DEVELOPMENT OF AN INTEGRATED PEST MANAGEMENT STRATEGY FOR THE CONTROL OF *Maruca vitrata* ON COWPEA IN KEBBI STATE OF NIGERIA

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DEDICATION

This thesis work is dedicated to my parents

ABSTRACT

The study was undertaken with the objective of developing an IPM control strategy against *M. vitrata* in cowpea which will replace the existing use of calendar based application of broad spectrum chemical insecticide (Mixture of 30g cypermethrin and 250g dimethoate) in Kebbi State of Nigeria. The study initially made use of a survey backed up by focus group interviews to gather information on the types of farmers' cowpea cultivation practices, their perceptions on pests and pesticides and the economics of cowpea cultivation with the aim of incorporating those practices that were found to be IPM compatible in the strategy developed. The result showed that most farmers were small scale growers who inappropriately used chemical insecticides due to lack of knowledge of other alternatives. Farmers had good scouting ability as demonstrated by their knowledge of field insect pests of cowpea, the nature of their feeding habit and magnitude of damage due to these insect pests. Cowpea cultivation in Zuru is profitable, labour and insecticides costs were the major profit limiting factors in cowpea cultivation. Therefore, an on-station trial was conducted which initially focused on the evaluation of four potential IPM components for their suitability as control tools against *M. vitrata* using two cowpea varieties [Danzafi (local) and improved Kanannado (IT89KD-245-1)]. The result showed that neem (nke) at 5% concentration was as effective as chemical insecticide (mixture of cypermethrin and dimethoate) in terms of reducing larval infestation/damage, pods and seeds damage as well as increasing yield of cowpea. In the next season another on-station trial was conducted to validate use of nke on scouting basis as an IPM system for the management of *M. vitrata* using the same cowpea varieties. The result showed that, the scouting based nke application had significantly higher larval infestation/damage which significantly lowered yield in comparison with the calendar based insecticide application. However,; the highest cost benefit ratio was sustained by the scouting based nke application. During the third season on-farm trial, although nke on scouting based application had significantly higher larval infestation/damage compared to calendar based chemical insecticide application yield was similar, indicating that it was not affected. The application of nke on scouting basis did not affect the abundance of the natural enemies. It was therefore concluded that nke application on scouting basis has the potential as an IPM control strategy against *M. vitrata* in cowpea.

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DECLARATIONS

I certify that this work has not been accepted in substance for any degree, and is not concurrently being submitted for any degree other than that Doctor of Philosophy being studied at the University of Greenwich. I also declare that this work is the result of my own investigations except where otherwise identified by references and that I have not plagiarised the work of others.

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LIST SYMBOLS AND ABBREVIATIONS

AFFD	Agriculture Forestry &Fisheries Department
CHEM	Chemical
CABI	Centre for Agricultural Biosciences International
CGIAR	Consultative Group on International Agricultural Research
CTA	Technical Centre for Agriculture and Rural Development
DFID	Department For International Development
ESCAP	Economic and Social Commission for Asia and the Pacific
Fig.	Figure
FMANR	Federal Ministry of Agriculture and Natural Resources
GDP	Gross Domestic Product
g	Grammes
IITA	International Institute of Tropical Agriculture
IAPPS	International Association for Plant Protection Sciences
ICIIPE	International Centre for Insect Physiology and Ecology
IFAD	International fund for Agricultural Development
ha	Hectare
Kg	Kilogram
L	Litre
M	Metre
MSU	Mississippi State University
Nke	Neem Kernel Extract
NRC	National Research Council
NRCS	Natural Resource Conservation Service
NPK	Nitrogen, Phosphorous and Potassium
Pr	Probability
UFIFA	University of Florida Institute of Food and Agricultural Sciences
UC	University of California
WIR	World Resources Institute
WWF-SA	World Wild Life Fund-South Africa
=	Equal to
>	Greater than
<	Less than
+	Plus

-	Minus
%	Per cent

CHAPTER ONE: INTRODUCTION AND OBJECTIVES

1.1 INTRODUCTION

The environment of tropical Africa, which is very conducive to rapid plant growth, also favours the rapid proliferation of pest populations, resulting in serious reductions in yield of most crop plants (Wrigley, 1981). Insect pests are by far the most important pests of crops such as cowpea in the entire West African region (Komolafe, 1985). Little wonder there is the assertion that: "farming looks mighty easy when your plough is a pencil and you are a thousand miles away from the corn" (Eisenhower, no date). In sub-Saharan Africa where poverty has soared above 50%, most people directly or indirectly depend upon agriculture for their livelihood (The World Bank, 2008). Most of the urban and rural poor of this region of Africa obtain a significant proportion of their protein needs from cowpea. The prospect of increasing yield losses of such a potential food and cash crop will not only undermine the economy of nations in this region, but also the nutritional status of the populace at large (Wrigley, 1981; Ntare and Singh, 1989; Egho, 2010). At the world cowpea research conference held in Senegal in September 2010, cowpea was recommended as a perfect crop for alleviating hunger in Africa, where food production lags behind population growth (International Institute of Tropical Agriculture, 2010).

Cowpea is second only to cereals in importance as a food crop to people of Kebbi State, and Zuru local government area in particular, where the cost of animal protein is beyond the reach of the poor. However, the palatability and protein content of cowpea makes it liable to pest attack at nearly every stage of growth, especially by the pod borer *Maruca vitrata* (Fabricius) (Lepidoptera: Pyralidae), considered its principal enemy (Campbell and Reed, 1987; Steele *et al*., 1985; Ward *et al*., 2002). *M. vitrata*, targets the budding, flowering and podding stages of growth of cowpea and by so doing, is responsible in Nigeria, for up to 80% loss in yield (Komolafe *et al.,* 1985; Duke, 1981; Steele *et al.*, 1985). It is against this formidable cowpea pest that farmers of Zuru local government area embark on calendar-based use of organo-phosphate broad spectrum chemical pesticides (Ukaegbu, 1991). Even though this may lead to an increase in crop yield, the use of such broad spectrum chemical pesticides in an indiscriminate manner is known to be injurious to farmers' health and the environment (Oudejans, 1991; Egho, 2010).

Integrated pest management (IPM) does not exclude the use of chemical pesticides, but seeks to restrict their use to situations where no other alternatives are available. However the growing awareness of the negative impact of chemical pesticides on farmers' health and the environment, with subsequent intense criticism of them worldwide, has stimulated research on alternative means of control, such as IPM (Jakai, 1995). It is against this background that this study was undertaken in order to develop a farmer acceptable, sustainable and environmentally benign IPM control strategy against *M. vitrata*. Farmers survey backed up by focus group interview were used to ascertain the various IPM compatible farmer practices that could be integrated in the project. A two year on-station experiment was used to validate the use of neem for its suitability as an IPM control tool against *M. vitrata*. In order to make the developed IPM control strategy to be farmer oriented, farmers were involved in an on-farm validation of the use of neem on a scouting basis as an IPM control strategy against the pest. During this on-farm trial, the effect of neem on beneficial insects was also evaluated.

1.2 ABOUT THE STUDY AREA

The area of the study is Zuru local government area of Kebbi State of Nigeria. It occupies an area of about 3,974 km^2, comprising of six administrative districts, namely Dabai, Rafin Zuru, Rikoto, Manga, Ushe and Sanchi. The total population of Zuru local government area was as at 2006 census, 175,864. (Kebbi Investments Company Limited, no date). The average annual rainfall is 895.25mm and the mean monthly temperature is 27^oC (Source: Extension Department College of Agriculture Zuru) and the vegetation is northern Guinea savannah (Komolafe, 1985). The major ethnic groups within the local government area are the "Dakarkari", "Achifawa", "Bangawa", "Dukkawa", "Fakkawa", "Kambari", "Hausa", "Fulani", "Igbo", "Yoruba" and several others from the various parts of Nigeria (HRH Sami Gomo II, 2005).

The major occupation of the people is farming, growing both food and cash crops such as rice, sorghum and cowpea. Before the advent of Islam and Christianity, the people of Zuru practiced traditional religion which still survives in many parts of the local government area (HRH Sami Gomo II, 2005). Zuru town is the administrative headquarter of Zuru local government area; a trunk A road links Zuru town to both Northern and Southern parts of Nigeria and there are many primary and post primary schools scattered all over the major towns and villages of the local government area.

There is an Agricultural College for the training of both middle and senior level personnel located within Zuru town. In order to ensure proper security for the nation, there is an Army barracks in Zuru town currently occupied by a Nigerian Army light tank battalion.

1.3 STATEMENT OF THE PROBLEM

The insect pest of cowpea *M. vitrata* threatens the production of cowpea in Zuru local government area by attacking the crop at the crucial stages of growth namely; budding, flowering and podding stages, sometimes causing total crop failure (Adamu, 2005). Most farmers respond by spraying chemical pesticides (such as DDT and mixture of 30g Cypermethrin and 250g Dimethoate) as many as 7-8 times, based on the advice of Government agricultural extension workers who still use the early literature prescription of 6 – 7 weekly sprays, starting from a few days after the crop emergence until maturity (Ukaegbu, 1999; Ajeigbe and Singh, 2005). Such massive usage of a persistent pesticide like DDT is injurious to both the farmer and the environment (Oudejans, 1994). Chemical pesticides such as cypermethrin and dimethoate are now less effective for the pod borer control, due to insecticide resistance in the pest (Ekesi, 1999). It is against this background that several questions arise. Can the use of host plant resistance/tolerance and botanical extracts such as those from Neem Kernel (nke) produce a viable control option? How will judicious use of chemical pesticide produce effective means of control for this pest? Can intercropping cowpea with a locally used insect repellent plant *H. spicegera* produce some form of control? How will these various control options be put together as an IPM strategy for the control of *M. vitrata* in a sustainable manner that will safeguard farmers' health and the environment in Zuru? This is the focus of the study. The IPM strategy developed using neem as an alternative to chemical pesticide, if implemented by the cowpea farmers in Nigeria, is expected to reduce the countries annual spending on chemical pesticide importation amounting to US$350 million. With the soaring prices of chemical insecticides, The beneficiaries who are mostly resource poor farmers will adopt the technology with great enthusiasm and the savings obtained can be used to cultivate extra hectares of cowpea. This will reduce Nigeria's import of cowpea to meet the increasing domestic demand.

1.4 OBJECTIVES OF THE STUDY

The World Health Organization estimated that each year 20000 unintentional deaths occur as a result of pesticide poisoning, mostly from the developing countries (Meerman *et al.,* 1997). Many of the causalities are expected to be in Nigeria where the bulk of the world cowpea is being produced and, where farmers particularly in Kebbi State rely on the use of broad spectrum chemical pesticides as many as 7-8 times for the control of the damaging insects such as *M. vitrata*. Apart from the dangers posed on the farmer's health, such type of chemical insecticide usage is known to negatively affect the natural enemies, the environment at large as well as resulting into pest "resistance" and "resurgence" (Oudejans, 1994). Research has shown that no any single control action can by itself offer lasting solution to *M. vitrata* cowpea damage. Therefore, the central objective of this study is to examine and assess the potential use of some locally available methods of control of *M. vitrata*, then to combine the most promising ones into a single IPM control strategy that offers the cowpea farmers in Zuru, cost effectiveness, simplicity and sustainability.

1.5 SIGNIFICANCE AND SCOPE OF THE STUDY

The study is expected to be a means of introducing IPM strategies for farmers' use in the study area. By using a botanical pesticide (neem) which is not harmful to the predators and parasitoids (Egho, 2010), the natural enemies' activity will be enhanced there by increasing the impact of the control mechanism on *M. vitrata* which will subsequently increase yield of cowpea. Farmers production cost is expected to be scaled down and profit increased, as a result of using self-made pesticide (neem). The various unintentional deaths due to chemical pesticide poisoning (Meerman *et al.,* 1997), will be averted and the sustainability of the farming enterprise will be enhance as a result of having healthier farming population devoid of long term negative effects of chemical pesticides(Oudejans, 1994). The study is also expected to stimulate secondary industries for the fabrication of neem kernel grinding and processing equipment there by increasing the revenue base of Kebbi state and Nigeria at large. It is expected to be a basis for future research in the area of study in Zuru local government area. It will also sensitize government and other agricultural personnel in their role towards reducing the use of such environmentally unfriendly broad spectrum chemical pesticides (DDT and

Mixtures of Cypermethrin + Dimethoate) currently used by the farmers in the control of *M. vitrata*. The study is centred on the development of an IPM strategy against the *M. vitrata* in Zuru local government area based on the use of locally available resources. The findings of the study may be applicable to other local government areas of Kebbi State and to Nigeria as a whole.

1.6 RESEARCH QUESTIONS/HYPOTHESES

It is not uncommon for farmers to report 100% cowpea crop failure due to *M. vitrata* damage in Kebbi state of Nigeria. Farmers respond through the application of broad spectrum chemical insecticides (Cypermethrin + Dimethoate) on calendar basis, which is known to negatively affect farmers' heath, the environment and the natural enemies. Ekessi (1999) has reported loss of effectiveness of the type of insecticide the farmers are using due to resistance developed by the pest against them. In order to arrest the situation and provide solution through the IPM approach, the study seeks to answer the following research questions/hypotheses:

1.6.1 Hypotheses

H_1: Interplanting cowpea with *H. spicegera* will significantly reduce *Maruca vitrata* infestation/damage and increase yield of cowpea in Zuru local government area.

H_2: The use of improved Kanannado (IT89-245-1) as a tolerant variety instead of "Dan zafi" a susceptible variety of cowpea will significantly increase cowpea yield and reduce *Maruca vitrata* infestation/damage on cowpea in Zuru local government area.

H_3: The use of botanical pesticide from Neem Kernels (nke) instead of chemical insecticides, will significantly increase yield of cowpea and reduce *Maruca vitrata* infestation/damage on cowpea in Zuru local government area.

H_4: The use of chemical pesticide on a needs basis (scouting) instead of being calendar-based will significantly increase yield of cowpea and reduce *M. vitrata* infestation/damage on cowpea in Zuru.

1.6.2 Additional research questions

1. Can pheromone traps be used to give an advance warning of an impending *M. vitrata* larvae attack on cowpea in Zuru?

2. How will the existing farmers' indigenous knowledge/cultivation practices be used in the development of the final IPM control strategy against *M. vitrata*?

3. How will the farmers' perception of pest and pesticides affect the adoption of IPM in Zuru.

4. How do biotic and non-biotic factors affect profitability of cowpea production?

CHAPTER TWO: LITERATURE REVIEW

2.1 BIOLOGY OF *MARUCA vitrata* (Fabricius) (Lepidoptera: Pyralidae)

2.1.1 Taxonomy

The cowpea pod borer *Maruca vitrata*, popularly known as the spotted borer or mung moth (Fig.2.2b) was first described in the work of Hubner which was published after his death by Geyer, to whom modern taxonomists ascribed *Maruca testulalis* syn. *Maruca vitrata*. It is generally agreed that the species exist in a complex and Dr E. G. Munroe of Ottawa Canada did some work to separate the species (Taylor, 1967). *M. vitrata* belongs to the Order Lepidoptera, Family Crambidae and Genus *Maruca*. The accepted scientific name is *Maruca vitrata* Fabricius and other scientific names are *Maruca testulalis* Geyer and *Crochipora testulalis* Geyer (Ayodele and Kumar, 2010).

2.1.2 Distribution

M. vitrata commonly inhabits tropical and sub-tropical regions of the world, especially sub-Saharan Africa, where there is a vast range of host plant legumes, and high temperature and relative humidity favouring its development (Cork and Hall, 1998; Campbell and Reed, 1987; Shanower *et al.*, 1999). The geographical range of the moth has extended in the year 2000 as it has been detected in parts of Europe such as Southern England, possibly dispersed in pods via other transport means (UK moths 2013). The worldwide distribution (Table 2.1) of the insect pest stretches from West Africa to as far east as Fiji and Samoa including South Africa, the West Indies and South America (Egho and Emosairue, 2010; Sharma, 1998; Taylor, 1967).

It is a moth commonly found on shoots, leaves, flowers and pods of cowpea, although Hyacinth bean is the preferred host. *M. vitrata* has been detected on 39 alternative hosts, 37 of which are legumes such as *Crotalaria* spp. Having no diapauses and many alternative hosts, allows the pest to survive during the dry season (Sharma *et al.*, 1999). Despite such availability of alternative hosts in West Africa, *M. vitrata* tends to be a migratory pest, moving from south to north, following the inter tropical convergence winds and making a return journey via trade winds, in search of more preferred flowering plants on which new generations breed and multiply (Arodokouna *et al.*, 2006; Sharma 1999). Genetic studies have shown that three *Maruca* species have unique geographical distributions; namely, Australia, Taiwan and West Africa. It is in

West African countries such as Nigeria, Niger and Burkina Faso where, in conjunction with others such as *Aphis craccivora, Ootheca mutabilis and Helicoverpa armigera* it has formed part of a complex of insect pests attacking cowpea. Damage is usually attributed to the pod-borer complex and *M. vitrata* is considered the most damaging among the group (Egho and Emosairue, 2010; Venu *et al*., 2010).

Table 2.1 World distribution of *M. Vitrata.* Adapted from Singh and Rachie (1985).

Region	Country	Main Host
Asia	China	Cowpea
	Indonesia	Yard long bean
	India	Legumes
	Japan	Adzuki beans
	Malaysia	Long beans
	Pakistan	Pulses
	Philippines	Grain Legumes
	Sri Lanka	Pigeon pea
	Taiwan	Grain legumes
	Thailand	Pigeon pea
Africa	Benin	Cowpea
	Burkina Faso	Groundnut
	Ghana	Cowpea
	Kenya	Cowpea
	Niger	Groundnut
	Nigeria	Cowpea
	Senegal	Cowpea
	Sierra Leone	Grain legumes
	South Africa	Cowpea
	Uganda	Cowpea
	Sudan	Faba bean
	Zambia	Beans
Australia	Australia	Adzuki bean
	Papua and New Guinea	Cowpea
North America and South America	USA	Grain legumes
	Brazil	Grain legumes
	Colombia	Grain legumes
	Cuba	Lima bean and other legumes
	Puerto Rico	Lima bean and other Legumes

2.1.3 Morphology

The larval stage of *M. vitrata* is a serious pest of cowpea, attacking it from initiation of flowering to the maturation of pods (Atachi *et al*, 2002). The larvae are whitish in colour with two pairs of black spots on each segment of the body (Fig.2.2a). The adult (Fig 2.2b) is brown, with a mixture of white on the vertex with large eyes and long antenna, almost the same length as the wings. It has brown forewings with three white spots and greyish white hind wings, with the wing span ranging from 28 – 34 mm and is highly active during the rainy season. Both adult and the larvae are nocturnal; with the adult found resting with wings in a spread manner below the host plant during the daytime Sharma *et al*., 1999).

2.1.4 Life cycle

There have been extensively studies of the biology of *M. vitrata* in Africa. Mating is done mostly once between 21.00 h and 05.00 h. The highest mating percentage and oviposition is obtained when the temperature range is between 20^0C and 25^0C with relative humidity over 80%. The moth lays its eggs on flower buds, flowers and young leaves in batches numbering 4 - 6 and each carrying more than 100 eggs. The female is known to lay up to 400 eggs in 2 to 16 batches. The eggs measuring 0.65 x 0.45 are oval or round in shape and yellow or translucent in colour, with the thin delicate chorion, and hatch in about 2-5 days. The whitish and dark spotted larvae (Figure 1.2a) that emerge between 20.00 h and 23.00 h. have up to five instars, lasting for about 8-14 days, before the pupal stage (Shanower *et al*, 1999; Sharma, 1998). The pupal stage begins in plants debris in the ground or on the plant itself, by using a silky material to cover the pupae and this period could last between 6-9 days. Lower and upper temperature thresholds for this development stage are, between 15.6 to 17.8^0C and 28^0C to 34^0C, respectively. The generation time is usually 18-25 days, even though up to 57 days have been documented. Development to adult stage is facilitated at the optimum temperature of 22^0C to 28^0C with 34^0C being lethal to the larvae. (Shanower *et al*, 1999; Campbell and Reed 1987; Cardona and Karel 1990; Sharma, 1998).

2.1.5 Types of damage caused

The larvae produce silk material that is used to stitch the affected parts of the plant together forming a web like structure, inside which it feeds on the part of the plant attacked. The flower corolla of the attacked plant will appear to have round holes bored into them and the whole of it could be reduced to a dirty brownish mess within 24 hours (Sharma, 1998). Sometimes the larvae bore into the newly formed pods or stems or the leaves; flowers and pods will become webbed together. This concealed feeding of the larvae makes it difficult to be reached with pesticide sprays and natural enemies. Young pods at least 5 days of age are preferred by the third and fifth instars and will appear to have tunnels in them as a result of the larvae feeding, hence the name “pod borer”. The first and second instars larvae feed on new leaflets and other reproductive structures which will appear rolled up and webbed (Jakai *et al*., 1996; Sharma and Franzmann, 2000; Huan *et al*. 2003). Yield losses between 20-80% have been documented as a result of larvae feeding on cowpea. The cultivars that have pods bunched up together appear to be more severely attacked than those cultivars having pods separated along the plant (Taylor, 1967: Ekesi, 1999). If the stem is affected, death of the whole plant is the end result (Fig.2.1) (Campbell and Reed, 1987; Karel and Autrique, 1989).

Fig.2.1 Cowpea plant attacked by *M. vitrata* (Stunted growth with complete flower loss in cowpea in Zuru). (Photo by Easy, Zuru).

Fig.2.2a *Maruca vitrata* larva
Photo Prof A Cork

Fig.2.2b *Maruca vitrata* adult
Photo Prof A Cork

2.2 METHODS OF *M. vitrata* LARVAE INFESTATION/DAMAGE ASSESSMENT IN COWPEA.

Flowers can be sampled morning and evening from each sampled plant, then opened and examined in the field for the presence of larvae, an exit/entry hole and dirty frass. Any flower found with any of these, is counted as infested or damaged and the result of the count is expressed as the percentage of the total number of flowers sampled (Oghiakhe *et al*., 1991; Asiwe *et al*., 2005).

2.3 ASSESSMENT OF PODS AND SEED DAMAGE DUE TO *M. vitrata* ATTACK.

Percentage pod damage is obtained by sampling and harvesting a given number of pods per plot, examining and separating the borer damaged ones from the undamaged ones. The number of damaged pods divided by the total pods harvested multiplied by 100, gives the percentage pods damaged (Oghiakhe *et al*., 1991) Pod damage due to *M. vitrata* larvae feeding can also be assessed using a pod evaluation index (ipe), which takes into consideration two parameters namely: pod damage (PD) and pod load (PL). The pod damage signifies pods having dirty frass and entry/exit holes while pod load signifies the degree of successful pod production. Each of these parameters are scored on a 9-point scale which rates 1 as low and 9 as high for both pod damage and pod load. Pod evaluation index (ipe) is thus derived as ipe = PL x (9-PD) (Asiwe, 2009). Seed damage is sometimes assessed by obtaining seed damage index (Isd), given by the formula: Isd = ds x 100/pt. Where ds = number of damaged seeds per sampled pods, pt = number of pods sampled (Oghiakhe *et al.*, 1991).

2.4 YIELD LOSS AND *M. vitrata* INFESTATION RELATIONSHIP

Each *M. vitrata* larva is capable of consuming 4-6 flowers before the completion of larval stages and this causes the affected flowers not to bear pods (Taylor, 1967; Sharma, 1998). A population of twelve to fifteen larvae per plant could cause 100 percent yield loss even if the plant looks vigorous in growth (Taylor, 1967). The author further stated that a single larva is capable of causing up to 20 percent damage of pod content and secondary infection by plant pathogens resulting from the larvae feeding further increases the damage level. Larval infestation is at its peak between the sixth and eighth week after planting and yield losses usually depend upon (1) the number of larvae that are actively feeding (2) the duration of the larval development. (3) The incidence of larval infestation corresponding to flowering cycle (Taylor, 1967).

2.5 CONTROL MEASURES OF *M. vitrata*

2.5.1 Use of chemical pesticides

Coulson and Witter (1984: 197) stated that, insecticides are a category of pesticides and can be defined as: "any substance or mixture of substance intended to prevent, destroy, repel or mitigate insect pest or (2) literally killers of insects". Some of the important types of pesticides used for the control of *M, vitrata* are as follows:

2.5.1.1 Organophosphates

Organophosphorus insecticides affect insect pests by inhibiting the enzyme acetylcholinesterase which is responsible for hydrolising acetylcholine, the substance that transmits nerve impulses (Burn *et al*., 1987). Coulson and Witter (1984: 199) stated that three groups of organophosphates exist: "(a) aliphatic derivatives (malathion, monocrotophos and dichlorvos), (b) phenyl derivative (ethyl parathion and methyl, parathion) and (c) heterocyclic derivatives (diazinon, azinphosmethyl, chlorpyrifos)" Karel and Autrique (1989) reported that several insecticides including monocrotophos, offer protection against *Maruca* larvae. Monocrotophos used at 0.04% effectively controlled the pod borer and gave the highest grain yield of 1154kg/ha compared to other insecticides such as 0.07% endosulfan and 0.04% quinaphos (Prajapati, 2002). However, Singh and co-workers (1990) noted that application of monocrotophos reduces the legume pod borer natural enemies.

2.5.1.2 Synthetic pyrethroids

Pyrethroids are artificially made synthetic chemical insecticides adapted from pyrethrins. Their mode of action is similar to the pyrethrins but they have improved stability in sunlight. Their use has increased in recent times due to declining use of organophosphates which are toxic to the environment and mammals. Sometimes pyrethroids contain a synergist such as piperonyl butoxide to enhance their effectiveness (US Environmental Protection Agency, 2013). Egho (2011) indicated the effectiveness of a synthetic pyrethroid, cypermethrin sprayed on calendar basis, starting from 25 days after planting (25DAP) in controlling insect pests in cowpea, as well giving high yield (745kg/ha).

2.5.1.3 Use of mixtures of organophosphates and pyrethroids

Dimethoate in mixtures with cypermethrin at the dose rate of 30 + 250 g a.i/litre effectively reduced the pod borer populations by 44% (Dzemo, 2010). In a multi location trial in Nigeria, Kamara and co-workers (2007) obtained a reduction in the pod borer populations in cowpea using the same insecticide mixture at the same tank dose rate. Mixtures of deltamethrin combined with dimethoate and lamda-cyhalothrin are also effective against *M. vitrata* in cowpea (Federal Ministry of Agriculture and Natural Resources, 1996). Singh and co-workers (1990) noted that for effective control of post flowering insects pests of cowpea such as *M. vitrata*, synthetic pyrethroids have to be mixed with other insecicides such as endosulfan or dimethoate. Afun, (1991) reported the use of lamda-cyhalothrin and dimethoate at (17g +35 g a.i 1^{-1}) on a calendar basis and obtained a significant reduction of the pod borer populations in cowpea in comparison to the unsprayed controls. According to Steele and co-workers (1985), mixtures of malathion and monocrotophos applied as a calendar based spray six times, commencing before the flowering begins, increases yield of cowpea ten-fold compared to unprotected plots. However, use of mixtures of cypermethrin and dimethoate (10mls and 25mls respectively) has been found to significantly reduce the populations of natural enemies such as ladybeetles, syrphids in cowpea (Munyuli *et al.,* 2007).

