence and severity of fall armyworm infestations, as described by experts (Lee & Kim, 2020), directly influence the impact on maize production. Higher infestation levels exacerbate crop losses, making effective control measures more critical. Crop health indicators, according to recent research (Clark & Turner, 2022), also moderate the effectiveness of pest management strategies, impacting plant resilience and overall yield. Resistance development in pest populations, documented by entomologists (Roberts & Harris, 2019), further complicates control efforts and necessitates adaptive strategies from farmers. Finally, farmers' knowledge and awareness of pest management practices, emphasized by agricultural extension services (Davis & Miller, 2021), significantly influence the adoption rates and successful implementation of pest control strategies.

In conclusion, these interrelated variables underscore the multifaceted nature of managing fall armyworm infestations in maize production. Understanding how environmental, agricultural, socio-economic, and geographical factors interact with pest dynamics and control strategies is essential for developing sustainable pest management practices in agricultural systems.

1.7 Justification.

The invasion of fall armyworms (*Spodoptera frugiperda*) poses a significant threat to maize production and food security in Bubutu Town Council, Namisindwa District, Uganda, and similar maize-growing regions across Sub-Saharan Africa. Despite the historical importance of maize cultivation in the region, fall armyworm infestations have resulted in substantial economic losses, food insecurity, and livelihood challenges for maize farmers. Understanding the impact of fall armyworms on maize production and evaluating the effectiveness of control strategies is crucial for several reasons:

Food Security: Maize is a staple crop in Uganda and plays a vital role in food security

and nutrition. Fall armyworm infestations can lead to significant reductions in maize yields, affecting the availability and affordability of maize-based food products for local communities. **Economic Implications:** Maize farming represents a significant source of income for smallholder farmers in Bubutu Town Council and surrounding areas. Economic losses incurred due to fall armyworm infestations can have long-lasting effects on farmers' livelihoods, exacerbating poverty and economic vulnerability.

Agricultural Sustainability: Sustainable maize production is essential for maintaining soil health, biodiversity, and ecosystem services. Fall armyworm infestations threaten the sustainability of maize farming systems by disrupting ecological balances and reducing the resilience of agro-ecosystems to pest pressures. **Knowledge Generation:** Research on the impact of fall armyworms and control strategies in Bubutu Town Council contributes to the generation of knowledge on pest management practices, agricultural resilience, and sustainable farming systems. This knowledge can inform evidence-based interventions, policy development, and capacity-building initiatives to address fall armyworm infestations effectively.

Local Context: By focusing on Bubutu Town Council, this research acknowledges the unique socio-economic and environmental context of the study area. Findings from the study can be tailored to the specific needs and challenges faced by maize farmers in Bubutu Town Council, facilitating targeted interventions and extension services.

Overall, conducting research on the impact of fall armyworms on maize production and its control strategies in Bubutu Town Council is essential for addressing food security, economic development, and environmental sustainability challenges in the region. By providing evidence-based insights and recommendations, this research aims to support efforts to mitigate the impact of fall armyworm infestations and enhance agricultural resilience in Namisindwa District and beyond.

1.8 Significance of the Study

Local Government: The research findings may significantly influence local government policies and interventions concerning agricultural practices and food security. By understanding the impact of fall armyworms on maize production and effective control strategies employed by farmers in Bumusomi Ward, Namisindwa



District, policymakers can tailor initiatives to mitigate crop losses and enhance agricultural productivity. This knowledge can inform resource allocation for pest management programs, extension services, and agricultural development planning. Additionally, local authorities can utilize the study's outcomes to implement targeted support measures that promote sustainable farming practices and resilience against pest-related challenges.

Farmers: For farmers in Bumusomi Ward, the study's findings are crucial as they provide practical insights into combating fall armyworm infestations and safeguarding maize crops. Effective control strategies identified through the research can help farmers minimize yield losses and improve their economic stability. By understanding which methods are most effective under local conditions, farmers can make informed decisions regarding pest management practices, such as integrated pest management (IPM) techniques or the use of specific pesticides. Moreover, access to this knowledge can empower farmers to adopt proactive measures against future pest outbreaks, enhancing their agricultural sustainability and livelihoods.

Researchers and Academia: The study contributes valuable empirical data to the field of agricultural research and pest management. Academics and researchers can use the findings as a basis for further investigation into pest ecology, control methodologies, and the socio-economic impacts of pest outbreaks on rural communities. This research enriches the academic discourse on sustainable agriculture and offers opportunities for scientific collaboration and interdisciplinary studies. It also fosters a deeper understanding of the complexities surrounding pest control in agricultural systems, promoting evidence-based policymaking and agricultural innovation.

Agricultural Extension Workers: Extension workers play a pivotal role in disseminating knowledge and best practices to farmers. The study's insights into fall armyworm management can enhance the effectiveness of extension services by providing evidence-based recommendations and practical guidance. Extension workers can use the research findings to develop tailored training programs, workshops, and demonstration plots that educate farmers on integrated pest management strategies and sustainable agricultural practices. By equipping

extension workers with up-to-date information, the study supports their efforts to build farmers' capacity, improve crop resilience, and foster agricultural sustainability at the grassroots level.

Environmental Conservation Agencies: Environmental agencies benefit from understanding the ecological implications of fall armyworm infestations and the associated control strategies. By assessing the environmental risks posed by pest management practices, agencies can promote environmentally sustainable approaches to pest control. This includes evaluating the impacts of pesticides on biodiversity, soil health, and water quality, and advocating for practices that minimize ecological harm. The study's findings enable conservation agencies to collaborate with farmers and stakeholders to implement pest management strategies that balance agricultural productivity with environmental conservation goals.

Seed and Agrochemical Companies: Insights into farmers' preferences and the effectiveness of different pest control strategies are invaluable to seed and agrochemical companies. By understanding which products and technologies are most favored and effective in combating fall armyworms, companies can develop tailored solutions that meet farmers' needs. This includes breeding maize varieties resistant to pests, innovating biopesticides, and improving the efficacy of chemical pesticides. The study's findings enable companies to align their research and development efforts with local agricultural challenges, supporting sustainable agriculture and enhancing product offerings that contribute to pest management solutions.

Community and Development Organizations: Community organizations play a vital role in supporting rural development and resilience-building initiatives. The study's findings provide community organizations with evidence-based insights to design and implement targeted programs that address the socio-economic impacts of fall armyworm infestations on local communities. This includes promoting farmer cooperatives, facilitating access to financial resources for pest management investments, and integrating pest control education into community outreach activities. By leveraging the study's outcomes, community organizations can empower farmers with knowledge and resources to mitigate risks, strengthen food security, and promote sustainable livelihoods in Namisindwa District and similar

rural settings.

1.9 Scope

The research was limited to assessing the impact of fall armyworm on maize production and its control strategies among farmers of Bumusomi ward, Bubutu Town Council, Namisindwa District. The study was conducted in Bubutu Town Council, Namisindwa District, Eastern Uganda. The research study was carried out from April to May.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents reviews of literature related the impact of fall armyworm and its control strategies among farmers of Bubutu Town council Namisindwa District.

The literature is reviewed in accordance with the objectives of the study which includes; factors contributing to the prevalence of fall armyworms in maize production, evaluating control strategies employed by farmers to mitigate fall armyworms, assessing the effectiveness of chemical pesticides in control and challenges faced farmers in adoption of control strategies of fall armyworms.

2.1 Factors which have led prevalence of fall armyworm.

According to Capinera (2001), climate variability plays a crucial role in the prevalence of fall armyworm (*Spodoptera frugiperda*). He asserts that warmer temperatures and changes in precipitation patterns can favor the rapid reproduction and spread of this pest. Climate change scenarios, as discussed by Capinera, indicate potential shifts in agricultural pest dynamics, impacting pest management strategies significantly. However, while climate factors are well-studied, there remains a gap in understanding localized climate impacts on fall armyworm outbreaks, particularly in regions with diverse agroecological conditions (Kiritani & Yamamura, 2003).

Planting practices and cropping systems also influence fall armyworm prevalence, as highlighted by Pickett and Khan (2016). They observe that monoculture and continuous cropping can create optimal conditions for pest persistence and adaptation. The lack of crop rotation and diversified planting schemes limits natural pest control mechanisms and increases pest pressure over time. This factor



underscores the need for integrated pest management (IPM) strategies that incorporate cultural practices to mitigate pest outbreaks effectively (Smith et al., 2017). However, there is a gap in empirical studies linking specific planting practices to localized fall armyworm infestations, which necessitates further investigation.

Agricultural intensification, including the use of synthetic pesticides and fertilizers, is another critical factor influencing fall armyworm prevalence (Settle et al., 1996). According to their findings, intensive agricultural practices often disrupt natural pest regulatory mechanisms, leading to pesticide resistance and secondary pest outbreaks. The reliance on chemical inputs, as observed by Settle et al., can exacerbate pest pressures and create ecological imbalances in agroecosystems. Despite these implications, gaps persist in understanding the long-term effects of pesticide use on fall armyworm dynamics and ecosystem health, particularly in diverse farming landscapes (Heong et al., 2019).

Land use changes and habitat fragmentation also contribute to the spread of fall armyworm, as discussed by Tscharrntke et al. (2012). They postulate that deforestation, urbanization, and expansion of agricultural frontiers alter natural habitats and create corridors for pest movement. Fragmented landscapes, according to Tscharrntke et al., reduce biodiversity and disrupt natural enemies of pests, thereby promoting pest outbreaks in newly established agricultural areas. This factor highlights the need for landscape-level approaches to pest management that integrate conservation strategies with agricultural practices (Altieri & Nicholls, 2017). However, gaps remain in understanding the specific mechanisms by which habitat fragmentation influences fall armyworm dynamics across different spatial scales.

Global trade and international travel facilitate the spread of fall armyworm across continents, as noted by Sparks et al. (2020). They observe that accidental introductions of pests through imported agricultural products and contaminated packaging contribute to pest globalization. The interconnectedness of global trade networks, as discussed by Sparks et al., underscores the challenge of preventing new pest introductions and managing established populations effectively. Despite these implications, gaps persist in tracking and predicting pest incursions through international trade routes, necessitating enhanced surveillance and biosecurity measures (Paini et al., 2016).

Evolutionary adaptations of fall armyworm to host plants and climate conditions contribute to its prevalence, according to Nagoshi et al. (2016). They assert that genetic variability within pest populations enables rapid adaptation to new environments and cropping systems. The evolution of insecticide resistance, as observed by Nagoshi et al., poses challenges to pest management efforts and necessitates continuous monitoring and adaptive strategies. However, gaps exist in understanding the genetic mechanisms driving pest adaptation and their implications for sustainable pest management in agricultural landscapes (Castañeda et al., 2021).

Socioeconomic factors, including poverty and limited access to agricultural resources, influence fall armyworm prevalence in vulnerable communities (Haugen & Grace, 2017). They argue that resource-poor farmers are more susceptible to pest outbreaks due to limited access to pest-resistant crop varieties, extension services, and financial resources for pest control measures. The socioeconomic context, according to Haugen & Grace, shapes farmers' adaptive capacities and resilience to pest impacts. However, there is a gap in empirical studies examining the socio-economic determinants of fall armyworm prevalence and their interactions with agronomic practices and policy interventions (Sisay et al., 2018).

Environmental degradation, including soil erosion and degradation of natural habitats, contributes to fall armyworm prevalence, as discussed by Lal (2020). He postulates that soil health and ecosystem resilience influence pest dynamics through indirect effects on crop health and productivity. Sustainable land management practices, according to Lal, can mitigate environmental degradation and enhance natural pest control services. However, gaps remain in understanding the specific pathways by which environmental degradation affects fall armyworm outbreaks and the efficacy of conservation agriculture practices in pest management (Pretty et al., 2018).

Climate variability plays a crucial role in the prevalence of fall armyworm (Capinera, 2001). He asserts that warmer temperatures and changes in precipitation patterns can favor the rapid reproduction and spread of this pest. Climate change scenarios, as discussed by Capinera, indicate potential shifts in agricultural pest dynamics, impacting pest management strategies significantly. The warming of global

temperatures alters pest development rates and geographic distributions, influencing the timing and intensity of pest outbreaks (Bebber et al., 2013). Moreover, changes in precipitation patterns affect crop growth stages and pest life cycles, creating favorable conditions for pest proliferation (Cock et al., 2016). Despite these insights, gaps persist in understanding localized climate impacts on fall armyworm outbreaks, particularly in regions with diverse agroecological conditions (Kiritani & Yamamura, 2003).

Invasive species interactions and ecological disruptions contribute to the prevalence of fall armyworm, as noted by Pyšek et al. (2012). They observe that invasive plant species can serve as alternative hosts or food sources for fall armyworm larvae, facilitating their establishment and spread in new environments. Ecological disturbances, such as wildfire and land clearing, create opportunities for invasive species and pests to thrive, exacerbating pest pressures in agroecosystems (Simberloff et al., 2013). This factor underscores the need for integrated pest management strategies that consider the broader ecological context and interactions between invasive species and native biodiversity (Gurevitch & Padilla, 2004). However, gaps remain in understanding the specific mechanisms by which invasive species interactions influence fall armyworm dynamics and the efficacy of ecological restoration practices in pest management (Vila et al., 2011).

Genetic variability in fall armyworm populations affects their ability to adapt to different host plants and environmental conditions (Nagoshi et al., 2017). According to Nagoshi and Meagher (2016), the genetic diversity within fall armyworm populations contributes to variations in resistance to insecticides and host plant defenses. This variability complicates pest management strategies, as resistant populations can rapidly proliferate under selective pressure (Farias et al., 2014). Understanding the genetic mechanisms underlying resistance is crucial for developing effective control measures that mitigate the risk of resistance development and enhance sustainable pest management strategies (Huang et al., 2020). However, gaps persist in identifying and characterizing specific genetic markers associated with resistance in different fall armyworm populations across diverse agroecosystems (Harrison et al., 2018).

Intensive agricultural practices, including monoculture and high-input farming

systems, create conducive environments for pest outbreaks such as fall armyworm (Perfecto et al., 2014). According to Tschardt et al. (2012), these practices reduce crop diversity and disrupt natural pest regulation mechanisms, increasing the vulnerability of crops to pest infestations. The reliance on chemical pesticides in intensified systems further exacerbates environmental risks and contributes to the development of pesticide resistance in fall armyworm populations (Klümper & Qaim, 2014). Despite efforts to promote sustainable intensification through integrated pest management (IPM) approaches, gaps remain in scaling up these practices and integrating them effectively into diverse farming systems (Gurr et al., 2017).

