KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

COLLEGE OF SCIENCE

DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY

The Management of Field Pests on Cowpea (*Vigna unguiculata* (L.) Walp) using Botanicals [Tobacco (*Nicotiana tabacum*) Leaves, Neem (*Azadirachta indica*) Leaves, Ginger (*Zingiber officinale*) Rhizomes and Onion (*Allium cepa*) Bulbs]

By

MONFANKYE, ROLAND

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Of

Master of Science (Environmental Science)

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DECLARATION

I, hereby, declare that this is the result of my own work towards the award of MSc (Environmental Science) and that no previous submission for a degree in this University or elsewhere has been made.

References made therein are duly acknowledged.

MONFANKYE ROLAND ……………………. Date…………………..

P G 6508011 SIGNATURE

(Student Name & ID)

Certified:

DR. J. ISSIFU ADAM ………………… Date……………………..

Supervisor(s) Name SIGNATURE

Certified:

REV. S. AKYEAMPONG ...………………..……. Date…………………….

Head of Department Name SIGNATURE

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ABSTRACT

Theinsecticidal effect of four plant extracts tobacco (*Nicotiana tabacum*) leaves, neem (A*zadirachta indica*) leaves, ginger (Z*ingiber officinale*) rhizomes and onion (A*llium cepa*)bulbs onpests of cowpea was studied. The study was conducted at the Soil and Irrigation Research Centre, Kpong of the University of Ghana, Legon during the minor rainy season (September to mid November, 2012).Aqueous extracts of these botanicals were sprayed on the cowpea plants. A synthetic chemical insecticide,cymethoate, was used as the standard insecticide, and a treatment without any of the extracts (negative control), i.e. just water.The completely randomized design (CRD) was used and each treatment was replicated three times. The effects of these treatments on the population dynamics of the insect pests, total pod weight, total number of pods, number ofdamaged pods and grains, 100 grain weight (g) and grain yield (Kg/ha) were assessed. Results showed that cymethoate effectively controlled field pests of cowpea such as whiteflies, aphids and pod borers during the study. It also resulted in higherweight, pod numbers, and grain yield as well as less number of damaged pods and grains. Neem extract showed no significant difference over the other botanicals for the control of whiteflies, aphids and pod borers and consequently better yield of the cowpea. A hundred (100)grain weight and control of whiteflies at eight weeks after planting (WAP) were significantly different between the treatments (P =0.0120). Although adequate yield was not obtained from ginger, onion and tobacco treated plants, they still showed higher yield compared to the cymethoate. The study also revealed that the two weeks spraying interval employed was effective.Based on the results of the study two key recommendations were made namely, (1) Neem and tobaccoof the botanicals can be used to effectively replace synthetic chemicals as the botanicals are more environmentally

safe and less expensive, and adoption of the two-week interval spraying, because of its effectiveness, so as to minimize cost of production.

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% Hundred Percent

ai Active Ingredient

ANOVA Analysis of Variation

Cm Centimeters

CRD Completely Randomized Design

CRI Crops Research Institute

DAP Days After Planting

E East

FAO Food and Agricultural Organization

Fig. Figure

g Gram(s)

IITA International Institute of Tropical Agriculture

IPM Integrated Pests Management

Kg/ha Kilogram/hectare

L Litre

L D50 Dosage of insecticides that is lethal/will kill 50% of the exposed population of an insect species under specialized conditions

LSD Least Significance Difference

m Meters

ml Millilitres

mm Millimeter(s)

N North

NS Non-Significance

^{O}C Degree Celsius

pH Hydrogen ion Concentration

SIRECSoil and Irrigation Research Centre

tTonne(s)

UNESCOUnited Nations Educational Social and Cultural Organization

USDAUnited States Departmentof Agricultural

WAPWeeks After Planting

WASWeeks After Spraying

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CHAPTER ONE

INTRODUCTION

1.1 Background

Cowpea (*Vigna unguiculata* (L.) Walp), is one of the most important leguminous crops that is widely grown throughout the tropics, especially in the savanna zone of West Africa and other parts of the world (Singh, 1990). Cowpea is highly palatable, providing plant protein for human and animals (Okosun and Adedire 2010), very nutritious and relatively free of anti metabolites. In West Africa cowpea is the major source of protein, carbohydrate-based diet (Uweagbute *et al*., 2000), where they are consumed in different forms. In Nigeria, cowpea can be consumed, boiled as (porridge) or boiled and eaten with stew. It can also be ground and processed into flour and used to make many traditional foods: for example, “Akara” (bean balls), “moi-moi” (bean cake) etc (FAO, 2000). In Sudan and Ethiopia, its roots are eaten as vegetable. Also in Ghana, leaves are eaten as vegetable(Asawalam and Dioka 2012).Apart from the traditional products, cowpeas are processed into flour for the production of bakery products such as cookies and breads (Kethireddipalli,*et al*., 2002; Hallen *et al*., 2004; McWatters *et al*., 2005) as well as comminuted meat product such as chicken nuggets (Prinyawiwakul*et al*.,1997) and meat balls (Serdaroglu *et al*., 2005). Apart from the grains farmers also benefit from the fodder yields which they use to feed their livestock. However, in spite of the high nutritional values and usefulness of cowpea, the plant is attacked by a wide range of insect pests, which significantly reduce the yield.

The best control of the numerous pests that attack cowpea, *Vigna unguiculata*(L.) is largely obtained by the use of synthetic insecticides (Jackai, 1993; Jackai and Adalla, 1997;Agona *et al*., 2000 and Dzemo *et al*., 2010). The use of insecticides increases cowpea yields tremendously (Jackai and Daoust, 1986, Jackai, 1993; Karungi *et al.*, 2000). However, because of the high cost implication, these synthetic insecticides are out of the reach of most cowpea farmers, considering their small holdership scale of production (Mabbet, *et al*., 1984; Jackai and Daoust 1986; Afun *et al*.,1990). As a result, cowpea grain yields in Africa are very low (50 – 150 kg/ha) (Jackai, 1993). In the West African sub region, low levels of cowpea yield (200-350 kg/ha) obtained by some farmers are directly attributed to insect pest damage in the field (IITA, 2007). The yields of the cowpea in Ghana, however, are among the lowest in the world, averaging 310 kg/ha (Ofosu-Budu *et al*., 2007). Grain yield varies with variety and the method of field insect pests control. However, relatively higher yields have been recorded on farmers' fields. Yields of up to1.5 t/ha was cited (Sokoto and Singh 2008), whereas between 1.8 and 2.5 t/ha has been obtained on researchers' plots (Adu-Dapaah *et al*., 2005) in West Africa.

The major insect pests which severely damage cowpea during all growth stages are the cowpea aphids (*Aphis craccivora*Koch), foliage beetles (*Ootheca spp, Medythia spp*), the flower bud thrips (*Megalurothrips sjostedti* Trybom) the legume pod borer (*Maruca vitrata* Fabricius) and the sucking bug complex, of which *Clavigralla spp, Anoplocnemis spp, Riptortus spp, Mirperus spp*, *Nezara viridula* Fab and *Aspavia armigera* L are most important and are prevalent. Without their control, reasonable grain yield cannot be obtained (Jackai and Daoust, 1986; Suh *et al*., 1986). Several control measures are available (Jackai *et al*., 1985) but chemicals are most effective, giving several fold increase in grain yield (Jackai,1993). These insect pestsinfest cowpea and severely reduce the quantity and quality of both the grains and fodder yields. This implies losses in both grain and fodder. Other measures used to reduce insect damage to cowpea are bio-intensive approaches that rely more on manipulating the plant or its environment. These include the use of resistant varieties, habitat modification, cultural and biological control. In spite of the use of these methods, Jackai (1993) observes that control may not be optimal because of great diversity of pests involved. This prompted the investigation into alternative insecticides. It is a widely known that, in this era of environmental awarenessthe use of synthetic insecticides pose environmental problems, which maketheir useunsuitable for farming.

However, as stated by Jackai (1983) and Amason *et al*.,(1989), there are insecticides of plant origin that can be used without the problems associated with synthetic insecticides.

1. 2 Problem Statement

Cowpea is an important protein and carbohydrate source in the diet of humans as well as livestock. However, it is highly susceptible to insect pest infestation both in the field and in storage due to its nutritional contentthus leading to very low yield ifthe pest infestation is not controlled.

1. 3 Justification

The dried seed provides an inexpensive source of protein in many diets in the tropics and sub-tropics. The grain contains 23-33 % protein, 60-66 % carbohydrate, 5-6 % fibre, 3.7-4.4 % ash and 1.1-3. 0 % oil (Bressani, 1985).Many studies in Africa, however, showed that despite the attributes of the crop, cowpea yields at farm level are very low (Singh and Jackai, 1985; Alghali, 1992; Sabiti *et al*., 1994; Omongo *et al*., 1997). Insect pests are one of the major constraints for cowpea production, by direct reduction of crop yield and quality, or indirectly by acting as vectors of important plant diseases (Alghali, 1992; Omongo *et al*., 1997; Dugje *et al*., 2009). According to several authors, insecticides are the most effective control measure against these pests (Jackai *et al*., 1985). However, chemical insecticides have over the years been found to be toxic to our health as well as pollute our environment. Besides they are very expensive and their use results in increased cost of production (Pretty and Waibel, 2005).

In addition, not much work appears to have been done on the use of these extracts to control pests on cowpea field conditions. It is postulated that the use of these botanicals on cowpea in the field at SIREC - Kpong may require entirely different regime of formulations to ensure efficacy and effectiveness. This research was therefore set out to explore these possibilities.

This study is considered relevant to cowpea production in Ghana where the smallholder farmer is constrained by the lack of resources to purchase expensive synthetic insecticides to control pests, coupled with the inability of most farmers to use the synthetic insecticides effectively and efficiently due to inadequate technical knowhow. When the smallholder farmer is compelled to use these synthetic insecticides on cowpea instead of using available local materials (botanicals), the food consumer as well as the environment (Schwab *et al*., 1995; Lale *et al*., 2000) tends to suffer. The effect on human health, including deaths, associated with pesticide poisoning has been documented (Lale and Mustapha, 2002). It is the expectation that the reduction in the use of synthetic chemicals on cowpea will go a long way to reduce the associated negative health and environmental impacts especially in less developed countries where pesticide pollution is on the increase (Wilson and Tisdell, 2001).

1. 4 Main Objective

The overall objective of this study was to assess the insecticidal propertyof some botanicals (tobacco leaves, neem leaves, ginger rhizomes and onion bulbs) on cowpea field pests and yield.

