

KWAME NKURUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY –

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DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY

**THE EFFECT OF AQUEOUS GINGER (*Zingiber officinale*) EXTRACTS
ON THE MANAGEMENT OF MAJOR PESTS OF CABBAGE (*Brassicae oleracea*
var.capitata)**

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DEDICATION

To her who inspires me, who tells me I can make it, who wants the best for

*Me, to her I dedicate this thesis with love. God bless you, **Madam Felicia Brobbey.***

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
cm	Centimetre(s)
FAO	Food and Agriculture Organization
g	Gram(s)
kg	Kilogram(s)
KNUST	Kwame Nkrumah University of Science and Technology
L	Litre(s)
ml	Millilitre(s)
RCBD	Randomised Completely Block Design
w/v	Weight by volume
WHO	World Health Organisation
PAN	Pesticide Action Network
DBM	Diamond- Back Moth
AD	Alzheimer disease
NPAS	Northern Presbyterian Agriculture Services
BC	Before Christ
DNA	De-oxy Ribo Nucleic Acid
DDT	Dichlorodiphenyl-trichloro ethane
DDE	Dichlorodihenyldichloro ethylene
HCH	Hexachlorohexane
UN	United Nations
EPA	Environmental Protection Agency
SAS	Statitiscal Analysis System
GLM	General Linear Model
SNK	Student Neuman Keul's
NRCs	Natural Resource Consevation Service
WAT	Weeks After Transplanting

ABSTRACT

Insect pests are a serious constraint to cabbage production in Ghana. Every phenological stage in the life cycle of the crop has at least one major insect pest. Caterpillars of the diamond back moth (*Plutella xylostella*), the cabbage web-worm (*Hellula undalis*) and cabbage aphids (*Brevicoryne brassicae*) are the most serious pests of cabbage in Ghana. These pest cause percentage leaf damage between 18 % and 31 %. The attack of one or more of these pests may result in total crop loss. Their successful management is therefore critical to ensuring food security. The use of synthetic insecticides for the control of these pest has been the standard practice, however, an increasing awareness of the environmental hazards associated with insecticide use as well as the high costs of control has intensified the need for a less hazardous form of pest control. Biopesticides have long been an alternative to synthetic chemical insecticides for pest management because botanicals apparently pose little threat to the environment and to human health. The efficacy of aqueous extract of the rhizome of ginger, *Zingiber officinale* was therefore assessed for the control of the major insect pests of cabbage in the 2013 minor season and 2014 major season. Four concentration of the rhizome extract – 5 %, 10 %, 15 % and 20 % - were tested along with a synthetic insecticide (Abamectin) and control (water) to assess the potency of the extract. The synthetic insecticide, Abamectin was superior in reducing insect populations and compared favourably with the aqueous ginger extract for many of the parameters measured. For example, in the minor season, the mean pest numbers recorded for *Brevicoryne brassicae* was 0.15 for the abamectin and the least of 0.52 recorded in 15 % ginger-sprayed plots while in the major season, 0.20 mean numbers were recorded on abamectin sprayed plots and the least of 2.14 recorded on the 5% ginger-sprayed plots. The yields for plots of the aqueous ginger extract performed almost the same as the synthetic insecticide spray plots. Mean numbers of 0.57 kg was recorded for the insecticide spray plots and 0.72 kg, 0.45 kg, 0.50 kg, 0.53 kg for 5 %, 10 %, 15 % and 20 % ginger-sprayed plots respectively in the minor season. The insecticides - sprayed plots recorded the mean weight of 1.39 kg, whilst the least (0.77 kg) was recorded on the 20 % ginger sprayed plots in the major season. Even though the aqueous ginger extract could not completely manage the pest of cabbage, it reduced the numbers due to its repellent properties even though not as effective as the insecticide spray, Abamectin

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Cabbage (*Brassica Oleracea Var. capitata L*) is a vegetable crop which is grown worldwide (FAO/WHO, 1995). The Food and Agriculture Organization has named cabbage as one of the top twenty vegetables and an essential source of food globally. Cabbage is a foreign leafy vegetable cultivated in many African countries. Cabbage is well-known in Ghana and especially among peri-urban and urban residents (Timbilla & Nyarko, 2004). Although it is a biennial crop, cabbage is widely grown as an annual. It thrives best in moderate climatic conditions (Cabbage, Encyclopedia Britannica, 2010). Structurally, cabbage has a short thickened stem surrounded by alternation of overlapping expanded leaves which form a compact head (Rice, R. P., Rice, L. W., and Tindall, H. D., 1986). The importance of cabbage as a cash crop of economic importance and as a vegetable food in various household in Ghana cannot be overlooked. Cabbage is mostly used to prepare stews, soups and can also be eaten fresh as an important component of salads (Van der Vossen & Seif, 2004). According to Norman (1992), cabbage is a nutritious leafy vegetable. The nutritional values in per 100g of raw cabbage are: 21 cal energy, 1.2 g protein, vitamins as well as some minerals such as potassium, phosphorus, magnesium and sodium (Baidoo & Adam, 2012). Over the years, farmers have grown cabbage more intensively to meet the rising demands. There are several constraints to the cabbage industry in Ghana. Out of these constraints, pests contribute greatly to high yield losses before harvest. The increase in the production of cabbage, has led to problems of high incidence of pests infestations. The diamond back moth (*Plutella xylostella*) is one of the most important pest of cabbage. The damages caused by this pest is a serious challenge to cabbage production worldwide, sometimes resulting in

more than 90 % crop loss” (Iqbal M., Verkerk R. H. J, Furlong M. J., Ong P. C., Syed A. R., Wright D. J., 1996). Other pests of cabbage are Aphids (*Aphis brassicae*), the cabbage webworm (*Hellula undalis*), and the cabbage looper (*Trichophisia ni* (Baidoo & Adam, 2012). These pests causes damage to cabbage heads by perforating the leaves, destroying the growing buds and burrowing into mature heads. The feeding action of these pests decreases the quality and the markets value of cabbage, leading to financial loss to farmers. The deleterious nature of these pests has made it necessary to apply control measures to minimize their effects. Over the years, chemical pesticides have been used to control insect pest in vegetable crop production, however, there are several problems with the used of these chemical pesticides. The increased health hazards to applicators, development of resistance by pest, environmental contamination and hazardous to consumers due to high residual levels are some of the problems associated with chemical pesticides. The swift rise in the numbers of these pests necessitates the application of high quantities of pesticides (Kim, J. J., Lee, M. H., Yoon, C., and Kim, H., 2001).

The adverse impact of pesticides has raised the interest in alternative control methods, highlighting on the use of biological control, the use of resistant varieties, cultural control and other non-polluting methods (Lim, G.S., Sivapragasam, A., and Loke, W.H., 1996). Considerable efforts have been created to minimize the use of synthetic pesticides, specifically the use of chemical insecticides. One of the efforts is the development of botanical insecticides as a nobel and secure alternative strategies. Botanical insecticides, which contain plant extracts as active components, are safer as well as environmentally friendly than synthetic insecticides.

This work was done with the primary aim of using indigenous control methods that are environmentally friendly, cost effective and could easily be practiced on cabbage farms. Therefore, this study was conducted to assess the effectiveness of ginger, *Zingiber officinale* formulations in managing the major insect pests of cabbage.

1.2 PROBLEM STATEMENT/JUSTIFICATION

The indiscriminate application of chemicals has given rise to a number of complications including genetic resistance of the insect pest species, accumulation of toxic residues in treated grain (Singh, R. N., Maheshwari, M. and Saratchandra, B., 2004). Other environmental problems include extensive groundwater contamination, killing of nontarget organisms and serious health hazards to applicators. Chemical insecticides are also expensive and their use results in increased cost of production (Pretty & Waibel, 2005). These problems have compelled the search for alternative and effective environmentally safe insecticides, which have greater selectivity. Plant extracts, as bio pesticides, are gaining popularity because they are inherently less harmful than conventional pesticides (Oparaeke A. M., Dike M. C., Amatoobi C. I., 2000a). Most plant- derived products are considered to be less toxic to non-target organisms, easily breakdown and therefore do not persist in the environment as opposed to synthetic products which often end up being pollutants. Plant products are also less expensive especially if they are available locally

(Isman, 2006).

Over the last few decades, there has been rising focus on plant-derived products to curb and minimize losses caused by agricultural pests and diseases (Devi & Gupta, 2000). This study therefore sought to assess the impact of some botanicals on the management of major pest of cabbage.

1.3 GENERAL OBJECTIVE

The main objective of the study was to determine the effects of aqueous extract of *Zingiber officinale* rhizome on major cabbage pests.

1.3.1 Specific Objectives

The specific objectives of the study were to:

- ▶ Determine the effect of different concentrations of aqueous extract of *Zingiber officinale* on major cabbage pests.
- ▶ Determine the minimum concentration of aqueous extract of *Zingiber officinale* that can significantly reduce the pest of cabbage.



CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 HISTORY OF CABBAGE

Cabbage (*Brassica oleracea* L.var. *capitata*) belongs to the Brassicaceae families, which include Brussels sprouts, cauliflower, broccoli, collards, kale and mustard and. These crops

are collectively known as cole crops or crucifers. The literature of the Roman and the Early Greek make reference to the growing of cole crops for their anticipated medicinal properties as well as its use as a source of food (Kemble, J. M., Zehnder, G.W., Sikora E. J. and Patterson, M. G., 1999). They believed that these crops alleviated conditions such as deafness, gout and headaches had resulted in the spread of Cole crops from the Mediterranean through the Old World. Cabbage and many of the Cole crops are now cultivated worldwide for use in the fresh state and in processed forms.

The cabbage plant is native to the Mediterranean environs of Europe in the wild and is quite similar in features to a leafy canola plant. People who lived in the Mediterranean regions began cultivating this ancient cabbage plant as a first leafy vegetable sometime soon after the domestication of plants began. It was normal that those plants with the most leaves would be selective to be propagated for next year's crop, because leaves were the part of the plants which were eaten. This led to the development of larger-leafed plants as the seed from the largest-leafed plants were favoured. Continued preference for ever larger cabbage leaved plants by the 5th century B.C. led to the improvement of the vegetable we now call Kale.

Cabbage has been grown as a leafy vegetable for thousands of years, and is still cultivated currently. People began to show interest for those plants as time passed, with a cluster of soft young leaves in the centre of the plant and also at the top of the stem. These plants were chosen and grown more again and again because of the interest for plants in which there were a large number of tender leaves firmly packed into the terminal bud at the top of the stem. A continuous favoritism of these plants for hundreds of successional generations resulted in gradual arrangements of a more and more dense array of leaves at the top of the

plants. The array of leaves eventually became so large and dominated the entire plant, and the cabbage “head” we know today was born. The plant was then called *Brassica oleracea* variety *capitata* which means cabbage of vegetable garden with head (Baldwin, 1995).

2.2 NUTRITIONAL AND HEALTH BENEFITS OF CABBAGE

Cabbages contain tremendous nutritive value. It contains important vitamins, carbohydrates, vital minerals and proteins (Norman, 1992). Tindall (1983) enumerated the nutritive components of cabbage leaves per 100g edible portion as follows: water – 93 ml, fat – 0.2 g, carbohydrates – 4 g, protein – 1.5 g, fiber – 0.8 g, calcium – 40 mg, calories – 23 ml, riboflavin – 0.05 mg, iron – 0.5, vitamin potency – 30 iu, niacin – 0.3 mg, ascorbic acid – 40 mg and thiamine – 0.05 mg. A study on 600 men at University of Utah medical school disclosed that, people who ate a lot of cruciferous vegetables contracted much lower risk of colon cancer. On the other hand, consuming too much of cabbage may contribute to problems of the thyroid, possibly goiter (Anonymous). Juice from cabbage is a well-known antidote for treating peptic ulcers. In a medical study at Stanford University’s School of Medicine, thirteen ulcer patients were administered with five doses of cabbage juice each day and all were cured within seven to ten days (Allen & Allen, 2009).

Lin (2008) reported that, people eating a lot of cruciferous vegetables have a much minimal risk of contracting prostate, lung cancer and even colorectal when compared to those who eat other vegetables regularly.

2.3 MAJOR PESTS OF CABBAGE IN GHANA

According to Mochiah, M. B., Baidoo, P. K., and Owusu-Akyaw, M. (2011), the Diamond back moth caterpillars (*Plutella xylostella*), the cabbage web-worm (*Hellula undalis*) and

cabbage aphids (*Brevicoryne brassicae*) are the most severe pests of cabbage in Ghana given rise to percentage leaf damage between 18 % and 31%. Cabbage pests might occur at the different growth stages of the cabbage plant as indicated in Table 1.