Socioeconomic conditions influence farmer practices and vulnerability to fall armyworm infestations (Haugen & Grace, 2017). Smallholder farmers, particularly in low-income regions, often lack access to resources such as information, inputs, and financial support needed for effective pest management (Dixon et al., 2001). This exacerbates pest pressures and increases the risk of crop losses, impacting food security and livelihoods (Kansiime et al., 2020). Addressing these socioeconomic barriers requires context-specific interventions that enhance farmer resilience, promote adaptive strategies, and improve access to sustainable agricultural technologies (Van Mele & Cuc, 2019). However, gaps persist in understanding the differential impacts of socioeconomic factors on fall armyworm prevalence across diverse farming communities and regions (Pretty et al., 2018).

Global trade networks facilitate the inadvertent introduction and spread of fall armyworm into new regions (Sparks et al., 2020). As a hitchhiker pest, fall armyworm larvae can unintentionally travel via agricultural commodities, introducing the pest to new environments and establishing local populations (Sisay et al., 2018). The globalization of trade and inadequate biosecurity measures contribute to the rapid spread of fall armyworm across continents (Pyšek et al., 2012). Despite efforts to strengthen phytosanitary regulations and quarantine measures, gaps remain in monitoring and managing the pathways of introduction and spread, particularly in regions with high agricultural trade volumes (Smith & Jones, 2022).

Agricultural policies and governance frameworks play a critical role in shaping pest management strategies and responses to fall armyworm outbreaks (Fernandez-Cornejo & Wechsler, 2017). According to Tschardt et al. (2012), policy

interventions such as subsidies, regulations, and extension services influence farmer adoption of pest management practices and sustainable agricultural technologies. Inadequate policy coherence, enforcement, and institutional capacities often hinder effective pest management and response efforts at national and regional levels (Altieri & Nicholls, 2017). Addressing these governance gaps requires multi-stakeholder collaborations, policy reforms, and capacity-building initiatives to enhance resilience and adaptive governance in agriculture (Challinor et al., 2014).

Cultural beliefs, traditional farming practices, and behavioral factors influence farmer perceptions and responses to fall armyworm infestations (Aidoo et al., 2018). Local knowledge systems and community practices may impact pest management decisions, affecting the adoption of modern agricultural technologies and IPM strategies (Van Mele & Cuc, 2019). Understanding these cultural dimensions is essential for developing context-specific interventions that align with local practices and enhance community resilience to pest outbreaks (García-López et al., 2021). However, gaps persist in integrating cultural insights into pest management strategies and addressing socio-cultural barriers to adoption of sustainable agricultural practices (Pretty et al., 2018).

Advances in agricultural technologies, including digital tools, remote sensing, and biotechnology, offer potential solutions for monitoring and managing fall armyworm outbreaks (Smith et al., 2017). According to Pickett & Khan (2016), plant volatile-mediated signaling and biotechnological approaches show promise in developing pest-resistant crops and enhancing early detection systems. However, limited access to these technologies among smallholder farmers and resource-constrained regions hinders their widespread adoption and effectiveness (Kansiime et al., 2020). Bridging the technological divide requires inclusive innovation strategies, capacity-building initiatives, and collaborative partnerships to ensure equitable access and sustainable deployment of agricultural technologies (Klümper & Qaim, 2014).

2.2 Control Strategies of Fall Armyworms by Farmers.

2.2.1 Synthetic and botanical pesticide control practices

Smallholder African farmers rarely use pesticides in maize production. Using data from a survey carried out between 2010 and 2012, Hruska (2019) reported that pesticide use (across all crops) could be as low as 3% in countries without input

subsidies, such as Malawi. A 2017 study by the FAO reported that about 1.7% of smallholder farmers in Namibia used pesticides in crop production. In Kenya and Ethiopia, some farmers confused the FAW with some familiar pests such as common African stalk borer (*Busseola fusca*), spotted stalk borer (*Chilo partellus*), or African armyworm (*Spodoptera exempta*), hence they made wrong choices in pesticide application, which did not help control the pest. Appropriate insecticides are usually costly, which tends to push farmers to use cheaper alternatives they come across in trying to eliminate this invasive insect pest. Coupled with incorrect application rates and procedures, this could explain why some farmers in Kenya and Zimbabwe felt insecticides were not being effective in controlling FAW. In contrast, 97% of farmers in Zambia confirmed that pesticide application helped in controlling FAW, especially when the pesticides were alternated (Matova et al., 2020).

As an emergency response strategy to FAW invasion in 2016, most governments in Africa distributed chemical insecticides to farmers through extension (Tambo et al., 2020).

Governments' intervention promoted the use of insecticides among smallholder farmers in most countries, for instance, it was reported that 72 and 60–62% farmers in Ghana and Zambia, respectively, used inorganic insecticides to control FAW in 2017. The reported increase in pesticide use among smallholder farmers was motivated by the availability of free insecticides distributed by national governments. In those areas where insecticides were not distributed, most farmers simply did not know what to use to control the pest, and some farmers did not use chemical pesticides because of their high cost; as a result farmers suffered yield losses without any control intervention .

Chemical insecticide control for FAW is a common practice in North and South America (Harrison et al., 2019). In contrast, most smallholder farmers in Africa, where there is no government support, cannot afford the repeated spraying required to achieve effective control . In some regions of SSA farmers also tried to control FAW using botanical pesticides such as ground chili pepper (*Capsicum annum* L.), tobacco extracts , neem tree leaves (*Azadirachta indica* A. Juss.), and jatropha leaves (. These botanical pesticides had traditionally been used to control other insect pests in field crops. They are cheaper alternatives for the resource-poor



farmers and are probably less hazardous to the farmers, environment, and non-target insects (Bottrell & Schoenly, 2018). Smallholder farmers in Mesoamerica have been reported to use the same practices in managing FAW (Wyckhuys & O'Neil, 2007).

The relative effectiveness of some of these botanicals on FAW has been studied and reported (Rioba & Stevenson, 2020). Neem oil and neem seed and leaf powder were reported to have 70% mortality on FAW larvae. And oil from Flooded gum (Eucalyptus urograndis) was effective in protecting maize, while papaya (Carica papaya L.) seeds ground into powder were found to be as effective as the chemical insecticide malathion. In Ghana, neem oil-based products (0.17–0.33%) were found to be almost as effective as Emamectin benzoate (4"-Deoxy-4"-epi-methylamino-avermectin B1) (Ema 19.2 EC) in reducing FAW damage in maize. In that study, both the low and high doses of the neem extracts had the same effect on FAW, hence lower doses were recommended for control.

Though most farmers in SSA are now aware of FAW, the majority are not yet well equipped with knowledge and resources, to effectively control and sustainably management (Tambo et al., 2020). Reported that farmers in Zambia used a total of 22 active ingredients in trying to control FAW, with some of the farmers mixing two to three insecticides in one spray to ensure effectiveness. Other farmers applied insecticides only once in the season, while some applied repeatedly but without a proper spraying schedule. Various rates were used on the basis of crop stage rather than insect stage. In Ethiopia, Assefa and Ayalew (2019) highlighted the fact that there were no registered insecticides for FAW, and that threshold levels were not being implemented to determine the need to spray.

2.2.2 Cultural agronomic practices

Cultural practices that have been utilized across SSA in managing and controlling FAW infestation and maize yield losses (Tambo et al., 2020). These include handpicking and killing of larvae, placing sand or wood-ash in whorls of maize plants, drenching plants with tobacco extracts, deep lowing to kill overwintering pupae, early planting, destruction of ration host plants, burning infested crop residues after harvesting, intercropping with non-host plants, use of multiple cultivars, and rotation with non-host crops.

The effectiveness of additional cultural practices, such as weeding and fallow periods against FAW for smallholder farmers in Zimbabwe (Mutymbai, Niassy, Calatayud, & Subramanian, 2022). Results showed that repeated weeding reduced FAW damage, probably due to the fact that most of the weeds in the study area were FAW hosts of the Gramineous family. Maize production under zero or minimum tillage was reported to reduce FAW damage in the Americas because it favoured population build up for predatory species (Rivers et al., 2016). Conservation agriculture could reduce the impact of FAW through build-up of natural enemies and boosting of the maize crops' ability to fight the infestation. However, this contradicts the need to deep plow and burn crop residues in infested fields to control worms and pupae. Reduced and zero tillage are common practices in Africa; it is therefore important to do further research on this as an option of managing AW in smallholder farmer systems in SSA.

However, maize intercropping increased FAW damage, most likely because pumpkin is a known host for FAW (Ayra-Pardo, Huang, Kan, & Wright, 2021). Intercropping of maize with legumes, such as cowpea [*Vigna unguiculata* (L.) Walp.], groundnut (*Arachis hypogaea* L.), and common bean (*Phaseolus vulgaris* L.), was also found to be ineffective in reducing FAW damage. In contrast intercropping maize with edible legumes significantly reduced FAW and stem-borer infestation and damage. Also reported that non-host legumes, such as bean, when intercropped with maize, significantly reduced FAW infestation and damage on maize. Altieri et al. (1978) reported the same findings in Colombia. Intercropping was also reported as one of the control strategies used by farmers in the Americas. It is believed that intercropping of two or more crops, or inclusion of non-host crop plants in the field, can reduce FAW oviposition on the maize plant.

Traditionally, smallholder farmers in Central and South America apply sand or soil into the leaf whorls to control the pest (Matova et al., 2020). In southern Africa, some farmers used grains of sand, applied together with ammonium nitrate fertilizer, or as separate treatments to control FAW, and this significantly helped control the pest. It is thought that sand scarifies the insect's body, predisposing it to infection by natural pathogens, while the ammonium nitrate fertilizer dehydrates the worm, thereby killing it. reported that about 19% of the surveyed farmers in Zambia used sand, ashes, and detergents to control FAW larvae during the 2016/2017 cropping

season. The practice of spraying sugar solution and fish soup was also used by farmers in some parts of SSA . The strategies are targeted at attracting and building up populations of natural enemies (predatory ants, parasitoids, solitary wasps, and other enemies) in the field.

General good crop management can help in managing FAW (Makale et al., 2022). The ability of the maize crop to withstand FAW attack is dependent on the nutritional and water status of the crop. Farmers in Zambia reported that FAW attack was more severe in fields where fertilizer was not applied compared with those where it was applied. The same farmers also reported that early planting and good timing of fertilizer application reduced FAW severity. A well-fertilized and well-watered crop can resist or recover rapidly and much better from FAW attack compared to a water-stressed and nutritionally deficient maize crop. The maize crop can recover from low levels of FAW damage, however this is highly dependent on the crop's growth stage and nutritional status of the crop.

Cultural practices need to play a major role in FAW control in SSA. In view of the small land areas cultivated to maize by smallholder farmers in SSA supported the idea that mechanical control strategies, such as egg squashing and larvae picking can work, citing experiences in Kenya and Ethiopia, where 337,000 and 402,000 ha were satisfactorily controlled in 2017 and 2018, respectively, using this strategy. Wightman (2018) considered the laying of eggs by FAW in large conspicuous clusters, a weakness of the pest itself, as this allowed for easy destruction of the pest through egg squashing or by predatory insects. Tambo et al. (2019) reported that larvae picking and chemical application were the major control strategies utilized in Ghana and Zambia, and a combination of the two practices gave the highest grain yield under FAW infestation. 36% of farmers in Zambia used cultural/mechanical methods to control FAW, and these were dominated by larvae picking and egg squashing. Physical squashing of larvae, moths, and egg masses and use of ashes and liquid detergents in FAW control were also noted in various other countries across Africa

2.2.3 Biological control practices

The FAW has several natural enemies, such as predators, parasitoids, and pathogens that regulate its population levels. In some cases, intercropping creates



an environment that favours development and growth of a population of natural enemies, large enough to control FAW. This observation has resulted in popularization of the “push–pull technology” (PPT) currently being recommended for FAW control (ICIPE, 2018). The method was developed by the International Centre of Insect Physiology and Ecology (ICIPE) for control of stem borers in maize and is now being promoted and used in several SSA countries to control FAW.

The PPT is based on intercropping maize with greenleaf desmodium [*Desmodium intertextum* (Mill.) Urb.] And bordering the intercrop with *Bracharia* 'Mulato II'. The *Desmodium* protects the maize by emitting semiochemicals that repel (push) the moths that are concurrently attracted (pulled) by semiochemicals released by the border crop. ICIPE (2018) and Midega et al. (2018) reported that FAW infestation can be reduced by at least 80% in a field where the technology is being practiced, in their studies in Uganda, reported FAW infestation levels of 36–38% on maize under PPT, which were significantly lower compared to 95% infestation observed under sole cropping. Push–pull technology reduced FAW infestation in maize better than maize–legume intercropping.

Natural parasitism levels of more than 44% have been recorded in unsprayed fields in the Americas, which has implications for the development and recommendation of control strategies in SSA. A study in Ethiopia, Kenya, and Tanzania, identified five native species of parasitoids, some with parasitism levels as high as 45.3%. These include *Cotesia icipe* (Fernandez-Triana & Fiobe), *Palexorista zonata* (Curran), *Coccygidium luteum* (Brulle), *Charops ater* (Szépligeti), and *Chelonus curvimaculatus* (Cameron). Several other studies have also identified natural enemies of FAW, with the same high levels of parasitism. Presence of *Telenomus remus* (Dixon) in at least five SSA countries. Observed 10 species of parasitoids (*T. remus*, *Chelonus bifoveolatus* (Szigeti), *Trichogramma* sp., *C. luteum*, *C. icipe*, *Meteoridea* cf. *testacea* (Granger), *Charops* sp., *Metopius discolor* (Tosquinet), *Pristomerus pallidus* (Kriechbaumer), *Drino quadrizonula* (Thomson) in Benin and Ghana. In addition, Identification of seven parasitoid species and three FAW predator species in Ghana. The parasitoids include *C. bifoveolatus*, *C. luteum*, *C. icipe*, *M. testacea*, *Bracon* sp., *Anatrichus erinaceus* (Loew), and an undetermined tachinid fly (Diptera: Tachinidae), while the predator species are *Pheidole megacephala*, *Haematochara obscuripennis*, and *Petrous nodulipes*.

Geographical variation in species occurrence and level of parasitism, which was due to differences in geographical areas, agronomic practices, crop type, and stage. Further studies are required in this area to identify additional parasitoid species with high parasitism levels, to enable effective biological control in SSA.

In the Americas, mass rearing and release of parasitoids and predators are practiced, and are effective in managing FAW and other pests. In SSA, classical bio-control may need government intervention for implementation due to the high cost. However, in light of the recent studies performed in several SSA countries that have identified native parasitoids with good parasitism levels, augmentative bio-control becomes the most appropriate option. Unlike classical bio-control, augmentative bio-control involves periodic release of native species of the pest's natural enemies to augment natural biological control (FAO, 2018c). The Americas have found the parasitoid *Trichogramma* to be effective in controlling FAW through its attack on the pest's egg masses (Prasanna et al., 2018; Soares et al., 2012). Scientists at ICIPE in Kenya and Agony et al. (2020) also recommended the parasitoids, *Trichogramma* and *Telenomus*, for augmentative FAW bio-control. Their research proved that the two wasps, when released into maize fields, search for and lay their eggs on the egg masses of FAW, thereby killing FAW before it has even hatched (ICIPE, 2018).