1. 4. 1 Specific Objectives

The specific objectives were to determine:

1. The effect of extracts of the botanicals (tobacco leaves, neem leaves, ginger rhizomes andonionbulbs)onfield insect pests of cowpea.
2. The insecticidal effect, if any, of the extracts on the insect pests of cowpea
3. The effect of the treatments on the yield of cowpea (mean numbers and weight of the pods and grain weight, and
4. The extent (%) of damage to the pods and grains caused by the insects.

CHAPTER TWO

LITERATURE REVIEW

2.1 Cowpea

2.1.1 Taxonomy and Origin

The name 'cowpea' probably came about as a result of the crop being an important source of hay for cows in south-eastern United States and some other parts of the world (Timko *et al*., 2007). Although a single crop species, cowpea has a wide diversity in terms of seed morphology shape, size and colour (Plate 1). Some varieties such as the black-eyed peas and the crowder peas are indigenous to specific regions of the world (Timko *et al*., 2007).

Plate 1 Diversity of seed types in cowpea - seed shape, colour and texture (Source: Timko *et al*., (2007)

Africa is the origin of cowpea where domestication took place (Zeven*et al*., 1982, cited by Angessa, 2006). Centres of diversity have been identified in both Africa andAsia, however, the exact region of domestication is still under speculation (Angessa, 2006).

Cowpea (*Vigna unguiculata*)(L.) Walp)is a leguminous crop belonging to the Family Fabaceae and in cultivated as a major arable crop in the tropical and subtropical regions of the world. Man benefits from it in several ways; the grainsare a cheap source of protein to man (IITA, 1984; Anderson, 1985; Alabi *et al*., 2003) and in recent times, we largelydepend on it because of the rising cost of meat, fish and egg (IITA, 2007). Cowpea is rich in vitamins, minerals and low infats. Its other importance is in the livestock industry (Job *et al*., 1983), fibre production (Rachie, 1985),as a green manure crop, nitrogen-fixing crop and for erosion control (Davis *et al.*, 1991).

From a single planting, one may be able to have several products such as leaves, immature pods, immature and mature seeds. According to the study by Bittenbender *et al.*, (1984), cooked bean leaves contain two-thirds protein, seven times calcium, three times iron, half phosphorus, eight times riboflavin, five times niacin and several hundred times ascorbic acid and beta-carotene of the cooked seed. Amino acid composition was found to indicate cowpea leaf protein as superior to seed (Bittenbender *et al*., 1984). Careful and positive attention to cowpea would support 850 million people in the world with high incidence of undernourishment in sub-Saharan Africa as documented by FAO (2005, 2006).

On the other hand, cowpea has many desirable horticultural characteristics usually non-food associated. It is an efficient nitrogen fixing, heat and drought-tolerant legume (Bittenbender *et al*., 1984). In most African countries, cowpea is either grown alone or intercropped with various other crops such as leafy vegetables, maize, millet, sorghum, beans, pigeon peas, bananas and others (Bittenbender *et al.*, 1984; Singh *et al.*, 1997). In intercropping production systems, the spreading indeterminate type of cowpea serves as a ground cover(Onwueme and Sinha, 1991) and, thus, suppresses weeds as well as protects the soil against erosion (Lawson *et al*., 2006).In addition, some cowpea varieties cause suicidal germination of the seed of *Striga hermonthica,* a parasitic plant that usually infests cereals with devastating effects (Quin, 1997). In spite of all these advantages derived from cowpea production,without the control of insect pests, reasonable grain yield cannot be obtained(Jackai and Daoust, 1986; Suh *et al*., 1986).

2. 1. 2 Cowpea Production

In cowpea production; two main groups of growing habits exist. They include prostrate or indeterminate type and erect or determinate type and they can be distinguished from one another by different factors such as seed size, colour, taste, yield and time to maturity. The indeterminate which are also spreading types are both early and late-maturing with large and small seeds being produced, while determinate types of cowpea are early maturing type with small leaves and seeds (Duke, 1981; Yost and Evans,1988 cited by Nkongolo, 2003), Keding *et al*., (2007).

2. 1. 3 Pest Management on Cowpea

Cowpea is very attractive to insects. Insect pests have remained the most important setback to cowpea production, because each phase of growthattracts a number of insect pests. The main pests during the growing season are pod sucking bugs(*Riptortus spp, Nezara viridula* and *Acantomia spp*.), aphids(*Aphis fabae, Aphis craccivora*), blister beetle(*Mylabris spp*.) and pod borer(*Maruca vitrata*). The management methods includes: Organic and synthetic pesticides (insecticides).

Organic

The danger associated with the use of chemicals include environmental pollution, toxicity to mammals, hazards to users and consumers (Alabi *et al*., 2003), alternative control measures are being sought. Neem (*Azadirachta indica*) has been reported to be effective against some cowpea pest species both on the field and at storage (Jackaiand Oyediran1991).

Chemicals

Currently, synthetic insecticides are the chief means of insect pests control both in the field and in storage (Jackai and Oyediran 1991; Jackai and Adalla, 1997). They have shown efficacy against a wide range of pest species of agricultural crops. Chemical control is generally practiced by farmers for higher gains, but its injudicious utilization has created many problems. Sole reliance on chemical control leads to problems of pests resistance, resurgence of pests, pesticide residues, destruction of beneficial fauna (non-target) and environmental pollution, human poisoning, destruction of natural enemies of pests, crop pollination problem due to honey bee losses, domestic animal poisoning, contamination of livestock products, fish and wildlife losses and contamination of underground water and rivers (Ewete and Alamu1999; Asawalam and Adesiyan, 2001; Lajide *et al*., 2003; Epidi *et al*., 2008; Karnataka, 2008).As yields are however, generally low (Olatunde *et al*., 1991),sometimes total yield losses and crop failure occur (Singh and Jackai 1985) due to the activities of a wide spectrum of insect pests which ravage the crop in the field at different growth stages, sometimes farmers spray their farms as many as eight to ten times during the growing season (Omongo *et al.*, 1997; Isubikalu, 1998).

Most of these insecticidal compounds that are used to control pests on cowpea production fall within four main classes - organophosphates, organochlorines, carbamates and pyrethroids. As a result of their problems,organochlorine has been reportedly banned in the developed countries as well as in developing countries like Ghana (www.ncbi.nlm.nlh.gov/pubmed/24210596).

2.2 Environmental Requirements

2. 2. 1 Climatic Requirement

Cowpea grows primarily under humid conditions. It is tolerant to heat and drought conditions. Cowpea is sensitive to frost. It germinates rapidly at temperatures above 18.3^{O}C; colder temperatures slow germination. The optimum temperature for growth and development is around 30 ^{O}C (www.daff.gov.za/docs/Broshures/proguideCowpea.pdf).

It can grow under rainfall ranging from 400 to 700 mm per annum. Well-distributed rainfall is important for normal growth and development of cowpea.Adequate rainfall is important during the flowering/podding stage (www.daff.gov.za/docs/Broshures/proguideCowpea.pdf). Cowpea react to serious moisture stress by limiting growth (especially leaf growth) and reducing leaf area by changing leaf orientation and closing the stomata. Flower and pod abscission during severe moisture stress also serves as a growth-restricting mechanism to help it cope with that condition(www.daff.gov.za/docs/Broshures/proguideCowpea.pdf).

2. 2. 2 Climate Change

The synthetic insecticides are also associated with various ecological problems such as environmental hazards. Though other agricultural practices can have negative impact on climate, synthetic pesticides and fertilizers often made from fossil fuels and widely used in agriculture have been cited to be responsible in a large measure to climate change and global warming (Zuzuki, 2005). Manufacturing and transporting these chemicals uses significant quantities of energy and produces greenhouse gases. Surprisingly, studies have shown that chemical farming uses considerably more energy per unit of production than organic farming, which does not use these chemical inputs. In addition, the use of synthetic nitrogen fertilizers in soils produces nitrous oxide, a greenhouse gas that is approximately 300 times more powerful than carbon dioxide at trapping heat in the atmosphere (Zuzuki, 2005).

2. 3 Soil

Cowpea is well adapted to a wide range of soils and conditions. It requires well-drained sandy loam or sandy soils where the soil pH is in the range of5.5 to 6.5 (Davis *et al.*, 1991).Cowpea is grown under both irrigated and unirrigated regimes (Davis *et al.*, 1991).

2. 4 Fertilization

Fertilizer application in cowpea production depends on anticipated yield and soil fertility. As a legume, cowpea fixes its own atmospheric nitrogen through symbiosis with nodule bacteria (*Bradyrhizobium* species) (Singh *et al* 1997). As a result, it fixes atmospheric nitrogen up to 240 Kg/ha and leaves about 60 to 70 Kg nitrogen for succeeding crops (CRI, 2006). Therefore, farmers usually do not apply fertilizers to their cowpea fields, although it has been reported that cowpea responds significantly to fertilizers including poultry manure and mineral fertilizers (Agyenim Boateng *et al*., 2006; Sokoto and Singh, 2008).

2. 5 Use of Botanicals

Botanical insecticides are naturally occurring chemicals, extracted from plants which break down readily in the soil and are not stored in plant or animal tissue. Often their effect are not long lasting as those of synthetic pesticides (Arong *et al.,* 2011). Botanical insecticides are generally pest–specific and are relatively harmless to non-target organisms. These natural insecticides especially those of plant origin have proved to be effective, biodegradable, low cost, low technological base, selective and environmentally friendly (Shazia *et al.*, 2006). Also, the possibility of insect developing resistance to botanical insecticide is less (Scott *et al*., 2005).Furthermore, plant extracts act as mortality agents, repellents, anti-feedants, attractants, oviposition deterrents and sterility agents (Lale, 2002).

Research on the use of natural pesticides as an alternative to synthetic insecticides (Olaifa and Erhun 1988;Ivbijaro, 1990; Emeasor *et al*., 2005;Oparaeke *et al*., 2002;Tripathi *et al*., 2002;Iloba and Ekrakene 2006;Adesina *et al*., 2012)for both field and storage crop protection are increasing because of their low toxicity to human beings (Raja *et al*., 2000). Stoll (1988) and Panhwar (2002) whoindependently reported that the effect of plant extracts on crops yield and yield component is dependent on the effectiveness of the individual plant extract. However, many require other plant spices with different mode of action, depending on the ratio and rate of application to increase their potency (Sommers, 1983; Oparaeke, 2004)

Over 2000 species of plants are known to possess insecticidal activities (Sariah, 2010; Arong *et al*., 2011). Such plant materials include powders, water extracts, oil and wood ash from plants like Neem tree (*Azadirachta indica*), groundnuts (*Arachid hypogeal*), nutmeg (*Myristica fragrans*) and coconut. Others are leaf extracts offish bean (*Toprasla vogelli),* ginger (*Zingiber offficinale*) garlic (*Allium sativum),* African Black Pepper *(Piper guineensis)* tobacco (*Nicotiana tabacum*),cashew (*Anacadium occidental*), (Ivbijaro, 1983; Hall and Harman, 1991, Ho *et al.*, 1997; Grainger and Ahmed, 1988; Oparaeke *et al*., 1999; 2000; 2003).

