FACULTY OF SCIENCE AND EDUCATION

DEPARTMENT OF BIOLOGY

Comparison of the Effectiveness of Botanical Extracts of *Allium Species* with Synthetic Chemical Pesticides against Aphids on Kale (Brassica Oleracea)

BY

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(SCE)

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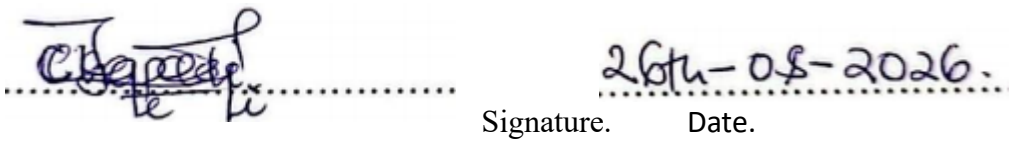
Abstract

The increasing demand for sustainable vegetable production has created a need for effective botanical alternatives to synthetic pesticides under open-field conditions. This study evaluated the comparative effects of garlic (*Allium sativum*) and onion (*Allium cepa*) botanical extracts and a synthetic pesticide, Dudu Acelamectin, on the growth of kale (*Brassica oleracea* var. *acephala*). A controlled field experiment comprising five treatments was conducted: garlic and onion extracts combined (Tr1), garlic extract alone (Tr2), onion extract alone (Tr3), Dudu Acelamectin (Tr4), and an untreated control (Tr5). Kale growth was monitored for six weeks, with plant height used as a key growth indicator. Data were analyzed using two-way analysis of variance (ANOVA) to determine differences among treatments. The results indicated that the combined garlic and onion extracts produced superior kale growth compared with garlic alone, onion alone, Dudu Acelamectin, and the untreated control. The two-way ANOVA further indicated a statistically significant effect of treatment on kale plant height. The findings suggest that combining garlic and onion extracts may provide an effective botanical option for supporting kale growth under natural field conditions while potentially reducing reliance on synthetic pesticides. The observed effectiveness may be associated with the bioactive compounds present in the plant extracts, which can contribute to pest management and sustainable crop production. The study recommends the use of combined garlic and onion botanical extracts as a promising alternative to synthetic pesticides in open-field kale production. Further research should evaluate their effectiveness when combined with other botanicals, such as red pepper, for broader pest management.

Keywords**:** botanical extracts, garlic, onion, kale, Dudu Acelamectin, plant growth, sustainable agriculture

Declaration

I, Bulukwa Chapeli (Reg. No: BU/UP/2023/1626), certify that this dissertation titled *"Comparison of the Effectiveness of Botanical Extracts of Allium Species with Synthetic Chemical Pesticides against Aphids on Kale (Brassica Oleracea)*" is my novel work and has never been submitted to any other higher learning institution for any award. Where other sources were used, they were appropriately acknowledged.

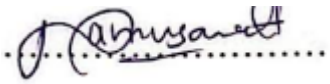
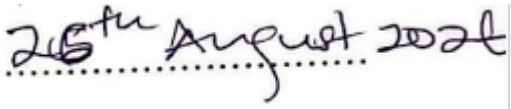


Signature. Date.

BULUKWA CHAPELI.

Approval

I certify that this research dissertation titled **"***Comparison of the Effectiveness of Botanical Extracts of Allium Species with Synthetic Chemical Pesticides against Aphids on Kale (Brassica Oleracea)***"** is submitted with my approval as the university supervisor.

Signature.  Date. 

MS NAMUSANA HELLEN

Dedication

I dedicate this research dissertation to my beloved brother, Nandaba Ronald, and sister, Nekimite Irene, for their unwavering support throughout my academic journey. Your contribution has been invaluable materially, through your generous assistance in meeting my school dues and other educational needs; spiritually, through your prayers and encouragement; and academically, through your insightful guidance, counsel, and constant motivation.

Indeed, your love, kindness, commitment, and selfless support have played a significant role in shaping me into the person and responsible citizen I am today. Your sacrifices have nurtured my academic growth and strengthened my determination to pursue excellence despite the challenges along the way. I will forever remain deeply grateful and indebted to you for believing in me, standing by me, and investing in my future. May your kindness and generosity be rewarded abundantly.

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Table of Contents

Abstract i

Declaration ii

Approval iii

Dedication iv

Acknowledgement v

LIST OF FIGURES ix

LIST OF TABLES x

CHAPTER ONE 1

1.0 INTRODUCTION 1

1.1 Background. 1

1.2 Problem statement 2

1.41 General objective 2

1.42 Specific objectives 3

1.5 Research questions 3

1.51 Research hypotheses 3

1.3 Justification of study 4

1.6 Significance of study 4

1.7 Scope of study 5

2.0 Introduction 6

2.2 Kale production and constraints 7

2.3 Significance of Sukuma wiki. 7

2.31 Climatic conditions for kale 8

2.4 Characteristics of kale. 8

2.5 Environmental conditions for Sukuma wiki. 8

2.6 Aphid description. 9

2.61 Life cycle of aphids. 9

2.62 Holocyclic lifecycle. 9

2.63 Anholocyclic life cycle. 9
2.64 Aphid eggs. 10
2.65 The nymph. 10
2.66 Adult. 10
2.7 Methods of controlling aphids on Sukuma wiki (kale). 11
2.71 Physical removal; 11
2.72 Insecticidal soaps. 11
2.73 Chemical control. 11
2.74 Biological control method. 12
2.75 Cultural control. 12
2.76 Botanically derived treatments. 12
2.9 Preparation of extracts. 13
2.92 Extracts derived from garlic. 14
2.93 Comparison between synthetic and botanical pesticide. 15
3.0 CHAPTER THREE; METHODS AND MATERIALS. 16
3.1 Study site. 16
3.2 Land and nursery bed preparation. 16
3.21 Experimental Design and Linear Model. 17
3.22 Preparation of Plant Extracts. 18
3.23 Preparation of onion and garlic extracts 18
3.3 Data collection 19
3.4 Data analysis. 19
3.5 Sources of Sukuma wiki seeds. 19
3.51: Farm activities (Crop Maintenance) 20
3.6 Application of treatment. 23
3.61 Sampling procedures 23
3.7 Data collection methods and instruments used. 23
3.71 Data collection. 23
3.74 Number of leaves. 24

3.75 Leaf length. 24
3.76 Leaf width. 24
3.77 Leaf area. 24
3.8 Limitation of study. 24
4.0 CHAPTER FOUR: RESULTS. 25
4.1 Data analysis. 29
5.0 CHAPTER FIVE 34
5.1 DISCUSSION. 34
5.2 Conclusion. 35
6.0 REFERENCES. 36

LIST OF FIGURES

Figure 1: Showing preparation of land for planting 17
Figure 2: Showing field layout for research 20
Figure 3: Showing weeding of kale 21
Figure 4: showing planted kale 22
Figure 5: Showing kale on nursery bed. 22
Figure 6: Graph showing change in kale height in 3 weeks 26
Figure 7: A graph showing average increase in number of leaves 27
Figure 8: A graph showing the change in plant width. 29

LIST OF TABLES

Table 1: showing abbreviations and what they stand for 17
Table 2: Showing the mean average plant height of the plant. 25
Table 3: Showing the average number of leaves 26
Table 4: Showing the average leaf width in centimeters. 28
Table 5: Showing Tests of Between-Subjects Effects 30
Table 6: Showing Tests of Between-Subjects Effects 30
Table 7: Showing Tests of Between-Subjects Effects 31
Table 8: Showing Tests of Between-Subjects Effects 32

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background.