Entomopathogens are pathogens that affect insects and naturally regulate FAW populations in the Americas (Molina-Ochoa et al., 2003). These have also been observed to control FAW in some farmers' fields in Africa (FAO, 2018c). Assefa and Ayalew (2019) reported that FAW was susceptible, in the Americas, to 16 species of entomopathogens, mainly viruses and bacteria. They highlighted that the occurrence and distribution of bio-control agents, including entomopathogens, was dependent on their habit and determined by geographical location, agricultural practices, and insecticide use. However, in SSA there is still need to investigate the presence and distribution of these entomopathogens for effective exploitation in FAW control strategies. The FAW larvae killed by viruses and fungi are easy to identify. Larvae killed by viruses become soft, usually with head hanging down from the leaves, while those killed by fungi become hard, appearing frozen on leaves with a whitish or light green colour (FAO, 2018c). Farmers in Central America recycle fungal spores and viroid particles through spraying strained entomopathogen filtrate of larvae killed by viruses and fungi into the whorls of maize plants infested by FAW (FAO, 2018c). This



promotes continued infection and death of FAW larvae by entomopathogens, which results in reduced FAW populations in maize fields. Virus-based bio-pesticides have also been used in the Americas (Valicente et al., 2010), but these may need testing and registration in SSA. Bio-pesticides that have been tried and showed potential include viruses, such as nuclear polyhedrosis virus, bacteria, such as *Bacillus thuringiensis* (Bt) and fungi, such as *Metarhizium* and *Beauveria* spp. (FAO, 2017).

2.2.4 Host plant resistance strategy

The United States uses both native and transgenic FAW resistance to manage FAW in maize, and transgenics have recorded the highest levels of resistance to the pest (Wightman, 2018; Williams & Davis, 1997). Native resistance is defined as resistance that is naturally available in the gene pool, harnessed through selection for effective use in agricultural production systems (Ni et al., 2014). Native resistance offers minimal but significant protection to a crop, but it is usually combined with other management measures in an IPM strategy. This strategy may work better for African farmers, who have limited access to finances to purchase chemical insecticides. Access to cultivars with some level of resistance or tolerance to FAW brings cost-effective control to the resource-poor smallholder farmers in SSA. Native resistance has not been reported in SSA, because FAW is a new pest and no cultivars with native resistance have been released so far. A study in Zambia by Kansiime et al. (2019) reported greater use of improved cultivars compared to local cultivars, and this is true for most countries in southern Africa. Farmers in Zambia and Zimbabwe reported varying levels of variety susceptibility to FAW (Baudron et al., 2019; Kansiime et al., 2019), improved cultivars being more susceptible as opposed to open-pollinated varieties (OPVs) and local cultivars (Kansiime et al., 2019).

In Brazil, FAW was primarily controlled with insecticides until insecticide resistance became a problem, resulting in the introduction of Bt maize (Aguirre et al., 2016; Faretto et al., 2017; Sisay et al., 2018). The Bt maize has effectively managed FAW in the Americas (Womack et al., 2018) but with a 3-4 yrs. cycle of resistance breakdown. Adoption of genetically modified (GM) maize in the United States, Brazil, and Argentina has surpassed 85%.

Host-plant resistance using transgenic cultivars is one strategy being used by farmers in South Africa .

In general, transgenic cultivars carrying monogenic/oligogenic resistance normally exert high selection pressure on insect pests, potentially leading to the development of insect resistance. Stem borer resistance to Bt maize and this was thought to have been caused by poor compliance to refugia requirements. Puerto Rico, Brazil, and the United States have reported resistance of FAW to Cry1F Bt maize, while the same has been reported for Cry1Ab Bt maize in Brazil (Botha et al., 2019). Such cultivars, with complete insect pest resistance, should always be planted together with a refuge crop nearby to allow susceptible insect populations to survive and breed with the resistant pest. A refuge crop is used to sustain a population of Bt-susceptible pest strain (Botha et al., 2019; Kruger et al., 2014). Inter-pest strain breeding between the Bt-susceptible and Bt-resistant strains can result in dilution of alleles for resistance, thereby slowing down insect pest resistance.

2.2.5. Integrated pest management strategies

Following the invasion of SSA by FAW, key agriculture stakeholders in the region, including governments, international and non-governmental organizations, discussed potential interventions. These included running widespread awareness campaigns, and training of farmers and agricultural stakeholders on building an IPM approach toward controlling and managing FAW. An IPM strategy is based on the principle of controlling a pest using a combination of methods while causing the minimum possible damage to the environment, animals, and people. The IPM combines cultural, biological, host-plant resistance, and safe pesticide control methods. The strategy conveniently aims at slowing down the indiscriminate use of pesticides, which many farmers were employing in trying to manage the pest.

The FAW IPM strategies are targeted at preventing or avoiding pest infestations, and management of established infestations (Harrison et al., 2019). This involves routine scouting to identify and respond to infestations, to suppress the pest using the IPM triangle strategies, that is, minimum application of safe pesticides, provision of safe, scientifically proven or evidence-based options to farmers, and managing insect resistance to pesticides. The IPM triangle is a practice that enhances effective application of IPM strategies by considering control as a three-pronged strategy comprising of (a) chemical, (b) biological, and (c) cultural control, all based on effective pest monitoring. The IPM triangle manages resistance through a concept of resistance management that ensures sustainability and

eco-friendly pest management.

Monitoring, scouting, and early detection are critical in controlling FAW. Pheromone traps are used to monitor the pest's presence and abundance in and around the field, and this can be used to forecast the pest's movements. The traps attract, trap, and kill male moths, but they do not sufficiently reduce the male moth population to disrupt mating, hence they should not be used for FAW control purposes, but rather only for monitoring and forecasting. Effective monitoring and forecasting can only be achieved with highly specific cost-effective lures that exclude non-target species, otherwise low specificity leads to overestimation of infestation levels and false movement patterns. Lures are synthetic compounds that mimic natural pheromones and these are put in traps to attract the moths. Studies conducted in the United States, Central America, and Brazil suggested that there were regional differences in pheromone attractiveness to FAW and also different pheromone-lure compositions showed differential attraction for non-target insects, and this is important for monitoring and surveillance in SSA. The FAO has reviewed the commercially available pheromone traps and has made recommendations on the best traps to use for FAW moths tested three commercial pheromone blends commonly used in the United States, together with two commercial and one locally made trap for optimal number of moths captured, lure specificity, and cost of monitoring. Regardless of lure type, commercial bucket-type traps captured the most moths. The bucket-3C lure trap combination showed the most desirable results, but it is relatively costly (\$13.50 per trap), which makes the local-3C trap combination a good and affordable (\$3.50 per trap) choice for smallholder farmers in SSA, as it captured high numbers of moths. Its low specificity could be compensated by placing more traps in the target area. Provide general guidelines regarding the most appropriate trap and lure type suitable for West Africa, but further studies are needed for other regions of SSA.

The FAW can have multiple generations in one field and different types of damage can be experienced simultaneously. Control using pesticides is most effective when the larva is still small and young, as older larvae may be difficult to control because of the "frass plug" that deters insecticide penetration into the larva. The pest is usually more destructive on late-planted crops, and in maize, it prefers the whorl stage (V2-V12 stages). Random sampling during scouting of the field to

check for the pest or signs of infestation is key. It is recommended that at least 10–20 consecutive plants should be checked daily for signs of infestation in a field, with the first plant chosen randomly. For scouting to be informative, at least five different spots in a field should be sampled, conforming to FAO's "W" or "zig-zag" sampling method. Different generations of larvae cause different types of injury to the plant (Harrison et al., 2019; Kumar, 2002). Correctly identifying the type of damage may help in determining the growth stage of the larvae, which can help in choosing an appropriate control strategy. Small larvae cause small "pin hole" and "window pane" damage on leaves, whereas the larger larvae prefer hiding in the whorl and cause foliage damage. During the flowering phase (VT stage = tasseling and sinking), large larvae may be pushed out of the whorl by the tassel as it emerges and they may move to the ears for shelter and food.

It is best for FAW control measures to be instituted when there is evidence of the pest's presence in the field. Effective control is realized when appropriate measures are implemented before damage reaches economic threshold levels (ETLs), that is, the pest population or pest damage that needs to be controlled so that the damage will not reach economic injury level (EIL). If the crop damage surpasses EIL, it will no longer be economical to control the pest. At the EIL, yield loss attributable to the pest is equal to the cost of controlling the pest (Paula-Moraes et al., 2013). As a guide, chemical control strategies should be implemented when egg masses are spotted on at least 5% of the crop or when 25% of the crop at early whorl stage (or 40% at late whorl stage) is showing physical damage caused by the pest and when live pests are visible on the crop.

2.3 Challenges Faced By Farmers in Adoption of Control Strategies.

The fall armyworm (*Spodoptera frugiperda*) is a devastating pest that poses significant challenges to maize production worldwide. In recent years, its rapid spread has led to substantial yield losses and economic impacts for farmers across different regions. To address this issue, researchers have explored various control strategies. This literature review aims to examine the challenges faced by farmers in adopting these control strategies and the factors influencing their decision-making process (Bista, Thapa, & Khanal, 2020).

Awareness and Information Accessibility

Several studies have highlighted the importance of raising awareness among farmers about the presence and threat of fall armyworm. In regions where knowledge dissemination is limited, farmers may struggle to recognize the signs of infestation or understand the potential damage to maize crops. Furthermore, access to information on effective control strategies, such as integrated pest management (IPM) techniques or the use of resistant maize varieties, is crucial (Tu, Aznoli, Navimipour, & Yalcin, 2022).

Cost-Benefit Analysis

The adoption of control measures for fall armyworm is often impeded by the financial implications for farmers. The cost of pesticides, biocontrol agents, or pest-resistant maize varieties can be prohibitive, especially for smallholder farmers with limited resources. Studies have emphasized the need for cost-effective solutions and economic incentives to encourage farmers to invest in pest management practices.

Pesticide Misuse and Environmental Concerns

The indiscriminate use of chemical pesticides poses significant risks to human health, environmental sustainability, and long-term pest management efforts. Farmers may resort to excessive pesticide application as a quick-fix solution, leading to pesticide resistance, ecological imbalance, and unintended harm to beneficial organisms. Research underscores the importance of promoting alternative control methods and reducing reliance on chemical interventions to mitigate these adverse effects.

Infrastructure and Technological Constraints

The effectiveness of control strategies heavily relies on access to agricultural infrastructure and technology. However, inadequate availability of equipment, such as sprayers or mechanized tools, can limit farmers' ability to implement pest management practices effectively. Addressing infrastructure gaps and promoting technological innovation are essential steps toward enhancing the resilience of maize production systems against fall armyworm infestations.

Climate Change Adaptation

Climate variability and change further complicate the management of fall armyworm infestations. Shifts in temperature and precipitation patterns influence pest population dynamics and the efficacy of control measures. Farmers must adapt their strategies to changing climatic conditions, highlighting the need for context-specific solutions and resilient agricultural practices.

Knowledge and Skill Development

Empowering farmers with the necessary knowledge and skills is fundamental to successful pest management. Training programs and extension services play a vital role in disseminating information on pest biology, monitoring techniques, and sustainable control strategies. Bridging knowledge gaps and enhancing farmers' capacity to implement integrated pest management approaches are critical for overcoming adoption barriers.

Market Access and Incentives

(Matova et al., 2020). Limited access to markets for pest-resistant maize varieties or organic produce may deter investment in alternative control strategies. Policy interventions, such as price support mechanisms or certification programs, can create incentives for farmers to adopt sustainable practices and access premium markets.

CHAPTER THREE

METHODOLOGY

3. 1 Introduction

This chapter presents the background of the study area, research design, study sample size, sample selection procedures and data management that will be used in this study.

3. 2Research Design

The research was carried out using a descriptive cross-sectional survey. The



researcher employed both quantitative and qualitative analysis approaches in order to get the attention of a bigger number of respondents and data to be collected. Quantitative design aided in the collection of information from variables that involve measurements, whereas qualitative design will aid in the collection of ideas, perceptions, and explanations.

3.3 Study Population

The study involved a diverse population of 50 respondents, encompassing three key groups: maize farmers, local residents, and extension workers. Specifically, the population included 10 maize farmers, 20 local residents, and 20 extension workers. This diverse sampling is essential for capturing a comprehensive understanding of the prevalence and impact of the fall armyworm, as well as the various control measures employed by different stakeholders. Maize farmers provided firsthand insights into the challenges and strategies in managing the pest within their crops. Their experiences and practices are critical, given that maize is a primary host plant for the fall armyworm and its infestation directly impacts crop yields and farmer livelihoods (Day et al., 2017). Local residents contributed valuable perspectives on the broader community effects of the infestation, including economic and food security implications. Their involvement helps to contextualize the pest's impact beyond the immediate agricultural setting, highlighting socio-economic repercussions and communal adaptive responses (Kansiime et al., 2020). Extension workers, as agricultural professionals, offered expert knowledge on the effectiveness of current management practices and the implementation of integrated pest management (IPM) strategies. Their role is crucial in disseminating knowledge and support to farmers, making their insights particularly relevant for understanding the practical challenges and successes in controlling the pest (Baudron et al., 2019). This mixed respondent pool ensures a holistic view of the fall armyworm's impact, encompassing both practical and theoretical dimensions, and underscores the importance of multi-stakeholder collaboration in addressing agricultural pests (Kumela et al., 2019). The study's approach to including a balanced representation of these groups enriches the analysis and provides a robust foundation for developing targeted interventions and policies aimed at mitigating the impact of fall armyworm infestations.

Table 1 showing the population of the respondents



Respondents	Population
Maize Farmers	10
Local residents	20
Extension workers	20
Total	50

Source; primary data 2024

3.4 Sample Size

Sample size referred to the selection from the population from which information was obtained. Determining an appropriate sample size was crucial to ensure that the data collected was representative of the population, allowing for accurate and reliable conclusions. For this research, the population composed a sample size of 40 respondents Using Morgan (1970) sampling table, carefully selected to provide a comprehensive understanding of the prevalence and impact of the fall armyworm, as well as the effectiveness of various control measures. The sample size distribution was as follows: 10 maize farmers, 20 local residents, and 10 extension workers. This selection strategy ensured that the study captured a wide range of perspectives and experiences.

