**BINDURA UNIVERSITY OF SCIENCE EDUCATION**

**FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE**

**DEPARTMENT OF ENVIRONMENTAL SCIENCE**

# The effectiveness of traditional remedies in controlling weevils in maize

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## DECLARATION

I certify that the ideas, experimental work, results analysis and conclusions reported in this dissertation are completely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted, except where otherwise acknowledged.

The undersigned certify that they have read and recommended to the Department of Environmental Science for acceptance, a dissertation entitled:

THE EFFECTIVENESS OF TRADITIONAL REMEDIES IN CONTROLLING WEEVILS IN MAIZE

A dissertation submitted by Mudiwa Salome N in partial completion of the requirements of Bachelor of Science Honours Degree in Natural Resources Management.

Approved by: Supervisor......................................................... Date.....................................

Signature...........................................................

Student signature............................................... Date......................................

## DEDICATION

To my parents, relatives and friends for their prodigious love, care, and support.

## ACKNOWLEDGEMENTS

I want to express my gratitude to all those that made this project a possibility. First, I give my most sincere gratitude to my supervisor Doctor Mureva for supporting me during my period of study and for his time in editing this document. Many thanks goes to smallholder farmers for assisting with the weevils

l wish to express my thanks to my parents for supporting financially and for their wise counsel and sympathetic ear. To my relatives and friends, thanks for your distinctive ideas. Above all, thanks to the Almighty God for his favor, wisdom, love, guidance and inspiration and for giving immeasurable blessings, for without him this could not have been possible.

## ABSTRACT

Sitophilus zeamais is the major insect pest seen damaging stored maize in Zimbabwe. The environmental hazards of synthetic insecticides, the unreliability supply and high costs of these chemicals resulted in the search for cheaper and safer use of the naturally available plant material to control this pest. This study evaluates effective rates for Eucalyptus, Lantana camara and cassia abbreviata leaf powder. Bioactivity of these leaf powders extract was evaluated under average room temperature at three dosage levels (0. 5g, 1.0g and 1.5g. A positive control of Actellic Gold Dust was also used at label rates and the effect of time, dosage and treatment on mortality of maize weevils was assessed. The 1.5g of eucalyptus that recorded the highest mortality inflicted 85.25%.

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**LIST OF ACRONYMS**

AGRITEX : Agricultural Technical and Extension Services

ANOVA : Analysis of variance

CRD : Complete Randomized Design

FAO : Food and Agricultural Organization

g : grams

kg : kilograms

LGB : Larger grain borer

P<0.05 : Probability less than 5%

WHO : World Health Organization

# CHAPTER 1:INTRODUCTION

## 1.1 Background to the study

The majority of the world's population consumes cereals as their main source of calories (Maga, 1978). Food grains are the most often kept commodities in Africa, where they are used as planting seeds as well as food and feed reserves. Grass crops like maize are among of the most common crops produced for these uses (Lyon.2000). In addition to providing a significant portion of the world's food for both people and animals, they are also converted into a variety of industrial goods, such as green fuel (ethanol), whose consumption lowers air pollution (Suganya, Varman et al. 2016, ogunsina et al.2011). Starches, breweries (to make alcohol), medical industries (to make oil and as a provider for vitamin supplements and medications), cereal products, high fructose syrup, dextrose, maize oil, cosmetics, beverages, crayons, soaps, biodegradable plastics, absorbent material for nappies, and nutrient supplements are all examples of industrial products made from food grains. (Jadhav, Lutz et al. 1998). The analyses above show that maize grain is an essential component of both man and his environment.

There is a worrying trend of postharvest losses which remain a major concern to many of the smallholder farmers in Zimbabwe. This is caused by pests such as weevils jeopardizing food security and causing economic losses (Ileke and Oni 2011, Tefera 2012, Banga, Kumar et al. 2020). It is estimated that a sizable portion of food grains sustain damage after harvest as a result of inadequate storage facilities and insect pest damage. This is further supported by (Giga et al., 1991), who calculate that losses attributable to maize weevils range from 20% to 90 (De Lima 1987).

Farmers long ago used to take measures like using  appropriately ventilated storage facilities and drying maize thoroughly before storing it, to minimize losses that occur after harvesting (Nduku et al. 2013,De Groote, Kimenju et al. 2013).  that are moisture-proof and adequately ventilated, drying maize sufficiently before storing it to reduce losses that occur after harvesting aired (Nduku et al. 2013,De Groote, Kimenju et al. 2013).

The majority of the buildings were built at the start of the period of harvesting, and the harvesting period varied depending on the agro-climatological zones. Solarization, open-air or aerial storage, metal or plastic drums, granaries, and mud rhombuses are a few of the conventional techniques and methods used to store grains.