2.5.1.4 Advantages of chemical control

According to Graham-Bryce (1987) chemical control has the following advantages:

(1) Chemical control presents an effective insect pest population modifying tool.

(2) Chemical control has drastic and dramatic effect in pest population reduction.

(3) The wide range of activity of chemical insecticides, makes them suitable for various intended functions such as total elimination or selective effect depending upon which product is used.

(4) Chemical insecticides are cheap and readily available.

(5) A wide range of chemical insecticides application formulations and application equipments are available for insect pest control.

2.5.1.5 Disadvantages of chemical control

According to Kumar (1984) chemical control measures have the following disadvantages:

(1) Chemical control does not result in permanent lowering of the number of insect pests to such an extent that they no longer cause an economic problem.

(2) Chemical control measures may result in damage to non target species such as parasites and predators.

(3) The residual effect of many chemical such as DDT makes them environmentally unfriendly and may have a long term negative effect on exposed persons.

(4) Chemical control especially when not appropriately used may result in insect "resistance" and "resurgence".

(5) Several species of insect pest have the ability to detect specific insecticides; hence can avoid them before being exposed to lethal dose by not ingesting plant food.

According to Horn (1988) chemicals used in insect pest control may become adsorbed to soil particles thereby contaminating ground water and lakes with devastating effect on marine fauna.

2.5.2 Botanical Pesticides

Botanical pesticides are pesticides derived from plants an example of which are: Nicotine an alkaloid extracted from tobacco, pyrethrins (toxicant) extracted from the flower head of chrysanthemum, and azadirachtin extracted from neem trees. For over 400 million years plants have defended themselves against insect pests using their naturally developed insecticides/repellants. Botanical pesticides most especially neem *(Azadirachta indica* J.) are an important and promising alternative to chemical pesticides Silva-Aguayo, 2013). Pyrethrums, which are insecticides made from pyrethrins, have rapid knock-down of insect pests, generally have low mammalian toxicity, and are environmentally non persistent. Rotenone, which is extracted from roots of legumes belonging to the genera *Derris* and *Lonchocarpus*, is highly toxic to insects and fish, with very low mammalian toxicity (Coulson and Witter (1984). In evaluating the use of native black soap (mixture of water + cocoa pod ashes + plantain skin ashes + palm oil) as a botanical insecticide for the control of major insect pests of cowpea, 2% concentration of the botanical effectively controlled *M. vitrata* at the early season and cowpea yield increase of 570kg/ha was obtained (Egho, 2010). When the efficacy of six plant extracts (sweetsop, chilli pepper, garlic, ginger, neem and tobacco) at 5% concentration each, was tested for control of field insect pests of cowpea, all the plant extracts were found to reduce *M. vitrata* populations after three days of post treatment (Ahmed *et al.,* 2009).

In neem extract 18 compounds have been identified and the most prominent one is azadirachtin, which has been found to have antifeedant, growth regulation, oviposition deterrent and sterilizing effect on insects pests (Silva-Aguayo, 2013) However, Adati *et al*., (2008) reported that the active ingredient of neem kernel azadirachtin, has shown great variability over the geographical zones of Africa. In the control of the pod borer, Sharma (1988) noted that, 5%, 10% and 20% concentration of neem oil emulsifiable concentrate (NOEC) gave effective control of *M. vitrata*. The author further stated that neem seed kernel extract also provided some measure of control but was not as effective as NOEC. Oparaeke (2006) also found that the application of 5% neem kernel solutions adequately protected cowpea from damage by *M. vitrata* larvae. Egho, (2011) evaluated neem for the management of cowpea insect pests and concluded that neem seed kernel extract at 5% concentration is quite effective in controlling *M. vitrata*, but caused delay in cowpea flowering. Adati and co-workers (2008) reported that, among the problems of the use of neem kernels is that the seeds are not found year round and therefore might not always be available when they are needed.

2.5.3 Use of microbial pesticides

Microbial pesticides make use of microorganisms such as bacteria, protozoa, fungi and viruses or their by-product in order to control insect pests, plant diseases and weeds (Chandler *et al.*, 2004). Graham-Bryce (1987) reported that microbial pesticides action is similar to a residual stomach-poison insecticide and their prospect for use as insect control agents has significantly been improved with the developments in biotechnology. According to Flint and Van den Bosch (1981), microbial pesticides have the advantage of being nontoxic to non-target species and in many instances they are able to self-multiply after application thereby giving long sustained action. However, Graham-Bryce (1987) noted that *Bacillus thrungiensis* (Bt) when applied, does not spread, nor does it become a self-sustaining infection, hence there is the need to ensure proper coverage of vulnerable plant parts. According to Sharma (1998) (Bt) is an example of a microbial pesticide which can kill a variety of insect caterpillars and is very effective in controlling *M. vitrata*. Chandler and co-workers (2004) reported that microbial pesticides take less than 1% of the world agrochemical pesticides market and 90% of the world market for microbial pesticides is dominated by commercial Bt preparations. Langewald and Cherry (2000) stated that the effectiveness of Bt in the control of *M. vitrata* resulted in its commercial mass production in Ghana. Among the different Bt formulations used against *M. vitrata*, at the Asian Vegetable Research Development Centre (AVRDC) in Taiwan, Dipel (Bt subsp. Kurstaki) and Florbac Bt (subsp. aizawai) were found to be highly effective for control of *M. vitrata* (General news, no date).

Horn (1988) stated that microbial pesticides are applied in a manner similar to that of conventional chemicals using standard spray equipment and care must be taken in integrating them with broad-spectrum chemicals which may inactivate Nuclear polyhedrosis virus (NPV). David and co-workers (2009) noted that they are best used as "curative" treatment to control existing pest populations and in some instances their use as "preventive" measure is limited due to their lack of persistence in the environment. International Institute of Tropical Agriculture (IITA) scientists in Benin have discovered a virus affecting *M. vitrata* but its sub-lethal ability was found to be of little practical application. Scientists at AVRDC in Taiwan have discovered a more virulent strain, a multi-Nuclearpolyhedrosis virus (*Mavi*MNPV) affecting *M. vitrata*. Trials in Kano, Nigeria using *Mavi*MNPV on cowpea, the result showed the virus was as effective as the conventional chemical insecticide in the control of *M. vitrata* and cowpea yield increase of 67.2% due to the application of the microbial was obtained over unsprayed controls (Tamo and Srinivasan, 2012). Adati and co-workers (2008) reported that Cypovirus (CPV) was found infecting *M. vitrata* larvae in Benin and the infected larvae showed reduction in feeding while pupae and adult become malformed spp. thereby reducing mating ability and fecundity.

Adati *et al*., (2008) further stated that CPV is usually transmitted to the next generation resulting in non-viable offspring. Three species of fungal diseases namely *Fusarium* spp. *Paecilomyces* sp. and *Beauveria bassiana* were discovered on dead larvae in Taiwan. In Nigeria isolates of *B. bassiana* and *Metarhizium anisopliae* were discovered to have an ovicidal effect on *M. vitrata* eggs and their potential as control agents on food legumes is still not practically exploited. However, among the drawbacks of the use of microbial pesticide is there is a delay between application and mortality of the pest and any damage that occurs during the delay period may not be economically acceptable to the farmer. Microbial pesticides are liable to degradation by ultra violet light and their dilution ratio has to be limited if each droplet of the spray is to contain pathogen (Mathews, 1984; Horn, 1988).

2.5.4. Semiochemicals as *M. vitrata* monitoring devices

The term "Semiochemicals" is defined as "all chemicals that act as messengers between organisms" (Coulson and Witter, 1984: 208). These authors further stated that the most widely used semiochemical in insect pest management is the pheromone which is defined as "a chemical emitted by an organism that induces a behavioural or physiological response in another organism of the same species". According to Graham-Bryce (1987), the range of potential areas of application of pheromones in insect pest management include; attraction, repellence, location of food, oviposition, mating, feeding etc. A very small quantity of pheromone, as low as 10^{-14} µg can stimulate a response from the target insect. Horn (1988) reported that sex attractants are the most widely used pheromones and sometimes the effectiveness depends upon a complex blend of the isomers rather than a single chemical. In another instance, Graham-Bryce (1987) noted that, in view of the fact that pheromones are highly degradable in the environment, formulations have to be protected in order to ensure an appropriate rate of supply.

Coulson and Witter (1984) categorised pheromone usage in insect pest management as follows:

(I) Biomonitoring: refers to the use of pheromone to detect pest species. The target insect is attracted to a mechanical trap baited with synthetic lures and by so doing the distribution and relative abundance of the pest are monitored.

(II) Mass Trapping: this involves using pheromone traps to catch a significant proportion of individuals from a population.

(III) Mating Disruption: the objective here is to use a pheromone to interfere with sexual communication between males and females of a species. A synthetic attractant is released to confuse the mates who will be unable to find each other. According to Horn (1988) mating disruption is a confusion technique that relies upon the ability of the dispersed pheromone to disorient male insects so that they are unable to locate and mate with females thereby reducing the overall fecundity to a non-viable level.

In Benin Republic, traps baited with blend of EE 10, 12-16:Ald, EE 10, 12-16:OH and E 10-16:Ald in a 100:5:5 ratio (sex pheromone) caught more males than traps baited with the major component alone and trap catches occurred up to 12 days before flower infestation by *M. vitrata* larvae (Downham, 2003). This indicated the suitability of pheromone traps as a reliable means of early warning of approaching infestation even before flowering starts. However, Adati and co-workers (2008) reported that low pheromone catches of adult *M. vitrata* were recorded both in Ghana and Northern Nigeria compared to light traps primarily due to geographical differences in responses elicited by the pest.

2.5 .5 Biological control through use of predators and parasites of *M. vitrata*

The term "biological control" was coined by Smith (1919) and refers to the use of natural enemies, either native or exotic, to regulate insect pest populations. Natural enemies include all predators, parasites and pathogens of insects (Coulson and Witter 1984: 212). Horn (1988: 170) defined biological control as "importation, conservation and encouragement of parasites, parasitoids and predators in order to reduce pest densities below their economic injury level and (ideally) to maintain them there".

However, Coulson and Witter (1984: 212) noted that, some entomologists prefer the definition "any method of pest control that utilizes living organisms or their natural (nontoxic) products". Coulson and Witter (1984) further stated that biological control or bio control is categorised under the following areas; use of natural enemies, use of pheromones, use of sterilization techniques, use of plant resistance through genetic manipulations. Pest control by natural enemies is cheap, effective, permanent and non-disruptive of the environment therefore should be the pest manager's first line of defence. This supposed first line of defence is unfortunately easily disturbed through indiscriminate use of agricultural chemical pesticides; as such any use of agro-chemical pesticide shoulds take into consideration their impact on the already existing natural control exerted by natural enemies (Flint and Van den Bosch 1981). According to Kumar (1984), natural enemies can exist only if there are pests as such there is a delicate equilibrium between the two. Some important components of biological control are given below:

2.5.5.1 Predators

Predators (Fig.2.3) work by consuming their individual insect prey in order to reach maturity. Each predator normally kills many prey in its lifetime. The generalist predators have a wide range of prey while the specialists prey only on a few species of insects (Verkerk, 2001). Almost all insect orders contain members that consume other insects and examples of such predators are lady beetle (Coccinellidae), larvae of hover flies (Syrphidae), assassin bugs (Reduviidae) and wasps (Vespidae and Sphecidae) (Horn 1988). In Nigeria, *Orius* sp. (Hemiptera: Anthocoridae) has been found to predate on both egg, larvae and adult of *M. vitrata* Tamo *et al.*, 1997).

Fig.2.3 Predatory ground beetle (*Calosoma scrutator*) consuming moth larva (Coulson and Witter, 1984)

2.5.5.2 Parasitoids and parasites

A century ago O. M. Reuter first coined the term parasitoids to describe the feeding habit of certain insect. Parasitoids are organisms which spend part of their lifetime eating another animal (host). They may live within or be attached to its body and their feeding habit may cause it to die. The larval stages of most parasitoids mainly attack arthropods with the exception of the Dipterans which have a wide range of hosts such as flat-worms and toads. The adult parasitoid is a free living organism that has other alternative foods such as flowers. Parasites have similar life time feeding habit but unlike parasitoids they rarely kill their host unless their populations on the host are high (Gonzaga, 2013)**.** Parasitoids lay their eggs in or on the bodies of other insects and develop while the host dies slowly, finally killing it. Most parasitoids belong to the insect orders Hymenoptera and Diptera. Among Diptera, the Tachinidae family (Fig.2.4) are parasitic especially on Lepidoptera and among Hymenoptera, families Braconidae and Ichneumonidae are exclusive parasites of insects, their host range is narrow which makes them very suitable as biological control agents (Kumar 1984). They are extremely sensitive to pesticides such as organophosphates and carbamates (Horn, 1988) In the Philippines, inundative releases of *Trichogramma evanensis* Westwood (Hymenoptera: Trchogrammatidae) resulted in 43% increase in parasitism of *M. vitrata* eggs during the rainy season, but the number of larvae per plant and pod damage were not reduced (Ulrichs and Mewis, 2004). Natural enemies as larval parasitoids such *Phanerotoma leucobasis* and *Braunsia kriegeri* and egg parasitoids such as *Trichogramma eldanae* have been found parasitizing both larvae and eggs of *M. vitrata* in West Africa, even though the percentage parasitism was low (8%)(Adati *et al*., 2008). According to Steele (1985) brachonid wasps of the genera *Braunsia* and *Bracon* are larval parasites of *M. vitrata* occurring in many parts of tropical Africa. Below are some of the methods used in the introduction of a biological control agent

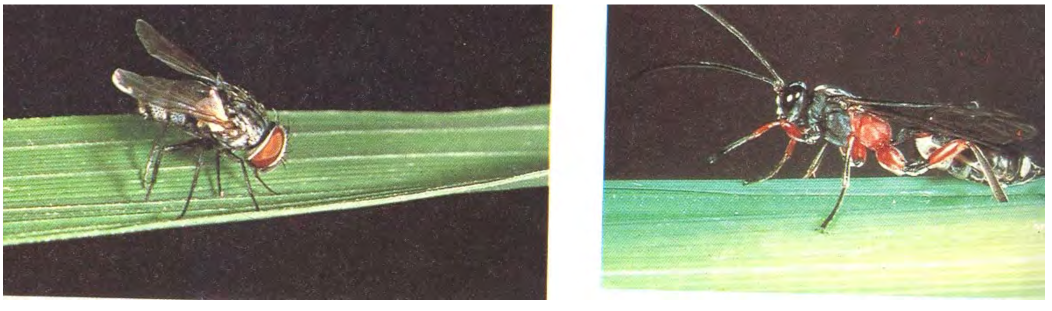

Fig.2.4 Larval parasitoids: Left; tachinid fly (*Argyrophylax n.*), Right; Ichneumonid wasp (*Amauromorpha acceptametathoracita*) (Oudejans 1991)

2.5.5.3 Importation and colonisation

This involves the classical approach by introducing suitable exotic natural enemies of a pest into an area where they do not naturally occur. The techniques works well on exotic pests that have accidentally become established in large numbers due to lack of natural enemies. Great care and caution is taken through extensive laboratory trials to make sure that an imported natural enemy does not become a pest and in collecting well suited and adaptable potential natural enemies, appropriate quarantine procedures and biological testing are needed (Loise Flint and Dreistadt, 1998)

2.5.5.4 Augmentation technique

This technique involves manipulating the natural enemies in such a manner that enhances their activity through the additional releases from a source with readily available large numbers of the natural enemies. This may be done through mass culture and periodic release of the natural enemy and breeding new strains of natural enemy (Ulrichs and Mewis, 2004).

2.5.5.5 Conservation and environment

This technique involves good habitat management in favour of the biological control agent by provision of shelter (Horn 1988). Kumar (1984) reported that effective use of the environment to attract natural enemies requires good knowledge of the biology and behaviour of the pest, as well as the enemy species. This may entail (1) modification of the existing cultural practices such as inter planting of suitable crops (2) provision of sources of carbohydrate and protein such as honeydew, nectar, pollen and other flora (3) protection from careless use of broad spectrum chemicals.

2.5.5.6 Advantages of biological control

Successful, biological control is relatively safe, permanent and economical after the initial costs of establishment and environmentally friendly and should be one of the pest manager's line of defence. In the natural ecosystem, biological control exerts pressure on pest populations thereby causing suppression effects on the pest even without the use of chemical pesticides (Horn 1988). Flint and Van den Bosch (1984) also stated that biological control easily fits in as a component of the integrated pest management technique due to its environmentally friendliness.

2.5.5.7 `Disadvantages of biological control

According to Kumar (1984) the biological control exerted by natural enemies exists in a delicate equilibrium between pest and natural enemies and can easily be upset by human activities such as use of insecticides. Coulson and Witter (1984) reported that the application of biological control requires greater knowledge of pest biology and the natural enemy ecosystem. Horn (1984) noted that sometimes a biological control agent may suddenly disappear after release.

2.5.6 Cultural control measures of *M. vitrata*

Cultural practices are the measures the farmer takes by himself in order to protect his crop; they are effective and sometimes may cost him nothing. Cultural practices are “preventive” rather than “curative” measures (Elliot (1995). Coaker (1987) noted that knowledge of the crop and pest biology, ecology and phenology in relation to the “weak links” in the pests life cycle, is very important in the design and implementation of the cultural control. Some important cultural controls of *M. vitrata* are given below

2.5.6.1 Intercropping

Intercropping is defined as “the growing of two crops on the same piece of land at the same time”. The rows of each crop are placed alternately, side by side (Elliot, 1995) (Fig.2.4). According to Horn (1988), the practice of monoculture results in high incidence of pests in cowpea and the technique of intercropping practiced by small scale farmers reduces numbers of *M. vitrata* in cowpea intercropped with cereals such as sorghum. Jakai (1985) noted that intra-row mixing of cowpea and sorghum resulted in less *M. vitrata* damage to flowers. However, Adati and co-workers (2008) further stated that studies have revealed that a certain crop arrangement actually makes crops within a mixture more liable to some insect pest attack such as *M. vitrata*. According to Sharma (1998), planting cowpea simultaneously with maize resulted in an increase in borer damage. Hassan, (2009) reported significant reduction of the pod borer populations in cowpea and sorghum intercropping in comparison to sole cropping However, Elliot (1995) stated that intercropping works well as long as there is sufficient moisture for growth of the two crops; otherwise, in times of moisture scarcity, strong competition for the little available moisture results between the two crops. Cowpea intercropping as practiced by farmers in the savannah zone of Nigeria is known to be the major reason preventing its successful mechanization (Itulya *et al.,* 1997).

Fig.2.5 Cowpea sorghum inter-cropping, with sorghum rows alternate to that of cowpea (www.icrisat.org/.../plant_nutrient/crop2.JPG)

2.5.6.2 Planting of trap crops

Trap crops serve the purpose of diverting the insect pest attack away from the cowpea crop by using a more attractive food source that should be planted earlier than the crop. For the system to be effective the trap crop should be different from the target crop and about 5-15% of the total area should be dedicated to the trap crop. The trap crop should be attractive to the target pest and tolerant to heavy attack by the pest. The trap crop is then sprayed with an insecticide to destroy the pest with reduced damage to natural enemies Coaker (1987). Trap cropping as a control mechanism has been established with success on *M. vitrata* using *Crotalaria junces* as a trap crop (Jakai *et al*., 1985). These authors also noted that trap crops may invite other pest species capable of causing damage to the cowpea crop if they invade the cowpea crop before the trap crop is sprayed (Jakai *et al*., 1985)

2.5.6.3 Planting density

Asiwe and co-workers (2005) noted that plant spacing can reduce or increase insect pest infestation depending upon the degree of interaction between the plant variety and spacing and this principle can be used as a strategy for controlling insect pests on cowpea. Horn (1988) stated that studies have shown close spacing of cowpea results in doubling of infestation levels of some insect pests of cowpea such as *M. vitrata*. Similarly, studies under taken by Karungi and co-workers (2000) showed that, without insecticide intervention, larger numbers of *M. vitrata* were recorded on cowpea at close spacing (30 x 20cm) than at wider spacing (60 x 20cm). However, according to Coaker (1987) high planting density per unit area of the cowpea crop modifies the crop micro-climate in favour of the natural enemies and growth development which in turn can reduce pest numbers and damage caused by *M. vitrata.*

2.5.6.4 Manipulation of planting date

According to Kumar (1984) insect pests can be controlled by growing the crop when the target pest is not present or planting the crop such that the most vulnerable stage of growth of the crop does not coincide with the time when the pest is in abundance. Ekesi and co-workers (1996) reported on a study conducted in Nigeria to determine the relationship between planting dates and damage to cowpea by *M. vitrata* which showed that early planting (July) suffered lower attack by *M. vitrata* larvae, compared with late planting (August between the years 1993 and 1994 (Fig. 2.5). Sharma (1998) noted that planting cowpea 12 weeks after planting maize in a maize- cowpea intercrop resulted in decreased pod borer damage.

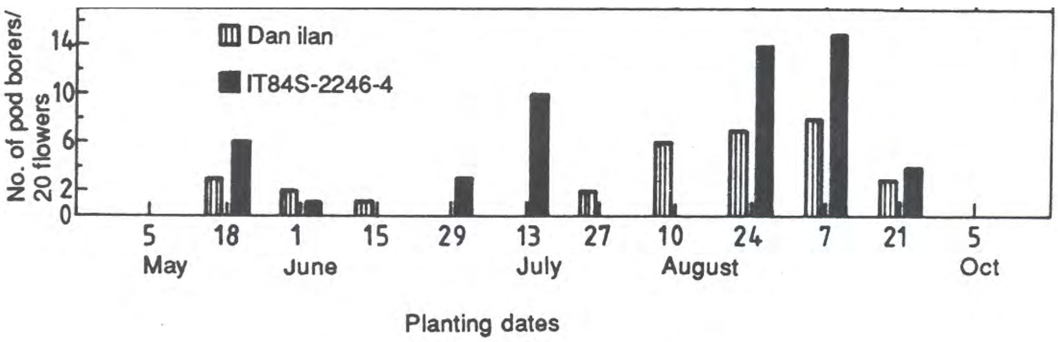

Fig.2.6 Planting date effect, on *M. vitrata* larvae infestation on two cultivars of cowpea in Nigeria (Alghali, 1993).

2.5.6.5 Farm Sanitation

Full grown *M. vitrata* larvae usually pupate in a cocoon in the plant debris and farm sanitation is used in the removal or destruction of such refuge and over wintering sites of pests. The technique is used to control nearly every type of insect pest afflicting grain crops such as cowpea (Flint and Van den Bosch 1987; Federal Ministry of Agriculture and Natural Resources, 1996). Coaker (1987) stated that weeding cultivation as a method of farm sanitation promotes rapid growth of cowpea and shortens the susceptible stages giving the crop a better chance to tolerate as well as compensate for any insect damage. According to Sharma (1998) studies showed that three or four weedings in cowpea resulted in less flower infestation by *M. vitrata* larvae compared to non-weeded cowpea plots.

2.5.6.7 Advantages of cultural control measures of *M. vitrata*

Cultural controls are an effective and cheap way of controlling insect pests of cowpea such as *M. vitrata* with no danger to the environment. These control measures can become a “second line of defence” when pesticides are to be used in an integrated pest management strategy (Flint and Van den Bosch, 1981; Matthews, 1987). According to Horn (1988) the cultural control practice of ploughing exposes larvae to the surface for birds and other predators to feed on them. Elliot (1994) noted that cultural control practices are readily available to rural farmers with little or no extra investment in equipment in order to be adopted.

2.5.6.8 Disadvantages of cultural control measures of *M. vitrata*

According to Kumar (1984) cultural control tactics are generally labour intensive which makes them unattractive in the developed world. Horn (1988) reported that in order for cultural control to be effective, a thorough understanding of the pest and crop biology is needed which is mainly lacking by the small scale farmers of tropical Africa. Kumar (1984) stated that cultural controls measures are not standardized and are therefore liable to variation depending upon the local conditions. According to Steele and co-workers (1985) to date many cultural controls are yet to be assessed in terms of efficacy which makes their role in the integrated pest management somewhat doubtful.

2.5.7 Host plant resistances

In IPM, host plant resistance to insect pests refers to the use of a resistant crop variety to suppress damaging insects and is normally used together with other control measures. Therefore, plant resistance is defined as “the consequence of heritable plant qualities that result in a plant being relatively less damaged than a plant without the qualities” (Teetes, 2007). Host plant resistance is the centre of pivot of any integrated pest management strategy against *M. vitrata.* The adoption of resistant varieties does not disrupt the farmers’ existing cultural practices (Steele *et al*. 1985). Host plant resistance is one of the most successful and environmentally friendly techniques employed against various cowpea pests. Host plant resistance could be due to physiological factors such as antibiosis or mechanical factors such as cuticle that is too tough for insect pests to penetrate. Cowpea plants having more than one resistant gene offer more durable resistance against insect pest such as *M. vitrata* (Flint and Van den Bosch 1981). In this regard, Steele and co-workers (1985) reported that resistance of various types have been identified in some wild cowpea varieties against legume pod borer *M. vitrata.* Studies conducted in Nigeria using cowpea cultivars ICPL88034 and MPG 679 show that both cultivars are tolerant to *M. vitrata* larvae damage and have shown excellent recovery from damage. Consequently, these lines are recommended for resistance screening (Sharma, 1998).

Wild cultivars such as TVu 946 and TVu 4557 which have long peduncles, pods held over the plant canopy and at a wider angle than normal, have been found to have resistance to *M. vitrata* damage (Sharma, 1998). Cowpea variety TVx7 having a high density of trichomes is resistant to *M. vitrata*. Varieties with pigmented calyx, petioles, pods and pod tips are found to suffer less damage from *M. vitrata* than non-pigmented varieties (Adati *et al*., 2008). A transgenic cowpea variety incorporating *Bacillus thuringiensis* (Bt.) has now been successfully developed by IITA but is still in the trial stage and so not yet available to farmers in Nigeria (Ezezika and Daar, 2012).

2.5.8 Integrated Pest Management (IPM)

IPM can be defined as "mix of farmer driven, ecologically based pest control practices that seek to reduce reliance on synthetic chemical pesticides. It involves (a) managing pests (keeping them below economically damaging levels) rather than seeking to eradicate them; (b) relying, to the extent possible, on non chemical measures to keep pest populations low; and (c) selecting and applying pesticides, when they have to be used, in a way that minimises adverse effects on beneficial organisms, humans and the environment" (The World Bank, 2011). Oudejans (1991: 7) defined IPM as a "pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains pest populations at levels below those causing economic injury". Kumar (1984) stated that IPM achieves the above objective by harmonizing various methods of insect pest controls into an organised, compatible, multiple and flexible system. IPM hangs on a set of ecologically based principles which rely on the natural control forces such as pest predator relationship, host plant resistance, timing and selection of a variety of cultural practices like tillage, planting density and residue management. IPM is generally based on scouting to determine pest infestation level which consequently leads to proper timing of the application of insecticide taking into consideration the natural control already taking place (NRCS, 1989).