Kale (*Brassica oleracea* var. *acephala*), a member of the Brassicaceae family, is one of the most widely cultivated vegetables globally, valued for its adaptability to diverse climatic conditions and its rich nutritional profile (Fayaz, 2023; Harte et al., 2024). Originating from the Mediterranean, Western Europe, and Central Asia, kale is now grown extensively across continents, with significant production in Brazil, Africa, and East African nations such as Kenya, Tanzania, and Uganda (Abate, 2025; Ortega-Hernández et al., 2021; Peters et al., 2019). Its high content of essential minerals (potassium, calcium, magnesium), vitamins (A, C, K), and low caloric value renders it a vital dietary component and a source of income for both small-scale and large-scale farmers (Munthali & Tshegofatso, 2014; Pathirana et al., 2017; Wekha et al., 2023). The increasing urban demand for kale has intensified production efforts, often necessitating pest control measures to maximize yield.

Despite its hardiness, kale production is severely constrained by phytophagous insect pests, with the kale aphid (*Brevicoryne brassicae*) among the most destructive (Khan et al., 2020). These aphids infest the undersides of leaves, feeding on phloem sap, which results in leaf curling, yellowing, stunted growth, and deformation, leading to substantial yield losses and reduced market quality (Baidoo & Mochiah, 2016; Rani et al., 2020). Furthermore, their excretion of honeydew promotes sooty mold growth, diminishing photosynthetic efficiency, and they act as vectors for plant viruses (Khuhro et al., 2022; Singh & Sharma, 2021). Economic losses from aphid infestations can exceed 60%, driven by the insect's attraction to kale's volatile compounds (Bakri & Douglas, 2005; Dube et al., 1998).

To mitigate these losses, synthetic chemical insecticides have been the primary control method due to their rapid efficacy and ease of application, contributing to increased food production (Baidoo & Mochiah, 2016). However, the over-reliance on broad-spectrum pesticides has precipitated significant challenges, including the development of aphid resistance, environmental contamination, and adverse effects on non-target organisms, such as pollinators and natural enemies, as well as human health risks due to toxic residues and inadequate protective equipment among smallholder farmers (Bass et al., 2019; Desneux et al., 2022; Tadesse et al., 2022). These issues underscore the urgent need for sustainable pest management alternatives that align with the United Nations Sustainable Development Goals (UNSDG), particularly Goal 2 (Zero Hunger) and Goal 15 (Life on Land), which advocate for sustainable agriculture and the protection of terrestrial ecosystems.

Consequently, interest in botanical insecticides, which are biodegradable and environmentally benign, has grown. Plants like garlic (*Allium sativum*) and onion (*Allium cepa*) contain bioactive compounds, such as sulphur volatiles from allicin, that exhibit insecticidal and repellent properties (Isman, 2020; Koch & Lawson, 1996). Given the documented challenges of synthetic pesticides and the potential of botanicals, this study aims to comparatively assess the effectiveness of garlic and onion extracts against synthetic chemical pesticides in managing aphid populations on kale, thereby contributing to the development of safer, integrated pest management strategies.

1.2 Problem statement

Kale (*Brassica oleracea*) is a nutritionally vital vegetable that enhances food security, human health, and rural livelihoods through its rich vitamin and mineral content, while also contributing to soil fertility and employment (Loxdale et al., 2020; Yang et al., 2023). Protecting kale from aphid infestations is therefore essential. Despite existing control measures, including synthetic insecticides and biological agents, aphids (*Brevicoryne brassicae*) continue to cause substantial crop losses (Nyamweha et al., 2020). The introduction of fast-maturing, high-yielding kale varieties has not alleviated this problem. Furthermore, repeated synthetic pesticide applications have resulted in pest resistance, environmental degradation, and health hazards (Berge et al., 2019), underscoring the need for safer alternatives.

Previous studies have demonstrated the efficacy of botanical extracts, including garlic and onion, against aphids (Kembabazi, 2021). However, limited empirical evidence exists comparing the effectiveness of these Allium species applied singly or in combination against synthetic pesticides specifically on kale. This study therefore evaluates and compares the effectiveness of *Allium cepa* and *Allium sativum* extracts against synthetic chemical pesticides for managing aphids on kale, contributing sustainable pest management solutions for smallholder farmers.

1.41 General objective

The purpose of this study was to compare the effectiveness of botanical extracts from *Allium cepa* (onion) and *Allium sativum* (garlic), applied singly and in combination, against a synthetic chemical pesticide (Dudu Acelamectin) in managing aphid (*Brevicoryne brassicae*) populations and promoting growth of kale (*Brassica oleracea* var. *acephala*) under open-field conditions.

1.42 Specific objectives.

i. To evaluate the efficacy of garlic (*Allium sativum*) extract, onion (*Allium cepa*) extract, and their combination on aphid (*Brevicoryne brassicae*) mortality on kale (*Brassica oleracea* var. *acephala*).

ii. To assess the comparative effectiveness of garlic and onion botanical extracts against a synthetic chemical pesticide (Dudu Acelamectin) in controlling aphid populations on kale.

iii. To determine the synergistic effects of combining garlic and onion extracts on kale growth parameters, specifically plant height.

iv. To establish the most effective treatment among garlic extract alone, onion extract alone, combined extracts, and synthetic pesticide for sustainable aphid management in open-field kale production.

1.5 Research questions

i. What is the efficacy of garlic (*Allium sativum*) extract, onion (*Allium cepa*) extract, and their combination on aphid (*Brevicoryne brassicae*) mortality on kale (*Brassica oleracea* var. *acephala*)?

ii. How does the effectiveness of garlic and onion botanical extracts compare with a synthetic chemical pesticide (Dudu Acelamectin) in controlling aphid populations on kale?

iii. What synergistic effects do combined garlic and onion extracts have on kale growth parameters, specifically plant height?

iv. Which treatment garlic extract alone, onion extract alone, combined extracts, or synthetic pesticide is most effective for sustainable aphid management in open-field kale production?

1.51 Research hypotheses

H_{01}: Garlic (*Allium sativum*) extract, onion (*Allium cepa*) extract, and their combination have no significant effect on aphid (*Brevicoryne brassicae*) mortality on kale (*Brassica oleracea* var. *acephala*).

H_{02}: There is no significant difference in effectiveness between garlic and onion botanical extracts and a synthetic chemical pesticide (Dudu Acelamectin) in controlling aphid populations on kale.

H_{03}: Combined garlic and onion extracts have no significant synergistic effect on kale growth parameters, specifically plant height.

H_{04}: There is no significant difference in effectiveness among garlic extract alone, onion extract alone, combined extracts, and synthetic pesticide for sustainable aphid management in open-field kale production.

1.3 Justification of study

The overreliance on synthetic chemical pesticides for pest management in vegetable production has raised significant environmental and public health concerns, necessitating the exploration of safer alternatives. Pesticide residues accumulating on fresh produce pose serious risks to consumer health, particularly in export markets such as the European Union and United Kingdom, where strict maximum residue limits (MRLs) are enforced (Fulano et al., 2021). These regulatory pressures, combined with growing consumer awareness, have accelerated the search for sustainable pest control strategies. Botanical pesticides, derived from plant sources, offer an environmentally benign alternative due to their biodegradability, low mammalian toxicity, and reduced persistence in ecosystems (Isman, 2020).

However, despite their potential, botanical extracts face limitations related to variable efficacy, inconsistent preparation methods, and fluctuations in bioactive compound concentrations depending on plant variety, growing conditions, and extraction techniques (Pavela & Benelli, 2016). These inconsistencies hinder their widespread adoption and commercial viability. Consequently, there is an urgent need to systematically evaluate and compare botanical extracts under standardized conditions to establish their reliability and effectiveness relative to synthetic pesticides. This study addresses this gap by investigating the efficacy of garlic and onion extracts against aphids on kale, thereby contributing empirical evidence to support the development of standardized, effective, and sustainable botanical pest management solutions for smallholder farmers and commercial producers alike.