Table 1: Cabbage growth stages and associated pest .

Growth stages	Insect/mite Pests
0 stage -seeds	Ants
Seedling stage - Leaves and leafstalks - Roots	Cutworm Aphids Diamondback moth Flea beetles Whiteflies Cabbage root maggot
Vegetative stage (true leaf development up to cupping) - Leaves and leafstalks	Aphids Cabbage head caterpillar Cabbage looper Cabbage webworm Cabbage white butterfly Diamondback moth Flea beetles Spider mites
Maturation stage (Pre head formation up to head fill) - Developing and maturing head - Roots	<i>Aphids</i> <i>Cabbagehead caterpillar</i> <i>Cabbage looper</i> <i>Cabbage webworm</i> <i>Diamondback moth</i> <i>Cabbage root maggot</i>

Source: http://www.oisat.org/downloads/field_guide_cabbag

These are the insect pests of economic importance although other insects do attack cabbage. Attack from any of these pests has been reported to cause reduction in the yield of the crop. Because of the economic importance of these pests, it is important that efforts are channeled into their control.

2.3.1 Cabbage Aphids (*Brevicoryne brassicae*).

According to Amoah (2010), there are about 4,000 known species of aphids of which about 250 are severe pests. About 25 % of all plants are infested with aphids (Moran & Baumann, 1994). During dry spells, cabbage aphids occur usually in large numbers mainly (Amoako, 2010). They attack cabbage quite early in the field. Greenish grey colonies of tiny round aphids can be found under the basal leaves of cabbage.

The adult and the nymph both penetrate the tissues of the plant to extract the plant sap. The leaves of infested plants become seriously damaged when the saliva of aphids are infuse into them. Persistent feeding by aphids causes yellowing, defoliation, wilting, stunting of plants, crinkling and cupping of the leaves due to feeding on the plant (Opfer & McGmath, 2013). Huge amount of sugary liquid waste called honeydew which is produced by aphids gather on leaves and branches and make room for the growth of a fungus called sooty mould and thus turn branches and leaves black. The presence of a sooty mould on plants is an evidence of an aphid infestation. According to Griffin and Williamson (2012), plants seriously infested, become covered with an assemblage of small sticky aphids (due to honeydew secretions), which in the cause of time lead to death and decay of leaves. The eggs of the aphids are very little, shiny and black, and are located in the crevices of stems, buds and barks of the plant. The nymphs are very much alike to the young adults and are fully-grown within 7-10 days and are ready to reproduce(Fig.1). The adults have soft body with two projections on the rear end and with two long antennae. They are small and about 3-4 mm long (Pesticides Action Network (PAN), 2008). The colour of their bodies ranges from green, yellow, brown, to purple etc.



Fig 1: Nymphs of Aphids (*Brevicoryne brassicae*)

Source: <http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=9629>

Cabbage aphids often have a waxy appearance (Roger *et al.*, 2005). Their females can lay eggs as well as give birth to live nymphs. Nevertheless, the main means of perpetuation for a lot of aphid species is asexual. Their eggs hatch inside their bodies, and they give birth to live young ones. Adults are black in colour and possess wings, which are produced only when there is overcrowding in colonies, when it is necessary for the colony to move, or when there is adverse climatic condition. Cabbage aphids also have natural enemies such as ladybird beetle which usually control these pests effectively (Youdeowei, 2002).

2.3.2 Diamond-Back Moth (DBM) (*Plutella xylostella*)

The diamond back moth, *Plutella xylostella* (L.), (DBM), is one of the most critical pests of cruciferous crops all over the world and can cause severe economic losses if not controlled (Oke O. A., Charles N. C., Ismaell C and Lesperance D., 1996). It is the most serious pest of

cabbage, often occurring in large numbers as the generations develop within a few weeks (Amoako, 2010). According to PAN (2008), their eggs are very small, ovateshaped, and yellowish-white in appearance. Their eggs are laid individually or in groups along the veins in the upper and lower leaf surfaces. The eggs of this pest take about 5-6 days to hatch. The larvae of diamond back moth are pale yellowish-green to green covered with fine, dispersed, upright hairs without stripes, and tapered at both ends as shown in Fig

.2. When it prodded, it wiggles its whole body vigorously and usually drops from the plant (Welty, 2009)



Fig. 2 Larvae of Diamond back-moth (*Plutella xylostella*)

Source: <http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=9629>

The just hatched larvae mine and tunnel in the leaves. As they grow older; they feed on the undersides of the leaves resulting in a 'window effect'(PAN, 2008). The larvae make nonuniform holes and burrow into the cabbage heads and by that, the larvae prevent further development of the cabbage heads. Diamond back moths (DBM) causes damage by feeding

on the leaves but do not cause damage to flower heads (PAN, 2008). The adult's diamond back moth (DBM) are slender, very small, with folded wings flaring outward and upward at their posterior ends. They can easily be identified by their three pale, triangular markings along the inner margin of the wings. They can cause heavy perforations on heads and render cabbage heads unmarketable. They are resistant to many conventional pesticides and so spraying diamondback moth infested cabbage often have little effect and the main natural enemies of diamondback moth are ladybird beetle, parasitic wasps and predatory ants (Youdeowei, 2002).

2.3.3 Cabbage Webworm (*Hellula undalis*)

These are light brown caterpillars found on cabbage. The adult is grayish-brown in appearance with pale-dusky hind wings. Each forewing possesses a projected black spot and zigzag light-brown lines.

According to PAN (2008), the central band between the light-brown lines is sometimes filled with dark-brown scales. The adult moth of the cabbage webworm is capable of flying long distances. The webworm causes damage by boring into the main veins of leaves of cabbages and later into the centre of the stems where they then feed. This makes the pest difficult to control with pesticides because of their feeding habit. Plants and seedlings that are attacked by cabbage webworm do not survive. They destroy the heads completely in mature cabbage plants making them unsuitable for sale. The eggs are ovoid in shape, pinkish in colour and are quite flattened from the surface of deposit. The eggs, when laid are pearly white in appearance. It then turns pinkish and then to brownish-red with the dark head of the larvae observable at one end just before hatching (Fig.3) (Harakly, 1968).



Fig. 3: Larva of webworm (*Hellula undalis*)

Source: <http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=9629>

Caterpillars of this pest are grayish-yellow in appearance and have five longitudinal stripes on dorsal surface, which have purplish and reddish brown shade (Singh & Rose, 2009). It is about 1.2 to 1.5 cm when fully. It takes about 6 to 18 days to complete the larval stage whereas the stage of the pupa last around 4 to 20 days (PAN, 2008). The pupa is usually found inside a loose cocoon and possesses a shining pale-brown colour with a dark dorsal stripe.

The larva of the cabbage webworm causes damage by mining or boring holes into leaves and stems. They cause damage first by feeding on the peripherals of the leaves and then extend their feeding into the terminal bud. They feed underneath their protective webs that they manufacture from the silken like threads that they produce and can be identified by their webs, frays, and other feeding debris produced. Damage is most serious between transplanting and the heading stage of cabbage even though the larvae exist in the field throughout the crop (Sivapragasam & Aziz, 1990). Plants infested with cabbage webworm produce small heads or no heads at all in severe cases. The main natural enemies of the webworm are predatory ants and parasitic wasps (Youdeowei, 2002).

2.4 THE USE OF PESTICIDES FOR THE CONTROL OF INSECT PESTS

Agricultural plants in their growth phase or in storage are attacked by 70,000 species of mites and insects and around 10,000 species of them cause significant economic harm (Gruzdyer, G. S., Zinchenko, V. A., Kalinin, V. A. and Slovtov, R. I., 1983). The pioneers of the use of insecticides were recorded around 4500 years ago by Sumerians who applied sulphur compounds to control insects and mites. At the same time, the Chinese around 3200 years ago were using mercury and arsenic compounds to control body lice (Unsworth, 2010). The first records of insecticides as reported by (Stiling, 1985) were made as far back as the year 2500 BC. The absence of chemical industries during ancient Greek and Roman periods led to the use of plant or animal products or minerals that could be easily obtained. Some of such practices include the use of smoke against mildew and blights and tar on tree trunks to allure creeping insects. Weeds were controlled mostly by hand weeding but diverse “chemical” methods such as the use of salt or seawater were also described. Biopesticides such as Pyrethrum, which is obtain from the flowers of dried *Chrysanthemum cinerariaefolium* has been applied as an insecticide for over 2000 years. The powder obtained from *C. cinerariaefolium* was also used by Persians to protect stored grains. The first recorded use of a pesticide was elemental sulphur dusting against lice in 2000 BC. The Pre-Roman civilizations burned Sulphur and used as a medicine, as bleaching agents, as fumigants and incense in religious rites. Homer reported the same uses of sulphur in the Odyssey in 1000 B.C (Fishel, 2013). According to Homer, people knew the methods of fumigating premises against insects by burning sulphur, which has also, became a herald of the sulphur fungicides used until today. The Chinese have been known to use lime, sawdust,

street dust and insecticides of plant origin to protect seeds against pests as early as in 1200 BC (Banaszkiewicz, 2010). Poisonous chemicals such as Mercury, Lead and Arsenic use were reported as early as the 15th century. More or less at the same time as in 1200 BC, in China, various substances containing mercury and arsenic were used to control lice in humans (Banaszkiewicz, 2010). A natural pesticide such as pyrethrum and rotenone, which is obtain from the roots of vegetables in the tropics, was introduced in the 19th century (Miller, 2002).

A lot of inorganic chemicals have been used as pesticides since the early times and chemicals like the Bordeaux mixture is still used against different fungal diseases. The real revolution in chemical control of pests took place in 1939, when a Swiss chemist, Muller, who was awarded the Nobel Prize in 1948 demonstrated the insecticidal properties of DDT (dichlorodiphenyltrichloroethane) (Banaszkiewicz, 2010). This hurriedly became the most extensively used pesticide in the world. Manufacturers then began to mass produce synthetic pesticides in the 1940s and their use became widespread. Some authors consider the 1940's and 1950's to have been the inception of pesticide revolution but pesticide use has been elevated fifty folds (Murphy, 2005). The growth of synthetic pesticides increased with the discovery of the potency of contact insecticides from a group of chlorinated hydrocarbons such as dichloro-diphenyl-trichloroethane (DDT), hexa-chlorocyclo-hexane (HCH), aldrin and dieldrin, endrin, chlordane, parathion and captan in the 1940's. They were distinguished by their exceptionally broad spectrum of action and the low cost of manufacturing (Gruzdyer *et al.*, 1983). They were effective and inexpensive with DDT being the most popular, because of its broad-spectrum activity.

However, problems arose through the indiscriminate use and in 1946 resistance to DDT by houseflies were made known due to its common use. There were reports of danger to nontarget animals and plants as well as problems with residues. During the 1950's and 1960's there were several reports on resistant plaques. Rachel Carson, an American marine biologist and conservationist published "silent spring" in 1962. This book created an alertness of revealing pesticides as the reason for systematic poisoning of the ecosystem by causing eggshell defects which resulted in the reduction in the population of birds (Unsworth, 2010). About 2.3 million tons of pesticides manufactured by industries are now used each year since 1950 (Miller, 2002). Seventy-five percent (75 %) of all pesticides in the world is used in the developed countries but its use in the developing countries is rising (Miller, 2004).

2.5 NEGATIVE EFFECTS OF PESTICIDES

2.5.1 Health

Pesticides can represent a potential risk to humans when humans are exposed although it is used extensively all over the world to protect crops in agriculture and in public health to control diseases. Over ninety-eight percent (98%) insecticides and ninety-five percent (95%) of herbicides sprayed reach a point other than their target species, in addition to non-target species, water, air and food (Miller, 2004). Pesticide drift takes place when pesticides suspended in the air as particles are transported by wind to other areas potentially polluting them and this has raised environmental concerns. The exposures of people to these pesticides may account for a wide variety of acute and chronic health effects and this depends on the kinds on pesticide and the quantity exposed to. Acute poisoning may cause vomiting, rashes,

nausea, headache, and diarrhea. Chronic exposure to some types of pesticides may bring about asthma symptoms; other groups may raise the risk for certain types of cancers and birth defects, or cause impairment to the genetic and immune systems.