In trying to achieve IPM control of *M. vitrata* and other cowpea pod borers, models such as: Host Plant Resistance-Intensive IPM (HPR-model); Biological Control-Intensive IPM (BC-model) and Chemical-Control-Intensive IPM (Insecticide-based model) were developed as part of the cropping system (Jakai, 1995). This author further stated that, IITA has been a strong proponent of the Host Plant Resistant-Intensive IPM in which resistant cowpea cultivars incorporated into different crop mixtures allowed for a large reduction in insecticide sprays.

2.5.8.1 Advantages of IPM

According to NRCS (1989), farmers' adoption of IPM has the following advantages:

(1) IPM programmes are based on economic thresholds which consequently results in increased returns for growers in most cases.

(2) IPM growers have better knowledge of the eco-system including pest and predator populations.

(3) IPM enables farmers to accurately and precisely time pesticide application resulting in cost saving pesticide application that is based on scouting.

(4) IPM farmers have better knowledge of insecticides especially new ones which are environmentally friendly and are effective at lower rate. They also have better knowledge of older pesticides.

(5) IPM farmers take advantage of cultural and biological controls in the process of pest and disease control, thereby giving them environmental benefits.

(6) IPM does not seek to completely eradicate pests (which may not possible) but tends to suppress them, thereby preventing or retarding the risk of pest resurgence and resistance.

(7) IPM farmers tend to achieve a higher degree of insect pest control than non IPM users.

(8) IPM farmers tend to receive higher average yield per hectare compared to non IPM farmers.

(9) IPM farmers tend to receive higher prices for their crops and with a lower risk of crop rejection due to the issue of residue levels than non IPM farmers.

(10) IPM has many long term and sustainable benefits.

2.5.8.2 Disadvantages of IPM

According to Gips (1987) IPM has the following disadvantages:

(1) IPM requires the farmer to tolerate up to 10% damage which causes IPM products to have lower cosmetic value.

(2) Quantifying the impact of pest management decisions on social aspect of human life such as health, wealth and nutrition is not easy under IPM's cost/benefit ratios.

(3) There is a lack of trained scientists and technicians to implement IPM.

(4) The system of pest monitoring and economic thresholds of many insect pest species is still not yet available under IPM programmes.

(5) IPM programmes usually take a long time before benefits are reaped.

(6) The efficacy of certain components of IPM such as cultural control has not yet been adequately evaluated.

2.5.8.3 Some Barriers to IPM Adoption

According to Gips (1987) there have been problems with IPM adoption which are in most cases human "entomophobia"; a situation whereby every insect seen by the farmer must be eliminated, so that even the beneficial insects are wiped away. Gips (1987) further stated that consumers are accustomed to cosmetically perfect agricultural products necessitating massive use of insecticides which is against the spirit of IPM.

2.5.8.4 Some established IPM control measures against *M. vitrata*

According to Adati and co-workers (2008) experience has shown that no single component is an effective control measure against *M. vitrata* by itself and there is the need to combine application of botanical/synthetic pesticides with appropriate dose and timing based on *M. vitrata* monitoring, in order to provide sustainable control. According to Jakai, (1995), studies were conducted by Afun and co-workers (1992) at three locations in Nigeria, using an action threshold of all major cowpea pests, including *M. vitrata*. These studies showed that monitoring of these pests before deployment of chemical pesticides (Lamdacyhalothrin + Dimethoate) greatly reduced insecticide application and in one of the locations (Ibadan) despite the drought that occurred, 2 sprays based on monitoring gave 440kg/ha while calendar based spraying of 7 days interval gave 425kg/ha. Jakai, (1995) further stated that studies based on integrating host plant resistance using cowpea cultivars with architectural attributes such as open canopy, wide pod angle and exposed fruiting structures and intercropping with sorghum/cowpea or maize/cowpea, greatly reduced the need for insecticide sprays. In another development, on-station IPM studies conducted by Asante and co-workers

(2001) showed that manipulating planting date, combined with insecticide sprays, using the resistant cowpea cultivars, (IT90k-277-2, IT93k-734, IT93k-452-1 and IT93k-513-2) planted in July and August and sprayed twice with sherpa plus®(Cypermethrin 30g + Dimethoate 300g) at bud initiation and at 50% flowering stage, gave a larger grain yield (900kg/ha) compared with planting in June with no spray at all (225kg/ha).

Singh and co-workers (1990) reported that in South Western Nigeria, the resistance based IPM model is widely used giving good results. These authors further stated that this model relied heavily on the use of a resistant variety combined with mixed cropping and the judicious use of insecticide based on scouting. According to Karungi and co-workers (1999) on-station studies conducted at three sites in Uganda used two cowpea varieties (“Ebelat” and “Icirikukwai”) planted early at the onset of rains, g close spacing (30x 20cm) and single sprays at budding, flowering and podding with a mixture of dimethoate (200g a.i. ha^{-1}), cypermethrin (200g a.i. ha^{-1}) and intercropping with greengam bean coupled with seed dressing. The result showed that this trial gave the highest yield of 1136kg/ha per hectare compared to other treatments such as sole crop with same insecticide treatment which yielded 935kg/ha. In another related instance, Nabirye and co-workers (2003) reported that studies in Eastern Uganda used farmer participatory research to evaluate cowpea IPM against the major insect pests, which included the cultural practice of cowpea/sorghum intercrop 1:1 mixture early planting (onset of rains), wider spacing (60 x $20cm^2$), seed dressing with Furadan 5G at rate of 1.5g per 1m row as a soil drench and three insecticide (mixture of dimethoate 200g a.i./ ha^{-1} + cypermethrin 200g a.i./ ha^{-1}) application at budding, flowering and podding. The result showed that this trial gave the highest yield of 791kg/ha per hectare compared to what was obtained (527kg) under farmers practice of weekly sprays (5-6 times) in the growing season . However, the on-station IPM developed by Afun (1992), Asante (2001) and Karungi and co-workers (1999) cannot be called a true IPM system, since it did not involve the farmers. IPM technologies which exclude farmers at the planning and validation stages will not be farmer oriented and in the long run, farmers will abandon them (Rajasekeran, 1993; Andrews, 1992). The IPM strategies developed by Karungi and co-workers (1999) even though farmers were involved, cannot be called IPM technically. This is due to the fact that the insecticide spray schedule was rather more of calendar based by having fixed schedule (Budding, flowering and podding stages) spraying without the conventional scouting and use of action threshold as required in IPM. None of these IPM strategies evaluated the natural control exerted by predators and parasites and so the impact of such control strategies on these beneficial organisms is not certain and therefore, cannot be called sustainable. Conservation of the natural enemies is one aspect of the objectives of any sustainable IPM control strategy (World Bank, 2011). Another issue is that all these so called IPM strategies presented, utilized chemical insecticides whose use IPM tends to eliminate because of their negative effects on the farmers health and the environment (Isubikalu, 1999). Against this background, it is necessary to devise a sustainable farmer involved IPM control strategy which utilizes safer alternatives to chemical insecticide whose impact on the beneficial organism is positive not negative therefore deemed sustainable. These gaps will be addressed by this research work through the following specific objectives:

1) To determine the impact of chemical (mixture of 30g Cypermethrin and 250g Dimethoate) and botanical (neem kernel extract - nke) pesticides on *M. vitrata* larvae infestation, natural enemies, and yield parameters of cowpea in Zuru.

2) To determine the efficacy of interplanting cowpea with Farm basil (*Hyptis spicegera*) in the control of *M. vitrata.*

3) To determine the role of pheromone traps in monitoring and forecasting of *M. vitrata* adult and larvae population abundance as well as determining action threshold in Zuru, following the procedures used by Downham and co-workers(2003) in Benin.

4) To determine if a variety considered tolerant to *M. vitrata* could contribute to the IPM control strategy against *M. vitrata.*

5) To determine factors militating against the profitable cowpea production in Zuru.

6) To finally develop an initial IPM package for the control of *M. vitrata* in Zuru.

7) To determine those farmer traditional *M. vitrata* control methods that could be incorporated into the final IPM control strategy.

CHAPTER THREE: GENERAL METHODOLOGY

3.1 SURVEY ON FARMERS' COWPEA CULTIVATION PRACTICES

3.1.1 Research design

The survey method was used in order gain more insight into the existing farmers' cowpea cultivation practices so as to enable the development of farmer oriented IPM control strategy against *M. vitrata*.

3.1.2 Population of the study

The population of the study comprised of cowpea farmers from three randomly selected districts in Zuru local government area of Kebbi State of Nigeria.

3.1.3 Sample size and sampling technique

The researcher used the "dip hand" random sampling technique to select three out of the six administrative districts that make up the local government area. The technique involved writing the names of the six administrative districts on pieces of ballot papers which were closed and rolled like balls and put inside a can. The can was shaken vigorously and the ballot balls were poured out of the can. Three ballot balls were picked up and opened to reveal the names of the district they contained. In this manner Zuru, Manga and Dabai districts were selected for the purpose of the study. Using the same technique, twenty cowpea farmers were randomly selected from the list of cowpea farmers with varying farm sizes and years of cowpea farming experience as given by the agricultural extension officers of the various selected districts. A total sample of 60 farmers was selected for the purpose of this study.

3.1.4 Research instrument

A questionnaire was used in collecting data from the cowpea farmers. It was made up of structured and unstructured questions. The structured questions were made of statements were specific answers were sought. The respondents were given unrestricted freedom of self-expression in the case of the unstructured questions.

3.1.5 Validity and reliability of the instrument.

Content of the questionnaire was validated by consulting experts in social science so as to determine how adequately the contents of the questionnaire measured what it was intended for. The reliability of the questionnaire was established using the test-retest method, whereby the same questionnaire was administered two times to the same group of people (10) within an interval of two weeks. The results were compared using Pearson's product moment correlation co-efficient (r). The value obtained (0.87) showed that the instrument was reliable. (http://www2.statistics.com/resources/glossary/t/trtreliab.php)

3.1.6 Administration of the instrument

The researcher personally visited the selected districts. The services of two research assistants whom the researcher trained, was used in order to save time. The questionnaires upon completion were collected on the spot. The researcher chose this method of hand to hand because: 1) It gave the opportunity to clarify questions not understood by the respondents, 2) It ensured that completed questionnaires were returned to the researcher.

3.1.7 Statistical instruments

The data collected were analysed using frequency tables and simple percentages.

3.2 FOCUS GROUP DISCUSSION ON FARMERS' PERCEPTION OF PESTS AND PESTICIDES AND THE ECONOMICS OF COWPEA PRODUCTION IN KEBBI STATE

Four cowpea farmers were randomly (dip hand method) selected from each of the selected districts among the farmers who were administered with the questionnaire to attend a focus group interview. They were categorised into three groups based on their farm sizes namely: group A comprising of those farmers cultivating 1ha and below, group B comprising of those farmers cultivating 2 – 3ha while group C comprises of those farmers cultivating 4 and above ha of cowpea. In each group there were four farmers making at total of 12 farmers used for the session. The responses from the interviews were transcribed in the farmers' language before translating into English. An evaluation was carried out after the interview, the transcribed notes were read to the participants so as to further clarify all that was said during the interview. All the answers from the questions were presented and analysed using frequency tables. Notes from the interview were included in the report where necessary.

3.3 MONITORING AND FORECASTING OF *M. vitrata* POPULATION ABUNDANCE IN COWPEA IN KEBBI STATE USING PHEROMONE TRAPS

3.3.1 Experiment site and trap positioning

The experiment was carried out in 2008 following the procedures of Downham (2003) and the experiment site was located in the experiment farm of the College of Agriculture at Zuru. The vegetation is Northern Guinea savannah with rainy a season starting from April/May and ending in November. Four types of experiments (see the experiments under 3.4 below) were carried out involving two day-length sensitive varieties of cowpea, one of which is a susceptible variety (Danzafi) and the other is tolerant variety (Improved Kanannado) planted on 17^{th} July 2008. The pheromone lures were three component blend type (0.1mg of EE10,12-16:Ald, EE10,12-16:OH and EE10-16:Ald in ratio 100:5:5) contained in polyethylene vial dispensers and produced at the Natural Resources Institute, UK. The traps are bucket funnel types (see chapter seven, plate 3), and a small quantity of water and soap were poured into the bucket to help drown the moths caught. Altogether, 20 traps were used for the experiment and 15 were deployed on the experiment farm on 7^{th} August 2008 while the remaining five traps were deployed on the students' plots (See appendix 2.1 for experiment lay out and trap positions) which were planted with groundnuts and soya beans and other early maturing cowpea varieties in the same week with those of the experiment farm and were at least 300m away from the rest of the traps. Each trap was suspended from wooden pegs 1.2m above the ground and spread 20m apart in line across the replications. The deployment was 3 weeks after planting and the lures were changed every 4 weeks to ensure that they remained attractive. Traps were numbered, 1, 2, 3....20 and were checked three times per week (Monday, Wednesday & Friday) for possible catch and counting.

3.4 EFFICACY OF IPM COMPONENT TECHNOLOGY

There were four experiments carried out during the year 2008 (first year) in Zuru local government area of Kebbi State of North Western Nigeria for the purpose of assessing their suitability as IPM control options against *M. vitrata*. The varieties of cowpea used were: Danzafi which was a small seeded susceptible local variety & Improved Kanannado (IT89.245-1) which was an IITA improved version of the local Kanannado. It was derived from cross IT87F-177-2 (a Kanannado selection x IT84S-2246-4. This dual purpose improved variety is also known as Kanannado Dan IITA (Kanannado son of IITA). It is resistant to the major reproductive insect pests (Singh, *et al*., 1997). In all the experiments stated above, each of the subplots measured 6m in length and consisted of 5 rows of cowpea spaced 1.2m apart (Plate 2) and spacing between stands of 0.3m. This wider spacing was chosen because of the spreading nature of the varieties used and because it does not favour *Maruca* and aphid proliferation (Summerfield *et al*. Asiwe *et al*. 2005). The spacing between plots was also 1.5m. The replications were located 2m apart. All the experimental plots were disc harrowed (Plate 1) and cow manure was applied at the rate of 3t/ha. This method of fertilising was chosen for sustainable soil fertility management (Harris 2002). Seeds were obtained from the local market and seed treatment was carried out using a mixture of 25%Thiram and 20% Lindane (Fernesan D) chemical pesticide at the rate of 1 sachet per 2kg of seeds for the purpose of controlling soil-borne diseases and insect pests (Oparaeke, 2005). Early planting was carried out on 17th July 2008 (Information and Communication Support for Agricultural growth in Nigeria, 2002). Among the numerous advantages of early planting of cowpea is that the crop recovers from early season damage by pests without affecting yield (Adipala, *et al*. 2000). Four cowpea seeds were planted per hill and later thinned to 2 per stand (komolafe *et al*. 1985). Weeding was carried out in all the experimental plots 3 and 6 weeks after crop emergence (Alghali, 1993). Measures were taken to avoid biasness in all the farm operations. Experienced farmers were used to do the weeding. The same persons did both first and second weeding. The researcher personally supervised the quality of the weeding by ensuring weeds are properly removed with including their roots especially the perennial ones, or covered with earth in such a manner as to prevent regrowth. Care was taken to ensure that weeding was done during dry and sunny weather conditions to allow weeds to die after weeding. Measures were also taken to avoid bias in harvest. Experienced people who could distinguish between matured ripened pods and un-ripened ones. Edge effect bias was avoided by demarcating plots and harvesting the entire plot in order to determine plot yield. All experiment plots received same cultural treatment on the same date.

Experiment 1

Using an on-station experiment two cowpeas varieties (Danzafi VI and Improved Kanannado V2) were interplanted with *H. spicegera* at two levels 0*H. Spicegera*/ha and 356 *H. Spicegera*/ha. This plant has been used by the local people in Kebbi as a mosquito repellent by burning the leaves inside their rooms. Recently, studies on its insecticidal effect have shown that it has both insecticidal and repellent effect on the worldwide serious stored grain pest *Sitophilus granaries* (L.) (Coleoptera: Doryophthoridae). Sixty volatiles have been detected in the essential oil (which has both repellent and insecticidal effect) of this plant and monoterpene hydrocarbons were the dominant (70.4%) followed by sesquiterpene hydrocarbons (22.6%) (Conti *et al.*, 2010). The varieties of cowpea used in the research work are spreading and photosensitive types. The experiment was in Randomised Complete Block design (RCB) using four replications on four treatment combinations. Each subplot had two stands of the interplanting material. The interplanting was carried out in August when rainfall had stabilized to avoid death of the intercropping material. Hoe and wheel barrow were the equipment used for the transplanting operation.

Experiment 2

Using an on-station experiment two cowpea varieties (Danzafi V1 and Improved Kanannado V2) were sprayed with chemical pesticide (cypermethrin + dimethoate) at two levels 0l/h and 1l/ha at two frequencies, using weekly and need based (scouting) based application. The experiment was in a Randomised Complete Block design (RCB) with 4 replications and six treatment combinations.

Experiment 3

Using an on-station experiment two cowpea varieties (Danzafi V1 and Improved Kanannado V2) were sprayed with neem kernel extract (nke) insecticide at two levels 0l/h and 300l/ha weekly starting from 8 weeks after planting as farmers do in Zuru. Seven sprays were carried out using a 16 litre knapsack sprayer. The concentration of the pesticide was 5%. This was achieved by mixing 50g of ground Neem kernels in one litre of water using a protocol provided by Stevenson (personal communication). The experiment was set up in RCB design using 4 replications and four treatments combinations. There were four subplots per replication.

Experiment 4

This on-station experiment which was a single factor type, in which two cowpea varieties (Danzafi V1 and Improved Kanannado V2) were tested for resistance to *M.*

vitrata. The experiment was set up in RCB design using seven replications and treatments were the two cowpea varieties. There were two subplots in each replication. The experiment relied on natural infestation. There was no chemical protection carried out against *M. vitrata* in this experiment.

Plate 1 Harrowing the experiment farm

Plate 2 Planting cowpea

3.4.1 Data collection

A simple sampling square (Plate 4) 1m x 1m made of elephant grass stalks was constructed locally and made use of in sampling damaged flowers, flower buds and pods. This was done because the interlocking nature of the spreading cowpea varieties made it difficult to distinguish individual plant stands. A sample of 25 flowers/flower buds was randomly selected from each of the two sampling units per plot and these were opened and examined on the spot for larval presence/damage. This rapid visual estimate method (RVE) was used to determine flower damage as a result of larvae feeding indicated by dirty frass or exit holes (Asante, *et al*. 2001). An action threshhold of 60 percent larval infestation/damage (NRI, 2007) was used to indicate the need for chemical pesticide application (Plate 3) in the case of need based control strategy. Percentage larval infestation/damage was determined by dividing the number of flowers/flower buds infested/damaged by the total number of flowers sampled and multiplying the value obtained by one hundred. In the case of pod damage assessment, 25 pods were collected from each of the two sampling units using the sampling square, and examined for pod borer damage indicated by stitching together of pods using silky material or the presence of exit holes or dirty frass or in-pod feeding larvae. Seed damage data was collected by threshing the sampled pods and the seeds showing signs of larval feeding were counted as damaged. The sampling operation was carried out at weekly starting from 3rd November 2008 which corresponded with 50% flowering stage and ended on 17th November 2008. Yield data was obtained by harvesting pods from each individual plot (Plate 5); threshing and weighing (Plate 6) to obtained plot yield in kg which was later converted to kg/ha. The benefit/cost ratio was calculated in line with Asante (2001) whereby: “Yield increase (Kg/ha) = yield of spray treatment less yield of no-spray. Due to lack of any statistical difference in yield between the two cowpea varieties, average yield of the two varieties was used in computing the value of yield increase. Value of yield increase in Naira = Yield increase multiplied by the market value of a kilo of cowpea grains at harvest (N100.00/kg) (for the first season and N200.00/kg for the second and third seasons), Profit = Value of yield increase less total pest control cost. Benefit-Cost ratio = Value of the increase yield divided by cost of pest control of that treatment”. Partial budgeting was used so costs of land preparation, weeding and harvesting were not included. It was assumed that yield increase was due to insecticide application. Straight line Depreciation value was calculated following Nwalor (1986): Annual Depreciation = cost less salvage value divided by years of useful life. The purchase cost of the sprayer was N7000.00 in the first and second season and N9000.00 in the third season. The useful life of Knapsack sprayer was determined following Alghali (1993). The salvage value or scrapped value was determined locally and found to be N500.

3.4.2 Data analysis

All the data collected on larvae infestation, yield, pods and seeds damage were subjected to two way analysis of variance (Anova) using R statistics software. The means were separated using Turkey HSD multiple comparisons.

Plate 3 Spraying plots with insecticide

Plate 4 Use of sampling square

Plate 5 Harvesting plot yield

Plate 6 Weighing plot yield

3.5 VALIDATION OF THE IPM SYSTEM FOR THE MANAGEMENT OF *M. vitrata*

Experiment

There were two cowpea varieties (Plate 7 and 8) Danzafi (V1) and Improved Kanannado (V2) treated with neem and chemical insecticide (30g cypermethrin + 250g dimethoate) at two frequencies (weekly and scouting based) There were five treatments namely: 1. calendar based commercial insecticide application, 2. scouting based commercial insecticide application, 3. calendar based nke application, 4. scouting based nke application and 5. unsprayed control. These treatments were assigned to each variety of cowpea to obtain ten treatment combinations which were randomly assigned to the sub plots of the four replications. The experiment was a Randomised Complete Block design (RCB) (See appendix 2.5). Details about plot sizes, spacing and, weeding (Plate 12), the action threshold used, and time of commencement of calendar spray remained the same as used in the first year (2008). All the cultural treatments were the same as used in the first year.

3.5.1 Data collection

The same procedure was used as described in the efficacy of IPM components above**.**

5.5.2 Data analysis

The same statistical instruments and software was used as in the year 2008.

Plate 7 Danzafi treated with nke on need basis

Plate 8 Improved Kanannado treated with chemical insecticide on need basis

3.6 ON-FARM VALIDATION OF THE IPM SYSTEM FOR THE MANAGEMENT OF *M. vitrata*.

The investigation was carried out in Manga village of Zuru Local Government Area of Kebbi State of Nigeria between July and December 2012.

The experiment was an on-farm type involving one factor which was insecticide of two types, commercial insecticide (Cypermethrin + Dimethoate) and 5% neem kernel extract (nke). The two types of insecticides were applied on calendar (weekly) and scouting (need) basis. The whole experiment was set up in Randomised Complete Block Design (RCB) (see appendix 2.6). Five volunteer farmers were used and the field plots of each farmer represented a block. The treatments were located within these bocks. The tolerant cowpea variety Improved Kanannado was used. Five treatments namely: 1. calendar based commercial insecticide application, 2. scouting based commercial insecticide application, 3. calendar based nke application, 4. scouting based nke application and 5. unsprayed control, were randomly assigned to the sub plots of a replication. Each subplot measured 4m x 10m and contained four rows of cowpea spaced 1m apart. The spacing between stands was 0.3m. The subplots were separated 2m apart. Weeding was carried out twice by the same persons (3 and 6 weeks after crop emergence). The procedure for the calendar and scouting based sprays was as used in the first year 2008 experiment (see 3.5.1).

3.6.1 Data collection

See 2008 methodology for information on the various damage assessments and yield data collection. For more information about natural enemies sampling see chapter 10.

3.6.2 Data analysis (same as 2008, also see chapter 10 methodology)

CHAPTER FOUR: SURVEY ON FARMERS' COWPEA CULTIVATION PRACTICES IN ZURU LOCAL GOVERNMENT AREA OF KEBBI STATE OF NIGERIA

4.1 INTRODUCTION

Cowpea is a very versatile crop in Africa in the sense that it feeds people with its protein rich grains by providing about two hundred million Africans with food, feeds their livestock with its fodder, and feeds next year's crop by improving the fertility of the soil through nitrogen fixation (Gomez, 2004). Nigeria is the largest producer and consumer of cowpea and 58% of the world's cowpea is produced in Nigeria (International Institute of Tropical Agriculture, 2009). Production of this important food and cash crop is largely carried out by resource poor subsistence farmers in this sub-Saharan region of Africa. Cowpea has a yield potential of up to 3000 t/ha, but at farmer level in sub-Saharan African countries such as Nigeria the average yield is below 400kg/ha as a result of many production problems such as that of insect pests attacks (Opolot *et al*., 2006). Farmers respond through applying pesticide as much as 7 times during the cropping season which may in turn harm both farmers' health and the environment (Asante *et al.,* 2001). Farmers need a safe method for addressing pest problems such as Integrated Pest Management (IPM). However, previous research has shown that technologies intended for use by peasant farmers have either not been adopted by these farmers or, have totally failed as a result of not taking into account farmers objectives, their indigenous knowledge and practices or, because they were not directly involved in technology development (Kossou *et al.,* 2001; Truntmann *et al*.,1993). It is against this background that a survey was carried out in order to gain more insight into farmers' cowpea cultivation practices, with a view to integrating those findings that are IPM compatible into a farmer acceptable IPM package that could be developed for the control of *Maruca vitrata*.

4.2 MATERIALS AND METHODS

The respondents comprised of cowpea farmers (Plate 9) from three randomly selected districts out of the six administrative districts in Zuru local government area. For more details see general methodology 3.2.

