IDENTIFICATION AND VALIDATION OF AFRICAN INDIGENOUS KNOWLEDGE PRACTICES ON MANAGEMENT OF CROP PESTS IN KITUI WEST SUB COUNTY

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DECLARATION

I understand that plagiarism is an offense and I therefore declare that this thesis report is my original work and has not been presented to any other institution for any other award.

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This thesis report has been submitted for examination with our approval as the University Supervisors

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ADP	**:**	Area Development Program
AIK	**:**	African Indigenous Knowledge
ASAL	**:**	Arid and Semi-Arid Land
GDP	**:**	Gross Domestic Product
GoK	**:**	Government of Kenya
IK	**:**	Indigenous Knowledge
IPA	**:**	Integrated Program Area
LIFDC	**:**	Low Income Food Deficit Country
MPRP	**:**	Mutonguni Poverty Reduction Project
NGO	**:**	Non-Governmental Organization
SAP	**:**	Sustainable Agricultural Practices
SCAO	**:**	Sub County Agriculture Officer
SDGs	**:**	Sustainable Development Goals
UNDP	**:**	United Nations Development Programme
WARM	**:**	Water and Agriculture Recovery in Mutonguni
WHO	**:**	World Health Organization
WVK	**:**	World Vision Kenya

ABSTRACT

Agriculture in Sub-Saharan Africa is predominantly subsistence and perennial food deficits, cyclic famines characterize it, and poverty is prompted largely by erratic rainfall patterns, declining soil fertility, and pests and diseases. In Kitui County, farmers are largely small-scale and face various challenges: from poor soil fertility to erratic rainfall. The farmers, too, have not been spared by the pest menace. Consequently, they have resorted to unwarranted and unregulated application of synthetic pesticides. Besides the dangers of exposure to the chemicals are erosion and even total loss of the much-valued Indigenous Knowledge developed and accumulated over time. The current study was therefore carried out to identify, document, and validate identified Indigenous Technologies practiced in the management of key field and storage pests in the Kitui West sub-county. The study focused on collecting information on the traditional practices used to manage field and storage pests. It involved a field survey using a questionnaire administered to randomly selected farmers and a desk review of existing information in Kitui west. The current study's findings indicate that farmers use a variety of African Indigenous Knowledge (AIK) methods to manage field and storage pests. The study established that the older generation of farmers (46.10%) is more inclined to use indigenous pest control methods than the younger generation (0.7%) of farmers. It was also established that the more educated farmers leaned more towards using chemicals in pest control compared to the lesser educated lot. Participants frequently identified the application of ash as one of the most crucial aspects of pest management. They pointed out that they dusted/applied ash on the grains immediately before storing them to curb the spread of pests. The effectiveness of ash in controlling the primary storage pest of cowpeas, the cowpea bruchid *(Callosobruchus maculatus)* that affects cowpea, was determined in the laboratory. Wood ash provided cheaper and safer control of the cowpea bruchid. The use of wood ash provided mechanical protection, especially when it was thoroughly mixed with cowpeas. The cowpea bruchids also find it difficult to move around cowpeas that had been mixed with ash. The current study recommends that more farmers be encouraged to embrace AIK through proper education and sensitization, especially the younger generation through the use of government and non-governmental organizations. The organizations can play their part in ensuring the proper use of indigenous methods and the availability of resources that encourage the use of traditional methods.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

Agriculture in Sub-Saharan Africa is predominantly subsistence, and it's characterised by perennial food deficits, cyclic famines and poverty prompted largely by erratic rainfall patterns, declining soil fertility, and food grain crop pests and diseases (Ogendo *et al.*, 2013; Mihale *et al.*, 2009). Grain pests pose the biggest threat to food grain production, storage, and handling in subsistence agriculture (Ogendo *et al.*, 2013). The occurrence, severity, and diversity of field insect pest damage differ between seasons, crops, stage of crop growth, and agronomic practices (John *et al.*, 2015). Pests lead to on-farm and post-harvest losses and, consequently, food insecurity in a country. According to the low-income food-deficit country (LIFDC) list for 2013 by Food and Agriculture Organization (FAO), Kenya is a low-income food-deficit country (LIFDC) among sixty-two other countries of whom the majority belong to Africa and Asia continents (FAO, 2013). This is further supported by data from the World Bank (2012), which estimates Kenya's poverty levels to stand at 33.6% of the total population. Agriculture is the largest sector in the Kenyan economy, contributing to about 30% of the Gross Domestic Product (GDP) (Mariara and Karanja, 2007). Crop production is an important part of the agricultural sector, therefore making pest control necessary for the economy's thriving and food security.

Approximately 1.3 billion tons of food produced globally (one-third of food produced worldwide) are lost annually during postharvest operations (Gustavsson *et al.*, 2011). The biggest losses occur during the storage stage, with insect pests being the main cause of these losses (Kumar and Kalita, 2017). Storage plays a vital role in the food supply chain, and several studies reported that maximum losses happen during this operation (Kumar and Kalita, 2017). One of the reasons for these losses of food is the type of storage structures. Costa (2014) estimated losses as high as 59.48% in maize grains after 90 days of storing them in traditional structures like granary and polypropylene bags. African Indigenous Knowledge in Kenya was practiced before the arrival of the colonialists (Muraya, 2019). The indigenous methods used in pest control in Kenya have varied from region to community, owing to the vast, rich cultures in Kenya. The word indigenous itself points out that a certain activity is rooted in a culture and is unique to certain people and regions. African Indigenous Knowledge (AIK) practices of pest control in Kenya relied solely on the provision of nature in fighting pests. For instance, in regions such as Muranga and Kericho, where tea is grown, abundant rainfall is expected; therefore, pest management methods differ. The AIK applied on pest control of tea included bush sanitation, plucking, and shade regulations (Nyabundi *et al.*, 2016). On the other hand, Kitui county generally experiences hot and dry weather during the year (Omoyo *et al.*, 2015). Crops grown in Kitui are mainly maize (*Zea mays),* green grams *(Vigna radiata),* beans (*Phaseolus vulgaris),* cowpeas *(Vigna unguiculata),* and pigeon peas *(Cajanus cajan)* (Khisa *et al.*, 2014). The most common pests in Kitui include seed weevils, mainly affecting maize, mites affecting beans, and aphids affecting pigeon peas. In Kitui West Sub County, field and storage pests continue to be among the largest threats to food production (WVK Mutonguni ADP program redesign report, 2012). Pests affect crops by feeding on leaves, roots, stems, and flowers, hindering crops' ability to produce. They indirectly affect field crop production by acting as vectors of plant diseases. Pests' onslaught on stored harvest makes it unsuitable for human consumption.

Synthetic pesticides have been recommended and promoted in Kenya for over five decades (Ogendo *et al.*, 2013; Constantine *et al., 2020*). This has continued despite the high costs of pesticides, environmental pollution, and surface water contamination. According to Aktar *et al.* (2009), pesticides contaminate soil, water, turf, and vegetation and are toxic to birds, fish, beneficial insects, and non-target plants. Surface water contamination is common in areas where pesticides are applied as the pesticide residues are washed to waterways by surface run-off. This affects the quality of aquatic ecosystems. According to Rani *et al.* (2021), groundwater pollution due to pesticides is a global menace, and pesticides found in groundwater include pesticides from every major chemical class. Once groundwater has been contaminated, it may take years for the chemicals to be diluted and for the chemicals to be cleaned up, and cleaning up chemicals from underground water resources might prove very costly and complex (Aktar *et al.*, 2009). The resistance buildup is another problem associated with pesticides, whereby pests mutate and become resistant to a pesticide such that its use does not affect or kill them.

Before introducing synthetic pesticides, farmers relied on indigenous knowledge (AIK) to manage pests. With the knowledge of the adverse effects of synthetic pesticides worldwide, attention is rapidly shifting to non-chemical eco-friendly options like AIK (Ogendo *et al.*, 2013). Pottorf (2004) reported that micro-organisms, microbial products, mineral-bearing rocks, and plant/animal derivatives (extracts, powders, ashes, manure, etc.) are among the recommended pesticides in organic agriculture. With farming becoming more modernized, the threat of indigenous knowledge on pest management being lost is becoming more real with the new generation of farmers opting for synthetic pesticides. Capturing this knowledge, developed over time through interaction with the natural environment, is important as locals depend on it for survival. Despite the enormous potential of AIK that has existed for generations, the indigenous pest control practices have remained largely unexploited with limited regional research intervention and resources committed. Upon realizing this problem, there was a need to determine and document the indigenous knowledge on pest management among farmers in the Kitui West sub-county.

1.2 Problem Statement

Pests and diseases pose the greatest threat to food production, storage, and handling, accounting for 15 – 100% and 10 - 60% pre-and post-harvest food grain losses, respectively (Saxena and Jilani, 1990). Kaminski and Christiansen (2014) estimate postharvest losses in maize crop in Uganda, Malawi, and Tanzania that is attributed to pests alone in the range of 1.4% to 5.9%. In Kenya, pests' total perceived postharvest losses were estimated at 7.2± 1.0% (Mwangi *et al.,* 2017). As a result, food security is greatly threatened by pests. Farmers have often responded to the pest's menace by using synthetic pesticides. However, most subsistence farmers have inadequate knowledge of the safe use of synthetic pesticides, which has led to the contamination of farm produce by pesticide residues. According to WHO (2016), continuous consumption of pesticide residue in foods is the main contributor to the increasing incidences of diseases such as cancer. Pesticide use has also negatively affected the pollinating insects leading to declining agricultural productivity (Thompsons and Hunt, 1999). In Kitui West Sub County, there has been an unprecedented increase in the use of pesticides as a response to pests on agricultural crops (Mutunga *et al., 2017*). This may negatively affect the health of the farmers and the pollinators associated with the agricultural ecosystems, leading to reduced productivity. In addition, the extensive use of pesticides has increased the cost of production. The current climate changes mean more future confrontations with insect pests. This will translate to more challenges associated with the use of pesticides in pest management.

Interestingly, before the introduction of modern pesticides, farmers successfully utilized African Indigenous Knowledge (AIK) in the management of field and storage pests at the farm level (Kiplang'at and Rotich, 2008); hence, they were less exposed to chemicals, and there was little or no negative impact on pollinators. Studies have shown that coupling the existing scientific knowledge with African indigenous knowledge (AIK) offers better solutions for pest management (Ogendo *et al.*, 2013). However, with the current trends in the use of pesticides and the fact that much of the AIK is largely undocumented, there is a growing fear that this AIK might erode completely with the changing generations; hence, the need to identify and document AIK methods used in Kitui West Sub County.

1.3 General Objective

The general objective of the current study was to identify, document, and validate key indigenous knowledge practices used in managing crop pests among farmers in the Kauwi and Mutonguni Divisions of Kitui West Sub, Kitui County.

1.3.1 Specific Objectives

The specific objectives were to;

i. Identify farmers' key African Indigenous Knowledge (AIK) practices in managing field and post-harvest crop pests in Kauwi and Mutonguni Divisions of Kitui West sub-County.
ii. Determine whether farmers' age and education level affected the use of AIK in the management of key field and storage pests.

iii. Validate the effectiveness of identified key AIK methods in managing major field and storage pests of key crops in Kitui West Sub-county.

1.4 Research Questions

To achieve the research objectives, the main questions that the study sought to answer were:

i. What are the key indigenous pest control/management methods used by farmers in the Kauwi and Mutonguni Divisions of Kitui West Sub-County, Kitui County?
ii. Does the age and education level of farmers influence the use of AIK practices in managing key field pests?
iii. How effective are the key AIK methods used in managing crop pests in Kitui west Sub County?

1.5 Justification

The use of synthetic pesticides has raised several ecological and medical problems, yet their use has not substantially reduced the pest losses (Blackman and Eastop, 1999). Kumar (2010) observed that with the rapid environmental, social, economic, and political changes occurring in many areas inhabited by indigenous people comes the danger that the indigenous knowledge they possess will be overwhelmed and lost forever. Despite the apparent danger of the erosion of this resource, AIK has been recognized as an important source of information for sustainable development (Anyira, 2010; Claxton, 2010) and offers great opportunities for improved agricultural production and sustainable food security (Zaid and Egberongbe, 2011). The knowledge systems of farmers in Kenya have never been recorded systematically in written form, hence they are not easily accessible to agricultural researchers, extension workers, and development practitioners. With the changing generations and new farming techniques, the dangers of erosion of this knowledge are real. This may lead to increased use of modern chemical pesticides, associated unnecessary high costs, and undesirable health and environmental hazards. As a national development resource, there is a need to identify and document this AIK knowledge in the Kitui West sub-county. This will provide valuable grounds for research that will help policymakers, research institutions, and other stakeholders pursue sustainable agricultural production.