1.6 Significance of study

This study provides practical and scientific contributions to sustainable pest management in kale production. To Farmers: The study offers affordable, locally available botanical alternatives to expensive synthetic pesticides, reducing production costs and health risks while enhancing crop productivity and income. To Consumers: It promotes food safety by minimizing pesticide residues on kale, a widely consumed vegetable, thereby reducing health risks associated with chemical ingestion. To Policymakers: The empirical evidence generated will inform policy formulation on integrated pest management and support the registration and commercialization of botanical pesticides for sustainable agriculture. To Researchers: The study contributes to the body of knowledge on Allium species efficacy against aphids, providing a foundation for further research on formulation optimization and synergistic combinations with other botanicals. To the Environment**:** By promoting botanical alternatives, the study supports biodiversity conservation,

protects beneficial organisms, and reduces environmental contamination from synthetic pesticide runoff.

1.7 Scope of study

This study focused on comparing the effectiveness of botanical extracts from garlic (*Allium sativum*) and onion (*Allium cepa*), applied singly and in combination, against a synthetic chemical pesticide (Dudu Acelamectin) for managing aphid (*Brevicoryne brassicae*) populations and promoting growth of kale (*Brassica oleracea* var. *acephala*).

Geographical scope

The field experiment was conducted at Nagongera Faculty of Science and Education, Tororo District, Uganda, located at approximately 00°46′12″N, 34°01′34″E (elevation ~1,136 m above sea level). Laboratory analyses, including extract preparation and aphid counting, were carried out at the Biology Laboratory of the same faculty. The site was selected for its representative agro-ecological conditions suitable for kale production, accessibility, and availability of research facilities.

Content scope

The study exclusively evaluated five treatments: garlic extract alone, onion extract alone, combined garlic and onion extracts, Dudu Acelamectin, and an untreated control. Key variables assessed included aphid mortality, population reduction, and kale plant height as a growth indicator. The study did not evaluate other botanical extracts, pest species, or kale varieties beyond those specified.

Time scope

The research was conducted from proposal development (September 2025) through field experiments, laboratory analyses, and report writing to completion in August 2026, covering 12 months.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Kale is one of the most highly consumed vegetables in Kenya. They have high nutritional value and are well adapted to most climatic conditions. They are a source of income to both small- and large-scale growers. Despite their adaptability to a wide range of climatic conditions, kale production is affected by poor seed quality, pests and diseases, drought, poor market channels, poor transport to markets, and lack of agronomic and utilization packages **[1].**

Major insect pests attacking kales include cutworms, diamondback moth, white grubs, bugs, and aphids**.** The kale aphids **(Brevicoryne brassicae Linnaeus)** are the most notorious pests of kales due to their ability to cause substantial plant and economic losses, and to develop resistance to a wide range of insecticides. Their feeding causes wilting, yellowing, and stunted plant growth. They are also known to transmit viral diseases and secrete honeydew, which attracts sooty mold and a number of insects **[2].** Most farmers have continually used different types of synthetic pesticides that are systemic and broad-spectrum to manage aphids, including methomyl, emamectine benzoate, pyrethroids, and neonicotinoids **[3**]. However, these insecticides have resulted in the development of pest resistance and in negative side effects on humans and the environment including beneficial insects [4]. Furthermore, they are of high costs which make them unaffordable to many farmers and thus farmers have resorted to using botanical plant extracts.

Botanical plants are readily accessible to small scale farmers and they have been found to be environmentally safe having low toxicity to mammals, fish and pollinators [5]. For these reasons, this study aims at evaluating botanical plant extracts in control of kale aphids and this would help to minimize the negative effects of synthetic pesticides.

2.2 Kale production and constraints

Kale production in east African countries serves as a significant means of income generation and employment opportunities, as it is the most cultivated vegetable(Mwangi et al., 2021). It is mostly produced in the central, western, and eastern regions of Kenya. Excess nitrogen 6 will result in tissues that are weak and sensitive to cold. Provided there is sufficient water from irrigation and rain, along with organic and chemical fertilizers, the crop can thrive in nearly any location. It thrives in well-drained soil with adequate organic matter content, with a pH range of 5.5 to 7.0 (JICA). The demand for kale in Kenya is substantial, necessitating a continuous supply. When properly nourished, kale produces large quantities of leaves that are harvestable multiple times per week(Wekha et al., 2023). According to research conducted in Kiambu, it was found that kale had the greatest impact on household income compared to other crops. Additionally, kale demonstrated the highest returns on variable inputs when compared to the other crops (Salasya & Burger, 2010). According to Maina and Mwangi (2008), reduced production costs result in decreased selling prices in the market, thereby increasing affordability for households with lower incomes. Despite being the most widely consumed leafy vegetable in Kenya, the economic production of kale is hindered by various factors, such as inadequate soil fertility and interference from weeds and pests

In general, increasing the production of kale can shift African economies and make a significant contribution towards poverty reduction.

2.3 Significance of Sukuma wiki.

Sukuma wiki (kale) is said to have a high nutritive value. Kale can be consumed as a raw vegetable, but most the times is first cooked. On Guam, kale has become a popular vegetable for salads and fresh blended shakes. It is rich in beta carotene, Vitamin A, Vitamin C, Vitamin K, Folic Acid, Calcium, zeaxanthin, roughages and is a good source of Dietary Fiber the table below shows basic nutrition facts of raw kale as provided by the United States Department of Agriculture (USDA)(Extension, 2018).

Like other kales, collard greens are an undeniable source of vitamin C with the capacity of about 58% of daily value. They provide calcium to strong teeth enamel at about 23% of daily meal and also vitamin B-6 which is good in metabolism rate and ability to sharpen how our brain functions.

And also in minerals like Calcium and Iron needed for a healthy family Origin(Thousand-headed, n.d.).

2.31 Climatic conditions for kale

kale can grow in any climatic condition but thrive mostly in warm weather, with optimal daytime temperatures between 20°C and 27°C.Temperatures above 30°C can adversely affect leaves setting, while temperatures below 10°C slow down growth and can cause leaves to fall off. The plants need at least six hours of direct sunlight each day to produce healthy leaves (Ddamulira et al., 2021).

The ideal soil should be deep, well-drained, fertile, and rich in organic matter. Sandy or loamy soils are often preferred, but tomatoes can grow in a wide variety of soils as long as drainage is good.

Kale are heavy feeders and require ample nitrogen, phosphorus, and potassium for optimal growth and high yields (Ddamulira et al., 2021). A consistent and adequate water supply is also critical for better leaf size. However, the soil should not become waterlogged, as this can cause root rot. Favorable conditions will increase production. kale take two months to mature.

2.4 Characteristics of kale.

Sukuma wiki is the most consumable type of crop grown both in urban and rural areas of the country. And it is easier to be grown by local farmers compared to other vegetables because it requires less labor and chemical input.

2.5 Environmental conditions for Sukuma wiki.

Sukuma wiki is one of the vegetables that almost grown in every environmental condition but it best performs in altitudes of about 880m to 2200m above the sea level. The temperature should vary from at least 16 º C to 22º C with also at least 6 hours of sunlight energy.

The land should be well drained with much organic content and receives rainfall of minimum 750mm. and the land should be ploughed deep to allow faster and faster root growth. But growth of Sukuma wiki is affected by a numberer of factors of which they include pests like aphids.

2.6 Aphid description.

Aphids are small bodied insects with two small spines protruding from the back of the abdomen called cornicles (Kim et al., 2011). Aphids belong to class insecta, order Hemiptera and family Aphidoidea. This aphids feed on sugary sap inside plant tissues using specialized piercing and sucking mouth parts. Their specialized mouth parts pierce plant tissues to suck the fluid which can cause curling or yellowing of the leaves, leaves sometimes drops off and sometimes the plant dries which results into death of it if the population is high. They have long antennae and pear-shaped bodies. They exist in wide range of colors depending on the species and also the species of the plant they have affected for example they can be green, white, red, black, yellow mention but few. And aphids secrete a sticky fluid from abdomen as they feed on the honey dew (Professionals, 2013). This aphid can produce with or without a male and can produce up to about 12 live offspring's in a day (Professionals, 2013).

