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FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

DEPARTMENT OF CROP SCIENCE

Assessment of yield economic losses caused by pests and diseases in selected maize production ecosystems in Shamva District Mashonaland Central

by

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A research project submitted in partial fulfilment of the requirements of a Bachelor of Agricultural Science Honours Degree (Crop Science).

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DECLARATION BINDURA UNIVERSITY OF SCIENCE EDUCATION

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The undersigned certify that they have read and recommended to the Department of Crop Science, this dissertation titled:

Assessment of yield economic losses caused by pests and diseases in selected maize production ecosystems in ward 26 Shamva District Mashonaland Central province in Zimbabwe

Supervisor…………………………………………..

Date……………………27/09/2025

Chairperson ……………………………………………………

Date……………………….

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DEDICATION

I dedicate this write up to to my family for their profound understanding as l deprive them same of their time with me as l committed myself to my studies ,my husband Sariroona for his undying love and shouldering the care for me and our sons Tawanda ,Tavonga ,and Tinomudaishe ,my sister Jesilline , my aunt Filder ,also being there for me throughout my degree programm. Of special mention also are my daughter Paidamoyo ,son in law Norman and my grandson Makomborero for showing great concern through encouragement as well as offering unwaving support to me ,morally and materially during my studies . Lastly but not least ,all the AGRITEX officers and my supervisor Mr Ndhlovu for their massive backing to ensure that l understand to the core the nitty gritties of the Agriculture extension officer .Be abundantly blessed by the Almighty .

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ABSTRACT

The study sought to assess the impact of pests and diseases on maize yield, to explore the role of pests and diseases on causing economic losses in maize production and to determine effective pest and diseases control strategies that can enhance yields and improve the financial conditions of maize farmers. A mixed method research methodology anchor on pragmatist philosophy and a case study research design was used in this research due to its ability to merge quantitative and qualitative components of data collection and presentation (Benton, and Craib, 2023). Findings indicated that Fall Armyworm is a significantly important pest aggravating the impacts of pre-existing invasive alien species. The pest was noted to result in an average of 0.7 tons per acre of maize loss incurred by farmers with the highest reported being 2.7 tons per acre in the study area. The study found that maize yield losses related to Fall Armyworm were aggravated by the area under maize production, group membership, household size, and Fall Armyworm damage intensity as described by farmers. The yield losses were found to decrease with access to extension services, years of formal schooling attained, farm income, and distance to market. The findings are contrary to the stated hypothesis that, farmer, farm specific, and institutional factors taken individually have no effect on the magnitude of yield losses in maize. Farmers seemed not to harbor any reservations on the efficacy of the practices they employed to increase maize productivity by managing the pest and promotion efforts to encourage the use of the practices. This implies that farmers perceived that combination of practices as a leveraging approach towards maximizing the efforts on effective management of the pest. .

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CHAPTER ONE: INTRODUCTION

1.1 Introduction

Crop losses are a major threat to the wellbeing of rural families, to the economy of traders and governments, and to food security worldwide (Zadoks and Schein, 1979; Savary and Willocquet, 2014; Avelino et al., 2015). In Southern Africa, crop losses are a resultant effect of pests and diseases especially for major food and cash crops (rice, wheat, barley, maize, potatoes, soybeans, cotton, and coffee). Pest and diseases induced losses were estimated to range between 20-40% in (Oerke et al., 1994; Oerke, 2006).

Attacks of pests and diseases can occur in the agricultural land during the production cycle (pre-harvest) and/or during the storage (post-harvest). In both stages, the yield of the crop product as well as its quality can be reduced (Savary et al., 2006b), which implies that financial returns will be also compromised because of less production to sell and/or less quality to offer to buyers (Nutter et al., 1993).

Furthermore, implications of crop losses can reach levels far beyond farms, given that a reduced production can affect entire rural communities and regions, national markets and exportations, and at broadest level, the food availability for the world population. Given the negative implications of crop losses, strategies and measures at different levels (from farms to governments) are needed to reduce them, and must be based on reliable assessments.

Quantification of crop product losses and a better understanding of their drivers have been mentioned as essential to (i) evaluating the efficacy of crop protection practices (Oerke, 2006), (ii) making better decisions for integrated pest management (Savary et al., 2006a), (iii) assessing the sustainability of agricultural production systems (Cooke, 2006), (iv) evaluating the effectiveness of pest and disease regulation as an ecosystem service (Avelino et al., 2011; Allinne et al., 2016), and (v) guiding government agencies and other potential donors about where, how and when allocate resources for better control of pests and diseases, and therefore avoid crop losses (Cooke, 2006). The results of these evaluations and guidance could contribute to the design of better

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practices to reduce the incidences of pests and diseases, as well as to the design of agroecosystems with characteristics (structurecomposition-management) aimed to reduce crop losses (Avelino et al., 2015).

Despite the importance of the assessment of crop losses, efforts to quantify them and analyze their causes are considered still scant (Cheatham et al., 2009; Avelino et al., 2011; Savary and Willocquet, 2014). This is an issue for all crops in general, and specially for perennial crops. The most remarkable efforts in the last two decades were concentrated in the quantification of relative yield losses due to pests and diseases through experiments and surveys and this study contribute towards these efforts to quantify yield loss caused by pests and diseases.

