BUSITEMA UNIVERSITY
Pursuing Excellence

P.O.Box 236, Tororo
Gen:+256-454448842
Dir: +256-454448864
Mob: +256-782999874
Fax: +256-454436517
Email:ar@acadreg.busitema.ac.ug
Website:www.busitema.ac.ug

. **RESEARCH PROPOSAL**

TOPIC; EFFECT OF DIFFERENT STORAGE MATERIALS IN CONTROLLING MAIZE WEEVILS IN KILAKI DISTRICT; CASE STUDY ANYARA SUB COUNTY.

By

ESANYU GEORGE WILLIAM

REG No:

BU/UP/2019/1639

STUDENT No:

1900401639

Email; georgeesanyu21@gmail.com

SUPERVISOR

Mr. Ongua Fanuel

A SPECIAL PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF AGRICULTURE IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF SCIENCE AND EDUCATION IN AGRICULTURE OF BUSITEMA UNIVERSITY.

DECLARATION

I **ESANYU GEORGE WILLIAM** declare that this research report is my original work and is submitted for the award of the degree of bachelor of Science and Education in Agriculture of Busitema University. This report has never been submitted to any university for any award whatsoever.

Signature ..... Date 22/04/2023

APPROVAL

This research report has been under my supervision and is now ready for submission to Busitema University for examination.

Signature ..... Date 08/06/2023

Mr. Ongua Fanuel

DEDICATION

I dedicate this report to my mother Alupo Alice Ariokot for bringing me forth into this world and for all that she has done in my life, my siblings for their unforgettable support in my education, to the Church in Mbale for impacting me so much on both my social and spiritual life.

ACKNOWLEDGEMENT

I thank the Almighty God for his love, care, wisdom and provision that made me first of all reach this level and secondly successfully complete it. Lord thank you for loving me.

I would like to express my heartfelt appreciation to all who contributed to the entire process of developing this report. In a special way, I congratulate my academic supervisor, Mr. Ongua Fanuel upon his incredible attention, suggestions, comments and guidance accorded to me during this study. I also thank all the farmers and traders for their accurate responses and friendliness.

Special thanks to my mother Alupo Alice Ariokot for her financial support that enabled me to carry out this entire study. I am also grateful to all my friends for their sharing of knowledge and views with me.

Lastly, I extend my sincere thanks to all my family members for always being there for me and their encouragement that gave me confidence in what I was doing.

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PHLs -Postharvest losses

SSA - Sub-Saharan Africa

FAO -the food and agriculture organization

FAOSTAT- the food and agriculture organization corporate statistical database.

IPM – Integrated pest management. economic injury level (EIL) and economic threshold (ET)

ET- Economic Threshold

EIL – Economic Injury Level

NGO - Nongovernmental Organization

OECD – The Organization for Economic Cooperation and Development

CABI – Center for Agriculture and Bioscience International

FGDs – Focus Group Discussions

ABSTRACT

The study was done to assess the effect of the different storage materials/methods in controlling maize weevils in Kalaki district; case study anyara sub county**.**

This study aimed at identifying and assessing the effectiveness of the different storage materials in controlling maize weevils with specific objective to identify the different storage materials used for storing maize grains in Kalaki district, Anyara sub-county, assessing the level of damage caused by the weevils to the maize grains under different storage materials and finally identifying and assessing the most effective storage material/method in controlling maize weevils in Kalaki district, Anyara sub-county. The study employed a cross-sectional design because the aim was to collect data on the prevailing situation relating to smallholder maize storage materials and to conduct an assessment and examination on the effectiveness of different storage materials used in controlling maize weevils.

From the research findings, the highest percentage of respondents say that the level of damage caused by the weevils is high followed by those who say it's very high, and the lowest percentage of the respondents say it's low.

Therefore, the level of weevil attack in the study area was very high and demands for an immediate intervention to control the level of damage caused by the weevils and the local farmers are recommended to use modern materials for storage such as hermetic bags and metal silos to help in the effective control of maize weevils although they prefer the use of polypropylene bags because they are affordable and easily accessible.

CHAPTER ONE: INTRODUCTION

1.0 Background

1.1.1 Origin and distribution

Maize (Zea mays L.) is recognized to be one of the first plants cultivated by farmers between 7000 and 10000 years ago (Ranum, Peña-Rosas and Garcia-Casal, 2014). The word maize is synonymously used with corn. It is believed to have originated in central Mexico 7000 years ago from wild grass and Native Americans transformed maize into a better source of food (Ranum *et al.*, 2014). Maize belongs to the grass family- Gramineae/Poaceae which includes other important cereals such as finger millet, rice, wheat, and barley. From its center of origin (Mexico), maize has spread to the rest of the world and become an important staple among many cultures including Sub-Saharan Africa (SSA) (Shiferaw, Prasanna, Hellin and Bänziger, 2011: Tefera, Mugo and Likhayo, 2011). Maize is the most widely grown cereal in the world, with grain yield slightly ahead of rice and wheat (Sylvain, Adamou, and Ayo, 2017). It is a critical income generation and nutrition and food security crop in most developing countries (Midega, Murage, Pittchar, and Zeyaur, 2016). It is reported that maize is the most widely cultivated crop in Uganda (Bold, Kaizzi, Svensson, and Yanagizawa Drott, 2017). It is also a major staple food for a majority of the people in Uganda (Kaaya *et al*., 2005). In Kalaki district, it is second to cassava and sorghum as a staple (Mukiibi, 2011) as cited in (Owach, Bahiigwa, and Elepu, 2017) but because of its short production period, it is the most important food security crop in this district.