2. 5. 1 Neem Extract

Neem (*Azadirachta indica)* is a tree in the Family Meliaceae. It is one of two species in the genus *Azadirachta*, and is native to India.It isa tropical evergreen tree and is also found in other southeastern countries example South East Asia, Australia, South and Central America. In India, neem is known as “the village pharmacy” because of its healing versatility, and it has been used in medicine for more than 4,000 years due to its medicinal and other healing properties (www.organeem.com/neem_tree.hthl). Neem extracts can affect nearly 200 species of insects some of which are pests resistant to chemical pesticides or extremely difficult to control with them. Neem products do not necessarily kill insect pests – they are not always biocides or pesticides, but incapacitate them in several other ways, for example by interfering with development and growth of insects, act as anti-feedants on the host plant, or prevent them from depositing their eggs. Often, the precise effect is unknown (Vijayalakshmi *et al*.,1995). Neem extracts effectively reduced pests damage leading to increased yields (Jackai and Oyediran, 1991; Tanzubil, 1991, 2000). Neem products have shown efficacy againstpod borer (*Maruca vitata*), pod sucking bugs complex(*Clavigralla tomentosicollis*) (Jackai and Oyediran 1991; Jackai *et al*., 1992)and other insect pests (Zongo *et al*., 1993; Saxena, 1981). Schmutterer (1990), Jacobson (1986), and Saxena (1989) observed that neem products have shown activity on a wide range of insect pests.Ulrichs *et al*.,(2001) discovered that commercial neem,NeemAzal T/S significantly reduced the number of *Aphis craccivora* in cowpea.

2. 5. 2 Tobacco Extract

Tobacco (*Nicotiana tabacum*) is cultivated for use in the tobacco industry to make cigarettes, bidis and chewingtobacco. It has excellent insecticidal properties and farmers use extract of nicotine sulfate from the leaves for killing insect pests.Fuglie (1998) showed that a timely

application of the tobacco solution especially at the onset of flowering and pod formation prevented an initial build up of infestation pressure and consequently increases the yield of the crops. Pure nicotine is a tobacco extract highly toxic to warm-blooded animals. The insecticide usually is marketed as a 40% liquid concentrate of nicotine sulfate, which is diluted in water and applied as a spray. Dusts of tobacco can irritate the skin and are not normally available for garden use. Nicotine is used primarily for piercing sucking-insects such as aphids, whiteflies, leaf hoppers and thrips (www.customers.hbci.com/~wenonah/hydr/pestcost.htm).
Nicotine is more effective when applied during warm weather. It degrades quickly, so can be used on many food plants nearing harvest. It is registered for use on a wide range of vegetable and fruit crops (www.customers.hbci.com/~wenonah/hydr/pestcost.htm). However its usage must be restricted because it may cause harm to beneficial insects.

2. 5 .3 Onions Extract

The of origin of onion (*Allium cepa*) is Central Asia from which it spreads likely through trading activities to the Middle East and the Mediterranean region, and subsequently to many countries of the world. Onion is different from the other edible species of alliums for its single bulb and is usually propagated by true botanical seed (www.en.wikipedia.org/wiki/Onion)

According to Dahlgren *et al*., (1985) onion is one of the oldest cultivated vegetables, and has been in cultivation for more than 4,000 years. It is used primarily as flavouring agents and its distinctive pungency, which is due to the presence of a volatile oil (d-n-propyl disulfide and methyl -propyl. The mature bulb contains some starch, appreciable quantities of sugars, some protein, and vitamins A, B, and C (Decoteau, 2000). It is reported by William and Abridge(1996) that onion contains certain organic chemicals that have negative impact on grain development.

2. 5. 4 Ginger

Most recent studies on ginger (*Zingiber offficinale*) showed that it has both prophylactic and therapeutic cadmium detoxification effect (Egwurugwu *et al*., 2007). Panhwar (2002) alsoreported that good aqueous solution of ginger will effectively control worms, beetles and thrips incowpea. It also controls American boll worm, aphids, plant hoppers, whitefly, root knot nematodes, brown leaf spot on rice, mango anthracnose, and yellow vein mosaic (Sridhar *et al.*, 2002). These authors also reported that it has no side effect to humans since ginger rhizome is being consumed by man.

2. 5. 5 Garlic

Garlic *(Allium sativum)* originated in Central Asia and has now spread across the world. It has medicinal, anti-feedant, bacterial, fungicidal, insecticidal, nematicidal and repellent properties (Lale, 2002). Aphids, ants, termites, whiteflies, beetles, borers, caterpillars, slugs and army worms are some of the pests that can be suitably controlled using Garlic. Stoll (1988) and Panhwar (2002) who independently reported that garlic cloves are good bio-control agents of some insect pests of cowpea. Garlic makes an excellent economical, non-toxic pesticide for the garden. It has natural fungicidal and pesticidal properties that work effectively to control pests. For maximum efficacy in pests control by garlic, avoid using any chemical fertilizers. Fertilizers diminish the capacity of vital ingredients in garlic to fight pests.

2. 6 Treatment Formulation

The medicinal properties or active ingredients derived from plants can come from many different parts of a plant including leaves, roots, bark, fruit, seeds, flowers. The different parts of plants can contain different active ingredients within one plant as well as different levels of the same ingredient. Thus, one part of the plant could be toxic while another portion of the same plant could be harmless (www.fs.fed.us/wildflowers/ethnobotaby/medicinal/parst.shtml). For instance, Pharmacognosy Review(2012) reported that the percentage distribution of anti-diabetic ingredients in about 80 plants studied differ from one part of a given plant to another. While 36 % of the active ingredient was found in leaves, 12 % each was found in fruits and seeds. While 9% was found in roots, 8 % was found in the stems and only 3 % was found in flowers respectively (www.phcogrev.com/viewimage.asp?img). These percentage distributions differ from plant to plant.

2. 7 Outstanding Issues Relevant to the Research

Many researchers have worked on the use of botanicals for the control of pests. In particular, many research works have dwelt on the use of neem seeds for storage pests on cowpea. Furthermore, available literature on investigations worldwide on the use of these botanicals(Saxena 1989; Schmutterer 1990) indicates that a lot of work has been done on the use of these botanicals on stored grains of cowpea using formulations suitable for storage conditions (Ivbijaro 1983; Lale and Ajayi 1996; Oparaeke and Dike (1996).

However, there has not been much work on the use of these botanicals on field pests of cowpea.

CHAPTER THREE

MATERIALS AND METHODS

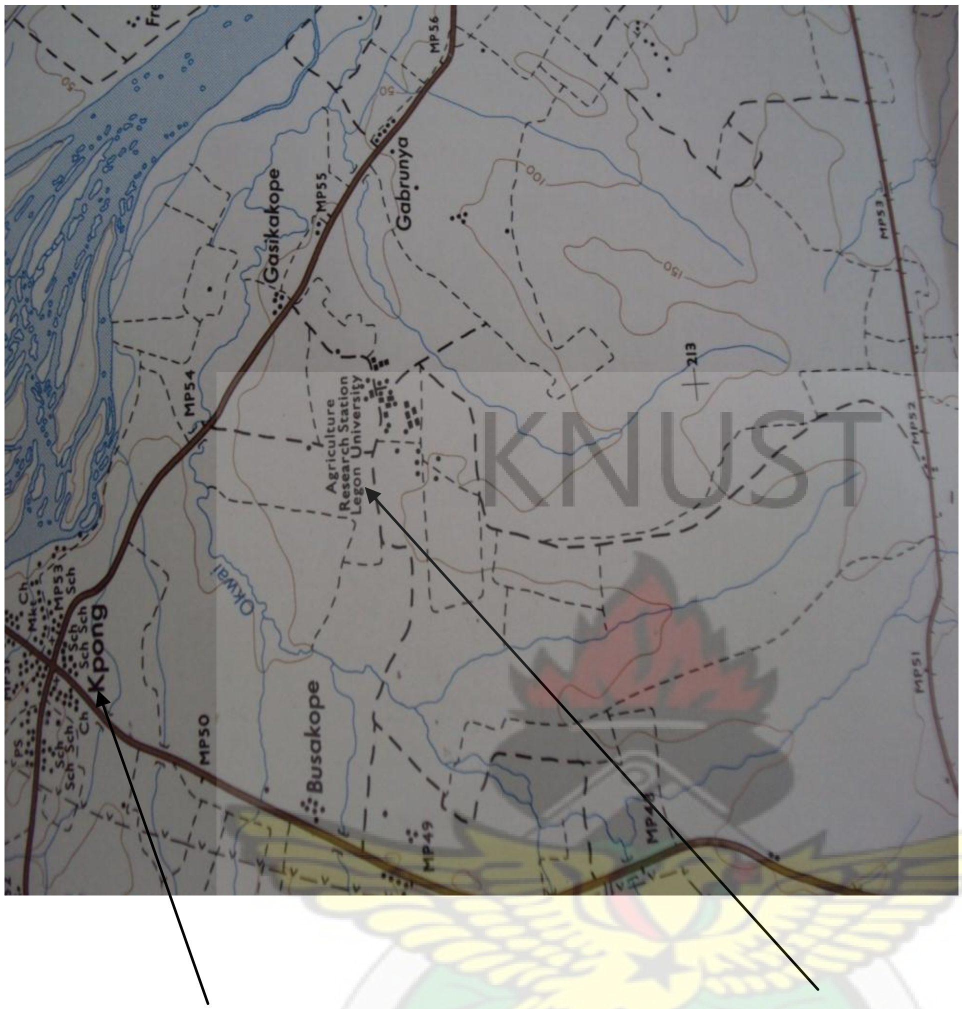
3.1 Site Description

The study was conducted at Soil and Irrigation Research Centre (SIREC) - Kpong of the University of Ghana, Legon during the minor rainy season (September to mid November, 2012). The site is located on latitude $06^0 09'$ N and longitude $0^0 04'$E and at an altitude of 22 m above mean sea level. The rainfall is about 1,200 mm falling in two seasons; major, April to mid-July and minor early September to mid-November. Mean air temperature is 27.2 ^{0}C, mean maximumandminimum temperatures of 33.3 ^{0} C and 22.1 ^{0} C. respectively. Relative humidity for the night time to early hours of the day ranges from 70 % to 100 %. The common soil atSIREC is colluvial material derived from the weathering of garnetiferous hornblende gneiss (Banner, 1995), classified as calcic vertisole (FAO/UNESCO, 1990) and Typic calcic (Soil Survey Staff, 1998).