This study will also have a tremendous contribution in the realization of Sustainable Development Goals (SDGs), especially SDGs 1- on Poverty eradication, and SDG-2 on Zero Hunger. Promotion and use of these AIK methods in the management of crop pests and diseases will largely play a big role in poverty reduction and therefore impacting SDG 1. AIK methods are locally available and basically tap on the existing knowledge practices in the control and management of crop pests and diseases. This unlike use of the modern pest control techniques which are costly and often come with health effects, AIK is lesser or no cost at all on the part of the farmers and therefore costing the farmer less to manage and maintain the crops up to post harvest operations. This will eventually result to increased production with lesser production costs. When food production increases, the quality of lives of farmers and individuals increases (Grofova and Srnec, 2012). This leads to a reduction in poverty and an increase in the earnings of individuals which lowers the rate of global inflation as forces of demand and supply are balanced.

Through AIK, farmers can save 1.3 billion tons of food annually. This food is lost on post-harvest operations (Gustavsson *et al.,*2011). This loss equates to US$1trillion. This food can feed 2 billion people annually (Searchinger *et al.*, 2019). The study will impact the SDGs by helping to reduce the amount of food waste through the use of proper and effective AIK methods. These AIK will contribute to the preservation of the crop from destruction by pest and ensure that food is preserved from planting to consumption stage.

The study will also play a vital role in Kenya's Vision 2030. Agriculture is among the six pillars that make up a large part of Kenya's Gross Domestic Product (GDP). The main focus on Kenya's agricultural sector from Vision 2030 is to ensure that food security is boosted by 30% by the year 2030 (Mabiso *et al.*, 2012). Eradication of pests through AIK will enable farmers enjoy larger crop yields and contribute to the fast growth of food production as more food will be saved from destruction by crop pests and will be used to ensure food security in the country. The study will also play a role in the improvement of the Kenyan population health, and global health at large. The methods in use are purely indigenous and therefore have no adverse effect on the crops, thereby guaranteeing a healthier society, and lessening the weight of diseases brought about by use of pesticides and insecticides such as cancer (Pretty and Prevez, 2015).

The study will not only impact Kenya's vision 2030 and the SDGs, it will also be a great contributor to The Big Four Agenda, established in 2018 by President Uhuru Kenyatta that directly relates to vision 2030. The main focus the study will aim to impact on The Big Four Agenda is Food Security (Njura *et al.,* 2020). Consistent and correct use of AIK Methods will lead to minimal post-harvest losses and therefore lead to an increase in food production and therefore contributing to increased GDP.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Indigenous knowledge (AIK) is the knowledge that has been developed over time in a community mainly through the accumulation of experiences and intimate understanding of the environment in a given culture (Tikai and Kama, 2003). The subsistence nature of production and high poverty levels in ASALs of Kenya make farmers rely on indigenous knowledge to manage pests, and as a result, pest problems intensify and become more pronounced due to the failure of integrating synthetic pesticides into their existing pests' management systems (Mihale *et al*., 2009). According to Mugisha-Kamatenesi *et al.* (2008), major pests that affect food production, especially in Arid and Semi-Arid Lands (ASALs), include: ants, birds, aphids, scale insects, mealy bugs, caterpillars, spider mites, grasshoppers, man, millipedes, rodents, spotted cricket, wildlife, moths, and cutworms. Pests significantly diminish the yields of crops harvested from the field stages and reduce the quality and value of crops during storage.

2.2 Significance of African Indigenous Knowledge (AIK)

African Indigenous Knowledge is location specific and therefore varies from geographical location to another. Studies on AIK done in Uasin Gishu and Keiyo Districts in Rift valley province, Kenya, by Kiplang'at and Rotich (2008) underscore the importance of AIK to local communities. They indicated that AIK is a valuable national resource. They further observed that AIK helps to ensure that the end-users of specific agricultural development projects are involved in developing technologies appropriate to their needs. They also revealed that by working with and through existing agricultural systems, change agents could facilitate the transfer of technology generated through the research network in order to improve local systems. AIK is cost-effective since it builds on local development efforts, enhancing sustainability and capacity-building.

Tikai and Kama (2003) defined African Indigenous Knowledge as the knowledge developed over time in a community mainly through the accumulation of experiences and intimate understanding of the environment in a given culture. In their conclusion, Tikai and

Kama (2003) observed that there is much to learn from the AIK system if we move towards interactive technology development from the conventional transfer of technology approach, as it is feasible, efficient, and cost-effective to learn from the village.

According to Mihale *et al.* (2009), farmers' indigenous knowledge holds the key to the attainment of any pest management undertakings at the farm level. Mihale *et al.* (2009) also acknowledge that the potential of AIK to significantly contribute to pest management is enormous and it has existed for generations without exploitation. Interventions through research and financial resources committed to supporting AIK have been limited in Kenya. This calls for a shift in focus and approach towards interactive technology where we can learn from AIK systems and improve on pest management.

2.3 Chemical Control of Pests

Though the use of pesticides and other chemicals is regarded as a quick and easy way of controlling pests, the associated impacts of this use on human and environmental health is upsetting. Use of quality sprayers, avoiding smoking while spraying, wearing appropriate gear while spraying, and changing clothes after spraying are some of the means to reduce chronic and acute health hazards (Biswas *et al.*, 2014).

Biswas *et al.* (2014) pointed out that the continued use of agrochemicals for the control of pests and diseases in agriculture poses serious threats to human and environmental health. In his report, Biswas *et al.* (2014) revealed that cancer, neural disorders, birth defects, mutagenicity, and reproductive and human developmental anomalies are linked with exposure to agrochemicals. Hashmi *et al*. (2011), observed that pesticides play a pivotal role in meeting the food demand of escalating populations and control of vector-borne diseases. However, most of the applied pesticides get dispersed in the environment and affect the health of unprotected agricultural and industrial workers.

Hashmi *et al.* (2011) also cited that the health effects of pesticide exposure are difficult to monitor in the farmers, especially when a mixture of pesticides is used over a period of time. This, therefore, explains the long-term effect of pesticide contamination on the health of users, especially resource-poor farmers. Hashmi *et al.* (2011) noted that pesticides induce a wide array of human health effects through oxidative stress causing cytogenetic damage and carcinogenicity. This many time results in the uncontrolled growth of body cells, eventually leading to cancer infections or other terminal illnesses. Linkages between pesticides and human health were first suspected around the 1960s and 1970's when the uncommon increase in Non-Hodgkins Lymphoma was observed in areas of high pesticide use (Gupta, 2012). Biswas *et al.* (2014) point out acute illnesses, chronic illnesses, killing of non-target animals and plants, killing of beneficial soil micro-organisms, and water contamination as some of the human and environmental health hazards of pesticides.They also narrowed the scale down to human health hazards, pesticides are poisonous and human exposure to them can cause fatigue, body and headaches, skin discomfort and rashes, poor concentration, circulatory problems, dizziness, nausea, impaired vision, tremors, and panic. Eddleston and Hawton (2008) found out that most stored pesticides were used for self-harm through ingestion due to their easy accessibility. Biswas *et al.* (2014) caution that commonly used pesticides such as organophosphates, carbamates, pyrethroids, and chlorophenoxy herbicides ought to be considered neuro-developmental toxicants. Bodeker and Dummler (1993) found a correlation between pesticide use and sarcomas, multiple myelomas, brain tumors, cancer of the prostate, pancreas, lungs, ovaries, breasts, testicles, liver, kidneys, and intestines.

2.4 Biological Control of Pests

Biological pest management is an important component of integrated pest management and the method relies on predation, parasitism, herbivory, and other natural mechanisms to control pests (Chidawanyika *et al*., 2012). Biological pest control methods are sustainable and ecologically friendly although in some instances they may not be economically viable, they may be complex and their efficacy due to weather and climate changes varies (Chidawanyika *et al*., 2012). Concerns towards reducing public health and environmental risks associated with chemical pesticides have prompted the adoption of biological IPM in many developing and developed countries (Lynch, 1998). Lockwood and Ewen (1997) described three basic categories of biological pest control methods namely: conservation, classical, and augmentation. Conservation biological control involves deliberate practices of man that favour survival of natural enemies at the expense of pests (Eilenberg *et al.*, 2001). For instance, planting ecological strips of non-crop plants to create shelter, be a source of food, and protect local natural enemies from pesticide harm, is a method practised in the farming of cereals, cabbages, and orchards (Landis *et al.*, 2000). Classical biological control involves the assemblage of natural enemies from the area of origin and introducing them in a new area where their host pest was introduced unintentionally (Van Lenteren, 2011). Augmentative biological control involves the periodic release of large populations of mass-reared natural enemies with the objective of flooding natural enemy populations to add on their numbers (Van Lenteren, 2011).

Generally, biological pest control methods are safer than chemical pesticides to human and environmental health, and they don't leach into groundwater to cause pollution or create resistant strains of pests (Agrawal, 2010). On the flip side, biological control methods are more expensive than chemical control methods due to the expenses of studying, choosing, testing, and breeding a bioagent (Agrawal, 2010). Also, biological control methods often take more time as they may act over several generations to successfully manage the pest, they require a more skilled professional level to accomplish, and sometimes non-native bioagents introduced into an area to control non-native pests can turn to become pests (Agrawal, 2010).

2.5 Integrated Pest Management (IPM)

Integrated pest management is a holistic and broad approach to pest control that targets to suppress pests' populations below the economic injury level. FAO defines IPM as "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment (CO Ehi-Eromosele, 2013). In essence, IPM focuses on the growth of healthy crops with minimum interference to the agroecosystem and ensures the least use of pesticides while promoting natural pest management. A good IPM system is designed around the principle of acceptable pest levels whereby IPM aims at controlling pests to levels below economic injury but not total eradication of pest species as such attempt may be impossible to meet or maybe expensive and unsafe to achieve, and preventive cultural practices where a mix of the best pest control techniques that are most suitable to the local conditions are selected (CO Ehi-Eromosele, 2013)

2.6 African indigenous Practice on Pest Control

Movare *et al.* (2011) noted that indigenous knowledge provides problem-solving strategies for local communities and helps shape local solutions to revitalize farming systems and environment. These authors also observed that there is a disparate comparison of non-adoption of sustainable agricultural practices (SAPs) and blaming farmers, their farms, and methods of conventional farming practices in most cases. Mwine *et al.* (2011) carried out a study in South Uganda on AIK on plant species that had pesticide properties and they found out that Meliaceae and Euphorbiaceae plant families were the most useful for having several species with pesticidal features. Plants produce substances like alkaloids, tannins, phenols, and terpins which are meant to protect the plants against pathogens and herbivores (Dethier, 1980; Bernays, 1981; Schutte, 1984). According to Gatehouse (2002), these plant substances can be exploited to make pesticides. Mwine *et al.* (2011) found out that leaves followed by fruits, seeds, and bark in that order constitute large portions of the plant substances that can be used to make pesticides. For Euphorbia, which does not have conspicuous leaves, the plant utilizes its stem to store substances held to have pesticide properties. In their study, Mwine *et al*. (2011) also mentioned that ash of no particular plant species (which was a constituent of many species concoctions) was identified as an effective pest control technique.

The stinging nettle extract is used as a repellant as a preventive measure against pests such as aphids (Kaberia, 2007). The blackjack plant is another common pest control measure used in Kenya. Blackjack is boiled for about 10 minutes and left to cool, or the seeds are ground and soaked in water for a day. The mixture is then sprayed on crops to eliminate pests such as aphids, caterpillars, crickets, mites, and termites (Munyua and Wagara, 2015). Mexican marigold is used as a control measure against crops in Kenya. It is done by crushing about 3kg Mexican marigold leaves in 4 litres of water and is left for 5 to 8 days before boiling for 20 minutes then cooling. The mixture is filtered and added to soapy water and sprayed on crops to eliminate pests such as ants and caterpillars. Marigold mixed with pepper helps control aphids, beetles, grasshoppers, and weevils (Smart Farmer Kenya, 2020). Marigold can also be planted alongside crops to curb pest because the roots produce alpha-terthienyl, a naturally occurring toxic used in producing nematicides and other pesticides, which helps control pests.