Maize is the most-produced cereal worldwide (www.ipbo.vib-ugent.be). It is grown throughout the world, despite large differences in yields (www.ipbo.vib-ugent.be: Ranum *et al*., 2014). In 2014, more than 1,022 million tons of maize were produced in more than 170 countries on about 181 million hectares of land. The top five producers were the United States of America with 361 million tons, China with 216 million tons, Brazil with 80 million tons, and Argentina and Ukraine with 33 and 28 million tons, respectively (www.ipbo.vib-ugent.be). It is also estimated that in 2012, the total world production of maize was 875,226,630 tons, with the United States, China, and Brazil harvesting 31%, 24%, and 8% of the total production of maize, respectively (Ranum *et al*., 2014). In 2000, at the continental level, the largest producers of maize are North America (41% of the global maize crop), Asia (28%), Europe (10%), South America (10%), and Sub-Saharan Africa (6%). In Africa, 51 countries produced approximately 75 million tons of maize in 2014

(7.4% of the total world production) on 37 million hectares (20.44% of the total area planted worldwide) (www.ipbo.vib-ugent.be) indicating low production in Africa at large and SSA in particular. Production yields in Africa are still very low stagnating at around 2 tons/hectare/year. In 2016, Uganda's maize production was at 2,663,025 tons giving a yield of 23,177 kg/ha (FAO, 2017). Maize production in SSA in general and Uganda in particular is limited by an array of factors both biotic and abiotic.

1.1.2 Effect of Maize Weevil on Maize Production in Africa/Global, East Africa and Uganda.

In Sub-Saharan -Africa (SSA), maize (Zea mays) is the most important staple crop among five biggest crops that contribute more than 45% of total crop production value (OECD/FAO,2018). In Uganda, average per capita consumption was estimated to be 415 kcal/capita/day (FAOSTAT,2016). although maize is considered to be an important crop in eastern Africa, there is still a deficit in production of the staple due to low soil fertility, frequent droughts, and insect pest damage. small holder farmers in eastern Africa experience pre- and post-harvest production stresses either individually or in combination at different stages of the crop cycle. the maize production deficit is aggravated by overwhelming post-harvest losses. most important economic quantifiable post-harvest losses occur in the field (15%), during processing (13%-29%) (Abass *et al*.,20140). Among other storage pests, grain weevils (*sitophilus zeamais* and *S. granaries*) and large grain borers (*Prostephanus truncatus*) are responsible for their major losses (Abass *et al*.,2014)

Losses of up to 15%-90% among smallholder farmers (Tefera *et al*.,2011) are attributed to the maize weevil hence ranking it among the most destructive pests of maize grain in the tropical and sub-tropical regions of the world. *S. zeamais* infestation in the storage leads to reduction of the quantities of grains and lower nutritional and market values of the grains, and thus increase poverty (Kebba and Sori,2013). Additionally, *S. zeamais* infestation affects percentage germination which results in low production since seeds and grains are stored together (Pingali,2001).

1.2 Statement of the problem

Maize is a critical food and nutrition security and livelihood crop in Kalaki district, Anyara sub-county Uganda (Kaaya *et al*., 2005) and SSA at large. However, its production is still low in Sub-Saharan Africa including Uganda. Postharvest losses (PHLs) are identified as being the main factor for this low level of total maize production (Lane and Woloshuk, 2017: Midega *et al*., 2016). The

primary cause of PHLs is storage insect pests (Hiruy and Getu, 2018a: Lane and Woloshuk, 2017: Abdoulaye *et al*., 2016: Tefera et al., 2011) contributing 20-30% (Shiferaw *et al*., 2011) to total loss. In particular, maize weevil is the most destructive Storage insect pests in Kalaki district, Anyara sub-county causing considerable loss (both quantitative and qualitative) of up to (15%-90%) hereby reducing sellable product. As a result, they present a big threat to food security and livelihood of smallholder farmers in Uganda, particularly Kalaki district, Anyara sub-county. Shiferaw *et al*. (2011) reported that minimizing such losses will significantly contribute to food and nutrition security.

Research has been focusing on the management of these pests. Consequently, a number of management approaches (cultural, biological, chemical and host resistance) have been developed. However, to successfully control maize weevils, there is need for the smallholder farmers to identify the different various materials and method used for storage of the maize grains after harvesting is done, and to be in position to assess the effectiveness of each those different storage materials identified in controlling maize weevils.

1.3 OBJECTIVES

1.3.1 General objective:

To identify and assess the effectiveness of the different storage materials in controlling maize weevils in Kalaki district, Anyara sub-county.

1.3.2 Specific objectives

1. Identify the different storage materials used for storing maize grains in Kalaki district, Anyara sub-county.

2. Assess the level of damage caused by the weevils to the maize grains under different storage materials

3. Identify and assess the most effective storage material/method in controlling maize weevils in Kalaki district, Anyara sub-county.

1.3.3 Research Questions

The study will be guided by the following research questions.

1. What are the different storage materials used by small scale farmers for storing maize grain?

2. What is the level of damage caused by the weevils to maize grain under different storage materials?

3. Which storage material is most effective in controlling maize weevil?

1.4 Justification

The demand for maize in developing countries is projected to double by 2050 (Shiferaw *et al*., 2011). This is due to the increasing human population, changes in income and urbanization, and increasing livestock (particularly poultry) production. Consequently, threatens the food security of poor households. This, therefore, requires an enormous increase in the production of maize. To increase production, there is a need to control PHLs. Controlling PHLs means controlling storage insect pests especially the weevils which are the drivers of PHLs (Abdoulaye *et al*., 2016). Determination of diversity and proper identification of maize weevils during the maize production process and storage is critical for developing an integrated approach to control maize weevils. This is because it documents the role of commerce in spreading pests and helps obtain published information on the biology, ecology, and behavior of these pests to use in designing control strategies. Integrated pest management (IPM) uses economic injury level (EIL) and economic threshold (ET) principles which are dependent on density and diversity.

It more realistically directs the efforts of stakeholders (government agencies, NGOs, researchers) towards a specific stage along the chain where to effectively apply control measures. As a result, minimizing the cost of control which undermines profits from these interventions. It further identifies pest species in a specific agroecological zone which is important for quarantine interventions.