2.61 Life cycle of aphids.

The aphids start with an egg which is laid before winter. The eggs hatch into fundatrix. Aphids are either host alternating or non-host alternating. Aphids with non-host alternating remain on one host throughout without migrating to other plant species while those with alternating host have both primary and secondary host which migrate seasonally incase the conditions worsens where no food is. These aphids may or may not have wings. Aphids only develop wings in seasons where they sense that there is no food or when the population is high and this makes them to migrate to other areas looking for both food and reducing competition as well with others. Aphid undergo two lifecycles depending on the season namely Holocyclic and anholocyclic

2.62 Holocyclic lifecycle.

Which is wingless female aphid. The fundatrix will create a daughter clone. These females will then go creating both male and female. The males and females formed can mate and produce eggs that can survive in winter.

2.63 Anholocyclic life cycle.

Here female aphids simply give birth to alive off springs of themselves without the help of the male. Female under anholocyclic life cycle sometimes has wings while sometimes lacks wings but

it creates a colony called aptera. The aptera is unwinged and can survive the winter conditions and then continues with the cycle by creating more colonies.

2.64 Aphid eggs.

This is an important stage of the life cycle in aphids, especially for species which under sexual reproduction. Their characteristic, mode of development, and adaptability to environmental conditions play a crucial role in spread of aphid population.

Aphid's eggs are generally small, oval shaped and difficult to be seen by our naked eyes due to their small size. They measure about 0.1 to 0.3 millimeters in length. Initially these eggs are pale but easily change their color to either black or blue and this is the way they can camouflage against predators and harsh weather conditions. The surface of the egg is usually smooth and slightly shinny giving it a glossy appearance. The outer known as the chorion is tough and durable allowing these eggs to withstand environmental stress such as cold winters and dry periods and this outer layer provides protection over desiccation.

2.65 The nymph.

This is the juvenile stage of the small sap sucking insect and plays an important role in growth and reproduction cycle of aphid species. Nymphs go through several growth stages knowns as instars before arriving at an adult stage. This stage of development resembles an adult in many ways but they are smaller and wingless where they range from the size of 0.5 to 2 millimeters depending on the species and the stage of development. The nymphs' body is soft pear-shaped and sometimes segmented. Like adult aphids, nymphs have long, slender legs and a pair of cornicles extending from the rear of their abdomen. These cornicles secrete mainly defensive chemicals. Also, these nymphs vary in colour depending on the species but generally have a pale green, yellow or black color and this eventually changes in some of the species as it matures.

2.66 Adult.

These are small bodied insects known to be sap sucking which can cause significant damage to plants and crops. They are members of the sub family Aphidoidea. Aphids are generally small with length ranging from about 1 to 10 millimeters depending on the species. Despite their small size but they can appear on the plant in large number making them very noticeable on plants. They have a soft-bodied, pear-shaped bodies with long, slender legs and antennae. Their body shape

tapers from a rounded abdomen to a narrower head. Their small size and soft body makes them vulnerable to predators. As well adults also vary in colour depending on the species depending on the environmental conditions. Common colors include green in colour, white, and some are black and many other colors and they have a distinctive structure called cornicles on the posterior of their abdomen. These cornicles secrete a defensive chemical, such as waxy fluid and cornicles help in distinguishing of these aphids from other insects and adults have either wings or not.

2.7 Methods of controlling aphids on Sukuma wiki (kale).

2.71 Physical removal;

This involves removing aphids from the plants manually. This involve washing plants with aphids by water or it may involve brushing aphids down of the plant and because of their soft body most of their body is destroyed by killing them and this method is environmentally friendly since it does not cause harm to any organism within the eco-system but the only disadvantage of this method is that it cannot work on large scale farms and it is time consuming.

2.72 Insecticidal soaps.

These are pesticides made up of natural fats and potassium salts. This work by suffocating the aphids and disruption of the cell membrane eventually causing them to dehydrate and die. Examples of such insecticide include safer brand insect killing soap, bonide insecticidal soap and garden safe insecticidal soap and this are more effective in areas with little rainfall. And makes someone to first consider whether changes before application. And the only disadvantage is that it is expensive to some farmers and may also require skilled personnel in mixing of the chemicals.

2.73 Chemical control.

This involve use of synthetic pesticide and this is applied mainly when other method has failed and also when insects have reached economic injury level and this is widely used method worldwide. Examples of such chemicals include malathion, Shumba. It has been noticed that the use of chemicals is more effective over a short time. But this pesticide applied always intend to kill non targeted organisms by interrupting their normal and biochemical and also physiological activities. However, this has proven to be effective and proven in terms of reliability. But this approach seems to be dangerous, especially when the chemicals are washed into the water bodies of organisms and eaten by some organisms resulting into biomagnification and bioaccumulation

and this disrupting the eco-system and also need skilled personnel especially in mixing of chemicals.

2.74 Biological control method.

Biological control of aphids falls into 3 categories (Van Driesche and bellows, 1996):

(I) classical, involving introductions of natural enemies into geographic areas where did not occur previously(Sutherland, 2006). (ii) Augmentation involving mass rearing and release of natural enemies that already exists in the system but which do not occur naturally in sufficient numbers or at optimum time to control the target pest. And lastly is conservation biological control which includes enhancement of naturally occurring wild population of natural enemies by means of habitat management and manipulation of their behavior. The natural enemies include parasitoids, predator and pathogens(Extension, 2018).

Despite their use in controlling the population of aphids, they are not frequently used by the farmers because they are economically viable, complex and efficacy affected by whether and climate change and this require some of the skilled personnel to handle bio-agent and they are more expensive than chemical agent.

2.75 Cultural control.

Cultural control as management tools and activities that make the crop habitat less favorable for pests to survive and cause damage (Summy, 1992). Cultural management practices make crop inhospitable to pests directly for example by planting cultivars that are resistant to aphid attack or by practicing crop rotation to deny over wintering of pests their preferred food source.

2.76 Botanically derived treatments.

Pesticides are the cornerstone upon which the pest management practices are based as is long as they are effective and inexpensive chemicals are available (Nabil, 2013). Botanicals are divided into two generations that is to say first generation which includes Nicotine, Rotenone, Sabadilla, Ryania, pyrethrum and plant oils while second includes synthetic pyrethroids as well as potential new botanicals (Regnault-Roger et al., 2008).

2.8 Importance of managing aphids.

Aphids are one of the detrimental insect pests in the world that have caused a significant problem with the production of Sukuma wiki and thus affecting the yields and their quality produced (Olivo & Corronca, 2013). Aphids have strong mandibles characterized by piercing and sucking mouth parts which they use to suck the sap from the Sukuma wiki resulting into stunted growth, curled leaves and also reduced surface area for photosynthetic function (Olivo & Corronca, 2013).And their ability to proliferate fast and spread plant viruses worsens the harm they inflict on the plant and thus has resulted into a substantial reduction in crop yields (Løe & Løe, 2023).

Efficient management of pests is very important to guarantee the long-term viability of Sukuma wiki cultivation to attain food security in places where the crop is the primary source produced.

Improper management of pest results in financial setbacks for very many farmers who are financially unstable whereby getting money to purchase some of the synthetic pesticide, insecticide and some of the reasonably pest management practices like integrated pest management is quite difficult for them. However, the uncontrolled application of artificial pesticide can result into harmful problems on human well-being and other organisms within the eco-system because of the fumes they emit and are non-biodegradable since they can stay in the soil for even more than 50 years and this results into insect resistance to other pesticide to applied and also result into insect resurgence and has resulted into development of other alternative control measure that is to say botanical which include use of plant extracts because it is environmentally friendly and it does not cause any harm to other organism with in the world.

2.9 Preparation of extracts.

2.91 Extracts derived from onions.

Onion extracts consist of several compounds including Sulphur. One of these components is allicin which was proved to contain insecticidal, antifungal and anti-bacterial effects.