1.2 Statement of the Problem

The maize yield in ward 26 Shamva District is not proportionate to the maize input. The input-put put invariability has been a subject of debate and scholars alluded to other causes yet neglecting the influence of pests and diseases in contributing towards yield losses in maize production. Pests and diseases represent one of the main problems of maize production and their contribution in causing yield economic loss in maize production need to be explored. From the scientific point of view, first there is a need to increase the knowledge on crop losses and their causes for making better decisions for integrated pest management (IPM), and for developing agroecosystems capable to balance good yields and regulate the impacts of pests and diseases through ecosystem services (Savary et al., 2019; Avelino et al., 2021).

1.3 Aim of the Study

The study aim at assessing the yield economic losses caused by pests and diseases in selected maize production ecosystems in ward 24 Shamva District Mashonaland Central province in Zimbabwe.

1.4 Justification of the Study

This research developed and combine methods original or suggested by the scientific literature in order to quantify and analyze maize yield and economic losses, caused by

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pests and diseases. Experiments, surveys and modeling will be combined to achieve that goal. The main results are expected to be useful for a better understanding on how maize yield losses occur, and to identify the combinations of management strategies and production situations in which maize agroecosystems are capable to regulate pests and diseases, while providing other ecosystem services for smallholder farmers. This knowledge is necessary to design and manage sustainable maize agroecosystems.

1.4 Research Objectives

1. To assess the impact of pests and diseases on maize yield.

2. To explore the role of pests and diseases on causing economic losses in maize production.

3. To determine effective pest and diseases control strategies that can enhance yields and improve the financial conditions of maize farmers.

1.5 Hypothesis

1. What is the impact of pests and diseases on maize yield?

2. What is the role of pests and diseases on causing economic losses in maize production?

3. What are the effective pest and diseases control strategies that can enhance yields and improve the financial conditions of maize farmers?

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CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Maize is a major food crop in Africa, especially in the southern regions of the continent. For many people, it is the main staple, as evidenced by annual consumption levels of 81 kg/per capita in the region. Food production has not kept pace with population growth, and most of the arable land is now being cultivated, leading to serious problems in food security. Agricultural intensification often leads to higher pest and diseases pressure leading to yield loss in Maize production.

2.2 Maize Viruses and Yield Loss

The first maize virus was found in the U.S.A. in the 1920's when Brandes discovered a mosaic disease of maize found near sugarcane fields (Gordon, 2021). This virus was identified as sugarcane mosaic virus (SCMV) . From the beginning of the 1960's maize viruses became more important in the U.S.A., when major epiphytotics occurred (Shepherd, 2025). In 1965 Williams and Alexander described the virus associated with the maize dwarf disease as maize dwarf mosaic virus (MDMV) and since then MDMV has been found in most of the maize growing areas in the U.S.

In South Africa, Storey (2019) reported the presence of a virus which he first detected in 1924 near Pretoria in Sorghum arundinaceum Stapf., a wild grass. The virus caused a mosaic disease on maize and sorghum and was not distinguishable from SCMV by symptoms, but it did not infect sugarcane. Later, in 1967, Von Wechmar and Hahn reported a separate strain of SCMV infecting sorghum, on the basis of serological tests. Erasmus (1979, Hons. project, U.C.T.) compared a sorghum and two sugarcane isolates using the indirect ELISA method, and found that all three were closely related serologically to an SCMV strain from sugarcane (von Wechmar and Hahn, 2017).

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Erasmus (1979, Hons. project U.C.T.) was the first to use ELISA for serological comparison of SCMV isolates in South Africa. SCMV and MDMV are considered strains of the same virus (Pirone, 2022). Both viruses infect similar host ranges restricted to the Gramineae family. SCMV and MDMV are members of the Potyrivus group. MDMV and SCMV occur worldwide, in the States, Europe, Asia and Africa (Gordon, 2021) .

A broad generalization of symptoms produced by MDMV in the hosts it infects is given. Many hosts show a mosaic symptom and in some cases, for example, maize (Zea mays L.), MDMV causes dwarfing (Williams and Alexander, 2022; Seghal and Jean, 2018; Tosic and Ford, 2022). Some varieties of sorghum show necrosis and leaf reddening when infected with MDMV and can cause stunted growth and subsequently low yield (Pirone, 2022; Martin and Hackerott, 2022).

Yield losses due to MDMV infection in maize crops have been recorded to range from 10 to 54% (Williams and Alexander, 2022; Gregory and Ayers, 2022; Kuhn and Smith, 2017; Gordon, 2021). Various methods for controlling virus disease spread have been suggested, e.g. use of insecticides (Ferro and Mackenzie, 2020), application of carbofuran to soil to prevent further dissemination of virus by vectors (Rains and Christensen, 2023). But these methods would only prevent secondary spread of the virus. A more effective way of control would be to breed maize lines for resistance to virus, e.g. as suggested by Scott and Findley, 2024 and Martin, 2024. It has been shown that different maize lines have different responses to MDMV infection (Louie, 2016). Breeding maize for resistance to MDMV is important in the light of the seed transmission of the virus.

2.3 Types of Diseases

2.3.1 Common Rust

Common rust, caused by Puccinia sorghi Schw, is a devastating disease that causes yield losses of up to 61 percent in disease epidemic years in the country's key maize growing highland areas. Maize common rust (CR) is found in temperate as well as subtropical and tropical agricultural zones (FAO Stat, 2019). Puccinia sorghi is a parasitic obligate host. Common rust disease epidemics have short latency periods of

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five to ten days at temperatures ranging from 15 to 25°C, and they are more common at relative humidity levels of at least 98 percent. The disease has become a potential hazard to maize agriculture in Africa. It emerges in the early phases of maize development and, if adequate management is not implemented in a timely manner, it harms the plant, resulting in larger yield losses.