1.5 Scope of the study

The study will be conducted in Kalaki district where over 90% of the population depends on agriculture for a livelihood (Ronner & Giller, 2003). Specifically, it will be carried out in Anyara sub-county. Being part of eastern region in Uganda, it is among the highest maize producers (Uganda National Agriculture Census,2008/2009). smallholder maize farmers' household

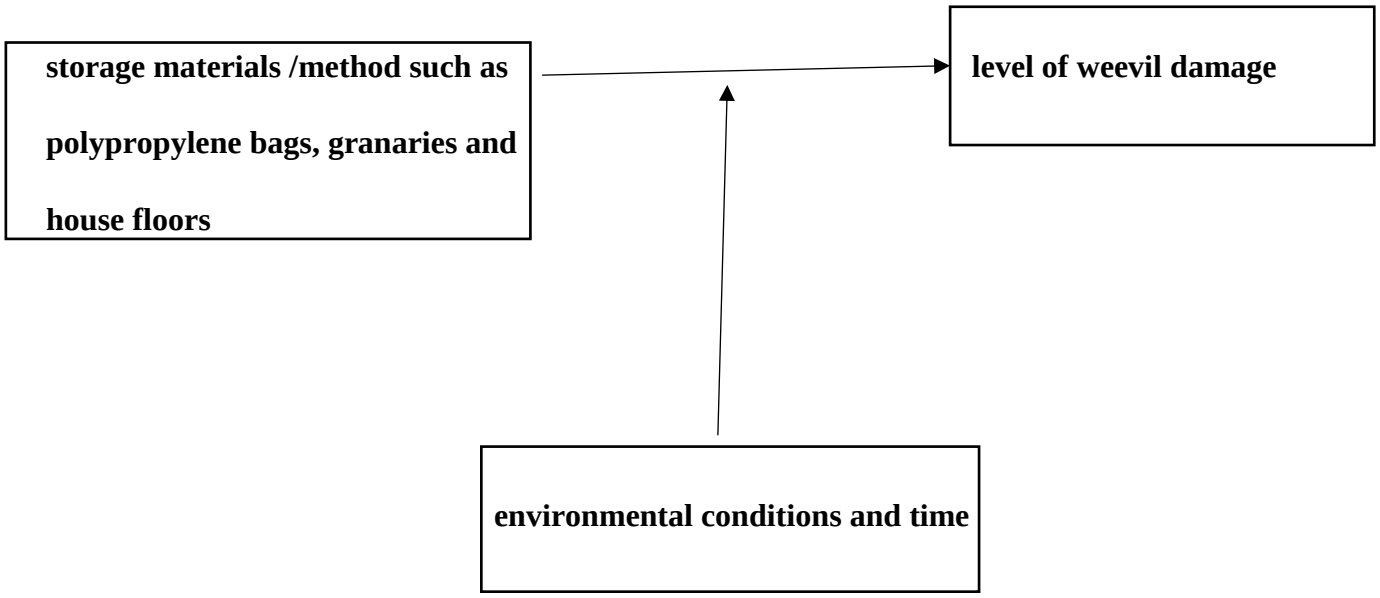
characteristics will be studied to understand how they impact on the share of their final produce to the market through maize storage materials and methods. Different storage materials will be examined to identify the most appropriate one that is most effective in controlling maize weevils in the sub-county. The research will be centered on the different storage materials used by smallholder farmers and their effectiveness controlling maize weevil in Anyara-sub-county.

1.6. Significance of the study

- The study will help in policy planning for future reference of post-harvest handling technologies at all levels and the knowledge generated
- Will be useful in promoting research on post-harvest handling technologies with the purpose of minimizing post- harvest losses between harvesting and actual consumption of maize.
- It will contribute to researchers' academic progress towards acquiring a bachelor of science degree in education of Busitema University.

1.7 The conceptual frame work of the study.

In this research study, the maize weevil level of damage depends on the different storage material /method used by the correspondents storing their maize. Therefore, the different storage materials /methods represent the dependent variable while the level of damage caused by the weevils is the independent variable. Other the different storage materials, environmental conditions and time could also be s0me of the dependent variables in this study.



CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction.

This chapter presents a concise explanation of the different storage materials or methods used in controlling weevils, assessment of their effectiveness and their implications to the smallholder maize farmers in Anyara sub-county. This study suggests that the smallholder maize farmers will benefit from storing maize more efficiently using the most effective materials/method because it will lessen the damage and it can be sold later at a higher price and used in input production, or for meeting unexpected future demand (Stronzik, Rammerstorfer & Neumann,2009)

2.1 Maize weevils

The maize weevil is found in all warm and tropical parts of the world. It is a pest of stored maize, dried cassava, yam, common sorghum and wheat. Both adults and *larvae* feed on internally on maize grains and an infestation can start in the field (when the cob is still on the plant) but most damage occurs in storage. (keys.lucidcentral.org.)

Common names.

English: maize weevil, greater grain weevil, northern corn weevil, greater rice weevil (CABI. (2010)).

Taxonomic position.

Phylum: Arthropoda; Class: Hexapoda; (insecta); Order: Coleoptera; Family: Curculionidae.

Origin and Distribution.

The origin of the maize weevil is not known but now it is found in all warm and tropical parts of the world.

Description.

Adult maize weevils are 33.5 mm long, dark brown-black in color and shiny and pitted with numerous punctures. The punctures on the thorax are in an irregular pattern while those on the elytra (wings cases) are in lines. The elytra also usually have four pale reddish-brown oval markings. The maize weevil has the characteristics rostrum (snout or beak) and elbowed antennae of the family Curculionidae (weevil family) (CABI, 2010). The antennae have eight segments and

are often carried in an extended position when the insect is walking. The larvae of maize weevils are white, fleshly and legless**((***www.kznhealth.gov.za**)***.

HOST RANGE.

The maize weevil can develop on a range of cereal crops. It is a serious pest of stored maize, dried cassava roots, yams, common sorghum and wheat in the East African region.

DAMAGE SYMPTOMS.

the pest causes hollowing of the whole previously undamaged grains. in severe infestations only the grain hull is left along with powdery white frass (insect waste). the large emergence holes with irregular edges are characteristic. grains which float in water often indicate larval damage.

2.2. Description of the Different Storage Materials/Methods used for storing maize grains in Kalaki district Anyara sub-county.