The use of ash in Kenya is also a common AIK practice in the management of pests. The ash is used as a grain protectant (Wambugu *et al.*, 2009). It mainly controls pests such as weevils, stalk borers, and aphids. Ash is beneficial to plants as it is a source of phosphorus and also acts as a physical poison for pests by causing abrasion of epicuticular waxes, exposing pests to death through desiccation. It also interferes with the chemical signals emitted by the host plants, obstructing pests' initial host location.

Pepper is also an AIK practice in controlling pests in Kenya. Capsaicin is a naturally occurring chemical derived from red peppers. It is most commonly found in animal repellents, but it can also be found in products that kill mites and insects or prevent them from feeding on plants. Capsaicin produced by the red peppers is a preffered method of AIK because it is less toxic to the environment compared to synthetic pesticides since it is Capsaican is a botanical pesticide: plant-derived, making it a naturally ocurring toxin extracted from plants. The red pepper is used as an AIK practice for controlling mites and insects (Nanyunja *et al.*, 2016).

2.7 Factors Affecting Adoption of AIK

The adoption and use and utilization of AIK is slowly declining. there are various reasons that account for this decline, with the main one being improper documentation. Without proper documentation, the culture is bound to decline over time as the main form of transmission is through word of mouth (Tusiime *et al.*, 2016).

Ottong (2008) emphasized that Indigenous Knowledge evolves over centuries, and thus it represents all of the people's skills and innovations, as well as the collective wisdom and resourcefulness of a community. However, indigenous knowledge documentation and dissemination are critical. Documentation is concerned with preserving such knowledge in its entirety for posterity, whereas dissemination is concerned with encouraging access to documented knowledge for planning and decision-making.

Documentation, like any social practice, is part of a specific cultural universe and is guided by beliefs, codes, and values that are not always shared by the communities whose heritage it depicts (Arantes, 2010). Documentation allows one to investigate whether solutions to a given problem can be applied to a different country or time period. Documentation facilitates sharing and is one method of preserving Indigenous Knowledge (CEFIKS, 2006). Documentation of AIK in Kenya should therefore be given priority as it is a key player in the incorporation of AIK practices for the next generations.

People have indigenous knowledge of nearly all-natural resources, including water, plants, insects, animals, soil, and atmospheric conditions. Indigenous knowledge takes the form of household labor relations, community by-laws, taboos, and customs, among other things, and is embedded in community practices, institutional relations, and rituals. It is an integral part of the social order of the community (Documentation of Indigenous Knowledge enables the community to fixate information for broad scrutiny and ownership. If traditional knowledge is not properly documented, analyzed, and disseminated, it may be lost forever.

Another factor affecting the adoption of AIK is government policies. Strategic planning and implementation are constitutional requirements for state organizations in Kenya. According to Kwanya (2020), AIK is local in nature and is specifically tailored to the needs and context of the local community. According to Kamara (2005), local communities in Africa have local knowledge that assists them in environmental management and coping with various environmental changes. This means that if the government incorporates the knowledge of the local for example AIK, it can can help with disaster prevention, food security, and health management through the sustainable elimination of pests.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was conducted in Kitui County, Kitui west Sub County in Kauwi and Mutonguni Divisions. Kitui County (Fig 1.) is one of the 47 counties in the country, located about 160km east of Nairobi City, the capital of Kenya. It is the sixth-largest county in the country, covering an area of 30,496.4 km^2. It lies between latitudes 0°10 South and 3°0 South and longitudes 37°50 East and 39°0 East (“Kitui County,” 2022). Kitui west Sub County is an administrative unit with three divisions namely: Kauwi, Mutonguni, and Usiani. Kauwi and Mutonguni divisions were purposively selected in the current study where groups were identified from the agricultural office and sampled. According to the 2019 census report, Kitui West Subcounty had a population of 70,871 people (“Kitui County,” 2022). Kitui West Subcounty receives scanty and erratic rainfall and the region is categorized as an arid and semi-arid land (ASAL). Agriculture in the area performs average to poor with maize and beans being the main crops planted. Other common crops grown include green grams, cassava, millet, sorghum, cowpeas and pigeon peas.

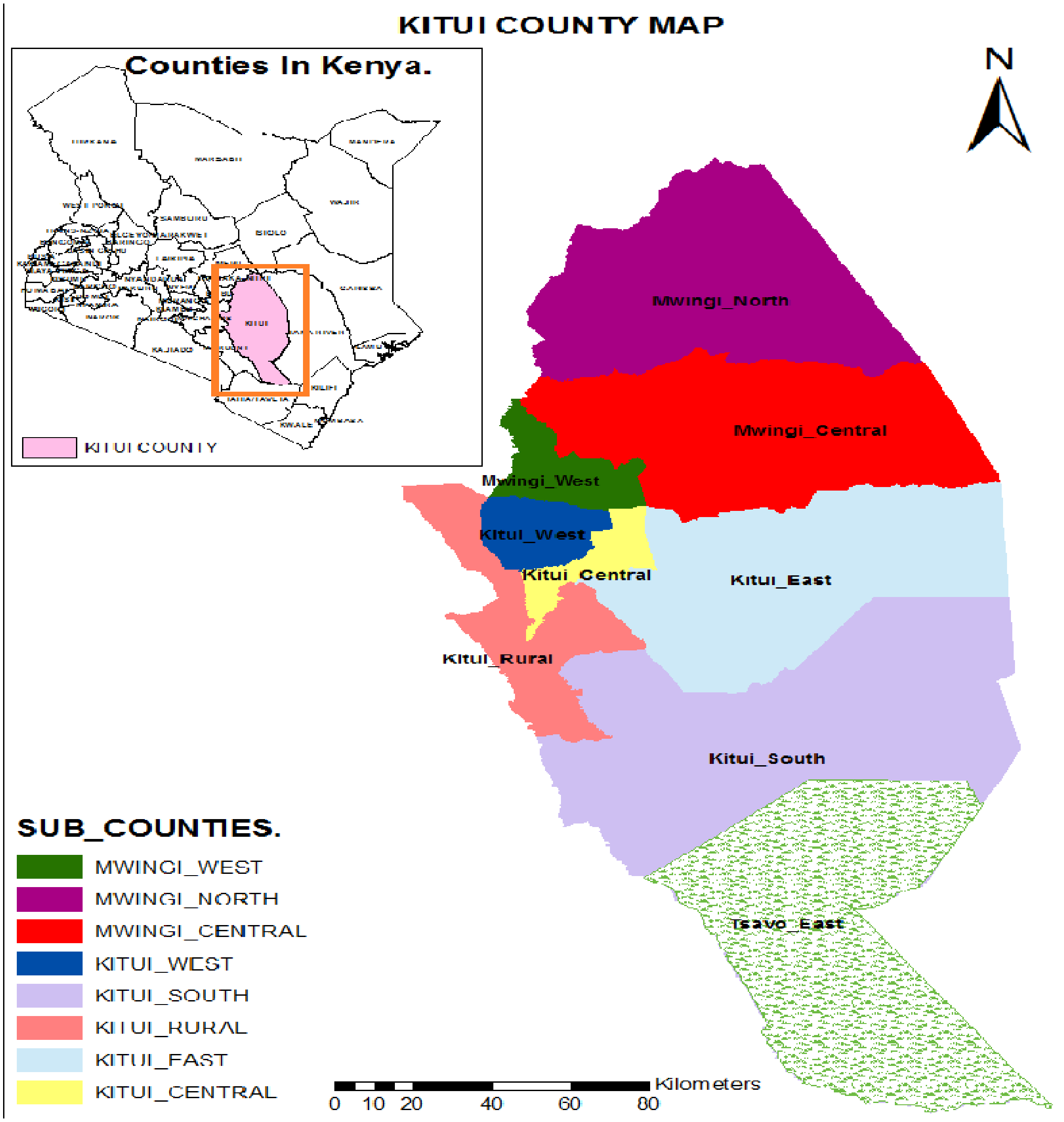

Figure 1: Location of Kitui County in Kenya

Key: Kitui West Sub-county

Source:https://www.semanticscholar.org/paper/Socio-%E2%80%93-Economic-Benefits-and-the-Associated-of-%26-Mutisya-Mwinzi/03ec8b6d95b0eb3e595f6a082fe05c36dd345f39/figure/0

3.2 Sample Size and Sampling Technique

A total of 184 respondents were randomly selected from a target population of 500 farmers in Kauwi and Mutonguni divisions of Kitui West Sub County, and they were identified through stratified multi-stage sampling. The 184 respondents were selected from 25 well-established small-scale farmer groups in the Kitui West sub-county each group comprising an average of 20 farmers. A sampling of the farmer groups began by availing a list of all these groups from the district agriculture office. According to Mugenda and Mugenda (2003), each of the groups from the two locations had an equal and known non-zero chance of being selected. The names of the groups from each location were then coded and subjected to a star trek random event simulation program. This helped in randomizing the sample to eliminate bias and achieve the 184 respondents. By using this design, each population unit had an equal probability of inclusion in the sample (Bryman, 2004).

3.3 Data Collection Method

Both Primary and secondary data were collected. The collection of primary data involved field observation, note-taking, and interviews. The structured questionnaire which comprised both closed and open-ended questions were used. Section A and B comprised of closed-ended questions-18 in total, and section C comprised 7 open-ended questions and 15 closed-ended questions. The questionnaire was pretested in a pilot study carried out prior to the survey exercise, with 18 respondents representing 10% of the total respondents randomly selected from the initial sample. The study was adopted as 18 respondents were a realistic target to work with. Secondary data was generated mainly from a review of literature from books, publications, scientific journals, discussion papers, theses, institutional reports, and working papers relevant to the study.

3.3.1 Determining the Effect of the Level of Education on the Use of IK

The population described in 3.2 above was used for this study. The 184 respondents were purposively divided into different levels of education namely; primary, secondary, tertiary, and informal education. Respondents in each category, based on their level of education were interviewed to determine their knowledge of and their use of AIK.

3.4 Determining the Effectiveness of Ash in Controlling Cowpea Bruchids (*Callosobruchus maculatus*)

The study was carried out at South Eastern Kenya University Agriculture Laboratory. Ten (10) kilograms of freshly harvested cowpeas were obtained from respondents' fields in Kauwi and Mutonguni Divisions in Kitui West Sub-county for use during the experiments. Ash was chosen for use in the validation study because it is the most common control measure which was mentioned by the respondents (Kitheka, unpublished data). Ash weighing 2 kilograms was collected from South Eastern Kenya University (SEKU) kitchen backyard and was sieved using a 2 mm sieve to separate the residue and the solution. A total of 100 seeds of cowpea, considered as a sample unit were randomly selected from the 10 kgs and the number of infested seeds (if any) was counted and recorded. The 100 seeds were then put in a khaki paper packet (4 inches × 8 inches). This was repeated until 120 samples, each of 100 seeds were obtained. These 120 samples (each containing 100 seeds) were then randomly divided into four groups (each of 30 samples) and kept on a bench at room temperature in the laboratory at SEKU. Group 1 was left without any treatment to act as a control experiment. Sample groups 2, 3, and 4 were treated with ashes of different concentrations of 5, 10, and 15 grams of ash, respectively. The number of infested seeds in each sample in all the treatments was counted and recorded weekly for a period of five weeks.

3.5 Data Analysis

Field data was analyzed using both qualitative and quantitative methods. The data collected was cleaned, validated and bench checked. Data on gender, age, education level, and sizes of the land of respondents were subjected to measures of central tendency and chi-square independence tests to measure how variables were dependent or independent of other variables. Chi-square tests were performed to determine whether there were significant differences in production, approximate sizes of land, and application of AIK between the two divisions of Kitui West Sub-county. Qualitative data was organized into themes, categories, and patterns and then analyzed using the content analysis technique with the objective of identifying trends and patterns. Data on the effect of gender on the use of AIK and the effect of education on the use of AIK were subjected to correlation analysis to study the strength of the relationship between gender and education level on the use of African indigenous knowledge. Data on the rates of infestation of cowpea were subjected to Analysis of Variance (ANOVA) using the statistical analysis software (SAS Institute 2018).