In the publication of their findings the database listed several studies that linked pesticide use to Alzheimer's diseases (AD), asthma, diabetes, leukemia and several other types of cancers (Owens, K., Feldman, J., and Kepner J., 2010). Other health – related conditions associated with pesticide use are learning and developmental disorders and autism. A study by Settimi *et al.* (2003), reported an increased risk of up to forty percent (40%) of prostate cancer in agriculture workers.

A recent review of individuals from an agricultural community in Utah exhibited higher risks among pesticide exposed individuals for all causes of dementia and an even higher risk for AD. The risk of AD connected with organophosphate exposure was the highest followed by organo-chlorines (Hayden, K. M., Norton M. C., Darcey, D., Ostbye T., Zandi P. P., Breither J. C. S and Welsh-Bohmer K. A., 2010). The use of pesticides in urban agriculture has negative health effects on the farmers including impotency in men and infertility in women in Ghana (Mensah, E.; Amoah, P.; Abaidoo, R. C.; and Drechsel, P., 2001).

In Ghana, the Northern Presbyterian Agricultural Services (NPAS, 2012) has for years been announcing complications experienced by farmers in the use of pesticides. General body weakness, skin irritations, dizziness, headaches and difficulty in breathing are some of the problems experienced by farmers who use pesticides. In a survey of 183 farmers in 14 villages in Upper East Region of Ghana, more than a quarter had in recent times suffered from directly from respiring chemicals and one fifth from spillage of chemicals on the body.

15 farmers perished from suspected pesticide poisoning in Upper East Region in late 2010 and the greatest of these death were assigned to poor storage of pesticides, which seeped into food stocks (NPAS, 2012).

According to NPAS (2012), a 2008 study of pesticide contamination on farmers in Ghana showed the presence of organo-chlorine residues, as well as DDT, in the breast milk and blood of humans of vegetable farmers. Pesticides can be dangerous to bystanders, workers during manufacture, transport, consumers or during and after it application. According to World Health Organization and the United Nation Environmental Program, every year estimated three million workers in agriculture in developing countries experience serious poisoning from pesticides and from this number, about eighteen thousands of them died (Miller, 2004).

2.5.2 The environment

Pesticides are one of the agents of water contaminations and some pesticides are continuous organic contaminants and contribute to soil contamination. The indiscriminate use of pesticides, careless operation of machinery and application of pesticides can result in over spraying and therefore the contamination of freshwater by spray-drift. Splashing and spillages when sprayers are filled, emptied and cleaned, or when they are left out in the rains, run-off from treated areas and leaching through the soil are also some of the ways that pesticides can enter the environment. Pesticides can sometimes be used directly on the surfaces of water in some situations. A typical example is the control of mosquitoes. The pollution of water rely mainly on the properties of soil, weather conditions, landscape , nature of pesticides, and also the interval between an application sites to a source of water. Groundwater contamination may be caused by heavy rainfall shortly after applications of the

pesticide to wet soils. Even though pesticides are used to improve the yield and quality of food produce, Carvalho (2006) cited that regardless of the rising food production, excessive use of pesticides has caused severe contamination of aquifers and surface water bodies, deteriorate the quality of water for human consumption. Results from allembicing set of studies done by the U.S. Geological Survey (USGS) on major river basins across the country in the early to mid- 90s revealed an impressive results where more than ninety percent (90 %) of water and fish samples from all streams composed of one, or numerous pesticides (Kole, R. K., Banerjee, H. and Bhattacharyya, A., 2001). Pesticides were discovered in all the samples from major rivers with mixed agricultural and urban land use influences, and ninety-nine peercent (99 %) of samples of urban streams.

Diazinon and diuron were found at levels transcending concentrations approved by the National Academy of Sciences for the protection of aquatic life (Aktar, W., Sengupta D. D. and Chowdrury, A. A., 2001).The ground waters of more than 43 states in the United States have been found to contain every major pesticide chemical group over the past two decades (Waskom, 1994). During one study in Bhopal, India, Organo-Chlorine pesticides were detected in fifty-eight percent (58 %) of water samples drawn from different hand pumps and wells and these were beyond the EPA standards (Aktar *et al.*, 2001).

In the intensive cocoa cultivation zones in the Eastern and Ashanti Regions of Ghana, samples of water from rivers were found to contain lindane and endosulfan (Acquaah, 1997). In Akumadan which is a major vegetables growing town in the Ashanti region of Ghana, serious levels of pesticides residues have been recorded in water bodies. The Oda, Kowire and Atwetwe Rivers of Ghana were found to contain pesticide residues. The mean concentrations of pesticides contain in water samples for lindane and endosulfan were 19.4

and 12.4 $\mu\text{g}\cdot\text{L}^{-1}$ in the Oda, 16.4 and 17.9 $\mu\text{g}\cdot\text{L}^{-1}$ in Kowire 20.5 and 21.4 $\mu\text{g}\cdot\text{L}^{-1}$ in Atwetwe, respectively (Acquaah, 1997).

Some pesticides such as soil fumigants and nematicides are utilized precisely in soils to check pests and plant diseases present in the soil. Natural processes, chemical properties, physical properties, as well as biological properties of the soil decide the tenacity, degradation, transport and fate of pesticides in the soil. These agents also affect sorption or desorption, volatilization, plants uptake, run-off, and leaching of pesticides (PAN, 2010). According to Goody, D. C., Chilton P. J. and Harrison I. (2002), once an agrochemical is sprayed to the soil, a number of things may take place. It may either be used up by plants or consumed by worms, insects or microorganisms in the soil. It can also vapourize and penetrate the atmosphere, degrade through solar energy, breakdown through chemical and microbial pathways into compounds that are less toxic or descend into the soil and either dissolve or cleave to particles. About 3.10^9 kg of pesticides globally is used annually with a purchase price of nearly \$40 billion each year (Hussain *et al.*, 2009), but the quantity of applied pesticides that get to the target organism is around 0.1 % while the remainder pollutes the soil environment (Carriger, J. F., Rand, G. M., Gardinali, P. R., Perry, W. B., Tompkins, M. S., and Fernandez, A. M., 2006).

Pesticides interact with soil organisms and their metabolic activities (Singh and Walker, 2006). Pesticides can also modify the physiological and biochemical behaviour of soil microbes. Glover-Amengor and Tetteh, (2008), measured the effects of over application of chemicals on biomass and microorganism in vegetables agro-ecosystems. They found that the pesticides reduced the populations' bacteria's which affected nitrification and other microbial processes thereby reducing the fertility of the soil.

According to Hussain S. A., Siddique T., Muhammad S., Muhammad. A., and Azeem K. (2009), many recent studies have exposed the detrimental impacts of pesticides on soil microbial biomass. A decrease in soil respiration indicates the reduction in microbial biomass whereas increase in respiration signifies enhanced growth of bacterial population. The application of pesticides may also inhibit or it may be lethal to some class of microorganisms and improve upon other groups by eliminating them from the competition. For instance Chen *et al.* (2001), reported that the applications of fungicides destroyed and inhibited the action of certain fungi which led to a rapid flush of bacterial activity.

Pesticides have also been reported to have detrimental impacts on algae by controlling their development, nitrogen fixation, biochemical composition, photosynthesis and metabolic activities, etc. (Hussain *et al.*, 2009)

The Environmental Protection Agency (EPA), (Ghana) has refused the importation of 25 agrochemicals because of their toxicological risks to humans, animals other crops and the environment. This comprises toxaphene, captafol, aldrin, endrin, chlordane and DDT. In addition, 118 chemicals were endorsed for importation after undergoing testing for potency and safety under local conditions. Twenty four Agrochemicals were given provisional clearance for one year but if these chemicals prove ineffective or dangerous they will be banned. There is a worry that Africa has been turned into discarding grounds for unsafe chemicals. Ghanaian scientists have been prompted by the EPA to prioritize the use of biological control methods in other to reduce the over-dependence on chemicals. .

2.6 PESTICIDE RESIDUES IN VEGETABLES

Organic and synthetic pesticides residues can be detected in consumables like poultry, vegetables, bread, fruits, meat, fish, and some foods made from them. Some of this pesticide pollution is legal, but does not mean it is free from harm. Much of it is illegal, with residues found in excess of regulatory safe levels (Amoako, 2010). In order to assure the health of humans and the environment, the level of trace contaminants in our food need to be identified and determined.

In order to determine the extent of pesticides contamination in the food stuffs, programs entitled 'Monitoring of Pesticide Residues in Products of Plant Origin in the European Union', started to be established in the European Union since 1996. Seven pesticides (acephate, chlorpyrifos, chlorpyrifos-methyl, methamidophos, iprodione, procymidone and chlorothalonil) and two groups of pesticides (benomyl group and maneb group, i.e. dithiocarbamates) were analysed in grapes, lettuce, mangoes, strawberries and apples. For each pesticide or pesticide group an average of about 9700 samples were analysed and out of that 5.2 % of the samples were found to contain residues and 0.31% had residues greater than the respective MRL for that specific pesticide. Lettuce registered the highest number of positive results, with levels of residues going beyond the MRLs more frequently than in any of the other crops investigated. The maximum value found in lettuce in 1996 correlated to a mancozeb residue of 118 mg/kg (Aktar *et al.*, 2009).

Organochlorine pesticides are commonly used due to their efficacy and their broad spectrum activities. Lindane has been an extensively used chemical in Ghana on plantations of cocoa

and on vegetable farms. Endosulfan, advertised as Thiodan is generally applied in cotton growing areas, coffee plantations and on vegetable farms

(Gerken, A., Suglo, J. V. and Braun, M., 2001).

Cocoa beans assembled from predominantly cocoa cultivation zones and two shipping ports (Tema and Tarkoradi) in Ghana showed appreciable quantity of lindane insecticides. A study to evaluate the residual level of chosen pesticides applied on tomatoes in Ghana, revealed the presence of organochlorines and organophosphates. Ntow (1998) detected levels of endosulfan, chlopyrifos, and lambda-cyhalothrin, DDT and lindane residues in onion, tomato, cabbage and lettuce sampled on the Ghanaian market.

Amoah *et al.* (2006) carried out a research to assess and relate the current levels of vulnerability of people to dangerous pesticides and contaminations from faecal coliforms through the consumption of fresh vegetable produced with waste water irrigation. The results showed that most of the residues recorded surpassed the maximum residual limits safe for consumption. This study implies that the public health of Ghanaians and its neighboring countries are threatened from pesticide because several vegetables are eaten in their raw state or sometimes partially cooked. Amoah *et al.* (2006) indicated that the most suitable entry points for risks minimization that also addresses post-harvest contamination is cleaning vegetables before they are used. A research on street vending foods conducted by Acquah (1997) in Accra, showed disturbing levels of contaminations by mycotoxins, pesticide, microorganisms and heavy metals.

Despite the fact that organochlorines are illegal, purchase and its application in the country, there is proof of their continuous applications. Bioconcentration and biomagnification of pesticide in food chains through concentration in the adipose tissues and in blood serum of

animal's results from the persistence and lipophilicity of these pesticides. Fishes were also found to contain organochlorines pesticide residues in a study conducted in selected farming communities in the Ashanti Region of Ghana (Osafu, A. S. & Frempong., 1998). A Data collected on 186 samples of 20 commercial brands of infants formulae also disclose residues of DDT and HCH isomers in about 70 % and 94 % of the samples with their utmost level of 4.3 and 5.7 mg/kg (fat basis) respectively (Aktar *et al.*,2009).

Meat may also contain elevated levels of pesticide residues as a result of concentration of residues in the tissues from dipping of cattle's or vector control or when cattle ingest feedstuffs polluted with these chemicals. Because these chemicals are deadly to organisms that are living, elevated accumulation in the food chain may cause severe health hazards to the general public (Jayashree & Vasudevan , 2007).

2.7 CHOICE OF CHEMICAL CONTROL (ABAMECTIN)

Abamectin which is also known as B1 and MK-936 is a Chinese pesticide which is one of the fermentation products from a strain of soil microorganism *Streptomyces avermitilis* possessing potent anthelmintic and insecticidal activities. It has other trade names such as Dynamec, Zephyr, Vertimec, Affirm, Agri-Mek, Genesis horse wormer and so on. It is made up of avermectins which is a macrocyclic lactone effective against agriculturally important insects and mites. The World Health Organization has been using doses of 50 to 200 ug/kg to treat human onchocerciasis also known as river blindness. Pesticidal activities of abamectin are related to the interaction with the nerve transmitter, gamma aminobutyric acid. It interferes with the neural and neuromuscular transmission by acting on a specific type of synapse located only within the brain.