Plate 9 Administering questionnaire

4.3 RESULTS

4.3.1 Respondents' background

Respondents were predominantly males (97%) and all of them were married. Their age mostly lies within 31-50 years and most of them (38%) had 3-4 years of farming experience (Table 4.1). There was wide variation between respondents in the total farm size, ranging from below 1 ha to over 5 ha. The amount of land used for cowpea cultivation ranged from 5% on the larger holdings to 32% on the holdings of one hectare or below (Table 4.2)

Table 4.1 Summary of the respondents' background information

Respondents gender	Responses n (%)
Male	58 (97)
Female	2 (3)
Respondents age(years)	
21-30	6(10)
31-40	27(45)
41-50	17(28)
51-60	7(12)
61-70	3(5)
Respondents marital status	
Married	60 (100)
Respondents years of cowpea farming experience	
1-2	7(12)
3-4	23(38)
5-6	12(20)
7-8	6(10)
9-10	5(8)
11 & Above	7(12)

Table 4.2 Summary of the respondents' farm size details

Respondents total farm size	Responses n (%)
1ha and below	6 (10)
1.1-1.9ha	22 (37)
2-2.9ha	11 (18)
3-3.9ha	3 (5)
4-4.9ha	3 (5)
5ha and above	15 (25)
Land devoted for cowpea cultivation	
1ha and below	19 (32)
1.1-1.9ha	23 (38)
2-2.9ha	5 (8)
3-3.9ha	4 (7)
4-4.9ha	6 (10)
5ha and above	3 (5)

4.3.2 Respondents cowpea cultivation practices

The majority (68%) of the respondents interviewed were growing improved Kanannado, a variety of cowpea reported to be tolerant to *M. vitrata*, while only 16% of them grew Danzafi, regarded as a susceptible variety. Few of the respondents (5%) were growing both cultivars (Table 4.3). 33% of the respondents growing the cultivar improved Kanannado stated that their reason for growing the cultivar was that of high market price whilst 7% grew it for its high yield. Respondents that grew the local variety Danzafi explained their choice by its ability to give acceptable yield, even without chemical insecticide sprays (18%) or the ease of obtaining the seed. (12%)

(Table4.4).Those that grew both cultivars stated that it was because of household consumption (Table 4.4). 80% of the respondents sourced their seed supply from the local market. Only a few farmers (3%) obtained their seed supply through government agricultural supply company. The majority (87%) carried out a primary tillage operation before planting cowpea and animal drawn ploughing was the most widely used (98%) method. Only 2% of the respondents who carried out primary tillage were found to use the traditional hand held hoe for tillage operations (Table 4.3). Those respondents who stated they did not carry out primary tillage before planting cowpea gave their main reason as a strategy to save money (62.5%), followed by the inability to possess the traction animal or money to hire them (37.5%)(Table 4.3)

Table 4.3 Respondents' seed sources and methods of tillage

Respondents gender	**Responses n (%)**
Improved Kanannado	41(68)
Local variety Danzafi	16 (27)
Both varieties	3(5)
Respondent's sources of seed supply	
Local market	48(80)
Previous year's harvest	10(17)
Government Company	2(3)
Respondents method of land preparation	
Use of animal drawn ploughs	51(98)
Use of hand hoe	1(2)
Respondents using/not using primary tillage	
Respondents that did not use primary tillage	8(13)
Respondents that did primary tillage	52(87)
Reasons for lack of primary tillage	
Direct planting saves me money	5(62.5)
I have no traction animal or money to hire one	3(37.5)

Table 4.4 Respondents' reason for growing their chosen cultivars of cowpea

S/N	**Reasons for use of cultivar**	**Type of cultivar**			**Responses n (%)**
		Kanannado	**Danzafi**	**Both cultivars**	
1	High yield	4	Nil	Nil	4 (7)
2	Home consumption	2	Nil	3	5 (8)
3	Yield acceptable without protection	Nil	11	Nil	11(18)
4	Ease of getting seeds	Nil	7	Nil	7 (12)
5	High market price	33	Nil	Nil	33 (55)
6	Others specify	Nil	Nil	Nil	0(0)

Most of the respondents interviewed (62%) did not carry out seed dressing before planting. 25% Thiram + 20% Lindane (Fernesan D$^{(R)}$) and 0.05g Cypermethrin (Rambo Powder) were the most widely (52.2% and 30.4%, respectively) used seed dressing materials. A few (8.7%) farmers were found to be using charcoal as seed dressing material and 4.3% of them used 17.5% SL Imidacloprid (Table 4.5). The main reason (51.4%) given by the respondents for not using seed dressing was that their crop emerged well even without seed dressing, followed by the fear of poisoning their poultry (24.3%), lack of funds to buy the chemical (13.5%) and lack of knowledge about the seed dressing chemical (10.8%)(Table 4.6). Intercropping was the main method (73%) used by the respondents to plant cowpea and less than one third (27%) were found to be growing the cowpea as a sole crop (Table 4.6). All the respondents interviewed carried out weeding operations on their cowpea farms and the traditional hand held hoeing combined with hand picking of weeds was the farmers' major (83%) method of weed control. Only 17% of the farmers used herbicides with hand picking as a means of weed control (Table 4.6). 78% of the respondents interviewed did not use any kind of fertilizer for cowpea cultivation. Among those that used fertilizer, manure (a mixture of animal and house-hold wastes) was the main (69%) type of fertilizer used. Only 31% of those using fertilizer used chemical fertilizer in the form of NPK. All of these fertilizers were found to be applied once during the cropping season (Table 4.6).

Table 4.5 Respondents usage of seed dressing and reasons for non-use

Type of seed dressing material	**Responses n (%)**
17.5% SL Imidaclropid (Courage)	1(4.3)
0.05g Cypermethrin (Rambo)	7(30.4)
25% Thiram + 20% Lindane (Fernesan D)	12(52.2)
75% WP Tricylazole (Profit)	1(4.3)
Charcoal	2(8.7)
Reasons for lack of use of seed dressing	
My crop emerge well even without seed dressing	19(51.4)
I don't want to poison my poultry	9 (24.3)
I have no money to buy the chemical	5(13.5)
I don't know about it	4 (10.8)

The main reason (33%) given by the farmers using hoe weeding was that hoeing makes cowpea produce more flowers and pods, followed by hoeing was the only one the farmer could afford (25%) and hoeing eases work and does not damage cowpea vines (17%). Those respondents that used herbicide with hand picking, stated that their main reason (17%) for using the method was that it reduced their number of weeding operations followed by that it gave better control of weeds (8%)(Table 4.7).

Table 4.6 Respondents' methods of planting cowpea and weed control

Respondents method of planting cowpea	Responses n (%)
Sole cropping	16(27)
Intercropping	44(73)
Respondents method of weed control	
Hand hoeing + Hand picking	50(83)
Use of herbicide + Hand picking	`10(17)
Types of fertilizer used by the respondents	
Manure	9(69)
NPK	4 (31)

Table 4.7Respondents reasons for the choice of method of weed control

Reasons	Responses n (%)
Reason for the use of hand hoeing + Hand picking	
It is the one I can afford	15(25)
It is easy and does not damage the crop	`10(17)
It makes the crop to produce more flowers	20(33)
Reasons for the use of herbicide + Hand picking	
It reduces my number of weeding operations	10(17)
I do get better weed control	5(8)

4.3.3 Respondents various methods of protecting cowpea from field insect pests

82% of the respondents interviewed protected their cowpea from field insect pests with commercial chemical insecticide (Table 4.8). 51% of them stated that the reason for their use of purchased insecticide was their lack of knowledge of alternatives. 28.6% of them gave the reason that the use of chemical pesticides gave them high yields. Only 20.4% reported that the use of chemical pesticide enabled them to destroy all damaging insects on their farm (Table 4.8). The majority of the respondents who were using chemical control (79.6%) used the mixture of 30g Cypermethrin + 250g Dimethoate (Uppercott) which was applied at the tank dose rate of 60mls per 15Litre knapsack sprayer load, at the frequency of 7 times per season (Table 4.9) in their control of the various insect pests of cowpea.

Table 4.8 Respondents using chemical control option and reasons for the use

Type of protection measure used by the farmers	Responses n (%)
Chemical control	49(82)
Reason for the use of chemical control	
I do not know any other alternative	25(51)
It gives me high yield of cowpea	14(28.6)
It enables me to eradicate all damaging insects on my farm	10(20.4)

Table 4.9 Summary of the nature of the respondents' usage of chemical insecticide

Type of insecticide used	Responses n (%)	Tank Dose(mls)	Responses n (%)	Spray Frequency	Responses n (%)
15g/L Lamda Cyhalothrin + 300g/L Dimethoate	3(6.1)	150mls	3(6.1	5	2(4.1)
Cypermethrin 10% EC	1(2)	150mls	1(2)	4	1(2)
Cypermethrin 0.05% + Propoxur 0.5%	4(8.2)	150mls	4(8.2)	2	4(8.2)
Dichlorovous 100% EC	2(4.1)	150mls	2(4.1)	3	2(4.1)
Cypermethrin 30g + 250g Dimethoate	39(79.6)	60mls	39(79.6)	7	39(79.6)

N = 60

Those respondents applying insecticide 2 times per season gave the reason of allowing pod sucking bugs to build up before spraying whilst those using 3 sprays stated that it was because they applied the first spray during the vegetative stage, followed by two sprays at the reproductive stage. Those who applied four or five sprays stated their reason as wanting to eliminate all damaging insects as well as taking the advice of the pesticide merchants. Farmers who applied seven sprays gave their main reason (42.9%) as trying to prevent insect pests from quickly returning, as well as giving high yield of cowpea and protection from early bruchid attack during storage (36.7%)(Table 4.10).

Table 4.10 Respondents' reasons for the frequency of insecticide application

Frequency of insecticide use	Reason for the frequency of insecticide application	Responses n (%)
Two sprays	I do allow the populations of pod sucking bugs to build up before spraying insecticide	4 (8.2)
Three sprays	First spray I target the vegetative pest and the other two I target the flower pests	2 (4.1)
Four sprays	I want to eliminate all damaging insects	1(2)
Five sprays	I was advised by the pesticide merchants	3 (6.1)
Seven sprays	1) To stop insect pests from quickly returning to my crop.	21 (42.9)
	2) To get high yield and prevent early bruchid attack in storage	18 (36.7)

The majority of the farmers who use insecticide (67.3%) had encountered one problem or another with regards to the type of insecticide they used and the major (76%) problem encountered by those with problem with regards to the type of insecticide used was that it was not as effective as it used to be, followed by the instability of insecticide supply (15%) and burning of crop foliage (9%)(Table 4.11).

The majority of the respondents (52%) obtained cowpea yields above 400kg/ha in the previous season, and 33% of them obtained cowpea yields above 604kg/ha (Table 4.12).

Table 4.11 Respondents who had problem with regards to the type of chemical pesticide they are using.

Respondent	Responses n (%)
Insecticide users with problem	33 (67.3)
Insecticide users without problem	16 (32.7)
Type of problem encountered	
Burning of crop foliage	3 (9)
Insecticide not as effective as before	25 (76)
Insecticide supply not stable	5 (15)

Table 4.12 Farmers average annual cowpea grain output

Respondent	Responses n (%)
Below 100kg/ha	6 (10)
100 – 199.9kg/ha	11 (18)
200 – 299.9kg/ha	8 (13)
300 – 399.9kg/ha	4 (7)
400 – 499.9kg/ha	7 (12)
500 – 599.9kg/ha	4 (7)
600 – and above	20 (33)

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4.4 DISCUSSION

The male dominance in the respondents population can possibly be attributed to female marginalization in many sub Saharan African countries, in terms of access to important factors of production such as farm lands, despite the fact that in this region it is the women that comprise 70% of agricultural work force (Wakhungu, 2010). In many instances, cultural and social constraints make women further marginalised in various aspects of the society (CTA, 2000; Mcdowell *et al.,* 2001) A typical example is in the tradition of Zuru people where females' role is that of domestic chores and production farm labour force (HRH Sami Gomo II, 2000). Various governments in many sub-Saharan African countries, including Nigeria, have policies aimed towards improving female rights, especially land rights, but women have not benefited due to ever increasing population pressure on already depleted land (Saito, 1994). However, it has been observed that increase in proportion of women as independent producers, could lead to "feminization" of agriculture which to some people, could lead to the deterioration of quality of agricultural work force (possibly due to the fact that women may find it difficult to do some more strenuous manual farm tasks especially while pregnant) (FAO, 2010). In many African societies feminization of agriculture due to male out-migration has led to the decline of agricultural production, as wives take over the subsistence farming (Dugbazah, 2012). In spite of the vast contribution of women in the traditional African Agriculture, they seldom are the recipient of the benefits of new agricultural improvement technology programmes in many parts of Africa, primarily due to social, cultural and economic and other discriminatory conditions (Rathgeber, 2011). Where women get the chance to control land, it is often of poor quality and without access to extension services, and so they are less able to adopt new farming technologies than male farmers (FAO, 2011). Authors such as Mangheni and co-workers (2010: 4) noted that it is the failure to realise the full potential of women in agriculture that made Africa's agriculture to have low growth, with accompanying food insecurity. These authors further noted that "no society can progress if some of its population are disadvantaged for reasons of gender, ethnicity or any other bias"

Having found all the farmers interviewed to be married can partly be explained by their age since they were all mature adults, or it was an indication of the significance of marriage in West African society such as Zuru. In this region of Africa pre-marital and extra-marital sexual activity is less permissible compared to other parts of Africa (Beth, 1994). Another possible clue to the marital status of the farmers is that of the role played by the women folk (wives) in the traditional African agriculture which is observed to heavily rely on females for such farm activities as weeding and harvesting, in addition to the large amount of unpaid household responsibilities such as food preparation and collecting of fuel and water (Team and Doss, 2011). Babatunde (2012) noted that overcoming food insecurity remains a major challenge confronting West African countries; therefore for any IPM programme to be successful in overcoming food insecurity in Africa, it must incorporate the role of women, in view of their vast stored experience as suppliers of farm labour from time immemorial in Africa.

The United Nations define young people as "those aged between15-24" (Bennell, 2010: 2). Going by this definition, then most of the farmers interviewed were not young. A scarcity of young people in agriculture is a manifestation of the modern trend in many developing counties, whereby this category of people with vast energy resource, are abandoning their rural farming communities in search of opportunities somewhere else (Bennell, 2010). During the Young People, Farming &Food Conference held in Accra Ghana on19th-21st March 2012, experts noted with concern the aging farm population and loss of farm labour associated with African agriculture (Future Agricultures, 2012). Apart from education, age 40 years and below has been known to be a factor that favours the adoption of IPM technologies among the rice farmers of Mekong delta (Chi and Yamada, 2002).

The majority of the respondents possessed farms below 2.5ha, indicating the small holder nature of the farming enterprise in the area of the study and typical of African traditional agriculture and those under which cowpea is cultivated in Nigeria (Adeola *et al.,* 2008; Adati *et al.,* 2008). The smallness of land holdings per household usually puts farming under stress and is made worse by pressure from an ever increasing population, making it no longer possible for many households to meet their own food needs in Africa (CTA, 2000; Dio *et al.*, 2006). Africa's agricultural growth output is lagging behind its population growth and has the lowest productivity per unit area land compared to other parts of the world as a result of its agriculture largely being in the hands of resource poor farmers cultivating fragmented lands. (Youm *et al*., 1990; Saito *et al.,* 1994; Al Ghali, 1993; Abate *et al.,* 2000 and Dio, 2006).

A possible explanation for the relatively low level of cowpea farming experience associated with the majority of the farmers in the study area is that, until recently by virtue of the crop assuming cash crop status, the dominant work of Zuru farmers was sorghum cultivation (HRH Sami Gomo II, 2000). However, when factors affecting the adoption of IPM strategies in cowpea cultivation in Kumi district (Uganda) were studied, farm size did not affect adoption which indicates that IPM technology adoption is "scale neutral" (Bonabana-Wabbi, 2002). Although, no such information exist in the study area, it has been observed that African small holding farming characteristics remain the same (Salami *et al.,* 2010). This implies that in the event of any introduction of IPM in Zuru, the majority of the cowpea farmers (1.5-2ha and those with below 1ha) stand the chance to benefit. On the other hand, IPM stands to benefit from the vast local knowledge of insecticide free pest control strategies used by these low input farmers especially from those cultivating cowpea on less than 1ha who are not likely to be using chemical insecticides (Alghali, 1993). In many instances IPM control strategies are built upon the existing traditional methods.

Most farmers were cultivating the tolerant variety of cowpea (Improved Kanannado) due its high market price. It has been observed that as long as a cultivar has high market value, farmers are prepared to grow it, even if it is susceptible to insect pests and are ready to invest heavily in pesticide applications to ensure high quality at harvest. On the account of its high yield, some respondents were found growing the cultivar. This may be explained by the work of Singh (2006) whose research showed that the cultivar has been known to have yield potential of over 2500kg/ha and up to 3000kg/ha. Olufowote and Barnes-McConnell (2000) also noted that the cultivar is drought tolerant and resistant to Striga. The drought tolerant nature of the cultivar is especially important in the savannah region of Nigeria where rainfall is now becoming very unstable due to climate change. The seeds of Improved Kanannado variety of cowpea are large and white, a characteristic much desired by the consumers (Adati *et al.,* 2000). However, with all these desired characteristics, this cultivar as is the case with many other tolerant/resistant cowpea varieties may require some additional insecticide protection against field insect pests and about 2-3 insecticide applications are considered adequate for good yield (Dugie, 2008). Insect pests are by far the most important cowpea production constraint in sub Saharan Africa where they cause both reduction of yield and seed quality (Kossou *et al.,* 2001; Bashir, 2002 and Oparaeke, 2006). Few farmers grew the susceptible cultivars Danzafi, and the main reason tabled by these farmers was that of obtaining some acceptable yield from this cultivar without insecticide spray. Although a high yielding improved variety is available, these farmers are still fond of their local cultivar possibly due to its adaptation to the insecticide-free traditional pattern of mixed cropping prevailing in the savannah zones of Northern Nigeria. A number of such local cultivars possessing some resistance to pod-borer have contributed to the gene pool for many of the International Institute of Tropical Agriculture's breeding programmes (Adati *et al.,* 2008). However this local cultivar has low market value in comparison to Improved Kanannado possibly due to its small seeded nature which buyers do not prefer. Growing both cultivars of cowpea as some few farmers were found to be doing for home consumption is likely be due to fact that cowpea plays a vital role in the preparation of different traditional African meals and seasonings (Gomez, 2004). Although the history of cowpea is not a long one in the study area, being a multi ethnic society with many settlers may explain the prevalence of different types of cowpea menu in the study area. Each of the cultivars has its role in the Nigerian menu. The tolerant variety improved Kanannado with its large white seeds is suitable for preparing rice with bean dishes, while the small seeded Danzafi is suitable for making cakes (Akara).

Among the objectives of IPM is to reduce, or where possible eliminate, the use of chemical pesticides and increase crop yield and profit (Sorensen, 2012). With the majority of the farmers cultivating the tolerant variety primarily due to its high market price, the major challenge to IPM introduction in Zuru is that of increasing the level of the farmers' cultivation of their much favoured tolerant cowpea variety in a sustainable manner. The majority of the farmers obtained their seed supply from the local markets, possibly due to the resource poor nature of most of the cowpea farmers in the sub Saharan African Region. These informal markets remain a vital source of seeds, in the absence of Government certified seeds which, as an external input, remain beyond their reach (Asante, *et al.,* 2001). Cowpea grains of various cultivars are readily available in various formal and informal markets in West Africa, where mostly women retailers are its merchants (Coulibaly and DeBoer, 2000). Another contributing factor to farmers patronizing the local markets for seed supply is the lack of seed companies, as a result of the oil boom in Nigeria which has had a negative impact on agriculture in the country. This has resulted in mass farmers rural-urban migration which forced many agro-allied companies (such as seed companies) to shut down (Yakubu and Stephen, 2000). In Nigeria, deficiencies in supply and delivery of farm inputs, such as Government certified seeds, is one of the major problems of agriculture in the country (Adejobi *et al.,* 2005). This erratic nature of the supply of the basic farm inputs from the Government companies, could possibly account for the majority of the farmers shunning them and turning to the local markets. However, one of the key IPM strategies is prevention and this can be achieved through the use of clean certified seed. With the vast number of farmers in Zuru not having access to clean certified seeds, their seed supply could be contaminated with viruses, such as aphid-borne mosaic potyvirus (Bashir, 2002), without farmers knowing about it. Consequently an outbreak might occur which could (in addition to insect pest problems) further jeopardise yield.

Most of the farmers were using oxen drawn ploughs for primary tillage. Tillage is important in influencing sustainability of farming at crop level through its direct effect on yield and profit. It is known to be a means of eradicating weeds as well as disposing of pathogen-infested crop residues (Rattan, 1995). Ridge tillage which farmers in the savannah zones of northern Nigeria use is known to significantly increase cowpea yield and its components (Akinyemi *et al.,* 2003). Since the first demonstration of the oxen drawn plough in 1922 by the British colonial government in Nigeria, peasant farmers in northern Nigeria nowadays make extensive use of draught animals for ridging and weeding operations (Ajav, 2000; Haque *et al.,* 2000). Use of draught animals for small holder tillage operations has been known to be advantageous through its better return to land, labour and capital compared to others such as use of tractors (Abubakar and Ahmad, 2010). This method of land tillage is also known as smallholder mechanization and has the advantage of offering the farmer extra labour capacity he needs to cultivate more farmland (Ajeigbe, 2010).

Some farmers were still using the traditional hoe for primary tillage. However, this method of tillage has its drawback due to the fact that the extent of cultivated land is very limited (Dixon *et al.,* 2001). A handful of farmers were found not to carry out primary tillage before planting cowpea for various reasons such as in ability to purchase oxen as well as trying to save costs. These farmers knowingly or unknowingly were practicing reduced tillage, an important aspect of conservation agriculture through which some soil properties such as moisture is conserved. Conservation agriculture lowers production costs, increases labour productivity and spares draught animals for use in other vital activities such as transport (Jayawardena *et. al.,* 2001 and Jim and Andy, 2004). However, primary tillage when carried out properly is known to reduce herbicide usage and as such, plays a vital role in IPM (NRCS, 2002). This has also been confirmed through the focus discussions held with the farmers.

Most farmers did not use any seed dressing before planting cowpea and many considered that their cowpea emerges well even without seed dressing. Other reasons given by farmers for not using a seed dressing included fear of poisoning their poultry, lack of money to buy the seed dressing chemical and lack of knowledge of the existence of the chemicals. Despite the insistence of the farmers that lack of seed dressing had no effect on their crop emergence, it has been reported that seed dressing is a means getting good seed germination and subsequent good crop stand which is paramount to obtaining good yield. Seed dressing prevents damage due to fungal infection as well as attack due to insect pests such as bean fly, which can cause poor stands (Dugie, 2009).

Even though cowpeas are not affected by many diseases compared to other legume crops (Onwueme and Sinha, 1991), yield limiting diseases such as those due to root-knot nematodes *Meloidogyne spp.* and bacterial blight (*Xanthomonas campestris pv. viticola*) are known to attack cowpea seedlings from the soil and their effects can be minimised by seed dressing (Okechukwu and Ekpo, 2008). Fear of poisoning of their poultry which some farmers said prevented them from carrying out seed dressing, has some basis in view of the effect of chemical pesticides on non-target organisms (ICRISAT, 2005). In many African countries, cowpea is mostly grown on farmstead fields where livestock such as chicken roam about on the open fields (Walter *et al*., 2002). Use of 25% Thiram + 20% Lindane as farmers' most favoured seed dressing chemical is now coming under criticism in view of its persistent effect in the environment due to its content of Lindane (ICRISAT, 2005). Lindane is an organochloride and the use of such chemical pesticides, apart from their persistent effect in the environment, has been known to adversely affect the reproductive system of many bird species such as falcons and the golden eagles (Coulson and Witter, 1984; Flint and Bosch, 1981).Those farmers who were not using seed dressing as a result of lack of funds, are an example of the plight of peasant cowpea farmers in sub Saharan Africa in gaining access to the basic farm inputs and who do not use chemical pesticides, due to their high cost and lack of availability (Asante *et al.,* 2001; Bottenberg, 2008).

Some farmers were found to use 0.05g cypermethrin powder as a seed dressing material. In view of its contact insecticidal effect, cypermethrin could give control of damaging soil borne insects such crickets and termites but cannot control seedling disease such as damping- off diseases caused by *Rhizoctonia* sp. (Department of Agiculture, 2006) which are capable of causing major seedling damage. Control of seedling diseases is very important with respect to good yield of cowpea. Moreover, from the pesticide label, the manufacturers approved use of this insecticide in Nigeria is for indoor use such as control cockroaches and outdoor use such as control of ants. Better and more effective seed dressing means of controlling both seedling diseases and dangerous seedling insect pest have been indicated through the use of Benomyl (50%) or Carbendazine or Thiram at the rate of 3g/kg of seeds (Dugie *et al.,* 2009). Charcoal, which was used by some farmers used as a seed dressing, has a long history of use by the Amazon Indians to create a substitute to organic matter which can last for thousands of years and the end result is “soil with chemical and biological properties that converts unproductive tropical oxisols to fertile soils” (Haard, 2008). Apart from acting as a carbon sink, charcoal is known to increase soil nutrient holding capacity which is a key factor in the maintenance of soil fertility especially in the humid tropics (Glasser *et al.,* 2001). This benefit of charcoal use in agriculture as farmers’ local knowledge if studied and adapted could eventually form the building block of successful IPM programmes (Meerman *et al.,* 1997).

A majority of the farmers used intercropping as a method of planting cowpea. This type of farming practice is generally known to be the appropriate farming system for the agro-ecological zone of the West African Savannah, where rainfall is low and soils are poor. Cowpea is a shade tolerant crop and therefore does well under intercropping system such as sorghum/cowpea or millet/cowpea (Adati *et al.,* 2008). Cowpea intercropping has been known to increase the diversification of farmers food supply, suppress weeds and ensure good economic return (Shinggu, 2011). Cowpea/millet intercropping has already been found to be beneficial in that it encourages transfer of natural enemies of *Heliothis armigera* between the two crops resulting in a reduction in the pest densities (Jackai *et al.,* 1990; Youm *et al.,* 1990). However, intercropping cowpea with maize has been shown to increase *Maruca vitrata* attack, but this is less so in the case of sorghum intercropping, meaning that crop selection is vital towards reaping the reward of intercropping (Hassan, 2009). Also, cultivar type influences the intercropping success, in the sense that cowpea cultivars that have bush-type characteristics appear to give high yield under sole cropping while the spreading type gives high yield when intercropped (Olufajor and Singh, 2002).

Despite the benefits derived from cowpea intercropping, this method of cowpea cultivation has been observed to be among the factors hindering the successful mechanization of the crop in Nigeria (Ajeigbe *et al.,* 2010). With most of the farmers in Zuru cultivating the tolerant spreading variety Kanannado in intercropping manner, great potential exists for adopting IPM which for long has used the strategy as an important component (Olufajo and Singh, 2002).

Since all the farmers weeded their cowpea farms, these farmers were well aware of the importance of weeding especially at the early stages of growth. Adequate weeding of cowpea is necessary because weeds can harbour insect pests which can reduce both yield and grain quality. Cowpea is also known to be a poor competitor with weeds at the early stage of growth (Dugie, 2009). Parasitic weeds such as striga are a major cowpea production constraint in sub Saharan Africa (Asiwe *et al*., 2005). Apart from making the environment more conducive to insect pest development, lack of weeding is known to cause up to 50-60% loss in yield of cowpea (Ezueh and Amusan, 1988; Takim and Udin II, 2010; Teli *et al.,* 2011). The majority of the farmers continue to rely on the traditional hand hoe for weeding. The resource poor nature of the peasant cowpea farmers in Nigeria means that they cannot afford chemical herbicides (Bottenberg, 1995). Hoeing has traditionally been the major means of tilling the soil and control of weeds by the peasant farmers in West African agriculture and IITA (2012) noted that up to two sessions of hoeing per season, with the first one within 3 weeks after planting and the second one between 4-5 weeks after planting, are enough to control weeds in cowpea. However, this method has some drawbacks as discussed earlier and in addition, about 50-70% of the farmers labour time is spent on hoe weeding (Gianessi, 2009). Possible explanations for the small number of farmers using herbicides for control of weeds in cowpea could be that this method favours large scale crop production and it is relatively new to the farmers of Northern Nigeria where it is known to have the advantage of saving the farmers’ time by replacing the laborious hoe weeding (Dugie *et al.,* 2008). Chemical weed control can be done in the form of the application of 4-5l/ha of glyphosate under zero tillage system two weeks before planting to control all perennial weeds or use of 4-5l/ha of paraquat plus butachlor two days after sowing (Onyibe *et al.,* 2006). Despite the effectiveness of this method of controlling weed in cowpea and giving higher yields than hoe weeding, it has been known to cause of loss of plant bio-diversity by killing both weeds and other vegetation as well as favouring the development of resistant biotypes especially with the use of non- selective type (Robinson, 2009).