Common rust produces severe yellowing and early desiccation of maize leaves, leading to leaf necrosis and total elimination of the photosynthetic regions. Heavy rust infestations can cause stunting, inadequate ear tip fill, and pustules on ear husks, lowering marketability and production.

Maize common rust causes a yield loss of 12–60% in Asia and occurs in all maize-growing places across the world. Currently, common rust is the most serious danger to maize production in Ethiopia's maizegrowing areas, causing major yield losses. Most maize cultivars grown in Southern Africa are susceptible to the disease, which causes significant output losses under good weather conditions. The disease occurs in many maize-producing areas throughout the country, resulting in grain production losses of up to 23%, with vulnerable cultivars such as CML-202 losing up to 60.5 percent of their output Deyle, et al. Similarly, Netsanet (2022) observed disease severity of up to 35% and relative yield loss of 29% in unsprayed plots owing to this pathogen Southern Africa.

One of the bottlenecks responsible for diminishing maize yielding potential in developing countries such as Ethiopia is the use of varieties with inferior genes, which are sensitive to diseases, insects, weeds, low yielding, and of poor quality. Furthermore, a lack of enough investment and trained labor to enhance varieties for high yield and disease resistance, as well as dwindling land and water resources and environmental pressures, is lowering the crop's producing potential. Crop rotation, sanitation, seed treatments, foliar fungicide application, fertility adjustment, and biological controls are among the many techniques for managing common smut that have been advocated or researched. According to Jeger; Madden, (2019), knowledge of plant disease epidemiological aspects is important for understanding the biology of their causative agents as well as for establishing, planning, and monitoring effective disease control

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methods. Understanding disease epidemiology and how it is impacted by various variables is also helpful in developing environmentally sustainable disease control methods and strategies.

Previous investigations in other parts of Africa, in particular in Eastern Africa investigated the disease’s relationship with farming patterns and various cultural behaviors. The use of fungicide is beyond the access of resource-constrained farmers and, moreover, increases the production costs. It is hazardous to human health and hasa negative impact on the environment. The use of resistant varieties is an effective strategy for resource-constrained farmers. This is the most durable and economical means for disease management. This principle is equally important for an eco-friendly environment.

2.3.2 Maize Lethal Necrosis Disease

Maize lethal necrosis disease is caused by a synergistic interaction between Maize Chlorotic Mottle Virus (MCMV) and Sugarcane Mosaic Virus (SCMV), as well as other viruses including Maize Dwarf Mosaic Virus (MDMV) and Wheat Streak Mosaic Virus (WSMV) [35]. MCMV and SCMV have been linked to MLN illness symptoms in Africa. Maize lethal necrosis (MLN) disease has emerged as the country’s single most significant production limitation. The disease was first reported in Kenya in 2012, then in Rwanda, the Democratic Republic of Congo, and Uganda’s border areas. For example, in Ethiopia, the disease was discovered in maize plants with severe yellowing and chlorotic mottle signs in July 2014, indicating that the disease was present. In 2014, both MCMV and SCMV were reported to elicit MLND symptoms in Ethiopia, either alone or in combination infections. However, a new maize virus, Maize Yellow Mosaic Virus (MaYMV), has just been discovered in Ethiopia. This might indicate that the viral situation in the country is constantly changing, requiring an immediate reaction from all stakeholders to meet the current difficulties.

Plants infected with MLND exhibit symptoms such as stunting, necrosis, mottling, streak and mosaic patterns, and extended yellow streaks parallel to leaf veins. Streaks

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can join together to form chlorotic mottling. Chlorotic mottling can be followed by leaf necrosis, which can cause “dead heart” symptoms and plant mortality, rapid aging of the plants, failure to tassel and sterility in male plants, deformed or no ears, failure of cobs to put on grains, and rot.

MLND poses a significant threat to maize production in Southern African nations such as Zimbabwe. The disease’s losses are determined by a range of conditions, including plant stage infection, variety type, viral strain, and climatic circumstances. Yield losses ranged from 31 to 70 percent in most Southern African countries. In both artificial and natural inoculations of maize crops in north central Kansas and south central Nebraska, yield losses of 50–90% have been documented. Even though the entrance of the disease into Ethiopia is intraclast, it threatens and limits maize output to its maximum potential. Subsequent reports of severe maize production losses as a result of the disease have been reported after its introduction to maize-growing areas in Zimbabwe. It has resulted in a 100% crop loss during the 2014 growing season. The susceptibility of the crop to the disease is not limited to one growth stage but all.

All stages of growth are revealed, from seedling to approaching maturity. Because the seedling stage is the most susceptible to infection, complete crop loss might occur. In most Southern African countries, the negative impact of MLND is already visible at the farm, country, and national levels. In some parts, affected farmers have lost their whole harvest. The loss is caused by diseased maize plants with tiny ears that are deformed and set few or no grains. However, the cost of producing maize is rising due to farmers’ use of herbicides and insecticides and from the expenditures required by seed providers for maize seed treatment, to reduce weeds and vector transmitters. Any interruption in production always undermines food and nutrition security for a substantial portion of the population. As a result, effective measures should be taken to manage and decrease disease-related losses while also optimizing production.