Solarization is the process of spreading food grains on bare grounds to allow heat from the sun to lower moisture content and eradicate the majority of infectious organisms (Wright, 1995). It is a long-standing tradition among farmers to do this before storing the grains and it is typical in areas where the outside temperature exceeds 20°C or greater. Chewing a few grains during solarization was the only way to know whether the grains were dried to an acceptable degree. If the grain is stored in an insect-proof container, it won't become infested (De Groote, Kimenju et al. 2013). But this was difficult, especially during unfavorable weather conditions during the rainy season when the farmers had to take food grains to a shelter so they wouldn't get wet by the rain. However, this was laborious especially when weather conditions were not favourable during the rainy season when the farmers had to carry food grains to a shelter so that they would not be soaked by rain.

Open fireplace was another traditional method used in controlling grain weevils. The majority of farmers in rural agricultural areas kept their grain supplies close to or above the kitchen, where the heat and smoke from burning firewood could permeate the grain and kill any growing larvae in the seeds as well as prevent insect pest infestation (Hayma 2003, Golob.2000). When it came time to store large quantities of grain, raised barns were built, a slow-burning fire was established, and hot air was managed to keep grains dry. Wood ash from fires has been utilized as a grain protectant in other parts of Africa (Akob and Ewete 2007).However, these methods became ineffective since some of the weevils were resistant to heat. Some food grains were destroyed by fire leading to hunger and starvation of some of the subsistence farmers.

Due to challenges faced, farmers were introduced to synthetic solutions which were more effective and lowered labor costs. The storage system and price are factors that determine how they are used. These can be used before signs of a bug infestation.

Later synthetic solutions became problematic to the users because toxic residue build up in foods, were causing some deleterious impacts on the environment, human health, and animal health, such as harming non-targeted organisms (Duke et al., 2003), the emergence of resistance strains, and the high cost of chemical procurement for subsistence farmers. After a short period one had to buy more insecticides to contain these weevils and other related maize pests (Epidi, Nwani et al. 2008). Some of the most common pesticides which were used in agriculture are Dursban and DDT. They were both banned by the USEPA based on their adverse effects such as those on wildlife as well as their potential human health risks especially to children (Alewu and Nosiri 2011). According to toxicology studies, early exposure to these pesticides may have an impact on how the nervous system functions later in life, which could lead to modifications in a person's behavior and learning patterns (Blair, Ritz et al. 2015). Therefore, this has necessitated a search for safer, cheap and more effective alternative methods to reduce these postharvest losses.

Plant materials were frequently used in traditional farm storage systems in the majority of developing nations by traditional farmers to guard stored products against pest damage.(Mbah and Okoronkwo 2008, Muzemu, Chitamba et al. 2013). At times, the grain bags were stacked one on top of the other in the store room, and occasionally farmers would layer in between them leaves from plants thought to have insecticidal properties (Greenberg et al, 2005). Maize could be kept for up to a year by using natural plant products. The specific approach taken by various communities varied from location to location and appeared to be influenced in part by the type and efficacy of suitable materials that were available in various places. There have been reports of pesticides being present in a variety of African plants. The grain bags were stacked one on top of the other in the store room, and occasionally farmers would layer in between them leaves from plants thought to have insecticidal properties.

Many African plants are potential sources of pesticides and have been known to contain either toxicants, antifeedants, repellent or insecticidal compounds (Elbrense, El Husseiny et al. 2022,Trivedi.2018). ln this practice, farmers used this method to stop pests from infesting their harvest through mixing ground-up plant materials with the grains in the storage container (lleke et at, 2016).

They often cause instant paralysis or a suspension of feeding in nuisance insects and are quick to stop them from feeding, even if they may not result in the insect's immediate death for several hours or days.(Muzemu, Chitamba et al. 2013). Therefore, the objective of this study is to determine the efficacy of different forms of cassia abbreviata (muremberembe), lantana camara, eucalyptus and actellic gold dust in weevil control on stored maize grain.

**Problem statement**

Weevils are a major problem in grain storage and these have caused grain losses among the peasantry. The United Nation agency pointed out the debilitating effects caused by weevils in grain crops worldwide, Zimbabwe included. If no new methods to control these weevils are introduced, definitely more severe grain losses will be witnessed.

ln most rural areas, weevils have caused untold suffering to the rural populace whose lives depend on grain crops like maize, and sorghum only to mention these few. Most households in rural areas are so poor that they cannot afford to buy pesticides whose costs have risen beyond the reach of many households with an income per capita which is less than a dollar a day (FAO, 2015). The synthetic pesticides like shumba and actellic because they are resisted by pests must then be applied more than once to try and control the pests thus, more money is required to buy the insecticides.

The destruction of maize crops by weevils due to the inability of farmers to buy grain pesticides and their harmful effects on human health and the environment has led the researcher to introduce plant pesticides that can be made using local plant materials which are easily accessible within the local environment and also these are cost-effective, user friendly and effective in controlling weevils.