Allicin is catalytically decomposed to produce allicin which is a non-protein amino acid found in onion tissues (Miron et al., 2002). The researchers have provided evidence on efficiency of using onion extracts in combating insects, pests for example aphids, thrips white flies (Mohican et al., 2011). Onion extracts have been discovered to be efficacious in controlling aphid in vegetables

(Mochiah et al., 2011). The study conducted by (Mandizvidza et al., 2021). It was found that the use of onion extracts resulted into a considerable decrease in the population of aphids and also have increased production and improved crop yields compared to control group that did not receive treatment. A study conducted by (Akunne et al., 2015) showed that combined use of garlic and onion extracts showed synergistic impact of controlling aphids.

2.92 Extracts derived from garlic.

Garlic (allium sativum L) is one of the most important vegetables grown throughout the whole world. With total harvested area of 1,437,690 ha and estimated annual production is 24,255,303 tonnes of dry bulb. The importance of garlic is due to it's not only for culinary but also for therapeutic and medicinal purpose in both traditional and modern medicine and as bio pesticide(Martins, N., Petropoulos, S. and Ferreira, 2016).

With the increasing resistance of pests, insects bacterial to antibiotics. There has been considerable development of bio pesticide which is other classes of antimicrobial for control of infections caused by different organisms. And here Garlic is known to have active ingredient which is known to have anti-bacterial, anti-fungal, ant-virus properties among others (Bakri & Douglas, 2005). The information collected has showed that applications of neem and pungam oil @ 20ml/l was significantly the most effective with reduction of sucking pests(leaf hoppers,70.20%; aphid 60.54%, white fly, 72.49%) .but garlic exacts is said to be the best (Gayathri & Geetha, 2020). Garlic. Allium starvum L. Alliaceae extracts have shown considerable toxicity to number of pest species across all life stages and susceptible orders to garlic extracts include Diptera, lepidoptera, Hemiptera, coleoptera (Moreno & Coban Cruz, 2015). Garlic extracts have been shown to inhibit egg hatching mosquitoes and have a diverse effect on the larvae. However, these products lack consistency in their insecticidal effects. Compared to commercial insecticidal effect(Moreno & Coban Cruz, 2015). Garlic contains several components which are toxic to both insects and pests including diallyl sulphide and diallyl trisulphide. The highly reactive nature of polysulphide has been reported to be responsible for the toxic effect by denaturing enzymes and altering enzyme activity of various insects their by inhibiting their activity and thus kills them(Moreno & Coban Cruz, 2015).

2.93 Comparison between synthetic and botanical pesticide.

Although synthetic pesticides have been instrumental in enhancing agricultural input and safeguarding crops against insect pests, their excessive use and indiscriminate use has resulted into excessive concerns on the ecosystems especially on the human health, non-target organisms. Synthetic pesticide is a chemical that is artificially made to reduce on the population of pests and it's internationally formulated to have high level of toxicity to target pests though it can also have dangerous effects on living organisms that are beneficial such as insects, birds and mammals. It has been found that excessive use of pesticide has resulted into pest resistance making this substance progressively ineffective. Some of these pesticides are washed by rain water and thus ends up in the water which ends up having a detrimental effect on human health such as potential carcinogenic, neurological and reproductive outcomes. The synthetic outcomes of it is becoming a worrying issue and it has to be worked upon because it has impacted the ecosystem through pollution and alternatives such as plant extracts must be employed.

3.0 CHAPTER THREE; METHODS AND MATERIALS.

3.1 Study site.

The study was conducted at Busitema University, Nagongera campus in eastern part of the country. This is specifically the biology land which is located behind paper pulp near project of black soldier fly. This area of study consists of both sandy and loamy soils with elevations of 1063m above sea-level and latitudes (Noo42.448 and E034012.077). The area is comprised of small holder student farmers who getting into vegetable production especially leafy vegetables.

3.2 Land and nursery bed preparation.

Primary cultivation was done using hoe and deep tilth was done to break down soil pans to enable water infiltration and turn down weeds such as lantana camara, coach grass, Congo signal and then they were collected and carried away from the site in preparation for plantation. The weeds were removed because they could compete with Sukuma wiki for nutrients and also making secondary tillage difficult not only competing for nutrients and making secondary tillage difficult but also could hinder sunlight and moisture as plant growth requirements. Secondary tillage was done to break large soil lumps into fine soil particles that can permit easy root penetration, soil aeration, water infiltration, and complete breakdown of lifecycle of weeds such as coach grass, lantana camera which could affect the yield of Sukuma and after the prepared land was left for about one week. After one week the site on prepared land was selected for nursery bed preparation. Nursery bed was prepared on 13th December 2025 on small plot of unfertilized soil near the black soldier fly unit with fine tilth and raised nursery bed was made. The dry stick was used to make narrow rills through the soil collard variety was selected due its high viability of about 85 percent and high resistance to pests and diseases as well as to hot and dry weather conditions. The nursery bed roughly measured about (1.5×0.7) cm$^{2\ above}$ sea level such that it's not affected by water. To shield or protect seedlings from weather conditions like direct sunlight a raised shed was consulted. This was supplemented by regular watering in the morning and evening for the period of 14 days and afterwards watering was done only in the evening. The nursery bed was weeded twice at an interval of 10days. After a period of 28days the seedlings were transplanted to the main garden in different plots.



Figure 1: Showing preparation of land for planting

3.21 Experimental Design and Linear Model.

1) The experimental design was a completely randomized block design with 5 treatments were garlic and onion (Tr1), garlic treatment Tr2, onion treatment (Tr3), positive control of chemical control Tr4 and negative control without any application Tr5 respectively and each experiment was replicated three times. Each experiment had 4 blocks each totaling to 20 plots and the plot size was 2x1 m^2 and all this were subjected under the same environmental conditions.

Table 1: showing abbreviations and what they stand for

Treatment	Description
Tr1	Garlic and onion extracts
Tr2	Garlic extracts only
Tr3	Onion extract only
Tr4	Synthetic chemical
Tr5	Without any treatment

3.22 Preparation of Plant Extracts.

Allium species were taken to the laboratory where they were cut into small pieces to increase their surface area for easy crushing. *Allium species* were then crushed separately using a mortar and pestle and then placed separately into the container.

3.23 Preparation of onion and garlic extracts

300 grams of crushed onions were mixed with 4liters of water and the solution was kept for 24 hours to isolate the liquid extracts from solid onion particles and also 200 grams of crushed garlic was also mixed with 4 liters of water and were kept separately for 24 hours before spraying.

After 24 hours, the mixture is filtered 2 liters of each (garlic and onion extracts) were measured separately into their respective beakers then after were mixed together to obtain the solution of both garlic and onion extracts which were poured in the nap suck sprayer and then applied to first plot named treatment one.

The remaining 2 liters of each sample that is to say 2 liters of garlic and 2 liters onion extracts were also filled in knap suck sprayer one at ago and then applied to their respective plots (plot 2 and 3 respectively) named treatment 2 and 3 respectively. The spraying was repeated at an interval of 7 days for 3 weeks. The various parts of the plants were sprayed, paying particular attention to the underside of the leaves. The control plants were left unsprayed. The first spraying of plants was done 2 weeks after transplanting and subsequently weekly for 6 weeks. Before each application of the plant extracts the insects were first checked to see how they have attacked the kale**.** For the first two weeks after transplanting, watering was done manually using watering can both in the morning and evening until full establishment. Watering was then reduced to once a day. Some mulches were applied to enhance water retention and only grasses were used as mulch for both experimental plots and nursery bed to conserve moisture as well as suppress weed growth throughout the growing period.

Weeding was done manually using a hand hoe and by uprooting. The first weeding was done after two weeks after transplanting followed subsequent two weeks interval. This schedule continued

for the interval of two weeks and all plots were weeded the same day. The knapsack sprayer was used to spray the mulches of dry grass using rocket such that to prevent kale from being attacked by termites.

3.3 Data collection

Simple random sampling was used to select 3 plants from each plot which were consistently used to determine all measurements of plant height, plant leaf width and number of leaves. kale plants were observed weekly for signs of and presence of insect pests.

From the time of transplanting, the selected plants were monitored to determine the time taken to determine plant height, number of leaves, and leaf width.