The purpose of plant disease control is to lower it to a level that will not cause considerable loss or crop damage. Disease management is accomplished by the integration of many solutions. Controlling MLND is challenging for two reasons. The

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disease is produced by a mixture of two or more viruses that are difficult to discriminate between based on visual symptoms, and the vectors that transmit the viruses may travel large distances via wind. The most common and extensively used strategies for managing MLND include pathogen exclusion and eradication, lowering the rate of infection by avoidance, plant protection, and resistant or tolerant cultivars.

In Ethiopia, a pilot study on eight maize genotypes, including Melkassa 1, Melkassa 2, Melkassa 4, MH 140, MH 130, MHQ 138, JIBAT, and CML 445, revealed the presence of different responses to MLND. She infected the viruses individually and in groups at the National Agricultural Biotechnology Research Center's greenhouse (NABRC) (Hooker, 2024). All genotypes have varying levels of severity. Melkassa 1, 2 and MHQ 138 were shown to be more resistant than the other genotypes employed in the study. Her findings were consistent with those of Jacob in Tanzania, who discovered that landrace genotypes were more suited to MLND than modified cultivars or inbred lines. The evolutionary association of Ethiopian isolates with other nations may serve as a foundation for applying management techniques to the Ethiopian situation. So, relevant recommendations for MLND management in Ethiopia could include monitoring the field once a week at all stages of development for symptoms of disease development, uprooting diseased plants and burning them immediately to stop the spread of the disease, and controlling vectors with pesticides such as diazinon 60 percent EC (1-1.5 lit/ha), malathion 50 percent EC (2 lit/ha), and lambda-cyhalothrin 5 percent (0.2-0.4 lit/ha).

In addition, rotate with pulse crops, use disease-free seed and fertilize at the necessary rate, weed fields on a regular basis to eliminate alternate hosts of insect vectors, and avoid growing a new maize crop near sick areas. Crop rotations and maize-free periods are short-term interventions that are thought to be especially efficient at limiting MLN. Farmers should be required to stop cultivating maize for a season and instead plant legume crops. Farmers must use several agronomic methods, such as timely planting and weeding, proper plant spacing, and enough fertilizer treatment to ensure optimal plant health across all genotypes.

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2.3.3 Gray Leaf Spot

Gray leaf spot is now recognized as one of the most severe maize (corn) yield-limiting diseases in the world. Gray leaf spot has become a pandemic throughout Africa. The discovery of the disease in the South African province of KwaZulu-Natal was the first official report from the African continent. Grey leaf spot was originally discovered in Ethiopia in 1997 along the border of the west Wellega and Ilubabor zones in western Ethiopia. It has been the most important maize disease in Ethiopia since 1998. According to the survey report, the prevalence of grey leaf spot has grown in the key maize producing areas of Western, Southern, and Northwestern Africa. According to the paper, grey leaf spot has been the most important maize disease in Ethiopia since 1998. Gray leaf spot, caused by Cercospora zeae maydis, has become one of the most important maize yield-limiting diseases in Southern Africa, including Zimbabwe. This disease is most severe and devastating during protracted periods of high relative humidity, sluggish drying of dews, and late-season fogs Lyimo, et al. Increased gray leaf spot occurrence in Zimbabwe has been linked to cultural practices such as reduced tillage, continuous maize production, and the adoption of vulnerable maize varieties. It is one of the most serious maize diseases in Ethiopia, particularly in the western Oromia region.

Gray leaf symptoms are usually initially noticed on the lower leaves. Initially, immature lesions are difficult to identify from lesions produced by other foliar diseases of maize [66]. Lesions first emerge as little tan patches, typically 1 to 3 mm long and rectangular to irregular in shape. Gray leaf spot is distinguished by the fact that lesions often run parallel to leaf veins. Further lesion growth causes lesion clustering and blighting of whole leaves. Stalk degeneration and severe lodging may develop with severe lighting. Sporulating lesions take on a grey hue, hence the term “gray leaf spot”. Gray leaf spot has an extended latent period when compared to other foliar diseases, and lesions can sporulate 14 to 28 days after infection. The size, quantity, and kind of lesions can vary substantially between genotypes. Susceptible inbreds and hybrids frequently have necrotic lesions, whereas moderately resistant inbreds and hybrids frequently have chlorotic and/or fleck-type lesions.

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Grey leaf spot in maize causes yield losses ranging from 11 to 69 percent, with estimated losses as high as 100 percent when severe epidemics contribute to photosynthetic area loss (Hooker, 2024). Severe lodging can also negatively affect mechanical harvesting and result in additional grain loss due to a reduction in harvestable grain yield. In South Africa, yield losses due to the disease were estimated to be 50% for moderately resistant hybrid maize and 65% for susceptible hybrid maize. In Ethiopia, Dagne reported that yield losses due to grey leaf spot on resistant, moderately resistant, and susceptible cultivars were between 0-14.9 percent, 13.7-18.3 percent, and 20.8-36.9 percent, respectively, during the 2003/2004 cropping seasons in Bako and its surrounding areas.