CHAPTER FOUR

4.0 RESULTS

4.1 Key African Indigenous Knowledge (AIK) Practices Used by Farmers in the Management of Field and Post-Harvest Pests in Major Crops in Kauwi and Mutonguni Divisions of Kitui West Sub-County.

Results of the current study indicate that a variety of crops are grown in the Kitui West sub-county as shown in table 1 below.

Table 1: Major crops that are grown in Kitui West Sub-county (Kauwi and Mutonguni Divisions)

Crop (Common and Scientific name)	Family	Percent
Maize (*Zea mays)*	Gramineae	17.1%
Greengrams *(Vigna radiata)*	Fabaceae	16.1%
Beans (*Phaseolus vulgaris)*	Fabaceae	15.3%
Cowpeas *(Vigna unguiculata)*	Fabaceae	15.3%
Pigeon peas *Cajanus cajan)*	Fabaceae	14.1%
Dolichos *(Lablab purpureus)*	Fabaceae	12.3%
Sorghum (*Sorghum bicolor)*	Poaceae	4.7%
Millet *(Pennisetum glaucum)*	Poaceae	2.8%
Bananas (*Musa acuminate)*	Musaceae	0.1%
Others: Sunflower (*Helianthus annuus)*	Asteraceae)	

The main challenges that affect crop production in the study area include unreliable and poorly distributed rainfall (36.6%), pests and diseases (26.0%), inadequate farm inputs (22.9%), inadequate knowledge and skills (10.5%), and unreliable markets and inadequate land (4.0%).

Results of the current study indicate that farmers have knowledge of a variety of pests that affect crop production in the area under study (Table 2). Stalk-borers, aphids, beetles, weevils, larger grain borers, rodents, and birds were mentioned by the majority (97%) of respondents as the main pests that affect their farming (Table 2). A variety of AIK techniques have been used for the management of both field pests (Table 3) and storage pests (Table 4) with different levels of effectiveness (fig. 2 and 3).

From the current study (Kitheka, unpublished data) 41.1% (Majority) of the farmers said they used ash for the management of storage pests. In addition, 21.7% of farmers identified cowpea as a key crop that is mostly affected by pests during storage. Due to this, ash and cowpea were selected for use in the subsequent validation exercise.

Table 2: Major pests that affect crops in Kauwi and Mutonguni Divisions of Kitui West Sub-county as reported by respondents.

NO.	Type of pest	Order	Crops attacked
1	Stalk borers *(Busseola fusca)*	Lepidoptera	Maize (*Zea mays*: Poaceae), sorghum *(Sorghum bicolor;* Poaceae*)*, Millets *(Pennisetum glaucum;* Poaceae*)*
2	Aphids *(Aphidoidea sp.)*	Homoptera	Beans (*Phaseolus vulgaris;* Fabaceae), cabbages (*Brassica oleracea var. capitate*), maize (*Zea mays)*, sorghum *(Sorghum bicolor)*
3	Whiteflies *(Aleyrodidae sp.)*	Homoptera	Beans (*Phaseolus vulgaris)*, cabbages (*Brassica oleracea var. capitate*), kales (*Brassica oleracea var. sabellica)*, cassava *(Manihot esculenta)*, green grams *(Vigna radiata)*, mango plant *(Mangifera indica)*, pigeon peas *(Cajanus cajan)*, pumpkins *(Cucurbita moschata)*, papaya *(Carica papaya)*, sweet potatoes *(Ipomoea batatas)*, water melon *(Citrullus lanatus)*
4	Weevils *(Curculionoidea sp.)*	Coleoptera	Sweet potatoes *(Ipomoea batatas),* Maize (*Zea mays)*, bananas *(Musa paradisiaca)*, cowpeas *(Vigna unguiculata)*, pigeon peas *(Cajanus cajan)*, green grams *(Vigna radiata)*, mango plants *(Mangifera indica)*
5	Red spider mite *(Tetranychus urticae)*	Trombidiformes	Maize (*Zea mays)*, amaranth *(Amaranthus viridis)*, avocados *(Persea americana),* beans (*Phaseolus vulgaris)*, cassava, mango *(Mangifera indica)*, papaya *(Carica papaya)*, passion fruits, pigeon peas *(Cajanus cajan)*, tomatoes *(Solanum lycopersicum)*, water melon
6	Leaf feeding caterpillars *(Spodoptera litura)*	Lepidoptera	Cabbage (*Brassica oleracea var. capitate*), kales *(Brassica oleracea*, *variety acephala*), maize *(Zea mays)*, sorghum, sugarcane (*Saccharum officinarum),* vegetables
7	Ants *(Formicidae sp)*	Hymenoptera	Citrus orchards (*Citrus lemoni)*
8	Thrips *(Thysanoptera sp.)*	Thysanoptera	Avocados (*Persea Americana)*, Bananas (*Musa acuminate*), beans (*Phaseolus vulgaris)*, cabbage (*Brassica oleracea var. capitate*), kales, cowpeas, green grams, mangoes *(Mangifera indica)*, onions (*Allium cepa)*, peas *(Pisum sativum*), pigeon peas *(Cajanus cajan)*, passion fruit *(Passiflora edulis*), pepper *(Capsicum frutescens)*, tomatoes (*Solanum lycopersicum)*
9	Grasshoppers *(Caelifera sp.)*	Orthoptera	Millet (*Panicum miliaceum)*, sorghum, maize, sugarcane, oranges *(Citrus sinensis)*, lemons, pawpaws (*Carica papaya)*

10	Cutworms *(Noctuidae sp.*)	Lepidoptera	Amaranth, beans, cabbage (*Brassica oleracea var. capitata*), kales, carrots, maize, pigeon peas, sorghum, pea, tomatoes, pepper
11	Leaf feeding Beetles *(Chrysochus auratus)*	Coleoptera	Water melon, beans, cowpea, green grams, Maize, peas, pigeon peas *(Cajanus cajan)*, sorghum
12	Termites *(Cryptotermes brevis)*	Isoptera	Maize (*Zea mays*), mango *(Mangifera indica)*, cassava, citrus plants, pigeon peas, sorghum*(Sorghum bicolor)*, sugarcane (*Saccharum officinarum)*, sweet potatoes
13	Squirrels *(Sciuridae sp*)	Rodentia	Maize *(Zea mays)*, mangoes, oranges, tree barks
14	Birds *(Aves sp)*	Passeriformes	Sorghum, water melons (*Citrullus lanatus*), mangoes, pawpaw, maize,

Table 3: AIK methods used in the management of key field pests in Kauwi and Mutonguni Divisions of Kitui West Sub-county

AIK Method	Form applied/method of application	Target pests	Target crops
Use of ash	Ash is sprinkled on the affected area of the plant	Beetles (Order: Coleoptera), Caterpillars (Lepidoptera), Thrips (Thysanoptera), Whiteflies (Homoptera), Aphids (Homoptera)	Maize (*Zea mays*), Sorghum *(Sorghum bicolor)*Beans (*Phaseolus vulgaris)*, dolichos, *(Lablab purpureus)*, pigeon peas *(Cajanus cajan)*, green grams, (*Vigna radiata)*, cowpeas*(Vigna unguiculata)*,
Ash mixed with cow *(Bos indicus)* dung	Ash is mixed with cow dung and the mixture soaked in water. The mixture is then filtered using a sieve and the filtrate is then sprayed to affected areas of crops	Beetles (Coleoptera), Caterpillar (Lepidoptera), Thrips (Thysanoptera), Whiteflies (Homoptera), Aphids (Homoptera)	Maize (*Zea mays*), Sorghum, *(Sorghum bicolor)* Beans(*Phaseolus vulgaris)*, Dolichos *(Lablab purpureus)*, pigeon peas *(Cajanus cajan)*, green grams (*Vigna radiata)*, cowpeas *(Vigna unguiculata)*,
Use of cow *(Bos indicus)* dung	Dry cow dung is burned in the field, strategically towards the direction of the wind. The smoke produced is blown towards the target plants by the prevailing winds.	Aphids (Homoptera), Thrips (Thysanoptera), Leaf feeding Caterpillars (Lepidoptera)	Maize (*Zea mays*), Sorghum *(Sorghum bicolor)* Beans (*Phaseolus vulgaris)*, Dolichos *(Lablab purpureus)*pigeon peas *(Cajanus cajan)*, green grams (*Vigna radiata)*, cowpeas *(Vigna unguiculata)*, mango trees (*Mangifera indica*)
Use of donkey(*Equus africanus)* droppings	Donkey dropping are burned in the field, strategically towards the direction of wind. The smoke produced is blown towards the target plants and pests are repelled.	Aphids (Homoptera), Thrips (Thysanoptera), Leaf feeding Caterpillars (Lepidoptera),	Maize (*Zea mays*), Sorghum *(Sorghum bicolor)*, Beans(*Phaseolus vulgaris)*, Dolichos, *(Lablab purpureus)*pigeon peas, *(Cajanus cajan)*, green grams (*Vigna radiata)*, cowpeas*(Vigna unguiculata)*, mango trees (*Mangifera indica*)

Use of hot pepper *(Capsicum frutescens)*	A handful of pepper fruit is ground until it's in powder form. Then water (About 5 litres) is added and stirred until the pepper powder and water mix well. The filtrate is sprayed on crops.	Aphids (Homoptera), Whiteflies (Homoptera), Caterpillars (Lepidoptera)	Maize (*Zea mays*), Sorghum *(Sorghum bicolor),* Beans (*Phaseolus vulgaris)*, Dolichos, *(Lablab purpureus)*, pigeon peas*(Cajanus cajan)*, green grams (*Vigna radiata),* cowpeas*(Vigna unguiculata)*, mango trees (*Mangifera indica*), kales, common bean, spinach
Use of Bee's wax *(Cera alba)*	Beeswax is burned in the field, strategically towards the direction of the prevailing wind. The smoke produced is blown away towards the plants and it repels pests	Aphids (Homoptera), Caterpillars (Lepidoptera), Weevils (Coleoptera), Whiteflies (Homoptera), Red spider mites (Trombidiformes)	Maize (*Zea mays*), Sorghum, *(Sorghum bicolor)* Beans(*Phaseolus vulgaris)*, Dolichos *(Lablab purpureus)*, pigeon peas*(Cajanus cajan)*, green grams (*Vigna radiata),* cowpeas*(Vigna unguiculata)*, sunflower, common bean, tomatoes
Use of tobacco (*Nicotiana tabacum)* and hot pepper *(Capsicum frutescens)* mixture	A cup of ground tobacco is mixed with a cup of grinded red pepper. The mixture is then sprinkled on crops in the form of powder.	Aphids (Homoptera), Whiteflies (Homoptera), Caterpillars (Lepidoptera),	Cowpeas *(Vigna unguiculata)*, Pigeon peas (*Cajanus cajan)*, Green grams(*Vigna radiata)*, Maize *(Zea mays)*, Dolichos *(Lablab purpureus)*, Common bean, Tomatoes, Kales, Spinach, cabbage
Use of tobacco, red pepper, and neem leaves mixture	A cup of ground tobacco, red pepper, and neem tree leaves powder (ratio 1:1:1) is added water and left for some hours to mix well. The filtrate is then sprayed on crops	Aphids (Homoptera), Whiteflies (Homoptera), Caterpillars (Lepidoptera)	Cowpeas*(Vigna unguiculata)*, Pigeon peas(*Cajanus cajan)*, Green grams (*Vigna radiata)*, Maize *(Zea mays)*, Dolichos*(Lablab purpureus)*, Common bean, Tomatoes, Kales, Spinach, cabbage
Smoking maize *(Zea mays)* cobs	Maize cobs are burned in the field, strategically towards the direction of the prevailing	Aphids (Homoptera), Thrips (Thysanoptera), Caterpillar (Lepidoptera)	Maize (*Zea mays*), pigeon peas *(Cajanus cajan)*, green grams, (*Vigna radiata)* cowpeas*(Vigna unguiculata)*, Beans

	wind. The smoke produced is blown away towards the plants and it repels pests		(*Phaseolus vulgaris)*, Dolichos *(Lablab purpureus)*, mango trees *(Mangifera indica)*
Use of Neem, cow urine and soap mixture	Neem leaves are crushed and ground to form a powder. Water is then added and the filtrate is sprayed on crops. The filtrate can also be mixed with cow urine and ordinary soap and sprayed on crops	Aphids (Homoptera), Stalk borer (Lepidoptera)	Maize (*Zea mays*), pigeon peas*(Cajanus cajan)*, green grams (*Vigna radiata),* cowpeas *(Vigna unguiculata)* , beans(*Phaseolus vulgaris),* Dolichos*(Lablab purpureus)*
Cow dung-wood ash filtrate	Cow dung powder is mixed with ash and water is added to the mixture. The filtrate is then sprayed on plants	Aphids (Homoptera), Whiteflies (Homoptera), Caterpillars (Lepidoptera), Stalk borer (Lepidoptera)	Maize (*Zea mays*), pigeon peas*(Cajanus cajan)*, green grams (*Vigna radiata),* cowpeas*(Vigna unguiculata)*
Use of anthill soil and ash mixture	Equal proportions of anthill soil and ash are mixed and sprinkled on leaves of crops	Aphids (Homoptera), Caterpillars (Lepidoptera)	Maize (*Zea mays*), Beans(*Phaseolus vulgaris)*, pigeon peas*(Cajanus cajan)*, green grams (*Vigna radiata),* cowpeas *(Vigna unguiculata)*

Results of the current study indicate that ash was the most effective AIK method for control of field pests followed by use of cow dung, donkey waste, pepper and honey wax (Fig. 2).