Abamectin is not readily absorbed through the skin of mammals and humans are less susceptible to its toxicity, however the mammalian blood–brain barrier can be penetrated at high doses causing symptoms such as tremors, lethargy, incoordination, excitation and pupil dilation. It can also cause death from respiratory diseases at high doses.

Emulsifiable concentrate formulations may cause slight to moderate eye irritations and mild skin irritations. Symptoms of poisoning observed in laboratory animals include pupil dilation, vomiting, convulsion or tremors and coma.

2.8 USE OF BIOPESTICIDES AND PLANT EXTRACT

Natural products have been used in traditional medicine all over the world for thousands of years, pre-dating the introductions of antibiotics and other modern drugs. Over the last five decades, more than 2,000 plant species have been known to contain toxic principles that can be used to control insects (Isman, 1997).

Bio-pesticides are pesticides derived from such natural materials as plants, animals, microorganisms and some minerals. Secondary products obtained from these higher plants represent vast array of biologically active compounds that have been taken advantage of as pesticides. The use of these bio-pesticides is gaining much popularity because of the diverse problems associated with the use of synthetic chemicals. These bio-pesticides have also proven effective for the control of numerous insects of economic interest. They break down easily in the soil and are not stored in animal and plant tissue, thus the advocacy for use in insect pest management. In recent times studies have increased on the use of naturally occurring pesticides for pest control. Leaves and seeds of many botanical families has been investigated by many researchers by isolating, identifying and screening for chemical

compounds that deter and inhibit growth (Reed *et al.*, 1982). Among the well represented plant pesticides is crude extracts of West African black pepper, *Piper guineense*, used by Oparaeke, A. M., Dike, M. C. and Amatobi, C. I. (2000b) and Oparaeke (2007) on cowpea insect pests. A systemic effect was noticed on thrips and *vitrata* larvae in cowpea flowers while direct contact with *Maruca* larvae and pod sucking bugs (adults and nymphs) was found to be highly devastating. Pod damage was greatly reduced and grain yields consequently increased in treated plots in comparison to the untreated control. These mixed properties of West African black pepper were found useful for it to be considered as a possible candidate in the efficient management of insect pests of arable crops (Oparaeke, 2007). Neem (*Azadirachta indica*), also known as the wonder tree originated from India and is one of the pesticidal plants that has received global attention for the last two decades. The seeds of neem are a wealthy storehouse for over 100 tetranotriterpenoids and varied non-isoprenoids (Devkumar & Sukhdav, 1993). Neem extracts have also been found to effectively control aphids, thrips, pod borers and pod sucking bugs on cowpea. Numerous plants are reported as effective repellent plants against various species of pod sucking bugs. These include African marigold, goat weed and garlic (Elwell & Maas, 1995). Studies by Keita, S. M., Vincent, J. P., Schmit, S. Ranaswamyang, A. Belanger (2000) have demonstrated that the cowpea beetle, *Callosobruchus maculatus* can be controlled with essential oils particularly those extracted from the genus *Ocimum*, the basil, making plant extracts a good substitute for synthetic insecticides. Small quantities of cowpea seeds can also be protected from *C. maculatus* by combining with edible oil. The oil covers the testa, acting as an ovicide by sealing the egg micropyle, thus interfering with oxygen supply to the embryo. In some situations the oil may prevent oviposition or cause lethality of the adult

bruchid (Singh *et al.*, 1997). Work done using plant extracts in controlling *M. vitrata* includes the use of tobacco extracts (Opolot, H. N., Agona, A., Kyamanywa, S., Mbata, G. N. and Adipala, E., 2006) and *Tephrosia* aqueous extracts (Kawuki, R. S., Agona, A., Nampala, P. and Adipala, E., 2005) Raw extract mixtures of chili pepper with neem leaf have been described to be effective in reducing the numbers of thrips (<0.5 thrips/flower) in cowpea flowers and afterwards ensured higher pod load per plant on treated plots (Oparaeke, 2007). These botanicals, including neem seed extracts deter oviposition and also act as anti-feedants (Elhag, 2000). Sweetsop (*Annona squamosa*) and soursop (*Annona muricata*) which has been found to contain compounds that are slow acting stomach poisons are particularly effective against chewing insects such as lepidopterans and the Colorado potato beetle, *Leptinotarsa decemlineata* (5fc Isman, 2006). Plants which is in the *Melia spp* , a closely related genus to *Azadirachta* is gaining popularity . The seeds from the chinaberry tree, *M. azedarach*, have been found to contain a number of triterpenoids, the meliacarpins that are similar but not identical to the azadirachtins, and these too have insect growth regulating bioactivities (Kraus, 2002). Biopesticides are prepared in the form of the crude plant material, extracts or resins. The crude plant material is mostly ground into powder and may be diluted with a carrier before use.

2.9 HISTORY OF GINGER

Ginger is one of the most traded spices all over the world. According to Ampomah, (2009), ginger derives its name from Sanskrit word stringa-vera, which means "with a body like a horn". Ginger is use greatly for culinary and medicinal application. The plant is actually a rhizome of the Ginger, which is often considers as root. Ginger as a spice was originally

found in China, but its productions spread to India and other Asian countries (Ampomah, 2009).

2.9.1 Origin and Distribution

The famous 18th century Swedish botanist and general naturalist, Carl Linnaeus coined *Zingiber officinale*, the botanical name of ginger (Aidoo, 2010). Ginger is native to Asia but it is now cultivated in all the tropical and sub-tropical regions of the world. Presently, ginger is grown on a large scale in India, China, Southeast Asia, West Indies, Africa, and Australia. Almost half of the world's production comes from India. Other countries that produce ginger extensively are Brazil, Jamaica, Nigeria, Thailand, Australia and Fiji (Heinrich, M., Barnes J., Gibbons S, 2004).

Bihar, Orissa, West Bengal, Himachal Pradesh, Madhya Pradesh, and Gujarat and some places of Western Ghats are the dominant cultivators of ginger in India (Yadav, S., Rai N., Vermal, A. K. and Rajeev K. S., 2012).

2.9.2 Description of Ginger

About 1400 species of plants are placed in the family Zingiberaceae. Ginger which is a perennial plant has a narrow stem which is about 24-39 inches. The underground stem (rhizome) of ginger is the most familiar part of the plant and it is frequently used for commercial as well as homely purposes.

Rhizome of ginger is fleshy, covered in rings and also covered with some rounded projections (knobs) (Aidoo, 2010). This part (rhizome) is used as food and medicine.

Rhizomes grow underground but they are not roots but stem. About 30 cm long purple flowers emerge vertically from the rhizomes. The surface of the rhizome is greyish white and bears some light-brownish rings. It has an aroma and a sharp spicy flavor. It has an aerial erect leafy stem which grows from the tuberous rhizome (Sharma, P. C., Yelve, M. B. and Dennis, J. J., 2002).

Ginger possess leaves that are lance narrow dark green in colour, with a rib which is noticeable The inflorescence of ginger is a terminal spike with irregular flowers which are white, yellow or greenish-yellow in colour with a purplish lip, however cultivated ginger barely flowers (Pizzorno J. E., Jr., Murray M. T., 2012). Although ginger can be grown domestically by planting its rhizome in soils such as mixed loam, sand, peat moss and compost with sufficient amount of sunlight and water, the preferred habitat for the cultivation of ginger is one with a moist and hot soil with shade. Ginger also prefers soil that is well tilled and rich in loam (Herbs, 2000).

2.9.3 Chemical Composition of ginger

According to Yadav *et al.* 2012, a number of compounds have been isolated from ginger. Some of them are starch which is a major component constituting about 50 %. It is also made up of about 6 %-8 lipids and about 2.5 %-3 % essential oils. Other components found in ginger are alfa-pinene, beta-pinene, cumene, camphene, myrcene, limonene, betaphell-andrene, linalool, borneol, farnsene and sabinene. The aroma of ginger is mainly due to the presence of zingiberol.

The essential oil of fresh ginger contains geranial (alfa-citral and neral beta-citral) and thus emits a lemony aroma while the presence of cineole gives a camphoraceous smell to ginger oil. Vitamins, amino acids and protease made up of other chemicals such as cineole,

dihydrogingerol (bitter principle), hexahydrocurcumin gingerene, zingiberol (fragrant principle) are also found in ginger. The oil content of ginger is said to be responsible for its fragrance and its pungency is determined by the non-volatile phenylpropanoids and diarylheptanoids (Ampomah, 2009). Gingerol and shoagaol, a chemical constituent of ginger is said to be responsible for the pungency of ginger.

2.9.4 Medicinal Properties of ginger

Ginger is said to carry certain pharmaceutical properties which assist in digestion and treat digestion related complications such as diarrhoea and stomach cramps. Ginger is effective against nausea pains arthritis, rheumatism, muscle spasms and reduces inflammation. It also assists in the circulation of blood, removal of toxins, cleans the bowels and kidneys and also aids in all skin related problems (Ampomah, 2009). Ginger is said to be a good remedy in the treatment of asthma, bronchitis and other respiratory problems (Ampomah, 2009).

Ginger rhizome which is sweet and pungent also helps to prevent the formation of gases in the gastrointestinal tract (carminative), reduces profuse perspiration (diaphoretic), promote the production of urine (diuretic), anti-spasmodic, anti-emetic, antithrombotic, antimicrobial, analgesic, anti-aggregant, anti-leukotriene, anti-cancer, anti-oxidant, antiinflammatory, anti-prostaglandin, anti-ulcer (Duke, 2002). Normon (1994) cited that ginger rhizome is anti-mutagenic, stimulant, peripheral vasodilator, antiseptic, anti-platelet, anti-pyretic, anti-serotonergic, hypouricemic, anti-depressant, hepato- and hypoglycaemic. Ginger also has a stimulating effect on the flow of saliva, raises the tonus of the intestinal musculature, triggers peristalsis, promotes gastric secretion and minimizes cholesterol levels. Ginger in it dried state is also said to be emollient, appetizer, laxative, stomachic, stimulant, anodyne, aphrodisiac, and anthelmintic (Sharma *et al.*, 2002). A lot of research

has been carried out on the diversified herbal properties of ginger. The crop contains volatile oil, phenols, alkaloids and mucilage. The herbal therapeutic benefits of ginger are due to the presence of volatile oils and its high oleoresin content.

2.9.5 Insecticidal, fungicidal and bactericidal properties of ginger

Modest antibacterial, antifungal and molluscicidal effects have been reported in ginger. It has also been reported that ginger possesses anti-rhinoviral activity due to the compound sesquiterpenes (Yadav *et al.*, 2012). Extracts from ginger have been broadly studied for a wide range of biological activities and among these are its antibacterial, anti-fungal, and other activities. Ginger has been found to contain strong anti-bacterial and to some extent anti-fungal properties. An in-vitro study conducted revealed that the active components of ginger inhibited multiplications of colon bacteria. It is also said to inhibit the growth of *Escherichia coli* and *Salmonella* (Gugnani & Ezenwanze, 1985).

Essential oils contained in the tuberous rhizome of ginger have been used as medicine since early times. Different scientists have reported the antifungal (Hasan *et al.*, 2005), antimicrobial and insecticidal properties of ginger (Ukeh, 2008). An example is a survey that was conducted in Jaffna, Sri Lanka, to determine the local medicinal uses of ginger.

The fungicidal properties of ginger rhizome extract were also evaluated. The result revealed 70 %, 71 % and 64.2 % growth inhibition of ginger on *Fusarium* spp., *Colletotrichum* spp. and *Curvularia* spp respectively (Krishnapillai, 2007).

Another experiment was carried out to examine the efficacy of some plant extracts for the control of yam tuber rot caused by *Fusarium oxysporum*, *Aspergillus niger* and *Aspergillus flavus* using hot water extraction from the leaves and seed of *Xylopiya aethiopica* and *Ginger*.

The results revealed the toxicity of the two extracts against the fungi .It was revealed that these extracts subdued the growth of these fungi in culture and minimized rot development in yam tubers (Okigbo & Nmeke, 2005).

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CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY AREA

The study was carried out on a parcel of land at the Department of Horticulture of the Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi. The study area is within the forest region of Ghana. The mean annual rainfall of the area is about 730 mm while the mean annual temperatures ranged between 21.5 °C and 32.1 °C (Addo-Fordjour, P., Yeboah-Gyan, K., Lawson B. W. L. and Akanwariwiak, W. G., 2007). The depth of the topsoil is about 0.3m deep and the soils of the area is sandy loam. The experiment was conducted during the minor rainy season of 2013 (September-November) and major season of 2014 (March-June).

