EFFICACY OF NEEM TREE EXTRACT ON WHITE CABBAGE APHID, *BREVICORYNE BRASSICAE* CONTROL

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REG. NO: 2014-M152-20002

UGANDA MARTYRS UNIVERSITY

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A POSTGRAUDATE RESEARCH DISSERTATION PRESENTED TO THE FACULTY OF AGRICULTURE IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRO-ECOLOGY OF UGANDA MARTYRS UNIVERSITY

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DEDICATION

First, I dedicate this work to my father Mr. Oming John and my mother Mrs. Margret Oming for their continuous love, support and faith towards this study project.

Secondly, to my children Mercy, Precious and Blessing, my husband Moses, my brother Emmy and other sisters whom I had missed for so long during the course of the study

Thirdly, to Mr. and Mrs. Rickin Madhvani for allowing me use their garden for this research study.

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God helps those who help themselves by being with us and blessing us at all times, provided we dare to dream and dare to achieve those dreams. If we reorganize and utilize the gifts God gives us, stay focused on our goals, keep positive thoughts, start the day with prayers praising his glory, he who moves the world, will definitely move the world for us. First of all, thanks to Almighty God for giving me a break through whenever I broke down and blessing me with whatever I have ever achieved.

Next, appreciation and thanks to the Joint Managing Directors and the Management of Kakira Sugar Limited for the opportunity offered to me in terms of time, materials and financial support for this degree programme. Also for allowing me conduct my research study successfully within their premises. The Chief Training Manager Mr. Obetti Bob Nzima, Agricultural Manager, Dr. Reddy and Horticulture Superintendent, Mr. Okello James Mawa for assisting me in various ways; especially materials for the research study.

The academic staff at the Faculty of Agriculture Uganda Martyrs University, Rubaga Campus and my Supervisor Bro. Marius Flarian Murongo for the guidance rendered and most importantly may the Almighty and Provident God for life, health and resources bless us all, Amen.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABSTRACT

A field study was carried out to investigate the efficacy of Neem tree extracts (root, bark and leaves) to control aphids in cabbage under smallholder farming systems. The objectives were to identify the effective dose of the admixture of Neem tree extract in controlling aphids on cabbage, to establish the effective frequency in application of Neem tree extract in controlling population of aphids on cabbage and to propose a hypothetical model for general cost of production using Neem tree extract in comparison with synthetic pesticides.

Methods employed to achieve this results were; freshly harvesting of Neem tree parts (root, bark and leaves), crashing into a mortar, weighing 1000g of each part, mixing together in 10litres of water for 12-24hours and spraying from four weeks after crop emergence up to harvesting. Three treatment tests varied were 20ml, 30ml and 40mls (in 10litres of water) in different plots. Frequencies of application were also varied at once a week, twice a week and once in 2 weeks. The experimental design used was a completely Randomized Block Design with the three treatments replicated 4 times. There was a significant difference ($P < 0.05$) in aphid counts among all treatments at the concentration of 30mls with 40mls treatment resulting in the second least aphid count. At week 8, the least counts were recorded in the 30mls, followed by 40mls and 20mls treatments, which were significantly different from the control. Overall mean aphid counts showed a reduction in number with an increase in the concentration of Neem tree admixture extract applied. Cabbage vigour of growth increased with increase in the frequency of Neem tree admixture extract applied twice a week and once a week at significant difference of $P = 0.05$. High concentration (40mls) effectively controlled aphids but resulted in some mild scorched leaves. The study showed that Neem tree admixture extract effectively controls aphids, with best results obtained with 30mls/10litres of water sprayed twice a week. Recommendation was made for further research on the field study on the general cost of production using Neem tree admixture extract.

CHAPTER ONE

GENERAL INTRODUCTION

1.0 Introduction

Cabbages are affected by a complex of aphid species, including turnip aphid, *Lipaphis erysimi* (Kaltenbach), and Cabbage aphid: *Brevicoryne brassicae* (*L*.) and green peach aphid, *Myzuz persicae* (Sulzer) (all Hemiptera: *Aphididae*), (Franke *et al.,* 2009; Boyles *et al.,* 2012) Aphids are polyphagous pest of many plant species cause damage to the plants by direct sucking of xylem sap from the stem or leaves of the plants. In addition to mechanical and physiological damage, they are also responsible for transmission of varieties of viral diseases.

Cabbage aphid: *B.brassicae* (*L*.) are the most problematic pest in smallholder vegetable production causing up to 70% yield loss in heavy infestations (Boyles *et al.,* 2012). The efficacy of Neem tree extract in terms of concentration (quantity in milliliters), its' rate / dosage of application, frequency on aphids in cabbage and the production cost- benefits ratio of using Neem tree extract in pest control to farmers have not been established despite of all many methods used locally concocted mixtures inclusive of extracts from trees and shrubs such as Neem extracts. The chapter will explain the background of the study, statement of the problem, objectives, hypotheses, justification, and scope of study, significance of the study, conceptual frame work

1.1 Background of the Study

White cabbage is one of the most widely grown vegetables in Uganda today (Mukiibi, 2001). Although white cabbage is mostly cultivated during the rainy season, the crop does equally well in the dry season with irrigation. For maximum economic benefit and better profit margins, farmers grow some cabbage crops in dry season (Mukiibi, 2001)

Cabbage crop is highly susceptible to various insect pests of which aphids both grey aphids, *B.brassicae (L.)* and green peach aphids, *M.persicae (*Sulzer) (all Hemiptera: Aphididae) (Franke *et al.,* 2009; Boyles *et al.,* 2012) cause heavy damage especially by spreading virus diseases to the plant especially when it forms dense colonies on developing head, yield losses of up to 70% have been reported if infestations are left untreated (Boyles *et al.,* 2012). This study agreed with the above findings but they used integrated pests management approach which involved synthetic chemical control approaches for quicker solution whereas this study looked at the Agro-Ecology systems wide thinking approach embracing social acceptability, economic viability and

environmental friendliness approach as a whole system functioning without compromising the other.

Earlier work by Kakuhenzire *et al.,* (1997) has shown that during the dry season both nursery and field crops of white cabbage were infested by cabbage aphids (*B.brassicae*), Diamondback moth (*Plutella xylostella*) and Cabbage lopper (*Trichoplusia ni)* Some biological control activity has been observed in the field with Coceinelids wasps, lady birds beetles and *Didegma species* being the common natural predators of the above mentioned pest, however, biological control is not sufficient during dry season. This study also agreed with their findings but the pests management approach used was through synthetic chemical method which addressed the economic aspect of sustainability by increased yields and income but leaving out the social equity and environmental friendly of the system functioning.

In Kakira region, the most common types of aphids on cabbage plants are grey aphids, *B.brassicae (L.)* and green peach aphids, *M.persicae (*Sulzer), with the grey aphids, *B.brassicae (L.)* being the strain of Economic Importance. This together with green peach aphids, *M. persicae (*Sulzer) rage havoc in the area (Boyles *et al,* 2012) Their damage potential is exacerbated by the capacity to vector over 100plant viruses, resulting in a wilting, deformation, premature leaf senescence, and retarded growth rate of the plant (Pegadaraju *et al.,* 2005). Hence they must be controlled. These aphids thrive well in both sunny and rainy seasons, and frequently cover cabbage plants in all stages of growth with dense clusters of whitish green and grey aphids. They suck sap from the leaves, and not only deform the plants but also cause economic loss. This is because in severe infestations, plants wilt, rot and die, causing volumes of loss to the local farmer.

Like other aphid species, *B.brassicae (L.)* is a significant challenge for agricultural pests' management programs. One of the principle options used by growers to protect their crops from aphids, particularly under outbreak situation, is the indiscriminate use of chemical / synthetic pesticides such as Chlorpyriphos 48% E.C and Demethrin 28% E.C, often leads to deleterious effects on beneficial insects and humans, development of resistance, secondary pest outbreaks, excessive pesticide residues, soil and water pollution and other ecological consequences of these pesticides As a result of these critical effects of conventional pesticides, growers have to adopt more environmentally friendly integrated pest management or organic farming approaches (Leake,

2000; Cuthbertson and Murchie, 2003). Most specifications of these chemicals are hardly understood by many farmers as most of farmers are illiterate, semi-illiterate or the language is complex and technical. Besides, adulteration of agro-chemicals and presence of counterfeits on the market make the pesticides non responsive. Ecological Organic Agricultural approaches such as relying on locally made natural pesticides give good results without harming the environment and with less expenditure on synthetic pesticides.

In Kakira**,** farmers use synthetic pesticides in control of crop pests including cabbage pests. Coupled with the expenses on its purchase cost, most specifications of these chemicals are hardly understood by many farmers as majority of farmers are illiterate, semi-illiterate or the language is complex and technical. Besides, adulteration of agro-chemicals and presence of counterfeits on the market make the pesticides non responsive hence pests build up resistance in the region. Whereas Neem tree is mostly known for treating Malaria because of its bitter tastes (Marlene, 2014). It has a repelling scent which may drive away or kill crop pests and it also a source for bio-pesticide, besides presenting antibacterial and antivirus properties (Wilson, 2005). Formulation of new bio-insecticides, particularly those based on Neem tree extract, was an exciting option for integrated pest management programs in Kakira. Plant-derived insecticides have various benefits, including selectivity, greater safety for non-target organisms, and compatibility with biological control organisms (Tang *et al.,* 2002). The primary active ingredient of most Neem-based pesticides is azadirachtin, a limuloid compound, which has multiple biological activities on more than 400 insect species from several orders (Schmutterer and Singh, 1995). Besides azadirachtin, there are other active components in some formulations. Azadirachtin-based compounds obviously have insecticidal, feeding deterrent, repellent, antioviposition, and physiological properties (Mordue and Nisbet, 2000; Ulrichs *et al.,* 2001; Tang *et al.,* 2002). In Sanambele, topical application of neem leaf slurry has been used as a pre-harvest pest management strategy since 2000 (Gamby *et al*, 2001; Howard *et al*, 2009) used only the supernatant while we used the entire Neem plant, thereby mimicking the actual concentration of the extract. Plant parts, such as cells and organelles, contributed to the weight used to calculate our concentration value.

In pests' control locally, some farmers in Kakira used Neem tree extract to control pests in their gardens but no dosage, frequency and its production cost has been established and documented.

A field study was carried out to explore possibility of using Neem tree extracts to control aphids in cabbages under smallholder farming systems. The main objective of the study was to investigate

the efficacy of Neem tree extract in control of aphids in cabbages and the specific objectives included; to identify the most effective concentration of the admixture of Neem tree extract in controlling aphids on cabbage, to establish the effective frequency in application of Neem tree extract in controlling population of aphids on cabbage

1.2 Problem Statement

Cabbages are affected by pests such as grey aphids, *B.brassicae (L)* and green peach aphids, *M.persicae (*Sulzer), with the grey aphids, *B.brassicae* being the strain of Economic Importance. These together with green peach aphids, *M.persicae* rage havoc in the Kakira region (Boyles *et al.,* 2012). Aphids are polyphagous pests of many plant species causes damage to the plants by direct sucking of xylem sap from the stems or leaves of the plants. In addition to mechanical and physiological damage, they are also responsible for transmission of varieties of viral diseases; their damage potential is exacerbated by the capacity to vector over 100plant viruses, resulting in a wilting, deformation, premature leaf senescence, and retarded growth rate of the plant (Pegadaraju *et al.,* 2005). Hence they must be controlled. These aphids thrive well in both sunny and rainy seasons, and frequently cover cabbage plants in all stages of growth with dense clusters of whitish green and grey aphids. They suck sap from the leaves, and not only deform the plants but also cause economic loss. This is because in severe infestations, plants wilt, rot and die, causing volumes of loss to the local farmer (Zachary, 2015)

In an attempt to deal with the loss, Farmers have always used synthetic pesticides to control the above mentioned pests but as a result of over use or not following specific instructions of these pesticides, pests especially aphids have built resistance to the synthetic pesticides (Randall, 1999, Cornelius *et al*, 2006, Joey 2014, and Zachary, 2015). In all efforts to provide an alternative, plants' extracts such as Neem leaves have locally been used by farmers to control the aphids on trial bases. However, the efficacy of the Neem tree extracts in the control of cabbage aphids has not been clearly studied to establish the extent to which it could control the aphid in production of cabbage and other crops, as well as its economic effectiveness which this study was intended. Hence; environmental, economic and social aspects of sustainability has been addressed in the study

1.3 Main Objective

The study's main objective was to investigate the efficacy of Neem tree extract against aphids in cabbages.

1.4 Specific Objectives

(a) To identify the most effective concentration of admixture of Neem tree extract in controlling aphids on cabbages.

(b) To establish the effective frequency of Neem tree extract application on cabbage aphids population.

1.5 Hypotheses

The study was be guided by the (Null) Hypotheses that Neem tree have unique scent that renders them less affected by pests, therefore creating an assumption that Neem scent and taste can repel cabbage aphids.

i. Different admixture of Neem tree extracts are significant to cabbage aphids control

ii. Cabbage aphids' population is affected by the frequency of Neem tree extract application

1.6 Justification of the study

Pest control, climate change; form the greatest challenge to cabbage producers in Uganda. The conditions provided by climate change favor crop pests to flourish. Limited tools to combat these pests are one of the major contributing factors to the high risk associated with Cabbage production in general. Consequently, high management level of pests control was required for success. Successful production of organically grown Cabbages requires an even higher level of management for profitability to occur because even fewer control tools are available to producers using this production system. Pest control was often a result of the cumulative effects of many production practices. Emphases were placed on prevention rather than control. This often was difficult to achieve with current technology. For instance; World Food Production experience the following problems: High energy costs / high cost of production, Groundwater contamination, Soil erosion, Loss of productivity, Depletion of fossil resources, Low farm incomes, Overuse of inorganic chemicals, Risks to human health and wildlife habitats, nutrient losses, soil degradation, and compromised biodiversity (Tilman *et al.*, 2001).

Pesticide problems, among which included economic and energy costs, pests resistance to pesticides, disruption of natural control, target pest resurgence, induced secondary pest outbreaks, Human health hazards (acute and chronic effects [user and consumer risks], environmental pollution and effects on wildlife and effects on pollinators). Therefore, growers must develop pest

control strategies by having an understanding of the pests and the natural enemies that usually occur in a given crop, the ability to anticipate pest problems at early stage and manipulate practices that minimize pests and maximize natural enemies' benefits.