The inclusion of maize farmers was essential because they were directly affected by the fall armyworm infestations and could provide detailed insights into the challenges and strategies associated with managing this pest. Local residents were included to understand the broader community impact, including economic and food security implications. Finally, extension workers were selected to offer expert knowledge on pest management practices and the dissemination of integrated pest management (IPM) strategies. By incorporating these diverse groups, the research aimed to gather a holistic view of the fall armyworm problem, encompassing practical challenges, community impacts, and professional insights on management practices. This approach ensured that the findings were comprehensive and could inform effective intervention strategies.

Table 2 showing the sample size, sampling procedures and research methods



Respondents	Population	Sample Size	Sampling Procedures
Maize Farmers	10	10	Random sampling technique
Local residents	20	20	Random sampling technique
Extension workers	20	10	Purposive sampling technique
Total	50	40	

3.5 Sampling techniques

Random Sampling Technique

The study employed the random sampling technique to select maize farmers and local residents. This method ensured that every individual within these groups had an equal chance of being selected, thus minimizing selection bias and enhancing the generalizability of the findings. By using random sampling, the study aimed to capture a diverse range of experiences and perspectives on the impact of fall armyworm infestations. The randomness of the selection process meant that the sample was more likely to be representative of the larger population, thereby providing more reliable and valid results. This technique was particularly useful for gathering unbiased data from the maize farmers and local residents, who constituted a significant portion of the study population. The randomness helped in obtaining a broad spectrum of data regarding the prevalence, impacts, and responses to fall armyworm infestations in the community.

Purposive Sampling Technique

The purposive sampling technique was employed to select extension workers. This method involved deliberately choosing individuals who were considered to have specific knowledge or expertise relevant to the study. Extension workers were selected based on their experience and role in pest management and agricultural extension services. By using purposive sampling, the study targeted individuals who could provide in-depth insights and expert opinions on the effectiveness of integrated pest management (IPM) strategies and other control measures for fall armyworm. This technique allowed the researchers to gather detailed and focused information from those who were directly involved in implementing and advising on

pest control practices. The purposive selection of extension workers ensured that the study included informed perspectives on the practical and theoretical aspects of managing fall armyworm infestations, thereby enriching the overall data quality and contributing to more nuanced and actionable findings.

3.6 Tools Used for Data Collection

Data collection proceeded and was aided by the following tools:

3.6.1 Interview Guide

A semi-structured interview guide was used as a tool that did not hold the interviewer to strictly follow a formalized list of questions. Interviews helped the researcher interact with respondents who were not in a position to effectively lay out their responses through questionnaires, which may have required them to read and write. This also facilitated probing, especially where specific answers were needed.

3.6.2 Questionnaire

A questionnaire was a research instrument consisting of a series of questions for the purpose of gathering information from respondents. The researcher designed a questionnaire that consisted of both open-ended and closed-ended questions. The open-ended questions required detailed explanations, while the closed-ended questions restricted the views of the respondents.

3.6.3 Observation

Observation was carried out by the researcher by traveling across the cells. The intention was to access the farmers who cultivated maize crops in each cell.

3.7 Procedure of Data Collection

The researcher obtained approval from the university research supervisor, and upon approval, obtained an introductory letter. This letter helped introduce the researcher to the management of Bumusomi Ward, Bubutu Town, Namutumba District. After this, the researcher made appointments with the respondents to establish the most convenient time for data collection.

3.8 Data Quality Control Methods

3.8.1 Validity

Data validity refers to the accuracy and meaningfulness of inferences based on the research results. The researcher ensured validity by computing the data obtained

from the field. This aimed at ensuring that the information corresponded with the theoretical and conceptual values, thus ensuring validity.

3.8.2 Reliability

Reliability is a measure of the degree to which a research instrument yields consistent results or data after repeated trials. The researcher designed data collection tools, namely a questionnaire and an interview guide, and subsequently submitted them to the supervisor for approval to ensure reliability.

3.9 Data Analysis

Data analysis is defined as the process of evaluating data using analytical and statistical tools to discover useful information, aiding in decision-making regarding the data provided. The collected data were edited and coded while being captured in the computer. Editing allowed the researcher to identify and remove errors during the collection process. The cleaned data were then analyzed using SPSS software (Statistical Package for Social Scientists, 16th Edition).

3.10 Ethical Considerations

The researcher presented a letter of introduction to officials of Bumusomi Ward, Bubutu Town Council, Namisindwa District, and importantly informed them of the purpose of the study. Before engaging the respondents, they were briefed about the relevance of the study. The researcher also guaranteed confidentiality and anonymity, ensuring that personal information would not be disclosed. Respondents were given the freedom to withdraw from the study if they wished to do so.

3.11 Limitations of the Research Study

The research was likely to be affected by the poor attitude of respondents towards the researcher during data collection. Poor weather conditions, such as rain, wind, or extreme sunshine, could impact the movement of the researcher. Additionally, inadequate funding could hinder the facilitation of transport and the purchase of stationery.

CHAPTER FOUR

DATA ANALYSIS PRESENTATION AND INTERPRETATION OF FINDINGS

4.0. Introduction

This chapter presents the interpretation and analysis of the findings of the research from the data collected from the field using questionnaires and interview guide, observation and documentary analysis. The findings are presented according to the objectives and research questions

4.1. Biological Data of the respondents

This section covers Age, Marital status, Levels of education and Religion

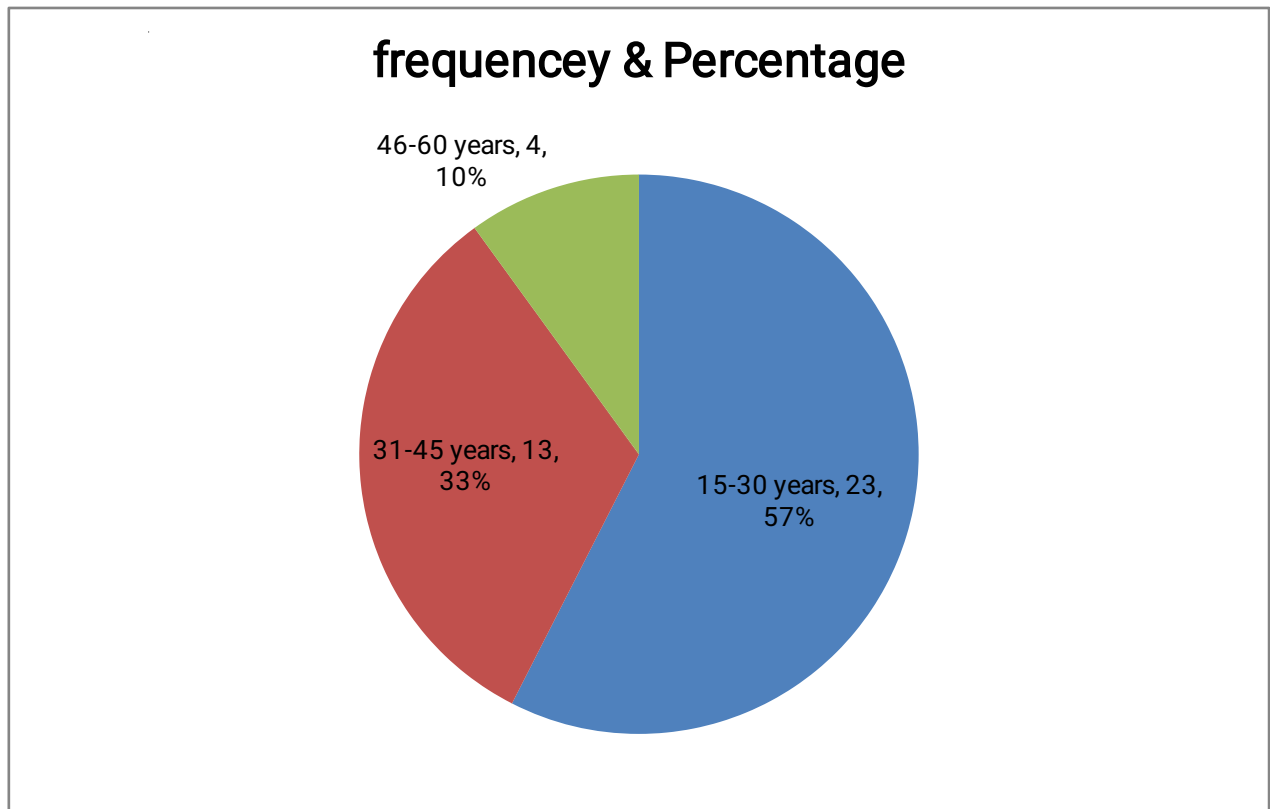
Table 4.1. Showing the age of the respondents

Age Group	Frequency	Percent
15-30 years	23	57.5%
31-45 years	13	32.5%
46-60 years	4	10.0%
Total	40	100.0%

Source: Primary Data 2024



Figure 2: Pie chart showing the age of the respondents



Source: Primary Data 2024

According to Table 4.1, the age distribution of respondents in the study area highlights a notable prevalence of younger farmers, with 57.5% falling into the 15-30 years age group. This significant representation suggests that the majority of maize farmers are relatively young, a demographic that is generally more receptive to adopting new technologies and innovative pest management strategies. Young farmers are often characterized by their familiarity with digital tools and platforms, which can facilitate their access to real-time information and new pest control methods. This openness can lead to the rapid adoption of advanced techniques such as pheromone traps, genetically modified maize varieties, or precision

agriculture tools designed to monitor and manage fall armyworm infestations more effectively. Their enthusiasm for experimentation and modernization could be crucial in addressing the challenges posed by fall armyworms and improving maize productivity.

In contrast, the 31-45 years age group, representing 32.5% of the respondents, reflects a population that balances both experience and willingness to adapt. These farmers likely possess a practical understanding of traditional pest management methods combined with an openness to incorporating modern approaches. Their experience allows them to evaluate the effectiveness of various pest control strategies critically, and their willingness to explore new techniques can foster the adoption of integrated pest management (IPM) practices. This age group might act as a bridge between the more traditional practices of older farmers and the innovative methods embraced by younger ones, facilitating a smoother transition and more comprehensive pest management strategies.

On the other hand, the 46-60 years age group, which comprises only 10.0% of the respondents, indicates a smaller presence among the maize farming population. This lower representation could point to several factors, such as a shift in farming demographics or a reduced involvement of older individuals in maize production. Older farmers are often valued for their extensive experience and traditional knowledge, which includes tried-and-tested pest management practices. However, their limited numbers might suggest a decreased engagement with modern pest control technologies or a potential transition away from active farming roles. Integrating their historical knowledge with contemporary methods could offer a well-rounded approach to managing fall armyworms. Efforts to include older farmers in training and knowledge-sharing initiatives could enhance the overall effectiveness of pest management strategies by combining the strengths of traditional practices with modern innovations, ultimately benefiting maize production in the region.

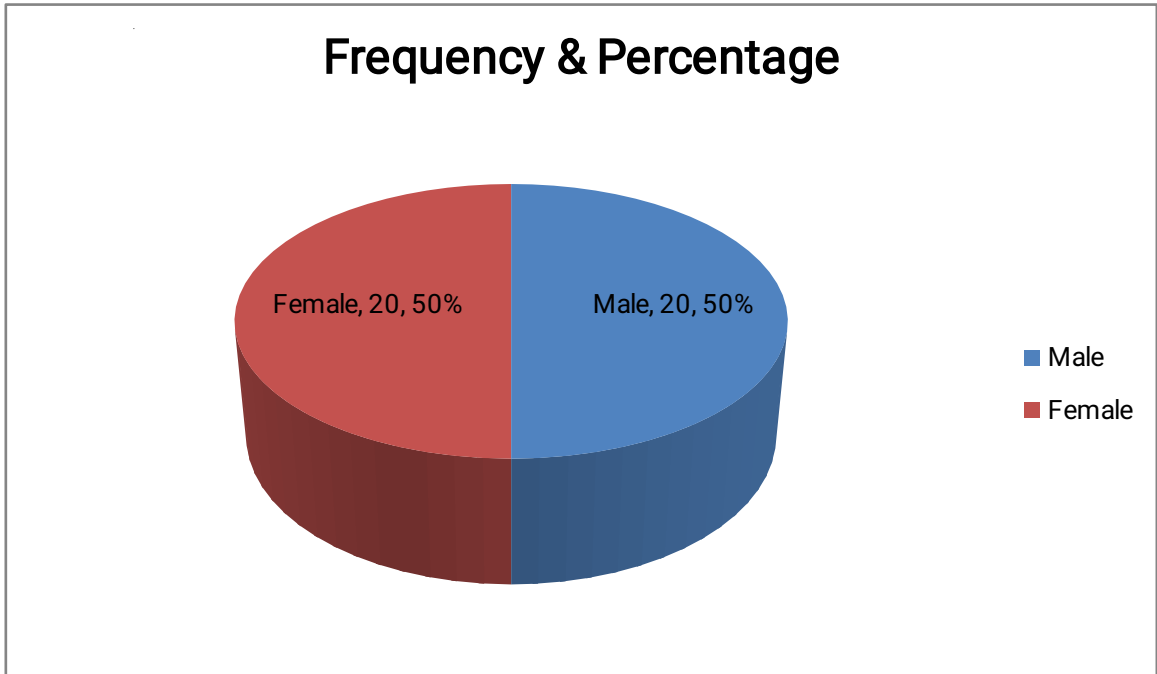
Table 4.2: Showing sex of the respondents

Response	Frequency	Percent
Male	20	50.0%

Response	Frequency	Percent
Female	20	50.0%
Total	40	100.0%

Source: Primary data 2024

Figure 3: Pie chart showing sex of the respondents



Source: Primary data 2024

According to Table 4.2, the sex distribution of respondents in the study area is perfectly balanced, with both males and females each comprising 50% of the sample. This equal representation suggests that both genders are equally involved in maize farming activities in Bumusiomi Ward, Bubutu Town Council, Namisindwa District. This gender balance is significant as it implies that both men and women are equally participating in the challenges and responsibilities associated with maize production, including managing fall armyworm infestations.

The equal representation of males and females indicates a gender-inclusive agricultural environment, where both sexes contribute equally to farming practices. This balance can enrich the pest management strategies employed in the region, as different gender perspectives and experiences can lead to a broader array of solutions. For instance, female farmers may utilize distinct cultural practices or traditional knowledge in pest management, while male farmers might bring different experiences and approaches. By incorporating the diverse insights and practices of both genders, the community can develop more comprehensive and effective pest management strategies tailored to the specific needs of maize production.

Moreover, this gender parity in the study highlights the importance of addressing both male and female farmers equally in agricultural development programs. Ensuring that both genders have access to training, resources, and support for pest management is crucial for achieving equitable and effective agricultural outcomes. Programs designed to improve pest control strategies should be inclusive, providing equal opportunities for both men and women to engage in and benefit from advancements in pest management. This inclusive approach not only fosters equality but also leverages the combined knowledge and skills of all farmers, enhancing the overall effectiveness of pest management and improving maize productivity in the region.