Among the significant disease restrictions on maize production in Ethiopia, diseases such as grey leaf spot cause considerable yield losses due to high grey leaf spot incidence and severity in farmers' fields (Hooker, 2024). Cultural methods and the use of fungicides have been used for grey leaf spot management Ward, et al. but they have not been effective because fungicide application is expensive and not practical in most operations for resource poor farmers as well as having unpredictable weather and environmental side effects. The availability and use of resistant maize hybrids would provide a low-cost method of reducing grey leaf spot. However, there is limited actual data on how different maize types react to the illness. Crop rotation, planting date/early planting, increased ploughing frequency, and conservation tillage are all cultural techniques for reducing the impact of gray leaf spot.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Area of study

The study was carried out in Shamva District ward 26 located in Mashonaland Central. The study area falls in Natural farming region IV and experiences average temperatures of 32 ^{0}C in summer and 27 ^{0}C in winter and annual rainfall ranging from 400 –

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600mm.The soils are sandy loam with a depth of 2 meters. The area is comprised of small holder farmers who are getting into maize production.

3.2 Preparation of the land and planting:

The research was carried out employing a randomised complete block design. Three blocks were chosen for the experiment, with each block comprising five plots. Each plot had dimensions of 5 metres by 1 metre with a pathway 1 metre wide between plots and 2 meters between blocks. The land was prepared using conventional agricultural methods. The land was initially cleared of vegetation and refuse. Afterwards, the land was cultivated using an ox-drawn plough to loosen the soil and establish a good seedbed. The clumps of soil were further pulverised using an ox-drawn harrow in order to attain a finer tilth.

2 furrows were excavated 45cm apart on each plot. A compound D fertiliser was applied to the furrows at the application rate of 150kg/ha. The furrows were thereafter lightly covered to ensure proper integration of the fertiliser into the soil.

The maize seed variety Gocha, SC 727 were planted in furrows at a depth of around 3cm and with a spacing of roughly 20cm between plants. The furrows were filled with soil, ensuring sufficient contact between the seeds and the soil to facilitate germination.

The planting technique was uniformly implemented in all plots inside the blocks to mitigate any possible discrepancies. The plots were labelled and marked to guarantee precise identification and data collection during the experiment.

3.4 Data collection

Pest and disease populations were assessed by conducting counts and observing symptioms and testing results. The counting technique entailed visually examining the sampled plants and documenting the quantity of pests encountered.

3.5 Data analysis

The gathered data was examined using statistical methods to extract significant

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insights. The statistical procedures of Analysis of Variance (ANOVA) were performed using GENSTAT. The analysis of variance (ANOVA) was utilised to ascertain significant distinctions across several groups or treatments. Statistical t-tests were also utilized.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter is concerned with the presentation of the research findings, their analysis and interpretation. This will be done per thematic area as it appears on the household questionnaire. The data was captured from respondents through the use of questionnaires, interviews and focus groups discussions.

4.2 Socioeconomic profile of sampled households

The descriptive statistics results for demographic and household characteristics indicate that, on average, the farmer's age was 45 years. This finding is in line with a report by FAO (2014) which states that the average age of a Zimbabwean farmer is

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approximately 45 years which is a concern as farming systems in Zimbabwe are labor-intensive. It was apparent that farming was the main economic activity, a majority of the respondents identified it as the main primary occupation in Ward 26 in Shamva District with an average of 18 years of maize farming (CIDP, 2018).

Taking farmers' average experience and age into consideration, maize farming is depicted as an enterprise mainly practiced by the elderly in the region (Olila, 2014). The average household size was 6 persons with a dependency ratio of 0.87, indicating the existence of high pressure on resources available and the productive population. Larger family sizes especially when the dependency ratio is high, present a scenario for the competition of resource allocation. Therefore, resources meant for farm management practices are redirected to cater to other family needs like nutrition, medical care, and school fees (Addai et al., 2014).

Further analysis showed that the ratio of male to female farmers was approximately 2:1 where 66 percent were male. However, the male to female household head ratio was 9:1. This is depictive of the socio-cultural setting of a typical African household where males are the primary decisionmakers (O'brien et al., 2016)

Predominantly, it was observed that land ownership was freehold with a majority (89 percent) having ownership to a registered title deed. Additionally, the mean average land size of the sampled households was 6.8 acres, on which the average proportion of land area allocated to maize production was 4.6 acres which corroborate with Kumela et al., (2019). These results are in tandem with those of Kiplimo and Ngeno (2016) in the study area who noted that land size holding was 7.2 acres with land allocated to maize being 6.7 acres. The decline in the area allocated to maize production could be attributed to the effect of over time land fragmentation.

Maize yield per acre (tones2 per acre) for the sampled households ranged between 0 to 2.97 tons per acre. The average yield was 1.48 tons per acre for the 2018 crop season, implying that farmers did not attain the optimal yield regardless of using commercially purchased improved seeds (Odhiambo, 2012; De Groote et al., 2020). This could

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possibly be attributed to risk factors such as pests and diseases, price risks, and weather variability.

Education level is considered an important aspect that impacts a farmer's ability to acquire process and utilize agricultural related information. The average years of formal schooling completed in the study area were 11 years. Further analysis showed that 27 percent of the respondents had acquired primary education, while 72 percent had acquired post-primary education and the most educated farmer had completed tertiary education with a master's degree. Therefore, with a bigger percentage having attained secondary education indicates that most of the households can make use of newly acquired information for incorporation into farm management practices.

Membership to groups both formal and informal was considered less important as the majority of the farmers (61 percent) had no group membership. Lack of interest (57 percent) was cited as the main reason for not joining a group. Out of those who have membership to a group, 44 percent belonged to an agricultural related group with a majority citing access to input supply as their main reason for joining (Sawenda & Liverpool-Tasie, 2012).