1. Hermetic Bags/ PICs Bags

Hermetic bags work by sealing the stored grain from the outside atmosphere. This means that once grains are sealed in a hermetic bag, they are air tight. As a result, moisture and oxygen cannot enter into the bag from the outside air.

As insects already present inside the grain continue to respire, carbon dioxide levels increase and oxygen levels decrease. At low oxygen levels, all insect's activity ceases and they cannot continue to attack grains.

Some hermetic bags come with an outer layer which is usually a polypropylene bag to protect the hermetic liner from damage. Hermetic bags have several advantages over other types of bags. They include being able to protect grains from insects and moisture which makes them ideal for long term storage. They are durable, easy to use and ensure that grains maintain their quality even after a year of storage. They can also be reused several times over, so long as the hermetic layer is not damaged.

The main drawback of hermetic bags is that they are generally more expensive than other types of bags, which may be prohibitive for some people. additionally, the hermetic capabilities may be damaged if the bag is punctured.

While hermetic bags may be expensive to purchase upfront, the benefits of preserving your grains far outweigh the initial costs.

2. **Polypropylene (PP) Bags.**

Polypropylene bags are also one of the most popular methods of storing maize grains in sub-Saharan Africa. Polypropylene bags are made from woven strip of polypropylene. These bags have a lot of advantages. They are air tight, easy to use, very affordable, easily accessible and come in different sizes (Thamaga-Chitja et al, 2004).

3. **Jute bags.**

The jute bag has been one of the oldest ways of storing grains and has been used to store grains for several centuries. Its material is made from the bark of the jute plant which makes it biodegradable and safe for the environment. Jute bags are usually inexpensive and readily available for purchase.

4. Granaries.

Edula is the local name for one of the most precious structures in a rural farming home-the granary. Since precolonial days, small-scale farmers used Edula to store their grains. (Joshua Kato, Harvest money Editor@New Vision).

It was normally used for storing cereals such as maize, millet and sorghum, plus pulses, like beans. In the central region, a granary is called ekyaagi and in the west, ekitara. However, the contruction differs.

When the colonialists came, they were mesmerized by the traditional granary and its effectiveness in storing food. In one of their writings in the East African Agriculture journal, in 1943, H. R Hosking called the granary ‘the wickerwork basket”

The first granaries reportedly appeared around 9500BC in the Jordan valley. By 6000BC they had reached Egypt. In East Africa, the granary reportedly arrived during the onset of civilization, when people started living in houses and growing crops

The granary is made from the locally available materials such as clay(elupe), conical straw or a certain type of grass species found in the swampy areas (Bett, C., and R Nguyo 2007). A compound

diameter of (2-4m by height of 2-4) to store all the harvest. The grain storage facilities called granaries help the communities build up climate resilience to small-scale farming household in Kalaki, Anyara sub-county by allowing storage of crops in between two harvests periods. (Djekore M. 2016).

This approach has allowed the communities develop capacities and build governance and planning tools in order to master the technique of food conservation for food security. The transmission of know-how has been passed on from generation to generation. The technology contributes to disaster risk reduction, as precautions are taken to secure production and combat food security.it makes it possible to have seeds of quality by a selection in anticipation of the next rainy season. the granaries are built in clay like houses with conical straw/grass thatched roofs, and are essentially small storage houses where the products from the harvest are storedriod. The range of crops that can be stored often varies between 250kg to 1000 kg. the chief granary for the concession is placed in the centre of the compound, Infront of the entrance. (Drame A. Kieme. 2016.)

The advantages and the performances of this technology are related to. (Granaries for crop storage-www.ctc-n.org):

- The sustainable quality of preservation without deterioration;
- Its relatively low cost;
- The generation -to-generation transmission system is a means of securing livelihoods;
- Its ownership is by the young generation.

5. Metal silo.

These are economically valid for storing large quantities of maize grain (Tefera., *et al* 2011) metal silos are often regarded as too costly for small scale storage (Zachary M *et al*, 2012). Nevertheless, certain projects have successfully introduced small metal silos, of 0.4 to 10 tones capacity at farm village level in developing countries: Swaziland (Walker, 1975), Bolivia (Anon, 1982), India (Anon, no date), to mention just a few. Metal silos are reported to have been used on farms and in villages in Guatemala for over 50 years (Breth, 1976) and in Swaziland, on a small scale, for possibly longer.

Such silos are made of smooth or corrugated galvanized metal, and are cylindrical in shape with a flat metal top and, usually but not always, a flat metal bottom. A man-hole with a cover, which

may be hinged but is nevertheless lockable, is located, usually to one side, in the top panel; and an outlet pipe provided with a padlock id fitted at the base of the wall (Shepherd,2012; Zuma-Netshiukhwi & Stigter,2016).

2.3 Economic Importance of Maize Weevil as a Post-Harvest Insect Pest.

Post-harvest insect pests associated with grains such as maize are of great economic importance in agricultural production. These being the first invasive forces to begin interaction with the grain (Hiruy and Getua, 2018a), present major threats to the grain's quality maintenance during storage. In addition, they are the most damaging and difficult to control of all other pests due to their small size, feeding behavior and ability to attack grain before harvest, and high fecundity. Besides most of them are cosmopolitan and polyphagous in their feeding behaviors thereby increasing their survival. Insects damage grain directly by their feeding -boring holes into the kernels and reducing grain quality through weight, nutritional, or quality loss (Hiruy and Getu, 2018a: Hagstrum, 2016); spreading and encouraging mold germination thereby contaminating with aflatoxins; 12 adding to the fatty acid content of the grain; and leaving quantities of uric acid that cause grain rancidity (Hagstrum, 2016). Their feeding also creates fines and broken kernels that reduce airflow through the grain when aeration fans are used, causing an increase in temperature thereby compounding the problem. In addition to the direct damage, they contaminate grains by excretion, molting, their existence, leaving their dead bodies, body fragments, webbing, and an unwanted odor or flavor, resulting in cash discounts for the grain. This is because their presence is detestable to many customers. Usually, insect pests also predispose stored grains like maize to secondary attack by disease-causing pathogens such as fungi. Insects feeding on the germ of the seeds saved for planting can reduce germination. The cost of insect sampling and insect pest management programs are also economic losses. Furthermore, a major concern with the presence of insects in storage is the potential to vector disease organisms (Hagstrum, 2016). This is because of the presence of hairs and indentations on their exoskeletons that can serve for the mechanical vectoring of pathogens. For instance, maize weevils have been reported to carry or vector several fungi species, including Aspergillus niger, A. glaucus, A. candidus, Penicillium islandicum, P. citrinum, Fusarium semitectum, and yeasts (Hagstrum, 2016). Consequently, infestations by the insect pests in grain storage such as maize, and damage and loss that result from them pose a major threat to food security and livelihood.