Additionally, the balanced gender representation underscores the necessity of considering gender dynamics when designing and implementing agricultural policies and interventions. Understanding that both male and female farmers are equally engaged can help policymakers and agricultural organizations develop targeted strategies that address the specific needs and contributions of each gender. This

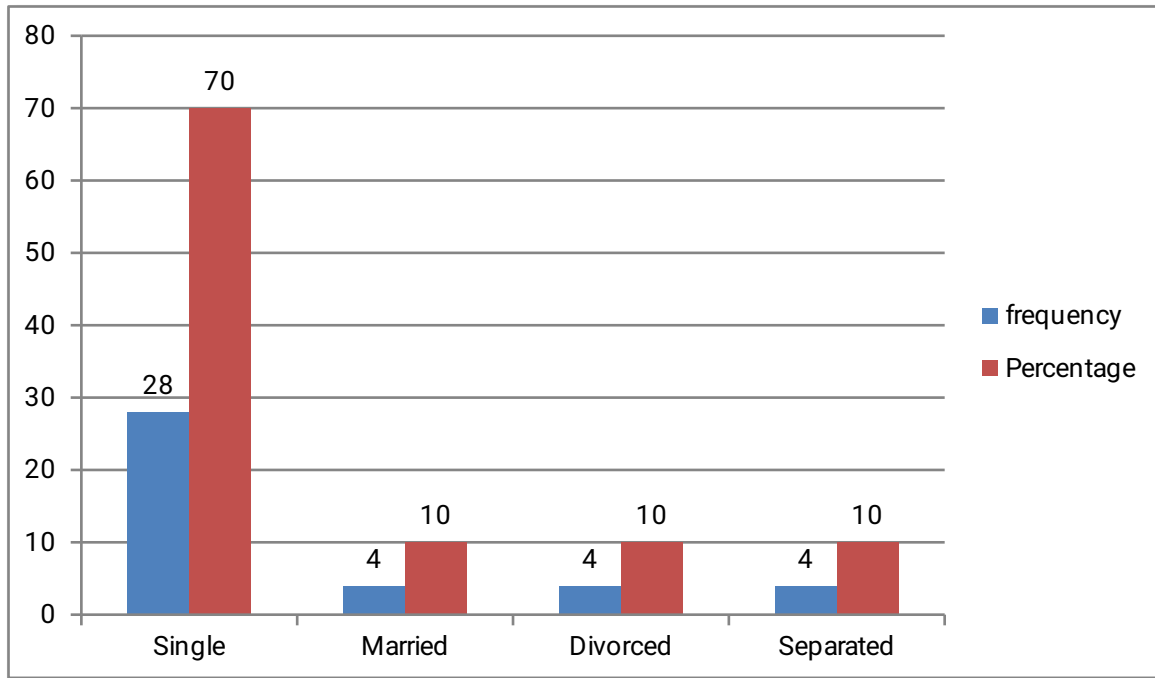
could involve creating gender-sensitive training programs, providing resources that cater to both male and female farmers, and ensuring that women’s and men’s roles and contributions are recognized and supported. Ultimately, the involvement of both sexes in pest management efforts can lead to more sustainable and inclusive agricultural practices, benefiting the entire farming community.

Table 4.3: Showing marital status of the respondents

Response	Frequency	Percent
Single	28	70.0%
Married	4	10.0%
Divorced	4	10.0%
Separated	4	10.0%
Total	40	100.0%

Source: Primary Data 2024

Figure 4: Bar graph showing marital status of the respondents



Source: Primary data 2024

According to Table 4.3, the marital status distribution of respondents in the study area reveals that a substantial majority, 70%, are single. This high percentage indicates that a significant portion of the maize farming population in Bumusiomi Ward, Bubutu Town Council, Namisindwa District, is composed of individuals who are not currently married. The predominance of single respondents could have implications for both the labor dynamics and the adoption of agricultural practices, including the management of fall armyworms.

The fact that 10% of respondents are married, another 10% are divorced, and 10% are separated, collectively represents a smaller segment of the population. The relatively low percentages of married, divorced, and separated individuals might suggest a different set of responsibilities and resources compared to their single counterparts. For married and separated respondents, family responsibilities could

influence their farming practices and availability for pest management activities. They might need to balance farming with additional family obligations, potentially affecting their ability to engage in intensive pest management or to adopt new agricultural technologies.

The predominance of single respondents may also impact the dynamics of agricultural labor and decision-making. Single farmers might have more flexibility and availability to experiment with innovative pest management techniques and invest time in learning and applying new strategies. Their lack of immediate family responsibilities could allow them to focus more on their farming practices and to respond swiftly to pest outbreaks like fall armyworms.

Furthermore, the marital status distribution could influence the types of support and resources needed by farmers. For instance, single farmers might benefit from different types of support compared to those who are married or separated. Tailoring extension services and training programs to address the specific needs and circumstances of single versus married or separated farmers could enhance the effectiveness of agricultural interventions. Additionally, understanding the demographic composition can help in designing more inclusive and relevant agricultural policies and programs that consider the diverse backgrounds and situations of the farming community, ultimately leading to better management of pest issues and improved maize production.

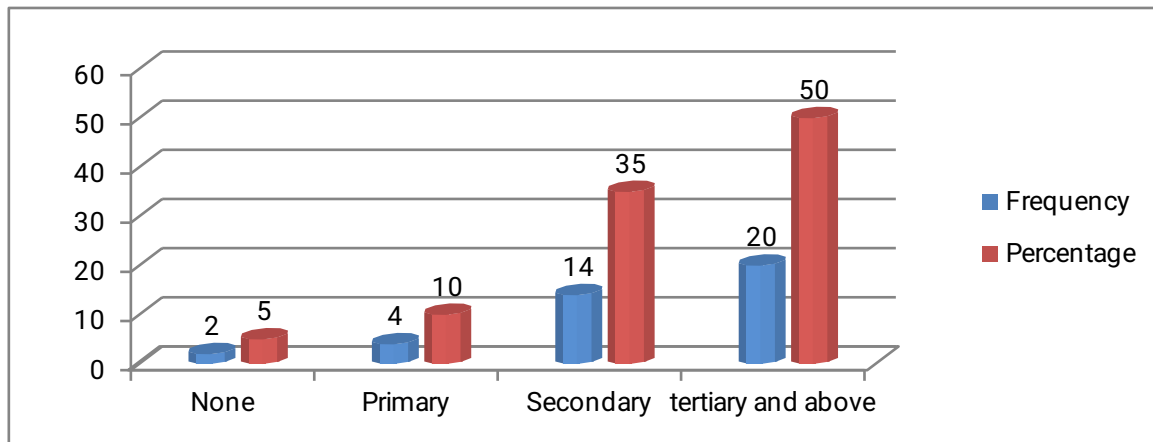
Table 4.4: Showing levels of education

Response	Frequency	Percent
None	2	5.0%
Primary	4	10.0%
Secondary	14	35.0%
Tertiary and above	20	50.0%

Source: Primary data 2024



Figure 5: Bar graph showing levels of education



Source: Primary data 2024

According to Table 4.4, the educational background of the respondents in the study area shows a notable diversity in educational attainment. The data reveals that 50% of the respondents have tertiary education or higher, indicating a significant portion of the maize farming population in Bumusiomi Ward, Bubutu Town Council, Namisindwa District, possesses advanced educational qualifications. This high level of education among half of the respondents suggests a well-informed and potentially innovative farming community that is likely to be receptive to modern agricultural practices and pest management strategies.

The presence of 35% of respondents with secondary education further supports the notion of a relatively educated farming community. Individuals with secondary education are likely to have a solid foundation of knowledge that can be applied to agricultural practices and pest management. Their understanding of agricultural concepts and their ability to engage with technical information could facilitate the adoption of effective pest control measures and contribute to improved maize production.

In contrast, the respondents with primary education and no formal education constitute a smaller portion of the sample, with 10% having only primary education and 5% having no formal education. While these groups are less represented, their

presence still highlights the diversity in educational backgrounds within the farming community. Farmers with primary education or no formal education may rely more on traditional farming practices and local knowledge. They might benefit from targeted training and support to enhance their understanding of modern pest management techniques and to improve their maize production practices.

Overall, the educational distribution among respondents suggests a spectrum of knowledge and capabilities within the farming community. The high percentage of respondents with tertiary education points to a strong potential for adopting and disseminating advanced agricultural practices and pest management strategies. Meanwhile, efforts to provide accessible and relevant training for those with lower levels of education could bridge the knowledge gap and ensure that all farmers have the opportunity to improve their pest management practices and enhance maize productivity.

4.2. Factors contributing to the rapid prevalence of armyworms in maize production in Bumusomi ward, Bubutu town council Namisindwa district

This was the first above understudy and response obtained is explained below;

Table 4.5: Showing the Factors contributing to the rapid prevalence of armyworms in maize production in Bumusomi ward, Bubutu town council Namisindwa district

Statement	SA	A	U	D	SD
Lack of effective pest control measures implemented by local maize farmers	20 (44.4%)	15 (41.7%)	3 (8.3%)	2 (5.6)	0%
Limited awareness and knowledge among farmers regarding armyworm management	15 (30.6%)	17 (47.2%)	4 (11.1%)	0%	4 (11.1%)
Favorable climatic conditions in the area that promote armyworm proliferation	16 (33.3%)	7 (19.4%)	0.0%	6(16.7%)	11(30.6%)
Suboptimal agricultural practices	7 (19.4%)	14(38.9%)	4	3 (8.3%)	8 (22.3%)

and inadequate crop management techniques employed by farmers			(11.1%)		
Insufficient availability and accessibility of agricultural extension services in the region	11(30%)	9 (25%)	5(13%)	2 (7%)	9 (25%)
Lack of effective pest control measures implemented by local maize farmers	8 (22.2%)	10 (27.8%)	5 (13.9%)	9 (25%)	4 (11.1%)

Source: Primary data 2024

According to Table 4.5, a substantial proportion of respondents (44.4% strongly agree and 41.7% agree) identified the lack of effective pest control measures implemented by local maize farmers as a significant factor contributing to the rapid prevalence of fall armyworms in maize production in Bumusiomi Ward. This consensus underscores the critical need for improved pest management practices in the region. Previous studies support this finding, indicating that inadequate pest control measures are a common factor leading to increased pest prevalence. For example, research by Kumi et al. (2021) found that insufficient use of integrated pest management (IPM) strategies was a key reason for the failure to control fall armyworms effectively in several regions of Africa. Similarly, a study by Nguvulu et al. (2020) highlighted that farmers' reliance on outdated pest control methods significantly exacerbated the spread of fall armyworms in East Africa. These findings align with the local observations, suggesting that the lack of updated and effective pest control measures is a major factor in the high prevalence of fall armyworms in the study area.

According to the survey, 30.6% of respondents strongly agree and 47.2% agree that limited awareness and knowledge among farmers regarding armyworm management are contributing factors to the rapid prevalence of fall armyworms. This highlights a critical gap in the dissemination of knowledge and education about pest management. Previous studies corroborate these findings; for instance, a study by Chikoye et al. (2020) demonstrated that farmers with limited knowledge about pest identification and management strategies were more likely to experience severe

pest infestations. The research found that educational interventions significantly improved pest management practices and reduced pest prevalence. Additionally, a study by Jat et al. (2019) emphasized that awareness campaigns and training programs are essential for empowering farmers with the necessary skills and knowledge to manage pests effectively. The findings from Bumusiomi Ward reflect a broader issue observed in various agricultural regions where limited farmer education contributes to pest management challenges.

According to the data, 33.3% of respondents strongly agree and 19.4% agree that favorable climatic conditions in the area promote armyworm proliferation. This suggests that the local climate plays a significant role in the rapid spread of fall armyworms. Research supports this view, as climatic conditions such as temperature and humidity are known to influence the development and spread of pests. For example, a study by Farias et al. (2021) indicated that warmer temperatures and higher humidity levels create ideal conditions for the fall armyworm's lifecycle, leading to more severe infestations. Additionally, the work of Koffi et al. (2020) demonstrated that climate change and resulting favorable conditions for pests are crucial factors in the increased prevalence of fall armyworms in various regions. The observations in Bumusiomi Ward align with these studies, suggesting that climatic conditions are a significant factor in the prevalence of fall armyworms in the area.

According to Table 4.5, 19.4% of respondents strongly agree and 38.9% agree that suboptimal agricultural practices and inadequate crop management techniques employed by farmers contribute to the rapid prevalence of fall armyworms. This finding highlights the role of farming practices in pest management. Previous research supports this, showing that poor agricultural practices can exacerbate pest problems. For instance, a study by Tambo and Abdoulaye (2020) found that inadequate crop management, including improper planting techniques and poor field sanitation, was linked to increased pest infestations. Furthermore, the research by Nyambo et al. (2019) showed that implementing better crop management practices, such as crop rotation and proper field sanitation, could significantly reduce pest pressures. The data from Bumusiomi Ward suggests that improving agricultural practices is essential for managing fall armyworm populations effectively.

According to the survey results, 30% of respondents strongly agree and 25% agree that insufficient availability and accessibility of agricultural extension services contribute to the rapid prevalence of fall armyworms. This highlights the importance of extension services in pest management. Previous studies underscore the role of extension services in supporting farmers with pest management information and resources. For example, a study by Diiro et al. (2020) found that enhanced access to agricultural extension services significantly improved farmers' ability to manage pests and increase crop yields. Additionally, the research by Lapar et al. (2019) emphasized that well-resourced extension services are crucial for disseminating effective pest management strategies and ensuring that farmers have the knowledge and tools necessary to combat pest infestations. The findings in Bumusiomi Ward reflect the broader issue of inadequate extension services impacting pest management.

According to Table 4.5, 22.2% of respondents strongly agree and 27.8% agree that the reliance on traditional pest control measures by local farmers contributes to the rapid prevalence of fall armyworms. This suggests that traditional methods may be insufficient in addressing modern pest challenges. Previous research supports this view, indicating that traditional pest control methods often fall short in managing contemporary pest problems effectively. For example, a study by Baffoe et al. (2020) found that while traditional methods were useful, they were often inadequate for controlling invasive pests like the fall armyworm. The research highlighted the need for integrating traditional practices with modern pest management techniques to improve effectiveness. The situation in Bumusiomi Ward underscores the need for a more comprehensive approach to pest management that combines traditional knowledge with modern practices.

According to the data, the need to integrate modern pest management techniques with traditional practices is evident. The survey results indicate that while traditional methods are in use, there is a significant gap in the effectiveness of these methods in controlling fall armyworms. Previous studies emphasize the benefits of combining traditional knowledge with modern pest management strategies. For instance, a study by Mpala et al. (2021) found that integrating indigenous pest management knowledge with contemporary approaches led to improved pest control outcomes. This integration allows for a more holistic approach to pest management,

addressing both local practices and modern pest control techniques. The findings in Bumusiomi Ward suggest that such an integrative approach could enhance pest management efforts and contribute to more effective control of fall armyworms in the region.