3.2 PREPARATION OF SEEDLINGS

The seeds of the cabbage were obtained from an accredited shop in Kumasi. They were raised in a nursery bed nearby the experimental blocks (Plate 1) until ready for pricking out. Pricking out of the seedlings took place 10 days after nursing and transplanting took place one month after pricking out.

Healthy and vigorously growing seedlings were selected and one seedling was planted per hole. The seedlings were transplanted on 13th December 2013. Thirty cabbage seedlings were planted on each plot at a spacing of 60 cm by 60 cm.



Plate 1: Nursery bed and pricking-out bed (14.1mega pixels).

3.3 LAND PREPARATION

The land was cleared of all vegetation, ploughed and harrowed approximately two weeks prior to planting. Roots of grasses and stumps of shrubs were removed from the soil and the soil was harrowed to give a fine tilt. The field was subsequently lined and pegged into 18 plots before sowing as shown in Plate 2.



Plate 2: Pegging and harrowing prior to bed preparation (14.1mega pixels).

3.4 EXPERIMENTAL DESIGN

Eighteen experimental beds each measuring 3.8 m x 3.2 m were raised and each bed was separated by 1m alley. The experiment was conducted in a Randomized Complete Block Design (RCBD) method with six (6) treatments and three (3) replications. The following treatments were used:

- 5 % of Aqueous Ginger Extract applied on cabbage plant.
- 10 % of Aqueous Ginger Extract applied on cabbage plant.
- 15 % of Aqueous Ginger Extract applied on cabbage plant.
- 20 % of Aqueous Ginger Extract applied on cabbage plant.
- No chemical application (control).
- 5 ml / 2 litre of Abomec (active ingredient: Abamectin) used as reference chemical insecticide)

3.5 CULTURAL PRACTICES

Watering, weeding and fertilization were some of the agronomic practices carried on the experimental plots during the study following Obeng-Ofori, D., Danquah, E.Y. and OfosuAnim, J (2007).

3.6 PREPARATION OF GINGER RHIZOME EXTRACTS

3.6.1 Source of extract material

Ginger rhizomes were bought from the Central Market at Kumasi.

3.6.2 Preparation of ginger powder

The rhizomes of ginger were thoroughly washed to remove dirt from the rhizome. The rhizomes were crushed using the local wooden pestle and the wooden mortar in order to increase the surface area for easy drying and milling into fine powder. The crushed ginger was sundried for 14 days and milled into a fine powder using an electric miller. The ginger powder was sieved to remove any coarse materials and stored in a plastic container for use.

3.6.3 Preparation of ginger extract

Different weights of the powdered ginger were taken using scout pro digital scale which is accurate to 0.1g. Extract concentration of 5 %, 10 %, 15 % and 20 % (w/v) of ginger were prepared by adding 100 g, 200 g, 300 g and 400 g of ginger to two litres (2 L) water respectively in a plastic container with vigorous stirring to mix the powder well with the water. The mixture was then sieved to prevent the solid particles from clogging the knapsack sprayer.

3.6.4 Spraying

The first spraying was carried out one week after transplanting with a 16 L Knapsack sprayer and subsequent spraying was carried out once every week in the morning for the whole experimental period. The intervals between each application were 7 days. Each experimental plant in plots was sprayed to dripping. Prior to spraying, the plants were sampled to check for infestation by insect pests.

3.6.5 Data Collection

Data were taken on the following parameters for the study: number of pests and species, plant heights, canopy spreads, number of heads and leaves damaged at harvests and fresh

weight of cabbage heads. During sampling for insects, five cabbage plants were sampled randomly from the inner rows and the leaves were examined for insects. Insects' numbers were counted directly and recorded.

3.6.6 Scoring Cabbage Aphids (*Brevicoryne brassicae*)

Scoring for aphids was done once a week. Visual infestation rating was done on five plants of cabbage randomly selected from each plot and average scores per plant calculated. A rating scale of 0 – 5 was used to score aphid infestation.

Table 2: Rating scale for scoring of aphids

Colony size	Rating
No aphids	0
Few individuals	1
Few isolated small colonies	2
Several small colonies	3
Large isolated colonies	4
Large continuous colonies	5

Source: Salifu, 1982

3.6.7 Diamond-Back Moth (DBM) (*Plutella xylostella*)

P. xylostella moth was sampled by opening up the young fold of cabbage leaves where eggs are laid and hatch into caterpillars and visual counting was done. The levels of presence of DBM were determined by recording the number of larvae observed. Each plot was considered in all treatments and five plants were randomly chosen from each plot.

3.6.8 Canopy spread

The two most outspread and directly opposite leaves of the plant were measured and this measurement was done at the time of harvest with a metre rule. This was measured horizontally from one end of the plant to the other.

3.6.9 Plant height

The height of the plant was determined by measuring from the surface of the soil to the tip of the plant using a metre rule. The values obtained from the highest point was taken as the height of the plant.

3.6.10 Number of Damaged Leaves

The number of damage leaves per cabbage plants during harvests, were counted and recorded. Five cabbage heads were randomly sampled from each bed and damaged leaves were detached from the rosette, one after the other until no damaged leaf was found. This was done for all the treatments and means were also recorded.

3.6.11 Number of damage heads

Damaged cabbage heads that were not marketable were counted and recorded. On each bed, five cabbage heads were sampled randomly and the weights were taken using a top pan balance. This was done for all the treatments and the mean for was taken for all the treatments.

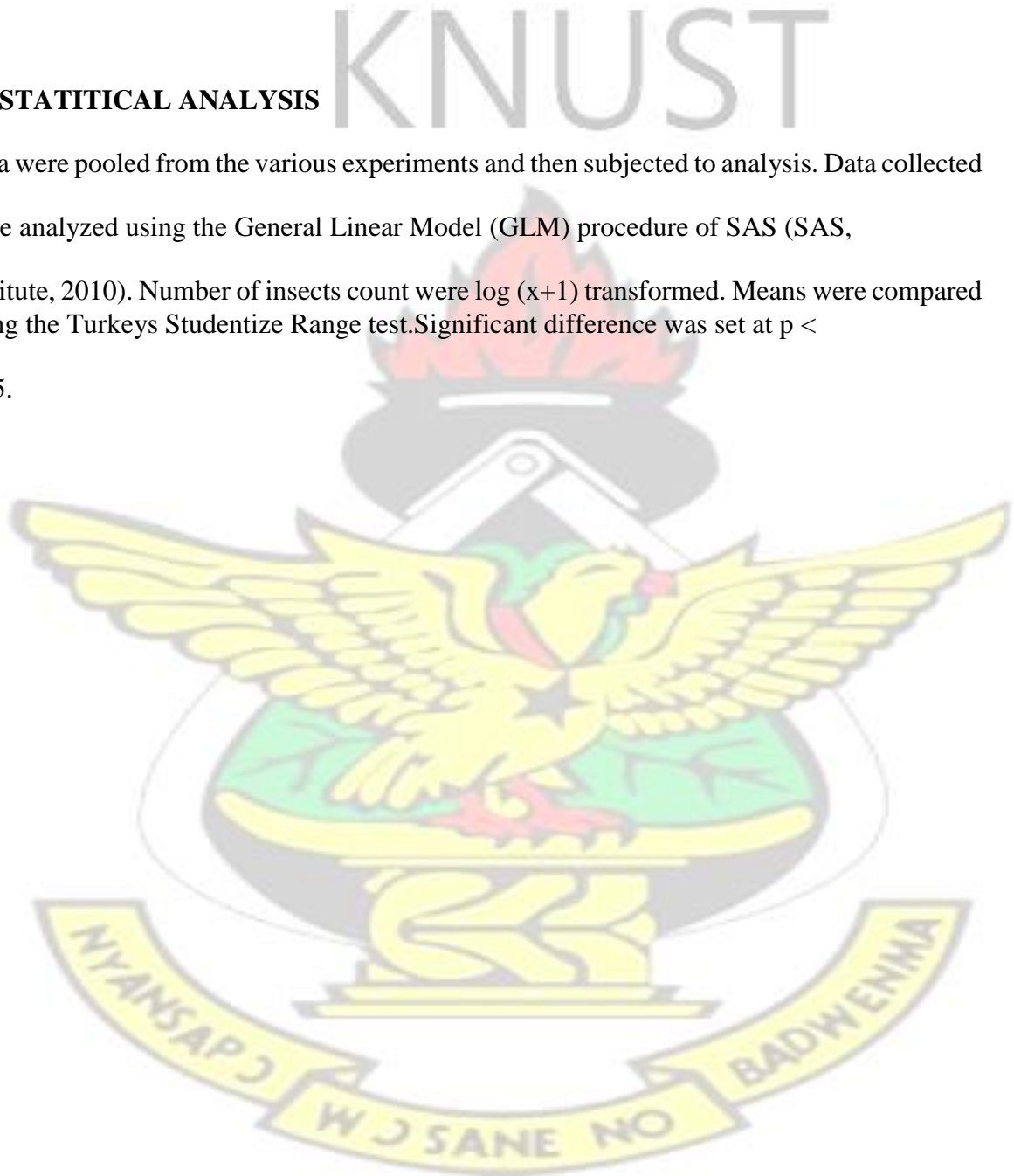
3.7 YIELD ANALYSIS

Cabbage heads were harvested one week after the last spraying. Five heads were randomly selected from each bed and weighed with a top pan balance. The yields from the control and

the standard reference chemical (Abamectin) sprayed plants were used for comparison with the four ginger concentrations. The mean weight of harvested heads per plant after harvesting was used in determining the yield of each plot.

3.8 STATITICAL ANALYSIS

Data were pooled from the various experiments and then subjected to analysis. Data collected were analyzed using the General Linear Model (GLM) procedure of SAS (SAS, Institute, 2010). Number of insects count were $\log(x+1)$ transformed. Means were compared using the Turkeys Studentize Range test. Significant difference was set at $p < 0.05$.



CHAPTER FOUR

4.0 RESULTS

4.1 INSECT POPULATION DURING THE MINOR SEASON

The major insect pest identified during the minor season in all the treatments were the cabbage looper (*Trichoplusia ni*), cabbage Flea beetles (*Phyllotreta spp*), Cabbage webworm (*Hellula undalis*) and cabbage aphids (*Brevicoryne brassicae*).

4.1.1 Cabbage looper (*Trichoplusia ni*)

The cabbage looper, *Trichoplusia ni* was observed on the plant at 5 WAT, with the largest number infesting the 20 % ginger-sprayed plots, whilst the least of (0.04) was recorded on the 5 % ginger-sprayed plots (Table 1). No significant differences were observed ($p=0.8371$). Thus ginger extract did not reduce the population of this pest on cabbage. The larvae fed on the leaves leaving irregular holes on the leaves and in severe cases defoliation of leaves occurred.

4.1.2 Flea beetle (*Phyllotreta spp*)

Scoring of the cabbage flea beetles, *Phyllotreta spp* commenced 2 weeks after transplanting (2WAT). Comparatively large numbers of *Phyllotreta spp* were recorded on both the 5 % ginger-sprayed plots and 10 % ginger sprayed plots (Table 1). The least of (0.19) *Phyllotreta spp* score was recorded in the application of the insecticide sprayed plots. No significant difference were observed between the treatments applications ($p=0.3990$). The flea beetles fed mostly on the above-ground portions of plants chewing the stems, leaves and cabbage heads showing small, rounded, irregular holes on the leaves.

4.1.3 Cabbage Webworm (*Hellula undalis*)

Cabbage webworm, *Hellula undalis* appeared on the plant at 5 WAT, which was relatively late in the growth of the plant. They were most abundant on the control cabbage plots. The highest (0.33) mean numbers of *Hellula undalis* was recorded in the control and the least of (0.04) was recorded on chemical insecticide-sprayed plots (Table 1). However the observed differences did not show any significant difference ($p=0.3644$) between the chemical insecticide-sprayed plots and the other treatments (Table 1). The *Hellula undalis* larvae fed externally on the leaves and continue feeding into the terminal buds by mining into the heads and stems of the cabbage plants.

4.1.4 Cabbage Aphids (*Brevicoryne brassicae*)

Brevicoryne brassicae was observed at 2 WAT. They caused damage by piercing into the plant and extracted the sap causing yellowing, cupping and wilting of some of the cabbage plants. Mean score of *Brevicoryne brassicae* was highest on the control plots (1.15). The least score of (0.15) was recorded on the insecticide-sprayed plots. There was significance difference between the insecticide sprayed plots and the other treatments ($p < 0.001$) (Table 1).