Coordinates: 6^{0} 32'N 0^{0} 49'W. Elevation702 ft (214 m)

Figure 1 Map of Ghana, Showing the location of Kpong

Source :(www.wikimedia.org/wikipedia/commons/7/7b/Ghana_location_map.svgen.wikipedia.org/wikiodumase_krobo). Retrieved (2013)


Gasikakope
Gabrunya
MP55
MP56
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Agriculture
Research Station
Legon University
Okwai
Kpong
Busakope
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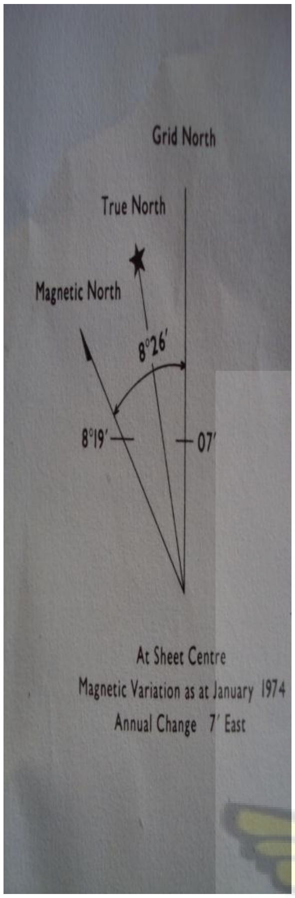

Kpong SIREC (Study Site)

Figure 2 Study Site, SIREC- Kpong

[Source : Survey Department, Map sales - Accra (2013)]

3.2 Experimental Design

The experimental design used was completely randomized design (CRD) with three replications. The treatments were 6, replicating each 3 times totaling 18 treatments with each plot measuring 5 m x 3 m with 2 m between replications and 1 m alley between plots leading to a total land area of 360 m^2.

3.3 Materials Used

The cowpea variety used was *Vigna unguiculata* var Asontem (Black eye), it was chosen because it is highly susceptible to insect pests attack. Two kilograms (2 kg) of seeds were purchased from a recognizable agro-shop called Ronet at Kpong. The treatments used were tobacco(*Nicotiana tabacum*) leaves, neem (*Azadirachta indica*) leaves, ginger (*Zingiber officinale*) rhizomes, onion (*Allium cepa*) bulbs, negative control (water only) and synthetic insecticide (cymethoate).

3.4 Land Preparation and Pegging

The land was sprayed with paraquate (200g/l SL) on 22nd September 2012 at a rate of 35 ml/ 15 litres of water. The land was cleared one week later (1st October, 2012) and demarcated into plots size of 5 m x 3 m across the slope to check erosion and taking into consideration of the fertility gradient of the soil. After getting the individual plots, they were labeled.

3.5 Planting

Planting was done on 3rd October, 2012 by using a garden line with a planting distance of 60 cm between rows and 20 cm within rows through dibbling, where 4 seeds were dropped in 5 cm deep hole and covered resulting to a total of 2 kg seeds used.Later on the seedlings were thinned to 2 per a hill.Pre-emergence herbicide (chemostom 500 E) was applied at a rate of 300 ml/15 litres of water after sowing in order to control the menace of weeds. However,regular control of weeds on the farm was carried out till maturity.

3. 6 Formulation of Treatments

It is well known that the level of concentrate or active ingredient in different parts of a plant differs. Thus the active ingredient in the leaves of given plant is likely to behigher or lower than what is found in its fruit, rhizome, bulb or bark of similar weight. For the above reason, different quantities of the treatments were used in this study.

3.6.1 Neem Extract

For the formulation of the neem extract, 1.3 kg of dried neem leaves at room temperature (24 ^{0}C)was weighed on a scale and blendedinto a fine powder. It was then soaked in 3.3 litres of water ina plastic bucket for 24 hours, strained (using a mesh of 1.5 mm) into a knapsack and then was used to spray on the cowpea plants following the method of Oparaeke *et al*., (2000).

3.6.2 Tobacco Leaves

In the same manner, 1.3 kg ofbruised tobacco leaves was soaked in 3.3 litres of water in plastic bucket overnight after which it was strained using a mesh of 1.5mm into a knapsack. This extract solution was used to spray the cowpea plants according to the method of Oparaeke *et al*., (2000).

3.6.3 Onion Bulbs

Exactly1.0 kg of onion bulb was blended in a blender and soaked in 3.3 litres of water inplastic bucket overnight. The mixture was sieved using a mesh of 1.5mm into a knapsack and sprayed onto the cowpea plants using the method of Oparaeke *et al*., (2000).

3. 6. 4 Ginger Rhizomes

A weight of 1.0 kg of ginger rhizomes was blended in a blender and soaked in 3.3 litres of water in plastic bucket overnight. The mixture was then strained using a mesh of 1.5 mm into a knapsack where the solution was sprayed onto the cowpea plants in line with the method of Oparaeke*et al*., (2000).

3. 6. 5 Cymethoate

A volume of 44 ml of cymethoate was measured and poured into a knapsackcontaining 3.3 litres of water and sprayed onto the cowpea plants using the method of (Oparaeke *et al*., 2000).

Spraying of the cowpea plants with the above treatments was done at 2, 4, 6, 8 and 10 weeks after planting (WAP).

3. 7 Data Collection

3. 7. 1 Plant Emergence

Planting was done on3rd October, 2012 where the seeds were observed to know the number of days they took to germinate from the soil. It was observed that, 50 % emerged after 5 days after planting(DAP) with 100 % emergence at 7 DAP.

$$\text{Percentage germination} = \frac{\text{Number of seeds that germinated}}{\text{Total number of seeds planted}} \times 100$$

3. 7. 2 Scoring of Pests

For the purpose of evaluating the efficacy of the treatments, five plants from each plot was selected randomly. Pre-spray populations of insect pests were recordedtwo weeks after planting (WAP)and thereafter scoring of pest population was doneat every two weeks after spraying (WAS);observations were made between 8.00 - 10.00 a.m. because of the usually high temperatures that characterize sunny days during the late mornings and afternoons which could cause these insect pests to escape from the cowpea plants.

The various pest populations recorded include whiteflies, aphids and pod borers (see below).

Plate 2Whiteflies (*Bemisia tabaci*)Plate 3Aphids (*Aphis craccivora*)

Plate 4 Pod Borer (*Maruca vitrata*) larva

Source: http://www.infonet-biovision.org. Retrieved (2013)

Table 1 Scale of rating insect infestation on cowpea

Rating	Number of Insect Pests	Appearance
0	0	no infestation
1	1-4	a few individual aphids
3	5-20	a few individual colonies
5	21-100	several small colonies
7	101-500	large isolated colonies
9	> 500	large continuous colonies

Adapted from Litsinger *et al.*, (1977)

3. 7. 3 Pod Weight

The cowpea pods were harvested when they were physiological matured(60 - 65 days and their weights (g) recorded by using the digital scale (model KERN 572-52).

3. 7. 4 Number of Pods

The cowpea pods per plot were counted and recorded.

3. 7. 5 Number of Damaged Pods

Pods that were damaged by pod borers were selected from each plotand counted.

3. 7. 6 Number of Damaged Grains

Grain quality estimation was done using a visual grain damage rating scale of 1 - 6. Damaged grains counted included all cowpea grains whose quality has been reduced as a result of the infestation by pod borers.

Table 2Scale of 1 – 6 ratingof grain damage of cowpea by Pod borers

Rating	Percentage (%) Grain Damage
1	1-5% damage grains
2	6-25% damage grains
3	26-50% damage grains
4	51-75% damage grains
5	76-95% damage grains
6	>95% damage grains

Scale of Rating afterPasserine and Hill (1993)

3. 7. 7 100 Grain Weight

One hundred grains were picked from the lot of each plot; they were weighed and their weights in grams (g) recorded.

3. 7. 8 Grain Yield

The grain yield per plot was weighed on a digital scale and recorded after threshing. The yield per plot was calculated as Kg/ha.

3. 7. 9 Analysis of Data

The means of whiteflies, aphids and pod borers population, total weight of pods, number of pods, number of damaged pods and grains, 100 grain weight (g) and grain yield (Kg/ha) among treatments were analyzed by subjecting all the data to one way Analysis of Variance (ANOVA) using Genstat Discovery (9.2th Edition 2014, PC/Windows). The least significant difference (LSD) test was used to separate the treatment means at 5 % significance level.

CHAPTER FOUR

RESULTS

4. 1 Whitefly Population

Results of the various treatments to control whiteflies population on cowpea after four to ten weeks after planting (WAP) are presented in Fig.3. Generally, the negative control (water only) recorded the highest whiteflies population throughout the period, while the chemical, cymethoate treated plants recorded the lowest whiteflies population. On the other hand, onion and ginger recorded the highest whiteflies population at 6 WAP as tobacco recorded the least. Whiteflies populationnumbersdid not show any significant difference among the various treatments at 4, 6 and 10 weeks after planting (WAP) respectively (P = 0.48, 0.397 and 0.178, Appendices 1, 2 and 4). However, there was significant difference between cymethoate when compared with ginger, neem and tobacco at 8-10 WAP (P = 0.026, Appendix 3).

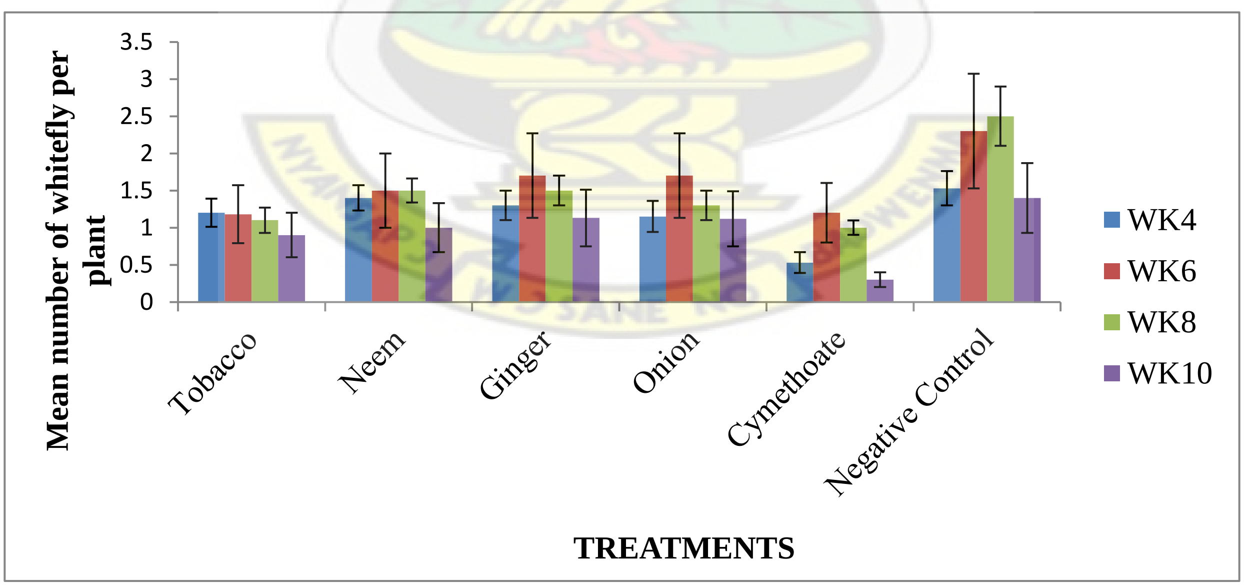

Fig. 3Effect of different individual plant extracts on mean number of whitefly population on cowpea.