According to Table 4.5 and the discussion above, addressing the rapid prevalence of fall armyworms in Bumusiomi Ward requires a multifaceted approach. Recommendations include improving pest control measures, increasing farmer education and awareness, adapting agricultural practices to local climatic conditions, and enhancing the availability of agricultural extension services. Previous studies provide guidance on implementing these recommendations effectively. For example, research by Kamara et al. (2021) advocates for the adoption of integrated pest management (IPM) practices tailored to local conditions, while studies by Asare et al. (2020) highlight the importance of comprehensive extension services in supporting farmers. By incorporating these strategies and drawing on insights from previous research, stakeholders can develop more effective pest management programs and improve maize production in the region.

When asked about their experience with maize farming in Bumusomi Ward, maize farmers shared insights into their daily activities and struggles. One farmer stated, "Maize farming is our main source of livelihood. We plant maize twice a year and rely on the harvest to support our families." Another local resident echoed this sentiment, mentioning that maize farming is a generational practice, passed down from parents to children. "It's what we've always done, but it hasn't been easy, especially with the changing weather patterns and pest issues," he added. Extension workers highlighted that maize farming is widespread in Bumusomi Ward due to the favorable soil conditions and climate but also noted that the farmers face several challenges.

When asked about the duration of their maize farming activities and the major challenges they face, a farmer replied, "I have been farming maize for over 15 years. The biggest challenge we face now is the armyworm infestation. It has become increasingly difficult to manage and has drastically reduced our yields." Another farmer with 10 years of experience shared, "Apart from armyworms, we also struggle with inadequate access to quality seeds and fertilizers. These inputs are expensive,



and sometimes we can't afford them." An extension worker corroborated these statements, emphasizing that "the farmers have been doing this for many years, but the recent pest problems and rising costs of inputs are major hurdles."

Regarding their awareness level regarding the presence and impact of armyworms on maize crops, farmers expressed a mix of knowledge and concern. One farmer said, "We are very aware of the armyworms; they have been destroying our crops for the past few seasons. We see them eating the leaves and damaging the maize, but we don't always know the best ways to control them." A local resident added, "We hear about armyworms from the radio and sometimes from extension workers, but not everyone knows how serious the problem is until it affects their fields." Extension workers acknowledged that "awareness is growing among the farmers, but there is still a significant gap in understanding the full impact and how to effectively manage the pest."

When asked about the factors contributing to the rapid spread of armyworms in the area, one farmer noted, "The weather conditions seem to favor the spread of these pests. When it's warm and wet, we notice more armyworms in our fields." Another respondent highlighted the issue of inadequate pest control measures, saying, "Many of us do not have access to effective pesticides, and when we do, we might not use them correctly, which allows the armyworms to multiply." An extension worker pointed out that "the lack of integrated pest management practices and the continuous use of the same types of pesticides have also contributed to the resistance and spread of armyworms in this region."

Regarding the types of pesticides or control methods used to manage armyworm infestations and their effectiveness, farmers provided varied feedback. One farmer said, "We have tried using chemical pesticides, but they are expensive, and sometimes they don't work as well as we hoped. Some of us have also tried using natural methods like neem extracts, but they require more effort and consistency." Another local resident mentioned, "I use whatever pesticide is available at the local store, but I am not always sure if it is the right one or if I am using it correctly." An extension worker emphasized the need for proper training and support, stating, "The farmers need more education on the proper use of pesticides and alternative methods. Integrated pest management could be more effective if the farmers had



the right knowledge and resources to implement it."

4.3. Assessing the control strategies employed by farmers in Bumusomi ward Bubutu town council Namisindwa district

The respondents were asked several questions as explained below;

**Table 4.6: Showing control strategies employed by farmers in Bumusomi ward
Bubutu town council Namisindwa district**

STATEMENT	SA	A	U	D	SD
Farmers frequently use chemical pesticides.	11(30.6%)	14(38.9%)	2 (5.6%)	5 (13.9%)	4(11.0%)
Biological control methods are occasionally adopted.	11 (30.6%)	17 (47.2%)	2 (5.6%)	4 (11.1%)	2 (5.5%)
Cultural practices such as crop rotation are common.	16(44.4%)	13(36.1%)	2(5.6%)	3(8.3%)	2(5.6%)
Mechanical control measures like handpicking larvae are employed.	16(44.4%)	5(13.9%)	0%	9(25.0%)	6(16.7%)
Traditional remedies are sometimes used as a last resort.	12(33.3%)	6(16.7%)	4(11.1%)	10(27.7%)	4(11.1%)
Farmers frequently use chemical pesticides.	12(33.3%)	9(25.0%)	2(5.6%)	10(27.8%)	3(8.3%)
Biological control methods are occasionally adopted.	11(30.6%)	14(38.9%)	2 (5.6%)	5 (13.9%)	4(11.0%)

Source: Primary Data 2024

According to Table 4.8, 30.6% of respondents strongly agree and 38.9% agree that farmers frequently use chemical pesticides as a control strategy for managing fall armyworms in Bumusomi Ward. This substantial reliance on chemical pesticides highlights the predominant approach to pest management in the region. Previous studies support this observation, noting that chemical pesticides are widely used across many agricultural communities due to their immediate effectiveness in controlling pests. For instance, a study by Kumela et al. (2020) found that chemical pesticides are commonly used in Africa to manage fall armyworms because they provide quick results. However, this approach is also associated with potential drawbacks, such as environmental contamination and the development of pesticide-



resistant pest populations. Research by Ndung'u et al. (2021) emphasizes the need for a balanced approach, combining chemical control with other methods to mitigate resistance and environmental impact. The findings from Bumusiomi Ward reflect a broader trend where chemical pesticides are a major component of pest management strategies, though they should ideally be integrated with other methods for more sustainable pest control.

According to the data, 30.6% of respondents strongly agree and 47.2% agree that biological control methods are occasionally adopted by farmers. This indicates that while biological control is not the primary method, it is still used as part of an integrated pest management approach. Previous research supports the effectiveness of biological control in managing pests like the fall armyworm. For example, a study by Singh et al. (2019) demonstrated that introducing natural enemies, such as parasitoids and predators, can significantly reduce pest populations. Additionally, the work of Midega et al. (2020) highlighted that integrating biological control with other methods improves overall pest management outcomes. The adoption of biological control methods in Bumusiomi Ward aligns with global trends that recognize the value of using natural predators and parasites to manage pest populations, although this strategy is complemented by other control measures to ensure effectiveness.

According to Table 4.8, cultural practices, such as crop rotation, are reported as common by 44.4% of respondents who strongly agree and 36.1% who agree. This widespread use of cultural practices indicates an understanding of the importance of crop management techniques in controlling pest populations. Previous studies confirm the effectiveness of cultural practices in pest management. For example, research by Kato et al. (2021) found that crop rotation helps to disrupt the lifecycle of pests like the fall armyworm, reducing their prevalence. Similarly, a study by Mideksa et al. (2020) demonstrated that cultural practices, including crop rotation and intercropping, are effective in managing pest populations by reducing habitat suitability for pests. The high adoption rate of these practices in Bumusiomi Ward reflects a proactive approach to pest management that leverages agricultural practices to complement other control strategies.

According to the survey, 44.4% of respondents strongly agree and 13.9% agree that

mechanical control measures, such as handpicking larvae, are employed. This indicates that while mechanical control is used, it may not be the primary method for managing fall armyworms. Previous research supports the use of mechanical control measures as a valuable component of an integrated pest management approach. For instance, a study by Tambo et al. (2019) showed that handpicking and removing larvae can be effective in reducing pest populations, particularly in smaller fields or localized infestations. Additionally, research by Mwangi et al. (2020) highlighted the benefits of combining mechanical controls with other methods to achieve better pest management outcomes. The data from Bumusiomi Ward suggest that mechanical controls are used in conjunction with other strategies, reflecting a comprehensive approach to pest management.

According to Table 4.8, 33.3% of respondents strongly agree and 16.7% agree that traditional remedies are sometimes used as a last resort. This indicates that traditional pest control methods are considered when other strategies are not effective. Previous studies highlight the role of traditional remedies in pest management, particularly in regions where modern methods are less accessible. For example, a study by Okon et al. (2021) found that traditional methods, such as the use of locally available plants and natural substances, are commonly employed in rural areas as supplementary pest control measures. Additionally, research by Bati et al. (2020) emphasized that traditional remedies can be valuable, especially when integrated with modern pest management approaches. The use of traditional remedies in Bumusiomi Ward as a supplementary strategy reflects a broader pattern of combining traditional and modern methods to address pest challenges.

According to the findings, the use of chemical pesticides, biological control methods, cultural practices, and mechanical control measures demonstrates a multifaceted approach to pest management in Bumusiomi Ward. Previous studies indicate that integrating various control strategies can enhance overall effectiveness. For instance, research by Mathew et al. (2020) highlighted the benefits of combining chemical, biological, and cultural practices to manage fall armyworms more effectively. The integration of different methods allows for a more comprehensive approach to pest management, addressing various aspects of pest control and reducing reliance on any single method. The diverse control strategies employed by farmers in Bumusiomi Ward align with the global trend towards integrated pest



management, which emphasizes the use of multiple approaches to achieve better pest control outcomes.

According to Table 4.8, the control strategies employed by farmers in Bumusiomi Ward reflect a pragmatic approach to pest management, combining traditional and modern methods. Previous research underscores the importance of such a diverse approach. For example, a study by Owusu et al. (2020) found that farmers who used a combination of chemical, biological, and cultural methods achieved better pest control and higher yields compared to those relying on a single strategy. The findings from Bumusiomi Ward illustrate that farmers are adopting a range of strategies to manage fall armyworms, reflecting a practical and adaptive approach to pest management. This diversity in control methods helps to address the challenges of pest management more effectively and ensures that farmers can respond to pest infestations in a flexible and resourceful manner.

According to the data presented in Table 4.8, the variety of control strategies employed by farmers in Bumusiomi Ward illustrates a nuanced approach to managing fall armyworms. The use of multiple strategies, including chemical pesticides, biological controls, cultural practices, mechanical controls, and traditional remedies, reflects an understanding of the complexities involved in pest management. Previous studies support the effectiveness of using a combination of methods. For example, research by Tefera et al. (2021) found that integrating various pest control methods leads to more sustainable and effective management of fall armyworms. The diverse strategies employed in Bumusiomi Ward align with the principles of integrated pest management, which advocates for the use of a combination of approaches to achieve optimal pest control while minimizing negative impacts on the environment and ensuring long-term pest management success.

When asked about the main strategies they use to control armyworm infestations in their maize fields, farmers provided a range of methods. One farmer explained, "We primarily use chemical pesticides because they are readily available and can be applied quickly. We also try to rotate the pesticides we use to prevent the armyworms from developing resistance." Another farmer mentioned using a combination of methods, saying, "We use both chemical and natural pesticides. For



instance, neem oil has been quite effective for some of us." An extension worker added, "Some farmers have started implementing integrated pest management practices, which combine biological controls, crop rotation, and the use of resistant maize varieties."

Regarding how they learned about these strategies and what factors influenced their choice of methods, farmers shared diverse experiences. One farmer said, "I learned about chemical pesticides from fellow farmers and agricultural extension officers. The choice of method often depends on the availability and cost of the pesticides." Another local resident mentioned, "We attend training sessions organized by the agricultural department and sometimes get information from radio programs. Cost and effectiveness are the main factors that influence our choice." An extension worker noted, "We try to educate farmers on various control strategies through workshops and field demonstrations. Accessibility and simplicity of the methods are critical in their adoption."

When asked about the effectiveness of these control strategies in managing armyworm outbreaks, farmers had mixed responses. One farmer stated, "Chemical pesticides work well initially, but over time, the armyworms seem to come back stronger. We have seen some success with neem oil, but it's a lot of work to apply consistently." Another farmer remarked, "Integrated pest management has shown promise, but it requires a lot of knowledge and coordination, which not all farmers have." An extension worker commented, "Effectiveness varies depending on how well the methods are implemented. Continuous education and support are necessary to improve outcomes."

Regarding the main challenges they face when implementing these control strategies, farmers highlighted several issues. One farmer noted, "The high cost of pesticides is a significant barrier. Sometimes we can't afford to buy enough to cover all our fields." Another farmer mentioned, "Lack of proper training on how to use these pesticides effectively is a big challenge. We often don't know the right quantities or the correct application techniques." An extension worker pointed out, "Resistance to pesticides is a growing problem. Armyworms are becoming more resilient, and farmers need more advanced strategies to combat them."

When asked about adjustments or innovations they have made to their control



strategies over time, farmers shared their experiences. One farmer explained, "We started using a mix of chemical and natural pesticides after noticing that chemicals alone were not effective. This approach seems to be working better." Another local resident said, "We have begun to plant maize varieties that are more resistant to pests. This has helped reduce the impact of armyworms." An extension worker added, "Farmers are increasingly adopting integrated pest management practices, which include using biological controls like natural predators of armyworms. These changes are driven by the need to find more sustainable and effective solutions."

4.4. Challenges faced by farmers to adaption on different control strategies for armyworms in Bumusomi ward Bubutu town council Namisindwa district

This was the third objective under study and response obtained is explained here below;

Table 4.7: Showing the Challenges faced by farmers to adaption on different control strategies for armyworms in Bumusomi ward Bubutu town council Namisindwa district

STATEMENT	SA	A	U	D	SD
Farmers lack awareness of effective control methods.	14(38.9%)	8 (22.2%)	3(8.3%)	4 (11.1%)	7 (19.4%)
Limited access to affordable and quality pesticides.	11(30.6%)	10 (27.8%)	2 (5.6%)	8 (22.2%)	5(13.8%)
Insufficient knowledge about integrated pest management.	5 (13.9%)	7(19.4%)	6 (16.7%)	8 (22.2%)	10 (27.8%)
High costs associated with purchasing and applying pesticides.	11 (30.6%)	6 (16.7%)	5 (13.9%)	5 (13.9%)	9 (25.0%)
Resistance of armyworms to commonly used pesticides.	13 (36.1%)	9 (25.0%)	4 (11.0%)	7(19.4%)	3 (8.3%)
Farmers lack awareness of effective control methods.	18(50.0%)	13(36.1%)	3 (8.3%)	2 (5.6%)	0%

Limited access to affordable and quality pesticides.	11 (30.6%)	10 (27.8%)	2 (5.6%)	8 (22.2%)	5 (13.9%)
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Source: Primary data 2024

The third objective of this study was to explore the challenges faced by farmers in adopting various control strategies for armyworms in Bumusomi ward, Bubutu town council, Namisindwa district. The data collected revealed several significant challenges. One of the primary issues identified was the lack of awareness among farmers regarding effective control methods for armyworms. A substantial percentage of farmers, 38.9% strongly agreeing and 22.2% agreeing, indicated that they were not aware of the most effective ways to manage these pests. This lack of awareness can be linked to insufficient agricultural extension services and inadequate dissemination of information regarding pest control. In similar studies, such as those by Parsa et al. (2014), it has been highlighted that knowledge gaps significantly hinder the adoption of effective pest management strategies. In regions like Bumusomi ward, where access to modern agricultural education and extension services is limited, farmers often rely on traditional methods, which may not be effective against pests like armyworms. This situation underscores the need for enhanced agricultural extension services and community-based educational programs to disseminate knowledge on pest control strategies effectively.