Table 1: Mean population of insect pests on cabbage (*Brassicae olearacea var oxyllus*) sprayed with different concentrations of ginger. Minor season, 2013

Treatments	<i>Trichoplusia ni</i>	<i>Phyllotreta spp</i>	<i>Hellula undalis</i>	<i>Brevicoryne brassicae</i>
5 % Ginger	0.04 ± 0.04 a	0.44 ± 0.11 a	0.19 ± 0.09 a	0.55 ± 0.12 b
10 % Ginger	0.07 ± 0.05 a	0.44 ± 0.10 a	0.19 ± 0.09 a	0.55 ± 0.11 b
15 % Ginger	0.04 ± 0.04 a	0.37 ± 0.09 a	0.15 ± 0.09 a	0.52 ± 0.10 b

20 % Ginger	0.11 ± 0.06 a	0.30 ± 0.11 a	0.19 ± 0.09 a	0.52 ± 0.12 b
Control (water)	0.04 ± 0.04 a	0.37 ± 0.11 a	0.33 ± 0.11 a	1.15 ± 0.15 b
Abamectin(Chemical)	0.07 ± 0.05 a	0.19 ± 0.08 a	0.04 ± 0.04 a	0.15 ± 0.10 a
F-value	0.42	1.04	1.10	7.32
P	0.8371	0.3990	0.3644	<0.001

Means with the same letters in the same column are not significantly different at $p < 0.05$

4.2 Population of insects during the Major Season

Table 2 shows the mean numbers of insect pests on cabbage (*Brassicae olearacea var oxyllus*) sprayed with different concentrations of ginger extract during the major season (2014). Two main insect pests were identified in all the treatments. These were the imported cabbage worm (*Pieris rapae*) and the cabbage aphids (*Brevicoryne brassicae*) (Table 2).

4.2.1 Imported Cabbage worm (*Pieris rapae*)

The imported cabbage worm was also observed on the plant at 4 WAT. Their damage was similar to that of the cabbage looper. Their larvae fed on the leaves leaving irregular holes on the leaves and fed closer to the center of the plant and on the underside of the leaves. The largest number (0.47) *Pieris rapae* count recorded on the 10 % ginger-sprayed plots while the least of (0.07) *Pieris rapae* count was recorded on the insecticide-sprayed plots.

No significant differences ($p=0.5601$) were observed in *Pieris rapae* count for all the plots.

4.2.2 Cabbage aphids (*Brevicoryne brassicae*)

This pest was observed 3 weeks after transplanting. The cabbage aphids damaged the cabbage plants by piercing into the plant and extracting the sap causing yellowing, cupping and wilting of the cabbage plants. The highest of (2.53) *Brevicoryne brassicae* score were recorded in the control treatment and the least of (0.20) *Brevicoryne brassicae* score were

recorded in insecticide-spray plots (Table 2). *Brevicoryne brassicae* score recorded on the insecticide-sprayed plots was significantly different ($p = <0.0001$) from the other treatments.

Table 2: Mean population of insect pest on cabbage (*Brassicae olearacea var oxyllus*) sprayed with different concentrations of Ginger. Major season, 2014

Treatments	<i>Pieris rapae</i>	<i>Brevicoryne brassicae</i>
5 % Ginger	0.33 ± 0.16 a	2.14 ± 0.21 a
10 % Ginger	0.47 ± 0.22 a	2.33 ± 0.29 a
15 % Ginger	0.40 ± 0.21 a	2.50 ± 0.33 a
20 % Ginger	0.20 ± 0.11 a	2.40 ± 0.35 a
Control (water)	0.33 ± 0.13 a	2.53 ± 0.29 a
Abamectin(Chemical)	0.07 ± 0.07 a	0.20 ± 0.11 b
F-value	0.79	11.03
P	0.5601	< 0.0001

Means with the same letters in the same column are not significantly different at $p < 0.05$.

4.3 NATURAL ENEMIES OF PEST OF BREVICORYNE BRASSICAE DURING THE MINOR SEASON

The three major natural enemies of some pest of cabbage identified during the minor season include ants *Camponotus pennsylvanicus*, spiders *Heteropoda venatoria*, and ladybird beetle *Cheilomenses* sp. The Ladybird beetle (*Cheilomenses spp*) are the natural enemy of the cabbage aphids (*Brevicoryne brassicae*). The presence of *Camponotus pennsylvanicus* indicate the presence of the cabbage aphids since they feed on honeydew produced by the aphids.

4.3.1 Black carpenter ants (*Camponotus pennsylvanicus*)

The largest (2.50) number of *Camponotus pennsylvanicus* was recorded in the 15 % ginger-sprayed plots whereas the least of (0.56) was recorded on the chemical insecticidesprayed plots. The application of chemical insecticides significantly reduced the number of *Camponotus pennsylvanicus* compared to all the ginger-sprayed plots and the control (Table 3).

4.3.2 Hutsman spider (*Heteropoda venatoria*)

The largest numbers of spiders (0.22) were recorded on the 5 % ginger-sprayed plots, whereas the least of (0.07) were recorded in 10%, 15%, and 20% ginger-sprayed plots (Table 3). There were no significant differences between the ginger-sprayed plots and the control ($p=0.5196$)

4.3.3 Ladybird beetle (*Cheilomenses sp*)

Large numbers of ladybird beetle (0.19) were recorded on the 15% ginger-sprayed plots whilst the chemical insecticides-sprayed plots were the least infested (Table 3). However no significant difference was observed between the control and the all the ginger treated plots.

Table 3: Mean numbers of natural enemies of Pest of cabbage (*Brassicae olearacea* var *oxyllus*) sprayed with different concentrations of ginger. Minor season,

2013

Treatments	Ants	Spiders	Ladybird beetle
5 % Ginger	2.30 ± 0.35 a	0.22 ± 0.10 a	0.04 ± 0.04 a
10 % Ginger	1.93 ± 0.36 ab	0.07 ± 0.05 a	0.04 ± 0.04 a
15 % Ginger	2.50 ± 0.39 a	0.07 ± 0.05 a	0.19 ± 0.09 a
20 % Ginger	2.30 ± 0.35 a	0.07 ± 0.05 a	0.15 ± 0.09 a

Control(water)	2.33 ±0.32 a	0.19 ± 0.09 a	0.04 ± 0.04 a
Abamectin(Chemical)	0.56 ± 0.26 b	0.11 ± 0.06 a	0.00 ± 0.00 a
F -value	4.01	0.85	1.61
P	0.0019	0.5196	0.1609

Means with the same letters in the same column are not significantly different at $p < 0.05$.

4.4 NATURAL ENEMIES OF PEST OF CABBAGE DURING THE MAJOR SEASON

Hoverflies (Syrphids), Black carpenter ant, *Camponotus pennsylvanicus*, Hutsman spider, *Heteropoda venotoria* and Ladybird beetle (*Cheilomenses* sp) were the natural enemies of pest during the major growing season of cabbage.

4.4.1 Hoverflies (Syrphids (Diptera, Syrphidae))

The 20 % ginger-sprayed plots resulted in the largest (0.73) Syrphids count while the least of (0.27) was recorded on the 10 % ginger-sprayed plots. No significant differences ($p = 0.8667$) were observed in all the treatments (Table 4).

4.4.2 Black carpenter ants (*Camponotus pennsylvanicus*)

Large number of *Camponotus pennsylvanicus* was recorded on 20 % ginger-sprayed plots and the control plots with a mean number of (2.33). Contrary to that, the least of (0.87) number of *Camponotus pennsylvanicus* was recorded on the chemical insecticide-sprayed plots (Table 4).

4.4.3 Spiders (*Heteropoda venotoria*)

Heteropoda venatoria were also identified and their numbers were largest on the 10 % ginger-sprayed plots and no incidence was recorded on the chemical insecticide- sprayed plots (Table 4).

4.4.4 Ladybird beetle (*Cheilomenses* sp.)

The largest (0.53) of *Cheilomenses* sp. was found in the 5 % ginger sprayed plots and the least (0.07) was recorded on the 20 % ginger-sprayed plots (Table 4). There was no significance difference between all the ginger-sprayed plots, the control plots and the chemical insecticide-sprayed plots ($p= 0.6220$).

Table 4: Mean numbers of natural enemies of pest of cabbage sprayed with different concentrations of Ginger, Major season, 2014 Treatments

	Ants	Spiders	Ladybird beetles	Hoverflies	
5% Ginger		0.47 ± 0.24 a	2.20 ± 0.35 a	0.07 ± 0.07 a	0.53 ± 0.37 a
10 % Ginger		0.27 ± 0.21 a	2.27 ± 0.44 a	0.40 ± 0.13 a	0.20 ± 0.11 a
15 % Ginger		0.47 ± 0.29 a	1.33 ± 0.32 a	0.13 ± 0.09 a	0.40 ± 0.21 a
20 % Ginger		0.73 ± 0.34 a	2.33 ± 0.45 a	0.07 ± 0.07 a	0.07 ± 0.07 a
Control (water)		0.53 ± 0.32 a	2.33 ± 0.37 a	0.27 ± 0.15 a	0.27 ± 0.12 a
Abamectin(Chemical)		0.33 ± 0.16 a	0.87 ± 0.19 a	0.00 ± 0.00 a	0.33 ± 0.19 a
F-value		0.37	2.96	2.34	0.70
P		0.8667	0.0164	0.0487	0.6220

Means with the same letters in the same column are not significantly different at $p<0.05$

4.5 GROWTH PARAMETERS OF CABBAGE DURING THE MINOR SEASON,

2013

4.5.1 Canopy Spread

The mean canopy spread ranged from 25.84 ± 0.92 cm to 40.38 ± 0.49 cm for ginger sprayed plots. Compared to the chemical insecticide- sprayed plots (25.84 cm), canopy spread on the ginger-sprayed plots did not vary significantly although all the gingersprayed plots recorded

higher values than the insecticide-sprayed plots. The control had the largest canopy spread which was significantly different from the other treatments

($p < 0.0001$) (Table 5).

4.5.2 Height of plants

The tallest plant was recorded in the chemical insecticide-sprayed plots (26.26 cm) was significantly different ($p = 0.0045$) from 5 %, 15 %, 20 % ginger-sprayed plots and the control (Table 5). However, the ginger-sprayed plots and the control did not vary significantly from each other.

4.5.3 Weight of cabbage head

Mean weight of cabbage heads ranged from 0.45 ± 0.05 kg to 0.72 kg with the largest mean weight of (0.72 kg) was recorded in the 5 % ginger-sprayed plots, whereas the least (0.45 kg) was observed on the 10 % ginger-sprayed plots. However, the observed difference between means of the 5 %, 15 %, and 20 % ginger-sprayed plots and the control did not vary significantly compared to the chemical insecticide-sprayed plots.

4.5.4 Plant with multiple heads

The number of multiple heads ranged from 0.67 ± 0.48 to 2.33 ± 1.20 . Large numbers of multiple heads were found on the 5 % ginger-sprayed plots (Table 5). The least of (0.67) mean numbers of multiples heads formation were found on chemical insecticide-sprayed plots but no significant difference were observed ($p = 0.6434$).

4.5.5 Damaged leaves.

Means damaged leaves ranged from 0.00 ± 0.00 on the chemical insecticide-sprayed plots to 3.50 ± 1.50 on the 10 % ginger-sprayed plots .The largest number of damaged leaves was recorded for the 10 % ginger sprayed plots. No damage leaves were recorded on the chemical insecticide-sprayed plots. The number of damage leaves of the chemical insecticide-sprayed plot did not show any significant difference from all the ginger-sprayed plots and the control (Table 5).