4. 1.1 Aphids Population

As shown in Fig. 4, very low numbers of aphids per plant were found and recordedduring the period of the study. However, cymethoate effectively controlled the aphids population at 4, 6 and 8 WAP, whilst negative control was the least to control the aphids population. There was no significant difference in aphids population between the different treatment plots at 4, 6 and 8 WAP (P = 0.944, 0.995 and 0.99, Appendices 5, 6 and 7).

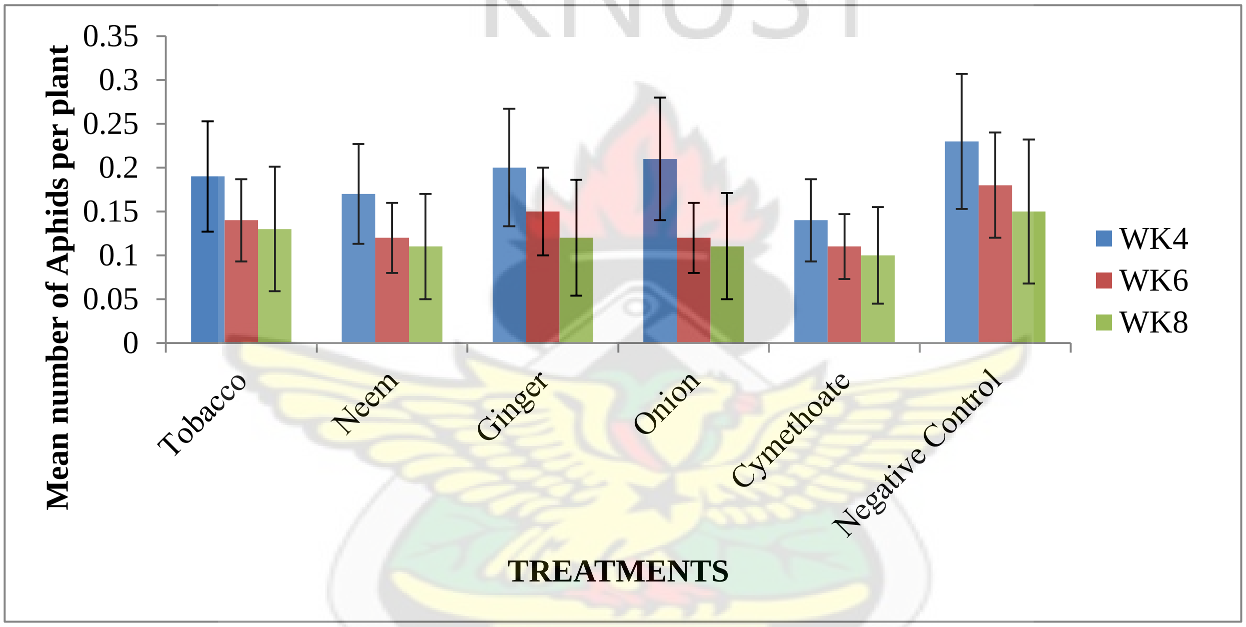

Fig. 4 Effect of different bioinsecticide sources on mean number of aphids on cowpea.

4. 1. 2 Pod Borer Population

The effects of the various treatments on the mean number of pod borers per plant at weeks 6, and 8 after planting is shown in Fig.5. Cymethoate was the best to reduce pod borer population followed byneem, tobacco, ginger and onion at 6 and 8 weeks after planting (WAP). The water only recorded the highest mean pod borer population and cymethoate recorded the lowest mean number of pod borer population per plant. There were no significant differences in pod borerinfestation among treatment plots at 6 and 8 WAP(P = 0.968 and 0.293, Appendices 8 and 9).

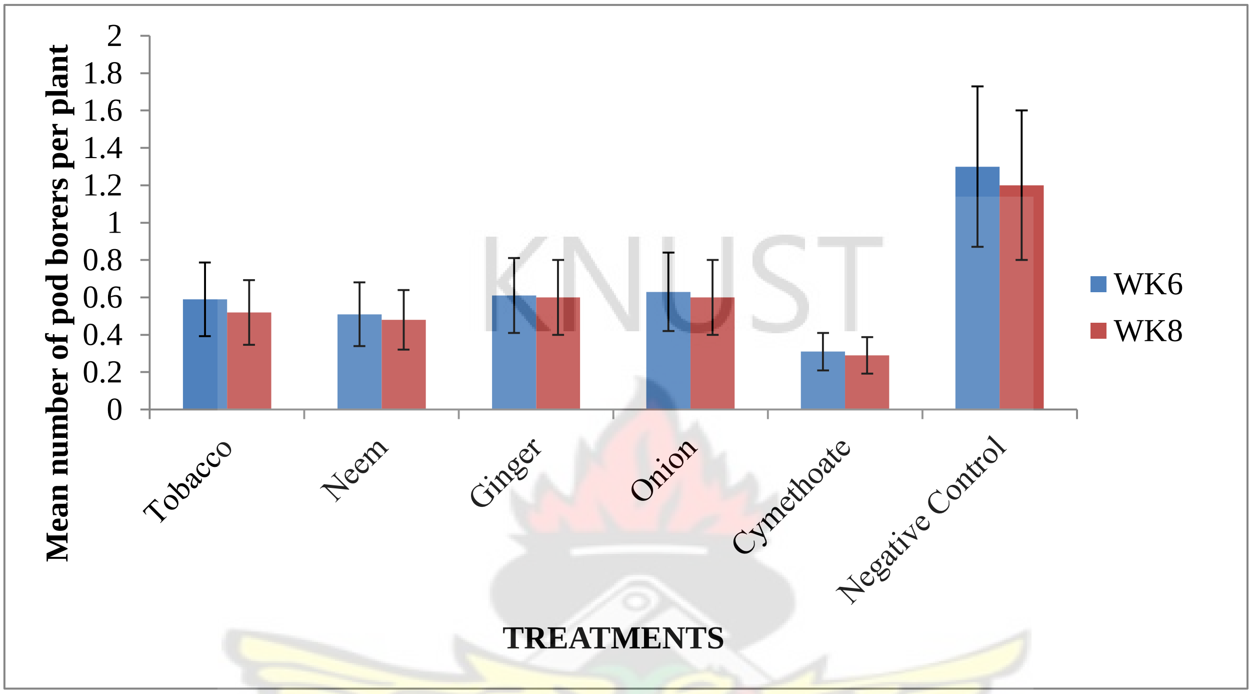

Fig. 5 Effect of different bioinsecticide sources on the mean number of pod borers (*Maruca vitrata*) at 6 and 8 weeks after planting.

4. 1. 3 Total Weight of Pods

The weights of cowpea pods for each treatment are given in Fig. 6. Cymethoate recorded the highest total pod weight; this was followed by neem, tobacco, ginger and onion. The negative control recorded the lowest total pod weight. Differences in total pod weight did not show significantdifference among treatments (P = 0.324, Appendix 10).

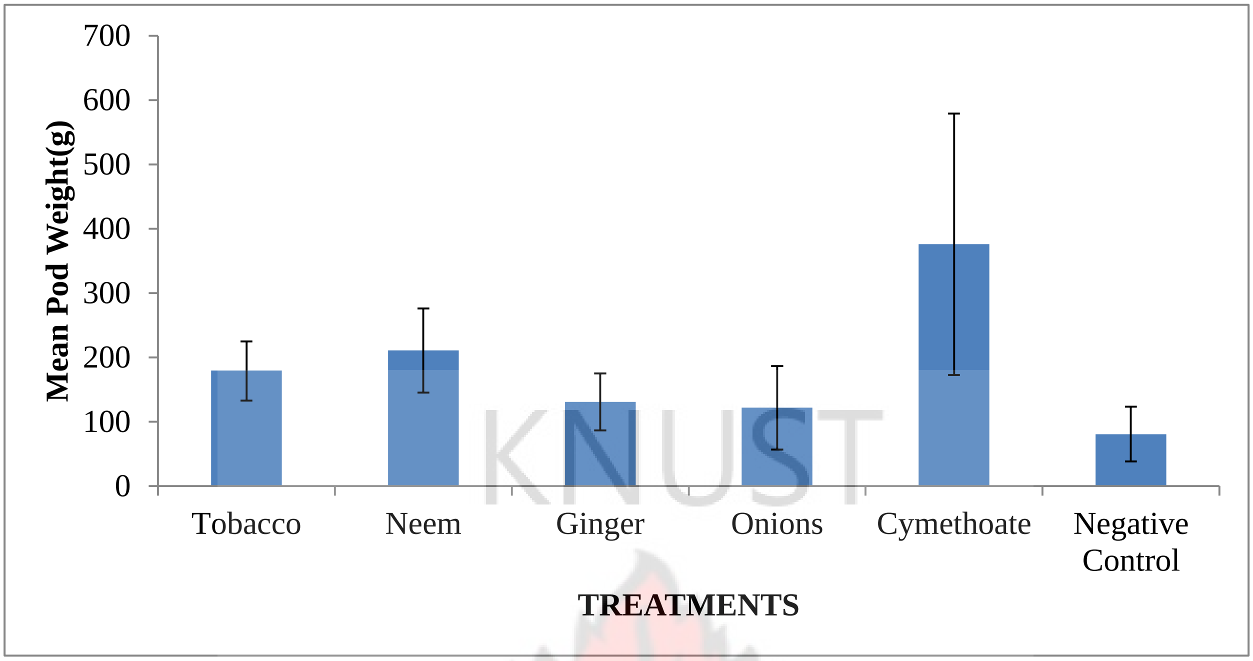

Fig. 6 Effect of different bioinsecticide sources on mean weight of cowpea pods

4. 1. 4Total Number of Pods

The results of the total number of pods for each treatment are presented in Fig.7.Cymethoate recorded the highest number of pods, followed by the neem and negative control being the least. The differences in the total number of pods were not significant among treatment plots (P = 0.240, Appendix 11).