The choice of the Neem tree extract was based on the assumption that the strong smell and other natural repelling properties could kill or drive away the pests during dry season. In a similar study about efficacy of Neem oil seeds on pests, an experiment was done in two jars, using two leaves, and two grasshoppers. One leaf was sprayed with a chemical insecticide and another with Neem oil. The two grasshoppers were put in the two jars, with one leaf each. The first grasshopper ate the leaf and died almost instantly. The second grasshopper with the Neem oil covered leaf did not die instantly; it lived at least for some few days; eventually it starved to death. Formulation of new bio-insecticides, particularly those based on Neem oil extract, has been an exciting option for integrated pest management programs, since such plant-derived insecticides had various benefits, including selectivity, greater safety for non-target organisms, and compatibility with biological control organisms (Tang *et al.*, 2002). This was the motivating factor for this study although the concentration in a leaf which killed the aphids was not known. The Neem tree plant was generally known to be harmless to the human being because of its medicinal properties and thus environmentally friendly. The extract of Neem tree was easy to get and cheap, especially if planted around the farm, therefore making it pocket friendly especially to the rural based farmers**.**

Plate 1.1: showing Neem Tree plant and its parts

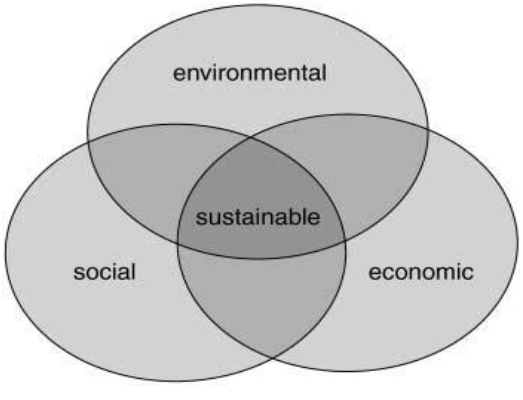
a: Neem Tree Plant b Neem Tree Root c Neem Tree Bark d Neem Tree Leaves

Source: researcher

Neem, *Azadirachta indica* is an evergreen tree, native to the Indian subcontinent. It belongs to Meliaceae family plants, which are the major source for diverse limonoids (Tan & Luo, 2011). Neem has been used in Ayurveda, Siddha, Unani and other Indian local health traditions. Over 700 herbal preparations and over 160 local practices containing Neem ingredients are known in India, which claim to prevent various ailments or disorders in humans (Brahmachari, 2004). Neem based Pesticidal formulations are widely regarded as organic, and are found to have low toxicity against non-target beneficial organisms as compared to synthetic pesticides

Although Neem tree extract has been researched upon, there is still information and research gap on the sustainable use of Neem tree extract on cabbage aphids control methods user friendly to the rural based white cabbage growing areas. This research aims at filling the information gap of the various Neem tree extract use as sustainable pests control method of white cabbage aphids. This will also improve on food security, house hold income of the peasant farmers and environmental health of the community in Kakira and outside Kakira Sub County. If the study was not conducted, the three pillars of sustainability would have not been addressed. An illustration of the three pillars of sustainability as shown below:

Figure 1.1; showing the three pillars of sustainability which use of Neem tree extract would address in the community



(Source: Bowler 2002)

Environmental health; sustainable production must be based on living ecological system (processes and recycling of resources) the concept of a living soil for healthier foods, enhanced use of local ecosystem resources and preserve biodiversity.

Economic profitability; economic production must be based on low production input cost with increased output(yields, quality , quantity and safety) through use of re-useable inputs, recycled energy, efficient management of materials to improve equitable and accounts for social and environmental course, care must be taken in the event of new technology and practices for safety and health of the system(attached values to ecological asset like bees that pollinate crops, medicine and the forests which act as wind breakers).

Social and economic equity; the study relates social and economic equity to the principle of health in Organic Agriculture that prohibits the use of synthetic chemicals in Agricultural production. Farmers are encouraged to produce high quality, nutritious food that contributes to preventive health care and wellbeing. At local level, farmers group participation, group action, and promotion of local institutions, culture and farming communities.

The study has contributed to the Government plans such as Plan for Modernization of Agriculture Evaluation, (2005), Prosperity for All under Strategic Development Plans of 2007-2011, Operational Wealth Creation which were being implemented by Soldiers (UPDF) among farmers throughout the country. All these PLANs aimed at poverty reduction among poor households through increase income, reduced cost of production, biodiversity conservation, collective marketing and value addition, food security, improved nutrition. The study recommends all the above in Government plans through promotion of Neem tree growing among rural households as per the health benefits, medicine, pesticides, carbon absorption, nutritional, wind breaks, hard wood when mature, renewable naturally and recyclable. Healthy soil produces healthy crops that foster healthy animals and human being for production labour.

1.7 Scope of Study

This experiment was carried out at Kakira Sugar Limited in Agriculture Department, Horticulture Section (SMM Bungalow), 13km East of Jinja Municipality (Uganda). The content of the study was investigation of the efficiency of Neem tree extract on cabbage aphids where freshly harvesting of Neem tree parts (root, bark and leaves) were done, crashing in a mortar, weighing 1000g of each part, soaking in 10litres of water for 12-24hours, sieving and varying in different

concentrations of 20mls, 30mls, 40mls and 00mls at random. The most efficient concentration was then varied at a frequency of once a week, twice a week and once in 2 weeks respectively. The study was conducted for two growing seasons; each season took a period of four months from planting to harvesting. All other cabbage field management practices were applied.

1.8 Significance

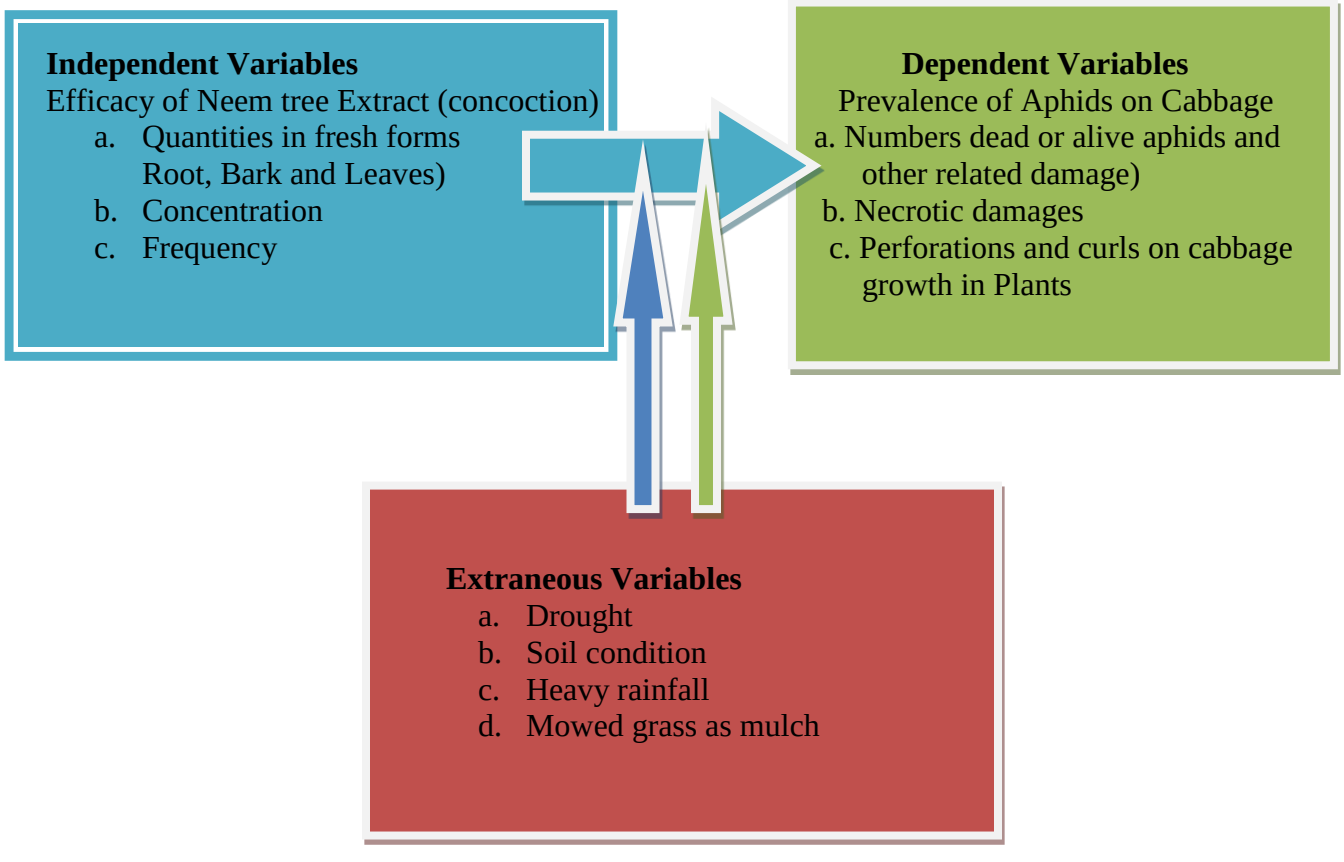
Table 1.1: The Results – Beneficiary Table

Results	**Beneficiary**	**Virgin land**
Social and economic equity: -Employment creation for cabbage producers - Production of high quality, nutritious food - Contribution to preventive health care and wellbeing of people - Promotion of local institutions, culture and farming communities - Promotion of farmers' group participation and action	- Local Farmers/ Organic producers benefit from shade during meetings / cultural gathering or function. -Consumers and the whole community including children, youths, adults and aged groups. - Environmental service such meeting gardens / prayer gardens for the community.	-Farm activities such as growing of cabbage crop in large scale for commercial purposes -Lower cost in production because you spend less on soil fertility management - Carbon dioxide sequestration services - Wind breakers and shade for home use
Economic profitability: - Low production input cost with increased output (yields, quality, quantity and safety of cabbages produced which attract premium prices hence higher income earnings. - Premium prices which leads to higher income earnings. - Food security the population -Used as human medicine in treating malaria and stomach pain	Local producers / consumers, Rural development Local government through taxes Central government through revenue levied cabbage exports.	-Inputs are re-useable, recycled energy, efficient management of Neem tree plant to improve equitable and accounts for social and environmental course - Attached values to ecological asset like bees that pollinate crops, medicine and the forests which act as wind breakers - Collective marketing / value addition
Environmental health - Living ecological system through processes and recycling of Neem tree parts (resources)	-Local producers / Kakira community / traders / service providers, children, adults and aged groups in the community - Soil biota and abiota	- Clean and healthy soil free from pollution reduces ill-health and related effects. - Microbial activities and functions through decomposition

- Enhanced use of local ecosystem resources and preserve biodiversity - Improved nutrition in terms high mineral and vitamin content - Soil fertility improvement		process of dead organic matter from cabbages and Neem tree parts.

Source: researcher

Figure 1.2: Showing Conceptual Frame Work



Source: researcher

Explanation of the Concepts in the Frame Work

The application of Neem tree extracts has a controlling effect on the aphids on cabbage. It is however, not established the extent to which this effect is effective. It is hereby conceptualized that application of different quantities of fresh form of Neem tree extracts, at difference times and varying concentrations determines the prevalence of cabbage aphids. The numbers of either dead or alive aphids, or the degree of damage the aphids inflict on the cabbage are all dependent on the

rate, amount, concentration and frequency of application of the fresh form of Neem tree extracts. It can never be ruled out that prevalence of the aphids and the damage inflicted on the plant may be as a result of other external factors such as, the weather conditions, soil conditions, availability of predators, and presence of alternative hosts. There are the external variables that may be the sources of error and usually need to be controlled.

1.10 Definition of Terms

Experiment: This is "engineering" particular forms of learning and systematically studying of those forms of learning within the context defined by the means of supporting them.

Efficacy: means effectiveness of Neem tree admixture extract.

Neem Tree Extract Admixture: addition of Neem tree parts (root, bark and root) in equal proportion and mixing them together

Treatment: allocation of different concentration of Neem tree admixture in (20mls, 30mls, 40 and 00mls) per 10liter of water into different plots randomly

Frequency: the rate at which Neem tree extracts application was done (once a week, twice in a week and once in 2 weeks)

Concentration: weight of Neem tree admixture extract realized from the root, bark and the leaves crashed, weighed and soaked in 10litres of water to obtained pure Neem tree juice which was further diluted and sprayed onto cabbage crops. The further dilution of the Neem juice is the concentration in this context.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The literature review is to provide the theoretical frame work of the research. It is to site various literatures on white cabbage growing in an organic set up and pest control among others. The relevant literatures were guided by the research hypotheses as outlined in chapter one. The sources were journals, text books, articles and reports which were supplemented by materials sited from the internet.

2.1 Theoretical Frame work

The study was guided by Wilson‘s theory of 2005 who stated in India on Mother Earth Magazine that Neem Tree Extract Obtained from leaves can be used in diluted form in several agricultural applications, as well as in medicine and veterinary purposes as this was one of the importance of Neem tree extract (Wilson, 2005)

According to Ozone-biotech (2012), “Neem tree is the world’s number one herb” Every part of this tree has medicinal value and all parts of this tree can be used, from the sap, twigs, flowers, and bark to the seeds, gum, fruit, and roots. Neem is used to combat tiredness, cough, fever, loss of appetite, and worm infestations, skin diseases, and excessive thirst. It heals wounds, reverses gum disease, reduces high blood pressure, and is used to treat arthritis, malaria, diabetes, liver disease, and cancer. Neem leaves reportedly remove toxins, purify blood, and prevent damage caused by free radicals in the body by neutralizing them. Neem seeds and leaves are purported to be spermicidal.

The same source reported that Neem Tree Extract obtained from leaves can be used in diluted form in several agricultural applications, as well as in medicine and veterinary purposes. Making an addition of distilled water to a jammed and triturated foliar mass the extract is obtained with a pleasant aroma. He further said Neem leaves liberate greasy acids to be used in essential oils to help on restoring skin elasticity, while it disinfects and cure many dermatological chronic illnesses and deep cuts that demand immediate action. The ingredients of this extract are, triturated leaves of Neem, alcohol from cereals, and distilled water (Wilson, 2005)

Dried Neem Leaves normally sold in bags of 25kg and destined to farmers as pesticide and insecticide. When added to water they form a composed liquid with addition of an emulsion agent. As a medicinal product, the Neem tea has been used as a natural help for arthritis, hematologic clutters, migraines, colds, diabetes, eczema and malaria. However, for being much bitter tastes it he has been now using in capsules (Wilson, 2005)

Neem powder from rind (bark) - the rind of trunk can be removed at regular intervals to be used as powder in predominantly medicinal form. It has also been used historically in some herbaceous

cosmetics, and in medicines and products for toiletry. In the ayurvedic medicine it is considered as anti-inflammatory and has proven anti-septic properties. It is efficient against cuts, wounds, acne, besides having analgesic effect and able for controlling diabetes. When mixed on water and oil, it may help on removal of skin spots. It has also veterinary applications for protecting animals from fleas and plagues. Also Neem powder extracts are excellent mouth deodorant (Wilson, 2005)

Neem is the "village pharmacy." Every part of the plant has bioactive compounds that can be used in medicine and agriculture. It is a fast growing tree that can provide fire wood, shelter, food, medicine, and crop protection. The western world is just beginning to learn of the benefits that this tree offers. Neem leaves are considered safe to take internally on a regular or daily basis provided you are not pregnant or trying to conceive (Chandra D. *et al,* 2014)

Marlene, (2014), stated that "Neem won't harm spiders, butterflies, ladybugs and other insects that pollinate plants because Neem must be ingested to be effective. Pests that eat the treated leaves will eventually die while 'good' insects are spared

The **proponents of Wilson's theory** were; Ermel *et al,* (1987) in their findings suggested that the growth regulatory effects of formulated Neem-based products may rely on the host plant, aphid species, treated aphid instar, or the climate conditions. Yes I do agree with them.

The second proponent of Wilson's theory were Akol *et al,* (2002) and Akol *et al,* (2003) in their study in Kenya found out that extracts from the Neem tree, *Azadirachta indica* A. Juss, was effective against the DBM and had low negative effects on *D. mollipa*, the indigenous DBM parasitoid, and therefore, could be used as alternatives to synthetic pesticides where they are available. This finding concurs with our study that Neem tree extract really control aphids it can be used as alternative to synthetic pesticide where they available or planting should be promoted.