Table 5: Canopy spread, Height of plant, Multiple heads, Damage leaves and Yield of cabbage (*Brassicae olearacea var oxyllus*) sprayed with different concentrations of ginger (Minor season, 2013) Treatments Canopy spread Height of plants Weight of Plant with Damage leaves

	(cm)	(cm)	heads (kg)	multiple heads	
5 % Ginger	31.20 ± 1.78 b	22.67 ± 0.88 b	$0.72 \pm .$ a	2.33 ± 1.20 a	$3.00 \pm .$ a
10 % Ginger	32.73 ± 0.87 b	21.07 ± 0.68 b	0.45 ± 0.05 a	1.33 ± 1.33 a	3.50 ± 1.50 a
15 % Ginger	35.14 ± 1.24 b	22.31 ± 0.51 b	$0.50 \pm .$ a	0.67 ± 0.67 a	$3.00 \pm .$ a
20 % Ginger	31.20 ± 0.78 b	22.15 ± 0.92 b	0.53 ± 0.31 a	1.00 ± 1.00 a	1.50 ± 0.50 a
Control (water)	40.38 ± 0.49 a	20.31 ± 0.57 b	$0.52 \pm .$ a	2.00 ± 1.15 a	3.00 ± 0.58 a
Abamectin (Chemical)	25.84 ± 0.92 c	26.26 ± 1.17 a	0.57 ± 0.07 a	$0.67 \pm .$ a	0.00 ± 0.00 a
F-value	19.44	6.25	0.19	0.48	3.76
P	<0.0001	0.0045	0.9519	0.7847	0.0690

Means with the same letters in the same column are not significantly different at $p < 0.05$

4.6 Growth parameters of cabbage during the major season

4.6.1 Canopy Spread

Mean canopy spread for the cabbage sprayed with ginger extract ranged from 37.84 ± 1.01 cm to 69.12 ± 0.68 cm. Compared to the chemical insecticide-sprayed plots (69.12), 15 % ginger-sprayed plots did not vary significantly although the other concentrations had

significant lower values. 10 % ginger-sprayed plots had the least canopy spread compared to the other treatment groups (Table 6).

4.6.2 Height of plants

The tallest cabbage plant (76.20 cm) was recorded in insecticide-sprayed plots with the least of 35.73 cm recorded on 5 % ginger-sprayed plots. The mean of all the gingersprayed plots differed significantly from the insecticide-sprayed plots but there was no significant difference between all the ginger-sprayed plots and the control (Table 6).

4.6.3 Weight of cabbage head

Mean weight of cabbage heads ranged from 0.770 ± 0.09 kg to 1.390 ± 0.11 kg. The insecticides-sprayed plots recorded the mean weight of 1.39 kg, whilst the least (0.77 kg) was recorded on the 20% ginger-sprayed plots. The chemical insecticide resulted in increased weight of heads compared to the other treatments but did not vary significantly from the application of 10 % ginger-sprayed plots ($P= 0.0068$) (Table 6). However, there was no significance difference between the 5 %, 15 % and 10 % ginger-sprayed plots and control.

4.6.4 Plant with multiple heads

Large numbers of multiple heads were found in both the 15 % and 20 % ginger-sprayed plots (Table 6). No multiples heads were found on the 10 % ginger-sprayed plots and the control. The observed differences were not significant ($p= 0.6434$) between the insecticidesprayed plots and the ginger-sprayed plots.

4.6.5 Damaged leaves.

Mean damaged leaves ranged from 1.33 ± 0.33 to 1.50 ± 0.50 with the largest number recorded in the application of 10% ginger-sprayed plots and least recorded on 5 %, 20 % ginger-sprayed plots and the control. No damaged leaves were recorded on the chemical insecticide-sprayed plots (0.00). The 5 % and 20 % ginger sprayed plots did not vary from each other but varied significantly from 10 %, 15 % ginger-sprayed plots ($p= 0.0025$) (Table 6).

Table 6. Canopy spread, Height of plant, Multiple heads, Damage leaves and Yield of cabbage (*Brassica olearacea var oxyllus*) sprayed with different concentrations of ginger (Major season, 2014)

Treatments	Canopy spread (cm)	Height of plants (cm)	Weight of heads (kg)	Plant with multiple heads	Damage leaves
5 % Ginger	52.83 ± 0.79 c	35.73 ± 2.04 b	0.81 ± 0.10 b	0.33 ± 0.33 a	0 ± 0 b
10 % Ginger	37.84 ± 1.01 d	60.05 ± 20.03 b	0.97 ± 0.03 ab	0.00 ± 0.00 a	1.50 ± 0.50 a
15 % Ginger	56.77 ± 3.82 ab	49.33 ± 1.21 b	0.89 ± 0.11 b	0.67 ± 0.33 a	1.33 ± 0.33 a
20 % Ginger	41.61 ± 4.06 dc	55.83 ± 2.45 b	0.77 ± 0.09 b	0.67 ± 0.67 a	0.00 ± 0.00 b
Control (water)	52.14 ± 3.33 bc	58.39 ± 1.73 b	0.84 ± 0.06 b	0.00 ± 0.00 a	1.33 ± 0.33 a
Abamectin (Chemical)	69.12 ± 0.64 a	76.20 ± 0.55 a	1.39 ± 0.10 a	0.33 ± 0.33 a	0.00 ± 0.00 b
F-value	16.89	25.78	6.31	0.69	8.30
P	<0.0001	<0.0001	0.0068	0.6434	0.0025

Means with the same letters in the same column are not significantly different at $P < 0.05$

CHAPTER FIVE

5.0 DISCUSSION

In this study the effects of different extracts of ginger at various concentrations were sprayed to control insect pest of cabbage in both major season and minor seasons. Two pests of cabbage were identified during the major rainy season. These were imported cabbage worm, *Pieris rapae* and the cabbage aphid, *Brevicoryne brassicae*. In the minor season, four pests

were identified including the cabbage looper *Trichoplusia ni*, the cabbage flea beetle, *Phyllotreta spp* and the cabbage webworm *Hellula undalis*.

5.1 EFFECT OF DIFFERENT CONCENTRATIONS OF GINGER RHIZOME EXTRACT ON CABBAGE APHIDS

Aphids are serious pests of cowpea and they attack the crop at the vegetative stage, particularly the seedling stage (PAN, 2008). It is therefore critical to control them for the survival of the crop. It was evident that on all plots, aphid scores were between 0-3. The maximum aphid score of 2.53 was recorded in the control plots and the least of 0.20 on the chemical insecticide plots. The chemical insecticide was very effective in reducing the numbers of aphids compared to the control and the various concentrations of the ginger. The low aphids score on the insecticide-sprayed plots might be attributed to persistent nature of Abamectin. This corresponds to a survey done in the Ejisu Juaben Municipality of the Ashanti region of Ghana which revealed that about 32.7 % of the forty nine (49) cabbage farmers ranked pesticides use in controlling insect pest as the most effective on cabbage, controlling about 80 % - 90 % of the pest (Amoako, 2010). Aphid score on the control was not significantly different from the different concentrations of ginger extract; this means that the ginger extract was not persistent enough, and therefore may require more frequent applications than synthetic chemicals (Oparaeke, 2007).

A similar situation occurred in the minor season where the control plots recorded the highest aphids score of 1.15 and the least score 0.15 was found in the insecticide sprayed plots. Abamectin significantly reduced the population of aphids but the four different concentrations of ginger were not significantly different from the control. This shows that the ginger extract could not control *B. brassicae*. *Brevicoryne brassicae* infestation was

generally low in all plots in the minor season compared to the major season. This may be due to the fact that cabbage production has not been done in this area for long resulting in low population buildup of pest and thus leading to a reduction in numbers.

5.2 EFFECT OF DIFFERENT CONCENTRATIONS OF GINGER RHIZOME

EXTRACT ON CABBAGE IMPORTED CABBAGE WORM (PIERIS RAPAE)

Pieris rapae larvae feed mainly on leaves causing irregular, rugged holes. They also bore through the leaves causing serious defoliation and stunted growth in plants. They can damage the seedlings, but damage usually occurs during head formation. Bensin, (2003) reported that imported cabbageworm causes similar damage as loopers, but feed closer to the centre of the plant and their larvae are often concealed next to veins or the midrib on the underside of the leaves.

The insignificant difference among the insecticide-sprayed plots, control and various concentrations of ginger extract against *Pieris rapae* shows that the plant extracts were equally effective in the management of these pests. Their reductions in number could be as a result of the repelling properties of the ginger (Prakash and Rao, 1997) extracts which also caused the relatively low numbers of this pest. Several studies have focused on the repellent properties and the insecticidal of plants on pests (Dover, 1985; Sharma and Gupta, 2009) and a plant like rosemary has the ability to repel insect pests. Dover (1985), found that the alcohol extracts of rosemary can repel *Pieris brassicae*.

According to Sharma and Gupta (2009), *Pieris brassicae* belongs to the same family as *Pieris rapae* and avoids feeding on leaves treated with hyssop, rosemary, sage, thyme, white clover and eucalyptus. *Pieris rapae* larvae avoid feeding on the wild mustard, *Erysimum*

cheiranthoides (Sachdev-Gupta *et al.*, 1993). This means that, *Pieris* spp reject various plants that contain repellents properties and this explains why low numbers of *Pieris rapae* were recorded on ginger- sprayed cabbage.

5.3 EFFECT OF DIFFERENT CONCENTRATIONS OF GINGER RHIZOME EXTRACT ON CABBAGE LOOPER (TRICHOPLUSIA NI).

The cabbage loppers, *Trichoplusia ni* was found on the underside of the leaves, feeding on the leaves and areas between the veins. Even though, lower numbers of *Trichoplusia ni* were recorded on the 5 %, 15 % ginger-sprayed plots and the control plots compared to the 20 % ginger- sprayed plots and the chemical insecticide, but the differences were not significant. This shows that the ginger extract could not control *Trichoplusia ni*.

5.4 EFFECT OF DIFFERENT CONCENTRATIONS OF GINGER RHIZOME EXTRACT ON CABBAGE FLEA BEETLES (*PHYLLOTRETA SPP*).

Low numbers of *Phyllotreta spp* were recorded on the control plot as well as the on the different concentrations of the ginger-sprayed plots and the insecticides sprayed plots. The relatively low numbers of the flea beetles may be due to the repellent properties of ginger (Prakash & Rao, 1997). Tahvanainen and Root (1972) stated that Ragweed (*Ambrosia artemisifolia* L.) has been used to repel the crucifer flea beetle (*Phyllotreta cruciferae*) from collards (*Brassica oleracea* L. var. *acephala*). A study in Colorado also showed that garlic extracts were successful in suppressing flea beetles, but its efficacy trailed off later in the season (Kuepper, 2003). In addition to garlic, the U.S. Natural Resources Conservation Service (NRCS) recommends onion and mint as natural flea-beetle repellants (Kuepper, 2003). These plants all contain repellent properties.

5.5 EFFECT OF DIFFERENT CONCENTRATIONS OF GINGER RHIZOME

EXTRACT ON CABBAGE WEBWORM (*HELLULA UNDALIS*).

There was low incidence of *Hellula undalis* on plots treated with the ginger extracts. Even though the numbers of this pest was low, the ginger-sprayed plots were not significantly different from the control but the chemical-insecticide sprayed plots performed better than the other treatments. It could therefore be said that ginger extracts could not control *Hellula undalis* at the concentrations used, even though *Hellula undalis* were successfully controlled with other pesticidal plants such *Lantana camara*. L and *Azadiracta indica* A.

Juss (Baidoo & Adam, 2012).

5.6 EFFECT OF DIFFERENT CONCENTRATIONS OF GINGER RHIZOME

EXTRACT ON NATURAL ENEMIES DURING THE MAJOR AND MINOR SEASON

Hoverflies (Syrphids), Black carpenter ant, (*Camponotus pennsylvanicus*), Spiders (*Heteropoda venatoria*) and Ladybird beetle (*Cheilomenses* sp) were the natural enemies of pest identified in the various treatments during the two growing seasons.

Low numbers for the natural enemies were recorded on the control plots than the various concentrations of ginger even though no significant differences were observed among them. This may be due effectiveness of the chemical insecticides on the natural enemies. A study which was conducted on the effects of insecticide treatments on time series of diamondback moth, its predators, parasitoids, and the diamondback moth parasitism revealed that, natural enemies density was generally lower in fields treated with insecticides in both seasons although not always significantly so (Bommarco R., Miranda F, Bylund H and Bjorkman C., 2011) . This confirms the relatively larger numbers recorded in the various treatment of the

ginger sprayed plots. Similarly, neem extracts was able to control *H. armigera* in greenhouses (El-Wakeil, N.E., Gaafar, N. and Vidal, S., 2006).