The purpose of the research is therefore to find effective remedies to control weevil destruction on grain using plant material from the muremberembe tree, lantana camara and eucalyptus shrub. These three shrubs contain antifeedant, repellant and insecticidal compound that has the potential to protect the stored product.

However, there is little to no literature on the efficacy of these shrubs in controlling weevils in maize grains.

## Justification

The study assesses the important role that traditional knowledge or indigenous knowledge systems (lKS) have in controlling maize weevils. It seeks to evaluate their effectiveness on maize weevil management. The study will assist smallholder farmers in establishing efficient remedies for controlling weevils. The study will help the stakeholders which seek postharvest loss reduction to know where to channel their resources. Issues and concerns raised in the investigation will help to conscientize people at all levels of society about the need to control and reduce maize weevils and to take a more effective approach to weevil management.

## RESEARCH AIM

To assess the effectiveness of cassia abbreviata, eucalyptus species, lantana camara and actellic gold dust in controlling maize weevils.

## OBJECTIVES OF THE STUDY

1. To determine the effects of cassia abbreviata, eucalyptus and lantana camara leaf powder (treatments) on weevil mortality in stored maize
2. To determine the effect of dosage on weevil mortality in stored maize
3. To determine the effect of time on weevil mortality in stored maize

## HYPOTHESIS

.There is significant effect of treatment on mortality of S. zeamais in stored maize.
. There is significant effect of dosage on mortality of S. zeamais in stored maize.
.There is significant effect of time on mortality of S. zeamais in stored maize.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Maize production and economic importance

According to the Atlas of Zimbabwe, maize dominates all agricultural ecological zones, taking up between 40 and 50 percent of the land planted with crops in natural areas 111, 1V, and V and between 50 and 70 percent in natural regions 1, 11A, and 11B. According to the National Early Warning Unit, the average maize acreage in the communal areas of natural regions 11A and 11B is 1.7 hectares. It may be grown well in soils with a pH between 5.5 and 7.5, appropriate moisture, and warmth from germination through flowering. For maize seed germination and seedling growth, the soil must be at least 10 to 13 degrees Celsius. Sixteen (16) to thirty-two (32) degrees Celsius is the best range for germination. All regions have seen a considerable decrease in the yield of maize.

Numerous studies have demonstrated that the maize weevil severely reduces the quantity and quality of stored maize grain in Africa, with untreated stored maize experiencing grain weight losses between 20 to 90%. (Muzemu et al., 2013, Giga et al., 1991). The storage facilities as well as the physical and chemical properties of the produce all affect how much damage is done. Heavy infestations of adult and larval maize weevil, which cause postharvest losses, have become increasingly important limits for storage entomology (Nukenine et al., 2002) and food security in the tropics. (Adedire, 2001; FAO, 2009; Nwosu et al., 2015a; Nwosu et al., 2015b). *S. zeamais* can penetrate and infest whole kernels of stored maize, making it the main pest. Farmers must practice hermetic storage, maintain sanitation, plant naturally resistant varieties, and crop them if possible to reduce storage losses (Kimatu, McConchie et al. 2012, Kumar and Kalita 2017). They should also use natural insecticides and insecticide-repelling plants rather than synthetic chemicals whenever possible.

## 2.2 Storage and post-harvest pests

If small-scale farmers don't preserve their crops, their labor is in vain. Several biotic restrictions make grain storage difficult, with insects being the most significant one.

The orders Coleoptera and Lepidoptera are home to the majority of the insect pests that attack stored grains (Bekele et al. 1996). Pests after harvest can be major (primary) or minor (secondary). Primary pests can attack intact grains whereas secondary pests attack damaged grains or grain products for they have weaker mouthparts (Rees 2007, Rajendran 2020). Other than these, insect pests do not reproduce in grain which has been stored, but their presence in grain storage facilities is deleterious since it degrades the grain's quality. They have no significant harm on food grains when directly fed on them, but they do produce foul odors and detritus. Ants, termites, silverfish, cockroaches, and other insects are among them (Srivastava and Subramanian 2016) (Upadhyay & Ahmad 2011). Maize storage is necessary to provide the nutritional and food security of the household. Increasing maize grain storage is especially important now that crop yields are being negatively impacted by linked weather conditions brought on by climate change. Research has shown that grain storage loss due to moisture, insect pests, molds, and mildew costs farmers 25 to 30% of their output, thus whatever is produced must be carefully handled.

## 2.3 Post-harvest pests in maize

Some of the insect pests that feed on stored maize are the Angoumois grain moth (*Sititroga cerealla Oliv.*), larger grain borer (*Prostephenus truncates*), rust red flour beetle (*Tribolium castaneum Herbst)*, and the maize weevil (*Sitophilus zeamais*) only to mention these few (Waktole and Amsalu 2012, Kocak et al, 2015,Hiruy et al.2018)

*Tribolium castaneum* is a little, reddish, 3–4 mm long fungus. When it lays eggs outside of sticky kernels, the eggs absorb flour and stick to the containers. The major food source for adults and larvae is cereal germ. It is a severe pest of maize, groundnuts, oats, rice, beans, wheat, and sorghum during harvest and storage. It renders grain unfit for human consumption through infecting it with excrement, damaging kernels and grains internally, and fostering the development of mold (Kocak, Schlipalius et al. 2015).