Results indicate that 52 percent of the farmers had contact with an extension service provider in the last 12 months. It was observed that 84 percent of the farmers received extension services from the County extension officers, while only 24 percent was through broadcast media (radio and television). Information obtained from accessed extension services mainly included pest management and maize crop production at 57 and 50 percent respectively. With exposure to extension which is an intellectual capital service, it can be said that most farmers were able to gain access to new skills, information, and technologies to enhance the quality and productivity of their produce (Handschuch & Wollni, 2016).

4.3 Fall Armyworm identification

Most of the farmers (99 %) were aware of Fall Armyworm having observed it in their maize plots in the 2019-2024 cropping season. The majority of the farmers (66 %)

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gained privy information on the pest's existence and form through broadcast media (radio and television). Moreover, approximately 54 percent of the farmers reported having noticed FAW in their maize plots between the months of March to May, in the 2019-2024 cropping season. Apart from the stalk borer and rodents, Fall Armyworm was reported as the most troublesome pest in this cropping season by 94 percent of the farmers. Farmers also noted the pest preference host was the maize crop.

Damage level was described as negligible, that is, less than 25 percent by 2.4 percent of the farmers. Most farmers (43%) described the damage caused by FAW as high, having damaged approximately 75 percent of the crop while 8 percent of the farmers described it as severe. Maize is infested by FAW at nearly every developmental stages. The pest population mainly at the larval stage, was noted to be high during the vegetative “knee-high” stage, at tasseling, and throughout the production cycle by 49 %, 25 %, and 16 % of the farmers respectively. At advanced development stages, the FAW larvae also feeds on the tassels, destroy the kernels and burrow into the cobs, as well as exposing the cob to infection by microorganisms, such as mycotoxin producing fungi. Such cobs are 100 % damaged hence non-harvestable (FAO, 2020)

The beginning of 2023 was characterized by an early dry spell (UNICEF, 2018), however, rainfall precipitation for the period March-May resulted in significant yield improvement than the preceding season. De Groote et al., (2020) established that high-potential zones in ward 4 Madziva in Shamva experienced a reduction in yield loss attributed to FAW for the 2022 long rain season as compared to the 2023 long rain season, implying the adverse damage from the sudden arrival of FAW. This could be explained by the heavy rains experienced during the 2023 March-May long rain season which probably hampered the larvae survival of the FAW lifecycle (FAO & CABI, 2019). This however contradicts the findings of Sparks (1979) and Flanders et al., (2017), who noted that heavy rainfall creates a suitable environment for the propagation of FAW which may cause severe damage to crops.

Despite the yield losses incurred, farmers managed to obtain a mean yield of 1.48 tonnes per acre after harvest. This implies that yield loss reduction due to FAW impedes

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the attainment of optimal maize yields of more than 2.5 tonnes per hectare (Odhiambo, 2012; De Groote et al., 2020). This has contributed to the effect of other pests in stagnating it to an average of below 2 tonnes per hectare (Kirimi, 2004; Olwande, 2012; Munialo, 2020). The mode accepted yield loss was 0.45 tonnes per acre (Table 3). This was recorded by 18% of farmers from the total sample. Cumulatively, 58% of the sampled farmers recorded a yield loss value lower than the average mean of the sampled farmers.

4.4 Maize yield losses due to FAW infestation

Elicited estimates through the bidding procedure revealed an average magnitude yield loss of 0.703 tonnes per acre with a standard deviation of 0.386, whereas, in perceived direct estimates farmers stated an average yield loss of 0.665 tonnes per acre with a standard deviation of 0.357. A two-tail t-test confirmed the existence of a statistically significant difference between the two estimate approaches with a p-value of 0.016, indicating a yield loss difference of 0.038 from the bidding procedureapproach.

Among the two approaches, the perceived farmer estimate approach has a higher likelihood of resulting in bias estimates as farmers relied on recall data from the previous cropping seasons to state a yield loss estimate due to FAW. This gives rise to the possibility of farmers making inaccurate estimates, resulting in nonrandom measurement errors which may be of economic significant size. This is different in the case of the iterative bidding procedure, as the bidding starting point obtained from a FGD was followed by a validation exercise with sampled respondents. Therefore, to correct for bias estimates, the follow-up certainty questions were essential as affirmed by Blumenschein et al., (2008). Therefore, given the possibility of recall

bias, Beegle et al., (2011); Wollburg et al., (2020), this study assumed the use of yield loss estimates established through the use of an iterative bidding approach.

The validation exercise basing on the initial bid value obtained from the FGD, depicted minimum variation from the average yield loss revealed by sampled farmers. The

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minimum quantity revealed as yield loss by farmers was 0.09, while the maximum quantity was 2.7 tonnes per acre. This provides a range of 2.61 tonnes per acre, an indication of statistical dispersion of yield loss among the sampled farmers. This provides a range of 2.61 tons per acre, an indication of statistical dispersion of yield loss among the sampled farmers. The yield loss is indicative of a range between the minimum and maximum stated yield loss, that could be attributed to the varying intensities and forms of farm management practices (Day et al., 2017; Lobell et al; 2018; Midega et al; 2018) which are mainly influenced by the demographic, socio-economic as well as external institutional linkages. Considering this, it is worthwhile to note that estimates obtained by the present study were under natural infestation conditions, which are not consistent over space and time hence the range recording of minimum and maximum yield loss estimates.