The main reasons given by the farmers who were using the traditional hoes plus hand picking in weeding their cowpea farms were that; it was the only method they could afford, it makes weeding easy with no damage to cowpea vines as well as hoeing at flower initiation makes the crop produce more flowers and pods. Adoption of the spreading cowpea variety (Improved Kanannado) in intercropping system makes it difficult to mechanize (Jirgi *et al*., 2010) but fairly easy to work with using the traditional hand hoe, especially when using the one with short handle. Hand picking has become necessary for those tall weeds that are not suppressed by the established cowpea canopy. Farmers recognised that there was more flower and pod formation when cowpea is weeded at flowering stage. Similar findings have already been documented by the researcher Shiggu (2011) who reported that hand hoeing of cowpea at 3 and 6 weeks after planting significantly increase the vigour of cowpea which in turn gives higher yields compared to non-weeded check plots. Farmers using herbicides plus hand picking stated that doing so reduced the number of weeding operations and gave better control of weeds. Chemical weed control is known to be more profitable than hoe weeding (Teli *et al.,* 2011) which consumes more than 50% of the farmers labour time (Gianessi, 2009), yet hand-weeding is still the most favoured farmers means of weed control in Zuru. IPM needs to find ways of making the hoe weeding equally profitable through its efficient management.

Most respondents were not using chemical fertilizers on cowpea. A possible explanation for this is the crop’s ability to fix its own nitrogen from the atmosphere thereby improving the soil fertility (Dugie, 2009). This makes its cultivation attractive to small scale farmers of West Africa who cannot purchase farm inputs such as chemical fertilizers. The crop is a known provider of nitrogen to other cereal crops when grown in rotation (Dugie, 2009). Those farmers who used manure as fertilizer were those who keep animals which are fed with the cowpea fodder (Asiwe, 2009). It has been observed that in recent times farmers are employing various techniques of soil fertility management in which manure is the cornerstone (Harris, 2002). A sustainable soil fertility trial in Niger Republic indicated that the use of three tonnes of manure per hectare can raise cowpea yield above 400kg/ha in this part of Africa where yield of cowpea at farmer level is mostly lower (Bationo, 2000). Cowpea may require the application of NPK only if the soils are poor in nitrogen and 15kg/ha of nitrogen application at the time of planting serving as a starter dose is recommended for a good crop. Application of phosphorus (30kg/ha) at the time of planting in the form of single superphosphate is more beneficial to cowpea than nitrogen since it enables the crop to nodulate well and fix its own nitrogen. Too much nitrogen causes the crop to produce more foliage at the expense of yield (Dugie *et al.,* 2009). Application of phosphate fertilizer at the rate of 30kg/ha has been reported to enhance cowpea resistance, by enhancing the crop's ability to rebuild damages and compensate losses due to insect pests such as *M. vitrata* (Asiwe, 2009).

All the farmers interviewed used insecticide and in Nigeria it is the most accepted and the most widely known means of controlling insect pests of cowpea among the peasant farmers (Egho, 2011; CGIAR SP-IPM, 2006). It has been observed that numerous insect pests attack the crop at nearly every stage of its growth and the most damaging of them are those attacking it during the reproductive stage causing a total loss in yield (Asante *et al.,* 2001). In view of its susceptibility to numerous insect pest attacks, cowpea has been regarded as a high risk crop and growing it on a large scale for commercial purpose is not feasible without insecticide application (Karungi *et al.,* 2000)). However, despite the widespread use of chemical insecticides among the cowpea growers in Nigeria, this control option is now under strong scrutiny worldwide in view of the negative effect on the environment and the farmer's health (Tamo *et al.,* 2003). It is documented that less than 0.1% of pesticide sprayed actually reaches the target pest, the rest ends up in the environment and could persist for a longer period (World Wild Life Fund-South Africa, 2012). In West Africa, insecticides which are meant for crops such as cotton are now being used on food crops, including cowpea, due to farmers' ignorance of the consequences of poisoning their food crop and themselves (CGIAR SP-IPM, 2006).

Surprisingly, farmers did not mention the use of botanical pesticides such as neem product in their fight against cowpea pests. Traditionally, farmers in Zuru have been using the leaves of *Ficus* spp. for the control of storage pest of a cowpea *C. maculatus*. The assumed superiority of chemical insecticides as propagated by pesticide merchants in the market, as well as farmers' perception of use of traditional methods as primitive, could have caused the respondents not to include the use of botanical control (Bottenberg, 1995).

A majority of the farmers who used chemical control option stated that it was due to lack of alternative means of control. Farmers' ignorance of alternatives to chemical pesticides plays a vital role in their decision to use them. It has been observed that alternatives such as bio pesticides are currently very new and not readily available to most small scale farmers in developing countries like Nigeria (CGIAR SP-IPM, 2006). Chemical pesticides are known to give cheap, quick and effective means of protecting the yield of cowpea, making their use attractive to farmers in Nigeria (CGIAR SP-IPM, 2006). It has been observed that many farmers, by virtue of their ignorance of the role played by the beneficial insects, tend to view every insect as worthy of eradication (Bottenberg, 1995). A few farmers gave the reason for their use of chemical control as a desire to eradicate all damaging insect pests from their farms. Farmers need to be aware that it is not possible to eradicate all pest populations, since they are part and parcel of the ecosystem and any attempt to entirely wipe out pests through the massive use of chemical insecticide, will only lead to more serious pest problems (The World Bank, 2011). The most widely used chemical insecticide among the farmers was the mixture of cypermethrin 30g/L and dimethoate 250g/l applied using tank dose rate 60mls and 7 spray regimes per season, which is not in accordance with the manufactures recommendation. From the pesticide label, this insecticide has been recommended for spray on a needs basis at the rate of 1l/ha or concentrate tank dose of 75-80mls per 15 litre knapsack load. This shows that the farmers were under- applying the insecticide and were not respecting the need based recommendations of the manufacturer. Lack of respect for recommended spraying dose and frequency has been known to result in hazardous pesticide application practices (Tamo *et al.,* 2003). Subsequently, this may lead to ineffectiveness of the insecticides due to the development of resistance by the insects (Fredric, 2008). In addition, this insecticide belongs to the organophosphate group (OPs) whose unrestricted use as the farmers were doing, could cause negative effect on the ecosystem and public health (World Resource Institute, 1999). OPs are known to have acute toxicity in man and the World Health Organization estimated that there are up to three million cases of pesticide poisoning and 20,000 unintentional deaths each year, mostly in the developing countries (Meerman *et al.,* 1997). Documented literature has shown that organophosphate insecticides harm the *Chilocorus* ladybird beetles which are important predators of scale insects (Kraiss and Cullen, 2008).

Trying to prevent insect pests from quickly returning after spraying was found to be the major reason that makes the farmer spray the mixture of cypermethrin 250g/L and dimethoate 300g/L up to seven times per season. The quick return of insect pests after spraying insecticide could be attributed to the eradication of parasitoids and predators, thereby leading to target pest resurgence. This is a situation whereby eradication natural enemies due to pesticide application leads to rebounding of target pest populations (Maxwell, 2013). Under normal circumstances the natural enemies activity keeps insect pest populations below damaging levels (Dufour, 2001). This type of farmers' action which negatively affects the natural control, could lead to pesticide dependence as the farmers rightly find themselves (Martern and Williams, 2006). Quick return of insect pests which the farmers fear could also be an indication of the development of resistance. It has been observed that cypermethrin and dimethoate are losing their effectiveness, as a result of the resistance developed against them by some damaging insects such as *M. vitrata* (Ekesi, 1991). Since farmers lack unified insecticide spraying, pest immigration from neighbouring untreated farms could also be a contributing factor to the quick return of insect pests as farmers complained. The farmers desire to obtain good yield and high quality bruchid free cowpea grains was a second reason given for the high frequency of pesticide application. Despite the fact that earlier literature has shown that chemical insecticide sprays in cowpea increased yield as much as 200% (Ajeigbe *et al.,* 2012), this could be at great cost to the environment. Consumer preference studies show that cowpea buyers have zero tolerance to insect damaged cowpea grains and bruchid holes have a negative impact on price of cowpea grains (Gomez, 2004). Such consumer bias attached to insect damage may encourage farmers to use more pesticide than is required. Another possible explanation for the high frequency of pesticide usage by the farmers is the indeterminate nature of the variety of cowpea the farmers are mostly using which has a long flowering period (Dugie *et al.,* 2009).

Only a few of the farmers were using Cypermethrin 10% EC at the tank dose rate of 150mls per 15 litre knapsacks load at the frequency of four applications per season. Even though research works such as those of Egho (2011), clearly indicated the effectiveness of Cypermethrin in controlling insect pests in cowpea, as well giving high yield, this insecticide is a broad spectrum synthetic pyrethroid with contact effect and is known to kill even the beneficial insects (Cornell University, 1993) . Despite the fact that the insecticide is only moderately toxic to humans by skin contact, it has been found to be highly toxic to bees and extremely toxic to fish and other aquatic invertebrates and is also classified as a Restricted Use Pesticide (Cornell University, 1993). Farmers carrying out 2 spraying operations gave reasons for their actions which were almost close to the IPM's principles of judicious use of chemical pesticides when conditions warrant their use, since their reason for the frequency of pesticide application strategy relies on pest population build up. Despite the fact that these farmers applying 2 sprays monitor the pod sucking bugs population before spraying, such spraying exercise is still not judicious from an IPM point of view, as it does not adhere to the standardised action threshold (Afun *et al.,* 1991). Action threshold of the various damaging insects pests of cowpea have been developed by experts, e.g. the pod sucking bugs, such as green stink bugs (*Nezera viridula* (L.) have an action threshold of 5000/ha (University of Florda Institute of Food and Agriculture, 2010). Also the type of insecticide used (broad spectrum type) is not IPM compatible, in view of its non-selectivity therefore having negative effect non-target organisms such as the beneficial insects e.g. bees (Cornell University, 1993). With most farmers using broad spectrum insecticides in cowpea cultivation in Zuru, the major challenge to a successful IPM adoption, will have to focus on equally effective alternative means of control that are devoid of all the risks associated with the chemical controls.

The majority of the pesticide users had one problem or another with regards to the type of insecticide they were using and the major one was the ineffectiveness compared to its previous known performance. Several factors can cause ineffectiveness of pesticides, including: lack of matching insecticide with the type of pest, improper dosage, wrong timing of the application, development of insect resistance, old insecticides that have not been properly stored as well as lack of following the instructions on the insecticide label (Ralph, 2008). Since the farmers' main sources of pesticide supply were the merchants in the local market, there is a possibility that the pesticides could lose effectiveness due to improper storage in the local market.

4.5 CONCLUSIONS

The majority of the farmers are smallholders who are most likely to be resource poor. This level of farmers is expected to benefit most from IPM strategy that utilizes alternative to chemical insecticides as external input. Farmers neglect of preventive measures through sourcing their seed supply from the local market. As a consequence their cowpea crops stand the risk of potential disease epidemics. This will necessitate farmer education with regards the important preventive measures as an IPM component capable of controlling seedling diseases. Farmers' reluctance to use fertilizer in their cowpea cultivation is a clear indication of their ignorance of the favourable response of cowpea to the application of the appropriate fertilizer. Farmers need education on the role of the use of recommended fertilizer can increase their potential yield of cowpea.

Farmers might be lacking the knowledge of alternative control options as indicated by their total reliance on the use of purchased commercial insecticide on cowpea. The most commonly used insecticide being a pre-mix of cypermethrin and dimethoate which has no selective activity meaning both the farmers' health and the environment are at risk. Frequent spraying of this insecticide as an 'insurance' against losses to insect pest was common practice with 7 sprays per season being widely used. Farmers might not be aware of the link between this massive use of broad spectrum insecticide and reduced natural control exerted by predators and parasitoids which could directly affect the efficacy of the insecticide as they now witness. They believed that the insecticide was becoming less effective which might also indicate the development of resistance in *M. vitrata*, necessitating the need for farmers to be educated on the use of IPM strategy. None were previously aware that neem could be used to control pod borer possibly due to the presence of cheap chemical insecticides in the market and which might be toxic. Both the farmers and the extension officers need education on alternatives to chemical insecticides using botanicals with proven insecticidal activity against *M. vitrata*, such as neem which is found all over Zuru local government area.

Lack of young people in cowpea farming in Zuru might signal a bleak future for farming in the area unless the trend is reversed, through drastic government intervention. Government intervention through pumping more incentives into agriculture in order to attract young people in the profession could arrest the situation. By eliminating drudgery in farming, through the introduction of modern farming equipment as against the traditional method, government may help make farming attractive to this energetic age group of people. The fragmented nature of the cowpea farming system in Zuru could hamper mechanized commercial large scale growing of the crop. However, this modern farming system is still feasible if farmers can be organized into cooperative groups so that modern machinery can be introduce in the cowpea farming system which will enhance productivity.

CHAPTER FIVE: FARMERS' PERCEPTION OF PESTS AND PESTICIDE IN ZURU

5.1 INTRODUCTION

Cowpea is considered a high risk crop whose cultivation on a large scale is not feasible without chemical pesticide protection. Application of chemical insecticide if not used judiciously could lead to ineffectiveness of control with many negative impacts on both farmer health and environment (Isubikalu *et al.,* 1999). With the advent of IPM, this chemical control measure is now considered socially unacceptable and can only be used when no other options are at hand. Among the objectives of IPM is to eliminate or limit the use of chemical insecticides in pest control. The cumulative farmers' knowledge and experience with regards to crop production can be a source of useful information upon which successful IPM control strategies can be developed (Isubikalu *et al.,* 1999) However, IPM has no single prescribed formula and the strategy that works in one location may not necessarily work in another location. Lack of understanding of farmers local knowledge, perceptions and practices has been known to be a very important constraint in IPM development and adoption (Van Mele *et al.,* 2002) Understanding the rationale behind farmers insecticide usage and the targeted pests will enable the development of a suitable IPM control strategy for farmers usage. This focus group interview was therefore conducted in order to gain more insight into the data collected through the questionnaire. This would facilitate broader understanding on the farmers' perception on pest and pesticides in Kebbi state of Nigeria, so as to enable the development of a safe, economical and sustainable alternative control option the form of the Integrated Pest Management (IPM) against *M. vitrata* a key insect pest of cowpea in the state.

5.2 MATERIALS AND METHODS

Twelve farmers from among those that have answered the questionnaire were selected randomly to attend the focus group interviews meant to gather the needed information. For more details see general methodology.

5.3 RESULTS

5.3.1 Farmers perception of field insect pests of cowpea

When farmers were asked to clearly state their most important of the numerous cowpea production constraints, the majority (Table 5.1) gave such answers as "our biggest problems with cowpea are the insects that damage it"; "Even market women selling cowpea grains will tell you that insects are the major problem of cowpea"; "No insect pests, no problem with cowpea cultivation". Three farmers among those cultivating 1ha and below (group A) considered finance as their number one cowpea production constraint (Table 5.1). When asked why some of them decided to choose finance as their primary production constraint, two of them replied "How can you farm nowadays without money?" and "Tangible farming means money nowadays". Further inquiries were made on why some farmers consider weather as their number one production constraint. One farmer from those cultivating 2-3ha (group B) replied that "these days rain used to cease prematurely which is affecting our cowpea yield".

Table 5.1Farmers perceived single most important cowpea production constraint

Type of production constrain	**Farmers group**			**Total**
	A	**B**	**C**	
Insect pests	1	2	4	7
Diseases	Nil	Nil	Nil	0
Weather	Nil	2	Nil	2
Finance	3	Nil	Nil	3
Parasitic weeds	Nil	Nil	Nil	0

Farmers were asked to rank the numerous insect pests of cowpea in accordance with the severity of damage caused. The various responses obtained were subjected to voting and the insect that received the highest vote was considered the number one most damaging insect. After, the next named insect was also subjected to vote in order to qualify as the second most damaging insect. Remarks about the nominated insect pest were recorded in order to further buttress the farmers' perceived ranking. Added to the votes obtained and through such remarks "flower worms (*M .vitrata* larvae) are the worst", "Is there any insect worse than flower worms?" and "until you have the flowers before you have the yield" from 11 out of 12 farmers, *M. vitrata* was considered as having been nominated by the majority of the farmers as the number one most damaging insect pest of cowpea against which they sprayed chemical insecticides (Table 5.2). The same procedure was followed to determine the rank of other insect pests as per farmers' perception. When farmers were asked if they knew the link between the so called worms (*M. vitrata* larvae) and a picture of an adult *M. vitrata* presented to them, some laughed and said *Bilbiline* meaning it is a butterfly, others gave the following answers "we do not know", "how do we know" . When farmers were asked if they know a particular crop or plant apart from cowpea that *M. vitrata* attacks, most of the participants gave such answers as "I have not seen" and "No". When farmers were asked if the know the time of arrival of the larvae during the season answers such as "They do not come until the crop starts flowering", "It is the flower scent that attract them to the crop" were obtained. Farmers were asked if, apart from flowers and pods, they know any other part of the plant attacked. Most of them gave such answers as "I did not notice", "I do not know". The complex of pod sucking bugs came second in farmers rating (Table 5.2) of the most damaging insect pests of cowpea. Nine out of 12 farmers indicated this through nomination and such remarks as "maikaho (Insect with horns) come next". Farmers gave them the name "insects with horns" due the two spines they have.. Farmers also gave them the name "Overcoat follows" in view of their appearance as if wearing coats.

According to farmers' ranking, the third most damaging insect pests were the thrips which farmers called *Bakin kuda*, meaning black flies. Seven out of 12 farmers ranked these insects as third among the damaging insect pests of cowpea (Table 5.2). Eight out of 12 farmers ranked Blister beetle (*Mylabris puntunata*) which farmers called *Bobo* as the fourth in damage severity ranking (Table 5.2). These farmers who ranked these insects as number four in damage severity were further questioned on their nature of cowpea cultivation. Responses such as "I do plant cowpea with maize and ground nuts" and "I grow cowpea with Sorghum and maize" were obtained. When these farmers were asked if they knew that there was a link between their farming system and the severe attack by Blister beetles, most of them gave such answers as "I do not know" and "I cannot tell". The fifth most damaging insect of cowpea according to farmers' ranking, were aphids (Table 5.2). They were also found to have good knowledge of the period of arrival of these insect pests. Farmers were also aware of the migratory nature of these insects, as one farmer in group C stated that "I do not consider *Bakin kaska* (aphids) to be a problem since only when you plant cowpea late that your crop gets into problems with them". Eight out of 12 farmers ranked the leaf feeding beetle *Ootheca mutabilis* which they called *Jan buzuzu*, meaning red beetle, as the sixth in damage severity ranking (Table 5.2). The pod borer complex came seventh in farmers perceived damage rank. Farmers were also aware of the time of arrival of these pod boring larvae, as one farmer in group C stated "You start seeing them when the pods are matured".

Further investigation revealed that farmers also knew the most damaging among the pod borers. Two farmers noted that that “green larvae are the most damaging”, “green larvae are the worst”.

Table 5.2 Farmers ranking of some important insect pests of in terms of severity of damage caused

Insect pest	Farmers group			Total
	A	**B**	**C**	
Maruca vitrata Fab	3	5	3	11
Thrips (*Megalothrips sjostedti* Trybom)	2	1	4	7
Leaf feeding beetle (*Ootheca mutabilis* Sahlberg)	2	2	4	8
Blister beetle (*Mylabris pustulata* Thurnberg)	4	0	2	6
Pod borer complex (*Helicoverpa. armigera, Spodoptera. Littoralis*	3	2	2	7
Aphids (*Aphis craccivora* Koch)	1	4	3	8
Pod sucking bug complex (*Anoplocnemis curvipes* Fab., *Riptortus dentives* Fab., *Nezara viridula* Linnaeus, *Clavigralla. tomentosicolis* Stal.)	4	1	4	9

Farmers were also found to have an excellent knowledge of the feeding habit as well as the yield loss due to pests. A typical example was the description of the damage symptoms due to *M. vitrata* feeding (Table 5.3) which farmers noted that “It perforates flower and eat it from inside and cause it to rot and fall”. They accurately quantified damage and yield loss which they estimated to be 9 out of 10 bags converted to 90% yield loss (Table 5.4). They gave a good description of the characteristic feeding of pod sucking bugs (Table 3) as well as a good estimate of damage due to them as reaching up to 8 out of 10 bags (80%) loss in yield (Table 5.4). Further investigation revealed that farmers were quite aware of the time of arrival of these insect pests of cowpea, as one farmer among those cultivating 4ha and above (group C) stated that “you start seeing them at the time of flower buds formation”. Farmers also described the characteristic feeding and nature of damage caused by these insect pests (Table 3). Reduction in yield due to thrips was said by the farmers to amount to 8 out of 10 bags (80%). Farmers gave an estimate of loss in yield due to Blister beetles as 7 out of 10 bags (70%) with the characteristic feeding as perceived by the farmers shown in Table 5.3

Farmers estimated yield reductions due to aphids as 4 out of 10 bags, which was converted to 40%. However further investigation revealed that farmers were not aware of the link between aphid feeding and cowpea diseases such as the yellow mosaic. Farmers call the disease *kuturun wake* meaning dwarf cowpea crop. Farmers rightly observe the presence of honey dew due to aphid feeding on cowpea which as one farmer in group B said as "causing diarrhoea to sheep and goats when they are fed with hay contaminated with the honey". They also observe the perforated nature of the cowpea green leaves as a result of the activities of the leaf feeding beetles (*Ootheca mutabilis*). These farmers noted the slow growth of the crop (Table 5.3) due to beetles feeding which most authors did not mention in their findings. Damage due to these insect pests was perceived to be 2 out of 10 bags when in large numbers (20%)(Table 5.4). From the farmers' point of view, under small numbers, damage due to these pests was not as serious as that due to those insects attacking cowpea at the reproductive stage. When the disease was described to them, farmers were not aware of the link between cowpea yellow mosaic usually encountered at the early season in Zuru and *Ootheca mutabilis.* However they quickly recognise the disease symptom. One farmer from group A stated that "why we did not worry about it when we saw it was that the crop recovered with time as long as the rain continued".

Pod borer which farmers called *Tsutsan wake* meaning Pod boring larvae were perceived by the farmers to "bore into mature but not yet dry pods and consume some portions of the seeds". Damage due to pod borer complex has been perceived by farmers to amount to 3 out of 10 bags converted to 30% (Table 5.4). Farmers (Plate 10) correctly observe the nature of feeding of pod borer complex (Table 5.3).

Plate 10 Taking participants details during interview

Table 5.3 Farmers recognition of the damage symptoms due to insect pests

Insect pest	Farmers damage symptom recognition
Pod sucking bug complex (*Anoplocnemis curvipes* Fab., *Riptortus dentives* Fab, *Nezara viridula* Linnaeus, *Clavigralla tomentosicollis* Stal.).	Suck juice from immature pods and cause them to shrink and dry.
Maruca vitrata Fab.	It perforates flower and eat it from inside and cause it to rot and fall. Also join mature pods together and eat them.
Thrips (*Megalothrips sjostedti* Trybom).	Cause flower to dry and fall without bearing pods.
Leaf feeding beetle (*Ootheca mutabilis* Sahlberg)	Perforate the green cowpea leaves which cause the crop growth to be slow.
Blister beetle (*Mylabris pustulata* Thunberg).	Eat the flower from inside causing it not to bear pods
Pod borer complex (*Heliothis armigera* Hubner and *Spodoptera littoralis* Boisd	They bore into mature but not yet dry pods and consume some portions of the seeds
Aphids (*Aphis craccivora* Koch)	Stick to the vines and pods in black large numbers and cause honey on the crop making it not to spread well.

Table 5.4 Farmers estimate of the maximum quantity of crop yield losses due to insect pests if not controlled

Insect pest	Farmers estimate of level of yield loss
Pod sucking bug complex (*Anoplocnemis curvipes* Fab., *Riptortus dentives* Fab, *Nezara viridula* Linnaeus, *Clavigralla tomentosicollis* Stal.).	8 of 10 bags (400 of 500kg = 80%)
Maruca vitrata Fab.	9 of 10 bags (450 of 500kg = 90%)
Thrips (*Megalothrips sjostedti* Trybom).	8 of 10 bags (400 of 500kg = 80%)
Leaf feeding beetle (*Ootheca mutabilis* Sahlberg)	2 of 10 bags (100 of 500kg = 20%)
Blister beetle (*Mylabris pustulata* Thunberg).	7 of 10 bags (350 of 500kg = 70%)
Pod borer complex (*Heliothis armigera* Hubner and *Spodoptera littoralis* Boisd	3 of 10 bags (150 of 500kg = 30%)
Aphids (*Aphis craccivora* Koch)	4 of 10 bags (200 of 500kg = 40%)

Table 5.5 Details of farmers' chemical insecticide usage

Type of insecticide	Farmers group			Total
	A	B	C	
Dichlorvos 100% EC (Novan) mixed with Cypermethrin 10% EC (Best)	2			2
259g/L Lamda Cyhalothrin +100g/L Cypermethrin (Sting) plus 15/L LamdaCyhalothrin + 300g/L Dimethoate (Magic force).		3		3
30g/L Cypermethrin + 250g/L Dimethoate (Uppercott)			4	4

5.3.2 Farmers perception of pesticides and pesticide application

When the farmers were reminded by the author on the insecticidal usage of some plant products such as *Ficus* spp. leaves in Zuru, two farmers from group B replied, "Before chemical pesticides were introduced in Zuru *Kmo* (*Ficus* spp.) leaves are used to protect cowpea from storage insect (*Callosobruchus maculatus*) damage while in Rhumbu (Store)", "Yes our fathers were really using *Ficus* spp. leaves to protect cowpea in storage but we do not know whether it will work for insects on the farm". Based on the author's experience, the attention of the farmers was drawn to just a few years back before the introduction of chemical pesticide in the study area when cowpea was doing well even without sprays. In response to this, one of the farmers from group A replied that "those days insect pests were not as numerous as the present day".

When farmers were asked about the source of their pesticides, 10 out 12 gave such answers as "I do purchase them from the market" and "I obtained mine from the market". The other two farmers replied "we got them through the government agricultural extension officers". Further questioning was made on why the farmers did not buy insecticides from the government stores. These farmers laughed and gave the following answers "If I am to rely on the ones supplied by the government then I will not farm", "Who do I know that will get me the insecticide from the government stores." Farmers who were cultivating 2 – 3ha (group B) were using two separate chemical insecticides per season (259g/L Lamda Cyhalothrin + 300g/L Dimethoate (Sting) and 15/L Lamda Cyhalothrin) + 300g/L Dimethoate (Magic force) (Table 5.5). When these farmers where asked why they were using two separate insecticides per season, one of them replied that "We used to spray Sting 2 times, first at the initiation of flower, and then we followed again with Magic Force also twice". When asked what the rationale behind the use of these two insecticide one after the other was, another farmer from the same group replied that "Sting makes cowpea to produce more flowers while

Magic Force makes the crop to produce large pods with large seeds". Farmers were found mixing two separate insecticides (Dichlorvos 100% EC (Novan) mixed with Cypermethrin 10% EC (Best) in ratio 1:1) (Table 5.5). When these farmers were asked why they mixed the two insecticides, one of the farmers from group A replied that "I used to have better control of the entire damaging insect when I mixed the two". Another farmer from group A doing the mixing culture stated that "If I apply the mixture of the insecticides it will take a lot of time before damaging insects come back". Further questioning was done on how the farmers did the mixing and one of the farmers replied that "I put some water in the sprayer tank first then I measured half peak milk tin of one of the pesticide and pour in the tank the same I do to the other; then I close the tank and shake well before filling it with water". Further investigation was made into how the farmers come about this idea, and one of the farmers stated that information was given "from the pesticide merchants in the market". When asked why the farmers were not liaising with the government extension agents, all the farmers laughed and one replied that "merchants are friendlier and more knowledgeable about insecticides than the extension officers".