*Angoumois grain moth* is another pest which results in post-harvest loss. Moth infestation begins in the field. Larvae that feed inside the maize may be detected in the infested maize in the field. Producing eggs on uninfested kernels happens as the adult matures, pupates, and emerges as an adult. Feeding leads the moth to shed weight and quality. Irritating smell arise from grain that has been extensively damaged. Minute perforations will be noticed on each kernel of the ears in these pest-infested cribs (Crombie 1943)

The larger grain borer was originated in Mexico, this means that the pest is new to Zimbabwe and is presumed to have arrived with Tanzanian maize assistance. It is a dangerous pest of dried cassava, housed maize, and some household goods. It bores into wood. This dangerous pest has catastrophic impacts and necessitates effective control planning. It is a pest that Zimbabweans can report (Tefera 2010). The LGB can consume all the grain and cause up to a 100% loss. The infamous pest is resistant to the majority of synthetic pesticides.

*Sitophilus zeamais* also known as the maize weevil, is a tiny, varyingly sized, black to reddish-brown snout beetle (Arnason, Conilh et al. 1994). Its average length is about 3.2 inches. One of the main harmful housed grain pests of maize and some cereal grains is said to exist in tropical and subtropical areas, including Zimbabwe (Suleiman et al., 2015). The grain that has been stored suffers a great deal of damage from S. zeamais because it is so harmful and has the ability to multiply to large populations. The loss of grain weight from S. zeamais infection is thought to be between 5 and 30 percent of the entire grain weight of the stored produce (Ojo and Omoloye, 2012). Untreated maize grain that is stored has been shown to have losses of up to 80% in other experiments.

It is believed that *Sitophilus zeamais* feed on grains internally. Usually, they have a length of 2.5 to 4.5 mm. The average lifespan of *S. zeamais* is between three and six months and one year. Sex pheromones are released by female weevils to entice males. When a kernel of maize is fertilized, the female makes a tiny hole in it with her nose before ovipositing, reproducing eggs, and sealing the opening with a waxy secretion. In ideal circumstances, each female can produce up to 150 eggs during her lifespan.

The small larvae that emerge from the eggs after about 6 days feed and grow inside the maize kernels for around 25 days. Total development times vary depending on the environment and might be between 35 and 110 days. To reach the testa, the adults must munch their way there, creating rough exit holes that damage the kernel and lower grain weight (Ojo et al., 2012). Due to the insects' metabolic activities, infestation with insects typically results in higher grain heating (temperature) and moisture content. As a result, fungi including toxic species like *Aspergillus flavus* link began to thrive and contaminate seed crops before and after harvest (McMillan, 1980).

### 2.4 Control measures of *Sitophilus zeamais*

There is an urgent need to reduce post-harvest losses in maize that has been stored. Due to the seasonal nature of maize, the produce must be stored for later use and, in certain circumstances, preserved seed for the following season. Maize has often been kept on hand for purchase during the off-season, when prices are typically higher. For many farmers, S. zeamais is a troublesome insect since it quickly reduces both quality and quantity of their crops. Since it attacks grain even before harvest, the insect poses a severe threat to food security if it is not controlled. Currently, a number of measures for stopping the invasion or infestation of this insect have been researched. Insect pest infestation causes grain weight and quality losses as infested grain typically loses colour and nutritional content. It is therefore important to reduce excessive losses by preventing, protecting and curing.

#### 2.4.1 Chemical control

These substances offer varying degrees of protection. Sadly, no chemical will completely eradicate every insect species, thus two are typically combined and put on the grain (Lorini et al., 2006). Shumba Super Dust®, Chikwapuro®, Ngwena Yedura®, Actellic Super Chirindamatura Dust®, Actellic Gold Dust®, and Phosphine fumigation pills, which are utilized in seed houses and industrial storage facilities, are some of the artificial grain protectants currently available in Zimbabwe on the market.

The active substances of the most popular organophosphate grain protectants in Zimbabwe are fenitrothion (C9H12NO5PS) and pirimiphos-methyl (C11H20N303PS). Thiamethoxam, a second component, is used in Actellic Chirindamatura Dust and Actellic Gold Dust to protect maize against pests like the maize weevil, a lethal insect(Hoferkamp et al, 2007). The vast majority of Zimbabwean farmers depend on synthetic chemicals. Despite being productive and efficient, farmers with limited resources cannot manage the constantly growing expenses, and in many cases, the chemicals are not easily accessible in rural markets. Additionally, the excessive use of pesticides poses a health risk to people and the ecosystem (Whight, 1995). A good example is the active ingredient in Actellic, only 15g of the main ingredient is needed per tonne and very few if any farmer works with the proper proportions.