2.4 EFFECTIVENESS STORAGE MATERIALS IN CONTROL OF MAIZE WEEVIL.

Hermetic/Pics bags.

Hermetic bags work by sealing the stored grain from the outside atmosphere. This means that once grains are sealed in a hermetic bag, they are air tight. As a result, moisture and oxygen cannot enter into the bag from the outside air. The mechanism for reducing storage loss and control of weevils with a hermetic system involves reducing the oxygen and increasing the carbon dioxide levels inside the system. the controls the activity and the number of live insects in the products. The oxygen reduction is partially caused by the oxygen use of the insects themselves (Murdock *et al*., 2012; Njoroge *et al.,* 2018).

Polypropylene (PP) Bags.

Polypropylene bags are also one of the most popular methods of storing maize grains in sub-Saharan Africa. Polypropylene bags are made from woven strip of polypropylene and are cheaper and easily available for every famer to access them from any market area. These bags have a lot of advantages. They are air tight, easy to use, very affordable, easily accessible and come in different sizes (Thamaga-Chitja *et al*, 2004).

Granaries.

Granary weevils have cylindrical bodies that are shiny red-brown or black. the primary and most effective way of weevils in the granaries is to take preventive steps. To help prevent weevils' infestations, clean and treat all empty bins thoroughly, including walls, floors cracks and crevices, prior to loading in grains.

CHAPTER THREE: MATERIALS AND METHODOLOGY

3.0 Introduction.

This chapter provides a detailed discussion of the research methods used to conduct the study. It covers the following elements: research design; site selection; sample size and sampling procedure; data collection and justification, data analysis, validation and reliability. These elements are discussed in order below.

3.1. Research design.

Research design describe the detailed blueprint that guides the study to answer the research question and achieve the research objectives. The design specifies the procedure to be followed while conducting the research in order to collect the data required to address the research problem. Thus, every researcher needs a design before they begin collecting data (De Vaus & de Vaus, 2001, p. 9). The study employed a cross-sectional design because the aim was to collect data on the prevailing situation relating to smallholder maize storage materials and to conduct an assessment and examination on the effectiveness of different storage materials used in controlling maize weevils. The design was ideal for the study because it permitted farmers' behavior to be observed. The exploration was conducted by interacting with farmers through focus group discussions, for purposes of understanding the relationship between storage materials and their effectiveness in controlling maize weevils.

3.2. Research Methods.

Both quantitative and qualitative methods were utilized in this study, in a concurrent mixed method approach (Johnson & Onwuegbuzie, 2004; Feilzer, 2010). A concurrent mixed method approach was pertinent for this study because it built on the strength and minimized the weaknesses of each approach.

First, a questionnaire approach was used to collect data via a survey from a larger population. Secondly, an in-depth qualitative study with a small number of respondents in a focus group discussion and key informants' interviews was conducted. Coupled with this, the researcher also observed and verified certain phenomenon's. The aim was to draw information from multiple sources in a convergent manner for confirmation and completeness that allowed for cross-verification from multiple data sources by matching for example, the different storage materials that were discussed during focused group discussions.

As noted by Greeene, Caracelli, and Graham (1989) and Crowe *et al.* (2017), when two or more methods are used to assess a phenomenon, it was to enhance the validity of the findings. Mixed methods allow for more complete comprehensive understanding of the phenomenon that was going to be investigated (Sparkes, 2015).

The quantitative approach was essential in describing, examining, and assessing the different materials used for the storage of the maize grains (Coyle *et al*., 2016), but the live experiences and perceptions of smallholder farmers relating to storage cannot be adequately investigated and conveyed using figures alone. Important unknowns from quantitative research were to be how smallholder maize farmers saw the impact of the different types of storage materials and their effectiveness in controlling maize weevils (Zimmerer,2004).

3.3. Site selection, description and justification.

Based on the assumption that demand for storage was a function of levels of production, Anyara sub-county, Kalaki district being part of Eastern region was selected because it was among the highest maize producing region. The region was referred to as Uganda's "food basket" because it was the highest maize-producing region in the country. In 2010, Eastern region accounted for over 50 percent of annual national production (Kagodi, Gidoi & Isabirye, 2016).

3.4. Geographical area, sample size and sample procedure.

The study was conducted in Anyara sub-county, Kalaki District between late December and early January. Kalaki district is located at a latitude of 1° 47'33" N and a longitude of 33° 57'20.30" E. To ease my sampling, I conducted informal interviews with some key informants to find out the different storage materials that they used for storing maize among the different villages in Anyara sub-county. The survey was first conducted in late December 2022 covering the main maize-growing villages. The study resumed in January to mid-January in the remaining villages. There are two maize seasons – April - May, and September - October. Harvesting is done in July or August for the first season and December or January for the second season. At the farmer level, the study focused on the second season (September-October) as this had a recognizable infestation.

3.5 Sampling.

This was done by selecting 3 villages from the three parishes within the sub-county, it was done based on the high, medium and low production selection procedure. A simple random sample of the above villages was done from each of the parishes to obtain the villages. From each of the three villages, a simple random sample of 10 respondents was done from a list of farmers obtained from the local leadership or farmers' groups in the village to a make a total sample of 30.

For the Focus Group Discussions (FDGs), the extension workers from the sub-county were asked to assist in identifying maize farmers who can constitute the FDGs. Focus groups were limited to 6 participants for ease of management (Goss & Leinbach,1996) and to eliminate concerns about the data saturation that can arise from large numbers (Mason,2010).