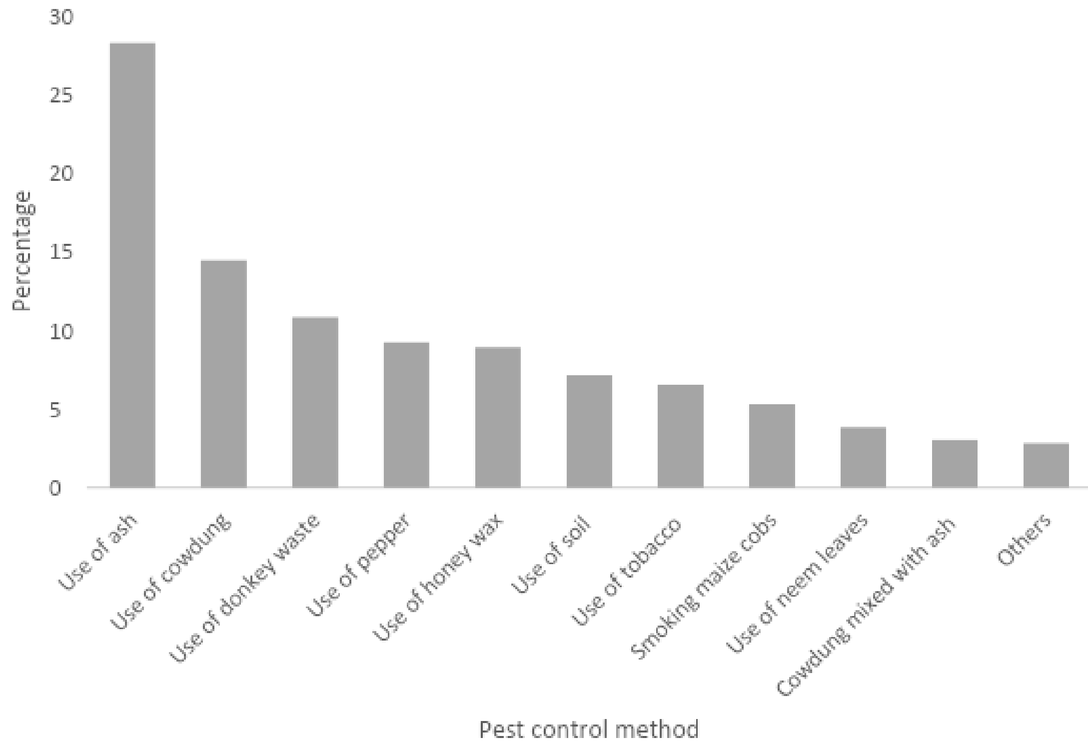

Figure 2: Effectiveness of different African Indigenous Knowledge (AIK) methods for the management of field pests in Kitui West as reported by the respondents.

Other field pest control methods mentioned include: uprooting affected plants and leaving them to die, use of a mixture of wood ash and cow urine, use of *Aloe vera* and detergent soap, use of green leaves maize soup, and use of scarecrow to scare birds away, use of poisoned bait to catch rodents, uprooting affected plant and burying in soil, use of coriander (*Coriandrum sativum*) seeds, the physical killing of the pests and use of *Aloe vera,* and neem (*Azadirachta indica).*

Table 4: AIK methods used in the management of storage pests in Kauwi and Mutonguni Divisions of Kitui West Sub-county

AIK Method	**Form applied**	**Target pests**	**Target crops**
Use of ash	Ash is mixed with grains and then put in a bag for storage	Grain weevils (Order: Coleoptera), larger grain borers (Coleoptera) Bruchids (Coleoptera)	Maize *(Zea mays)*, millet (*Panicum miliaceum)*, sorghum *(Sorghum bicolor)*, Cowpeas *(Vigna unguiculata)*, beans(*Phaseolus vulgaris)*, pigeon peas*(Cajanus cajan)* green grams (*Vigna radiata)*, Dolichos*(Lablab purpureus)*
Cow *(Bos indicus)* dung	Cow dung is burned until it becomes ash. The ash is mixed with grains and put in sacks for storage	Grain weevils (Coleoptera), larger grain borers (Coleoptera) Bruchids (Coleoptera)	Maize*(Zea mays)*, millet(*Panicum miliaceum)*, sorghum *(Sorghum bicolor)*, Cowpeas *(Vigna unguiculata)*, beans (*Phaseolus vulgaris)*, pigeon peas*(Cajanus cajan)* green grams(*Vigna radiata)*, Dolichos*(Lablab purpureus)*.
Neem *(Azadirachta indica)* leaves	Neem tree leaves are exposed to air and sunlight to dry up. After the leaves are dried up, they are ground to form powder which is mixed with grains and put in sacks for storage	Grain weevils (Coleoptera), larger grain borers (Coleoptera) Bruchids (Coleoptera)	Maize *(Zea mays)*, millet(*Panicum miliaceum)*, sorghum *(Sorghum bicolor)*, Cowpeas*(Vigna unguiculata)*, beans(*Phaseolus vulgaris)*, pigeon peas*(Cajanus cajan)* green grams(*Vigna radiata)*, Dolichos*(Lablab purpureus)*

Leaves of Eucalyptus *(Eucalyptus sp)*	Leaves of eucalyptus are exposed to air and sunlight to dry up. After the leaves are dried up, they are ground to form powder which is mixed with grains and put in sacks for storage	Grain weevils (Coleoptera), larger grain borers (Coleoptera) Bruchids (Coleoptera)	Maize, *(Zea mays)*, millet, (*Panicum miliaceum),* sorghum *(Sorghum bicolor),* Cowpeas*(Vigna unguiculata)*, beans,(*Phaseolus vulgaris)*, pigeon peas*(Cajanus cajan)* green grams(*Vigna radiata)*, Dolichos*(Lablab purpureus)*
Use of hot pepper	Red pepper fruit is exposed to air and sunlight to dry up. After the fruit has dried up, they are ground to form a powder. The pepper powder is then sprinkled on grains and then packed for storage.	Grain weevils (Coleoptera), larger grain borers (Coleoptera) Bruchids (Coleoptera)	Maize, *(Zea mays)*, millet, (*Panicum miliaceum),* sorghum *(Sorghum bicolor),* Cowpeas*(Vigna unguiculata)*, beans,(*Phaseolus vulgaris)*, pigeon peas*(Cajanus cajan)* green grams(*Vigna radiata)*, dolichos*(Lablab purpureus)*
Use of hot pepper and ash	Chilli fruit is exposed to air and sunlight to dry up. After the fruit has dried up, it is ground to form powder then mixed with ash. The mixture is then sprinkled on grains and then packed for storage.	Grain weevils (Coleoptera), larger grain borers (Coleoptera) Bruchids (Coleoptera)	Maize, *(Zea mays)*, millet, (*Panicum miliaceum),* sorghum *(Sorghum bicolor),* Cowpeas*(Vigna unguiculata)*, beans,(*Phaseolus vulgaris)*, pigeon peas*(Cajanus cajan)* green grams(*Vigna radiata)* Dolichos*(Lablab purpureus)*

The use of ash was ranked as the most effective method for controlling storage pests followed by the use of cow dung, pepper, eucalyptus and neem leaves in that order as shown in fig. 3 below.

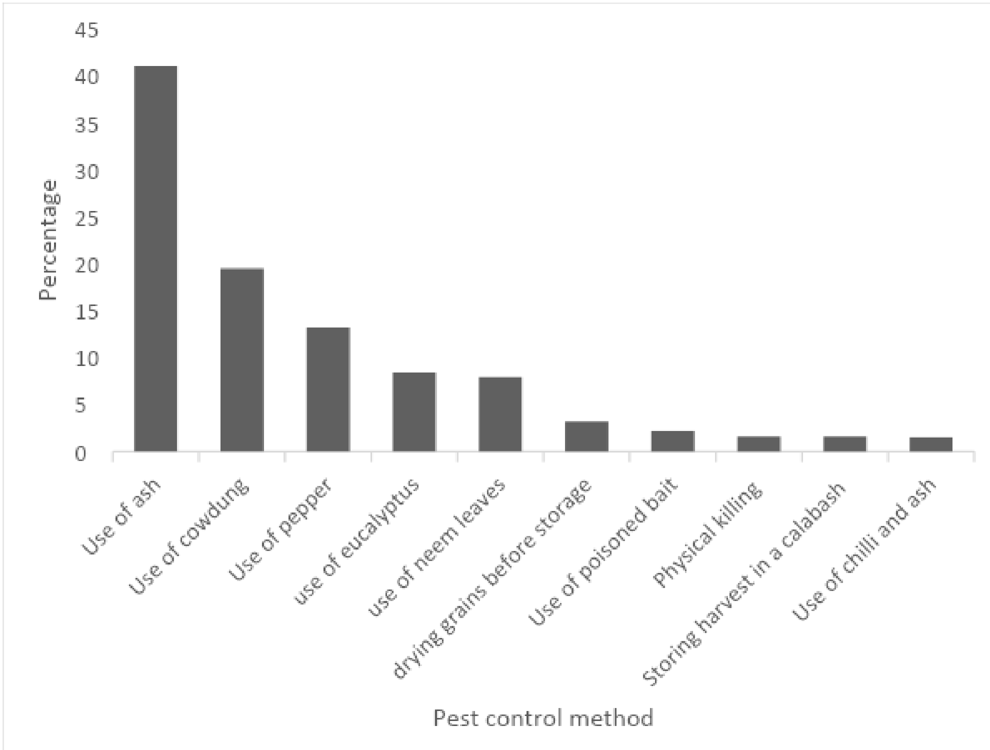

Figure 3: Popularity of different AIK techniques for management of storage pests in Kitui West

4.2 Effect of Age and Education on the Use of AIK

The age and educational levels between the two divisions of Kitui West Sub-county did not show significant variations. Also, the use of AIK between the two divisions did not show significant variations. The mean age of the respondents was 50 years. The majority of respondents (78.1%) covered by the study were above the age of 40 years while the minority (21.9%) were between the age bracket of eighteen years to thirty-nine years. The majority of farmers (46.10%) who were above the age of 50 years utilized AIK in controlling field and storage pests (Table 5). Age was found to be one of the key factors influencing the use of AIK (P-value=0.009). It was established that an increase in age was proportional to the increased use of AIK in pest management. Farmers aged 50 years and above were more experienced in using AIK methods and hence were more confident in applying the AIK practices.

The majority (53.5%) of the respondents who utilized AIK had primary education, followed by those who had no formal education (25.7%). Among the respondents, 14.1% who practised AIK had secondary education while 4.2% had university education. More males (2.5%) had undergone formal education than females with more males having secondary and tertiary education than females. A total 30% of the farmers had no previous training on the application and use of pesticides.