Another proponent of Wilson's theory was Liu and Liu, (2005) who suggested that alternatively, azadirachtin and other constituents in Neem extracts may vary in their efficacy depending on geographic origin and yearly variations in environmental growing conditions of the Neem tree. They said there was also evidence that the method of Neem extraction affects the effectiveness of the insecticide formulation, and thus may vary considerably between manufacturers of which I do agree with them

Birhanu *et al,* (2011) supported Wilson's theory by their laboratory experiment on the efficacy of Melia azadarach and Mentha piperita Plant Extracts against cabbage aphids, *B.brassicae* (Homoptera: *Aphididae*). The study mention that Gondar highlands were unable to afford the cost imported chemical pesticides. In order to find out which alternative strategies use in pests control, Farmer's laboratory studies were conducted to check the efficacy of solvent extract of *Melia azadarach* leaves and seeds and *Mentha piperita* leaves against aphids. Three concentrations of methanol and aqueous extract such as 0.25, 0.5 and 1% were tested against aphids by choice and no choice method. In no choice method methanol extract of *Melia* seeds treatment showed minimum number (1.3±0.57) of aphids at 0.25% concentration. Higher concentration (1%) of *Mentha* leaves and lower concentration (0.25%) of *Melia* seed treatment recorded only 0.6±0.57 aphids. Irrespective of concentration and period of exposure wide fluctuation was observed in choice method. Among the three extracts tested, *Mentha piperita* leaf extract and *Melia azadarach* seeds extract showed promising result. These two plants are easily growing in Ethiopian highlands and it is found to be suitable for resource poor farmers to control aphid menace in cabbage. The study concluded that the two plants studied under laboratory conditions showed promising results against aphids and also a lot of scientific reports confirmed the bioactivity of the selected two plants. Therefore, a small scale farmer can prepare any one of the plant extracts to protect their cabbage crop from aphid's infestation and guard their environment from dreadful toxic chemical pesticides used for pests control programme.

Wilson's theory was supported other authors such as Markouk *et al,* 2000; Tare *et al,* 2004; Ateyyat *et al,* 2009 who discovered how botanical insecticidal plants such as Neem (*Azadirachta indica* A. Juss.) and wild garlic (*Tulbaghia violacea*) works, their activity against specific target species and biodegradable to non-toxic compounds, which can be used in integrated management programmes. In their study, Neem extracts acted as a strong antifeedant and repellent, delay and prevent moulting, reduce growth, development and oviposition; and can cause high mortality, in more than 200 insect species, including whiteflies and aphids according to Mitchell *et al.,* 2004; Kumar *et al.,* (2005) and Kumar *et al.,* 2006.

Although all parts of Neem tree possess botanical, they have an effect on some important physiological processes in insect such as are survival, longevity, molting and reproduction (Mordue and Nisbet, 2000; Ulrichs *et al.,* 2001; Tang *et al.,* 2002). Despite the registration of Neem formulations for many insect species, their efficacy for several plant pests in field and

greenhouse experiments has been reported to be variable (Akey and Henne berry, 1999). Such variations in efficacy are both dose- and time- dependent and often times are caused by the mixture of components in Neem extracts (Mordue and Blackwell, 1993). Furthermore, methods of extraction, storage conditions, origin of Neem, or contamination with mycotoxins can affect their action (Ermel *et al.,* 2002). The objective of this work is to evaluate the efficacy of Neem tree extract on cabbage aphid

It was reported by Mukiibi, 2001 that growth and yields of cabbage can be seriously reduced by heavy infestation of aphids and Cabbage lopper (*Trichoplusia ni)* which feeds on the leaves and causes damage by cutting the foliage. Other pests they mentioned included; slugs, thrips, Bagrada bug *(Bagradahilarus),* American bollworm *(Helicoverpa armigera),* Cabbage webworm *(Helula spp.),* Greater cabbage moth *(Crocidolomi abinotalis),* Red spider mite, Cutworm *(Agrotis spp.),* and Nematodes. Aphids are managed by use of plant extracts and plant products that are eco-friendly and are more effective control of aphids. According to Shreth *et al,* (1998) use of Neem products and Lantana products to protect plants against aphids would be encouraged Some biological control activity has been observed in the field with *Coceinelids wasps, lady bird's, beetles, Didegma species and chicken* being the common natural predators of the above mentioned pest however, biological control is not sufficient during dry season, (Mukiibi, 2001)
Inorganic pesticides are also being used in control of the above pest but slugs, snails and aphids some time build resistance from this sprayed pesticide hence affecting production quality. Most of the population is low income earners: one third of the population earns less than $400 per week, indicating poor financial capacity to adapt to change. This may mean that many residents in the region are living below the poverty line, which is $234 per week. (Queensland government, 2014)

The opponents of Wilson's theory were; Griffiths *et al,* (1989) who in their findings found out that all Neem-based pesticides used in their study failed to significantly deter the settling behavior of *M. persicae* treated leaf disks for the same aphid species. However, aphids fed on treated plants produced significantly less honeydew during the first 24 h after Neem application relative to the control, including on plants with their roots immersed in Azatrol solution. I do not agree with them but the research is yet to prove whether it was right or wrong.

2.1.1 Neem Tree Extract Admixture Concentration for Cabbage Aphid Control

Objective one was to examine the most efficient concentration of Neem tree admixture extract that controls cabbage aphids. Here were some of the various literatures sited to aid in this objective one;

Neem tree (*Azadirachta indica* A. Juss.) belongs to Meliaceae family and is a multipurpose tree containing azadirachtin and other pesticide components. Sustainable pest management is crucial for successful farming in sub-Saharan. Africa as most economies are heavily dependent on

agriculture which has intensified the use of pesticides. However, farmers in this region repeatedly complain that synthetic products are unaffordable, unavailable, poorly labeled or packaged, frequently adulterated and sometimes sold after expiry date. Coupled with health and environmental hazards posed by the misuse of synthetic pesticides, there is now considerable interest in the application of botanical pesticides for crop protection. Botanicals are biodegradable and less persistent in the environment and their use should lower risks to health and development of resistance.

Despite the increasing interest in botanical pesticides, their commercial production remains limited. Several reasons have been suggested for the limited production including; i) lack of data on the efficacy and safety; ii) no ready to use products; iii) inconsistent performance of crude extracts and iv) lack of clear practicable registration procedures (Wilson, 2005). The demand for botanicals is poised to grow due to an increasing shift in consumer demands for safe food, increase in organic farming and lobbying from environmentalists. In India, four botanical bio-pesticides are registered under the Insecticides Act, 1968 of which only Neem, *Azadirachta indica* holds potential for a large scale use in agriculture. Over 450 azadirachtin based products are registered. The estimates show that about 2.7 million liters /1000 tons of Aza based pesticides are reportedly used per annum. These control a wide range of pests on a number of crops including pulses, vegetables, turmeric, ginger, rice, cotton, jute, sorghum, fruits, coffee, tea, and flowers

Neem Extract – Obtained from leaves as an extract which can be used diluted in several agricultural applications, as well as in medicine and veterinary purposes. Making an addition of distilled water to a jammed and triturated foliar mass the extract is obtained with a pleasant aroma. Also Neem leaves liberate greasy acids to be used in essential oils to help on restoring skin elasticity, while it disinfects and cure many dermatological chronic illnesses and deep cuts that demand immediate action. The ingredients of this extract are, triturated leaves of Neem, alcohol from cereals, and distilled water (Wilson, 2005).

The same author said dry Neem leaves normally sold in bags of 25kg and destined to farmers as pesticide and insecticide. When added to water they form a composed liquid with addition of an emulsion agent. As a medicinal product, the Neem tea has been used as a natural help for arthritis,

hematologic clutters, migraines, colds, diabetes, eczema and malaria. However for being much bitter taste it he has been now used in capsules.

Neem powder from rind (bark) - the rind of trunk can be removed at regular intervals to be used as powder in predominantly medicinal form. It has also been used historically in some herbaceous cosmetics, and in medicines and products for toiletry. In the ayurvedic medicine it is considered as anti-inflammatory and has proven anti-septic properties. It is efficient against cuts and wounds, besides having analgesic effect and able for controlling diabetes. When mixed on water and oil, it may help on removal of skin spots. It has also veterinary applications for protecting animals from fleas and plagues. Also Neem powder extracts are excellent mouth deodorant (Wilson, 2005).

In a similar study about efficacy of Neem oil seeds on pests, an experiment was done in two jars, using two leaves, and two grasshoppers. One leaf was sprayed with a chemical insecticide and another with Neem oil. The two grasshoppers were put in the two jars, with one leaf each. The first grasshopper ate the leaf and died almost instantly. The second grasshopper with the Neem oil covered leaf did not die instantly; it lived at least for some few days; eventually it starved to death. Formulation of new bio-insecticides, particularly those based on Neem oil extract, has been an exciting option for integrated pest management programs, since such plant-derived insecticides had various benefits, including selectivity, greater safety for non-target organisms, and compatibility with biological control organisms (Tang *et al.*, 2002) and lower relapse rates (Tang *et al.*, 2007), whereas others find no such effect (Tang *et al.*, 2002). However, it is important to note that the studies with null findings had significant treatments difference compared with control plots in which long-term effects were found. Specifically, Tang *et al*, (2002) examined supportive-expressive

The primary active ingredient of most Neem-based pesticides is azadiractin, a liminoid compound, which has multiple biological activities on more than 400 insect species from several orders (Schmuttere and Singh, 1995). Besides azadirachtin, there are other active components in some formulations. Azadirachtin-based compounds obviously have insecticidal, feeding deterrent, repellent, antioviposition, and physiological properties. They have an effect on some important

physiological processes in insect such as are survival, longevity, molting and reproduction (Mordue and Nisbet, 2000; Ulrichs *et al.*, 2001; Tang *et al.*, 2002).

Despite the registration of Neem formulations for many insect species, their efficacy for several plant pests in field and greenhouse experiments has been reported to be variable (Akey and Henneberry, 1999). Such variations in efficacy are both dose and time dependent and oftentimes are caused by the mixture of components in Neem extracts (Mordue and Blackwell, 1993). Furthermore, methods of extraction, storage conditions, origin of Neem, or contamination with mycotoxins can affect their action (Ermel *et al,* 2002).

Neem can be used against the following pests: African armyworm, African bollworm, Aphids, Banana weevil, Cabbage looper, Cabbage moth, Cabbage webworm, Coconut mite, Cutworms and Diamondback moth (Gianotti *et al,* 2008)

This implies that Neem stops insects from eating the plants; Part of this action is due to the hormone like action of Neem oil that was explained in the above experiment. Insects "forget" to eat after they have been in contact with even traces of Neem oil. But it is also the presence, the mere hint of a smell of Neem oil that seems to be enough to keep leaf eating insects away. Neem oil can be very powerful as an anti-feedant and insect repellent. This anti-feedant property is one of the most often advertised and lauded properties of Neem oil insecticide (Gianotti *et al,* 2008)

However, the hormonal effects described above are even stronger. Neem oil as an insect deterrent works well against grasshoppers and leafhoppers, but all other insect pests is controlled mostly through the hormone action. The delay of the hormonal effects, and the fact that they may take days or weeks to manifest; makes people overlook them; “It's a shame, because the hormonal effect is where the real power of Neem oil lies.” It's the key to Neem oil being an effective insecticide and good for the environment at the same time. It's also important to understand this effect to use Neem oil insecticide correctly
(http://www.discoverneem.com/neem-oil-insecticide.html viewed on 12th / November / 2015)

The same source reveals that Neem oil works from inside the plant: Many insecticides break down quickly. They wash away with rain, or when irrigating or the sunlight destroys them. You either have to spray all the time or you have to spray something that's so stable that it stays around forever. That means the chemical builds up everywhere and eventually poisons everything, including you. Neem oil breaks down very quickly, too. It is especially susceptible to UV light (Gianotti *et al,* 2008)

But Neem oil is also a systemic insecticide. That means it can be poured onto the soil (not pure Neem oil of course, a dilution or extract that the plants can absorb and take up into their tissue for internal protection. However, this does not work for all insect species. The Neem ingredients accumulate in the tissues deeper inside the plant. The phloem, the outermost layer, contains hardly any tiny aphid that feeds from the phloem; it cannot penetrate deep enough to get a dose of Neem. But any leaf hoppers, grass hoppers or similar chopping insects will be incapacitated quickly. People eat Neem leaves to cleanse the blood, stimulate the liver, and boost the immune system. So we certainly don't need to worry about a bit of Neem inside our lettuce leaves. To him this was a much more attractive option than having poisonous fungicides build up in the garden (Gianotti *et al,* 2008)

However, Neem oil suffocates insects both pests and beneficial insects; at this point it may be harmful to the beneficial insects therefore care must be taken to protect beneficial insects since they are mostly active during the day. The best time to spray Neem insecticide is very early in the morning, so the spray can dry before the good insects become active. Also a good time is the late afternoon or evening. Once the spray has dried it does not harm bees, ladybugs, lacewings, predatory mites and wasps. (Gianotti *et al,* 2008)

Cabbages been attacked by a complex of aphid species, including turnip aphid, *L.erysimi* (Kaltenbach), green peach aphid, *M.persicae* (Sulzer), and cabbage aphid, *B.brassicae* (L) (Franke *et al,* 2009 and Boyles *et al,* 2012). When aphids form dense colonies on developing flowers, yield losses of up to 70% have been reported if infestations are left untreated (Boyles *et al,* 2012). Cabbage aphid has become the most damaging aphid species colonizing winter canola under mixed aphid-species infestations (Boyles *et al,* 2012). Cabbage aphid is an herbivorous perennial pest restricted to members of the Brassicaceae (Boyles *et al,* 2012). Cabbage aphid develops through

four nymphal instars before reaching physiological maturity and starting parthenogenetic reproduction (Hughes, 1963).

Varela *et al*, (2003), in their study also found out that a wide range of insect pests' attacks to the crop was the key to its low yield. The aphids, *B.brassicae* (L), *L. erysimi* (Kaltenbach) *and M.persicae* (Sulzer), the webworm, *Crocidolomia binotalis* Zeller, thesawfly, *Athalia* sp. and cutworms, *Agrotis* species, were the major insect pests. Although aphids has been identified as the key pest of brassica crops in Kakira Region, Jinja district, Pests had been found to pose one of the greatest challenges to food security.

The randomized complete block design (RCBD) was the study design chosen since it was one of the most widely used experimental designs in forestry research. The design was especially suited for field experiments where the number of treatments was not large and there exists a conspicuous factor based on which homogenous sets of experimental units could be identified. The primary distinguishing feature of the RCBD was the presence of blocks of equal size, each of which contains all the treatments (Cocharan, 1980); (Clewer and Scarisbrick, 2001)

Early eighty's Cocharan stated that "Randomized Complete Block Design (RCBD) was the design used mostly in Agricultural research". He further said in the present work today, experimental plots would be first classified into groups or blocks, of the plots that would be nearly a like as possible. The treatments would then be assign to the plots within the blocks in such a way that each treatment would occur the same number of times, usually once within a block.

The objective was to make the variation from plot to plot as small as possible within each block while maximizing the variation among blocks. For this reason it was essential that not only should the plots be as alike as possible within the blocks, but during the course of the experiment uniform techniques or in other conditions that might affect the results should be made between blocks. If the fertility or the gradient exists, blocks should be a long and narrow, with the long axis perpendicular to the gradient. Blocks would be laid out to avoid the effect of such physical features as roads, fences, rows of trees, ridges, water courses, soil type, boundaries and buildings. When the blocks would be form, each was to be handled as a unit during the course of the experiment.

Field operation such as seeding, cultivation and harvesting would be completed in one block before moving to another.