### 2.4.2 Cultural control

No matter what kind of control strategy is used, cultural approaches always apply. A preventive, curative, or combined approach may be used in this case(Glen 2000). Sitophilus zeamais infests the maize as it is still in the growing stage. Crops shouldn’t be allowed to remain unharvested for a long time because maize is susceptible to these pests. Before keeping the produce, it is essential to screen it after shelling and clean off any pollutants. Farmers who had limited resources used sanitation, resistant cultivators, maintenance of storage facilities, and physical control to mantain their maize away from pests. Sanitizing storage areas and filling in any gaps, or holes in the floors can prevent infestation. When using sacks or bags, make sure to clean them by sunbathing them before staking grain in them. This will keep the bags clean and minimize insect damage during storage. It's also a smart idea to avoid combining new and old grains. This is typically done to little amounts of seed that will be utilized the second half of the season. Movement of the insects will be hindered, and the material may affect their cuticles, resulting in dehydration and eventual death. Strong husk types should also be cultivated since they keep insects from easily accessing the maize cob, lessening field infestation. Strong husk types should also be cultivated since they keep insects from easily accessing the maize cob, lessening field infestation.

Painter (1951) identified three categories of varietal resistance: tolerance, antibiosis, and non-preference. Antibiosis and non-preference are connected with resistance to post-harvest pest species (Panda and Heinrichs 1983, Pereira.2009). The grain must be stored after it attains the proper moisture content in order to avoid heat and fungal problems. Hermetic storage lowers oxygen levels and enhances carbon levels, which kills insects. Crop handling after harvest is typically inexpensive and practicable using traditional methods. To lessen insect activity during storage, various historically used materials are typically applied to the grain. To the stored product, for instance, inert dust is frequently added in varying proportions. Storage bug cuticles get desiccated after being rubbed against dust particles, which stunts the pest's growth

### 2.4.3 Botanical control

Due to its affordability and economic viability, this traditional practice makes a substantial contribution to food production and protection in maintaining livelihoods (Mkenda et al. 2015). The majority of the plants are foraged locally from the wild, such as in or around 24 homesteads, by the sides of the road, in farmland that has been left fallow, and in forest reserves. According to Bell et al. (1990), pesticidal plants can be directly harmful but frequently function through acting as repellents, growth regulators, and antifeedants as well as preventing insects from laying eggs.

The oldest pesticides used up until the end of World War II were poisons taken from plants, but synthetic compounds have a great knockdown impact on pest species. Secondary chemical compounds that are utilized by plants as a defence mechanism against insects that feed on plants and other herbivores are known to exist in plants (Lupina and Cripps, 1987). For example, nicotine has an impact on the synapses and axons of the nervous system.

Traditional grain protectants on farms have also included various neem tree pieces and other plant leaves (Jilani & Ahmad, 1982). Numerous botanical grain protectants are used in powder form in Southern Africa, including Zimbabwe, to lessen weevil infestation. These include *Tectona indicus, Tapirus grandis, and Eucalyptus grandis,Jatropha curcas, Lantana camara*(Ogendo,2000), *Lippia javanica* (Gadzirai et al 2006) and leaves.

To protect stored goods from insect pests, chemical pesticides have been widely utilized in grain storage facilities (Kim et al., 2012).

Although relying on insecticides like organophosphates and pyrethroids as well as respiratory insecticides like methyl bromide and phosphine, are effective at controlling coleopteran pests, but their prolonged use had negative impacts on the environment and human health. Therefore, applying botanicals to prevent insect  damage to stored grain is considered to be a safe and effective approach suitable for smallholder farmers(Van Lenteren 2006)

# CHAPTER 3: MATERIAL AND METHODS

## 3.1 Study site

The experiment was conducted in the Physics Laboratory at the Bindura University of Science Education. Throughout the experimentation period, the laboratory's temperature fluctuated between 25 and 30 degrees Celsius, and its relative humidity ranged between 65 and 75 percent. Throughout the investigation, the laboratory was kept properly aerated.

## 3.2 Experimental design and treatments

Completely Randomized Design (CRD) was used in the experiment to minimize door effects. Four treatments were replicated 3 times. To make appositive control Actellic Gold Dust was employed. Cassia abbreviata, Lantana camara, and eucalyptus leaf powder at varying concentrations of 0.5g/20g, 1g/20g, 1.5g/20g (Nicolas scale was used) Actellic Gold Dust and were used three times. Sixteen bottles were used in the experiment. Grain and leaf powder were mixed evenly to ensure even distribution of powder over the grain surface. After making the mixture twenty starved weevils were put in each of the sixteen bottles. A total of 320 weevils were used.