Table 1: Estimated magmitude of yield loss through iterative bidding

	Valid n	Mean	Std. D	Min	Max	t-value
Elicited Estimate	255	0.703	0.386	0.09	2.7	
Perceived Direct Estimate	255	0.665	0.356	0.18	2.7	
						2.246

The beginning of 2019 and 2023 was characterized by an early dry spell (UNICEF, 2018), however, rainfall precipitation for the period March-May resulted in significant yield improvement than the preceding season. De Groote et al., (2020) established that high-

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potential zones in Ward 26 in Shamva District experienced a reduction in yield loss attributed to FAW for the 2023 long rain season as compared to the 2022 long rain season, implying the adverse damage from the sudden arrival of FAW. This could be explained by the heavy rains experienced during the 2023 March-May long rain season which probably hampered the larvae survival of the FAW lifecycle (FAO & CABI, 2019). This however contradicts the findings of Sparks (1979) and Flanders et al., (2017), who noted that heavy rainfall creates a suitable environment for the propagation of FAW which may cause severe damage to crops. In Zambia, Kansiime et al., (2019) through the use of farmerbased estimates established a 28% yield loss attributed to FAW, from the season preceding FAW incidence. This is a lower estimate compared to that of De Groote et al., (2020) for the same season (2017 long rain). However, FAW being a case of natural infestation, it is rational to believe that farmer estimates obtained by the aid of carefully designed and executed questionnaires, while observing standardized survey protocols produces best loss estimates compared to other sources of loss reporting.

Despite the yield losses incurred, farmers managed to obtain a mean yield of 1.48 tonnes per acre after harvest. This implies that yield loss reduction due to FAW impedes the attainment of optimal maize yields of more than 2.5 tonnes per hectare (Odhiambo, 2012; De Groote et al., 2020). This has contributed to the effect of other pests in stagnating it to an average of below 2 tonnes per hectare (Kirimi, 2004; Olwande, 2012; Munialo, 2020). The mode accepted yield loss was 0.45 tonnes per acre. This was recorded by 18% of farmers from the total sample. Cumulatively, 58% of the sampled farmers recorded a yield loss value lower than the average mean of the sampled farmers.

Fall armyworm (Spodoptera frugiperda) is a significant pest that can cause substantial damage to maize crops, resulting in reduced yields and economic losses for farmers. The pest can infest maize plants at any stage of growth, causing defoliation, reduced photosynthesis, and increased susceptibility to other pests and diseases.

Nematode Infestation: Nematode infestation can lead to significant yield losses in maize production, with yield increases of up to 53% recorded after application of

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fenamiphos 40EC and 42% after lime application. Nematodes can cause damage to maize roots, reducing the plant's ability to absorb water and nutrients.

Aflatoxin Contamination: Aflatoxin contamination is a significant problem in stored maize, with hermetic storage technologies shown to reduce aflatoxin levels and economic losses. Aflatoxins are toxic compounds produced by certain fungi that can contaminate maize grains, posing a risk to human health and reducing the quality and market value of the grain.

Participants observed Maize Grain Weight Loss: Maize grain weight loss due to insect contamination can range from 2.54% to 6.11%, depending on storage methods. This can result in significant economic losses for farmers, particularly if they are selling their maize at a lower price due to reduced quality.

The yield data analysis reveals that pests and diseases had a significant effect on yield, as indicated by the ANOVA (F-value = 80.04, $p < 0.001$). Key findings from the Fisher's shielded LSD test were as follows: In terms of yield, Plot 1 was not significantly different from Plot 2 and 3. The yield of Plot 5 was noticeably lower than that of Plot 2 and 1 due to the effects of both pests and diseases.

4.5 Chapter Summary

Pest and disease management can increase costs for farmers, particularly if they need to apply pesticides or other control measures. This can reduce their profit margins and make it more difficult for them to invest in their farms. Pest and disease infestations can reduce maize yields and quality, resulting in lower incomes for farmers. This can have a ripple effect on the local economy, particularly in areas where maize is a major crop.

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CHAPTER FIVE: CONCLUSION AND POLICY RECOMMENDATION

5.1 Conclusions

Findings indicated that Fall Armyworm is a significantly important pest aggravating the impacts of pre-existing invasive alien species. The pest was noted to result in an average of 0.7 tons per acre of maize loss incurred by farmers with the highest reported being 2.7 tons per acre in the study area. The study found that maize yield losses related to Fall Armyworm were aggravated by the area under maize production, group membership, household size, and Fall Armyworm damage intensity as described by farmers. The yield losses were found to decrease with access to extension services, years of formal schooling attained, farm income, and distance to market. The findings are contrary to the stated hypothesis that, farmer, farm specific, and institutional factors taken individually have no effect on the magnitude of yield losses in maize.

Farmers seemed not to harbor any reservations on the efficacy of the practices they employed to increase maize productivity by managing the pest and promotion efforts to encourage the use of the practices. This implies that farmers perceived that combination of practices as a leveraging approach towards maximizing the efforts on effective management of the pest. These findings are contrary to the hypothesis which stated that farmers have negative perceptions towards the attributes of mitigation strategies used in Fall Armyworm management.

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5.2 Recommendations

5.2.1 Policy recommendations

Despite maize being an economically significant crop for the producing households, it is faced with the menace of FAW infestation which is likely to remain as an important pest in the foreseeable future. Consequently, farmers are subject to incur substantial welfare loss due to the reduced yield obtained, thus having an effect on their state of livelihoods. Therefore, the assessment of maize yield loses is essential for the improvement of production systems that contribute to the incomes of maize farming households and food security. The study noted that factors aggravating the stated magnitude of losses by farmers include area under maize production, household size, group membership, and pest damage intensity as described by farmers.