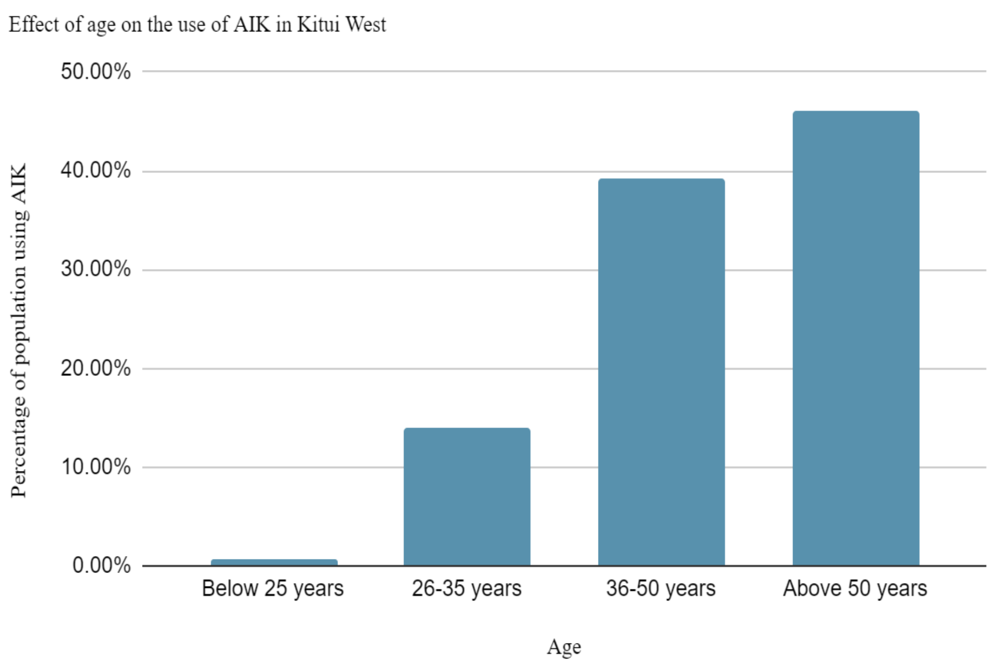

Figure 4: Effect of age on the use of African Indigenous Knowledge in Kitui West Kauwi and Mutonguni divisions

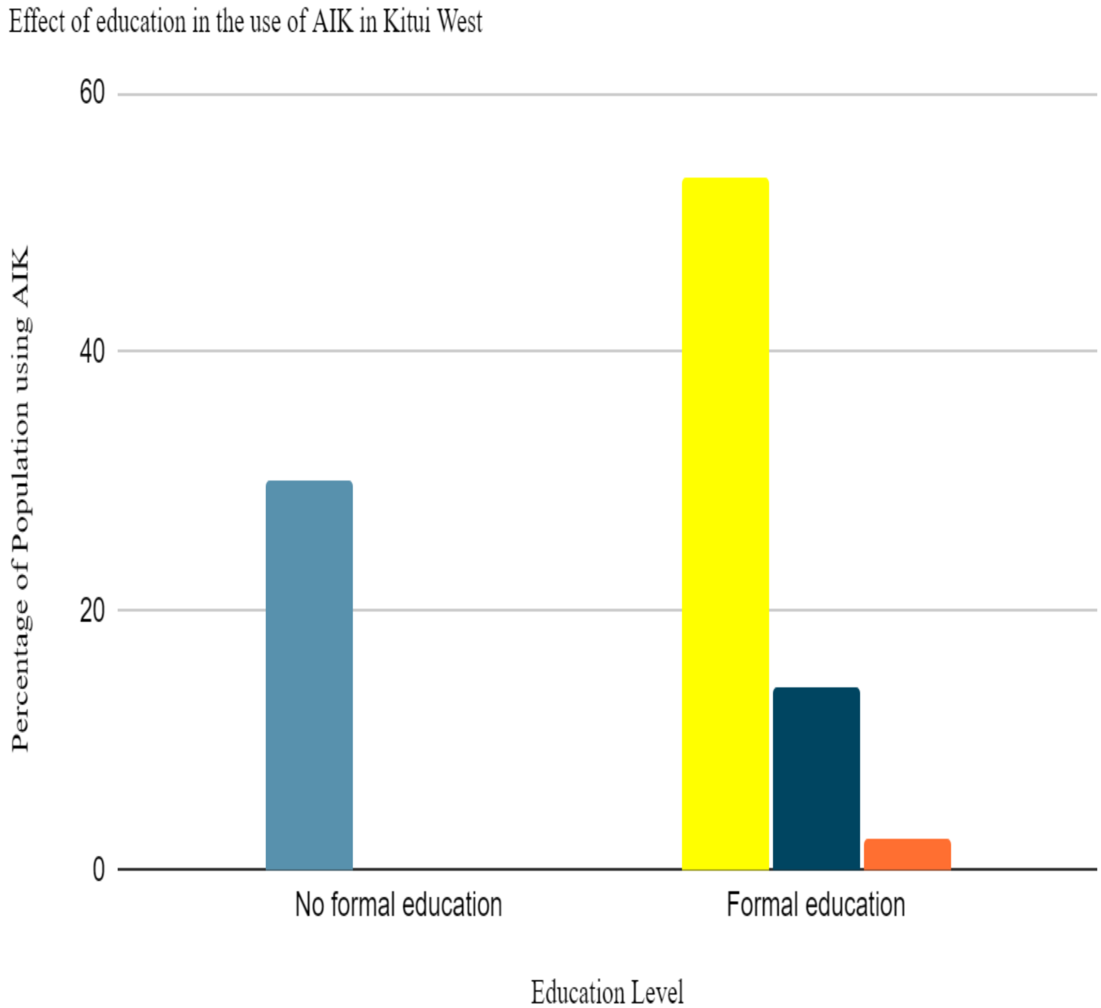

Figure 5: Effect of education on the use of AIK in Kitui West Mutnguni and Kauwi Divisions

Key: Formal education

Primary

Secondary

University

The results indicate that the level of education had an effect on the use of AIK. Compared to those respondents with secondary, primary, and no education at all, the respondents with university degrees least practised AIK with only 2.4% reporting to be practising. AIK was most practised by the majority of respondents with primary education (53.5%) followed by those with no formal education (30%).

4.3 Effectiveness of Wood Ash in Managing of Cowpea Bruchids (*Callosobruchus maculatus*) Under Storage Conditions

Results of the current study indicate that all concentrations of ash used had an effect on infestation rates of bruchids (*Callosobruchus maculatus)*. There was a significant difference in the infestation rate by bruchids under different ash concentrations. The results show that the infestation rate was higher when 5g of ash were used to treat a sample of 100 seeds, and very few when 10g and 15g wood ash were used. Nonetheless, the effect of infestation rate by bruchids between ash treatment of 10g and those of 15g in 100 cowpea grains was not significantly different at 7-days' time intervals. A similar trend was observed at 14-days, 21-days and 28-day time intervals.

Table 5: Effect of different concentrations of ash on infestation rates of Bruchids (*Callosobrochus masculatus)* on cowpea exposed for different lengths of time.

	Mean (±SE) number of infested seeds (n=30)				
Concentration of ash (grams per 100 seeds	After 7 days	After 14 days	After 21 days	After 28 days	*P-value*
0g	5.33±0.308Aa	3.97±0.337Abc	3.53±0.261Abc	4.03±0.36Abc	<0.05
25g	4.03±0.481Ba	2.87±0.302Bac	2.57±0.355Bcd	2.33±0.211Bcd	<0.05
50g	1.00±0.144Ca	1.00±0.136Ca	0.53±0.124Cbc	0.63±0.112Cac	<0.05
75g	1.13±0.150Ca	0.83±0.167Cab	0.57±0.114Cbc	0.33±0.100Cc	<0.05
P-value	<0.001	<0.001	<0.001	<0.001	

Means within a column followed by same upper-case letters are not significantly different and means within a row followed by same lower-case letters are not significantly different (Tukey test, P≤0.05).

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

5.1 Discussion

There is a consensus among scientists and all agriculture stakeholders of the importance of African Indigenous knowledge on pest management and AIK has gained global recognition (Muthee *et al.,* 2019). This is mainly because the chemical approach is causing more harm than good to the consumers and AIK relies solely on natural products and the use of AIK on pest management also plays a role in ensuring the sustainability of the planet. The majority of farmers in Kitui West mentioned insect pests, rodents, and birds as major constraints to their crop farming. These findings are similar to those of farmers of the Lake Victoria basin, Kenya, and Northern Tanzania (Deng *et al*., 2009; Laizer *et al*., 2019). Identified key indigenous pest control practices in Kitui West involve the use of ash, plant extracts, animal excretes, traps, and poisoned baits. Animal excretes are mainly cow urine, and are mixed with cow dung. Theresa and Hunt (2014) observed that damages caused by pests in Nigeria can be prevented through the use of AIK practices which also help in protecting the environment and are cheap in nature. This is corroborated by the current study where most farmers in the Kitui opt for the AIK methods mainly because of the high cost of pesticides, as their economic status would not accommodate such purchases. Results of the current study indicate that the use of ash was the most widely practiced and effective indigenous pest control method. These results corroborate similar findings from Rift Valley Province, Kenya, ash was mainly used to control a variety of pests and diseases in vegetable crops (Kiplang'at and Rotich, 2008). The popularity of ash as a pest control method is probably due to its availability in rural areas that use firewood as the main source of fuel.

According to a study by Kiplang'at and Rotich (2008), tobacco extract was effective in controlling weevils on crops such as maize and beans. This is corroborated by the results of the current study which established that farmers sprayed vegetables with tobacco extract to help in repelling weevils. Tobacco is also environmentally friendly and does not cause any damage to the plant. The current study also established that aphids could be controlled by spraying a mixture of wood ash with soapy water and/or lime. This agrees with observations made by Elwell and Maas (1995), who found that spraying crops with aromatic plants such as lantana and khaki weed emit a strong disturbing smell that is disturbing to the pests, assisting largely in repelling crop pests. These findings concur with those of Dethier *et al.* (1960) that ash and some plant extracts work to control pests mostly by repelling or having toxic compounds that kill pests. This may explain the effectiveness of the use of ash as a pest control measure in the current study.

Abate (2000) observed that pesticide use in sub-Saharan Africa is quite low as compared to Europe or Asia. This is corroborated by the observations that were made through the study; that most farmers in Kitui West Sub County prefer the use of AIK to the use of agrochemicals since the agrochemical's costs are higher compared to AIK, which is readily available according to the Ministry of Agriculture.

In his study, Deng *et al*. (2009) found that more educated African youth often cast aside traditional knowledge and that the mean age of farmers who utilized AIK was 55 years. Laizer *et al*. (2019) found out that the mean age of farmers who utilized indigenous knowledge on pest control in Northern Tanzania was 50 years. African Indigenous Knowledge (AIK) is best accumulated through knowledge of ecological conditions and climatic changes without any contribution of modern technologies, extension services, and modern inputs (Muthee *et al.,* 2019). This may explain why there was no correlation between the formal education of farmers and their indigenous knowledge. These results are also supported by the findings of Kiplang'at and Rotich (2008), who observed that those who possessed good AIK had informal education.

In another study in Ogun state, Nigeria, Abdulsalam-Saghir, and Banmeke (2015) also found out that education level has an inverse negative relationship with AIK. This means that the more educated one is, the poorer they are at AIK. This may be explained by the fact that young farmers have less time to associate with older farmers because of the busy school calendar (Tijani *et al*., 2007; Deng *et al.,* 2009; Abdulsalam-Saghir and Banmeke, 2015), hence have little AIK passed on to them. It could also mean that the more educated the farmers are, the more likely they are to get jobs and therefore are in a better economic position to purchase pesticides.

Stoll (2000) observed that the use of indigenous knowledge for pest control in Africa is an aspect of traditional knowledge and farming. This is in agreement with the results of the current study where traditional knowledge was mainly found within the older generations of farmers, whereas the younger generation was mainly inclined to the use of agrochemicals.