In short, it may be mentioned that while randomization is a method of eliminating a systematic error (*i.e*., bias) in allocation thereby leaving only random error component of variation, the other two *viz*., replication and local control try to keep this random error as low as possible. All the three however are essential for making a valid estimate of error variance and to provide a valid test of significance. (Clewer and Scarisbrick. 2001)

2.1.2 The frequency of Neem tree extracts application on cabbage aphids' population

Objective two was to determine the efficient frequency of Neem tree extract application on cabbage aphids' population. The various literatures sited to aid in this objective included;

Varela *et al.* (2003), whom in their study found out that cabbages were attacked by several aphids. Aphids are soft-bodied, small-headed insects with a pear shaped body. They suck the life out of all kinds of plants including trees, flowers and edibles. Leaves can turn yellow or brown – or curl up like a giraffe's tongue! They might resemble other bugs but their signature body parts are the two cornicles on their rear ends (actually the back of the abdomen). The cornicles can be short or long depending on the type of aphid. Honeydew was not excreted from them (that comes out of the aphid's anus). Cornicles release defensive and signaling substances called pheromones that can be used to alarm other aphids of an attack from a natural enemy. But the grey cabbage aphid (*B.brassicae*) and the green peach aphid *(M.persicae)* are the most common. Damage is caused when they suck sap from the plant and contaminate the edible product. Feeding of the cabbage aphid causes a chlorosis and malformation of the leaf. The larvae of the lacewing, syrpid fly and lady beetle are soft bodied, and these beneficial insects all feed on aphids during the larval stage.

Cabbage (*Brassica oleraceae*var. Capitata L) is an important leafy vegetable that provides vitamins and minerals for healthy body development. It is a popular vegetable throughout the world because of its adaptability to a wide range of climatic conditions and soil, ease of production and storage, and its food value. Cabbage grows best in a relatively cool and humid climate. The optimum temperatures for growth and development are from 18 °C to 20 °C. Its water requirements vary from 380 to 500 mm per crop, depending on climate and length of growing season, Cabbage

can be grown on a wide range of soils but it thrives on well-drained, moisture-retentive loamy soils well supplied with organic matter and it is propagated from seeds. All management practices from planting up to harvesting is monitored / observed at all stages (Kwa Zulu-Natal, 2001).

Organic agriculture: Focus on the presence of Azadirachtin, the main active element of the Neem, of great value for the organic pesticide industries, for its effectiveness and absence of toxicity. The normal text of Azadirachtin in the Neem oil is between
1,500ppm and 2,200ppm, while a special level (premium) can be achieved with values of Azadirachtin between 2,200ppm and 3,000ppm. Higher concentration values require manipulations in industrial processes.

- *Cosmetic and toiletry products*, as tooth pastes, soaps and shampoos.
- *Pharmaceutical industry* - production for several purposes, antibiotics, anti-septic, boiled musts. The essential oils elaborated from Neem are used for treatment of psoriasis, eczema, ulcers, diabetes and acne. For being until an excellent antiviral, it is being tested even in medicines against AIDS virus. India produces 600 types of medicines made with Neem.
- *Veterinary* - Neem has applications in medical care for domestic animals including the use of soaps, shampoos and conditioners, for being anti-septic, anti-fungi, and anti-bacterial stuffs. Also they are used in horses against itch, greasy foot, bites, eruptions for the cleaning and disinfection of horse stables through a disinfecting emulsion. These organic concentrates have not regard to any chemistry or phosphates, and so are biodegradable.(Wilson, 2005)

However, the above literatures did not mention the frequency of Neem tree extract application on cabbage aphids' population rather focuses on the presence of Azadirachtin, the main active element of the Neem, of great value for the organic pesticide industries, for its effectiveness and absence of toxicity.

Neem-based pesticides had been tested elsewhere in India and found to be compatible with arthropod natural enemies of DBM (Haseeb *et al,* 2004 and Leeson, 2001). As a result, Neem-based products are being promoted as alternatives to the commonly used synthetic pesticides among crucifer growers in the region. The author did not mention the

concentration used in the application during the production of crucifer using Neem-based pesticides. This left the gap which this study has fulfilled.

Using Neem tree extract to replace toxic chemical sprays for better pest control has been considered a top priority for sustainable agriculture in the new century. In this study not only on the aphids control effects of a Neem tree extract use versus farmers 'standard practice but also on the economics of both practices have been reported. Although conservation of natural enemies is one of the goals of a Neem tree extract pesticide (IPM) program to achieve high levels of predation or parasitism to aid in pest management, few natural enemies were recorded in the present study. This could be due to prolonged use of toxic chemicals in the region. However, the goal of conservation of natural enemies could be accomplished through the use of reduced-risk insecticides, (Haseeb *et al,* 2004)

The Neem tree belongs to the family of the mahogany and cedar. Its wood is remarkable among the highly valuable species, as all its components are highly quoted in market; the fruits and seeds, leaves, twigs, bark, roots and wood. Neem tree has a very long life of up to 200 years. Its oils and extracts are among some of the best existing sources for bio-pesticide, besides presenting antibacterial and antivirus properties. All parts of Neem tree have been used in India on domestic life, ever since thousand years ago making it a multipurpose tree (Wilson, 2005). He further mentioned that, modern research have found out that the products of Neem favorably act as pesticides, insecticides, but are also effective in the medicinal area, as well as in toiletry and cosmetics. Neem components are used as raw material attainment on several industries, as seed oil, cake or paste from fruit wastes, extracts and syrups from leaves, powder of bark and leaves, and valuable timber (trunk) and firewood (roosters and branches eventually transformed into charcoal). It can be an excellent economic activity in rural areas of tropical developing countries inserted on the category of projects supporting the sustainable development while contributing for environmental enhancement. Pesticidal plants have been used by African farmers for generations and are of particular importance to poor, small-scale farmers for effective, low-cost pest control on field crops, stored products and livestock. A better scientific understanding of how these plants growth, work and its production cost implication to optimize their sustainable use by farmers was of great importance in the study.

A hypothetical model on the general cost of production using Neem tree admixture extract was suggested for future practical studies. These included cost such as seeds, labour, pesticides (extract), harvesting, transport, taxes, life span of Neem tree, technical services, value addition, soil fertility etc. and benefits such as marketable yields, the value of the crop (based on the current market price), safety and quality of the food produced, premium prices if any, income, collective marketing, producers empowerment through trainings, workshops and seminar may be by NGOs or government extension service providers, carbon absorption / carbon markets, others (sale of timbers, fire wood, roots, bark, leaves, twigs and seeds), micro-climate of the place when there many Neem trees since they are ever green trees, human and animal medicine at homesteads, use of dry leaves as organic mulch in the field, pollination services, soil fertility enhancement through microbial activities within the soil, shade for cultural / religious functions, preserved biodiversity, preventive health care and wellbeing of the community of production.

The model suggested by the researcher was derived from modeling for all scales (book), an introduction to system stimulation by Howard T. Odum and Elisabeth C. Odum, 2000). Who mentioned that human mind is good at changing its scales of mental attention, much like a zoom microscope. He said good modeling requires zoom perspectives, some top down and some bottom up, only with stimulation testing, comparing and revising with the real-world observations (word model) into more précised form.

2.2 Summary

In objective one, the literatures agreed with the proposed study in terms of the expected results but did not specify efficient concentration of admixture of Neem tree extract that is effective in the cabbage aphids' control; in objective two, the cited literatures did not mention the frequency of Neem tree extract application on cabbage aphids' population rather focuses on the presence of Azadirachtin, the main active element of the Neem, of great value for the organic pesticide industries, for its effectiveness and absence of toxicity and objective three, the different literatures cited did not point out the cost of producing a unit volume of cabbage using Neem tree extract which is sustainable and that can contribute to enhancement of the environment rather it pointed

out the use of synthetic pesticides on salable cabbages which may cause health problem in our body in the long run, an investigation study was done on the efficacy of Neem tree extract in control of cabbage aphids.

CHAPTER THREE

METHODS AND MATERIALS

3.0 Introduction

The purpose of the study was to investigate the efficacy of Neem tree extract on cabbage aphids. Determination of the most efficient concentration of Neem admixture and establishment of the effective frequency of admixture application on cabbage for aphid control, were the study's particular objectives. Additionally the study sought to estimate the cost of producing the unit

volume of cabbage using Neem tree extract in comparison with synthetic pesticides. This chapter therefore, discusses the methods that were used to achieve the set objectives. In particular, the Research design, Area of study, treatments, sample size, materials, experimental site management, data collection and sources, quality control, ethical Considerations, data analysis plan and limitation s of the study are discussed

3.1 Research design.

The study designs were true field experiments set out in a randomized complete block design, (Plates 2 a, b, c, d, e, f, g and h), for two seasons

Plate 3.2: Experimental Layout

a. cabbage seedlings b. cabbage seedlings 4weeks c. Layout of plots d. transplanting c. seedlings

e. Transplanting cabbages f. One week cabbage g. Mulching done h. Cabbages at4weeks

Photo by researcher

Randomized Complete Block Design considers the uniformity of the experimental units and the preciseness**.** Blocking design technique was used to remove the known variation among experimental units from the unexplainable random variation. Thus that the error mean square could be reduced or the power of detecting treatment differences could be increased. Sixteen plots were organized in a Randomized Complete Block Design (RCBD) with 4 replications.

3.2 Experimental Site

Field Site was located in Horticulture Section, Agriculture department; Kakira Sugar Limited, Butembe county, Jinja district (Uganda). The Kakira Nuclear Estate is located on the Kampala-Jinja-Iganga highway in the Eastern Block of Uganda. It is approximately 13Km East of Jinja Municipality and a latitude of $0^{\circ}30'$ and a longitude of $33^{\circ}17'$E. The Mean altitude is 1222 meters above sea level. The South East side of the Estate is located on the shores of Lake Victoria. The soil in the area has a lot of decompose manure from press mud and mowed grass suitable for cabbage growing but pests have built up resistance due to over use of synthetic pesticides in the area. Field size included sixteen cabbage plots planted using a variety Zawadi F_1 hybrid at a spacing of (60 x 60) cm in between rows and plants respectively at recommended spacing. The layout of the plots was to enable easy monitoring and comparison of the three different parts of Neem plant extract performance (roots, back and leaves), the balance of the four plots were left as control plots. Each plot at with the size of (2X2.5) meters carried sixteen cabbage plants. In total two hundred fifty six plants were planted in (32 x 40) meters including walk paths of 0.5meters in between rows and columns in the whole field. The Neem tree extract mixture, which was 100% Neem juice mixed with water, was applied as a foliar spray as follows;

3.3 Treatments

Treatment one (T_1) was 2:1 ratio that is to say 20mls of NME verses 10l of water. This treatment controlled aphids but it seemed to have been an under dose for the pests as was observed by the sudden re-occurrence the aphids on all the 20mls sprayed fields.

Treatment two (T_2) was 3:1 ratio that is to say30mls of NME verses 10l of water. This treatment was found to be the best in controlling aphids as it ranked first by yield results (Table 3.5 &3.6)

Treatment three (T_3) was 4:1 ratio that is to say40mls of NME verses 10l of water. 40mls was effective in controlling aphids population only that some scorching and curls were observed

on tender cabbage leaves creating an assumption that it could have been an overdose to the plants but it was second best in the yields. (Table 3.5 &3.6)

Treatment four (T4) was 0:1 ratio that is to say 00mls of NME verses 10l of water. Control plots were left under natural environment, no application was done except water only. The aphids population increased, many perforation, curled leaves and stunted plant were observed in these fields which led to low yield and were the last in yield results (plate 3.4c & d, table 3.5 &3.6)

T_1 (20ml / 10litres of water)	**T_4** (00ml / 10litres of water)	**T_2** 30ml / 10litres of water)	**T_3** (40mls / 10litres of water
Walk path			
T_1 (20ml / 10litres of water)	**T_3** (40mls / 10litres of water	**T_4** (00ml / 10litres of water)	**T_2** 30ml / 10litres of water)

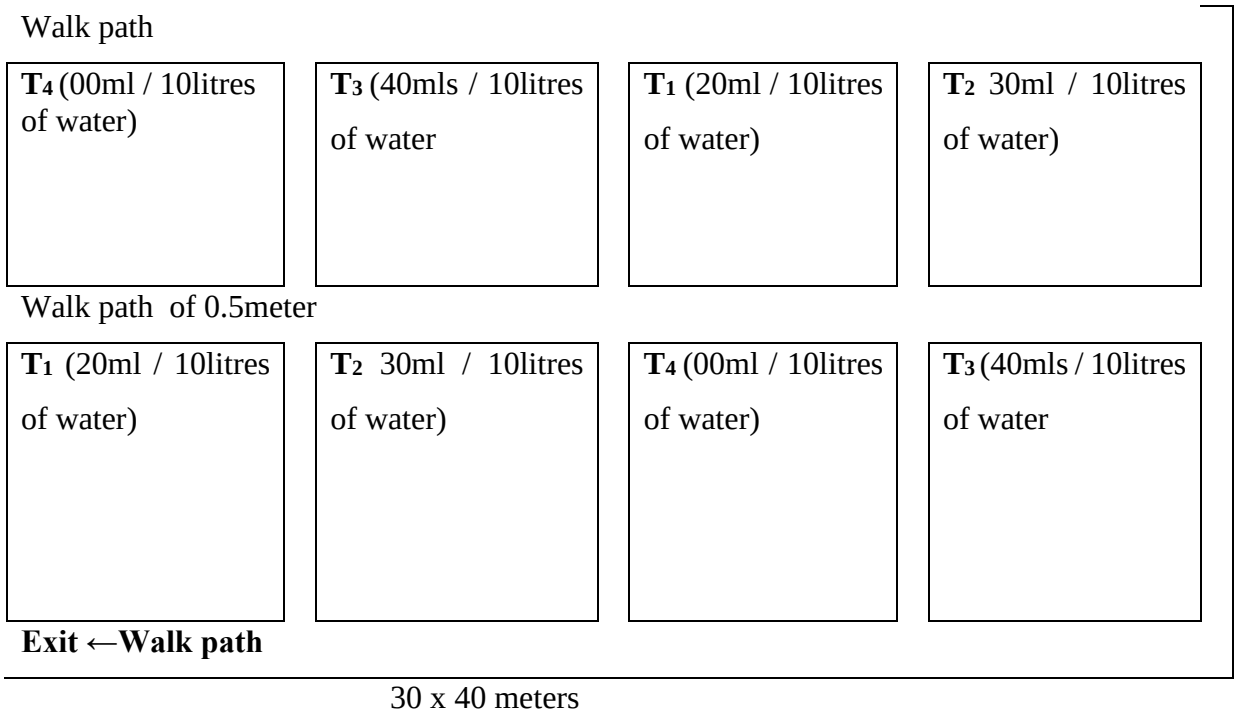


Figure 3.3: Layout of Experiment showing location of treatments

Source: Researcher

3.4 Sample Size / Plant Population

Each plot carried sixteen cabbage plants at the size of (2 x 2.5) meters per plot, totaling two hundred fifty six plants planted in (32 x 40) meters including walk paths of 0.5meter in between rows and columns in the whole field. Sample size was taken from the sixteen plots organized in a Randomized Complete Block Design (RCBD) with 4 replications to enable easy monitoring and comparison of the Neem tree extract efficacy and efficiency. Sampling patterns was done at random, problems area mapped and decision taken appropriately on the target pests.

3.5 Materials

Neem tree was identified from a geographical region of Kakira where the three parts were collected from the root, bark and leaves. Mature Neem leaves, bark and roots were collected from the same Neem tree, crashed, weighed1000g of each, mixed together in equal proportion and soaked in 10litres of water for 12-24hours, 1 week and 2 weeks respectively to get the concentration which was varied in 20ml, 30mls, and 40mls in 10litres of water dilution and sprayed on cabbage plants as three different treatments. Other inputs used included; cabbage seeds, watering can, water horse

pipes, mowed paspalam grass as mulch, one big 16liters hand spray pumps, two water buckets of twenty liters each for mixing three different Neem parts together, one measuring cylinder for the three treatments, one clean piece of cloth for sieving the solution, one plastic cup to aid in scooping solution for sieving , harvesting knife, weighing scale, a sack, a counter book, pen, pencil, ruler, digital camera, mowed paspalam grass as a mulch in all the sixteen plots and water source and the computer set for presenting this information orderly.