The proportion of farmer membership to an agricultural group was markedly low. This is an alarming concern to policymakers, considering that both government and non-governmentorganizations highly rely on agricultural groups when carrying out extension activities.

Nevertheless, tackling FAW cannot be solely done by farmers, as there is a need for concerted efforts from relevant institutions and policymakers to design policies that ensure a multistakeholder approach in managing FAW. Moreover, there arises the necessity to motivate farmers to organize themselves into groups related to their agriculture enterprises, which is essential as it will enhance access to relevant extension services thus contributing towards reducing FAW related losses. They will also get training on the use of control strategies and the acquisition of inputs at subsidized prices. Additionally, it will also aid in cutting down transaction costs incurred in accessing markets due to long distances covered to fetch information, as knowledge spillover from the groups will result due to the existing social capital.

The importance of extension services was shown by the findings as it was noted to contribute towards farmers' efforts to abate FAW related losses. This resulted to spillover effects as the location of a maize farming household with respect to the a

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priori anticipated outcome, had a contrary effect. This, therefore, calls for the increased efforts directed towards availing and provision of extension services aimed at FAW management. This will result to ensuring the presence of geographical highly mobile and institutional arrangements, which ultimately reduces transaction costs incurred by farmers thus reducing impediments towards reducing FAW related maize yield losses. Moreover, enhanced investment in education will play a significant role as it increases farmers' prudence levels in terms of knowledge management in the processing of knowledge obtained thus increasing their effort efficiency towards FAW control. Simultaneously, this improves the aspect of farmer resource allocation as the gross farm incomes obtained are spent diligently on-farm management aspects.

References

Abate T. S, Bekele S. H, Abebe M, Dagne W, Yilma K, (2015) Factors that transformed maize productivity in Ethiopia. Food science 7: 965-981.

Benti T, Ransom J. K (2023) Proceedings of the first National Maize Workshop of Southern Africa, IAR, Addis Abeba, Addis Abeba: IAR. pp: 43-51.

Gebre G, Isoda H, Rahut B, Amekawa Y, Nomura H (2019) Gender differences in the adoption of agricultural technology: The case of improved maize varieties in Southern Africa. Womens Stud Int Forum 76: 102264

FAOSTAT (2019) Food and Agriculture Organization statistics data.

Ethiopian Economic Association (EEA) (2017) Reducing the Maize Yield Gap in Ethiopia: Analysis and Policy Simulation.

CSA (2018) Agricultural sample survey reports on area and production of major crops for rural private peasant holdings. Statistical Bulletin 532: 11-14.

Tilahun, B, Dida M, Deresa T, Belay G, Girma D, (2017) Combining ability analysis of

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quality protein maize (QPM) inbred lines for grain yield, agronomic traits and reaction to grey leaf spot in mid-altitude areas of Ethiopia. Afr J Agric Res 12(20): 1727-737.

Mosisa W, Legesse W, Berhanu T, Girma D, Girum, A, (2022) Status and future direction of maize research and production in Africa pp: 17-23.

Worku, M, Twumasi-Afriyie S (2022) Meeting the Challenges of Global Climate Change and Food Security through Innovative Maize Research. Proceedings of the 3rd National Maize Workshop of Ethiopia. 18-20, Addis Ababa, Ethiopia.

Girma C, Sentayehu A, Berhanu T, Temesgen M (2015) Test cross performance and combining ability of maize (Zea mays L.) inbred lines at Bako, Western Ethiopia. Global Journal of Science 15(4): 2249-4626.

Zelalem B, Chemeda F, Dagne W, Temam H, Shimelis H, (2018) Combining ability and nature of gene action in maize (Zea mays L) inbred lines for resistance to gray leaf spot disease (Cercospora zeae maydis) in Southern Africa Crop Protection 112: 39-48.

Chavan S (2024) Identification of new sources of resistance against Ustilago maydis from the wild progenitor teosinte. Department of plant pathology, University of Georgia, Athens, GA 30602.

Gingera G. R, Davis D. W, Groth J. V (2024) Pedigree selection for improved partial resistanceto common leaf rust in sweet corn. Crop Science 34: 615-620.

Pataky J. K, Tracy W. F (2019) Widespread occurrence of common rust, caused by Puccinia sorghi, on Rp-resistant sweet corn in the midwestern United States. Plant Disease 83(12): 1177.

Bekeko Z (2019) Distribution and importance of common rust (Puccinia sorghi Schw.) of maize in Hararghe highlands, Eastern Ethiopia. East African Journal of Science 13: 135-144.

Pryor T (2024) Maize and Puccinia sorghi: A system for the study of the genetic and molecular basis of hostpathogen interactions.

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Hooker A. L (2024) Corn and sorghum rusts. In Diseases, Distribution, Epidemiology, and Control. New York: Academic Press pp: 207-236.

Jeger M (2024) Analysis of disease progress as a basis of evaluating disease management practices. Annual review Phytopathology 42: 61-82.

Madden LV, Hughes G, van den Bosch F (2017) The study of plant disease epidemics. St Paul: APS: 1-10.

Mahuku G, Wangai A, Sadessa K, Teklewold A, Wegary D, (2015) First report of Maize chlorotic mottle virus and maize lethal necrosis on maize in Ethiopia. Plant Disease 99: 1870.

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