The number of leaves were determined by direct counting; plant height was determined by measuring plant height and also applies to leaf width.

3.4 Data analysis.

Objective one data analysis to achieve the stated hypothesis refer to section (1.3) was done using IBM statistics version 26. Data for both categorical and continuous variables was entered and cleaned. Using a general linear model, univariate analysis was run against independent variables (plant height, number of leaves and leaf width and fixed factor of time in weeks and random factors of Tr1, Tr2, Tr3, Tr4 and Tr5. The F test statistics was performed and calculated. F-value were compared with the tabulated F-value at 0.05 percent significant level and degree of freedom (R-1), (R-2) (C-1)

3.5 Sources of Sukuma wiki seeds.

For this study, Sukuma seeds were bought from Tororo agricultural-input shop and the type of seeds planted were amazon seeds packed in a 10 g packet. 20 seedling lines were made in which seeds were sowed at a rate of 1g per seedling line. The nursery bed was mulched with grass and watered with water since the seeds were sowed in dry season. They were watered such that seeds can absorb water to active enzymes to break down stored food to release energy for germination of seeds. And also, the seeds were mulched with grass to keep the ground moist such that seedlings can penetrate the soil.

a shelter was built around to avoid direct sunlight since it was prepared in dry season. Watering was done daily both in the morning and in the evening. Weeding was done to remove weeds that were competing with seedlings. Hardening was done after 2 weeks of germination that is roughly 15 days after germination.



Figure 2: Showing field layout for research

3.51: Farm activities (Crop Maintenance)

Watering was initially done twice daily, then once every day after the seedlings had hardened.

Withered and damaged seedlings were gapped within the first week. Weeding was done as and when weed appeared, prevalent weeds were black jack and black night shades.



Figure 3: Showing weeding of kale



Figure 4: showing planted kale



Figure 5: Showing kale on nursery bed.

3.6 Application of treatment.

The application of the extracts will be based on the survey conducted on how the aphids have infested themselves against crops and this is done based on the threshold which will serve as a signal to show that aphids have reached appoint where action is necessary.

3.61 Sampling procedures

A sample of two plants of kale from each replicate plot a total of 40 plants for the whole experiment were always selected randomly and used for data collection to determine the growth rate for six weeks.

3.62 Sampling technique.

Two plants from each replicate plot were sampled using simple systematic random sampling technique whereby two plants were selected randomly from each plot is sampled. This was done by first giving plants numbers and writing letters corresponding to the plans to be sampled.

3.7 Data collection methods and instruments used.

During my study, the collection method used include observation, measurement, and recording method. Observation was done using naked eyes during taking measurement on parameters like leaf size, leaf length, leaf width and number of leaves. And these parameters were recorded on bok rate for further analysis.

3.71 Data collection.

The two outer rows were discarded and two Centre rows represented the net plot. Sampling was done by randomly selecting three plants in each row in the net plots. Systematic random sampling was used on selecting plants and the k-factor used was 3. In the first and second rows plant numbers 1, 4, 7 and 3, 6, 9 were selected giving a total of six plants per plot. Data collection for aphid count started at 2 weeks after transplanting and continued for six consecutive weeks. This was done by investigating growth parameters. Kale yield was harvested at 0ne weeks interval starting from second weeks after transplanting. Equal number of leaves were harvested from each plant.

The growth parameters measured on application of extracts of *allium species* and for control experiment of synthetic pesticide and one without any application. Growth traits determination for Sukuma wiki.

3.73 Sukuma wiki plant height.

Plant height was measured using a measuring tape and a meter rule from eight samples of each plot. The plant height was taken from the soil surface to the apical. The plant height measurements were recorded

3.74 Number of leaves.

The number of leaves for each plant were determined by counting leaves from each sample plants. The leaf was only counted when it has fully opened.

3.75 Leaf length.

Leaf length was measured using a ruler considering the largest leaves of the plant from plant from apex of the sample plant up to tip of the leaf and the values were recorded in centimeters

3.76 Leaf width.

Leaf width is taken from the same leaf that was used during recording of a leaf length from each sample plant using the same tool that was used to take the leaf length. It was measured from the margin of the leaf at exact midpoint of the leaf using a ruler.

3.77 Leaf area.

The area of the largest leaf will be calculated using values of length and width of the largest leaf following the formula. (Pi*LI)/4, L is the largest length, and I is the largest leaf width.

3.8 Limitation of study.

The study was affected by sunshine since study was carried out in dry season of January and February.

The study also was affected by insects which come in touch with plant stem in the soil and peels off the stem causing them to wilt and also there was Lack of water to be used in the watering of kale since the study was carried out in dry season. making them un watered some of the days.

4.0 CHAPTER FOUR: RESULTS.

The results of variables measured for the five treatments has been shown in the following.

The combination of garlic and onion named Tr1 had the highest plant mean height of 7.6cm, 17.25cm and 20.5cm for all one and half month, this was followed by treatment with garlic extracts named Tr2 with recorded mean height of 6.85cm,17.16cm and 19.2cm. the third treatment was from onion extracts named Tr3 with the average plant height of 7.1cm, 14.80cm and 17.28cm. the forth treatment was for synthetic chemical cyper acelemectin named Tr4 with average plant height of 7.3cm, 14cm and 17.3cm and control experiment(without any application) named Tr4 with recorded average plant heigh of 7.3cm, 14.1cm and 15.5cm.

Results have been presented in the table below

Table 2: Showing the mean average plant height of the plant.

Treatments	**Time in weeks**		
	Week one	**Week two**	**Week three**
Tr1	7.63	17.25	20.05
Tr2	6.85	15.1667	18.28
Tr3	7.1	14.6667	17.2667
Tr4	7.3	14	16.55
Tr5	7.3	14.17	16.49

Treatment Tr1 (garlic and onion extracts) achieved an overall plant height increase of 62%, effectively surpassing the 60%increase of those treated by garlic only (Tr2), 58% increase of plant height treated with onion extract and also greater than those treated with cyper acelemectin and the control experiment without any without any treatment which recorded the lowest percentage increase in plant height. Therefore, the there is a significant difference on plant height between treatments is accepted.

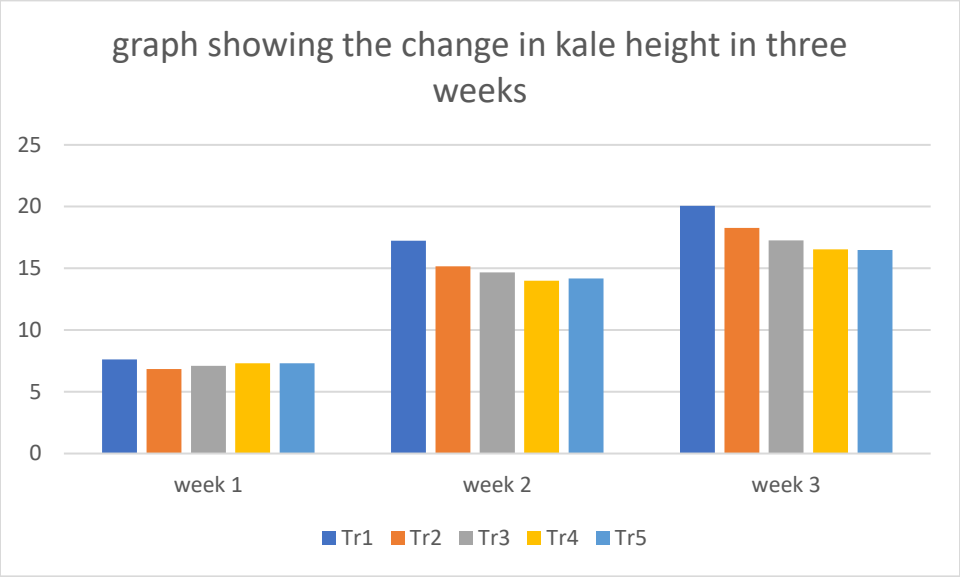


Figure 6: Graph showing change in kale height in 3 weeks

The Tr1 had the highest plant mean number of leaves of 4.5cm, 10.33cm and 12.5cm for all one and half month, this was followed by treatment with Tr2(garlic treatment) with recorded mean number of leaves of 4.5cm, 9.33cm, and 11.5cm6. the third treatment was from onion extracts named Tr3 with the average number of leaves of 4.5cm, 8.67cm and 10.5cm.the forth treatment was treated with synthetic chemical and is named Tr4 with mean average number of leaves of 4.33cm, 8cm and 9.83cm and last treatment was of control without any treatment and had the following average number of leaves of 4.2cm, 6.67cm and 8.33cm