## 3.3 Materials

A nearby farmer provided *Sitophilus zeamais* and left without food for a day. Local farmer supplied maize and the Actellic gold dust was acquired from a local hardware shop. Small holes were made on the bottles to allow in air for the weevils to breath. However, the holes made were so minute that the weevils could not exit the bottles. Dirt was removed from the maize for easy selection of damaged grain and the good grain selected was placed in a deep freezer to sterilize basal infestation for three days. After refrigeration, the maize was air dried under protection to avoid re-infestation by pests. Each of the perforated plastic bottles contained twenty (20g) grams of maize. Fresh leaves of Cassia abbreviata, Lantana camara, and eucalyptus were gathered from nearby bushes. The leaves were dried in an airy room for a fortnight. Smooth powder was made from the pounded dry leaves. These were sieved through a mesh which was 0.5mm in size so as to obtain uniform particle sizes.

### 3.4 Data collection

#### 3.4.1 Weevil mortality

After treatment the number of dead weevils from each bottle was counted and recorded. The recordings were done after periods of 2, 4 and 6 days. Insects were proved to have died after noticing their immobile bodies. Maize weevil mortality was assessed as (Number of dead insects/Total number of insects) x 100.

### 3.5 Statistical Analysis

Analysis of variance (ANOVA) was done using R Studio.

## CHAPTER 4: RESULTS

There was a significant difference ($p<0,05$) on weevil deaths on stored grain.Out of four treatments, Eucalyptus had the highest mortality of 95% followed by the manufactured pesticide (Actellic Gold Dust) with the mortality of 85%, lantana camara with 75% and cassia abbreviata had the lowest mortality of 25%.

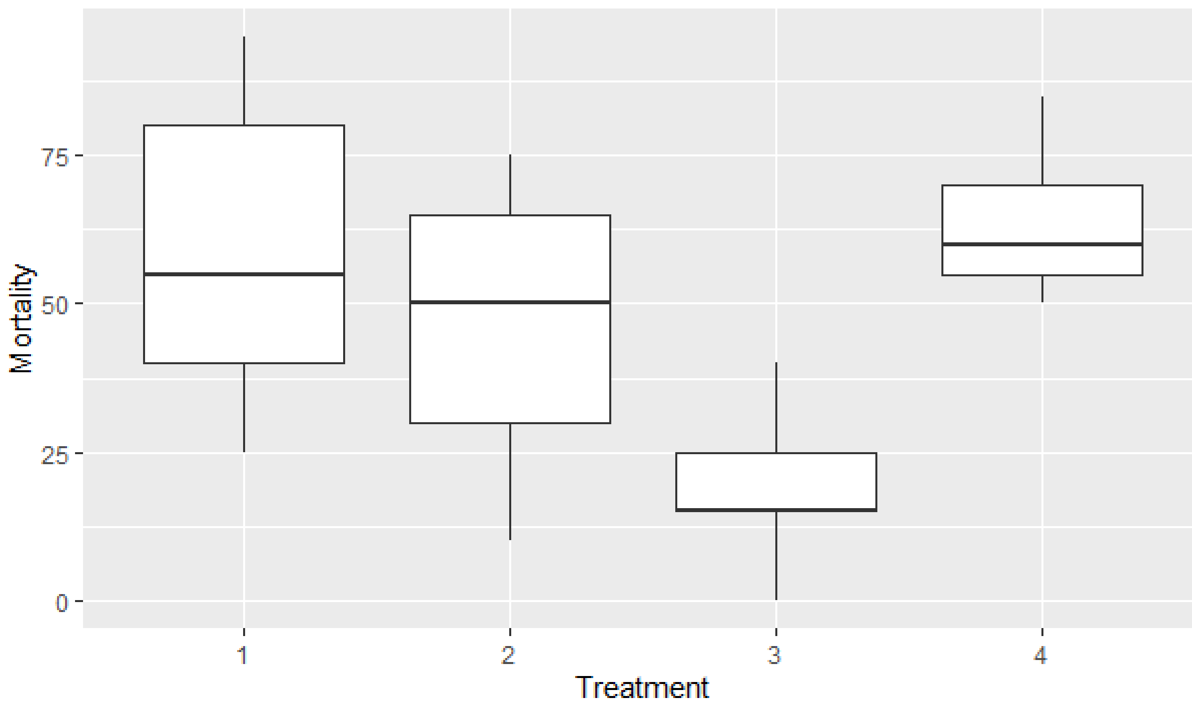


Fig 4.1. Showing the effects of 1- eucalyptus, 2-lantana camara, 3-cassia abbreviata , 4- actellic gold dust on weevil mortality.

There were noticeable differences among all dosages on the deaths of maize weevils in stored maize ($P<0.05$). Repellency and toxicity for botanical pesticides increased with increase in concentration until an optimum concentration was reached beyond which the number of dead and repelled weevils remained constant. Dosage 3 (1.5g) results in most mortality as compared to dosage 2 (1.0g) and 1 (0.5g) respectively. The highest dose was more effective on weevils than the lower doses. Therefore, the higher the rate, the quicker the knockdown and the greater the mortality.