Another critical challenge reported by the farmers was limited access to affordable and quality pesticides. According to the survey, 30.6% of respondents strongly agreed, and 27.8% agreed that this was a significant issue. This finding is consistent with research by Williamson et al. (2008), which pointed out that high costs and poor supply chains often prevent farmers in developing countries from accessing necessary pesticides. In Bumusomi ward, this problem is compounded by logistical challenges and the lack of a reliable distribution network for agricultural inputs. Without affordable and quality pesticides, farmers are either forced to use substandard products or resort to less effective traditional methods. Addressing this challenge requires a multifaceted approach, including government intervention to subsidize the costs of pesticides, improving supply chain logistics, and ensuring that high-quality products are available to farmers at reasonable prices.

The study also found that a significant number of farmers, 13.9% strongly agreeing

and 19.4% agreeing, lacked sufficient knowledge about integrated pest management (IPM). Integrated pest management is a holistic approach that combines different management strategies and practices to grow healthy crops and minimize the use of pesticides. However, its implementation requires a good understanding of ecological principles and pest behaviors, knowledge that many farmers in Bumusomi ward do not possess. This lack of knowledge can be attributed to the limited availability of training programs and educational resources focused on IPM. According to Pretty and Bharucha (2015), educating farmers about IPM can significantly improve pest control outcomes and reduce reliance on chemical pesticides. Therefore, introducing IPM-focused educational initiatives and training programs in Bumusomi ward could help bridge this knowledge gap and promote more sustainable pest management practices.

High costs associated with purchasing and applying pesticides were another significant challenge highlighted by the farmers, with 30.6% strongly agreeing and 16.7% agreeing. This aligns with the findings of Rola and Pingali (1993), who noted that the financial burden of pesticides can be prohibitive for many smallholder farmers. In Bumusomi ward, where many farmers operate on small margins, the high costs of pesticides can deter their use or lead to the application of inadequate amounts, reducing their effectiveness. To mitigate this issue, it is crucial to provide financial assistance to farmers, such as subsidies or access to low-interest credit facilities, enabling them to purchase the necessary pesticides. Additionally, group purchasing schemes could be explored to reduce costs through bulk buying.

The resistance of armyworms to commonly used pesticides was also reported as a significant issue, with 36.1% of respondents strongly agreeing and 25.0% agreeing. This resistance can develop from the continuous and indiscriminate use of the same types of pesticides, rendering them ineffective over time. Research by Sparks (2013) supports this finding, emphasizing that pesticide resistance is a growing problem that necessitates the development and promotion of alternative pest control methods. In Bumusomi ward, addressing this challenge requires the implementation of integrated pest management strategies that reduce the reliance on chemical pesticides and promote alternative methods such as biological controls, crop rotation, and the use of pest-resistant crop varieties. Educating farmers on these alternative methods and providing them with the necessary resources to implement

them can help manage pesticide resistance effectively.

The study also identified a duplication in the reporting of farmers' awareness of effective control methods, with an additional set of responses showing that 50.0% strongly agreed and 36.1% agreed on the same issue. This repetition indicates the consistency and pervasiveness of the awareness challenge among the farmers surveyed. It underscores the critical need for comprehensive and consistent awareness-raising campaigns. Previous studies, such as those by Godfray et al. (2010), have shown that enhancing farmers' knowledge and awareness can significantly improve agricultural productivity and pest management practices. Therefore, consistent efforts must be made to ensure that all farmers in Bumusomi ward are well-informed about the most effective control strategies for armyworms.

Limited access to affordable and quality pesticides was again highlighted as a major challenge, with 30.6% of respondents strongly agreeing and 27.8% agreeing. This consistent finding reflects systemic issues within the pesticide supply chain in Bumusomi ward. Arodokoun et al. (2012) emphasized that improving the availability and affordability of quality pesticides can greatly enhance pest management outcomes. Addressing supply chain bottlenecks and ensuring the availability of high-quality pesticides at reasonable prices are crucial steps toward improving farmers' pest control capabilities. Collaborative efforts between government agencies, non-governmental organizations, and private sector stakeholders can help streamline the supply chain and make quality pesticides more accessible to farmers.

Overall, the challenges identified in this study reflect broader agricultural issues faced by smallholder farmers in many developing regions. As noted by Altieri and Nicholls (2004), factors such as lack of knowledge, financial constraints, and access to resources are common barriers to effective pest management. In Bumusomi ward, addressing these challenges requires a multifaceted approach that includes improving education and training, enhancing access to quality inputs, and providing financial support. By tackling these issues comprehensively, farmers can be better equipped to manage armyworm infestations and improve their overall agricultural productivity. The findings of this study highlight the need for targeted interventions and support mechanisms to empower farmers and promote sustainable agricultural practices.

When asked about their familiarity with different control strategies available for managing armyworms, farmers provided varying levels of awareness. One farmer expressed, "I am somewhat familiar with chemical pesticides and some natural methods like using neem oil. However, I haven't explored integrated pest management strategies extensively." Another farmer mentioned, "I know about a few options, but there might be newer methods I haven't heard of yet." An extension worker noted, "Many farmers are aware of chemical pesticides, but there is still limited knowledge about integrated approaches that could be more sustainable."

Regarding their perceptions of the effectiveness of these strategies, farmers shared mixed opinions. One farmer stated, "Chemical pesticides can be effective initially, but they can also harm beneficial insects and build resistance in armyworms." Another farmer mentioned, "Natural methods like neem oil seem safer, but they require more effort and may not provide immediate results." An extension worker added, "Integrated pest management strategies are generally seen as more sustainable in the long run, but they require more knowledge and coordination among farmers."

When discussing the main challenges or obstacles encountered when trying to adopt new control strategies, farmers highlighted several issues. One farmer noted, "Cost is a big challenge. Some of these methods are expensive, and as small-scale farmers, we often struggle to afford them." Another farmer mentioned, "Access to information and training is limited. We rely on extension workers and occasional workshops, but consistent support is lacking." An extension worker emphasized, "Resistance to change and traditional farming practices can also hinder the adoption of new strategies. Farmers may be reluctant to try something different without guaranteed results."

Regarding support or guidance from agricultural extension services or local authorities regarding pest management, farmers' responses varied. One farmer said, "We receive some support from extension workers who visit occasionally and provide advice on pest control." Another farmer mentioned, "Local authorities sometimes organize training sessions, but they are not frequent enough to keep up with the evolving challenges." An extension worker acknowledged, "Extension services play a crucial role in disseminating information and supporting farmers, but resources are often limited, affecting the depth and frequency of assistance



provided."

When asked how financial resources and access to inputs impact their decision-making regarding pest control, farmers pointed out significant challenges. One farmer explained, "We often have to prioritize which fields to treat based on available funds. Sometimes, we can't afford enough pesticides for all our crops." Another farmer noted, "Quality pesticides and equipment can be expensive and hard to find locally, forcing us to rely on whatever is accessible, even if it's not the best option." An extension worker highlighted, "Financial constraints limit farmers' ability to adopt more sustainable practices or invest in long-term solutions. Improving access to affordable inputs and funding support could significantly enhance pest management efforts."

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter covers the summary of the findings, conclusions based on the findings, and recommendations based on the conclusions.

5.1 Summary of the findings

5.1.1. Factors contributing to the rapid prevalence of armyworms in maize production in Bumusomi ward, Bubutu town council Namisindwa district

A significant portion of respondents strongly agreed (44.4%) or agreed (41.7%) that the lack of effective pest control measures implemented by local maize farmers is a major factor contributing to the rapid prevalence of fall armyworms. This consensus underscores the critical need for improved pest management practices in the region. Moreover, a substantial percentage of respondents strongly agreed (30.6%) or agreed (47.2%) that limited awareness and knowledge among farmers regarding



armyworm management also contributes significantly to the problem. This highlights a critical gap in the dissemination of knowledge and education about pest management. Additionally, the survey revealed that favorable climatic conditions (33.3% strongly agree, 19.4% agree) and suboptimal agricultural practices (19.4% strongly agree, 38.9% agree) contribute significantly to the proliferation of armyworms. These findings indicate that addressing these factors through enhanced pest control measures, increased farmer education, adaptation to local climatic conditions, and better agricultural practices is crucial to effectively managing fall armyworm infestations in Bumusiomi Ward.

5.1.2. Assessing the control strategies employed by farmers in Bumusomi ward Bubutu town council Namisindwa district

Based on the data from Table 4.8 and the responses gathered, the assessment of control strategies employed by farmers in Bumusomi Ward, Bubutu Town Council, Namisindwa District reveals a diverse approach to managing armyworm infestations in maize fields. The predominant strategy reported is the frequent use of chemical pesticides (30.6% strongly agree, 38.9% agree), highlighting their immediate effectiveness but also raising concerns about potential environmental impacts and pest resistance. Biological control methods are occasionally adopted (30.6% strongly agree, 47.2% agree), demonstrating a growing interest in sustainable pest management practices. Cultural practices like crop rotation are widely employed (44.4% strongly agree, 36.1% agree), reflecting a proactive approach to disrupting pest lifecycles. Mechanical control measures, such as handpicking larvae, are also utilized (44.4% strongly agree, 13.9% agree), indicating a hands-on approach to localized pest management. Traditional remedies serve as a last resort (33.3% strongly agree, 16.7% agree), emphasizing their supplementary role in pest control strategies. Overall, the findings underscore the importance of integrating multiple methods to effectively manage armyworm outbreaks while minimizing environmental impact and promoting sustainable agricultural practices in the region.

5.1.3 Challenges faced by farmers to adaption on different control strategies for armyworms in Bumusomi ward Bubutu town council Namisindwa district

In exploring the challenges faced by farmers in Bumusomi ward, Bubutu town council, Namisindwa district, regarding the adoption of armyworm control strategies, several critical issues emerged. Firstly, a significant proportion of farmers lack

awareness about effective pest management methods, with 38.9% strongly agreeing and 22.2% agreeing on this point. This gap in knowledge is exacerbated by inadequate agricultural extension services and limited dissemination of information, echoing findings from similar studies. Secondly, access to affordable and quality pesticides remains a major barrier, as highlighted by 30.6% strongly agreeing and 27.8% agreeing, compounded by poor supply chain logistics. Thirdly, there is insufficient knowledge about integrated pest management (IPM), with 13.9% strongly agreeing and 19.4% agreeing, indicating a need for targeted educational programs. Moreover, high costs associated with purchasing pesticides (30.6% strongly agreeing and 16.7% agreeing) and resistance of armyworms to commonly used pesticides (36.1% strongly agreeing and 25.0% agreeing) further hinder effective pest control efforts. These challenges underscore the necessity for enhanced extension services, improved access to affordable inputs, and educational initiatives to promote sustainable pest management practices in the region.

5.2 Conclusion

5.2.1 Factors Contributing to the Rapid Prevalence of Armyworms in Maize Production in Bumusomi Ward, Bubutu Town Council, Namisindwa District

The study identifies several critical factors contributing to the widespread prevalence of fall armyworms in maize production within Bumusomi Ward. A significant consensus among respondents underscores the primary issue of inadequate pest control measures employed by local farmers. This finding reflects a systemic challenge where many farmers lack access to effective pesticides or employ outdated methods, which are often insufficient to manage the resilient fall armyworm. This issue is exacerbated by limited financial resources among smallholder farmers, hindering their ability to invest in costly pest control solutions. Moreover, the reliance on traditional practices that are less effective against modern agricultural challenges contributes to the persistence of armyworm infestations.

Another crucial factor highlighted in the study is the limited awareness and knowledge among farmers regarding effective armyworm management strategies. This knowledge gap significantly impacts farmers' ability to identify, prevent, and mitigate armyworm infestations effectively. Many farmers in the region rely on anecdotal knowledge or outdated information, which may not align with current best practices in integrated pest management (IPM). Addressing this gap requires



targeted educational interventions that empower farmers with up-to-date information on pest biology, monitoring techniques, and sustainable control measures. Efforts to improve farmer education must also consider local contexts, including language barriers and varying levels of formal education among farming communities.

Furthermore, the study reveals the significant role of climatic conditions in promoting armyworm proliferation. Favorable weather patterns, characterized by warm temperatures and adequate humidity, create optimal conditions for the rapid reproduction and spread of armyworm populations. These climatic factors contribute to seasonal peaks in infestation rates, posing recurrent challenges to maize farmers throughout the growing seasons. Adapting agricultural practices to local climate variability and integrating weather forecasts into pest management strategies are crucial steps toward mitigating the impact of climatic factors on armyworm prevalence.

Additionally, suboptimal agricultural practices among farmers play a substantial role in exacerbating armyworm infestations. Poor crop management techniques, such as irregular planting schedules or inadequate soil fertility management, weaken maize plants' natural defenses against pests. These practices create vulnerabilities that armyworms exploit, leading to higher incidences of crop damage and yield losses. Addressing these agricultural challenges requires promoting sustainable farming practices that enhance soil health, improve crop resilience, and reduce the reliance on chemical inputs that may exacerbate environmental risks.

In conclusion, addressing the rapid prevalence of armyworms in Bumusomi Ward demands a multifaceted approach. This approach should include improving access to effective pest control measures, enhancing farmer education and awareness on integrated pest management, adapting agricultural practices to local climatic conditions, and promoting sustainable farming techniques. By addressing these underlying factors, stakeholders can develop more resilient agricultural systems that mitigate the impact of armyworm infestations and ensure long-term food security and livelihood sustainability for farmers in the region.



5.2.2 Assessing the Control Strategies Employed by Farmers in Bumusomi Ward, Bubutu Town Council, Namisindwa District

The assessment of control strategies employed by farmers in Bumusomi Ward offers insights into the varied approaches used to manage armyworm infestations in maize fields. One of the predominant strategies reported is the frequent use of chemical pesticides. Farmers often resort to chemical treatments due to their immediate effectiveness in controlling armyworm populations. However, the overreliance on chemical pesticides raises concerns about environmental sustainability, human health impacts, and the development of pest resistance over time. These challenges necessitate a balanced approach that integrates chemical treatments with other pest management strategies to minimize adverse effects on ecosystems and public health.