The sampling techniques used were: stratification by district followed by a two-stage (cluster) sampling technique at Sub- County and village levels. 10 respondents were purposively selected from villages known to regularly produce maize from within the sub-county. Some of these traders who buy maize from the villages in large quantities became key informants. The number of respondents at the farmer level per village was dependent on the level of maize production in that particular village.

3.6. Unit of analysis.

The unit of analysis was the smallholder maize farmers; study from the perspectives of the storage types used, the effectiveness of the different storage types in controlling the maize weevils

3.7 Data collection

Data was collected through direct guided interview with full respondent participation. Most of the households in the villages had more than two members present who participated in the interview hence it was more or less a focused group discussion. The farmers were interviewed on among others; the different storage materials they used, the length of time they used for storage, whether they did inspection of pests in storage, effectiveness of the materials/method and form of storage.

3.8 Data validity

To test and ensure the validity of the data tools, the researcher prepared research instruments and subject them to validity tests before finally administering them on respondents. The draft questionnaire or interview guide was subjected to verification to determine the validity of the

questions. This was done by conducting the Content Validity Index (CVI). The Content validity was determined by having items on the instrument rated by the researcher. The Content Validity Index (CVI) was then determined by the formula and the workings below.

$$CVI = \frac{\text{Number of items considered valid}}{\text{Number of items on the draft questionnaire and the interview checklist}}$$

A CVI of 0.7 and above for any instruments was considered valid for the study in accordance. All questions deemed not valid were edited or dropped per the recommendation of the experts (Balungi, 2016).

3.9 Data Analysis.

Data was summarized and descriptive data analysis was conducted using means, frequencies percentages and proportions using Statistical Package for Social Sciences (SPSS) version 21.0 (2012). Graphical representation of data was also conducted using the same package

CHAPTER FOUR: PRESENTATION OF RESULTS

4.0 Introduction

This chapter presents the results obtained from the findings of the research from the respondents interviewed.

4.1 Demographic characteristics of the respondents

4.1.1 Gender of the Respondents

Table 4.1 1 shows the gender of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	female	21	52.5	52.5	52.5
	male	19	47.5	47.5	100.0
	Total	40	100.0	100.0	

From the respondents interviewed, 52.5 percent were females and 47.5 were males. The gender distribution shows that, women are most active when it comes to storage of maize at the farmer levels and most of the activities to do with buying and selling is done by them. Therefore, the information obtained from them is very relevant to the findings of the research.

4.1.2 The age of Respondents

Table 4.1 2 Shows the age of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	25-35	11	27.5	27.5	27.5
	36-45	17	42.5	42.5	70.0
	46-55	10	25.0	25.0	95.0
	56-above	2	5.0	5.0	100.0
	Total	40	100.0	100.0	

From the respondents interviewed, 42.5 percent of the respondents were in the age bracket of (36-45), followed by 27.5 percent who were in the age bracket of (25-35) years of age, followed

by 25 percent who were in the age bracket of (46-55) year. 5 percent were above the age of 56 years. From the research findings, most of the respondents are young are active in regards to agricultural activities. Therefore, the information obtained from this group is very relevant to the findings of this research.

4.1.3. The Educational Background of the Respondents

Table 4.1 3 shows the level of education of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Primary	30	75.0	75.0	75.0
	Secondary	9	22.5	22.5	97.5
	Tertiary	1	2.5	2.5	100.0
	Total	40	100.0	100.0	

From the respondents interviewed, 75 percent attained primary level of education, 22.5 percent had attained secondary education and only 2.5 percent had attained tertiary level of education. It is believed that an educated person can give a better information than an uneducated person. The findings show that the respondents had a formal level of education and the information obtained from them for this research is very relevant.

4.2 The different storage materials used for storing maize grains

Table 4.1 4 Shows the different storage materials commonly used for storing maize

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Granaries	4	10.0	10.0	10.0
	House floors	6	15.0	15.0	25.0
	PP bags	30	75.0	75.0	100.0
	Total	40	100.0	100.0	

4.2.1 PP bags

75 percent of the respondents reported that the most commonly used storage material in Anyara sub county is the Polypropylene bags. The reason given by the respondents is that it is cheap, available and also affordable by small scale maize grain farmers within the sub county.

4.2.2 House floors

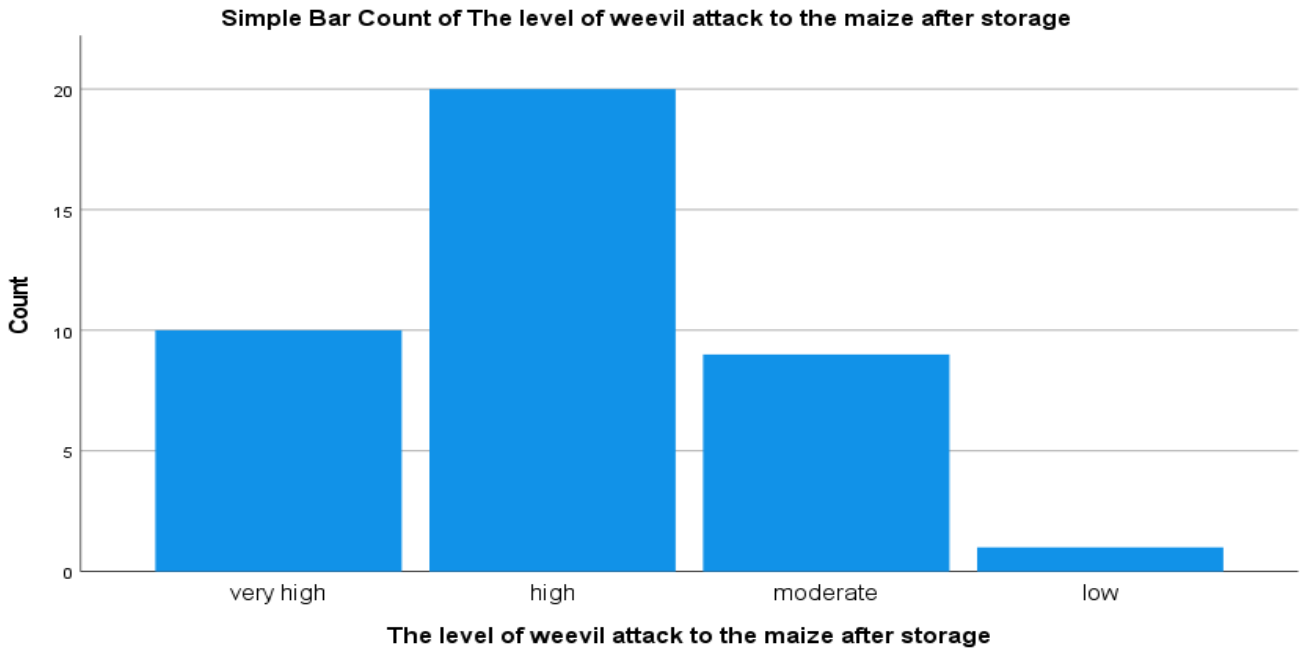
15 percent of the respondents interviewed reported that, the use the house floor for storing their maize grains. This practice is due to the availability of space and also cementing the floor hence feeling secure to store their grains on the floor.