Investigation revealed that none of the farmers doing the mixing was educated so that he could read the pesticide label, and from all investigations these farmers had no idea of the implication of the use of chemical pesticides on the environment. When the participants were asked if they know that these insecticides they are using could contaminate the water from the local stream they were using some answered "no" while others asked "how can that happen?" Next when they were asked whether they knew that long term exposure to these insecticides could affect them later in life through manifestation of diseases such as birth defects again the farmers answered "no" while others kept silent except one farmer from group C who said that "the only thing he knew was that they can cause stomach problem when you inhale it too much". Also when farmers were asked about their knowledge of predatory insects, example of which such as mantis and wasps were described to them, all the farmers recognise them. Further investigation was made on their knowledge of the role played by these insects on their farms. 11 out of 12 farmers indicated ignorance about their role through such answers "I just consider them as damaging insects because I don't know what they do on my farm" and "I am not aware about any of their functions so I take them to be damaging insects too". The remaining one farmer stated that "these insects help to eat other damaging insects on the farm". When this farmer was asked whether he took some measures to protect them, for example through using selective insecticide since he knew their benefit, he replied “no”. This farmer as investigation revealed holds a diploma in agriculture and therefore could have obtained the knowledge of the beneficial insects during his training years.

5.3.3 Farmers cases of insecticide poisoning

When farmers were asked whether they had any negative encounter with chemical insecticide, two farmers replied “Yes”. Again when these farmers were asked to state the type of negative encounter they had with chemical insecticide, one of them replied “My stomach pained me and swelled up after mixing of insecticides”; the other said “I had my back skin burned after the cover of my sprayer accidentally opened while I was spraying”. When these farmers were asked if they referred these cases to the hospital, the farmer with stomach swelling replied that “It is not small case like this that will make me go to see the doctor”. The other farmer also replied that “we have our traditional remedies for skin burn”. Further investigation revealed that these two farmers belong to the group cultivating 1ha and below and they were the people who sprayed mixtures of Dichlorvos 100% EC (Novan) mixed with Cypermethrin 10% EC (Best) in ratio 1:1). When the participants were asked whether they used some body protection before embarking on mixing insecticide or while spraying, they gave various answers such as “we did not buy them” and “we don’t have them”. Only one farmer who was a diploma holder in Agriculture from group C said “I use to cover my nose with a shield given to me by a road construction worker”.

Each of the two farmers with cases of pesticide poisoning in the absence of hospital referral did take some alternative remedial measures with the hope of relief as investigation revealed. These measures were “I took a mixture of peak milk and table salt for swollen stomach” as well as “I applied shear butter oil for skin burn”. The farmers considered these treatments to be effective. When these farmers were asked how they came about these remedies the farmer with stomach problem said “I was told by another farmer who witnesses the incidence”. The other farmer with burns said “That is our traditional remedy for burns”. Problems were encountered by the farmers with regards to the type of insecticide used as investigation showed. When farmers were asked to state these problems answers such as “Before I can take up to three weeks interval between sprays but now it is no longer possible insect will come back 5 days after spray”. “You see that *tsutsan fure* (*M. vitrata* larvae) and “Overcoat” (*Riptotus dentives*) do not die when you spray them with insecticides, they only run away from the farm and come back as soon as the odour of the insecticide goes”. “Dealers constantly introduce new insecticides and when you ask about the particular insecticide you have been using, they will say it is out of stock but if you so wish to have it then you have to pay higher price than before and they will bring it for you later".

5.4 DISCUSSION

Farmers' statements regarding their most important cowpea production constraint indicated that insect pests were their main biological constraint in the study area. Opolot *et al.*, (2006) concluded that in sub Saharan Africa insects are the most important yield limiting factor of cowpea cultivation. Nearly every stage of cowpea growth has some insect pests attacking it (IITA, 2009). Some farmers cited finance as their major cowpea production constraint. Small scale growers in sub Saharan Africa are faced with numerous constraints, such as financial inability to obtain the basic farm inputs like chemical pesticides (Langyintuo and Lowenberg-Deboar, 2006). As these farmers rightly said, premature termination of rains was a production constraint. Although cowpea is a drought tolerant crop, yield can be adversely affected if it does not get well distributed rainfall within the growing period and unreliable rainfall can adversely affect its production (Agriculture Forestry & Fisheries Department, 2011). However, these farmers could possibly be growing the local variety instead of the improved varieties which have been developed to withstand drought. Both the improved Kanannado and other hybrids such as IT89KD-288 and IT89KD-391 which are introduced in Nigeria are considered superior to local varieties in terms of resistance to drought (IITA, 2010). Farmers' agreement that *M. vitrata* is the most damaging insect pest is supported by Agunbiade (2012) who noted that *M. vitrata* is a major cowpea production constraint in Nigeria. Famers' inability to link the photograph of the adult of this pest with the larvae and their lack of knowledge of other crops attacked beside cowpea, was a clear demonstration that farmers were lacking the knowledge of the biology of the number one named enemy of their crop, as well as the role played by the alternative hosts in its abundance.

Farmers' description of the feeding nature of *M. vitrata* included symptoms such as perforations on flower, joining of pods and rotting of flowers. All literature sources agree on boring of exit hole with dirty frass as a symptom of *M. vitrata* cowpea flower feeding. However, the apparent rotting of the flower was what farmers did not understand to be the faecal material produces by the pest as it feeds on the flower. Farmers' inability to know other parts of cowpea plant attacked by this pest possibly showed that farmers were so much concerned with the damage to flowers and pods without checking the damage on leaves and other terminal shoots. *M. vitrata* feeding is known to start at the terminal shoots before spreading to the reproductive structures of cowpea (Ganapathy, 2010). Farmers quantifying of percentage yield loss (up to 90%) due to this particular insect pest was correct. Even though most authors such as Ezezika and Daar (2012) put the figure as up to 80% loss in yield which is a little below the farmers estimate, farmers estimate is still quite accurate in view of the fact that they have no formal education or laboratory in which they could experiment and derive the mathematical quantifications. Moreover, authors such as Tanzubil and co-workers (2008) even reported damage due to *M. vitrata* in the West African region as reaching up to 100% loss in yield. Farmers ranked pod sucking bugs as second to *M. vitrata* as a damaging insect of cowpea and their estimate of yield loss due to them was also correct. Agunbiade and co-workers (2012) reported that these insect pests inflict a lot of damage to cowpea by attacking it at the reproductive stage causing as much as 80% loss in crop yield in Nigeria. Researchers Tanzubil and co-workers (2008) noted that throughout West Africa, farmers have reported complete loss in yield due to pod sucking bug complex. Similar findings are documented by Dzemo and co-workers (2010) who noted that pod borer *M.vitrata* and pod sucking bug complex comprising of *C. tomentosicolis* and *Anoplocnemis curvipes*, remain the most damaging insect pest of cowpea in South Africa, attacking the crop at the reproductive stage causing extensive damage. Thrips nomination as the third most important pest is also supported by the literature. It is documented that in West Africa it is not uncommon to find farmers complaining of complete loss in cowpea yield due to thrips damage (Ayodele and Kumar, 2010).

The importance of blister beetles as fourth most damaging pests of cowpea may relate to the type of farming systems. All these farmers with blister beetle problem intercropped cowpea with maize. Dugie and co-workers (2009) noted that large numbers of blister beetles in cowpea could cause 100% crop failure and these insects are attracted to the crop due to the presence of maize pollen, as a result of cowpea maize intercropping. Aphids were considered the fifth most damaging insect pest and the stunted nature of cowpea growth due to aphids feeding on pods and vines as farmers observed, has also been reported by Ayodele and Kumar (2010). These authors showed that aphids suck sap from cowpea leaves, pods and other aerial parts of the crop resulting in substantial loss in yield. The farmers perceived yield loss due to aphids (40%) was somehow higher in comparison to what had been reported in other parts of Africa. In a three seasons research in eastern Uganda, yield loss in cowpea due to aphids was estimated at16.2% (Karungi *et al.*, 2000) Farmers rightly observed the honey dew associated with aphids feeding on cowpea, as well its negative effect on their livestock.

The Queensland Government (2010) noted that aphid attack on cowpea produces honey dew that produces sooty mould which reduces the crop photosynthesis and makes harvesting difficult. Farmers also noted the time of abundance of these pests as corresponding to their attack on late planted crops, indicating that they come at the late season. This farmer's finding is also supported by Egho (2011) who reported the abundance of these insect pests late in the season in Asaba, Delta State of Southern Nigeria.

Farmers' nomination of the leaf feeding beetles *Ootheca mutabilis* as the sixth must damaging insect pest of cowpea has some grounds. The work of Oso and Falade (2010) also indicated that *Ootheca mutabilis* are important pests of cowpea in Nigeria. The description of the type of damage done to the crop by these beetles, as well the good estimate of the yield loss due to them, demonstrated that farmers were well aware of the impact of various insect pests on their much valued crop. Authors such as Ekesi (2001) noted similar effects of beetle feeding, while the crop is in the vegetative stage (leaves still young and green). Farmers rarely attempted to control the beetles, on the grounds of the crop's ability to recover, as long as moisture is not lacking. Similar findings have been documented by Nabireye and co-workers (2003) whose work reported that cowpea is known to compensate by re-growth, for all the early season damage due to beetle feeding making any control measure due to this insect unnecessary.

Farmers perceived the pod borer complex as number seven in rank as most damaging insect pest of cowpea. Abdou and Abdalla (2006) reported that damage to cowpea by the pod borer complex comprising of *H. armigera* and *Etiella zinckenella*, is so serious as to have considerable impact on yield, in the newly reclaimed parts of the desert in Egypt. The description of the feeding nature of pod borers which farmers reported as boring on matured but not yet dried pods and consuming some portions of seed was correct. This means they do leave behind some portions of the attacked seeds and it is these leftover portions that researchers are looking for, as well as the nature of the entry holes, when they are assessing seed damage due to some of these insect pests. Among the pod borers, farmers noted that the green one was the most damaging. The green larvae as farmers observed were found to be *H. armigera* larvae and past works such as that of Egho (2011) noted that they are among the most serious insect pests of cowpea in Nigeria. This shows that they do considerable damage to cowpea causing some substantial yield loss. Thus this is a proof that the local farmers, even though lacking the modern education, are good observers and field evaluators, a skill considered vital in crop loss assessment and subsequent decision on necessary pest control actions which is very vital in IPM.

Through the various responses obtained, it was clear that these farmers have inherited an effective traditional botanical (*Ficus* spp.) for control of some field to store insect pests of cowpea which could possibly be effective against *M. vitrata* but has now been abandoned. Dreves (1996) noted that as pesticides were introduced in Africa many effective traditional control methods were lost and chemical pesticides became the sole tool of pest control. Farmers recalled that in those years before the introduction of chemical pesticides cowpeas were doing well, even without chemical protection. Their reaction towards this memory was only to declare that in those days there were no damaging insect pests in comparison to the present day. If in those days when pesticides where not used, there were no damaging insects, the presence today of damaging insects might suggest a link to chemical pesticide usage. The farmers' total reliance on chemical pesticides for control of insect pests in cowpea could be due to the fact that chemical pesticides have been known to be the most dependable means of controlling insect pests in cowpea once their populations have exceeded the economic injury level (Asiwe *et al.*, 2005). Their responses to the inquiry on why they relied on the merchants at the local market for the supply of insecticide instead of the government stores clearly pointed to the deficiencies in the government supplies of farm inputs.

All the farmers owning farmlands of 4ha and above were using the broad spectrum insecticide mixture 30g/L cypermethrin + 250g/L dimethoate applied as many as 7 times per season. Farmers' responses to an inquiry on how they came about the idea of spraying seven times, pointed at the pesticide merchants. It has been observed that in Nigeria private extension services with regards to pesticides were dominated by the pesticide dealers who are very aggressive towards promoting the use of pesticides. Many people in both rural and urban areas of the country are engaged in pesticide retailing with little or no training on agro-chemicals. They usually engage in all sorts of malpractices including giving farmers poor advice (Nyambo and Youdowei, 2007). Therefore it is not surprising why the farmers patronise them for supply. This may suggest that government intervention might be needed in the area of pesticide trade so that only trained and licenced persons in the aspect of chemical pesticide are allowed to sell them. However, the incorrect dosage and frequency of pesticide application imposed on these local farmers is a matter deserving the attention of the local authorities in Zuru.

Farmers were found to be mixing two different insecticides (75 mls Dichlorovos 100% EC mixed with 75mls Cypermethrin 10% EC) by themselves. Farmers' main reason for the mixing was to obtain better control of insect pest. Of course it has been observed that mixing two or more insecticides has some benefits through saving time and labour. Provided the two insecticides are compatible, this usually happens as a result of applying the two insecticides at once instead of separately. Also, sometimes one pesticide may not work well when applied alone on a particular pest but when mixed with another the total activity will be very effective. It is very important to read the labels of the insecticides to be mixed to ensure that they are compatible (University of Illinois, 1999). Moreover tank mixing of two emulsifiable concentrate insecticides as the farmers were doing, requires certain knowledge such as that of compatibility which need to be fully understood by the farmer before commencing. Signs of incompatibility include deactivation of the active ingredient or the mixture may form crystals and lakes which may block the nozzles of the sprayer (OVS, 2012). Also whenever insecticides are to be mixed there is a general guide line which governs the procedure Dreves (1996). However the implication here is that most of these farmers had no formal education as to read and find out whether the insecticides they were mixing were compatible or not. In response to the inquiry on why the farmers resorted to pesticide merchants on procedures for the mixing, merchants knowing more about pesticide than the government extension officers was the answer obtained. Farmers may have some basis here for underrating the extension officers. In another related incidence during a safety research study carried out in south eastern Nigeria more respondents claimed knowing about pesticide safety through friends and relatives than the government agricultural extension officers (Udoh, 19980). The issue of merchants knowing more about insecticides than the government paid extension workers appear to be a wonderful revelation from the farmers. However, a possible explanation for this is the issue of decreased funding of agricultural extension by the various governments in Nigeria causing a general downward trend in the quality of extension services and delivery (Abdullahi and Stigter, 1999). Merely taking the advice of the merchants by the farmers on how to do the mixing might not be the right idea. Merchants could be only interested in selling their product not the safety of the farmers. The farmers' response on the inquiry on their knowledge of the long term side effects of chemical insecticide on their health showed complete ignorance on the issue. Dreves (1996) also noted that when pesticides were introduced in the developing countries (such as Nigeria) farmers were not educated on their side effects on their health and the environment.

Some farmers reported they had experienced pesticide poisoning and, in view of the types of incidences, this was an indication of lack of taking safety precautions through use of protective clothing before spraying insecticides. It appeared that pesticide dealers were only interested in selling their products without properly educating farmers on safety measures as well as knowledge of consequence of pesticide poisoning. All these farmers with these negative incidences have not used protective devices such as hand gloves, face shield or suitable clothing such as thick long sleeved coverall which are recommended while mixing or applying chemical insecticides (Federal Ministry of Agriculture and Natural Resources, 2012). FAO (1990) noted that a leaking knapsack sprayer causes contamination of clothing and skin, which is the worst form of pesticide contamination compared to inhalation. Even though farmers gave their various reasons for not using protective clothing, the underlying causes are not far to be fetched. Environmental influences could be the possible explanation for lack of use of protective clothing by the farmers. Due to the nature of tropical environments farmers find it difficult to wear protective apparels in view of their low heat dissipation (FAO, 1990). Hence it has been observed that there is widespread insecticide related human health problems in Africa mainly due to lack of taking safety precautions. Use of an IPM control strategy is especially useful to the small scale farmers (like those in the study area) who cannot afford pesticide protection equipment (Morales, 2004). For not referring to the hospital as done by the farmers with pesticide poisoning, this showed that farmers were not aware of the dangers that may await them in the long term.

Pesticide poisoning could in the long term be the cause of Parkinson's disease, birth defects and depression (Sanborn, 2007). What the farmer who was found to have pesticide burning of back skin did not realize is that pesticide burn is not the same as a burn due to fire. The casual attitude of farmers towards pesticide poisoning has also been reported by Khan and co-workers (2010) who noted that farmers in Asia tend to view pesticide poisoning as normal and they have got used to it without knowing the consequence of the accumulated effect on their health. Pesticides upon contact with the skin tend to be absorbed through the body and become lethal to some organs such as liver heart and kidneys. However, the use of shea butter to treat pesticide burns as the farmer said could be such a novel discovery by the farmers if scientifically proven to be effective for such ailments like pesticide burns. Such farmers' discovery could be studied and be used in IPM First Aid schemes as local farmer knowledge which in many instances have serve as bedrock of the program. Scientifically, Shea oil is known to contain nonsaponifiable fatty acids which promote cellular growth that restore damaged skin. Traditionally, Africans call the Shea butter tree as a tree of life in view of the numerous healing properties associated with the tree products (Abderhalden, 2004). Other problems associated with the farmers insecticide usage include the unstable insecticide supply coupled with the merchants renegotiating with the famers at higher price before bringing the product; such trade is an unfair one and amounts to exploitation which deserves the attention of the authorities in the study area.

5.5 CONCLUSIONS

Farmers are experiencing some bottlenecks that frustrate them from sourcing clean certified cowpea seeds from the government stores and this could deter them from cultivating healthy crops. Lack of use of certified seeds could increase farmers use of chemical insecticides in the later part of the crop stage. Although farmers have a reasonable knowledge of the major insect pests afflicting their crop, however they lack the knowledge of the beneficial insects and how their present use of broad spectrum chemical insecticides could affect these organisms and their environment. In consequence, this can result in careless use of insecticides. Conventional education can be a source of gaining the knowledge of the beneficial insects but preservation of these organisms requires willingness on the part of the farmers. The present virulent nature of *M. vitrata* in Zuru is a clear indication of the inadequacy of the natural control process brought about by the inappropriate use of chemical insecticide by the farmers. Continuous inappropriate use of chemical insecticide as the farmers are presently doing to control *M. vitrata* will only lead to more pest problems as the farmers are now witnessing and eventually, this will lead them to perpetual dependence on chemical insecticides and loss of income. Pesticide merchants directly contributed to the farmers' dilemma with regards to pest and pesticide usage by giving them wrong advice on pesticide dosage and frequency of application as a consequence, endangering both farmers' health and the environment. This will necessitate on the part of the government action to regulate pesticide retailing in Zuru in order to safeguard the sustainability of farming. Although farmers have inherited the knowledge of botanicals for controlling storage pest of cowpea, such knowledge was left to die instead of being experimented on the field pests in this will mean unsafe food being consumed by the customers.

Farmers shunning the advice of the extension officers, with regards to chemical insecticide usage are a pointer to the need for the improvement of the calibre of the extension services in Zuru. Proper training is required on the part of the government extension officers so that they are equal to their tasks which will make them regain farmers' confidence especially in aspects related to pesticides usage. They can, as well, protect the farmers from exploitation by the pesticide merchants through the role they can play to introduce IPM to farmers in Zuru. The fact that farmers have become reluctant to use personal protection measures while spraying chemical insecticide is an indication of their ignorance of the numerous long term effects of exposure to chemical insecticides. Proper farmer education is needed on the use of safety precautions while handling chemical pesticides and how they could affect them in the long run through the manifestation of diseases of liver, kidney and cancer. This will ensure they refer cases of pesticide poisoning to the hospital instead of relying on local remedial actions. Those alternative remedies used by the farmers who had problems with pesticides should be studied scientifically as farmer knowledge which could be refined for possible use as First Aid tools in terms of emergency in IPM.

CHAPTER SIX: THE ECONOMICS OF COWPEA PRODUCTION IN ZURU

6.1 INTRODUCTION

About 70% of the people of Nigeria live on less than US$1.25 a day and poverty is especially pronounced in the rural areas of the country, where 80% of the populace live (IFAD, 2012). Cowpea is a very important source of protein to both urban and rural poor in Nigeria who mostly cannot afford animal protein. It is popularly known as “hungry season” crop because it rescues the peasant farmers from hunger at the period before cereals are harvested (Bisikwa, 2013). The crop is known for its adaptability to marginal soils and semi- arid conditions (Cisse and Hall, no date), which possibly make its cultivation attractive among the peasant farmers of the savanna zones of the country. Cowpea is also now the corner-stone of the country’s strategic grain reserve and food Aid programmes. Atypical example was the role it played in Nigeria’s recent food intervention in the war torn Dafur in the republic of Sudan. (Adejeobi, 2005). Despite this, the production and profitability of this important food and cash crop in the country is below what is obtained in other African countries such as Egypt and Malawi. The market potential of cowpea is growing and the projected demand from the year 2011 is expected to be in excess of 40,000 metric tonnes in sub Saharan Africa alone (Zulu, 2011). However, numerous factors are associated with this reduced productivity and profitability of cowpea in the country and insect pests are the most serious of these. The most damaging insect pests are the ones that attack the crop at the reproductive stage, such as *Maruca vitrata* Agricultural productivity is defined as “the ratio of the output that is produced to the inputs used” (Adeola *et al.*, 1011). Profitability of cowpea on the other hand is defined as “the revenue earned from cowpeas produced, less the cost of production” (Zulu, 2011: 5). Profitability has been known to be a factor motivating productivity (Adeola, 2011). Therefore, it is the objective of this study to use a focus group interview to determine the factors affecting profitability of cowpea production in Zuru, so as to use these findings for the development of a sustainable, farmer acceptable, Integrated Pest Management strategy against *M. vitrata*.

6.2 MATERIALS AND METHODS

The budgetary analysis was used to compute the profitability of cowpea production and the procedures were adopted from Omonona *et al.,* (2010) while the Benefit-Cost analysis and the determination of Internal Rate of Return were computed following the procedures of Shivananda (2005) and Adeola *et al.,* (2011) respectively. Monetary equivalent of family labour and borrowed labour were computed by determining the number of persons involved and the number of man days spent so that the monetary equivalent in the prevailing labour market could be given to such labour. As for the contract labour, its monetary value as given by the farmers was used. Labour for insecticide sprays was calculated based on the number of knapsack loads used during the spray and multiplied by the amount charged per knapsack load (N70.00). As for the value of land, the opportunity cost was used instead of the depreciation value, since land does not normally depreciate. For further details on the manner of farmers grouping see farmers' perception of pest and pesticide methodology. Total revenue was calculated by multiplying the total farmers produce in kilograms (kg) by the cowpea price per kg at harvest time (TR) and dividing TR by the number of hectares cultivated (ha) by the farmers gives TR per ha (TR/ha). Cost of input per hectare was calculated by obtaining the total amount of the input used divided by the total hectares cultivated and the result was multiplied by the unit price of the input. For harvest labour that was paid not in cash but in kind, as some farmers did, was estimated by the formula 5:1 (meaning to every 5 bags of cowpea 1 bag goes to the labourers), the monetary equivalent of the total number of bags given as payment was determined and documented as cost of labour for harvesting. Profit parameters were determined using the formula below; also see general methodology for participant selection procedures.

GM/ha = TR/ha – TVC/ha

Profit (π) = GM/ha – TFC/ha

B-C = TR/ha ÷ TC/ha

IRR/ha = GM/ha ÷ TVC. Where:

TR/ha = Total Revenue per hectare

TVC/ha = Total Variable Costs per hectare

TFC/ha = Total Fixed Costs per hectare

TC = Total Costs per hectare

B/C = Benefit-Cost Ratio

IRR = Internal Rate of Return per ha

GM/ha = Gross Margin per hectare

Efficiency = Profit ÷ TC

GM/ha = Gross Margin per hectare

π = Profit = TR - TC

6.3 RESULTS

6.3.1 Summary of the farmers' utilization of the basic farm inputs

Farmers were asked about their total farm sizes and how much of that was devoted to cowpea. Some farmers were unable to give exact figures their total farm land due to the scattered nature of the pieces of lands so they used an estimate of the area. Some whose farm land was not in pieces were able to give the exact measurements while others relied on estimate. On average basis farm sizes measured up to nine hectares with about seven hectares devoted for cowpea for large scale (Above four hectares) growers and about three for the small scale (Three hectares and below) growers with much of it used for cowpea This indicated more than 60% of the farmers total farm size was used for cowpea (Table 6.1). When the farmers were asked what seed rate they used per ha their various answers showed, that average seed rate per ha for the large scale growers was 10kg/ha while the small scale growers planted more than 11kg per ha. Next when the farmers were asked if they consulted the agricultural extension officers before they used their present seed rate, most of them replied in a negative manner showing extension advice was not sought for. When the author explained to the farmers the importance of planting the recommended seed rate on yields of cowpea, many farmers made statements which indicated that they intercropped cowpea with cereals.

When farmers were asked the price per kg of cowpea seeds in the market, the reply given indicated that there was wide variation of seed price between harvest and planting time when price can jump up to N500.00 as against N200.00 for the Improved variety while the local variety Danzafi may cost less. As the investigation continued, farmers were asked whether the types of seeds they used were certified seeds. The various answers obtained showed farmers were not even aware of where to obtain them or showed total ignorance about seed certification and its importance. Further investigation on the source of supply of farmers' seeds showed that farmers had various means of obtaining their seed supply. The large scale growers reserved their seeds from the previous year's harvest. Farmers were asked whether they used seed dressing before planting cowpea. Majority of the answers indicated lack of seed dressing and some felt that it is just not as important to them as control of the reproductive pests. Those that did seed dressing were few and they used “force” at the average rate of three satchets per ha which cost N200.00 per satchet (Table 6.1).

Further investigation showed that most of the farmers did not use fertilizers and where it was used; NPK was the farmers preferred fertilizer which was us applied at the rate of 50kg/ha. Generally it was the small scale growers that were using fertilizer (Table 6.1). Both contract and family labour were used for fertilizer application. When farmers were asked about the type of labour they used for land preparations, most of the small scale growers hired animal drawn ploughs for the job and paid up to the sum of N7000.00 per ha. There was strong determination from this group of farmers to obtain their draught animals which may cost up to the sum of N200, 000.00 to do so. Most of the large scale growers possessed their own traction animals which after finishing their farm works hired them to as a source of diversification. It may take a whole day or more for two bulls to cover one hectare. Timely land preparation was considered by the farmers as tantamount to getting good yield of cowpea.