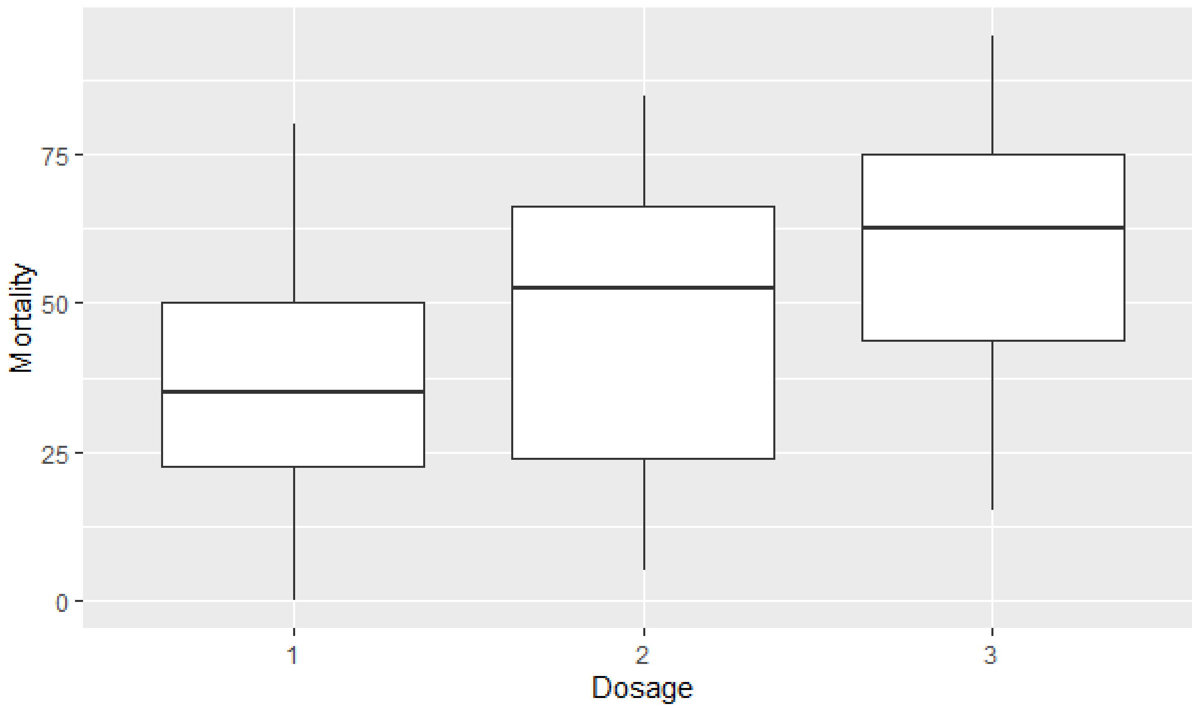


Fig 4.2. Mortality of Sitophilus zeamais treated with different doses of botanicals. 1-0.5g ,2-1.0g ,3-1.5g

There were significant differences ($p<0.05$) in deaths of weevils due to plant products. The more time the grain mixed with botanical pesticides, the high increase in weevil deaths was observed. In the first 2 days, the mortality was low in all treatments. This was followed by day 4and day 6 respectively. At  day 6, the efficacy of these botanicals were high.