3.6 Experimental Site Management

Procedure: Land preparation; Hand hoes, hand shovel sisal string, measuring tape, panga, wheelbarrow, spade and hand fork were used**.** Cabbage seeds were sown on a raised nursery bed a month before transplanting of the first season. All nursery management practices were applied (as shown in the plates 3.2a & 3.2b).

3.6.1Transplanting: Transplanting was done with each plot carrying sixteen cabbage transplants, daily monitoring was done to check on pests' infestation level, weeds management period, and when to apply Neem tree extract until field harvesting was done

3.6.2 Crop Management: timely weeding was done to enhance growth vigour. This was done after one week of transplanting; mowed paspalam grass (organic mulch) was added into the sixteen plots to enhance soil life. Scouting of pests were done in the whole field

3.6.3 Sampling was done at random; the first four random selections was treated with Neem tree extract concoction extracted in equal proportion of 1000grams of each fresh part crushed into the mortar which was then diluted into 20ml, 30mls and 40mls (in 10litres of water dilution), and one plot as control and the rest of other plots were also picked at random and given various treatments for both seasons respectively. This included; the second four random selections, the third four random selections and the forth four random selections. The whole field contained sixteen plots, of which each plot was planted with sixteen cabbage plants.

3.6.4 Monitoring and Treatment Decisions

Each field/ plot was examined at least twice a week. A sequential sampling program was available for cabbage crop. Samples were made from field borders and edges next to each cabbage plants at the beginning, where aphids tend to appear first, all quadrants of the field

were checked because aphid populations are often clumped. Checking was made for cabbage aphid in the youngest, highest, and innermost leaves of young plants and pull-back wrapper leaves, natural enemies. Before cabbage forms its heads, cabbage aphids must be controlled even if only a few are present. Because of the overlapping growth of their leaves, cabbage crops require more careful management and have less tolerance for aphids even during the early vegetative stages; treatments were done at a ratio of 2:1, 3:1, 4:1 and 0:1 of the Neem tree extract as soon as 1 to 2% of plants are infested with one or more aphids. After treatment, rechecking of the fields / plots was frequently done and treatment made whenever aphids' populations reappear until harvesting was done.

Plate 3.3: showing cabbage plant with different treatments 2weeks to harvesting.

a: Researcher sprayingb:30ml/10l of water c:20ml/10l of water d:40ml/10l of water

Source: Researcher

3.7 Data Collection and Sources

The primary data was collected from all the plants in the sixteen plots / fields by physically counting the number of cabbage aphid *(Brevicoryne brassicae* (L.) and *Myzus persicae)* per plant per treatment (dead / alive), prevalence of natural enemies was registered, pest prevalence (aphids cluster), pests damage (leaf perforations, curled leaves and stunted plants), proposed theoretical or hypothetical model for general cost of production using Neem tree extract in comparison with synthetic pesticide and yields (weight in kilograms [size] of heads) at harvesting was recorded for eight consecutive weeks after transplanting for all the seasons.

Table 3.2: Sampled plants and treatment rate

Plants sampled	Concentration	Treatment	Frequency
16	**20ml/10l of water**	**Treatment (T1)**	**twice a week**
16	**30ml/10l of water**	**Treatment (T2)**	**once a week**
16	**40mls/10l of water**	**Treatment (T3)**	**Once in 2weeks**
16	**00ml/10l of water**	**Treatment (T4)**	**Control**

Source: Researcher.

b. The proposed theoretical / hypothetical model for general cost of production using Neem tree extract in comparison with synthetic pesticides.

The researcher used the following information to propose a hypothetical model which may be use for future practical research.

Environmental health; living ecological system (processes and recycling of resources), the concept of a living soil for healthier foods, use of local ecosystem resources and preserve biodiversity, nutritional and safer food, gaseous exchange

Economic profitability; carbon sequestration / carbon market, increased yields, quality and safety foods, premium prices, use of re-useable inputs, recycled energy, soil fertility management , safety and health of the system (attached values to ecological asset like bees that pollinate crops, medicine and the forests which act as wind breakers). Life span of the tree, tree products (roots, bark, leaves, twigs fire wood and timber)

Social and economic equity; production of high quality and nutritious food, healthy environment, preventive health care and wellbeing, cultural / religious functions, farmers' group participation / group action, and promotion of local institutions, culture and farming communities such as use of Neem tree extract in their local pests control.

3.8. Quality Control

3.8.1 Validity: the research ensured accuracy of the data collected or measurements of the said variables done correctly by employing the correct design and instruments of data collection as shown in plate 3.2 c.

3.8.2 Reliability: this was verified by the consistency of the results as per this case easy trace back of the results from objective one, two up to objective three of the study and the similar length of confidence intervals in the ANOVA tables.

3.9 Ethical Considerations

This research considered acknowledgement of the contributions of other writers and researchers plus all those who participated in the research success. This was verified by the various citations made in the text using Harvard system of citation format and the guidelines by Uganda Martyrs University.

3.10 Data Analysis

All raw data were entered in Microsoft Excel spreadsheets from where they were exported into the Statistical Package for Social Scientists (SPSS version 16.0) a computer software program which was used in the Analysis of variance in the edited results. The number of dead and live aphids, perforated leaves, curls, stunted growth and yields recorded. These data were explored using descriptive statistics functions in the SPSS. ANOVA was used to determine the impact of variables collected on the dead or alive aphids, perforated leaves, curls and stunted plants within the different plots and level of significances were determined in the study. The results were then presented in form of tables and graphs as well as interpreted to give significant meaning.

3.11 Limitations of the Study

The limitations of this study was that, the nearby Neem trees to be used for extracts were few making it tedious and cumbersome in terms of plant parts collection; hand picking of the fresh leaves, roots and barks; weighing, crushing, extracting solutions and diluting it for spraying, however, Neem tree parts collections were made from neighboring villages to add on what we had on site for the research accomplishment.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

Determination of the most effective concentration of Neem admixture, establishment of the effective frequency of admixture application on cabbage for aphid control, and estimation of the cost of producing the unit volume of cabbage using Neem tree extract in comparison with synthetic pesticides were the objectives of the study whose purpose was to investigate the efficacy of Neem tree extract on cabbage aphids. Presented in this chapter are interpretations and discussions of the results for the above named three objectives.

4.1 Neem admixture concentrations

The foremost objective of the study was to identify the most effective concentration of admixture of Neem tree extract in controlling aphids on cabbages. Cabbage crops were treated with different

volumes of the admixture and observations on prevalence of pests (aphids' clusters, pest damage, perforations of leaves and curled leaves, stunted plants) and total cabbage yields for each season were made and results presented in the subsequent plates and tables below as visual evidence of the results of the study.

Plate 4.4: showing aphids' prevalence on cabbage plants before spraying.

a. Healthy plant (30ml) b. scotched leaves after c. Aphids' clusters on d. cabbage applied ((40mls) applied before spraying cabbage plant in control plots

Source: Researcher

In all treatment plots where 40mls of Neem extract were applied, there was curling of leaves, three days after the application of the concoction. (See plate 4.4b). Treatment plots treated with 30mls of Neem extract had health plants (plate 4.4a) whereas the aphid clusters were many on

cabbage plants from control plots. Besides the leaf perforations were equally high in the same plots (plates 4.4c and d).

The plants were healthy and pest free in plots treated with 30mls because it seems to be very effective in aphids' control. It can also be suspected that 40mls of the mixture were strong for the cabbage crops. This was evidence by the sudden curling of most of the cabbage plants in the whole fields three days after spraying the three different treatments. This was then a sign that the quantity of mixture of the three plant parts of Neem tree was overdose to the cabbage seedlings. The implication is that in applying the admixtures, stage of growth of the crops should be considered with respect to the concentration of Neem tree extract used.

Plate 4.5: showing cabbage plants recovery from aphids' damage, healthy plants forming heads after treatment.

a. After spraying (30mls) b. After spraying (20mls) c. Healthy cabbages forming d. Firm recovery from aphids' damage head ready for harvest

Source: Researcher

Cabbage plants recovered from aphids' damage after the three different treatments as shown in plate 4.5 a and b , healthy cabbage plants started forming the heads and resulted into the preeminent yield as shown in plate 4.5 c and d

Plate 4.6: showing aphids damage on cabbage plants

a. Aphids' population On cabbage leaf overwhelming

b. stunted cabbage plant

c. Cabbage plant nearing death (Extensive feeding by aphids in control plots)

Source: researcher

Number of live aphids increased in the control plots; with aphids' population on leaves exceeding 12clusters per plant in a block. Due to increased aphids' population on Cabbage plants, the leaves curled nearing death as a result of extensive feeding by aphids and sucking of sap. The cabbage plants further showed prominent stunted growth. These observations were more pronounced in the 20mls treated plots and control plots.

High infestation of aphids on the plants negatively impacted on the growth of the cabbage to poor head formation, death of the plant and in most cases, the plants were stunted. On one other hand, beneficial insects that are natural enemies of cabbage aphids were observed in the cabbage field. This suggested that Neem tree extract used was environmentally friendly.

The yield in the first season was higher than the second season. The first season was rainy season. It is suspected that rain contributed to washing away of some aphids resulting in fast recovery of infested cabbages and formation of firm and large heads (Plate 4.5b and d) below. This field

observation concurs with Ermel et al., (1987) in their findings which suggested that the growth regulatory effects of formulated Neem-based products may rely on the host plant, aphid species, treated aphid instar, or the climate conditions. The preliminary observation point to a conclusion that 30mls performed best among all the treatments, followed by 40mls, 20mls in comparison with the control

Plate 4.7: showing healthy cabbages ready for harvesting.

a & c. Cabbage crop at month to harvesting. b & d Firm head ready for harvesting.

Source: Researcher

Aphid prevalence: The aphid clusters on cabbages were recorded and results are presented in table 4.3.

Treatment	Block 1	Block 2	Block 3	Block 4	Totals
20mls	5	8	10	6	**29**
30mls	0	2	1	2	**5**

40mls	2	7	8	9	**26**
00mls	8	10	7	12	**37**

Source: data analysis

Table 4.3: Average number of aphids' cluster per block of cabbage

In table 4.3, the average number of aphids' cluster were more in control plots (00mls treatment) with a total number of 37 clusters in the four blocks, followed by 20mls whose total number of clusters was 29 compared to 40mls which had a total number of aphids' cluster at 26 whereas aphids clusters were less in 30mls treated plots at a total number of 5 clusters for all the four blocks, this was evidence that 30mls treatment was more effective in controlling the number of aphids below economic injury level. The lower the number of aphids on the plant, the more vigorous the plant grows and attains faster maturity, whereas the higher the number of aphids' cluster on the cabbage plant, the slower the plant growth, remain stunted and the less chances of forming head (plate 4 above) hence economic loss to the producer. This field observation concurs with Kumar et al., 2005 & Kumar et al., 2006 in their study found out that Neem extracts acted as a strong anti-feedant and repellent, delay and prevent molting, reduce growth, development and oviposition; and can cause high mortality, in more than 200 insect species, including whiteflies and aphids. This table makes me conclude that 30mls concentration of Neem tree extract still stand the best in lowering aphids' population in the cabbage field.

Table 4.4: Average number of pest damage (perforations of leaves and curled leaves, stunted plants) in cabbage field

Treatment	**Totals damage**
20mls plot 1	**0.87**

Plot 2	**1.38**
plot 3	**0.37**
plot 4	**6.56**
30mls plot 1	**0.00**
Plot 2	**0.00**
plot 3	**0.00**
plot 4	**0.00**
40mls plot 1	**7.44**
plot 2	**4.87**
plot 3	**0.37**
plot 4	**4.18**
00mls plot 1	**1.19**
Plot 2	**5.00**
Plot 3	**3.82**
Plot 4	**11.31**

Source: primary data.

In table 4.4, the average pest damage (perforations of leaves and curled leaves, stunted plants) in cabbage field were more in control plots with a total aphids' damage of 11.31, followed by 40mls treated plots with a total aphids' damage of 7.44 and 20mls treated plot with total aphids' damage of 6.56 and finally 30mls treated plots with less or no damage at tall (total aphids' damage 0.00). Meaning that 30mls treatment has been the best in reducing pests' damage in cabbage fields. When there is high pests' damage on cabbage plants, especially curling of leaves, perforation and stunting plants; the surface area for photosynthesis is reduced which means plants makes very little food

for its growth hence affecting the vigour, quality and quantity of that plant (cabbages). This work supported by Liu and Liu, (2005) who suggested that azadirachtin and other constituents in Neem extracts may vary in their efficacy depending on geographic origin and yearly variations in environmental growing conditions of the Neem tree. They said there was also evidence that the method of Neem extraction affects the effectiveness of the insecticide formulation, and thus may vary considerably between manufacturers of which I did agree with them and this makes me conclude that despite environmental growth condition variation in seasons and soil fertility management, still 30mls treatment emerge the best in controlling aphids on cabbages.

Table 4.5: Two-way table of blocks x treatment (yield of cabbages in kilogram/ head) for first season.

Treatments	Block I	Block II	Block III	Block IV	Total
20mls/10l of water	26.2	15.5	11.0	9.0	61.7
30mls/10l of water	30.8	18.5	14.1	10.0	73.4
40mls/10l of water	21.9	17.0	13.8	9.6	62.3
00mls/10l of water	21.3	6.0	6.9	8.0	42.2
Block totals	100.2	57.0	45.8	36.6	239.6

Source: data analysis

Table 4.5 presents' yields for first season, block one yielded very well for all the treatments because of the uniform soil fertility of that block, pests were few in this block whereas pests were more on blocks 2,3 and 4; more damages were caused to these blocks which resulted into yields variation in the table above

There were more aphids' prevalence on control plots, followed 20mls treated plots and 40mls treated plots but with less prevalence in 30mls treated plots. Whereas more damage were observed on control plots, followed 20mls treated plots and 40mls treated plots but with less damage in 30mls treated plots. This was evidence by the total yield variation in all the treatments given. 30mls treated plots emerge the best in yields with a total of 73.4 kilograms for first season, followed by 40mls treated plots with a total yield of 62.3 kilograms and 20mls treated plots with a total yield of 61.7 kilograms and control plots were the last with a total yield of 42.2 kilograms.

Table 4.6: Two-way table of blocks x treatment (yield of cabbages in kilogram/ head) for second season.

Treatments	Block I	Block II	Block III	Block IV	Total
20mls/10l of water	26.5	15.8	12.0	10.0	64.3
30mls/10l of water	28.3	18.8	14.6	13.2	74.9
40mls/10l of water	26.9	17.0	12.2	10.3	66.4
00mls/10l of water	20.1	16.0	10.6	8.0	54.7
Block totals	101.8	68.3	49.4	41.5	260.3

Source: data analysis

Table 4.6 presents yields for second season, block one yielded very well for all the treatments because of the uniform soil fertility of that block, pests were few in this block whereas pests were more on blocks 2, 3 and 4; more damages were caused to these blocks which resulted into yields variation in the table above.