According to Nyamweha *et al.* (2018), the main ingredient that ash contains that makes it suitable for pest control is silica which has insecticidal properties. The major advantages of using ash treatment are: it is non-toxic, widely locally available, environmentally friendly, simple, and low cost to implement (Grzywacz *et al.,* 2013). Results of the current study have also shown that ash was effective in the management of bruchids ***(****Callosobruchus maculatus*) in cowpeas *(Vigna unguiculata)*. Findings of the current study show that the effects of ash in reducing infestation rates of bruchids are observable a week after the application of treatment. These findings agree with studies by Andric *et al.* (2012) and Perisic *et al.* (2018) who underscored the importance of the duration of exposure to ash treatment for controlling bruchids. In their study, Bohinc *et al.* (2018) observed that the effectiveness of wood ash is determined by the length of period the pests are exposed to the treatment. The effectiveness of any pest control method requires knowledge to warrant that materials are applied optimally (Grzywacz *et al.,* 2013). In their studies, Wolfson *et al.* (1991) and Kitch and Sibanda (2001) found that the best control results for cowpea bruchids using ash were observed when fine wood ash was mixed with cowpeas in equal volumes. Similar results were also observed in thr current study.

In addition, Murdock *et al.* (2003) observed that the treatment with ash was more effective when the cowpea ash mixture was covered with a three-centimeter layer of ash. This is supported by the results of the current study, which showed that thicker layers of ash made it difficult for the bruchids to spread within the cowpeas. This may be explained by the fact that the bruchids that are inside the cowpeas grow old without mating and are entombed beneath the ash layer whereas adult bruchids from outside are unable to dig through the thick layer of ash to get to the grain.

5.2 Recommendation and Conclusion

From the current study, it can be concluded that:

1. There exists an abundance of AIK methods in Kauwi, and Mutonguni divisions of Kitui West subcounty, but the dangers of erosion and subsequent loss are real.
2. The age of the farmers plays a major role in the form of pest prevention methods, with the older generation leaning more towards the AIK methods and the younger generation focusing more on the use of agrochemicals.
3. The level of education is a major factor when it comes to pest control as farmers with a higher level of education prefer agro-chemical methods of pest control, while the ones with lower levels of education prefer the AIK practices.
4. Ash is a promising ingredient for the management of storage pests, especially *C. maculatus* in cowpea.

From this study, several recommendations can be made;

1. Deliberate efforts to conserve AIK knowledge are required.

   To combat pests in Kitui West, there is a need to encourage farmers to use AIK methods that have been proven effective and reliable in their areas of operation. More research should be conducted in collaboration with the government and other non-governmental organizations involved in the agricultural sector, as well as taking the lead in funding research of AIK practices, to enable farmers to learn more about effective AIK methods and incorporate them more into farming and pest control. Design extension and documentation programs to target young farmers.

   There are few avenues that are used in the understanding of AIK, especially for young farmers. This is a niche in the agricultural sector that can be filled through demonstration of the use of AIK through social media which is used by the majority of the youths. Creating short videos that educate on AIK in platforms such as TikTok, Facebook and Instagram to target young farmers can help create awareness among the young farmers. Demonstration through adverts on television or paid adverts on the internet can serve as educational materials as well for the youth in creating awareness on AIK.

2. Policymakers should be advised to mainstream AIK practices in conventional pest management practices. Encouraging farmers to delve into AIK will help in conserving soil fertility as well as saving on costs that would have been incurred in purchasing pesticides. The use of AIK will also help reduce the number of diseases related to the use of pesticides.
3. More studies should be incorporated in looking into the possibility of developing IPM of stored products with the use of ashes forming a major component. More AIK practices can be validated and incorporated in the agricultural sector across the country and not only in the Kitui West sub-county to promote indigenous culture and also promote healthier methods of pest control.
4. The public needs to be educated more on the effects of agrochemicals and be encouraged to use more AIK practices through seminars and campaigns which directly engage the farmers and aspiring in order to encourage more farmers to learn agriculture, enhancing their skills and attitudes towards AIK as this may increase sufficiency in food production by the farmers, meaning enough to feed the entire population with minimal to no losses.

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Appendix 1: House Hold Survey Questionnaire

Master of Science in Agriculture Resource management of South Eastern Kenya University

Identification and Documentation of Indigenous Knowledge on Management of Crop pests in Kitui West sub County; A case of Kauwi and Mutonguni Divisions

Target Respondent: Farmers in Kauwi and Mutonguni Divisions of Kitui West Sub-County

To be read to each respondent

This survey seeks to understand the Indigenous Knowledge on Management of Crop pests in Kauwi and Mutonguni Divisions of Kitui West Sub-County. You are free to ask any questions you may have. This questionnaire has been designed to guide our discussion. Once duly completed, the questionnaire will be a confidential property of South Eastern Kenya University (SEKU). No information therein will be revealed to any other party. It is important to note that only part from analysis of all questionnaires will be shared but not the contents of this questionnaire. There will be no right or wrong answers to the questions, but is important to give truthful and honest responses. Your participation is very important. We estimate to take about 30 minutes of your time. Your cooperation is highly appreciated.

Name of the Interviewer;____

Date:____

SECTION A

RESPONDENT'S PERSONAL DETAILS

A1	NAME	
A2	AGE ***1=Below 25, 2=26-35years, 3= 36 to 50years,*** ***4=Above 50 years***	
A3	CONTACT	
A4	GENDER: ***1=Male, 2=Female***	
A5	EDUCATION LEVEL: ***1=No formal Education, 2= Primary, 3= Secondary, 4= University Degree, 5= Postgraduate Degree, 10=Other(Specify)***	
A6	GROUP NAME	
A7	LOCATION: ***1= Mutonguni, 2= Kauwi, 3= Katutu, 4= Kakeani, 5=Kivani, 6=Musengo***	
A8	DIVISION: ***1 = Mutonguni, 2 = Kauwi***	
A9	DATE OF DATA COLLECTION	

SECTION B: FARMING BACKGROUND

B1	Do you own land? ***1 = Yes, 2 = No***				
B2	What is the approximate size of your land? (in acres): ***1=Less than three acres, 2=three to six acres, 3= six to nine acres, 4=More than nine acres***				
B3	Out of the total size of your land, what areas in acres do you to plant crops? ***1=Less than three acres, 2=three to six acres, 3= six to nine acres, 4=More than nine acres***				
B4	What size do you leave fallow i.e. not planted? ***1=Less than three acres, 2=three to six acres, 3= six to nine acres, 4=More than nine acres***				
B5	Do you lease farming land? ***1 = Yes, 2 = No***				
B6	If yes above, what is the size of your currently leased land (in acres)? ***1=Less than three acres, 2=three to six acres, 3= six to nine acres, 4=More than nine acres***				
B7	What are the four main sources of household livelihood/income? Ranked Orders ***1=Livestock, 2=Crops Production, 3=Business, 4=Casual Labour, 5=Formal Employment, 6=Rental Income, 7=Humanitarian Aid, 8=Remittances, 9=Begging, 10=Other(Specify)***	**1st**	**2nd**	**3rd**	**4th**
B8	What crop(s) do you grow in your farm? ***1=Maize, 2=Beans, 3=Cowpeas, 4=Green grams, 5=Sorghum, 6=Bananas, 7=Millet, 8=Dolichos (Mbumbu), 9=Pigeon peas, 10=Others specify***				
B9	What are the four main challenges faced in the production of the above mentioned crops? Ranked Orders ***1=Pests and diseases, 2=Inadequate and unreliable rainfall, 3=Inadequate knowledge and skills, 4= unreliable market, 5=inadequate farm inputs, 6=Inadequate land, 10=Other(Specify)***	**1st**	**2nd**	**3rd**	**4th**

SECTION C: Pests and Control Mechanisms

C1-What pest do you know that affect crops?

C2-Indigenous crop pest control knowledge

Note: Indigenous method is the natural method used traditionally by your community to control pests.

No.	What Indigenous pest control methods do you know?	What pests are/were controlled by this method?	Do you use the method(s) specified or not?	How do you go about using the method you have stated in column 1 in this table? (Please describe as guided below)	From your understanding on the method how do you grade its efficiency in controlling pests?
C2. 1			Used Unused	What crops are/were applied?	***1=Very Poor*** ***2=Poor*** ***3=Moderate*** ***4=Good*** ***5=Excellent***
				How is/was the method applied?	
				At what stage of the crop development is/was the method applied?	
C2. 2			Used Unused	What crops are/were applied?	***1=Very Poor*** ***2=Poor*** ***3=Moderate*** ***4=Good*** ***5=Excellent***
				How is/was the method applied?	
				At what stage of the crop development is/was the method applied?	
C2. 3			Used Unused	What crops are/were applied?	***1=Very Poor*** ***2=Poor*** ***3=Moderate*** ***4=Good*** ***5=Excellent***
				How is/was the method applied?	

				At what stage of the crop development is/was the method applied?	
C2. 4			Used Unused	What crops are/were applied?	***1=Very Poor*** ***2=Poor*** ***3=Moderate*** ***4=Good*** ***5=Excellent***
				How is/was the method applied?	
				At what stage of the crop development is/was the method applied?	
C2. 5			Used Unused	What crops are/were applied?	***1=Very Poor*** ***2=Poor*** ***3=Moderate*** ***4=Good*** ***5=Excellent***
				How is/was the method applied?	
				At what stage of the crop development is/was the method applied?	
C2. 6			Used Unused	What crops are/were applied?	***1=Very Poor*** ***2=Poor*** ***3=Moderate*** ***4=Good*** ***5=Excellent***
				How is/was the method applied?	
				At what stage of the crop development is/was the method applied?	

THANKS FOR YOUR TIME AND PARTICIPATION

Appendix 2: Kitui West District Demographic Data

DIVISION	LOCATION	SUB LOCATION	VILLAGE	HOUSE HOLDS	HH POPULATION
Mutonguni	Musengo	Kakumuti	Makani	88	414
Mutonguni	Musengo	Kakumuti	Syoita	62	291
Mutonguni	Musengo	Kakumuti	Mwikalanthi	57	268
Mutonguni	Musengo	Kakumuti	Kakumuti	85	400
Mutonguni	Musengo	Kakumuti	Mutindi	44	207
Mutonguni	Musengo	Musengo	Masaa	81	381
Mutonguni	Musengo	Musengo	Uvaani	108	508
Mutonguni	Musengo	Musengo	Kangolya	89	418
Mutonguni	Musengo	Musengo	Mathandeni	46	216
Mutonguni	Musengo	Musengo	Mateta	101	475
Mutonguni	Musengo	Musengo	Mutulu	89	418
Mutonguni	Musengo	Musengo	Mavalo	113	531
Mutonguni	Musengo	Musengo	Nzaweni	140	658
Mutonguni	Musengo	Musengo	Kyathani	92	432
Mutonguni	Musengo	Musengo	Ngoneni	95	447
Mutonguni	Musengo	Musengo	Ngaani	94	442
Mutonguni	Musengo	Musengo	Kyambiwa	100	470
Mutonguni	Musengo	Musengo	Kyamai	106	498
Mutonguni	Musengo	Musengo	Mwatate	99	465
Mutonguni	Musengo	Musengo	Kakukuni	87	409
Mutonguni	Musengo	Musengo	Munyuni	97	456
Mutonguni	Musengo	Musengo	Kaumoni	84	395
Mutonguni	Musengo	Musengo	Nguuni	90	423
Mutonguni	Musengo	Musengo	Muthale	118	555
Mutonguni	Musengo	Musengo	Muthamo	96	451
Mutonguni	Musengo	Musengo	Kilindini	96	451
Mutonguni	Musengo	Musengo	Kavweni	85	400
Kauwi	Kivani	Kivani	Kikunguu	43	202
Kauwi	Kivani	Kivani	Kivani	53	249
Kauwi	Kivani	Kivani	Mulakitete	108	508