4.2.3 Granaries

10 percent of the respondents reported that, they store their maize grain in the granaries. This is the most common traditional method of storing agricultural produce practiced by small scale farmers within the sub county. But fewer respondents reported about this due to the disappearance of the granaries because of the rampant theft of agricultural produce from the granaries.

4.3. The level of damage caused by weevils to the maize grains under different storage materials

Figure 4.1 1 Shows the level of weevil attack to maize grain

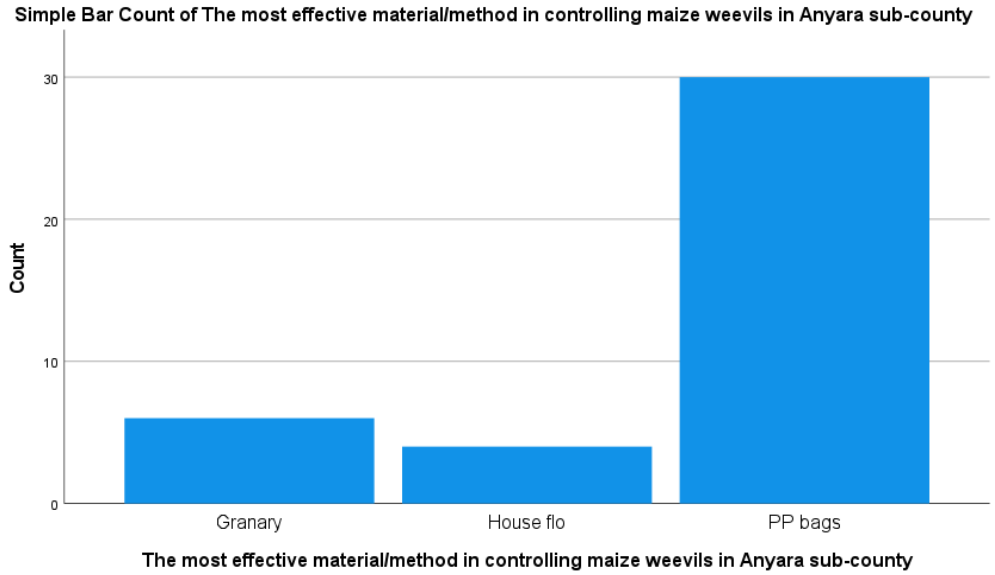


From figure 4.1 above, 50 percent of respondents reported that the level of damage caused by the weevils is high, this was followed by 25 percent of respondents who reported very high weevil damage. 22.5 percent reported moderate level of weevil damage and 2.5 percentage reported low

weevil damage respectively. This therefore shows that the level of weevil damage in this study area is high.

4.4. The most effective material /method in controlling maize weevils

Figure 4.1 2 Shows the most effective material/method in controlling maize weevil



From figure 4.3 above, 75 percent of the respondents interviewed stated that the use of polypropylene bags is most effective material used for controlling maize weevil. This was followed by 15 percent of the respondents who reported granary as the effective method for controlling maize weevil. 10 percent of the respondents reported house floor method.

CHAPTER FIVE. DISCUSSION

5.0 Introduction

5.1 Demographic characteristics of the respondents.

5.1.1 The sex of the respondents.

From the study, the number of women is greater than men with a 52 percent to 47 percent respectively. This is because women are majorly engaged in most agricultural activities compared to the men. This is important for the study because women participate in many aspects of production and postharvest handling of maize (Alexandra peralta,2021, Karen Ann McKenn,2014).

5.1.2 The age brackets of the respondents.

The majority of the respondents were between the age bracket of (36-45) years with a percentage of 42.5%, followed by (25-35) years with a 27.5% of the all population in the study area. This is because the youth at this age are energetic and ambitious. This is in correspondence () who concluded in his research study saying, one can conclude that the productivity of famers is generally greatest at the age groups of 25 to 34, or 35 to 45,

5.1.3 The level of education of the correspondents.

From my findings, the number of respondents who only ended in primary levels is very high with a percentage of 75.0% and number of respondents who have reached the tertiary level is the least with a percentage of 2.5%. This finding affected the study negatively because the majority of the respondents didn't have enough knowledge about different storage materials /methods and their importance. According to (Appleton and Balihuta,1994) estimated the returns education for farmers in Uganda using production functions and found positive results. compared to farmers with no education.

5.2 The different storage materials used for storing maize grains.

Polypropylene (PP) Bags.

From my findings, the different storage materials used for storing maize grains include: Granaries, House floors and Polypropylene bags. The highest number of respondents with a 75.0% used polypropylene bags, 15.0% of the respondents used house floors and those who used were the least

with 10.0%. This study corresponds with the study of (Thamaga-Chitja *et al* ,2004) who said polypropylene bags are also one of the most popular methods of storing maize grains in sub-Saharan Africa. Polypropylene bags are made from woven strip of polypropylene. These bags have a lot of advantages. They are air tight, easy to use, very affordable, easily accessible and come in.