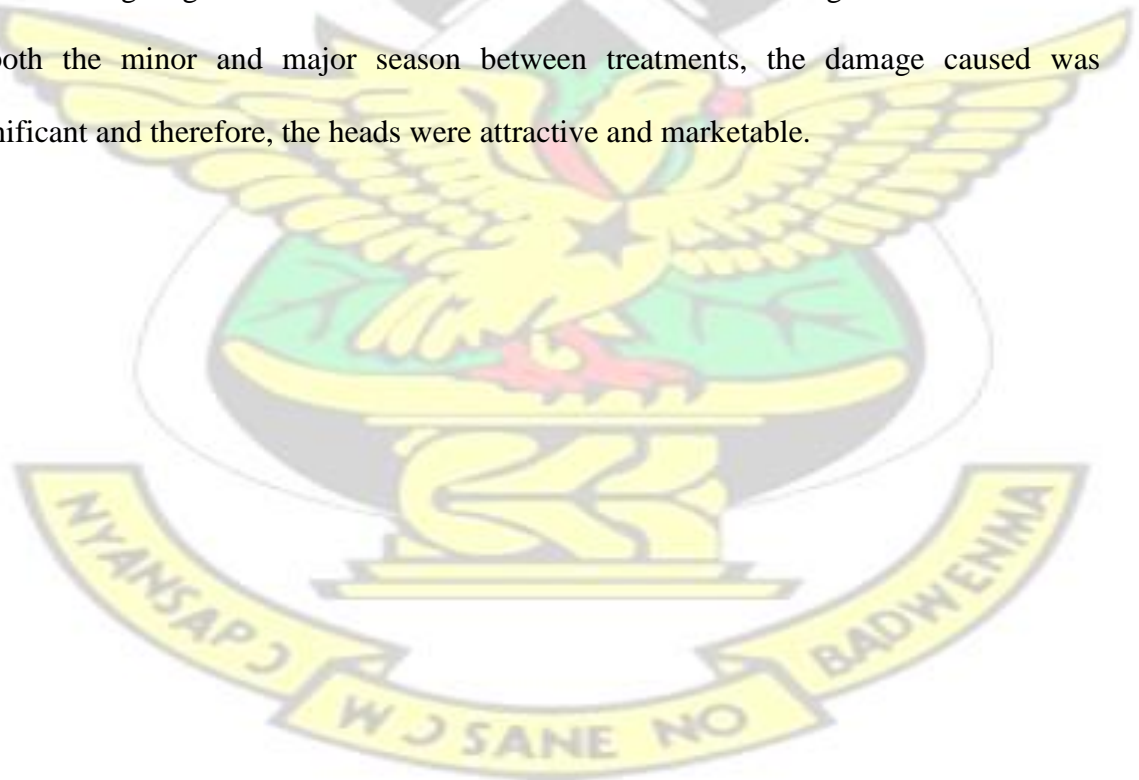
A significant difference was observed between the chemical insecticides sprayed plots and all the other treatments for ant populations. This was an indication that the chemical application reduced the population of the ants significantly compared to the various concentrations of the ginger treatment.

5.7 CANOPY SPREAD, HEIGHT OF PLANTS, AND MULTIPLE HEAD FORMATION, DAMAGE AND YIELD ASSESSMENT

The wider canopy spread and taller plant height observed on the insecticide sprayed plots compared to the control and the ginger sprayed plots in both the major and minor season may be due to reduced insect population on the insecticide spray plots. Asare *et al.* (2010) indicated that treating cabbage with insecticides reduced the insect population on cabbage, hence better growth of the crop. However in a work done by Feyissa and Tekbaw (2015), cabbage sprayed with neem, a botanical insecticide produced the tallest plants and the control had the shortest height.

The observed differences between the chemical insecticide-sprayed plots and the gingersprayed plots with regards to the weight of heads during the major season is attributed to lower pest numbers on the insecticide-sprayed plots. This result is in line with the findings of Sow *et al.* (2013). Their work revealed that, the agronomic features of cabbages such as the number of leaves, the weight and the diameter of cabbage heads were related to the level of pest when neem and *Bacillus thuringiensis* was used. However, there were no significant differences in the weight of heads between the ginger-sprayed plots and the control during the minor season.

Multiple head formation for both the major and minor season was relatively low and the recorded means did not show any differences between them. This may be the result of damages caused to the tip of the plant as results of low temperatures or damages during transplanting (Fritz, V.A., Rosen, C.J., Grabowski, M.A., Hutchison, W. D., Becker, R. L., Tong, C. B. S., Wright J. A and Nennich, T.T 2009; Verma, 2009). Significant differences were observed in the ginger sprayed plots and the control for the numbers damage leaves for both major and minor the season. Hasheela *et al.* (2010) reported that as compared to unsprayed cabbage, highest number of marketable cabbage heads was obtained from sprayed cabbage while the highest number of unmarketable cabbage heads was noted on unsprayed one. Even though significant difference between the numbers of damage leaves was seen in the both the minor and major season between treatments, the damage caused was insignificant and therefore, the heads were attractive and marketable.



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CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1. CONCLUSIONS

This study was carried out to determine the relative efficacy of different concentrations of aqueous extract of ginger against major insect pests of cabbage. Some pest identified during the study include *Brevicoryne brassicae*, *Pieris rapae*, *Trichoplusia ni*, *Phyllotreta* sp and *Hellula undalis*. In view of the results of the study, some conclusions can be drawn.

The chemical insecticide, Abamectin was consistently superior to all other treatments in reducing all the insect pests even though most differences were not significant. Abamectin is a recommended insecticide for controlling all field insect pests of cabbage. None of the concentration of aqueous ginger rhizome extract (5 %, 10 %, 15 %, and 20 %) exhibited the highest efficacy against all the pests when compared with the chemical insecticide, Abamectin. Some of the pests were reduced than others with the same concentration of extract even though the differences were not significant. For instance, aqueous ginger rhizome extract could reduce *Pieris rapae* numbers than *Brevicoryne brassicae* during the major season. The yields of chemical insecticide-sprayed plots and the different aqueous ginger extract plots were comparatively not different from each other during the minor

season. The chemical insecticide- spray plots recorded the highest yield than the gingersprayed plots during the major season.

6.2. RECOMMENDATIONS

6.2.1 Laboratory Bioassays

It is recommended that the study be repeated to validate the results obtained. Laboratory bioassays should be carried out. Although the study was to control field pests, performing bioassays could give an idea of the concentrations that may be effective in the field.

6.2.2. Preparation of Plant Extract

Other extraction methods could also be tested to ensure efficient extracts that are easy to prepare so that the resource limited farmer can effectively control the pests. Although some compounds are likely to dissolve better in water, it will be better ethanolic extracts of the material are developed and tested as ethanol have been used as extraction for other plants.

6.2.3. Source and Choice of Experimental Plant and/or Plant Part

Other parts of ginger could also be studied on the various pests of cabbage. The leaves, flowers etc. may contain different compounds which may be more effective in the control of these pests. The effect of dried rhizomes could also be compared with fresh rhizomes to determine which one is more effective. Drying may also take time which may therefore delay the preparation of the extract and subsequent application.

6.2.4. Effects of the Extract on Insect Pests

Higher concentrations of ginger could be tested to determine if they could better control the pest. The LC50 and LC90 values should be determined for the extract. This will make it easier to recommend effective concentrations and doses to farmers for effective pest control. This way will reduce or eliminate the problems associated with - under usage or over-dosage, contamination of produce and wastage of insecticide.



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APPENDICES

Appendix 1.0 ANOVA for the effects of treatment on (*Brevicoryne brassicae*) in the Major season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	12.58333333	2.51666667	6.60	<.0001
Error	174	66.36666667	0.38141762		
Corrected Total	179	78.95000000			

Appendix 1.1 ANOVA for the Effect of Treatments on the (*Hellula undalis*) in the Major season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1.09444444	0.21888889	1.08	0.3726
Error	174	35.23333333	0.20249042		

Corrected Total 179 36.32777778

Appendix 1.2 ANOVA for the effect of treatments on (*P. pchrysocephala*) in the Major season.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1.37777778	0.27555556	1.14	0.3393
Error	174	41.93333333	0.24099617		
Corrected Total	179	43.31111111			

Appendix 1.3 ANOVA for the effect of treatments on (*Tricholpusia ni*) in the Major season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.11111111	0.02222222	0.34	0.8874
Error	174	11.33333333	0.06513410		
Corrected Total	179	11.4444444			

Appendix 1.4 ANOVA for the effect of treatments on Ants (*Camponotus pennsylvanicus*) population in the Major season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	57.1166667	11.4233333	3.62	0.0039
Error	174	549.4333333	3.1576628		
Corrected Total	179	606.5500000			

Appendix 1.5 ANOVA for the effect of treatments on Spiders (*Heteropoda venatoria*) population in the Major season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.51111111	0.10222222	0.84	0.5255
Error	174	21.26666667	0.12222222		
Corrected Total	179	21.77777778			

Appendix 1.6 ANOVA for the effect of treatments on Ladybird beetle (*Cheilomenses sp*) in the Major season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.66666667	0.13333333	1.60	0.1635
Error	174	14.53333333	0.08352490		
Corrected Total	179	15.20000000			

Appendix 1.7 ANOVA for the effect of treatments on (*Brevicoryne brassicae*) in the Minor season.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	42.8348694	8.5669739	4.48	0.0009
Error	118	225.5119048	1.9111178		
Corrected Total	123	268.3467742			

Appendix 1.8 ANOVA for the effect of treatments on (*Pieris rapae*) in the Minor season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
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Model	5	1.11904762	0.22380952	0.74	0.5920
Error	120	36.09523810	0.30079365		
Corrected Total	125	37.21428571			

Appendix 1.9 ANOVA for the effect of treatments on Hoverflies (*Syrphids*) in the Minor season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1.42857143	0.28571429	0.36	0.8781
Error	120	96.57142857	0.80476190		
Corrected Total	125	98.00000000			

Appendix 2.0 ANOVA for the effect of treatments on Ants (*Camponotus pennsylvanicus*) in the Minor season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	21.3015873	4.2603175	1.37	0.2406
Error	120	373.3333333	3.1111111		
Corrected Total	125	394.6349206			

Appendix 2.1 ANOVA for the effect of treatments on Spiders (*Heteropoda venatoria*) in the Minor season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1.20634921	0.24126984	2.19	0.0600
Error	120	13.23809524	0.11031746		

Corrected Total 125 14.44444444

Appendix 2.2 ANOVA for the effect of treatments ladybird beetle (*Cheilomenses sp*) in the Minor season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1.40476190	0.28095238	0.68	0.6418
Error	120	49.80952381	0.41507937		
Corrected Total	125	51.21428571			

Appendix 2.3 ANOVA for the effect of treatments on Height of cabbage in the Major season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	27054.55252	5410.91050	2.51	0.0889
Error	12	25870.95453	2155.91288		
Corrected Total	17	52925.50705			

Appendix 2.4 ANOVA for the effect of treatments on multiple head formation in cabbage in the Major season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1.33333333	0.26666667	0.69	0.6434
Error	12	4.66666667	0.38888889		
Corrected Total	17	6.00000000			

Appendix 2.5 ANOVA for the effect of treatments on Weight of heads in the Major season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.75749375	0.15149875	3.62	0.0395
Error	10	0.41805000	0.04180500		

Corrected Total 15 1.17554375

Appendix 2.6. ANOVA for the effect of treatments on spread of canopy in the Major season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1873.528294	374.705659	1.44	0.2796
Error	12	3124.520600	260.376717		
Corrected Total	17	4998.048894			

Appendix 2.7 ANOVA for the effect of treatments on damage leaves, Major season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	7.60416667	1.52083333	0.85	0.5435
Error	10	17.83333333	1.78333333		
Corrected Total	15	25.43750000			

Appendix 2.8 ANOVA for the effect of treatments on canopy spread in the Minor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	348.975694	69.795139	1.25	0.3469
Error	12	671.408067	55.950672		
Corrected Total	17	1020.383761			

Appendix 2.9 ANOVA for the effect of treatments Height of cabbage in the Minor season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	63.3937778	12.6787556	0.59	0.7115
Error	12	259.9829333	21.6652444		

Corrected Total 17 323.3767111

Appendix 3.0 ANOVA for the effect of treatments on multiple head formation in cabbage in the Minor season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	7.33333333	1.46666667	0.48	0.7847
Error	12	36.66666667	3.05555556		
Corrected Total	17	44.00000000			

Appendix 3.1 ANOVA for the effect of treatments on Weight of heads of cabbage in the Minor season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.05364173	0.01072835	0.19	0.9519
Error	4	0.22748467	0.05687117		
Corrected Total	9	0.28112640			

Appendix 3.1 ANOVA for the effect of treatments on damage leaves of cabbage in the Minor season

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	65.50000000	13.10000000	5.82	0.0563
Error	4	9.00000000	2.25000000		
Corrected Total	9	74.50000000			