Kauwi	Kivani	Kivani	Komu	63	296
Kauwi	Kivani	Kivani	Muthi	50	235
Kauwi	Kivani	Kivani	Kavoo	61	287
Kauwi	Kivani	Kangungi	Matinga	84	395
Kauwi	Kivani	Kangungi	Kaanzooni	66	310
Kauwi	Kivani	Kangungi	Kasue	87	409
Kauwi	Kivani	Kangungi	Kasolelo	61	287
Kauwi	Kivani	Kangungi	Muthula	57	268
Kauwi	Kivani	Kangungi	Kangungi	79	371
Mutonguni	Mutonguni	Kaimu	Katoteni	81	381
Mutonguni	Mutonguni	Kaimu	Kiamani	75	353
Mutonguni	Mutonguni	Kaimu	Kathambangi	76	357
Mutonguni	Mutonguni	Kaimu	Kitumbi	78	367
Mutonguni	Mutonguni	Kaimu	Masia	97	456
Mutonguni	Mutonguni	Kaimu	Ngomangoni	77	362
Mutonguni	Mutonguni	Kaimu	Kavonge	115	541
Mutonguni	Mutonguni	Kaimu	Kangenge	143	672
Mutonguni	Mutonguni	Kaimu	Mwangya	98	461
Mutonguni	Mutonguni	Kaimu	Ngunyanoni	61	287
Mutonguni	Mutonguni	Kaimu	Tulia	100	470
Mutonguni	Mutonguni	Kaimu	Ngongu	56	263
Mutonguni	Mutonguni	Kaimu	Kamunyu	78	367
Mutonguni	Mutonguni	Kaimu	Nzinia	98	461
Mutonguni	Mutonguni	Kaimu	Malondo	79	371
Mutonguni	Mutonguni	Kaimu	Kyamutimba	123	578
Mutonguni	Mutonguni	Kaimu	Mulinduko	91	428
Mutonguni	Mutonguni	Kaimu	Kitulu	50	235
Mutonguni	Mutonguni	Kaimu	Mbuini	106	498
Mutonguni	Mutonguni	Kaimu	Mbukoni	105	494
Mutonguni	Mutonguni	Mithini	Ndatani	47	221
Mutonguni	Mutonguni	Mithini	Kololo	42	197
Mutonguni	Mutonguni	Mithini	Ithunzuuni	48	226
Mutonguni	Mutonguni	Mithini	Kyangulu	70	329

Mutonguni	Mutonguni	Mithini	Mithini	163	766
Mutonguni	Mutonguni	Mithini	Ngengi	64	301
Mutonguni	Mutonguni	Mithini	Muthale	64	301
Mutonguni	Mutonguni	Mithini	Ngavuni	57	268
Mutonguni	Mutonguni	Mithini	Kyambolo	468	2200
Mutonguni	Mutonguni	Mithini	Yenyaa	64	301
Mutonguni	Mutonguni	Mithini	Kiatine	68	320
Mutonguni	Mutonguni	Mithini	Iiani	48	226
Mutonguni	Mutonguni	Mithini	Kyathumbi	67	315
Mutonguni	Mutonguni	Mithini	Miterembu	55	259
Mutonguni	Mutonguni	Mithini	Kathiiya	49	230
Mutonguni	Mutonguni	Mithini	Kitamwiki	49	230
Mutonguni	Mutonguni	Mithini	Maeini	68	320
Mutonguni	Mutonguni	Mithini	Utoo	66	310
Kauwi	Kauwi	Kauwi	Kasue B	33	155
Kauwi	Kauwi	Kauwi	Kasue A	38	179
Kauwi	Kauwi	Kauwi	NgungaSyanthe	86	404
Kauwi	Kauwi	Kauwi	Kaeveti	42	197
Kauwi	Kauwi	Kauwi	Nzemeli	71	334
Kauwi	Kauwi	Kauwi	Kyondoni	80	376
Kauwi	Kauwi	Kauwi	Kitulu	78	367
Kauwi	Kauwi	Kauwi	Kaluni	53	249
Kauwi	Kauwi	Kauwi	Kaumoni	33	155
Kauwi	Kauwi	Kauwi	Kiluiya	52	244
Kauwi	Kauwi	Kauwi	Makalini B	20	94
Kauwi	Kauwi	Kauwi	Wangoli	50	235
Kauwi	Kauwi	Kauwi	Makalini A	22	103
Kauwi	Kauwi	Kauwi	Ithekethe	35	165
Kauwi	Kauwi	Kauwi	Kamukuyuni	47	221
Kauwi	Kauwi	Kauwi	Kauwi	50	235
Kauwi	Kauwi	Kauwi	Mathayoni	53	249
Kauwi	Kauwi	Kauwi	Kitteti	52	244
Kauwi	Kauwi	Kauwi	Kwanyingi	31	146

Kauwi	Kauwi	Kauwi	Kitote B	39	183
Kauwi	Kauwi	Kauwi	Kitote A	57	268
Kauwi	Kauwi	Kauwi	Kabati town A	78	367
Kauwi	Kauwi	Kauwi	Kabati town B	80	376
Kauwi	Kauwi	Kauwi	Kabati town C	105	494
Kauwi	Kauwi	Kauwi	Kabati town D	65	306
Kauwi	Kauwi	Kauwi	Kabati town E	87	409
Kauwi	Kauwi	Kauwi	Kabati town F	17	80
Kauwi	Kauwi	Kauwi	Kabati town G	53	249
Kauwi	Kauwi	Kauwi	Kabati town H	36	169
Kauwi	Kauwi	Kauwi	Kabati town I	54	254
Kauwi	Kauwi	Kiseveni	Mututa	21	99
Kauwi	Kauwi	Kiseveni	Kalinditi	26	122
Kauwi	Kauwi	Kiseveni	Mathunzini	30	141
Kauwi	Kauwi	Kiseveni	Syongula	37	174
Kauwi	Kauwi	Kiseveni	Kwangunzu	25	118
Kauwi	Kauwi	Kiseveni	Ithuka	19	89
Kauwi	Kauwi	Kiseveni	Mutini	51	240
Kauwi	Kauwi	Kiseveni	Iiani	15	71
Kauwi	Kauwi	Kiseveni	Kwakyondo	27	127
Kauwi	Kauwi	Kiseveni	Mutomo/kaliani	40	188
Kauwi	Kauwi	Kiseveni	Kathangathini	24	113
Kauwi	Kauwi	Kiseveni	Kiseveni	26	122
Kauwi	Kauwi	Kiseveni	Mwongoni	18	85
Kauwi	Kauwi	Kiseveni	Kiukuni B	21	99
Kauwi	Kauwi	Katheka	Kwandoi	36	169
Kauwi	Kauwi	Katheka	Munyiki	42	197
Kauwi	Kauwi	Katheka	Mangelu	45	212
Kauwi	Kauwi	Katheka	Kathekani	35	165
Kauwi	Kauwi	Katheka	Ndolo	70	329
Kauwi	Kauwi	Katheka	Kaumbulu	35	165
Kauwi	Kauwi	Katheka	Kathiani	26	122
Kauwi	Kauwi	Katheka	Kwanguu	33	155

Kauwi	Kauwi	Katheka	Makutano	43	202
Kauwi	Kauwi	Katheka	Kwanthia	24	113
Kauwi	Kauwi	Katheka	Makongo	26	122
Mutonguni	Kakeani	Kakeani	Mangelu	66	310
Mutonguni	Kakeani	Kakeani	Ukuni	113	531
Mutonguni	Kakeani	Kakeani	Kivanga	74	348
Mutonguni	Kakeani	Kakeani	Kakeani	133	625
Mutonguni	Kakeani	Kakeani	Kitundumo	88	414
Mutonguni	Kakeani	Kakeani	Nginyai	100	470
Mutonguni	Kakeani	Kakeani	Misyini	81	381
Mutonguni	Kakeani	Kakeani	Kyuthini	146	686
Mutonguni	Kakeani	Kakeani	Sokoni	69	324
Mutonguni	Kakeani	Kakeani	Iiani	69	324
Mutonguni	Kakeani	Kakeani	Muambani	79	371
Mutonguni	Kakeani	Kangii	Kivulu	124	583
Mutonguni	Kakeani	Kangii	Kutha proper	95	447
Mutonguni	Kakeani	Kangii	Kuthanzau	58	273
Mutonguni	Kakeani	Kangii	Kakuswi	101	475
Mutonguni	Kakeani	Kangii	Kangii	66	310
Mutonguni	Kakeani	Kangii	Ndovoini	79	371
Mutonguni	Kakeani	Kangii	Kalndangongo	76	357
Mutonguni	Kakeani	Kangii	Nyuani	95	447
Kauwi	KATUTU	Nzalae	Nzalae	24	113
Kauwi	KATUTU	Nzalae	Emivia	30	141
Kauwi	KATUTU	Nzalae	Muthunguthe	25	118
Kauwi	KATUTU	Nzalae	Kakuyuni	40	188
Kauwi	KATUTU	Nzalae	Katumbini	25	118
Kauwi	KATUTU	Nzalae	Kyeni	28	132
Kauwi	KATUTU	Nzalae	Muthungue	31	146
Kauwi	KATUTU	Nzalae	Kaluini	29	136
Kauwi	KATUTU	Nzalae	Malimbani	31	146
Kauwi	KATUTU	Nzalae	Kalimani	27	127
Kauwi	KATUTU	Nzalae	Kataa	21	99

Kauwi	KATUTU	Nzalae	Ngoano	26	122
Kauwi	KATUTU	Nzalae	Kithayoni	25	118
Kauwi	KATUTU	Nzalae	Kiunduani	23	108
Kauwi	KATUTU	Nzalae	Yatua	26	122
Kauwi	KATUTU	Kasakini	Mwandingu	50	235
Kauwi	KATUTU	Kasakini	Ngelu	48	226
Kauwi	KATUTU	Kasakini	Iyani	69	324
Kauwi	KATUTU	Kasakini	Iviani	28	132
Kauwi	KATUTU	Kasakini	Kwaluma	39	183
Kauwi	KATUTU	Kasakini	Kiatinenei	29	136
Kauwi	KATUTU	Kasakini	Kavenguria	29	136
Kauwi	KATUTU	Kasakini	Kasakini	33	155
Kauwi	KATUTU	Kasakini	Kaliku	36	169
Kauwi	KATUTU	Kasakini	Kathiani	36	169
Kauwi	KATUTU	Kasakini	Kikunguu	32	150
Kauwi	KATUTU	Kasakini	Kitulani	47	221
Kauwi	KATUTU	Kasakini	Mikuyuni	35	165
Kauwi	KATUTU	Kyenge	Ngunguuni	39	183
Kauwi	KATUTU	Kyenge	Maiyani	31	146
Kauwi	KATUTU	Kyenge	Kyenge B	27	127
Kauwi	KATUTU	Kyenge	Kyenge A	30	141
Kauwi	KATUTU	Kyenge	Kyoani	30	141
Kauwi	KATUTU	Kyenge	Mikuyuni	28	132
Kauwi	KATUTU	Kyenge	Ngekekani A	30	141
Kauwi	KATUTU	Kyenge	Mbingoni	35	165
Kauwi	KATUTU	Kyenge	Ngekekani B	28	132
Kauwi	KATUTU	Katutu	Mathunyani B	38	179
Kauwi	KATUTU	Katutu	Mathunyani A	28	132
Kauwi	KATUTU	Katutu	Katutu market	80	376
Kauwi	KATUTU	Katutu	Katutu	74	348
Kauwi	KATUTU	Katutu	Iiani	76	357
Kauwi	KATUTU	Katutu	Muaani	34	160
Kauwi	KATUTU	Katutu	Katulye A	37	174

Kauwi	KATUTU	Katutu	Katulye B	38	179
Kauwi	KATUTU	Kisayani	Mukuyuni	17	80
Kauwi	KATUTU	Kisayani	Maukuni	33	155
Kauwi	KATUTU	Kisayani	Kithumulani	28	132
Kauwi	KATUTU	Kisayani	Kathiani	23	108
Kauwi	KATUTU	Kisayani	Miwongoni	21	99
Kauwi	KATUTU	Kisayani	Kilile	25	118
Kauwi	KATUTU	Kisayani	Kwakasine	21	99
Kauwi	KATUTU	Kisayani	Kisayani	25	118
Kauwi	KATUTU	Kisayani	Kithalani	28	132
Kauwi	Mutanda	Mutanda	Muthi/kimelwa B	61	287
Kauwi	Mutanda	Mutanda	Komu	84	395
Kauwi	Mutanda	Mutanda	Mangunguntthe	61	287
Kauwi	Mutanda	Mutanda	Ungungua	38	179
Kauwi	Mutanda	Mutanda	Makongo	41	193
Kauwi	Mutanda	Mutanda	Mutanda	60	282
Kauwi	Mutanda	Mutanda	Kimelwa	51	240
Kauwi	Mutanda	Sangala	Kikumini	40	188
Kauwi	Mutanda	Sangala	Kwakyondo	43	202
Kauwi	Mutanda	Sangala	Kathiani	49	230
Kauwi	Mutanda	Sangala	Sangala	54	254
Kauwi	Mutanda	Sangala	Mangelu-Kwasimba	47	221