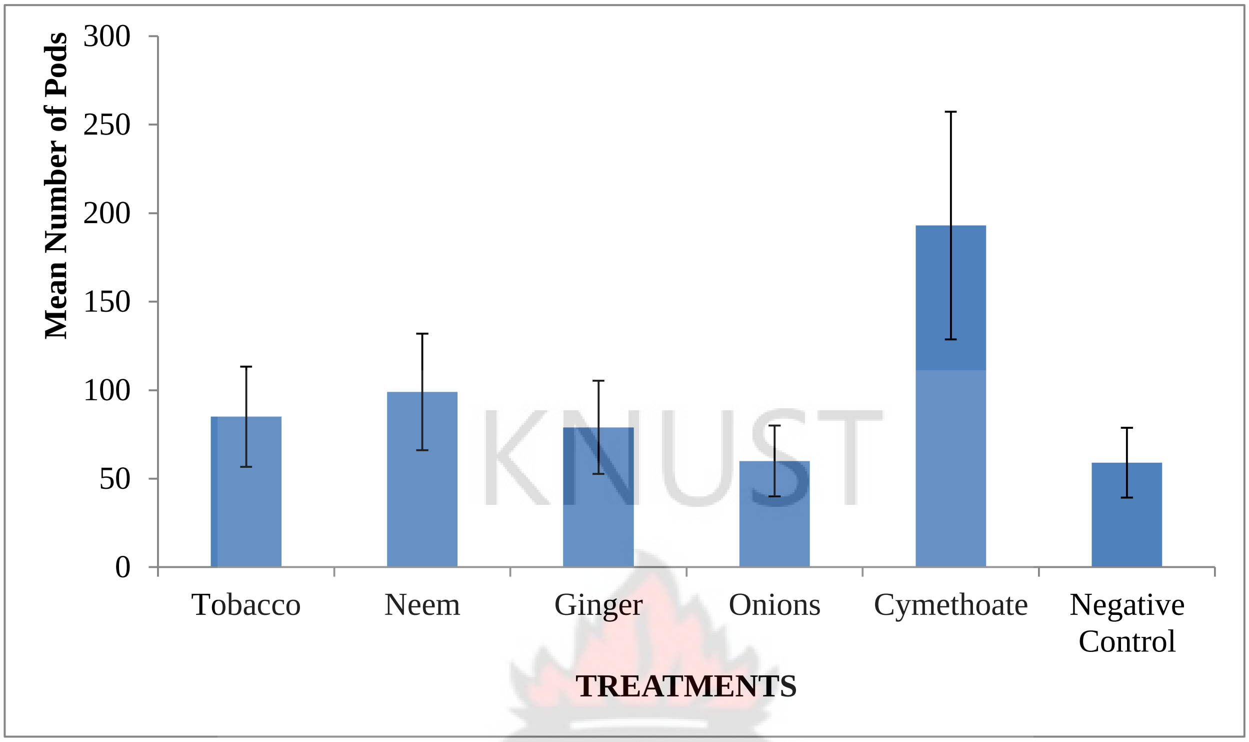

Fig. 7 Effect of different bioinsecticide sources on mean number of cowpea pods.

4. 1. 5 Number of Damaged Pods

From Fig. 8 the result of number of damaged pods is shown as,cymethoate recorded the least number of damaged pods, whereas the water only recorded the highest. The differences in the number of damaged pods were not significant among the treatments (P = 0.456, Appendix 12).

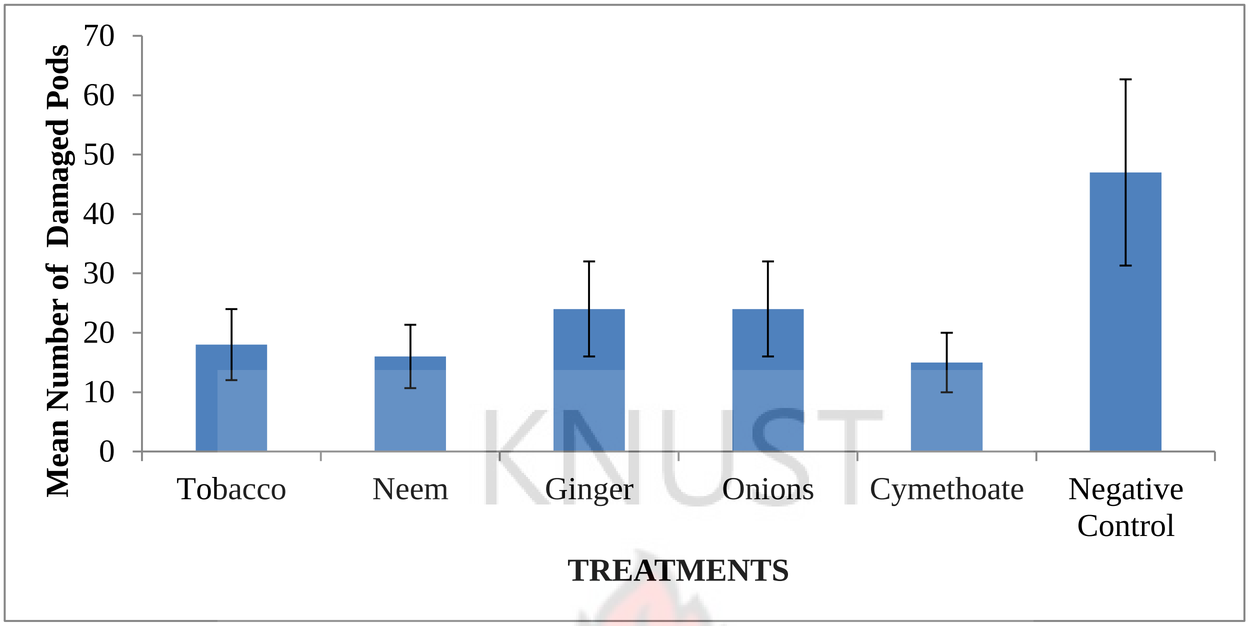

Fig.8 Effect of different bioinsecticide sources on mean number of damaged pods ofcowpea.

4. 1. 6 Number of Damaged Grains

The mean number of damaged grains is indicated in Fig. 9. Negative controlrecorded the highest mean number of damaged grains, followed byginger and onion, tobacco, neem and cymethoate being the least. There were no significant difference among the treatment means (P = 0.191,Appendix 13).

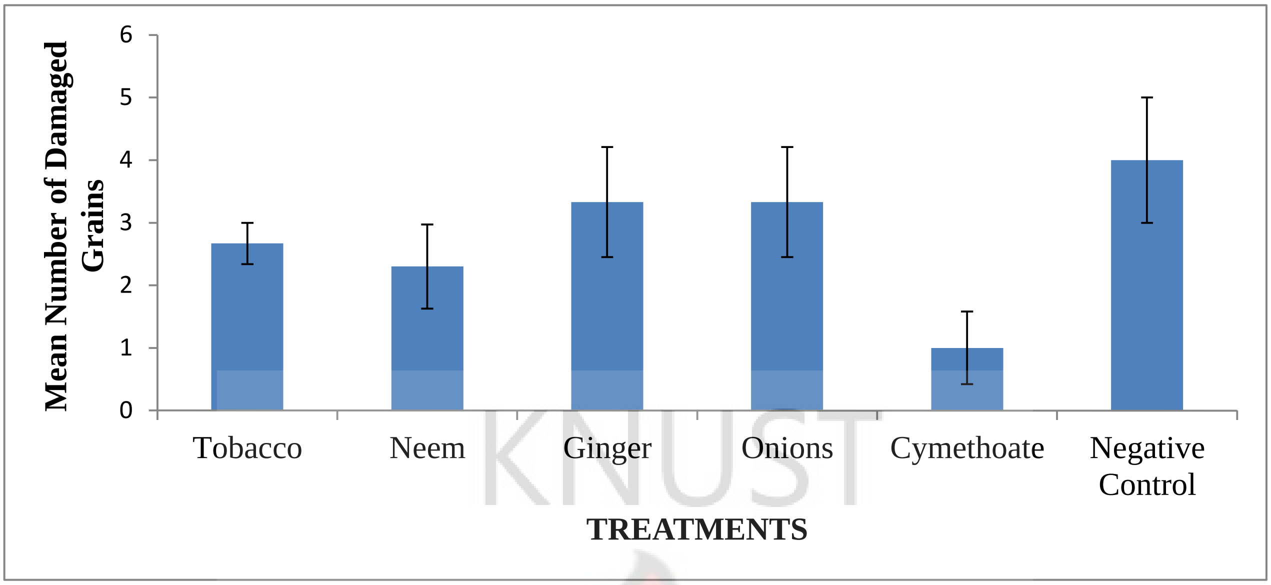

Fig. 9 Effect of treatments on mean number of damaged grains of cowpea.

4. 1. 7100 Grain Weight

Cymethoate treatment recorded slightly heavier weight Fig.10. However, tobacco, neem and ginger recorded similar weights, whilst onion was relatively lower and negative control (water only) recorded the least weight. There were significant differences in 100 grain weight of cowpea when cymethoate was compared with ginger, neem, tobacco, onion and negative control treatments (P = 0.0120, Appendix 14).

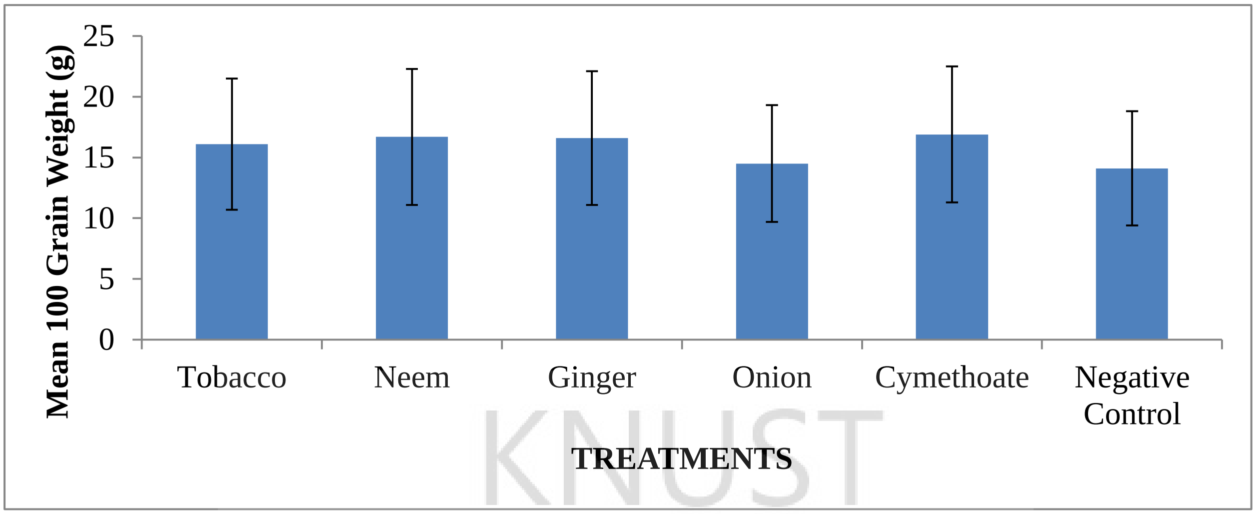

Fig. 10 Effect of different bioinsecticide sources on 100 grain yield of cowpea.