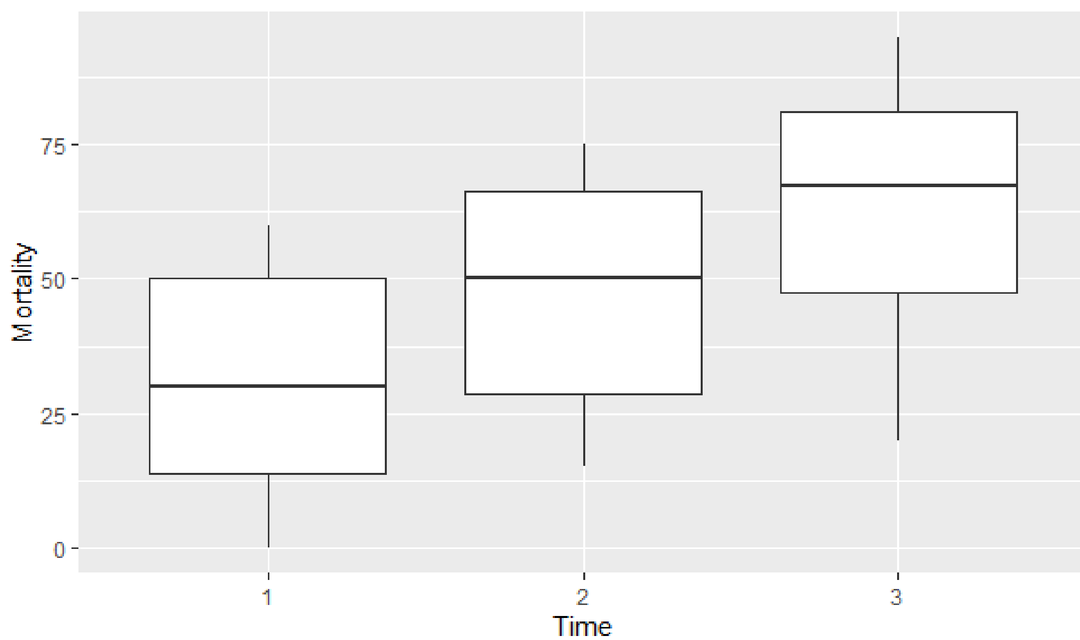


Fig 4.3. Effect of time on mortality of Sitophilus zeamais. 1-day 2, 2-day4, 3-day 6

# CHAPTER 5: DISCUSSION

The results observed have shown that botanical leaf powders can utilized in the control of S. zeamais in stored maize. Many plant products are used as stored crop grain protectants (Araya G. and Emana G. 2009). Of the botanicals used in the study, Eucalyptus leaf powder significantly reduced the number of maize weevils by at least 95%. Having shown its effectiveness, the eucalyptus powder can be used as an effective alternative against S. zeamais in stored maize. An increase in concentration of *Eucalyptus* leaf powder results in an increase in amount of eucalyptus oils, which possess repellent and toxic properties against *S. zeamais* (Thacker, 2002). However, a particular concentration is attained when the amount of the eucalyptus oils and other active ingredients are adequate to protect a given amount of grain (optimum concentration). According to earlier reports, application of the pesticide in excess of this concentration maintains the same efficacy as the optimum concentration but doing so wastes the active ingredients (Ogendo, 1990). However, different factors including chemical composition , vulnerability of the maize weevil species may affect how different plant components affect maize weevils.

In the same way, with *Lantana camara*, increasing the leaf powder concentration increases the concentration of the active components, such as lantine, flavonoids and triterporoids. According to Siddig (1980), these chemicals possess toxicity and repellency properties against *S. zeamais* and other arthropods such that an increase in their concentration increases repellency and toxicity (Owusu, 2000). Although at optimum concentrations and concentrations thereafter, 95% elimination of *S. zeamais* was achieved, more time was taken than time taken by 'Actellic gold' dust. This can be associated with a highly concentrated pure active ingredient in 'Actellic gold' dust. In botanical pesticide leaf powders, the active ingredients are not pure and concentrated, thereby lowering surface area for maximum activity requiring more contact time.

In the current study, it has been observed that the effectiveness of treatments increases with increasing dosages and the time of exposure that is eucalyptus at application rate of 1,5g over a period of 6 days has the highest mortality rate as compared to eucalyptus at application rate of 0,5g. The findings demonstrated that mortality was dose dependant, with higher dosage levels killing more weevils.

This is consistent with findings by (Khare, 1987), who found that the essential oil osdienen found in Lantana camara leaves has the ability to entoxicate insects. As a result, Sitophilus zeamais adults will be killed in grains treated with acceptable amounts of Actellic Gold Dust and Lantana camara leaf powder .According to Wheeler et al.(2001) dried botanical leaves offered the best defense against S. zeamais attack on maize and sorghum grains. This is in line with the findings showing that S. zeamais's gustatory and olfactory systems are repulsed by the leaf powder of Eucalyptus (Hall, 1990).

Also, Mulungu et al. (2007) revealed that pounded dry Eucalyptus leaves have been found to have an insecticidal effect and a repellant odor, which can be used to effectively manage pests that attack stored maize like S. zeamais. Due to the physical barriers impact of the leaf powders, the use of the three botanical powders in the study encouraged higher insect death.

This may be explained by the leaf powder's propensity to obstruct insects' spiracles, which hinders respiration and ultimately results in the death of the parent insect. In addition to causing adult mortality, the plant leaf powders either completely disturbed or considerably slowed down or prevented progeny from emerging showing their potential for use in the management of the maize weevil (Mulungu et al, 2007). This is consistent with Araya and Emana who reported that the insecticidal activities of the plant powders are variable and broad and dependent on different factors like the presence of bioactive chemicals which need to be identified, isolated and manufactured in the factory for pest management.  The results showed that the efficacy of botanical pesticides decreases with time.  This would imply that botanicals need constant reapplications for them to offer continual protection of the grain against maize weevils.

Also, botanical pesticides are cheap to produce and easily accessible to the poor households who cannot afford to buy high cost synthetic pesticides.

# CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

Without synthetic chemicals being used, communal farmers have the option of using Eucalyptus, lantana camara and cassia abbreviata leaves.  Pounding of botanical leaves into powder improved contact between the maize grain. It was discovered that the plant leaves have effective insecticidal activity towards maize weevil unlike synthetic chemicals that cause environmental health hazards and lethal dose to the users.

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