There were more aphids' prevalence on control plots, followed 20mls treated plots and 40mls treated plots but with less prevalence in 30mls treated plots whereas Aphids' damage were more control plots, followed 20mls treated plots and 40mls treated plots but with less damage in 30mls treated plots This was evidence by the total yield variation in all the treatments given. 30mls treated plots emerge the best in yields with a total of 74.9 kilograms for the second season, followed by 40mls treated plots with a total yield of 66.4 kilograms and 20mls treated plots with a total yield of 64.3 kilograms and control plots were the last with a total yield 54.7 kilograms. When aphids form dense colonies on developing cabbage head, yield losses of up to 70% have been reported if infestations are left untreated (Boyles et al., 2012). The poor yields are due to no treatment in controls, 20mls treatment could have been an under-dose for the pests for the aphids and 40mls being an over-dose to the crops causing some burns and curling of leaves of cabbages but was second best in total yield realized for both seasons to 30mls treatment which the best also for all the seasons.

The null hypothesis of the study stated that Neem tree have unique scent that renders them less affected by pests, therefore creating an assumption that Neem scent and taste can repel cabbage aphids. In this case, different admixtures of Neem tree extracts are significant to cabbage aphids control was the hypothesis for objective one

Table 4.7: Analysis of variance of three treatment effects on cabbage aphids in relation to control for both seasons

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Weight (kilograms)	Between Groups	57.269	3	19.090	32.112	.000
	Within Groups	149.806	252	.594		
	Total	207.075	255			
Average no. of dead aphids	Between Groups	17369.668	3	5789.889	10.049	.000
	Within Groups	145187.016	252	576.139		
	Total	162556.684	255			
Average no. of live pests	Between Groups	91527.543	3	30509.181	7.290	.000
	Within Groups	1054685.766	252	4185.261		
	Total	1146213.309	255			
Perforated leaves	Between Groups	15.969	3	5.323	.694	.557
	Within Groups	1933.969	252	7.674		
	Total	1949.937	255			
Curled leaves	Between Groups	52.719	3	17.573	6.149	.000
	Within Groups	720.219	252	2.858		
	Total	772.938	255			
Stunted Plants	Between Groups	.531	3	.177	1.625	.184
	Within Groups	27.469	252	.109		

	Total	28.000	255			

Source: data analysis

In table 4.7: Analysis of variance for the three treatments in relation to the control for both seasons were presented and discussed as below;

Weight in kilograms with mean square of 19.090, had a significant difference of .000, (P =0.05) meaning that the yield in kilograms was significant to Neem tree extract admixture application. Application of the extract significantly increases the average of cabbage. This finding agrees with Haseeb *et al*, (2004); Leeson, (2001) who found out that Neem-based pesticides tested elsewhere was compatible with arthropod natural enemies of DBM. As a result, Neem-based products were being promoted as alternatives to the commonly used synthetic pesticides among crucifer growers in the region.

Additionally, treatments were significant to the average number of dead aphids (.000), (P = 0.05). a significant number of aphids were counted dead as a result of application of extract of Neem tree this was in specific treatments of 30mls in 10 liters of water

Surprisingly, the average number of live aphids vis-à-vis the treatments were also significant (P = 0.000), (P < 0.05) meaning that the live aphids present in the field depended on the concentration of Neem tree extract admixture application on cabbages, or even frequency of application. The more the concentration of Neem tree extract admixture applied, the lesser number of live aphids were observed in the treated plots. This created an assumption that the concentration of Neem tree extract admixture application on various plots contributed positively in controlling aphids on cabbages and the various yield difference. This finding agrees still with Haseeb *et al*, (2004) and Leeson (2001) who found out that Neem-based pesticides tested elsewhere was compatible with arthropod natural enemies of DBM. As a result, Neem-based products were being promoted as alternatives to the commonly used synthetic pesticides among crucifer growers in the region.

Perforated leaves between groups, the sum of squares was 15.969 at a degree of freedom 3 and mean square of 5.323, a ratio of .694 had a significant difference of .557 ($P > 0.05$) meaning that the number of perforated leaves present in the field was insignificant to the concentration of Neem tree extract admixture application on cabbages. Perforated leaves were too few to cause an impact on the yield results of the various plots.

Curled leaves between groups, the sum of squares was 52.719 at a degree of freedom 3 and mean square of 17.573, a ratio of 6.149 had a significant difference of ($p = 0.000$), ($P < 0.05$), meaning that the number of curled leaves present in the field depended on the concentration of Neem tree extract admixture application on cabbages. The more the concentration of Neem tree extract admixture applied, the lesser number of curled leaves were observed in the treated plots. This created an assumption that the concentration of Neem tree extract admixture application on various plots contributed positively in controlling aphids on cabbages and the various yield difference. This result agreed with study hypothesis that Neem tree have unique scent that renders them less affected by pests, therefore creating an assumption that Neem scent and taste can repel cabbage aphids.

Stunted plants between groups, the sum of squares was .531 at a degree of freedom 3 and mean square of .177, a ratio of 1.625 had a significant difference of .184 ($P > 0.05$) meaning that the number of stunted plants present in the field was insignificant to the concentration of Neem tree extract admixture application on cabbages. Stunted plants were too few to cause an economic injury or impact negatively on the yield results of the various plots.

Table 4.8: Multiple Comparisons of the three treatment effect on cabbage aphids in relation to control for both seasons.

Tukey HSD

Dependent Variable	(I) Plot no	(J) Plant no	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Weight (kilograms)	1	2	.57656*	.13630	.000	.2241	.9291
		3	.99531*	.13630	.000	.6428	1.3478
		4	1.25000*	.13630	.000	.8975	1.6025
	2	1	-.57656*	.13630	.000	-.9291	-.2241
		3	.41875*	.13630	.013	.0662	.7713
		4	.67344*	.13630	.000	.3209	1.0259
	3	1	-.99531*	.13630	.000	-1.3478	-.6428
		2	-.41875*	.13630	.013	-.7713	-.0662
		4	.25469	.13630	.244	-.0978	.6072
	4	1	-1.25000*	.13630	.000	-1.6025	-.8975
		2	-.67344*	.13630	.000	-1.0259	-.3209
		3	-.25469	.13630	.244	-.6072	.0978
Average no of dead aphids	1	2	9.93750	4.24315	.091	-1.0364	20.9114
		3	-.10938	4.24315	1.000	-11.0833	10.8645

		4	-13.25000*	4.24315	.011	-24.2239	-2.2761
	2	1	-9.93750	4.24315	.091	-20.9114	1.0364
		3	-10.04688	4.24315	.086	-21.0208	.9270
		4	-23.18750*	4.24315	.000	-34.1614	-12.2136
	3	1	.10938	4.24315	1.000	-10.8645	11.0833
		2	10.04688	4.24315	.086	-.9270	21.0208
		4	-13.14062*	4.24315	.012	-24.1145	-2.1667
	4	1	13.25000*	4.24315	.011	2.2761	24.2239
		2	23.18750*	4.24315	.000	12.2136	34.1614
		3	13.14062*	4.24315	.012	2.1667	24.1145
Average no. of live pests	1	2	-1.87500	11.43632	.998	-31.4522	27.7022
		3	-31.85938*	11.43632	.029	-61.4366	-2.2821
		4	-43.71875*	11.43632	.001	-73.2960	-14.1415
	2	1	1.87500	11.43632	.998	-27.7022	31.4522
		3	-29.98438*	11.43632	.046	-59.5616	-.4071

		4	-41.84375*	11.43632	.002	-71.4210	-12.2665
	3	1	31.85938*	11.43632	.029	2.2821	61.4366
		2	29.98438*	11.43632	.046	.4071	59.5616
		4	-11.85938	11.43632	.728	-41.4366	17.7179
	4	1	43.71875*	11.43632	.001	14.1415	73.2960
		2	41.84375*	11.43632	.002	12.2665	71.4210
		3	11.85938	11.43632	.728	-17.7179	41.4366
Perforated leaves	1	2	-.15625	.48972	.989	-1.4228	1.1103
		3	.48438	.48972	.756	-.7822	1.7509
		4	-.07812	.48972	.999	-1.3447	1.1884
	2	1	.15625	.48972	.989	-1.1103	1.4228
		3	.64062	.48972	.559	-.6259	1.9072
		4	.07812	.48972	.999	-1.1884	1.3447
	3	1	-.48438	.48972	.756	-1.7509	.7822
		2	-.64062	.48972	.559	-1.9072	.6259
		4	-.56250	.48972	.660	-1.8290	.7040
	4	1	.07812	.48972	.999	-1.1884	1.3447
		2	-.07812	.48972	.999	-1.3447	1.1884
		3	.56250	.48972	.660	-.7040	1.8290

Curled leaves	1	2	.07812	.29885	.994	-.6948	.8510
		3	-.20312	.29885	.905	-.9760	.5698
		4	-1.06250*	.29885	.003	-1.8354	-.2896
	2	1	-.07812	.29885	.994	-.8510	.6948
		3	-.28125	.29885	.783	-1.0542	.4917
		4	-1.14062*	.29885	.001	-1.9135	-.3677
	3	1	.20312	.29885	.905	-.5698	.9760
		2	.28125	.29885	.783	-.4917	1.0542
		4	-.85938*	.29885	.023	-1.6323	-.0865
	4	1	1.06250*	.29885	.003	.2896	1.8354
		2	1.14062*	.29885	.001	.3677	1.9135
		3	.85938*	.29885	.023	.0865	1.6323
Stunted Plants	1	2	.04688	.05836	.853	-.1041	.1978
		3	-.07812	.05836	.539	-.2291	.0728
		4	-.03125	.05836	.950	-.1822	.1197
	2	1	-.04688	.05836	.853	-.1978	.1041
		3	-.12500	.05836	.143	-.2759	.0259
		4	-.07812	.05836	.539	-.2291	.0728
	3	1	.07812	.05836	.539	-.0728	.2291
		2	.12500	.05836	.143	-.0259	.2759

		4	.04688	.05836	.853	-.1041	.1978
	4	1	.03125	.05836	.950	-.1197	.1822
		2	.07812	.05836	.539	-.0728	.2291
		3	-.04688	.05836	.853	-.1978	.1041

*. The mean difference is significant at the 0.05 level.

Source: Data Analysis

The analysis was done at 95% confidence interval leaving 5% (standard error) of significant difference to the yield or pest damage or prevalence. Above 5% means it's not significant to our study and does not have an effect on the yield. From the analysis of variance for the three treatments in relation to the control during the first season and second season, the study found out that when the admixture quantity was maintained at 1000grams per 10litres of water in order to establish which quantity of the concentration of Neem tree extract (root, bark and leaves) was most effective in cabbage aphids' control. Treatments were significant to weight yield ($P < 0.05$) (table 4.8) hence the weight of cabbages depended on the treatment application. Treatments were also significant to the average number of dead aphids, ($P < 0.05$). A significant number of dead aphids were as a result of application of extract of Neem tree in specific a specific concentration of 30mls in 10 liters of water.

The average number of live aphids vis-à-vis the treatments were largely significant ($P = 0.029$, 0.001, 0.046, 0.002, 0.029, 0.046, 0.001 and 0.002), ($P < 0.05$) meaning that the number of live aphids present in the field depended on the concentration of Neem tree extract admixture application on cabbages, as well as the frequency of application. The more the concentration of

Neem tree extract admixture applied, the lesser number of live aphids were observed in the treated plots. The concentration of Neem tree extract admixture application on various plots contributed positively in controlling aphids on cabbages and the various yield difference.

Treatments were insignificant to perforated leaves. The application of Neem tree extract admixture concentration on cabbages resulted into few cabbage leaves being perforated hence less negative impact on the yield results of the various plots. If treatments were not applied, the leaves would have curled as a result of pest attack. Treatments were significant at ($P < 0.05$), ($P = 0.003$, 0.001, 0.023, 0.003, 0.001 and 0.023). This implies that the number of curled leaves present in the field depended on the concentration of Neem tree extract admixture application on cabbages. The more the concentration of Neem tree extract admixture applied, the lesser number of curled leaves were observed in the treated fields. The concentration of Neem tree extract admixture application on various fields contributed positively in controlling aphids on cabbages and the various yield difference. Treatments were not significant to stunted growth, ($P > 0.05$). Stunting does not depend on any of the treatments. Stunted plants were too few to cause an economic injury or impact negatively on the yield results of the various fields ($P = 0.853$, 0.539, 0.950, 0.853 & 0.143). This result agreed with study hypothesis that Neem tree have unique scent that renders them less affected by pests, therefore creating an assumption that Neem scent and taste can repel cabbage aphids.

4.2 Frequency of Neem tree extracts application

The second objective of the study was to establish the effective frequency of Neem tree extract application on cabbage aphids' population. Cabbage crops were treated with 30mls of Neem tree

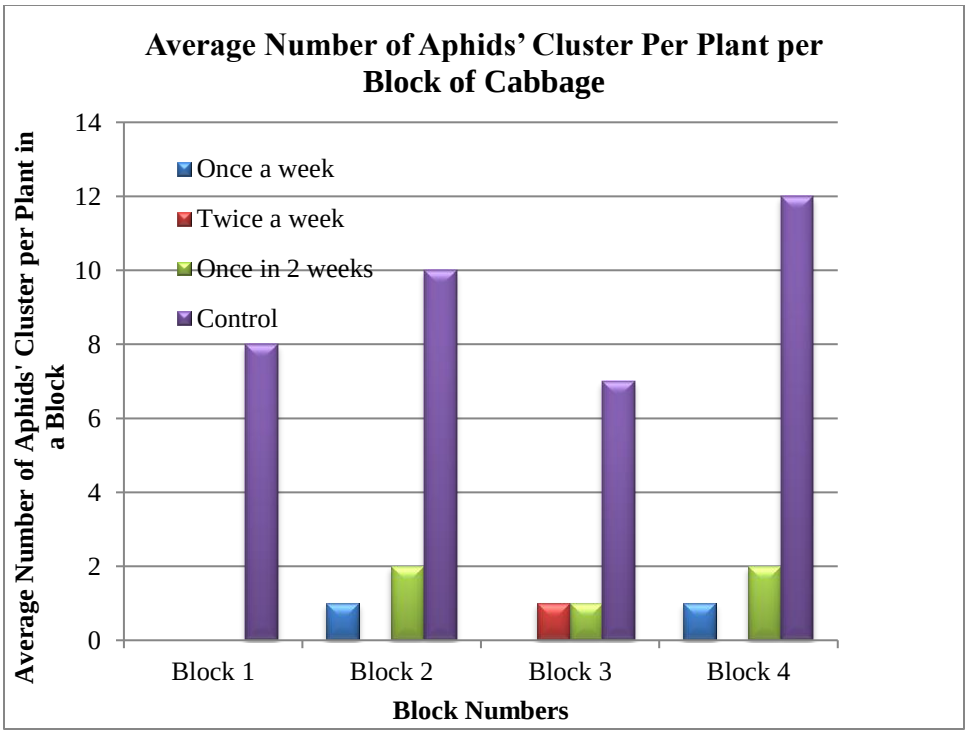
extract at different timings and observations on prevalence of pests (aphids, cabbage loopers etc.), pest damage (perforations of leaves and curled leaves, stunted plants) and total cabbage yields for each season were made and results presented in the subsequent plates and graphs below. The plates below are visual evidence of the presentation and discussions of findings of this study;

Plate 4.8: showing aphids' prevalence on cabbage plants before and after spraying.

a. Aphids on cabbage Before treatment b. Aphids on cabbage after treatment c. Healthy cabbage plant d. Ready head for harvesting