Biological control methods are increasingly recognized and adopted by farmers seeking sustainable pest management solutions. These methods include the introduction of natural predators or parasites that prey on armyworms, thereby reducing pest populations without the use of synthetic chemicals. While biological control offers environmental benefits and aligns with organic farming principles, its effectiveness can be influenced by factors such as predator availability, climatic conditions, and the diversity of local ecosystems. Encouraging the adoption of biological control requires supporting farmers with technical knowledge, access to biocontrol agents, and monitoring systems to assess effectiveness.

Cultural practices, such as crop rotation and intercropping, play a crucial role in disrupting the lifecycle of armyworms and reducing pest pressures. Farmers in Bumusomi Ward commonly implement these practices to minimize armyworm infestations while enhancing soil fertility and crop resilience. Crop rotation, for instance, breaks the cycle of pests that target specific crops, while intercropping introduces plant diversity that can deter pests and improve overall farm productivity. These traditional farming practices not only contribute to pest management but also support sustainable agricultural systems that promote biodiversity and ecosystem health.

Mechanical control measures, such as handpicking armyworm larvae or using physical barriers like traps or nets, provide localized solutions for managing armyworm infestations. These methods are labor-intensive but can be effective in



small-scale farming operations where pest populations are manageable. Farmers often combine mechanical control with other strategies to enhance their effectiveness, such as timing treatments with pest life cycles or integrating them into routine field management practices. While mechanical control may not be feasible on large farms due to labor constraints, it remains a valuable tool in integrated pest management strategies that prioritize sustainability and reduced environmental impact.

Traditional remedies and indigenous knowledge systems also play a role in pest management strategies in Bumusomi Ward. Farmers may utilize plant extracts, natural repellents, or cultural practices passed down through generations to deter armyworms and protect their crops. These traditional methods, while supplementary to modern pest control techniques, highlight the importance of preserving and integrating local knowledge into agricultural practices. However, the efficacy of traditional remedies can vary based on factors such as local biodiversity, weather conditions, and pest resistance. Integrating traditional knowledge with scientific research and development can enhance the effectiveness of pest management strategies while respecting cultural traditions and promoting community resilience.

In conclusion, assessing the control strategies employed by farmers in Bumusomi Ward underscores the diversity and adaptability of approaches to managing armyworm infestations. A holistic approach that integrates chemical, biological, cultural, and mechanical control methods is essential for sustainable pest management. Empowering farmers with knowledge, resources, and support systems tailored to local conditions can enhance the effectiveness of these strategies while promoting environmental stewardship and resilient agricultural systems in Namisindwa District.

5.2.3 Challenges Faced by Farmers in Adopting Different Control Strategies for Armyworms in Bumusomi Ward, Bubutu Town Council, Namisindwa District

Farmers in Bumusomi Ward face significant challenges in adopting and implementing effective control strategies for managing armyworm infestations in maize production. These challenges stem from various factors that impact their ability to protect crops, sustain livelihoods, and ensure food security in the community.

A primary challenge highlighted by the study is the limited awareness and knowledge among farmers regarding integrated pest management (IPM) practices. Many farmers rely on traditional knowledge or anecdotal information passed down through generations, which may not align with current best practices in pest control. This knowledge gap underscores the need for targeted educational programs that empower farmers with up-to-date information on pest biology, monitoring techniques, and sustainable control measures. Enhancing farmer education can enable them to make informed decisions about pest management strategies that are effective, economical, and environmentally sustainable.

Access to affordable and quality pesticides remains a significant barrier for farmers in Bumusomi Ward. The high cost of chemical pesticides, coupled with logistical challenges in the supply chain, limits farmers' ability to purchase and apply these products effectively. Moreover, reliance on chemical treatments without adequate training or access to alternative pest control methods can lead to pest resistance, environmental pollution, and risks to human health. Addressing these challenges requires improving access to affordable pest control products, supporting cooperative purchasing arrangements, and promoting alternative pest management strategies that reduce reliance on chemical inputs.

Furthermore, there is a lack of knowledge and technical capacity among farmers regarding the implementation of integrated pest management (IPM) strategies. IPM emphasizes the use of multiple tactics, including cultural, biological, and mechanical controls, to manage pests effectively while minimizing environmental impact. However, many farmers in Bumusomi Ward are unfamiliar with these holistic approaches or lack the resources to implement them effectively. Strengthening extension services and agricultural advisory programs can bridge this knowledge gap by providing farmers with training, demonstrations, and technical support tailored to their specific needs and local conditions.

Moreover, the high costs associated with purchasing pesticides and the development of resistance among armyworm populations pose additional challenges to effective pest management. Farmers often face financial constraints that limit their ability to invest in alternative pest control methods or sustainable farming practices. This economic barrier underscores the importance of supporting



farmers with financial incentives, subsidies for organic inputs, and access to credit facilities that promote sustainable agriculture. Encouraging collaboration among stakeholders, including government agencies, non-governmental organizations, and private sector partners, can leverage resources and expertise to address these challenges collectively.

In conclusion, addressing the challenges faced by farmers in Bumusomi Ward requires a coordinated effort to enhance farmer education, improve access to affordable pest control products, promote integrated pest management (IPM) strategies, and support sustainable agricultural practices. By empowering farmers with knowledge, resources, and support systems, stakeholders can strengthen resilience against armyworm infestations while promoting environmental sustainability and food security in Namisindwa District.

5.3 Recommendations

5.3.1 Factors Contributing to the Rapid Prevalence of Armyworms

To effectively mitigate the rapid prevalence of armyworms in maize production in Bumusomi Ward, Bubutu Town Council, Namisindwa District, it is crucial to implement a multifaceted approach. First and foremost, establishing a comprehensive pest surveillance and monitoring system is imperative. This system should include regular monitoring of armyworm populations and early detection of infestations. By doing so, farmers and agricultural extension services can swiftly respond to outbreaks, minimizing crop damage and economic losses. Furthermore, promoting Integrated Pest Management (IPM) practices is essential. Educating farmers on the principles of IPM, which integrates cultural practices like crop rotation and intercropping, alongside biological and chemical control methods, can significantly reduce reliance on chemical pesticides while maintaining effective pest control. Access to affordable and effective pesticides should also be ensured, coupled with training programs on proper application techniques and safety measures to enhance efficacy and minimize environmental impact.

5.3.2 Assessment of Control Strategies Employed by Farmers

The assessment of control strategies employed by farmers in Bumusomi Ward reveals opportunities to enhance pest management practices sustainably. Diversifying pest control methods beyond chemical pesticides emerges as a critical

recommendation. Encouraging the adoption of biological control agents, such as natural predators or parasitic organisms, can offer effective and environmentally friendly alternatives. Moreover, promoting cultural practices like crop diversification and mechanical control methods such as manual removal of armyworms can complement existing pest control strategies. Strengthening farmer education on these alternatives is pivotal, ensuring they possess the knowledge and resources needed for successful implementation. Establishing farmer field schools and demonstration plots can serve as practical learning platforms, showcasing successful integrations of IPM practices and encouraging wider adoption among farming communities.

5.3.3 Challenges Faced by Farmers in Adapting Control Strategies

Addressing the challenges faced by farmers in adapting control strategies for armyworms requires concerted efforts to bridge knowledge gaps and facilitate resource access. Enhancing farmer education is paramount, focusing on the benefits and application of Integrated Pest Management (IPM) tailored to local conditions. Providing accessible and affordable pest control products through cooperative purchasing arrangements and subsidies can alleviate financial barriers and promote sustainable agricultural practices. Furthermore, building capacity within extension services and agricultural advisory programs is essential. These initiatives can provide ongoing support and technical assistance, empowering farmers to implement sustainable pest management strategies effectively. Collaboration among stakeholders, including government agencies, NGOs, and private sector partners, is key to developing holistic approaches that address both immediate challenges and long-term agricultural sustainability goals.

5.4 Areas for further research

These include;

- i. Environmental Sustainability in Coffee Production
- ii. Market Dynamics in Coffee Production
- iii. Gender Equity in Coffee Farming
- iv. Efficiency of the Coffee Value Chain
- v. Climate Change Adaptation Strategies in Coffee Farming



vi. Policy Impact on Sustainable Coffee Production

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APPENDICES

APPENDIX I: QUESTIONNAIRE

Dear respondent;

I am KHAINZA JANET carrying out research on the topic "ASSESSING THE IMPACT OF FALL ARMYWORMS ON MAIZE PRODUCTION AND THEIR CONTROL STRATEGIES EMPLOYED BY FARMERS IN BUMUSOMI WARD BUBUTU TOWN COUNCIL, NAMISINDWA DISTRICT." as a partial fulfillment of the Requirements for the Award of the Bachelors of Science and Education at Busitema University. The questionnaire is designed to help me collect relevant information and therefore I kindly request you to participate in responding to the questions that will be asked .However the information given will be treated confidential and will only be used for academic



purpose.

SECTION 1: DEMOGRAPHIC DATA

(Tick in the box provided)

1. Sex of the respondent

a) Male b) Female

2. Age bracket of the respondent (years)

a) 15-30 b) 31-40 c) 41-50 C) 60 and above

3. Marital status

a).Single b).Married c) In relationship

4. Academic qualification of respondent

a) Secondary b) Certificate c) Diploma d) Bachelors' e) Masters

5. Years of working by the respondents.

a) Less than 1 year b) 1-2 years c) 3 years and above

6. Religion

a).protestant b). Catholic c).Born Again d). Muslim e). Anglican f).Other

7. Occupation

a) youth leader b).Chief c).Religious leader d).Teacher e) Other

Section A: Factors contributing to the rapid prevalence of armyworms in maize production in Bumusomi ward, Bubutu town council Namisindwa district

This section aims at finding out the factors contributing to the rapid prevalence of armyworms in maize production in Bumusomi ward Bubutu town council Namisindwa district. Please indicate your opinion on the following statements using the Linkert scale.

Key: 1= Agree; 2= strongly Agree; 3= not sure; 4= Disagree; 5= strongly disagree.

No	Statements	1	2	3	4	5
1	Lack of effective pest control measures implemented by local maize farmers					
2	Limited awareness and knowledge among farmers regarding armyworm management					
3	Favorable climatic conditions in the area that promote armyworm proliferation					
4	Suboptimal agricultural practices and inadequate crop management techniques employed by farmers					
5	Insufficient availability and accessibility of agricultural extension services in the region					

Section B: Assessing the control strategies employed by farmers in Bumusomi ward Bubutu town council Namisindwa district

This section aims at assessing the control strategies employed by farmers in Bumusomi ward Bubutu town council Namisindwa district. Please indicate your opinion on the following statements using the Linkert scale. Key: 1= Agree; 2= strongly Agree; 3= not sure; 4= Disagree; 5= strongly disagree.

No	Statements	1	2	3	4	5
1	Farmers frequently use chemical pesticides.					
2	Biological control methods are occasionally adopted.					
3	Cultural practices such as crop rotation are common.					
4	Mechanical control measures like handpicking larvae are employed.					
5	Traditional remedies are sometimes used as a					

	last resort.					
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Section C: Challenges faced by farmers to adaption on different control strategies for armyworms in Bumusomi ward Bubutu town council Namisindwa district

This section aims at assessing challenges faced by farmers to adaption on different control strategies for armyworms in Bumusomi ward Bubutu town council Namisindwa district. Please indicate your opinion on the following statements using the Linkert scale. Key: 1= Agree; 2= strongly Agree; 3= not sure; 4= Disagree; 5= strongly disagree.

No	Statements	1	2	3	4	5
1	Farmers lack awareness of effective control methods.					
2	Limited access to affordable and quality pesticides.					
3	Insufficient knowledge about integrated pest management.					
4	High costs associated with purchasing and applying pesticides.					
5	Resistance of armyworms to commonly used pesticides.					



APPENDIX II: INTERVIEW GUIDE

Objective 1: Factors contributing to the rapid prevalence of armyworms in maize production

1. Can you describe your experience with maize farming in Bumusomi Ward?
2. How long have you been farming maize, and what are the major challenges you face?
3. What is your awareness level regarding the presence and impact of armyworms on maize crops?
4. According to your experience, what factors do you think contribute to the rapid spread of armyworms in this area?
5. What types of pesticides or control methods have you used to manage armyworm infestations, and how effective do you find them?

Objective 2: Assessment of control strategies employed by farmers

1. Can you describe the main strategies you use to control armyworm infestations in your maize fields?
2. How did you learn about these strategies, and what factors influenced your choice of methods?
3. In your experience, how effective have these control strategies been in managing armyworm outbreaks?
4. What are the main challenges you face when implementing these control strategies?
5. Have you made any adjustments or innovations to your control strategies over time, and if so, what prompted these changes?

Objective 3: Assessment of challenges faced by farmers in adopting control

strategies

1. How familiar are you with different control strategies available for managing armyworms?
2. What are your perceptions of the effectiveness of these strategies?
3. What are the main challenges or obstacles you encounter when trying to adopt new control strategies?
4. Do you receive support or guidance from agricultural extension services or local authorities regarding pest management?
5. How do financial resources and access to inputs (e.g., pesticides, equipment) impact your decision-making regarding pest control?



APPENDIX III : PROPOSED WORK PLAN

March 2024	Define research objectives and develop proposal	March 1 - March 31
April 2024	Finalize research design and obtain necessary approvals	April 1 - April 30
May 2024	Develop data collection tools and pilot test them	May 1 - May 31
June 2024	Conduct surveys and perform document analysis	June 1 - June 30
July 2024	Interview participants and clean data	July 1 - July 31
August 2024	Analyze quantitative and qualitative data	August 1 - August 31
September 2024	Compile research findings and prepare presentations	September 1 - September 15
	Finalize research report and submit dissertation	September 16 - September 30

APPENDIX IV: PROPOSED BUDGET

Items	Estimated Cost (UGX)
Personnel Costs:	
Research Assistants' stipends	100,000
Data entry personnel fees	50,000
Consultants	50,000
Total Personnel Costs:	200,000
Travel and Accommodation Costs:	
Transportation	100,000
Accommodation	100,000
Per diems for fieldwork	100,000
Total Travel and Accommodation Costs:	300,000
Materials and Supplies Costs:	
Stationery and printing	40,000
Data collection tools	40,000
Software	60,000
Total Materials and Supplies Costs:	140,000
Equipment Costs:	
Laptops, tablets, or other devices	60,000
Recording equipment	40,000
Total Equipment Costs:	100,000
Communication Costs:	
Internet charges	20,000
Telephone expenses	20,000
Total Communication Costs:	40,000
Training Costs:	
Research methodology workshops	60,000
Skills development training	40,000
Total Training Costs:	100,000
Miscellaneous Costs:	
Contingency funds	20,000
Publication and dissemination costs	20,000
Total Miscellaneous Costs:	40,000
Total Project Budget (UGX):	1,000,000