House floors

From the study, 15 percent of the respondents used the house floor for storing their maize grains. This way of storing grains was on a temporal basis on a dry floor or on the mat. This study is in accordance to (FAO 1994) saying as far as storage on the ground, or on floors is concerned, the less exposed to risk if it's placed on wattle mats or laid on the ground or floor. Drying floors could be improved by making them of concrete; or by stabilizing the earth chemically or with natural materials such as nere juice

Granaries

According to the study, 10 percent of the respondents used the granaries and this was the least percentage of the respondents during the study. Granaries can house large quantities of maize grains but it does not provide an effective protection against weevils especially if no additional protection is provided. This is in accordance with (Drame A. Kieme. 2016, Bett, C., and R Nguyo 2007, Djekore M. 2016) the granaries are built in clay like houses with conical straw/grass thatched roofs, and are essentially small storage houses where the products from the harvest are stored. The range of crops that can be stored often varies between 250kg to 1000 kg.

5.3 The level of damage caused by weevils to the maize grains under different storage materials.

90 percent of the respondents encountered a challenge of maize weevils attacking and damaging their maize grains while 10 percent of the respondents said they didn't encounter the challenge of weevils. This is in correspondence with (Hiruy and Getu, 2018a: Hagstrum, 2016) suggesting that Insects damage grain directly by their feeding -boring holes into the kernels and reducing grain quality through weight, nutritional, or quality loss.

From the findings, the highest percentage of respondents reported that the level of damage caused by the weevils is high followed by those who say it's very high, and the lowest percentage of the respondents say it's low. This therefore shows that the level of weevil damage in this study area is

very high. In relation to the storage materials, the level of damage is very high with the use of Granaries, high for those who used house floors and it's low with the use of polypropylene bags. This can be attributed to the study done by (Thamaga-Chitja *et al* ,2004).

5.4 The most effective material /method in controlling maize weevils.

The highest number of respondents considered the use of polypropylene bags as the most effective material with 75 percent compared to the use of granaries 15 percent and house floors with 10 percent. This study corresponds with the study of (Thamaga-Chitja *et al* ,2004) who said polypropylene bags are also one of the most popular methods of storing maize grains in sub-Saharan Africa. Polypropylene bags are made from woven strip of polypropylene. These bags have a lot of advantages. They are air tight, easy to use, very affordable, easily accessible and come in different sizes.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The research findings showed that the majority of the respondents in this study area were females who were mostly in the age brackets of (36-45) and (25-35), this thus makes them more productive in agriculture production. It was also seen that most of the correspondents' level of education was primary level and this limited the awareness of the correspondents about different storage materials other than the traditional materials and methods.

Three major storage materials/methods identified were polypropylene bags, granaries and house floors and the polypropylene bags were the commonest storage material and the least number of correspondents used house floors for storing their maize grains.

90 percent of the respondents encountered a challenge of maize weevils attacking and damaging their maize grains while 10 percent of the respondents said they didn't encounter the challenge of weevils. and the level of damage caused by weevils was very high, and the lowest percentage of the respondents say it was low and the damage was very high for those who used granaries and house floors for those who used the polypropylene bags. These findings therefore showed that level of weevil attack in the study area was very high and demands for an immediate intervention to control the level of damage caused by the weevils.

From the findings obtained, the study shows that the famers in Anyara sub-county have considered polypropylene as the most effective material in control maize weevils.

6.2 Recommendations

It is recommended that modern storage materials like the use of the hermetic/pics bags and metal silos should be adopted by the local farmers in this study area since the pics bags and tend to be more airtight and they help to minimize environmental hazards.

IPM strategies that can easily be adopted by farmers should be designed with work on breeding for resistance emphasized to control these pests. Participants' knowledge of the pests and control practices should be used in designing appropriate IPM strategies.

Manipulation of the method and form of storage as control measure for various insect pests should be considered.

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APPENDICES

APPENDIX 1

RESEARCH QUESTIONNAIRE

(THE EFFECT OF THE MAIZE STORAGE MATERIALS IN CONTROLLING MAIZE WEEVILS IN KALAKI DISTRICT. CASE STUDY ANYARA SUB-COUNTY**)**

SECTION A: DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS.

(Fill in the boxes by ticking**)**

1.Age:18-25 ☐ **, 26-35** ☐ **, 36-45** ☐

2.Sex: Male ☐ **Female** ☐

3. Education: Primary ☐ **, Secondary** ☐ **, Tertiary** ☐

4. Occupation…….

SECTION B: DIFFERENT STORAGE MATERIALS for maize grains.

1. Are you a farmer of maize or a dealer in maize produce?

……
.

2. How long have you been dealing in/with maize production?

……..

3. What is the quantity of maize that you have been producing?

……

4. Do you have any knowledge about these storage materials: PICs bags, metal silos and Gunny bags?

……
.

5. Which materials do you use for storing the maize grains after harvesting or after buying from producer**?**

……
……
……
……

SECTION C: LEVEL OF DAMAGE CAUSED BY WEEVILS TO MAIZE GRAINS.

1.Have you ever encountered a challenge of your maize grains being attacked by weevils?

a). Yes ☐ **, b). No** ☐

2. If it is yes, at what stage do they always attack the maize grains?

a). before storage ☐ **, b). after storage** ☐

3.What is the level of weevil attack to the maize grains before storage?

a). High ☐

b). Moderate ☐

C). Low ☐

4. What is the level of weevil attack to the maize grains after storage?

a). Very High ☐

b). High ☐

d). Moderate ☐

C). Low ☐

SECTION D: THE MOST EFFECTIVE MATERIAL IN CONTROLING MAIZE WEEVIL.

1. What is the most effective material/method in controlling maize since it has become challenge to community?**.....**

2. What do you think makes the method/material you have mentioned above the most effective in controlling maize weevils?

……
……

APPENDIX II

Figure 1: polypropylene bags **figure 2: weevil damages**

Figure 3: polypropylene bags

Figure 4 : hermetic bags/ pics bags

figure 4: granary