Source: Researcher

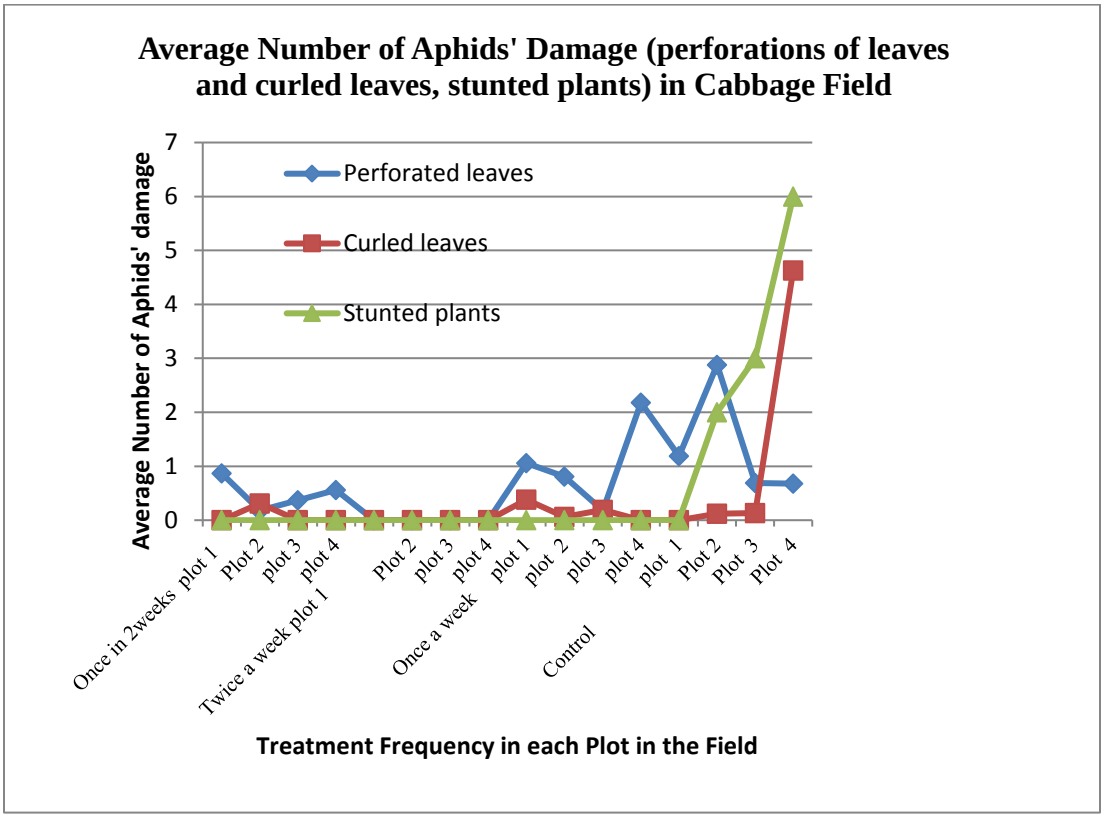
When 30mls of Neem tree extract was applied at different timings, once a week, twice a week and once in 2 weeks, there was healing of aphids' damage (plate 5 b). Twice a week became the best in lowering aphids' population, followed by once a week and once in 2weeks. Control plots were badly damage by aphids since they were left under natural environment. This field observation concurs with Mordue and Blackwell, (1993) who stated that the variations in efficacy are both dose and time dependent and often times are caused by the mixture of components in Neem extracts Furthermore, methods of extraction, storage conditions, origin of Neem, or contamination with mycotoxins can affect their action as seconded by Ermel et al., (2002). This work concludes that twice a week and once a week are the best frequency of Neem tree extract application.



Source: Data Analysis

Figure 4.4: showing the average number aphids' cluster per plant per plot of cabbage

Figure 4.4 above shows the average aphids cluster per treatment per block. Application of the extract twice a week had the lowest aphids cluster especially once a week treatment and once in 2 weeks treatment of Neem tree extract did not keep the aphids below economic injury level therefore it is not advisable to apply once in 2 weeks frequency of application. Control fields were heavily infested with aphids, population since they were left under nature to take its course. This field observation concurs with Kumar et al., 2005, and Kumar et al., 2006 who found out that Neem extracts acted as a strong anti-feedant and repellent, delay and prevent molting, reduce growth, development and oviposition; and can cause high mortality, in more than 200 insect species, aphids inclusive. This bar graph makes me conclude that twice a week and once a week frequency of Neem tree extract application still stand the best in lowering aphids' population in the cabbage field.

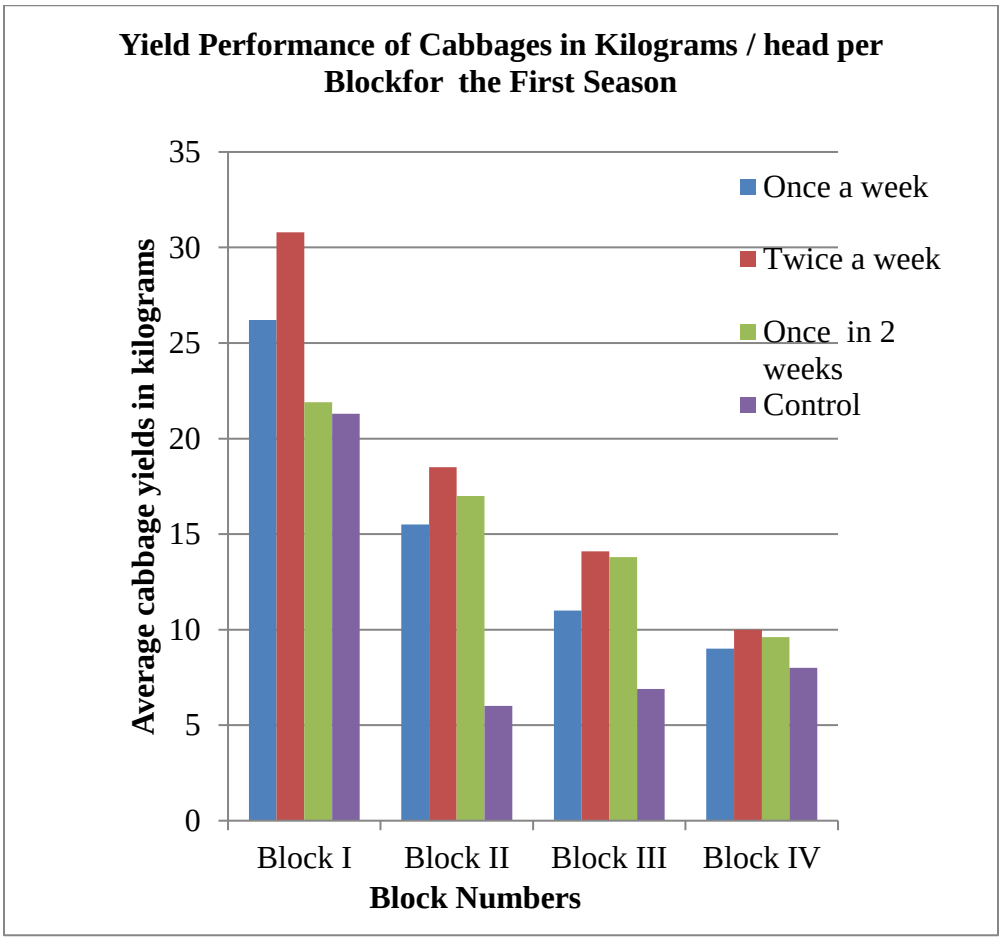


Source: primary data

Figure 4.5: showing the average number of pest damage (perforations of leaves and curled leaves, stunted plants) in cabbage field

Figure 4.5 above shows that average pest damage (perforations of leaves and curled leaves, stunted plants) in cabbage field were more in control plots with a total aphids' damage of 5.0, followed by application of the 30mls extract once in 2 weeks frequency treated plots with a total aphids' damage of 1.0 and once a week treated plot with total aphids' damage of 0.05 and finally twice a week treated plots with less or no damage at tall (total aphids' damage 0.00). Meaning that twice a week frequency treatment was the best in reducing pests' damage in cabbage fields When there is high pests' damage on cabbage plants, especially curling of leaves, perforation and stunting

plants; the surface area for photosynthesis is reduced which means plants makes very little food for its growth hence affecting the vigor, quality and quantity of that plant (cabbages). This work is supported by Liu and Liu, (2005) who suggested that azadirachtin and other constituents in Neem extracts may vary in their efficacy depending on geographic origin and yearly variations in environmental growing conditions of the Neem tree. They said there was also evidence that the method of Neem extraction affects the effectiveness of the insecticide formulation, and thus may vary considerably between manufacturers of which I did agree with them and this makes me conclude that despite environmental growth condition variation in seasons and soil fertility management, still twice a week frequency treatment emerge the best in controlling aphids on cabbages.



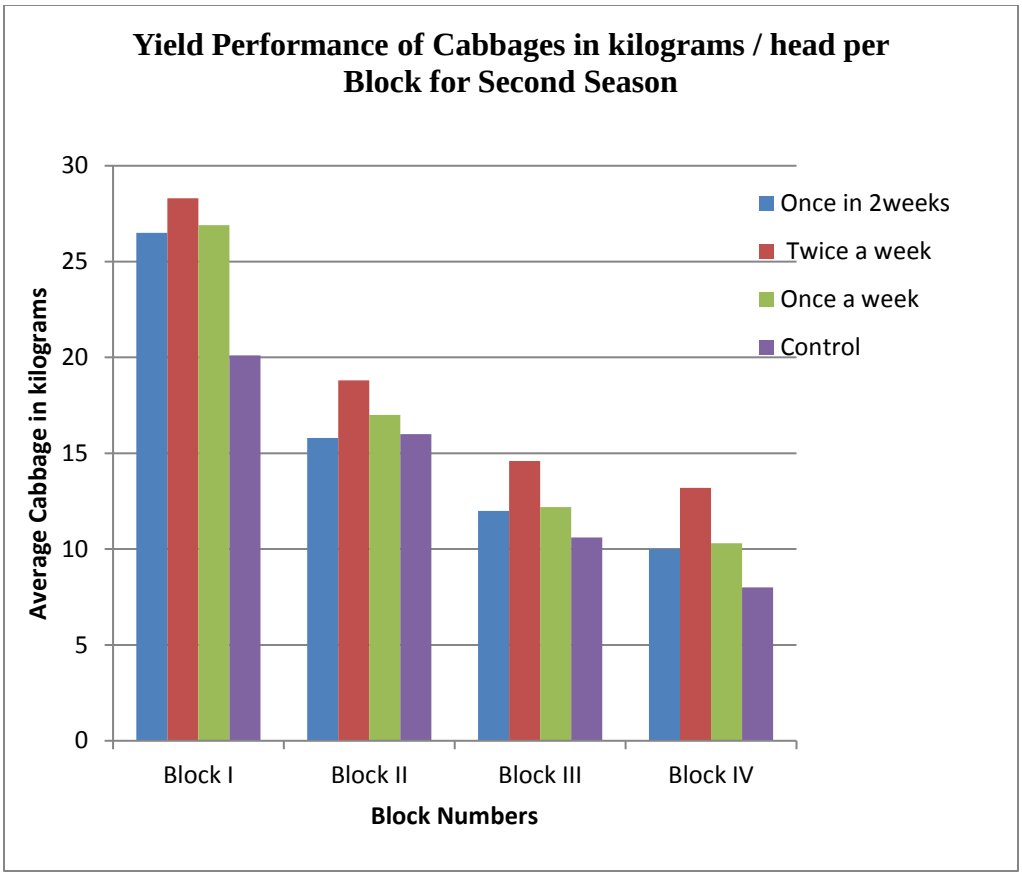
Source: data analysis

Figure 4.6: showing the yield performance of cabbages in kilogram/ head for first season

Figure 4.6 presents' yields for first season, block one yielded very well for all the treatments because of the uniform soil fertility of that block, pests were few in this block whereas pests were more on blocks 2,3 and 4; more damages were caused to these blocks which resulted into yields variation in the table above

There was more aphids' prevalence on control, followed once in 2 weeks frequency treatment and once in a week frequency treatment but with less prevalence in twice a week frequency treatment. Whereas more damage were observed on control, followed once in 2 weeks treatment and once a week treatment but with less damage in twice a week treatment. This observation was evidence in the total yield variation in all the treatments given.

Twice a week frequency treated plots emerge the best in yields with a total of 30.8 kilograms for first season, followed by once a week treated plots with a total yield of 26.2 kilograms and once in 2 weeks treated plots with a total yield of 21.9 kilograms and control plots were the last with a total yield of 21.3



Source: data analysis

Figure 4.7: Showing the Yield performance of Cabbages in kilogram/ head for Second Season.

Figure 4.7 present yields for second season, block one yielded very well for all the treatments because of the uniform soil fertility of that block, pests were few in this block whereas pests were more on blocks 2, 3 and 4; more damages were caused to these blocks which resulted into yields variation in the table above. There was more aphids' prevalence on control plots, followed once in 2 weeks frequency treated plots and once a week treated plots but with less prevalence and less damage in twice a week treated plots. This is evidence by the total yield variation in all the treatments given. Twice a week frequency of application in treated plots emerge the best in yields

with a total of 28.3 in first block for second season, followed by once a week treated plots with a total yield of 26.2 and once in 2 weeks treated plots with a total yield of 21.9 in the second season and control plots were the last with a total yield of 20.1. This work was supported by Boyles et al., (2012) who stated that when aphids form dense colonies on developing cabbage head, yield losses of up to 70% have been reported if infestations are left untreated This work concludes that the poor yields in control plots were contributed by no treatment applied leaving the aphids to over damage the cabbage crops, once in 2 weeks frequency in treatment application could leave a big gap for the aphids to rebuild up in the cabbage field and once a week was second best in total yield realized for both seasons to twice a week treatment which emerge the best for all the seasons.

The null hypothesis of the study stated that Neem tree have unique scent that renders them less affected by pests, therefore creating an assumption that Neem scent and taste can repel cabbage aphids. In this case, the second objective hypothesis was that Cabbage aphids' population is affected by the frequency of Neem tree extract application

Table 4.9: Analysis of variance of three treatment effect on cabbage aphids in relation to control

		Sum of Squares	df	Mean Square	F	Sig.
Stunted leaves	Between Groups	.112	3	.037	.275	.843
	Within Groups	35.155	258	.136		
	Total	35.267	261			
Dead aphids	Between Groups	5461.623	3	1820.541	4.661	.003
	Within Groups	100762.228	258	390.551		
	Total	106223.851	261			
Live aphids	Between Groups	8986.091	3	2995.364	1.592	.192
	Within Groups	485507.665	258	1881.813		
	Total	494493.756	261			
Perforated leaves	Between Groups	17.741	3	5.914	1.138	.334
	Within Groups	1341.210	258	5.198		
	Total	1358.950	261			
Curled leaves	Between Groups	41.872	3	13.957	8.945	.000
	Within Groups	402.571	258	1.560		
	Total	444.443	261			

Source: data analysis

Treatments were not significant to stunted growth, stunting does not depend on any of the treatments. Stunted plants were too few to cause an economic injury or impact negatively on the yield results of the various fields. This was verified by the sum of squares (.112) at a degree of freedom 3, mean square of .037, a ratio of .275 and significant of .843, ($P > 0.05$). This creates an assumption that the number of stunted plants present in the field was not significant to the frequency of Neem tree extract admixture application on cabbages.

Additionally, treatments were significant to the average number of dead aphids at sum of squares (5461.623) at a degree of freedom 3, mean square of 1820.541, and a ratio of 4.661 and significant of .003, ($P < 0.05$). This makes the study assumes that the number of dead aphids present in the field was significant to the frequency of Neem tree extract admixture application on cabbages. Much number of dead aphids in the field was as result of frequent application of Neem tree admixture on cabbages plots. The more frequent the application was, the lesser the damage on cabbage crop hence better yield results in various plots.