Table 6.1 Respondents farm holdings and input utilization

S/N	Group	Average total farm size (ha)	Average cowpea farm size (ha)	Percentage of land devoted to cowpea (%)	Inputs Used				
					Seeds	Fertilizer	Insecticides	Herbicides	Dress. Chem.
					Quantity used (kg/ha)	Quantity used (kg/ha)	Quantity used (L/ha)	Quantity used(L/ha)	Quantity used (Sachets/ha)
1	C	9	7	78.0	10	Nil	1	Nil	Nil
2	B	3.3	2.3	70.0	11.5	50	2	Nil	2.5
3	A	1.5	0.9	60	11.5	50	2	4	3

6.3.2 Farmer's utilization of labour for the basic farm operations

Farmers were asked about the type of labour they used for planting cowpea and the various responses indicated that all farmers cultivating one hectare and below used family labour in view of the smallness of their farm holding and as a means of cost reduction. When these farmers were asked what amount would they have paid if they were to hire labour, one farmer from the group replied indicating that it could cost up to the sum of N500.00 per worker per day and if on hectare basis, was negotiated between N2000-N2500.00. Again when asked how long it took them to plant one hectare, the same farmer indicated that up to four people are required. When the large scale growers were asked why their general preferences of contract labour for planting cowpea their reply showed that to some, the availability of cheap child labour provided by secondary school student in need of transport money was the reason, while others said because they had enough money obtained from diversification to pay for the job.

During the weeding process farmers were again divided with regards to labour usage. When farmers were asked about the type of labour they used for weeding. The small scale growers indicated to have family labour. Most of the large scale growers used contract labour which they said enabled them have quick control of weeds. When the farmers were asked why they made this division, two farmers among the large scale growers gave reason due to their farm size which timeliness in weeding was considered a very important step towards achieving good yield of cowpea. Others merely indicated that they had enough fund from diversification to pay for the job at that particular period. In contrast, some of the small scale growers who used family labour especially the first weeding, but hired labour for the subsequent weeding reported due to its abundance and cheapness at the later period of the season. As a strategy to reduce cost one small scale grower use Roundup (glyphosate) herbicide for the first weeding which just after planting and before the crop emerged then the second weeding he engaged his family and it took just a day. When this farmer was asked whether the Roundup will not affect the crop emergence, he replied not noticing any negative effect on his un-germinated crop. When the farmers where asked about the cost of the various weeding operations which they talked about, they replied that the first weeding was charged the sum of N 700.00 per worker per day while the second and third weeding were charged N500.00.

Farmers were asked if they protected their crop with chemical insecticide against field insect pests. All the farmers indicated to have done so. Again when they were asked to estimate the total cost of insecticide they used in the previous season, all the large scale growers replied to have purchased chemical insecticides worth between N40, 000.00 to N35, 000.00 at N5000.00/ha during the previous season. As for the small scale growers investment in to chemical insecticide was between N21, 600.00 to N14, 400.00 at N7200.00/ha as their reply showed. When farmers were asked about the type of labour they used for insecticide spraying, their various answers showed that the large scale growers used hired labour. When they were asked why they did this, one farmer from the group replied saying doing so enabled them to spray much area of the farm as the weather would permit; as well not giving insect pest the chance to re-establish. Another farmer from the same group replied saying he would not mind the spray cost since this was covered later after sales. In reply to the above question the small scale growers indicated to have used family labour. When they were asked why, another farmer among them said that use of family labour enabled him to obtain proper coverage of insecticide and better control of the insects. Again when the farmers were asked about the labour cost of their various spraying exercises, they indicated that it would cost N70.00 to spray one knapsack load of insecticide.

Farmers were asked about the type of labour they used at the time of harvesting. Most of the small scale growers indicted to have engaged all family members for harvesting. Further investigation revealed that among the small scale growers, farmers cultivating one hectare and below used one type of unconventional labour called *Mseve* (Borrowed labour) for harvesting cowpea. More questions on the nature of this *Mseve,* one farmer among those using this type of labour replied that, “a week before your harvest you send an invitation to your friends and neighbours and they come to assist you then, when it is their turn you also go and assist them”. On the contrary regarding the type of labour used during harvesting, most large scale growers used contract labour. When these farmers were asked why they resorted to contract labour for harvesting, one farmer among them replied that insecurity of the ripened cowpea at harvest time and the shortage of cash, but with the availability of grains made it fairly easy to pay harvest labour with grains. When the farmers were asked how the payments with the grains looked like, one farmer replied, there was a formula used whereby, for every five bags of threshed one bag was given as payment of their labour. When these farmers were asked whether that bargain did not affect their overall profit, one farmer replied that selling price at later period when price of cowpea had doubled covered everything. When those farmers among the small scale growers who used family labour for harvesting were asked to give estimate of what they would have paid if they were to use hired labour for the harvest, one farmer among them indicated that it cost N500.00 per worker per day.

Farmers were asked to give estimate of their farm yields for last harvest. Answers indicated that the large scale growers obtained between 375kg/ha to 333kg/ha of cowpea. Yield obtained by small scale growers was between 450kg/ha to 300kg/ha of cowpea. Again when farmers were asked what they did with the cowpea grains harvested, the large scale growers and some of the small scale growers said they sold their cowpea grains. Small scale growers, who cultivated one hectare and less, were found not to have sold their cowpea produce but utilized them for home consumption. Farmers who sold their cowpea produce were again asked how they found the buyers of their produce. All of them said they took their cowpea grains to the market. Again when these farmers were asked if it would not be more convenient for buyers to meet them at their various houses to purchase the grains rather than taking to the market. The reply obtained from one farmer indicated lack of interest in farm gate prices and fear of being exploited by the farm gate middle men.

Farmers were asked about their method of transporting their produce to the market. Most of the large scale growers indicated hiring vehicle to transport grains to the market. An exception was one farmer among the small scale growers who said he used his motor cycle. When these farmers were asked what amount of money they paid for the transportation, one farmer among the large scale growers indicated: “Initially we did not pay until we disposed the produce so the transporter financed everything. Then when we have sold the produce the transporter charged N5000.00 for every 10 bags (500kg) and we paid”. Again when the farmers were asked if they encountered any problem of transportation of their produce, most of them indicted the deplorable condition of the road as the transport problem. One farmer among the large scale growers stated that the poor condition of the road was making transporters to charge more money.

Again when the farmers were asked what quality of cowpea grains the buyers preferred, most of them replied that buyers wanted grains without insect holes. However, one farmer reported that “buyers preferred Improve Kanannado because its seeds are white and large. Even with that you should not allow the grains to have insect holes”. For more details about questions and the farmers’ various responses see appendix.

6.3.3 Profitability of cowpea farming enterprise in Zuru

Generally, cowpea farming was profitable in Zuru despite the expenses incurred by the farmers on basic farm inputs such as labour (Table 6.3). The average gross margin per hectare had a positive value (Table 6.3) showing the cowpea farming enterprise is profitable. The average internal rate of return (IRR/ha) was 0.35. The average Benefit/Cost ratio (B.C) was greater than 1. However, there was no significant difference in all these profit parameters measured between the experienced cowpea farmers and the inexperienced ones at 5% level of significance (Table6.3).

Table 6.2 Cost and return/ha of cowpea farming in Zuru

S/N	Item	Estimated Cost/ha
1	**Variable Costs N'000/ha**	
a	Seeds	2250.00
b	Fertilizer	5000.00
c	Insecticides	6500.00
d	Herbicides	3200.00
e	Seed Dressing Chemical	511.10
f	Labour	40,569.45
g	TVC/ha	98599.98
2	**Fixed Costs N'000/ha**	
a	Land	3000.00
b	TFC/ha	3000.00
3	TC/ha	101,599.98/ha
4	**Revenues N'000/ha**	
5	TR/ha	133,397.82/ha
6	π/ha	31,797.84
7	GM/ha	34,797.84
8	1RR/ha	0.35
9	B.C/ha	1.31

Note: TVC = Total variable costs, TFC = Total fixed costs, TC = Total costs, TR, Total revenue, IRR = Internal rate of return, B.C = Benefit- cost ratio, π = profit, ha = hectare.

Table 6.3 Profitability comparison between the inexperienced and experienced cowpea farmers

S/N	Item	Farmers group		t-value
		In experienced	**Experienced**	
1	π/ha	N30,143.10	N34,466.00	0.1940ns
2	GM/ha	N33,143.10	N37,455.83	0.1950ns
3	IRR/ha	0.88	0.99	0.3033ns
4	B.C/ha	1.73	1.83	0.3001ns

Ns = not significant at 5% level of significance

6.4 DISCUSSION

Most of the farmers devoted more than 60% of their total farm sizes to cowpea cultivation, indicating the significance of cowpea to the people in the study area. Although the emir of Zuru, HRH Sami Gomo II, 2000 noted that the predominant work of the people in the study area was sorghum cultivation, this sudden enthusiasm for cowpea, might be due to the fact that apart from household consumption, cowpea is gaining cash crop status due to the rise in demand for cowpea in sub Saharan Africa, estimated to exceed 40,000 metric tonnes in the next 10 years (Zulu, 2011). Most of the farmers used less than the recommended seed rate in view of their mixed cropping method of planting cowpea. This could be supported by the fact that seed rate might be expected to be lower when cowpea is intercropped. Dugie and co-workers (2009) noted that the seed rate could vary depending upon the cropping system. It has been observed that intercropping cowpea with cereals such as sorghum is a typical characteristic of the crop cultivation in sub Saharan Africa and is a strategy used by the farmers to diversify risks associated with farming, also enabling them to maximise income (Beets, 1990). The various responses made by the farmer on the inquiry on whether they used certified seeds plus seed dressing before planting cowpea, clearly indicated ignorance about it and consequently lack of the use of this important healthy plant cultivation strategy as well as and a means of seedling protection and cowpea yield increase (Nampala *et al.*, 1999; Sisse and Hall, 2013).

The majority of the farmers carried out land preparation before planting cowpea. Land preparation before planting enables seeds to be closer to soil moisture for better germination. It removes weeds and aerates the soil and encourages faster emergence of seedlings (The Organic Farmer, 2006) However, with the majority of the farmers cultivating small scale growers, contract labour is too expensive. Instead they rely on family labour. Added to this was the high initial cost of the oxen estimated N200, 000.00. For such small scale farmers such an amount of money is not easily obtainable in view of their lack of access to formal credit facilities in Nigeria (Modu *et al.*, 2009). As one farmer in group C correctly noted that, being left behind in land preparation, would amount to being left behind in yield of cowpea. It has been observed that in the rain fed agriculture of the dry lands such that of sub Saharan Africa water and nutrients are usually limited, so timeliness of field operations such as land preparation is very important in order to achieve good yield and biomass production (Food and Agriculture Organization, 2010). The large scale growers (group C) owned their own oxen which were hired to others for additional income. Of course this is a form of livelihood diversification which enabled these growers to earn extra income which they used to settle other hired farm works.

Another large scale grower who planted pepper in cowpea and utilised the money obtained from the sale of the pepper for other farm works, can also be regarded as using crop diversification to facilitate cowpea cultivation. It is apparent that all the large scale growers (farmers in group C) had one form of livelihood diversification or another and the income derived was invested in some other cowpea farming processes. Diversification has been known to be a very important source of cash income especially among the poor farmers in Africa (Baiphethi and Jacob, 2009).

For planting of cowpea, farmers were again divided with the large scale growers relying on contract labour while the small scale growers (farmers in group A and B) used family labour. From the various responses obtained when the farmers were asked why they made this division, it became apparent that as for the large scale growers, contract labour usage during planting was because they had the means, while family labour used by the small scale growers was a matter of economic necessity. Generally all large scale growers made use of contract labour for weeding which they paid for using income from diversification. These farmers with their large farms indicated timeliness as the main reason for not utilizing family labour. The importance of timeliness on farming success has already been discussed earlier in the land preparation chapter. In addition, timelines in weeding is very important so as to prevent the weeds from growing tall and shading the plant in its early stage of growth. Cowpea is a poor competitor at the early stage and weed completion is known to deplete both moisture and nutrients from the soil (Sisse and Hall, 2013).

However, all the small scale growers utilized family labour during weeding and as one farmer from the group noted, it was the scarcity of labour at the period of the first weeding that made them use family labour. Weeding is one of the most tedious and expensive farming operations and availability of labour for various farm operations such as weeding is a determining factor in the amount of land the farmer can cultivate each year (Tarawali *et al.*, 2013). This possibly explained why these farmers who used family labour during weeding also fall into the small scale grower group as found in this study. However, one farmer among the small scale growers in group A used glyphosate to control weeds just after planting and before his crop emergence. On inquiry about the safety of the un-germinated crop, this farmer replied that no harm was done to his crop by this herbicide. The farmer was also found to use direct planting without any initial land preparation. The use of this systemic herbicide immediately after planting is quite surprising since glyphosate is known to have soil activity and manufacturers recommended an interval of between 2 to 3 weeks between application and planting of crops. Farmers have a vast store of farming strategies that enabled them to adapt to the challenges of farming, especially at resource poor level which need to be studied and integrated in IPM components.

The various responses obtained from the farmers questioned the need for fertilizer application on cowpea, indicating the non-use of that input among most of these farmers. Such farmers' statements also indicated their ignorance of the role played by application of fertilizer on yield increase of cowpea and other benefits that could be derived due to fertilizing. Application of NPK in small quantity 20kg N ha^{-1} at early stage of the crop life is known to significantly increase yield and the plant overall vigour and dry matter production (Abayomi *et al.,* 2013). Those farmers that used fertilizer in the form of NPK, their application rate (1bag/*kadada* i.e. 50kg/ha) was not correct considering the recommended dose mentioned above. In view of this, it can be considered that these farmers were over applying the fertilizer. However, this excess application of NPK in addition to causing too much vegetative growth is also known to delay the crop maturity (Mississippi State University, 2010).

All the farmers used chemical insecticide to protect cowpea from field insect pests but were divided on the use of labour for the insecticide sprays. The large scale growers were generally using contract labour. One farmer in the group replied saying this was due to timelines, and by so doing insect pests are not given the opportunity to quickly re-establish. In addition weather factors such as rainfall is known to negatively affect insecticide efficacy by washing away the sprayed chemical if the rain falls during the spraying operation. This will result in the need to reapply the insecticide which will put additional burden on the farmers in view of the expensive nature of chemical insecticides. It has been observed that rain fastness or the ability of insecticide to withstand rainfall is a crucial factor affecting the efficacy of foliar applied insecticides (Wells and Fishel, 2012). With the small scale growers using more chemical insecticides than the large scale growers, this result is in conflict with the findings of Whittaker *et al.,* (1995) who reported that in the lake state-corn belt of USA, pesticide dependence (consumption) increased with increase in farm size. This result suggests the occurrence of agricultural intensification in the study area.

The reply given by one of the farmers in group C who reported not minding the expenses of hired labour in view the higher selling price at latter part of the year is also confirmed by the works of Odoemenem and Odom, (2010) who noted that, despite the high cost of labour, the profitability of a crop makes farmers invest in hired labour. Similar observation is also made by Odogola (1994) who noted that provided farmers can sell their produce and obtain reasonable price which compensates for their investment in insecticides and other inputs, they will not hesitate to make any investment in farming. The entire small scale grower groups used family labour for the spraying of their crop. As one farmer among them replied saying he obtained better insecticide coverage with subsequent better control of insect pest if he used family labour for spraying insecticide. This farmer's statement indicated his lack of confidence in the hired labour in getting good spray coverage with subsequent good control of insects. He could possibly be speaking from his experience with the contract labourers.

Farmers were again divided on the use of labour for harvesting. All the large scale growers utilized contract labour, while the other groups used family and *Mseve* borrowed labour. One farmer in group C said reported using contract labour for harvesting due to insecurity of produce when the operation is delayed. It has been observed that the traditional selective harvesting due to unevenness in ripening of pods is time consuming and the ripened pods are liable to bird damage and vandalism from baboons and other wild life (Odogola, 1994). For the farmers in group A utilizing *Mseve* (borrowed) labour is quiet surprising, since their farms were not all that large (1ha) and below. This system as the farmers describe it is cooperative labour rendered by friends and relatives to one another through invitation during harvest. Ideally this kind of cooperation is supposed to be used by the people with large farms (group C) rather than using hired labour. The case of these small holders using this type of farm labour may possibly indicate a festive mood during harvest. It has been observed in other human communities (Kiriwina), harvest period is usually attached with joy and given a character of delightful pastime which gratefully help the work accomplishment (Malinowski, 2002).

All the farmers who used to sell their cowpea produce transported them to the market for selling. Farmers did not like the idea of selling at the farm gate and as one farmer among the large scale growers replied saying he preferred to sell his cowpea in the market due to many price opportunities there and by so doing avoided being exploited by the middle men. This farmer could be right about the problem of the farm gate middle men in cowpea marketing in Nigeria. Adejeobi (2005) noted that in Borno state of Nigeria these middle men have been known for many unwholesome activities such as misleading the potential buyer or outright cheating of those that deal with them. The only transport problem encountered by the farmers during the transportation of their produce was that of poor road conditions. The various farmers response on poor road conditions are confirmed by the report IFAD (2012) which reported that the neglect of rural infrastructure in Nigeria through lack of good rural road is affecting agricultural productivity and agricultural commodities marketing.

All the profit parameters measured indicated that cowpea farming is profitable in Zuru, despite the expenses incurred by the farmers on basic farm inputs such as labour. The average gross margin per hectare had a appositive value meaning that cowpea farming enterprise is profitable (Segun-Olasanmi and Bamire, 2010). The average IRR/ha was 0.35 showing that for every one Naira spent by the farmers there is a profit of thirty five kobo. The average B.C/ha was greater than 1 showing that the investment is good. The lack of statistical differences in the profit parameter between the experienced farmers and the inexperienced indicated that it is the type of management given by the farmers that determined profitability of cowpea not their experience alone. In citing the characteristics of high profit farms, good management of farm expense through low cost per unit production has been identified as one of the key characteristics of high profit farms (Fore, 2002). This author further stated that “Good management is not about doing 1 thing 1000% better. It’s about doing 1000 things 1% better”.

6.5 CONCLUSIONS

Farmers inappropriately apply fertilizer NPK in excess of the recommended dose and as a consequence, apart from encouraging too much vegetative growth which may serve to make the crop microclimate more conducive to pest development, the yield of the crop and subsequent profit could also be affected. Although cowpea cultivation is profitable in Zuru, still more profit could be made if farmers make use of family labour and use IPM strategies in their crop protection which include alternatives to chemical insecticides. Adopting the technique of conservation agriculture through the use of herbicides plus direct planting as some farmers were doing could also cut down the farmers’ cowpea production costs and enable the cultivation of more hectares of land by the farmers. Farmers’ experience alone cannot be relied upon as the sole tool of making profit but when it is accompanied with appropriate types of farm management such as the efficient use of resources, profitability of farming could be increased.

As a logistic farming support, provision of a good road network by the government will ease the farmers' transport problem and reduce production costs, thereby making food cheaper to the consumers and more profitable to the farmers. Commercial growers stand to make more profit if they can make use of *Mseve* (cooperative) harvest labour during harvesting as the small scale growers did instead of hiring and paying labour with some substantial part of their harvest. To make more profit, the large scale growers need to combine their present minimum external inputs usage strategy with an IPM strategy that utilizes alternatives to chemical insecticide. However, as part of their strategy of investing heavily on hired labour on anticipation of recovering these expenses from higher prices at latter part of the season, loses can be incurred in the event cowpea grain prices remain stable.

CHAPTER SEVEN: MONITORING AND FORECASTING OF *MARUCA vitrata* POPULATION ABUNDANCE IN COWPEA USING PHEROMONE TRAPS

7.1 INTRODUCTION

In the West African region *Maruca vitrata* is identified by farmers to be a major problem of cowpea cultivation. Damage due to this insect pest can reduce yield by up to 80% with consequent reduction in seed quality. Farmers use cheap but highly toxic chemical insecticides for the control of the insect pest resulting into negative human safety problems (African Agricultural Technology Foundation, 2012). In Northern Nigeria *M. vitrata* is known to be migratory in nature moving from the southern part of the country to the northern during the rainy season during which it heavily attacks cowpea. At the commencement of the dry season in the north it makes a return migration in search of a more favourable environment via inter tropical winds (Bottenberg, 1997). Pheromone traps are an effective tool for giving early warning of the larvae attacks through the trapping and monitoring the abundance of the adult of this insect pest. In this manner farmers can predict the availability of the pest and can decide when and where to target their insecticide (Downham, 2006). These traps have been tested in Ghana and Benin and an action threshold based on the data from the catches was successfully developed to enable economically and biologically optimum application of insecticide (TECA, 2013). Pest monitoring/scouting is an integral part of any sustainable IPM control Strategy. It is therefore the objective of this research work to develop a sustainable IPM control of this insect pest through the use pheromone traps as monitoring devices for the abundance of the adults of the pest in Kebbi State of Nigeria. In the end farmers can use the results of the catches from these devices to relate such results to larvae attack on their cowpea and time their insecticide application in order to provide effective and sustainable control of this insect pest.

7.2 METHODOLOGY

The experiment was carried out in the year 2008 using 20 bucket pheromone traps (Plates 3and 4) with three blend lures and following the procedures of Downham (2003). For more details see general methodology.

7.3 RESULTS

7.3.1 Trap Catch

Out of the 15 traps on the experimental farm only one trap (Table 7.1) caught single adult male moth in the fourth week of September. Two pod borers one male and one female were caught in the third week of September in the No. 17 trap positioned in the students' plots (Table 7.1). No more moths were caught up to the end of the cropping season in December ending.

Table 7.1 Pheromone trap catch details

Trap . No.	**Monthly Catch/Sex of Month**										**Total**
	August		**September**		**October**		**November**		**December**		
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	
12	0	0	1	0	0	0	0	0	0	0	1
17	0	0	1	1	0	0	0	0	0	0	2
GT											

NB:

M = Male, F = Female & G.T. = Grand Total

7.4 DISCUSSION

Trap catches were very low in comparison to the trap catches obtained in Benin republic using similar traps. In Malanvile alone, more than 10 moths were caught per night per trap positioned in cowpea field between 21 August and 20th September in the year 2001 (Downham, 2003). Similar problems of poor trap catch were obtained by this author in Northern Nigeria while carrying out a multi season experiment using the same type of bucket pheromone traps in Kano and Abuja both of which are in Northern Nigeria. Factors such as faulty trap design can be responsible for poor trap catch due to its effect on the approach behaviour of the insect. Visual cues and ease of accessibility to the interior of the trap, as well as the trap's capability to prevent caught insects from escaping are a measure of good trap design (Downham, 2003). Faulty trap design has largely contributed to the failure of pheromone traps to catch any moths in an experiment on pigeon pea in Sri Lanka and Kenya (DFID, 1999). The geographical location of the deployment of synthetic pheromone traps, as well as the number of blends in the lure is known to affect catches. Northern Nigeria is particularly known to be a problematic area in terms of synthetic pheromone trap catches. Despite the high populations of *M. vitrata* as indicated by light trap catches (over 1500 moths per night) in this area, the synthetic pheromone traps baited with three component blend lures were found to have trapped very few moth compared to the light traps in a multi season experiments carried out in Kano State and Abuja (Adati *et al.,* 2008).

The three component blend lures were reported to have worked well in Cotonou, Benin Republic (Downham, 2003). After using several laboratory and field tests, it was discovered that *M. vitrata* responded to the single major component lures (EE10,12-16:Ald) instead of the three component lures in Burkina Faso. Therefore Hassan (2007) concluded that geographical location affect pheromone responsiveness in West Africa (Adati *et al.,* 2007). Another possible factor which could have contributed to the poor catch of the traps is the possibility of the female moths' out-competing the traps since Northern Nigeria is known for its high *M. vitrata* populations (TECA, 2013). Downham (2003) suggested that field variation in cowpea maturity within the locality due to the use of different varieties or different sowing dates could affect the predictive value of pheromone traps. The failure to attract more moth after the initial catch in September might possibly indicate the abundance of females that diverted the attention of the males from the traps. Also the flight characteristic of the strain of *M. vitrata* found in Northern Nigeria might not be compatible with the design of the funnel bucket traps used.

7.5 CONCLUSIONS

The pheromone traps were ineffective in trapping sufficient moths to be useful as a monitoring tool. It was therefore not possible during the research period to investigate the reason for the low numbers of moths caught in the traps and there was no option but to exclude pheromone monitoring from the IPM system. Pheromone monitoring was replaced by counting of pest infestation/damage and use of an action threshold for insecticide use.

Plate 11 Pheromone trap in the experiment farm

Plate. 12 Pheromone trap in the students' plots

CHAPTER EIGHT: EFFICACY OF IPM COMPONENT TECHNOLOGIES

8.1 INTRODUCTION

Worldwide there is estimated to be 11 million ha of land under cowpea production yielding over 5.4 million tonnes annually. Nigeria is the largest producer and consumer of cowpea, with about 4.5 million ha under cultivation producing about 58% of the world cowpea grains per annum (IITA, 2013). Cowpea is attacked by pests at every stage of growth, and *Maruca vitrata* is considered to be the principal pest causing up to 80% loss in yield (Komolafe *et al.*, 1985; Duke, 1981; Steele *et al.*, 1985). In Kebbi State, Nigeria most of the people are engaged in rain fed agriculture (Kebbi Investments Company Limited, no date) and most vegetable protein for these people comes from cowpea, while the hay is used as an animal feed (Alonge and Lagote, 2002; Kay 1979; Campbell and Reed, 1987). Because of its importance as a food and cash crop, as well as the numerous pests attacking it, cowpea is now considered as a high risk crop (Adipala *et al*. 1999). In Zuru local government area cowpea farmers indiscriminately use broad spectrum chemical insecticides, a mixture of 30g Cypermethrin and 250g Dimethoate in order to control these insect pests (Ukaegbu, 1991). Various research works have demonstrated that use of chemical insecticide even though effective might prove to be expensive and toxic to human health and the environment (Opolot *et al.*, 2006). Studies have already shown that *M. vitrata* has acquired resistance to chemicals such as cypermethrin and dimethoate which are commonly used by farmers (Ekesi, 1999). Alternative means of control as against total use of insecticides has now become the focal point of many research efforts (Atachi, 2002). Therefore the proposed research will assess locally-available resources and technologies to control the post-flowering insect pest of cowpea *M. vitrata*, with a view to developing a cost- effective, sustainable and environmentally friendly IPM control strategy for farmers.

8.2 MATERIALS AND METHODS

There were four experiment carried out during the first year in Zuru local government area of Kebbi State of North Western Nigeria for the purpose of assessing their suitability as IPM control options against *M. vitrata.* See general methodology for details.

8.2.1 Data collection

Refer to general methodology (3.4.1).

8.2.2 Data analysis

All the data collected from the four types of experiments were combined at the analysis stage despite the fact that there were unequal replications in the experiments. Several plots are in effect untreated and there were separate randomization for each and irregular blocking. However, modern anova programmes can cope with unbalanced design by using statistical modelling so when the programme estimates standard error for the means it allows for the number of replications. The standard errors will be smaller if there are more replicates. Tukey multiple comparisons used does not depend upon sample size so the large number of the untreated plots will not be a problem. The various treatments were examined and found to be comparable when combined. Although, the random components could probably increase as experiments were added, the residual degrees of freedom increases to allow for this. All the four separate experiments were carried out on the same plot and received the same type of cultural practices on the same day. Insecticides were applied on the same day. The data were subjected to single two way analysis of variance (Anova) using R statistics software. The means were separated using Tukey HSD multiple comparisons.