4. 1. 8Grain Yield

The study revealed that, cymethoate treatment recorded the highest grain yield followed by neem, tobacco, ginger and onion, whilst the water only was the least as shown in Fig. 11. Differences in grain yield werenot significant among the treatments (P = 0.383, Appendix 15).

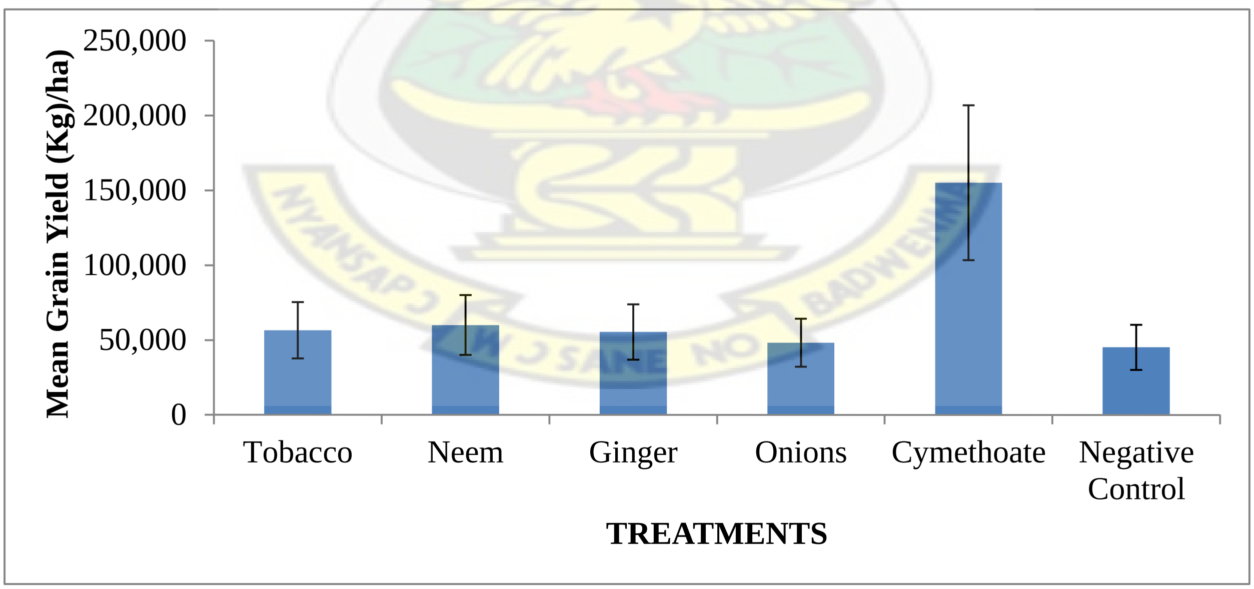

Fig. 11 Effect of different bioinsecticide sources on grain yield of cowpea.

CHAPTER FIVE

DISCUSSION

5. 1 Pre-sprayed Insect Population

Whiteflies, aphids and pod borers were not seen and recorded as they were not found two (2) weeks after planting (WAP), before the application of the treatments. This could probably be due to the very young nature of the seedlings and also as a result of the heavy rainfall experienced at the beginning of the study which might have washed off the whiteflies and the aphids.

5. 2 Whitefly Population

Synthetic insecticide, cymethoate effectively controlled the whitefly population at 4, 6, 8 and 10 weeks after planting (WAP) as compared to the botanicals [(neem) *Azadirachta indica*) leaves,tobacco (*Nicotiana tabacum*) leaves,onion(*Allium cepa*) bulbsandginger(*Zingiber officinale*) rhizomes].This could be due to the susceptibility of the whitefllies to cymethoate or toxicity of the active ingredient (ai) of cymethoate (cypermethrin) in controlling whiteflies on cowpea. It could also be due to the apparently fair weather conditions characterized by moderate level of rainfall and sun shine during treatment applications which made the chemical's residual effect last relatively longer against the whiteflies. The finding agrees with Jackai and Oyediran(1991) and Jackai (1993) who reported that synthetic insecticides effectively controlled whitefly pests on cowpea. The same observation was also made by Agona *et al*., (2000) where synthetic insecticides were reported to be more effective than botanical insecticides when both were applied under the same field conditions.

The effectiveness of onion extracts in controlling whiteflies throughout the study was not conclusive as its performance in reducing whitefly population at 6 and 10 WAP respectively were not significant compared to the other botanicals. This could probably be due to the presence of sugar content in onion which serves as a source of food for the whiteflies. This also implies that even among botanicals, certain pests on cowpea cannot be comprehensively controlled in spite of their environmental friendliness and other benefits. The active ingredients in onion (*Allium cepa*);allacin, probably were destroyed in sunlight or as a result of the increase in number of leaves as the plant grew serving as hiding places for these pests. It could probably be due to the solvent (i.e. water medium which is not lipophilic) used for the extraction of the *Allium cepa.*

5. **3 Aphid Population**

Aphids(*Aphis craccivora*)were observed on 4, 6 and 8 weeks after planting (WAP) during thestudy. The aphids were effectively controlled by cymethoat e which couldbe due to the efficacy of the chemical on aphids in the study Fig.4.This observation agrees with earlier report by Jackai *et al*., (1985). They reported that,insecticides are the most effective control measure against pests on cowpea. The insignificant number of *Aphis craccivora* population in the study area could probably be due to the wet weather conditions as experienced during the study period between September and November, 2012. Probably the rains had the effect of washing off the aphids thus accounting for the low numbers of *A. craccivora.* Perhaps *A. craccivora* could not thrive under those conditions. This observation agrees with the findings of Degri and Hadi (2000), who concluded that *A.craccivora* does not thrive on cowpea under heavy rainfall conditions.

5. 4 Pod Borer Population

Cymethoate effectively controlled the pod borer (*Maruca vitrata*) population at 6 and 8 WAP, because few were found at this stage of the plant growth Fig.5.The reason could be due to the potency of the cymethoate aided by good weather conditions during treatment applications. Neem and tobacco were also effective in controlling pod borer population.This could probably be due to the active ingredients of neem(azadirachtin) and tobacco (nicotine) extracts or probably due to anti-feedant action of neem and tobacco which reduced pod borer infestation. These observations agree with the findingsof Saxena,(1981); Jackai and Oyediran (1991); Jackai *et al*.,(1992);Jackai, (1993);Zongo *et al*., (1993) andAgona *et al.*, (2000) who reported thatneemand tobacco products showed efficacy against the pod borer(*Marucavitrata*), pod sucking bug complex(*Clavigralla tomentosicollis*) and other insect pests. They also agree with reports by William and Ambridge (1996); Fuglie (1998) and Gaby (2000) that plant extractsfromneem and tobacco were known to possess toxic organic components that were effective in reducing insect pests population on cowpea including pod borers.

Ginger and onion were however effective in controlling pod borer population at 6 and 8 WAP. This probably could be due to the distinctive pungency and the presence of volatile oil in these or possibly due to their repellant and insecticidal properties. This observation was also made by William and Ambridge(1996); Fuglie(1998) and Gaby (2000). These authors reported that plant extracts areknown to possess toxic organic ingredient that are effective inreducing insect pests populationincluding pod borers.

5. 5 Weight of Pods

Treatment with synthetic insecticide, cymethoate resulted in highest pod weightFig.6. This could probably be due to theefficacy of cymethoate to controlpests population. This observation agrees with the findings by Jackai and Oyediran(1991), Jackai *et al*., (1985) and Tanzubil (1991**,** 2000) in their respective earlier studies including a conclusion that complete crop failures often occurred whencowpea varieties were grown without insecticide sprays. The performance of cymethoate treatment was followed by neem and tobacco treatments. This probably could be as a result of the presence ofanti-feedant properties in these or possibly due to their repellant and insecticidal properties have effects on the pest population thus translating into pod formation hence increase in pod weight. This observation was also made byWilliam and Ambridge(1996); Fuglie(1998) and Gaby (2000). These authors reported that plant extracts areknown to possess toxic organic poison that is effective inreducing insect pests populationincluding pod borers.

The negative control recorded the least pod weight and this could probably be due to pests infestation on the cowpea plants. This possibly might have interfered with the physiological activities of the cowpea plants and thus prevented the cowpea from producing to its full potential, hence lower weight.

5. 6 Number of Pods

The highest number of pods was obtained in field treated with cymethoatewhich appeared to have had an effective control of pests on cowpea Fig. 7. Neem and tobacco were next in terms of the highest number of pods. This possibly could be attributed to the anti-feedant action of neem and tobacco extracts. This observation compares favourably with the findings of Jackai and Oyediran, (1991), Tanzubil, (1991, 2000), Jackai *et al*., (1992),Zongo *et al*., (1993) and Saxena, (1981) in their respective studies on cowpea and the use of botanicals.

On the other hand, the least number of pods observed was in the case of the negative control treatment which could be attributed to the absence of any treatment to prevent pests infestation.

5. 7 Number of Damaged Pods

It was observed that the water only treatment recorded the highest number of damaged pods (Fig.8).This means that there was probably a high pest infestation. Cymethoate recorded the least number of damaged pods. This probably could be due to the potency of cymethoate which controlled various pests (*Maruca vitrata,Clavigralla spp, Anoplocnemis spp, and Nezera viridula*) associated with cowpea resulting into less damaged pods. This observation is in line with earlier reports by Jackai and Daoust,(1986) and Suh *et al*., (1986). These researchers reported that, without the control of cowpea pests, reasonable grain yield cannot be obtained.

Ginger and onion recorded relatively higher numbers of damaged pods after the negative control. In other words, these two extracts are more beneficial to the farmer than not applying any control measure. The lower efficacy of these two extracts could be attributed to the fact that the active ingredients in ginger (gingerol, zingerone and shogaol) and onion (allacin) probably were destroyed in sunlight much faster therefore could not control more pod borers compared to the other botanicals.