Surprisingly, the average number of live aphids vis-à-vis the treatments were not significant at the sum of squares 8986.091, with a degree of freedom 3, mean square of 2995.364, and a ratio of 1.592 and significant of .192, ($P > 0.05$). This created an assumption that the number of live aphids present in the field was not significant to the frequency of Neem tree extract admixture application on cabbages. Live aphids in 30mls treated plots were too few to cause an economic injury or impact negatively on the yield results. The more frequent the applications, the lesser number of live aphids in the field and better yields of quality heads of cabbages.

Treatments were insignificant to perforated leaves. The application of Neem tree extract admixture concentration on cabbages resulted into few cabbage leaves being perforated hence less negative impact on the yield results of the various plots. This was verified by the sum of squares (17.741) at a degree of freedom 3, mean square of 5.914, and a ratio of 1.138 and significant of .334 ($P > 0.05$)

If treatments were not applied, the cabbage leaves would have curled as a result of pest attack. Treatments were significant at the sum of squares 41.872 at a degree of freedom 3, mean square of 13.957, and a ratio of 8.945 and significant of .000, ($P < 0.05$). This implies that the number of curled leaves present in the field depended on the frequency of Neem tree extract admixture application on cabbages. The more frequent the Neem tree extract admixture was applied, the lesser number of curled leaves were observed in the treated fields

Table 4.10: Multiple comparisons of the treatment effect on cabbage aphids per plant in a plot

Dependent Variable		(I) plot number	(J) plant number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Stunted leaves	Tukey HSD	1	2	-.05212	.06478	.852	-.2196	.1154
			3	-.02927	.06551	.970	-.1987	.1401
			4	-.04949	.06455	.869	-.2164	.1174
		2	1	.05212	.06478	.852	-.1154	.2196
			3	.02285	.06452	.985	-.1440	.1897
			4	.00263	.06354	1.000	-.1617	.1669
		3	1	.02927	.06551	.970	-.1401	.1987
			2	-.02285	.06452	.985	-.1897	.1440
			4	-.02022	.06429	.989	-.1865	.1460
		4	1	.04949	.06455	.869	-.1174	.2164
			2	-.00263	.06354	1.000	-.1669	.1617
			3	.02022	.06429	.989	-.1460	.1865
	LSD	1	2	-.05212	.06478	.422	-.1797	.0754
			3	-.02927	.06551	.655	-.1583	.0997
			4	-.04949	.06455	.444	-.1766	.0776
		2	1	.05212	.06478	.422	-.0754	.1797

			3	.02285	.06452	.723	-.1042	.1499
			4	.00263	.06354	.967	-.1225	.1278
		3	1	.02927	.06551	.655	-.0997	.1583
			2	-.02285	.06452	.723	-.1499	.1042
			4	-.02022	.06429	.753	-.1468	.1064
		4	1	.04949	.06455	.444	-.0776	.1766
			2	-.00263	.06354	.967	-.1278	.1225
			3	.02022	.06429	.753	-.1064	.1468
Dead aphids	Tukey HSD	1	2	-8.79839	3.46819	.057	-17.7666	.1698
			3	3.26761	3.50736	.788	-5.8019	12.3371
			4	-4.54949	3.45581	.553	-13.4857	4.3867
		2	1	8.79839	3.46819	.057	-.1698	17.7666
			3	12.06600*	3.45420	.003	3.1339	20.9980
			4	4.24890	3.40184	.596	-4.5478	13.0456
		3	1	-3.26761	3.50736	.788	-12.3371	5.8019
			2	-12.06600*	3.45420	.003	-20.9980	-3.1339
			4	-7.81710	3.44177	.107	-16.7170	1.0828
		4	1	4.54949	3.45581	.553	-4.3867	13.4857
			2	-4.24890	3.40184	.596	-13.0456	4.5478

			3	7.81710	3.44177	.107	-1.0828	16.7170
	LSD	1	2	-8.79839*	3.46819	.012	-15.6280	-1.9688
			3	3.26761	3.50736	.352	-3.6391	10.1743
			4	-4.54949	3.45581	.189	-11.3547	2.2557
		2	1	8.79839*	3.46819	.012	1.9688	15.6280
			3	12.06600*	3.45420	.001	5.2640	18.8680
			4	4.24890	3.40184	.213	-2.4500	10.9478
		3	1	-3.26761	3.50736	.352	-10.1743	3.6391
			2	-12.06600*	3.45420	.001	-18.8680	-5.2640
			4	-7.81710*	3.44177	.024	-14.5946	-1.0396
		4	1	4.54949	3.45581	.189	-2.2557	11.3547
			2	-4.24890	3.40184	.213	-10.9478	2.4500
			3	7.81710*	3.44177	.024	1.0396	14.5946
Live aphids	Turkey HSD	1	2	-7.30609	7.61294	.772	-26.9920	12.3798
			3	3.07614	7.69892	.978	-16.8321	22.9844
			4	-11.71522	7.58576	.413	-31.3309	7.9004
		2	1	7.30609	7.61294	.772	-12.3798	26.9920
			3	10.38223	7.58222	.520	-9.2243	29.9887
			4	-4.40913	7.46729	.935	-23.7185	14.9002

		3	1	-3.07614	7.69892	.978	-22.9844	16.8321
			2	-10.38223	7.58222	.520	-29.9887	9.2243
			4	-14.79136	7.55493	.207	-34.3273	4.7446
		4	1	11.71522	7.58576	.413	-7.9004	31.3309
			2	4.40913	7.46729	.935	-14.9002	23.7185
			3	14.79136	7.55493	.207	-4.7446	34.3273
	LSD	1	2	-7.30609	7.61294	.338	-22.2975	7.6853
			3	3.07614	7.69892	.690	-12.0846	18.2369
			4	-11.71522	7.58576	.124	-26.6531	3.2227
		2	1	7.30609	7.61294	.338	-7.6853	22.2975
			3	10.38223	7.58222	.172	-4.5487	25.3132
			4	-4.40913	7.46729	.555	-19.1137	10.2955
		3	1	-3.07614	7.69892	.690	-18.2369	12.0846
			2	-10.38223	7.58222	.172	-25.3132	4.5487
			4	-14.79136	7.55493	.051	-29.6685	.0858
		4	1	11.71522	7.58576	.124	-3.2227	26.6531
			2	4.40913	7.46729	.555	-10.2955	19.1137
			3	14.79136	7.55493	.051	-.0858	29.6685
Perforated leaves	Tukey HSD	1	2	.16679	.40013	.976	-.8679	1.2015
			3	.54365	.40465	.536	-.5027	1.5900

			4	.63189	.39870	.389	-.3991	1.6629
		2	1	-.16679	.40013	.976	-1.2015	.8679
			3	.37687	.39852	.780	-.6536	1.4074
			4	.46510	.39248	.637	-.5498	1.4800
		3	1	-.54365	.40465	.536	-1.5900	.5027
			2	-.37687	.39852	.780	-1.4074	.6536
			4	.08824	.39708	.996	-.9386	1.1150
		4	1	-.63189	.39870	.389	-1.6629	.3991
			2	-.46510	.39248	.637	-1.4800	.5498
			3	-.08824	.39708	.996	-1.1150	.9386
	LSD	1	2	.16679	.40013	.677	-.6212	.9547
			3	.54365	.40465	.180	-.2532	1.3405
			4	.63189	.39870	.114	-.1532	1.4170
		2	1	-.16679	.40013	.677	-.9547	.6212
			3	.37687	.39852	.345	-.4079	1.1616
			4	.46510	.39248	.237	-.3078	1.2380
		3	1	-.54365	.40465	.180	-1.3405	.2532
			2	-.37687	.39852	.345	-1.1616	.4079
			4	.08824	.39708	.824	-.6937	.8702
		4	1	-.63189	.39870	.114	-1.4170	.1532

			2	-.46510	.39248	.237	-1.2380	.3078
			3	-.08824	.39708	.824	-.8702	.6937
Curled leaves	Tukey HSD	1	2	-.88794*	.21922	.000	-1.4548	-.3211
			3	-.01364	.22169	1.000	-.5869	.5596
			4	.08287	.21844	.981	-.4820	.6477
		2	1	.88794*	.21922	.000	.3211	1.4548
			3	.87430*	.21833	.000	.3097	1.4389
			4	.97081*	.21502	.000	.4148	1.5268
		3	1	.01364	.22169	1.000	-.5596	.5869
			2	-.87430*	.21833	.000	-1.4389	-.3097
			4	.09651	.21755	.971	-.4660	.6591
		4	1	-.08287	.21844	.981	-.6477	.4820
			2	-.97081*	.21502	.000	-1.5268	-.4148
			3	-.09651	.21755	.971	-.6591	.4660
	LSD	1	2	-.88794*	.21922	.000	-1.3196	-.4563
			3	-.01364	.22169	.951	-.4502	.4229
			4	.08287	.21844	.705	-.3473	.5130
		2	1	.88794*	.21922	.000	.4563	1.3196
			3	.87430*	.21833	.000	.4444	1.3042
			4	.97081*	.21502	.000	.5474	1.3942

	3	1	.01364	.22169	.951	-.4229	.4502
		2	-.87430*	.21833	.000	-1.3042	-.4444
		4	.09651	.21755	.658	-.3319	.5249
	4	1	-.08287	.21844	.705	-.5130	.3473
		2	-.97081*	.21502	.000	-1.3942	-.5474
		3	-.09651	.21755	.658	-.5249	.3319

*. The mean difference is significant at the 0.05 level.

Source: data analysis

This result also showed that there was a mean significant difference of 0.05 in frequency of Neem tree extract application on cabbage aphids.

Treatment frequency were not significant to stunted growth, stunted plants did not depend on any of the treatments. Stunted plants were too few to cause an economic injury or impact negatively on the yield results of the various fields. As quoted in table (10), stunted plants mean difference was -.05212, standard error of .06478, significant of .852, (P > 0.05) at 95% confidence interval the lower bound of -2196 and upper bound of .1154. This has confirmed that stunted growth was insignificant to the treatment frequency.

Treatment frequency were significant to the average number of dead aphids at mean difference 12.06600 and-7.81710 standard error was 3.45420, significant of .003, (P < 0.05) at 95% confidence interval the lower bound of 3.1339 and upper bound of 20.9980. This makes the study assumes that the number of dead aphids present in the field was significant at (P = 0.05) to the frequency of Neem tree extract admixture application on cabbages. Much number of dead aphids

in the field was as result of frequent application of Neem tree admixture on cabbages plots. The more frequent the application was, the lesser the damage on cabbage crop hence better yield results in various fields.

The average number of live aphids vis-à-vis the treatments were insignificant at the mean difference of -7.30609, standard error of 7.61294, significant of .772, (P > 0.05) at 95% confidence interval the lower bound of -26.9920 and upper bound of 12.3798. This created an assumption that the number of live aphids present in the field was insignificant to the frequency of Neem tree extract admixture application on cabbages. Live aphids in 30mls treated plots were too few to cause an economic injury or impact negatively on the yield results. The more frequent the application was, the lesser number of live aphids in the field and better yields of quality heads of cabbages realized.

Treatments were insignificant to perforated leaves. The frequent application of Neem tree extract admixture on cabbages resulted into few cabbage leaves being perforated hence less negative impact on the yield results of the various plots. This was verified by the mean difference of .16679, standard error of .40013, significant of .976, (P > 0.05) at 95% confidence interval the lower bound of -8679 and upper bound of 1.2015.

If treatment frequency was not applied, the leaves curled as a result of pest attack. Treatment frequency was significant at mean difference (.88794,.87430, .97081), standard error of .21922, significant of .000, (P < 0.05) at 95% confidence interval the lower bound of -1.4548 and upper bound of -.3211. This implies that the number of curled leaves present in the field depended on the frequency of Neem tree extract admixture application on cabbages. The more frequent the Neem tree extract admixture was applied, the lesser number of curled leaves were observed in the

treated fields. This field observation concurs with Kumar et al., (2005) & Kumar et al., (2006) who found out that Neem extracts acted as a strong anti-feedant and repellent, delay and prevent molting, reduce growth, development and oviposition; and can cause high mortality, in more than 200 insect species, aphids inclusive. This work concluded that twice a week frequency was the best, followed by once a week frequency in Neem tree extract application.

CHAPTER FIVE

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Results of this study have confirmed our hypothesis that Neem tree has unique scent that renders them less affected by pests, therefore creating an assumption that Neem tree scent and taste can repel cabbage aphids.

5.2 Summary of findings

Objective one, freshly harvesting of Neem tree parts (root, bark and leaves), crashing in to a mortar, weighing 1000g each, mixing and soaking in 10litres of water for 12-24hours, sieving in a clean piece of cloth (concentration) and diluting into (20mls, 30ml, 40mls and 00mls) in 10litres of water and spraying on to cabbage crops; 30mls in 10litres of water emerged the best in cabbage aphids' control, followed by 40mls and 20mls last.

Objective two, 30ml in 10 liters of water was then varied at a frequency application of once a week, twice a week and once in 2 weeks. Twice a week frequency of application was found to be the best followed by once a week.

5.3 Conclusions on findings

Considering objective one, farmers could be advised to use fresh Neem tree admixture extract (root, bark and leaves) of weight 1000g soaked in 10litres of water for 12-24hours at the concentration of 30ml in 10litres of water and 40mls in 10litres of water in cabbage aphids' control would be advised. Efficacy of 20ml of Neem tree extract in 10litres of water could not be clearly ascertained in this experiment, there were little disappearance of aphids and sudden resurgence of the aphids' population. Meaning that 20mls was under-dose for the aphids population off-cabbage crop.

From the second objective, it was recommended that 30mls of Neem tree extract solution was the best as the most effective concentration of Neem tree extract in cabbage aphids' control during the first season and the second season of cabbage production. It was effective in cabbage aphids' control and other pests by lowering the aphids' population to at least 2% and also improving the quality of the marketable weight of cabbage. This would be more advantageous to the farmer if he /she use 30mls concentration of Neem tree extract as an organic pesticide in the garden. This results was followed by 40mls of Neem tree extract solution which was 2ndbest to 30mls (Table 4.5 & 4.6) yield results. 20mls of Neem tree extract lowered pests' population in the field at an early stage of cabbage growth most especially cabbage aphids; the effect was short termed for about 3 – 4 days only. This was a clear indication that the lethal-dose was not enough to keep the aphids' population below acceptable levels. As expected, control plots were heavily infested with cabbage aphids and cabbage loopers which was not our target pest in both first season and second season. Plants' growths were delayed because of pest's effect.

The study concluded that 30mls concentration of fresh admixture of Neem tree extract in 10litres of water which was soaked for 12-24hours was the most effective treatment. Heavier infestations, the study recommended 30ml of Neem tree extract in 10litres of water sprayed twice and once a week as their performance was the best in this experiment.

5.4 Recommendations on the conclusions

1. This work recommends that farmers use Neem tree extract in organic cabbage aphids' control and the concentration to use should be 30mls of fresh Neem tree admixture extract (root, bark and leaves) in 10litres of water soaked for 12-24hours for heavier infestations since its performance was the best in this experiment.
2. This work recommends that effective frequency of Neem tree extract application is twice a week and once a week to keep off the aphids' population.
3. The work recommend that farmers should plant more Neem trees around their farms and practice use of natural pesticides (plant extracts) in their farming systems in order to enhance biodiversity improvement and balancing the ecosystem as well as healthy environment
4. This work recommends practical / field study on the general cost of production using Neem tree extract (costs – benefits ratio to the producer).
5. Recommendations for Further Research on Neem tree extract use in combination with other plant extract such as eye- bird chili in pest control especially the loopers which did not respond to Neem tree admixture treatment well.

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