Table 3: Showing the average number of leaves

Treatments	Time in weeks		
	week one	week two	week 3
Tr1	4.5	10.33	12.5
Tr2	4.5	9.33	11.5
Tr3	4.5	8.67	10.5
Tr4	4.33	8	9.83
Tr5	4.2	6.67	8.33

Treatment Tr1 (garlic and onion extracts) achieved an overall increase in number of leaves 64%, effectively surpassing the 56%increase of those treated by garlic only (Tr2), 51% increase of number of leaves of treated with onion extract and also greater than those treated with cyper acelemectin and the control experiment without any without any treatment which recorded the lowest percentage in average number of leaves. Therefore, the there is a significant difference on number of leaves between treatments.

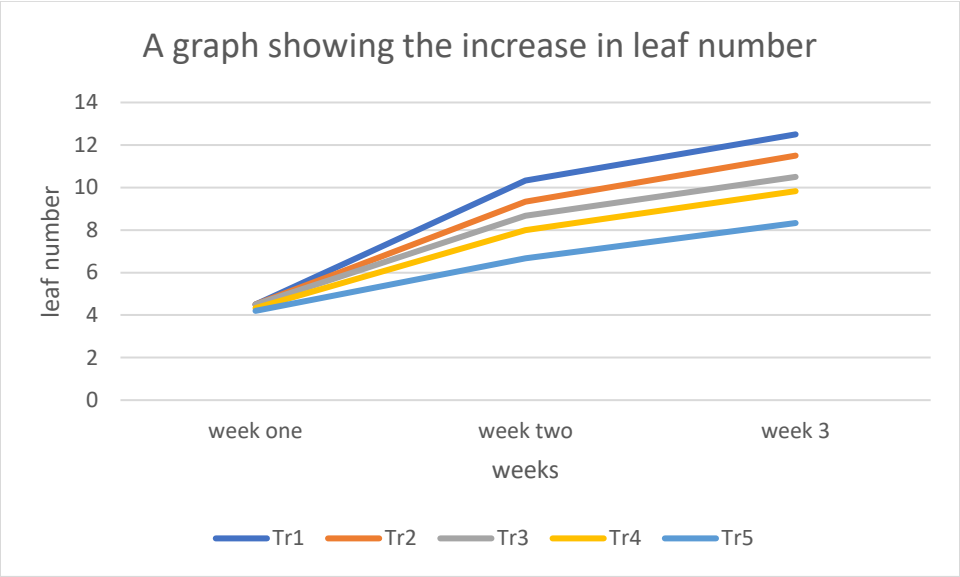


Figure 7: A graph showing average increase in number of leaves

The Tr1 had the highest plant average plant leaf width of 3.2cm, 19.2cm and 21cm for six weeks, this was followed by treatment with Tr2 (garlic treatment) with recorded average leaf width of 3.5cm, 16.1cm, and 20.1cm. the third treatment was for onion extracts named Tr3 with the average leaf width of 4.1cm 15cm and 17.8cm.The forth treatment was treated with synthetic chemical and is named Tr4 with average leaf width 3.68cm, 14.8cm and 16.8cm and last treatment was of control without any treatment and had the following average number of leaf width of 3.6cm, 14.2cm and 16.cm.

Table 4: Showing the average leaf width in centimeters.

Treatments	Time in weeks		
	week one	week two	week 3
Tr1	3.2	19.2	21
Tr2	3.5	16.1	20.1
Tr3	4.1	15	17.8
Tr4	3.91667	14.8	16.8
Tr5	3.683333	14.21667	16

Treatment Tr1 (garlic and onion extracts) achieved an overall plant height increase of 42%, effectively surpassing the 38%increase of those treated by garlic only (Tr2), 35% increase of plant average leaf width height treated with onion extract and also greater than those treated with cyper acelemectin and the control experiment without any without any treatment which recorded the lowest percentage increase in leaf width. Therefore, the there is a significant difference on plant height between treatments is accepted.

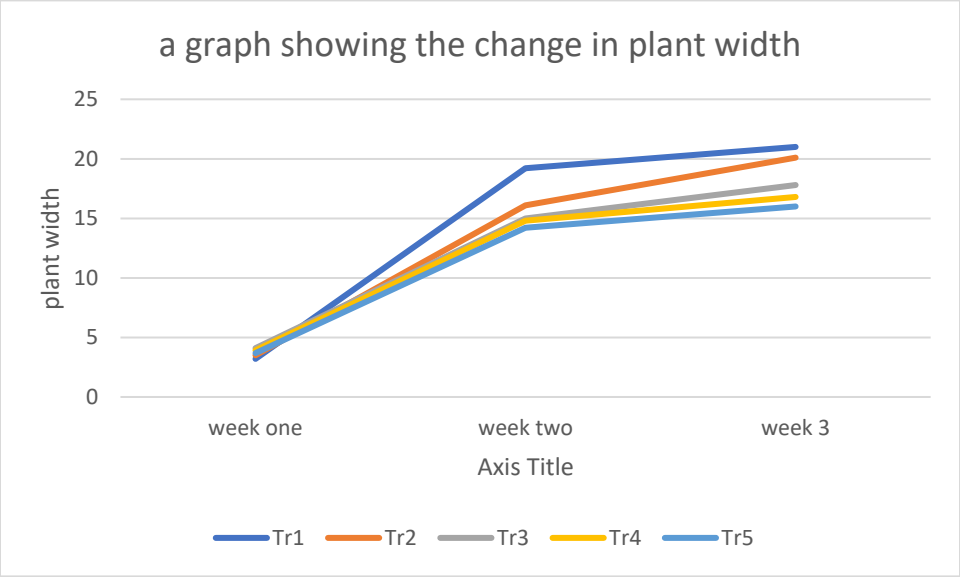


Figure 8: A graph showing the change in plant width.

4.1 Data analysis.

This Analysis of plant height was done in IBM statistics version 26. Data for both categorical and continuous variables was entered and cleaned. Using a general, linear model, a univariate analysis was run against the dependent variable (plant height) a fixed factor (time and weeks) and the random factors (Tr_1, Tr_2 and Tr_3). The F-test statistics was performed where the calculated F- value were compared with the Tabulated F-value at 0.05% significant levels and the degrees of freedom ((R-1), (R-1) (C-1)). Plant dimensions of plant height, leaf length, leaf width and leaf length were analyzed using descriptive statistics, comparing mean averages across treatments to quantify performance.

Table 5: Showing Tests of Between-Subjects Effects

Dependent Variable: average plant height						
Source		Type III Sum of Squares	Df	Mean Square	F	Sig.
Intercept	Hypothesis	2668.454	1	2668.454	938.572	.000
	Error	11.372	4	2.843[a]		
Weeks	Hypothesis	297.123	2	148.562	20.538	.000
	Error	4.669	8	.584[b]		
Treatments	Hypothesis	11.372	4	2.843	4.871	.028
	Error	4.669	8	.584[b]		
Weeks * Treatments	Hypothesis	4.669	8	.584	.	.
	Error	.000	0	.[c]		

[a] mean of squares for the treatments (Tr1-Tr5); [b] mean of squares for time in weeks' degrees of freedom, Fis calculated F value, sig, P-value

The F_{tab} =6.04 with (2,8) degrees of freedom at $\alpha = 0.05\%$ significant level, since F_{cal},20.538> 6.04 for weeks, reject the null hypothesis and accept the alternative hypothesis. Therefore, time in weeks had significant effect on plant height.