Extracts of neem treatment recorded the least number of damaged pods amongst the botanicals after the synthetic chemical, cymethoate (Fig.8). This observation is in line with the conclusions drawn by Jackai and Oyediran, (1991), Tanzubil, (1991, 2000), that such treatments with neem gave the least number of damaged pods.

5. 8 Number of Damaged Grains

The highest mean number of damaged grains was recorded on the negativecontrol plots (Fig. 9). This probably could be due to high insect pests infestation as no treatment was applied to the cowpea plants. This finding agrees with Jackai and Daoust, (1986); Suh *et al*., (1986)who also observed that, grain yield losses and grain quality caused by insect pests have been estimated to be very high in unprotected field. Cymethoatetreatedplantsrecorded the least damaged grains. This could probably be due to the efficacy of cymethoate which controlled the various pests (*Maruca vitrata,Clavigralla spp*, *Anoplocnemis spp, and Nezera viridula*) that caused damage to pods and grains. Jackai, (1993); Jackai and Adalla, (1997); Agona *et al*., (2000) and Dzemo *et al*., (2010)also recorded the same. These authors indicated in their report that, synthetic insecticide is the most effective to control insect pests on cowpea.

On the other hand, neem and tobaccoextracts treated plants recorded the least grain damage among the botanicals. This could be probably due to the anti-feedant properties in neem and tobacco extracts or probably due to theresident active ingredients which reduced insect pest infestationcaused by the borers. These observations agree with the findings of Saxena, (1981); Jackai and Oyediran (1991); Jackai *et al*., (1992), Jackai, (1993); Zongo *et al*., (1993) and Agona *et al.,* (2000) who reported that neem and tobacco aqueous leaf extracts were inhibiting against against the pod borer(*Maruca vitrata*), pod sucking bug complex (*Clavigralla tomentosicollis*) and other insect pests. William and Ambridge (1996); Fuglie (1998) and Gaby (2000) also showed biotoxins that fromneem and tobacco were effective in reducing insect pest population on cowpea including pod borers.

Ginger and onion recorded similar number of damaged grains. The lower efficacy of these two extracts in controlling insect pests could be attributed to the fact that the active ingredients in ginger(gingerol, zingerone and shogaol) and onion (allacin) probably were destroyed in sunlight much faster therefore could not control the pest effectively as compared to the other botanicals. It could also be that, they are weaker bioinsecticides or the rate of application was lethal.Present result were similar to the findings of Sommers (1983) and Oparaeke (2004) who reported that, some extracts may require other plant species with different mode of action to record adverse synergistic effect on the pest population.

5. 9 100 Grain Weight

Cymethoatetreatment recorded relatively heavier grain weight of 16.9 g compared to the other treatments Fig.10. This could probably be due to therelatively high number of well developed grains which translated into heavy grain weight.

On the other hand, neem, ginger, tobacco and onion treatments recorded 16.7 g, 16.6 g, 16.1 g and 14.5 g per 100 grain weight respectively. The differences between the results of these respective treatments were not significant.

However, the negative control appeared to have had more detrimental effect on grain weight as it recorded the least, 14.1 g per 100 grains. This could possibly be attributed to higher pests infestation on the cowpea plant which were not treated with any chemical to reduce the incidence of pests.

5. 10 Grain Yield

Data on the yield of cowpea showed that cymethoate treated plants produced the highest grain yield of 155, 089 kg/ha Fig.11.This may be due to effective nature of the chemical in controlling insect pest infestation leading to a greater dry matter accumulation and yield /ha. Similar observation have also been made by Jackai *et al*., (1986), Jackai and Oyediran, (1991), Jackai, (1993),Jackai and Adallah (1997);Karungi *et al*., (2000), Agona *et al*., (2000) andDzemo *et al*., (2010)on the effectiveness of cymethoate in controlling pests on cowpea leading to higher yields. Neem extract produced one of the highest grain weights of 16.7 g/100 grains next tocymethoate. It however yielded 60,066 kg/ha compared to the other treatments. This could probably be due to the efficacy of neem extract to control cowpea pests resulting into higher yields. This observation confirms the reports of Jackai and Oyediran, (1991) and Tanzubil, (1991, 2000). The negative control plants recorded the least grain yield of 45, 190 Kg/ha. This observation of poor yield performance was further augmented by the fact that the negative control plants produced theleast pod weight, least number of pods, higher number of damaged pods, damaged grains as well, least weight of 14.1 g/100 grains as well as grain yield Figs. 6 to 11. This could be probably due to high number of insect pests infestation during various stages of the plant growth. This observation agrees with the findings ofJackai and Daoust, (1986), and Suh *et al*., (1986). That, without the control of insect pests, reasonable grain yield cannot be obtained.In addition, though 100 grain weight of onion treatment was the least after the negative control and appeared to be significantly different from the other treatments, its overall lower yield 48,133 Kg/ha could also be attributed to many other factors. These include the relatively large number of damaged pods, least weight of pods and least number of pods this treatment produced except the negativecontrol. This could possibly be due to the low potency of onion to control field pests of cowpea or probably due to the presence of toxic organic compounds in onion that negatively affected grain development. This observation agrees with the findings by William and Abridge (1996). In their study, they concluded that, onion contains certain organic chemicalssuch as that have negative impact on grain development.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6. 1 Conclusion

Although, cymethoate had a better control of the field insect pests of cowpea, its well known health concern to human beings, wildlife, environment, water bodies and livestock may negate its usefulness. However, since neem extracts, gave promising results over the other botanicals (on population reduction of whiteflies, aphids and pod borersand consequently better yield), it can be conjectured that its prospect for use asthe negativecontrol agentof insectpests of cowpea is very high.

Although adequate yield was not obtained from ginger, onions and tobacco treated plants, it can be concluded from the study that they exhibitedreasonable insecticidal activities. Therefore they can be used alongside other forms of pest managements like IPM, these extracts can help reduce cost of production and the detrimental effect on the environment.

6. 2 Recommendations

From the study, it is recommended that:

1. Neem leaves extract could serve as a valuable alternativein the management of field pests of cowpea to the synthetic insecticides which come with many negative impacts enumerated in this study.
2. It is therefore, recommended to farmers to practice this spraying regime to effectivelycontrol such pests. It will alsominimize production cost incurred by farmers

who sprayeight to ten times during the cowpea growing season using expensive synthetic insecticides with disastrous environmental consequences to humanity.

3. It is recommended that future investigation into the four botanicals [tobacco (*Nicotiana tabacum*) leaves, neem (*Azadirachta indica*) leaves, ginger (*Zingiber officinale*) rhizomes and onion (*Allium cepa*) bulbs], should be carried out using different concentrations in order to determine the LD 50.

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APPENDICES

Appendix 1: Analysis of variance for whiteflies at 4 WAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	1.8400	0.3680	0.48	0.48 N.S
Residual	12	9.2000	0.7667		
Total	17	11.0400			

N. S (Not Significant)

Appendix 2: Analysis of variance for whiteflies at 6 WAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	1.5400	0.3080	1.13	0.397 N.S
Residual	12	3.2800	0.2733		
Total	17	4.8200			

N. S (Not Significant)

Appendix 3: Analysis of variance for whiteflies at 8 WAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	4.4444	0.8889	3.85	0.026 **
Residual	12	2.7733	0.2311		
Total	17	7.2178			

**** (SignificantP = 0.026)**

Appendix 4: Analysis of variance for whiteflies at 10 WAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	1.9311	0.3862	1.85	0.178 N.S
Residual	12	2.5067	0.2089		
Total	17	4.4378			

N. S (Not Significant)

Appendix 5: Analysis of variance for Aphids at 4 WAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	0.03778	0.00756	0.23	0.944 N.S
Residual	12	0.40000	0.03333		
Total	17	0.43778			

N.S (Not Significant)

Appendix 6: Analysis of variance for Aphids at 6 WAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	0.02000	0.00400	0.07	0.995 N.S
Residual	12	0.64000	0.05333		
Total	17	0.66000			

N.S (Not Significant)

Appendix 7: Analysis of variance for Aphids at 8 WAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	0.01111	0.00222	0.04	0.999 N.S
Residual	12	0.61333	0.05111		
Total	17	0.62444			

N.S (Not Significant)

Appendix 8: Analysis of variance for Pod borer at 6 WAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	0.7044	0.1409	0.17	0.968 N.S
Residual	12	9.8933	0.8244		
Total	17	10.5978			

N.S (Not Significant)

Appendix 9: Analysis of variance for Pod borer at 8 WAP

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	1.3511	0.2702	1.40	0.293 N.S
Residual	12	2.3200	0.1933		
Total	17	3.6711			

N.S (Not Significant)

Appendix 10: Analysis of variance for Total Pod Weight (g)

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	164611.	32922	1.31	0.324 N.S
Residual	12	302301	25192.		
Total	17	466912.			

N.S (Not Significant)

Appendix 11: Analysis of variance for Total Number of Pods

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	37479	7496.	1.58	0.240 N.S
Residual	12	57070	4756		
Total	17	94548			

N.S (Non Significant)

Appendix 12: Analysis of variance for Number Damaged Pods

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	2130.0	426.0	1.01	0.456 N.S
Residual	12	5086.0	423.8		
Total	17	7216.0			

N.S (Not Significant)

Appendix 13: Analysis of variance for Mean Number Damaged Grains

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	15.333	3.067	1.78	0.191 N.S
Residual	12	20.667	1.722		
Total	17	36.000			

N. S (Non Significant)

Appendix 14: Analysis of variance for 100 Grain Weight (g)

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	21.9850	4.3970	4.87	0.0120 **
Residual	12	10.8400	0.9033		
Total	17	32.8250			

**** (Significant P = 0.0120)**

Appendix 15: Analysis of variance for Grain Yield (Kg/h)

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE (SS)	MEAN SUM OF SQUARE (MS)	VARIANCE RATIO (VR)	F. RATIO
Treatment	5	2.646E+10	5.293E+09	1.16	0.383 N.S
Residual	12	5.482E+10	4.568E+09		
Total	17	8.128E+10			

N.S (Non Significant)

Appendix16: Plot Layout

Rep 1	**Plot 1** **Tobacco**	**Plot 2** **Neem**	**Plot 3** **Ginger**	**Plot 4** **Onion**	**Plot 5** **Control**	**Plot 6** **Cymethoate**
Rep 2	**Plot 7** **Cymethoate**	**Plot 8** **Control**	**Plot 9** **Tobacco**	**Plot 10** **Neem**	**Plot 11** **Ginger**	**Plot 12** **Onion**
Rep 3	**Plot 13** **Onion**	**Plot 14** **Cymethoate**	**Plot 15** **Neem**	**Plot 16** **Control**	**Plot 17** **Tobacco**	**Plot 18** **Ginger**