Table 6: Showing Tests of Between-Subjects Effects

The F_{tab} = 6.04 with (2,8) degrees of freedom at $\alpha = 0.05\%$ significant level, since F_{cal}, 4.871<6.04 for treatments, accept the null hypothesis and reject the alternative

hypothesis. Therefore, the different treatments had no significant effect on plant height.

Dependent Variable: average plant leaves						
Source		Type III Sum of Squares	Df	Mean Square	F	Sig.
Intercept	Hypothesis	923.396	1	923.396	289.125	.000
	Error	12.775	4	3.194[a]		
Weeks	Hypothesis	98.084	2	49.042	77.414	.000
	Error	5.068	8	.633[b]		
Treatments	Hypothesis	12.775	4	3.194	9.041	.025
	Error	5.068	8	.633[b]		
weeks * treatments	Hypothesis	5.068	8	.633	.	.
	Error	.000	0	.[c]		

[a] mean of squares for the treatments (Tr1-Tr5); [b] mean of squares for time in weeks' degrees of freedom, Fis calculated F value, sig, P-value.

The F_{tab} =6.04 with (2,8) degrees of freedom at $\alpha = 0.05\%$ significant level, since F_{cal},77.414> 6.04 for weeks, reject the null hypothesis and accept the alternative hypothesis. Therefore, time in weeks had significant effect on number of leaves.

The F_{tab} = 6.04 with (2,8) degrees of freedom at $\alpha = 0.05\%$ significant level, since F_{cal}, 9.041>6.04 for treatments, reject the null hypothesis and accept the alternative hypothesis. Therefore, the different treatments had significant effect on the number of leaves.

Table 7: Showing Tests of Between-Subjects Effects

Source		Type III Sum of Squares	Df	Mean Square	F	Sig.
Intercept	Hypothesis	2391.491	1	2391.491	509.616	.000
	Error	18.771	4	4.693[a]		
Weeks	Hypothesis	615.697	2	307.849	155.187	.000
	Error	15.870	8	1.984[b]		
Treatments	Hypothesis	18.771	4	4.693	8.366	.140
	Error	15.870	8	1.984[b]		
weeks * treatments	Hypothesis	15.870	8	1.984	.	.
	Error	.000	0	.[c]		

[a] mean of squares for the treatments (Tr1-Tr5); [b] mean of squares for time in weeks' degrees of freedom, Fis calculated F value, sig, P-value.

The F_{tab} =6.04 with (2,8) degrees of freedom at $\alpha = 0.05\%$ significant level, since F_{cal},155.187> 6.04 for weeks, reject the null hypothesis and accept the alternative hypothesis. Therefore, time in weeks had significant effect on plant leaf width.

The F_{tab} = 6.04 with (2,8) degrees of freedom at $\alpha = 0.05\%$ significant level, since F_{cal}, 8.366>6.04 for treatments, reject the null hypothesis and accept the alternative hypothesis. Therefore, the different treatments had significant effect on plant leaf width.

Table 8: Showing Tests of Between-Subjects Effects

Dependent Variable: average leaf length

Source		Type III Sum of Squares	Df	Mean Square	F	Sig.
Intercept	Hypothesis	7330.571	1	7330.571	406.304	.000
	Error	72.168	4	18.042[a]		
Weeks	Hypothesis	2340.112	2	1170.056	188.786	.000
	Error	49.582	8	6.198[b]		
Treatments	Hypothesis	72.168	4	18.042	4.871	.093
	Error	49.582	8	6.198[b]		
weeks * treatments	Hypothesis	49.582	8	6.198	.	.
	Error	.000	0	.[c]		

[a] mean of squares for the treatments (Tr1-Tr5); [b] mean of squares for time in weeks' degrees of freedom, Fis calculated F value, sig, P-value.

The F_{tab} =6.04 with (2,8) degrees of freedom at $\alpha = 0.05\%$ significant level, since F_{cal},$188.786 > 6.04$ for weeks, reject the null hypothesis and accept the alternative hypothesis. Therefore, time in weeks had significant effect on plant height.

The F_{tab} = 6.04 with (2,8) degrees of freedom at $\alpha = 0.05\%$ significant level, since F_{cal}, $4.871 < 6.04$ for treatments, accept the null hypothesis and reject the alternative hypothesis. Therefore, the different treatments had no significant effect on plant leaf length.

5.0 CHAPTER FIVE

5.1 DISCUSSION.

In week 1 there were no significant differences on aphid population between the control and those which had been sprayed with botanical sprays. This could have been due to poor establishment of aphids in different plots since the experimental site used was initially not over used for growing of kale. However, from week 2 onwards, application of botanicals significantly reduced aphid population. This could be because of the repellent and pesticidal effect of both garlic and onion. When garlic cloves are cut odorless, Sulphur containing amino acid derivative reacts with the enzyme alliinase to form allicin and other Sulphur compounds. The sulphur containing compounds are responsible for the garlic distinctive smell and pungency (Brewster, 1994). Strong smell produced is responsible for garlic preventing aphids from finding the crop plant (Dobson et al .2002). Amonkor and Baneji (1971) identified Diallyl di-sulphide, Diallyl tri-sulphide and Diallyl sulphide as major components having antagonistic properties against pests of economic importance including potato tuber moth, red cotton bug, red palm weevil, house flies and aphids. At week six botanicals recorded aphid populations that were not significantly different from each other. This can be attributed to kale developing tough leaves that might have become less ideal for aphids. As kale grow silica or lignin accumulates in leaves increasing fiber content thus reducing leaf palatability (Jonsell, 2000). Aphids are wingless in general but will produce wings and fly away when food resources are limited especially when crowded (Dube et al, 1998), this could also have resulted in even distribution of the aphids within the botanicals at week 6. There was a sharp increase in aphid population on cyper acelemectin sprayed crop from two weeks. This can be attributed to resistance development of aphids to the synthetic organophosphate insecticide. This can also be linked to the life cycle of aphids that is approximately two weeks (Sibanda et.al, 2000), hence new resistant progenies could have been produced leading to increased failure by cyper acelemectin to control aphids. Onions as a constituency of the botanical formulation could also have contributed to reduction in aphid populations. According to Brust (2006), onion acts as anti-feedent and repellent to a number of pests. A significant difference was also noted on the kale yields of different treatments. Increase in concentration of botanicals was directly related to an increase in yield. This can be attributed to the reduction of aphid populations on the kale by botanicals. The nymph stage and adult forms damage the plants by sucking sap from the tender

leaves, twigs, stems and inflorescence by means of piercing and sucking (Jonsell, 2000). Aphids, if in large numbers they remove sufficient sap to kill the leaves and growing tip. Infected seedlings become stunted and distorted; continual feeding on mature plants causes wilting, yellowing and general plant stunting (Hill, 1983), curling and subsequent drying up of leaves, hence reducing yields. Aphids also produce honey dew predisposing an affected plant to develop black sooty mold making the leaves age faster of the leaf and reducing photosynthesis (Jonsell, 2000).

5.2 Conclusion.

With increased population of the country and demand for enough food, the demand of insecticide to enhance crop production is very high. Farmers use synthetic chemicals like Malathion, acelemectin to control insects which has affected soils and biodiversity. The present study evaluated the effectiveness of use of botanicals like use of garlic and onion in the management of major insects of kale. The two botanicals proved to be cost effective plant protection alternatives to synthetic insecticides. Results from the study showed that the botanicals were able to reduce the incidence of pests on kale. The use of botanical insecticides by the average resource-poor African farmer will reduce their reliance on chemical insecticides and their attendant detrimental effects on non-target organisms. The use of botanicals in controlling insect pests will help conserve natural enemies of pests since these botanicals have limited negative effects on non-target organisms. These botanicals could therefore be considered as alternatives to the control of insect pests on crops.

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