8.3 RESULTS

8.3.1 Yield, larval infestation/damage, pod and seed damage

All spray treatments increased yield and reduced larvae infestation/damage, pod and seed damage below the unsprayed control plots. Highest yield increase, coupled with lowest larval infestation/damage, pod and seed damage was obtained by calendar based commercial insecticide spraying followed by the calendar based nke applications (Tables 8.1, 8.2, 8.3 & 8.4). A highly significant difference was observed between the mean yields of the calendar insecticide sprayed plots when compared with those of the unsprayed controls ($P \leq 0.001$) (Fig. 8.1). Yield increases of 25 and 27% over unsprayed controls were obtained from both varieties (V1 & V2) under calendar commercial chemical insecticide treatment, while nke spraying resulted in 20 and 21% yield increase of the same varieties of cowpea (Table 8.10. There was no significant difference ($P \geq 0.05$) in yield between commercial insecticide application and nke with weekly applications(Fig. 8.1). Calendar based spraying of chemical insecticide also resulted in a decrease of 31 and 33% larval infestation/damage of both V1 and V2 over unsprayed control, while that of calendar based nke application was 27 and 28% for both V1 and V2 (Table 8.2). Reduction of pod damage by 40 and 46% over the unsprayed controls was sustained by both varieties under calendar based chemical insecticide application while 37 and 46% reductions were obtained under calendar based nke applications (Table 8.3 & 8.4)).

Scouting resulted in no spray of commercial chemical insecticide being applied, because pest infestation/damage level did not reach the action threshold of 60% infestation/damage. As a result there was no significant difference ($P \geq 0.05$) between scouting based and the unsprayed control plots in such the scouting based plots in yield, larval infestation/damage, pods and seeds damage (Fig. 8.1, 8.2 and 8.4). *H. spicegera* interplanting did not increase yield or reduce larval infestation/damage, pod and seed damage below the uninterplanted control treatment. Both cultivars VI and V2 sustained a similar level of pest infestation/damage under the field resistance trial (Table 8.2). Perfect negative correlation was obtained between yield of cowpea and larval infestation/damage ($R^2 = 0.8086$) (Fig. 8.3).

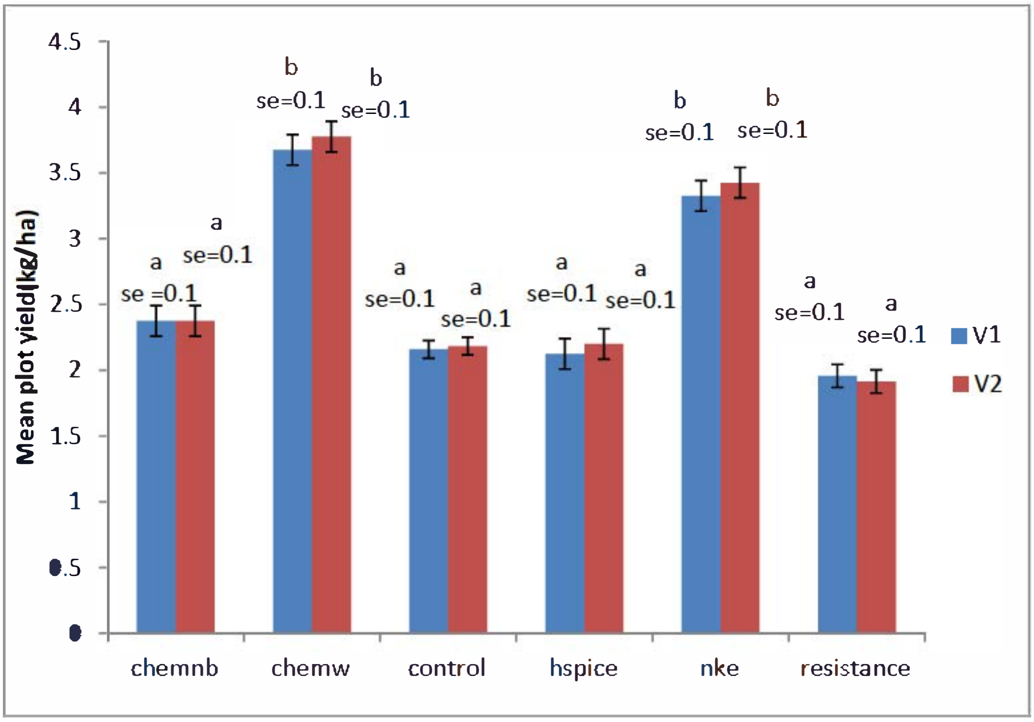

Fig.8.1 Mean plot yield of two cowpea varieties Danzafi V1 and Kanannado V2 under each of five IPM component treatment effects. Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$). Plot size = 6m x 6m.

Table 8.1 Percentage yield increase/reduction of two cowpea varieties (V1 & V2) under each of the five IPM components

Treatment	% yield increase	
	V1	V2
chemw	25	27
chemnb	4	4
nkew	20	21
hspice	-2	0
resistance	-5	-7
control (unsprayed)		

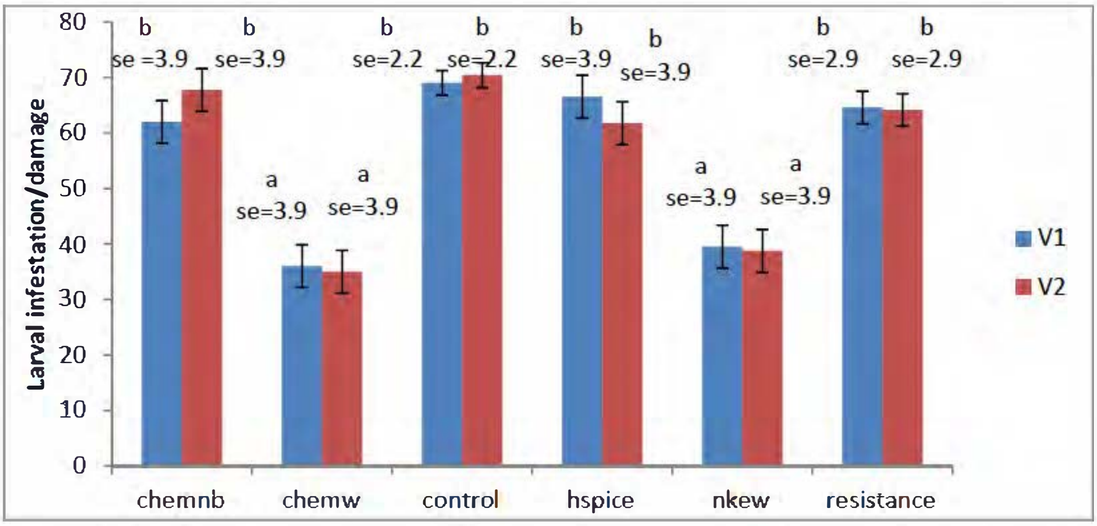

Fig.8.2 Larval infestation/damage of two cowpea varieties Danzafi (V) and Improved Kanannado (V2) under each of five IPM component treatment effects. Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$).

Table 8.2 Percentage reduction/increase of larval infestation/damage for the two cowpea varieties V1 & V2 under each of the five IPM components

Treatment	% reduction of larval infestation/damaged	
	V1	V2
chemw	31	33
chemnb	7	1
nkew	27	28
hspice	1	6
resistance	3	4
control (unsprayed)		

(chemnb = need base (scouting) chemical pesticide application. ccotrol = untreated controls , chemw = weekly application of chemical pesticide,, Hspice = *H. spicegera* interplanting, nkew = neem application weekly, and resistance = reisistance testing without normal pod borer spraying)

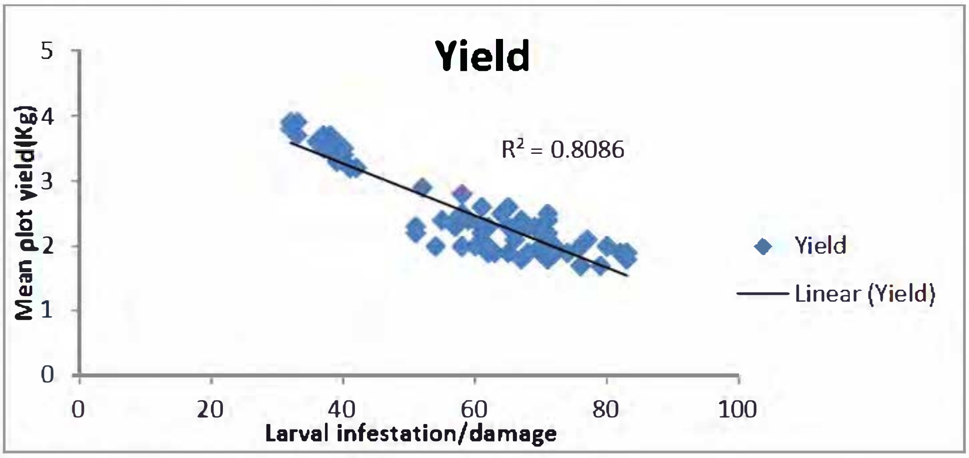

Fig.8.3 Relationship between yield and cowpea flower infestation/damage in the first year on-station experiment.

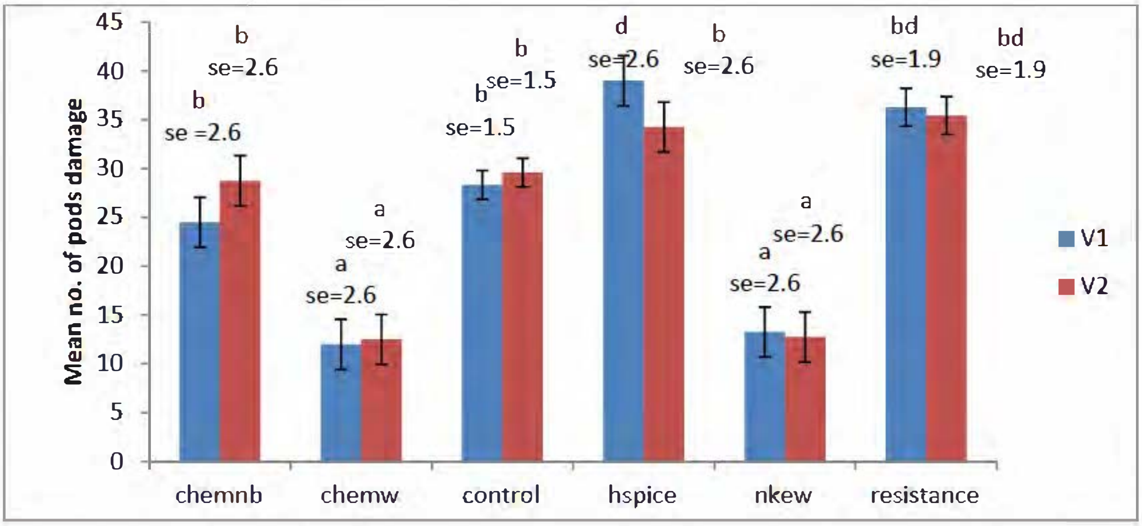

Fig.8.4 Mean number of pods damage of two cowpea varieties Danzafi V1 and improved Kanannado V2 under each of five IPM component treatment effects. Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$).

Table 8.3 Percentage reduction/increase of pod damage for the two cowpea varieties V1 & V2 under each of the five IPM components

Treatment	% reduction of pods damaged	
	V1	V2
chemw	40	46
chenmb	7	9
nkew	37	46
hspice	-16	1
resistance	-13	0
control (unsprayed)		

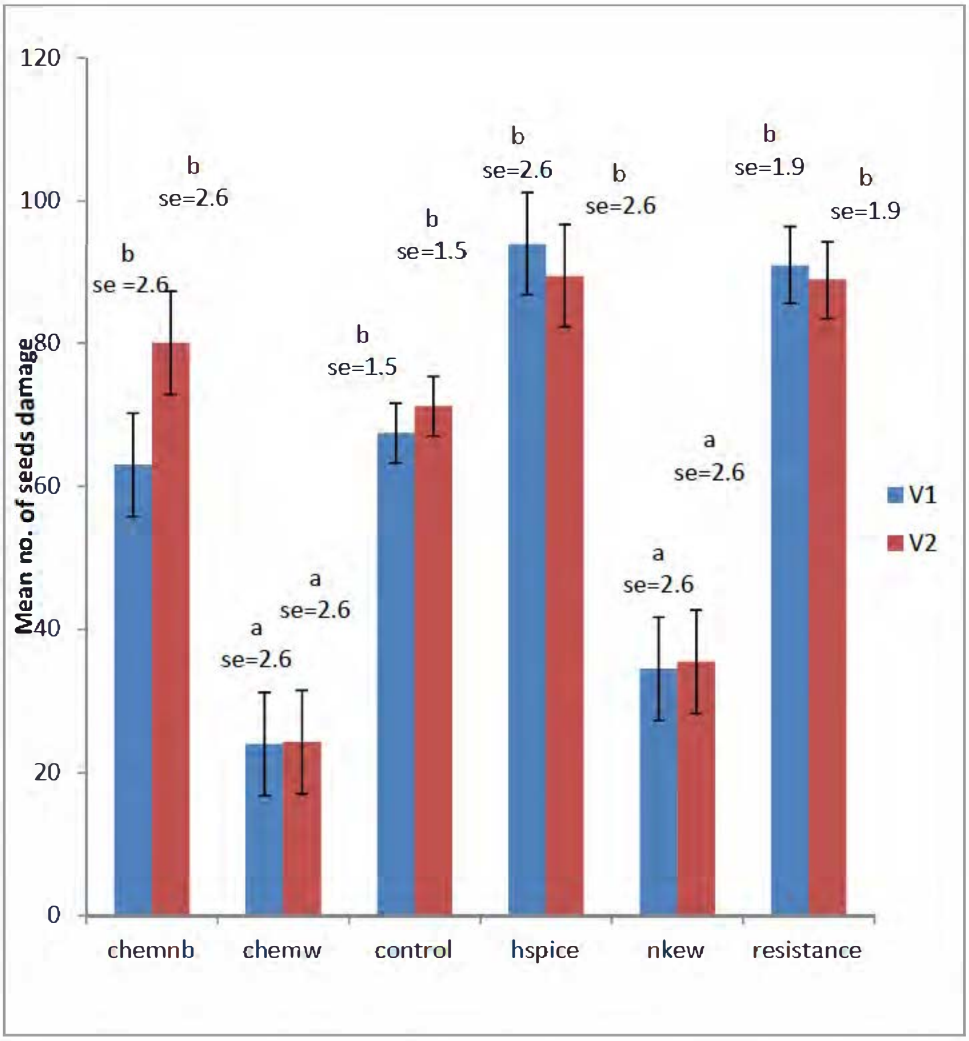

Fig.8.5 Mean number of seed damage of two cowpea varieties Danzafi V1 and Improved Kanannado V2 under of five IPM component treatments effects. Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$).

Table 8.4 Percentage reduction/increase of seeds damage of the two cowpea varieties V1 &2 under each of the five IPM components

Treatment	% reduction of seeds damaged	
	V1	V2
chemw	47	49
chemnb	3	-6
nkew	32	33
hspice	-17	-17
resistance	-15	-11
control (unsprayed)		

Table 8.5 Benefit/Cost analysis of some treatments in the first year

item	nke weekly	chem. weekly	Chem. scouting 40%	chem. scouting 60%
	costs	costs		costs
Seed dressing material (N)	800.00	800.00	800.00	800.00
Labour for seed dressing (N)	200.00	200.00	200.00	200.00
Insecticides (N)	900.00	7000.00	2000	Nil
Sprayers (N)	1300.00	1300.00	1300.00	1300.00
Sprayings (N)	6533.00	6533.00	1866.6	Nil
Scouting (N)	Nil	Nil	3000.00	3000.00
Mortar and pestle (N)	95.00	Nil	Nil	Nil
Total cost (N)	9828.00	15,833.00	9166.6.6	5300.00
Average yield (kg/ha)	944.4	1055.5	1000.0	666.6
Yield Increase (kg/ha)	333.3	444.4	388.9.0	55.5
Value of Yield Increase (N)	33,330.00	44,440.00	38,890.00	5550.00
Profit (N)	23,505.00	28,607.00		250.00
Benefit/Cost ratio	3.4	2.8	4.2	1.0

NB: Average yield of control plots=611.1kg/ha, nke scouting 40% = projected neem application at 40% flower damage, chem. scouting 60% = chemical pesticide application on scouting basis at 60% action threshold. For other details see general methodology. s

8.4. DISCUSSION

The efficacy of calendar based commercial insecticide application towards *M. vitrata* control was demonstrated in this study as result of its direct effect on yield increase and in maintaining lower larvae infestations/damage. Chemical pesticide application has been known to control *M. vitrata* and increase yield by several folds (Opolot, *et al*., 2006; Muthomi *et al.*, 2008; Egho and Emosairue, 2010). However, it has been observed that this calendar based method of control is wasteful and uneconomical; in addition, it does put the farmer's health and the environment at risk (Afun *et al*., 1991; kassou, *et al*., 2001). Insect pest damage at the vegetative state has less direct bearing on yield reduction compared to at the flower stage. Damage due to *M. vitrata* at the reproductive stage of cowpea is known to result in yield losses of up 80% (Ekesi, 1999). This makes spray action at the vegetative stage to be irrational and unjustifiable and uneconomical (Adipala *et al*., 2000; Karungi *et al*., 2000). Throughout the season pest infestation/damage never reached the point to warrant an insecticide spray. This study therefore demonstrated the significance of pest scouting as a means of avoiding unnecessary insecticide applications. This no doubt could save the farmer part of his meagre resource. Earlier studies have shown that when pest pressures are below economic damage level, pest control actions are not justifiable and greater benefits are obtained by no pest control actions (Flint and Van den Bosch, 1981). Cost saving through cutting down of the number of sprays has always been the characteristic of monitoring based control measure (Afun *et al*., 1991). However, with both the scouting based experiments and the unsprayed control had a similar level of larval infestation/damage and this was an indication that the action threshold (60%) used could be too high. This action threshold was found to be effective at Ibadan in southern Nigeria (NRI, 2007). If a lower threshold say 40% infestation/damage was used there would have been two insecticide spray at the right dose (1litre/ha) and a significant difference would have been obtained between scouting and the unsprayed control in both yield and larvae infestation/damage.

Both the weather and the nature of the varieties of cowpea used in this study possibly contributed to the no spray outcome encountered in the scouting based experiment. All the cultivars were photo- sensitive types which will not normally start flowering until towards the end of the season when the days are shorter than the nights and rains (Smart, 1990). At this period, rains have almost ceased and, as a migrant pest in Northern Nigeria (Bottenberg *et al*., 1997), *M. vitrata* could have started its return migration earlier via the trade winds which were observed in the first year to be beginning to set in earlier than their usual time of their arrival. The period of the trade winds is known not to be conducive for *M. vitrata* development (Kamara, *et al*., 2007). Another factor that might have contributed to the no spray outcome of the need based treatment was the possible intervention of natural enemies. It has been documented that many potentially injurious insect pests (such as *M. vitrata*) can be kept at very low levels and never to reach economic pest proportions as a result of effective actions of natural enemies (DeBach and Rosen, 1991). In order to protect and encourage the activities of the natural enemies, careful timing of the insecticide sprays was adhered to during the experiment. Insecticide sprays were carried out very early in the mornings so that the activity of the natural enemies was not jeopardized (Verkerk, 2001).

The neem kernel extract (nke) used in this study was obtained from Neem tree which is found all over Northern Nigeria, especially in Kebbi State, where it is used as a shade tree to check desert advancement (Jakai and Oyediran, 1991; Bottenberg and Singh, 1996). Earlier works on Neem showed that its various parts such as leaves and barks have an antifeedant and repellent insecticidal activity which makes it suitable for use in crop protection (Jackai and Oyediran, 1991). However, the relatively low level of control of in-pod borer feeding as indicated by relatively higher seed damage sustained by weekly nke applications in comparison to those sustained by calendar based commercial insecticide applications, might signify the difficulty of larval control once they are already inside the pods. Earlier studies have shown that the concealed feeding of *M. vitrata* larvae makes it sometimes difficult to be reached even with the use of conventional pesticide (Cork and Hall, 1988; Down ham, *et al*., 2003; Gopali *et al.,* 2010). In contrast, chemical pesticide application due to the systemic nature of the type of insecticide used effectively controlled in-pod borer feeding and decreased seed damage. The active ingredients (30g cypermethrin and 250g dimethoate) of the type of chemical insecticide used in the study have been known to have a systemic effect (Singh and Jakai, 1997).

Botanical pesticides have in many previous research works demonstrated capability for use as alternatives to conventional chemical pesticides in *M. vitrata* larvae control in cowpea (Oparaeke, 2005; Adati *et al*., 2008). With the benefit/cost ratio of weekly neem applications being higher than that of the commercial insecticide, it was a clearly indication of the efficacy of nke as an insecticide with alternative control and suitable for IPM control strategies (Jakai and Oyediran, 1991). Efficacy factor has always been at the forefront when famers are choosing pest control option (Belmain and Stevenson, 2001). The central theme of any IPM strategy is minimal pesticide use, combined with best economic return (Jackai, 1995). Although Downham and co-workers (2003) have observed that the labour cost involved in nke preparation (especially if on calendar basis) might affect its use by farmers, ultimately, the production and usage of this botanical pesticide by peasant farmers in crop protection will see a great boost in the near future because of its common occurrence and virtually all the equipment needed for the preparation are those used in day to day farm tasks (Foester, 2000). However, this author also noted the poor shelf-life of Neem products as a constraint to their use for pest control.

Intercropping food crops such as cereals with other plants such as *Desmodium uncinatum* to repel ovipositing lepidopteran pests (stem borers) is already gaining ground with farmers in Kenya (Khan *et al*., 2011), and similar technology was experimented in this study using *H. Spicegera*. The possibility of *H. spicegera* possessing some insect repellent activity was raised following the discovery of insecticidal activity of some volatiles of *Hyptis sauveolens* (L.) Poit proved to be effective against lepidopteran pests (Scientific Correspondence, 2005). However, the use of *Hyptis spicegera* as an interplanting material for the purpose of repelling *M. vitrata* adult and larvae did not prove effective. Thus, the anticipated benefit of higher yield without spray such as that enjoyed by farmers who intercropped cowpea with other plants such as green gram (Munyuli *et al*., 2007) was not realised.

8.5 CONCLUSIONS

Botanical pesticides such as neem can be an effective alternative to commercial chemical insecticides in terms of *M. vitrata* control in cowpea especially when applied on calendar basis. Although highest yields were obtained from calendar based commercial insecticide application, the greatest cost/benefit ratio was derived from neem applied on a calendar basis, demonstrating its efficacy as an alternative to chemical insecticides. Scouting which relied on an action threshold of 60% pest infestation/damage developed in southern Nigeria could be location specific. It is possible that it is too high a threshold for intervention in Kebbi state of Northern Nigeria, therefore it adversely affected the yield obtained compared to using a lower threshold. Although the 60% action threshold is observed to be too high, if a lower intervention level of, say, 40% were used there would probably have been two sprays and that will mean that the study confirmed the efficacy of pest scouting in reducing unnecessary spraying of insecticide as against the seven spray regimes used by the farmers. The local cultivar Danzafi could be a source of genetic materials for plant breeders wishing to develop *M. vitrata* resistant cowpea cultivars.

CHAPTER NINE: VALIDATION OF THE IPM SYSTEM FOR THE MANAGEMENT OF *M. vitrata*

9.1 INTRODUCTION

About 5.5million tonnes of cowpea dry grains were produced worldwide in the year 2010. Nigeria produced 2.2 million tonnes of this, making Nigeria the world largest producer (FAO, 2010; Ojuederie, *et al*., 2009). Because of the importance of cowpea in the Nigerian diet, the country has to import cowpea grains to cope with the domestic demand. The dry grains are used to prepare many types of menu, the green pods are eaten as vegetables and the hay is used to feed animals (Asante *et al*., 2001). Yields in Nigeria are below 400kg/ha at farmer level mainly due to numerous insect pests such as *Maruca vitrata*, *Megalothrips* spp. These insect pests attack the reproductive parts such as the flower and flower buds thereby causing substantial loss in yield up to 80% by *M. vitrata* alone (Oparaeke, *et al.,* 2005) By webbing together flowers, pods and young leaves, the larvae protect themselves from the reach of conventional pesticides and other natural enemies (Downham *et al*., 2003). Control is mainly through the use of insecticides which apart from endangering farmers health and the environment, could lead to pest resistance (Sharma, 2005). Conventional insecticides such as dimethoate and cypermethrin which were known to be effective against the *M. vitrata* are now becoming less effective due to resistance developed by the borer (Ekesi, 1999). In view of this, the use of integrated control (IPM) is now being advocated. The basic principle of IPM lies in the use of resistant cultivars, conservation of natural enemies and the judicious use of insecticides (Sharma, 2005).

Botanical insecticides in the form of nke have been known to have high insecticidal activity against *M. vitrata* and are environmentally friendly (Jakai and Oyediran, 1991). Results from the first year's field experiments when pest pressure was low demonstrated the value of scouting-based interventions to decrease insecticide use and the potential of neem as a natural insecticide. Other IPM components which were tested have been dropped from further validation as the pheromone trap was ineffective, *H. spicegera* provided no control of the pest and there was little difference between the cowpea varieties in resistance to *M. vitrata.* In view of the low pest pressure encountered during the first season the two varieties were again used in the second season to test in the event of greater pest pressures the improved variety will then outperform the local susceptible variety. In the second season, the use of neem and scouting were combined into an IPM system which was validated in an on-station field trial in comparison with the standard insecticide regime.

9.2 MATERIALS AND METHODS

During the second year, nke (Plate 15 and 16) was validated using on-station experiments.(Plate 13 and 14) There was only one type of experiment carried out see general methodology 3.6.

9.2.1 Data collection

This was the same as in the first year experiment (2008). Average yield of the two varieties was used in calculating yield increase.

9.2.2 Data analysis (See general methodology).

Plate 13 Second year on-station experiment plots

Plate 14 Weeding experiment plots

Plate 15 Drying neem kernels

Plate 16 Grinding neem kernels

9.3 RESULTS

9.3.1 Yields, larval infestation/damage, pod and seed damage

All spray treatments increased seed yield above the unsprayed controls. Larval infestation/damage, pod and seed damage were also reduced below those of the unsprayed control due to insecticide sprays. Highly significant differences were observed between the means of these parameters measured and those of the unsprayed control ($P \leq 0.001$) (Fig 9.1, 9.2, 9.4 & 9.5). Highest yield was obtained by weekly insecticide sprays followed by weekly neem applications (Table.9.1). Yield increase of 88% and 92% above the untreated controls were obtained by calendar chemical insecticide treatment for the varieties of cowpea (Danzafi (V1) and Improved Kanannado (V2) (Table 9.1) respectively. Scouting resulted in only one spray and yields for both commercial insecticide and neem extracts were similar. Yield increases of 82% and 89% above the unsprayed controls were obtained for the two varieties in the scouting based chemical insecticide treatments. A similar level of yield increase was sustained by both calendar and scouting base nke application (Table 9.1). Yield difference between chemical insecticide and nke treatments generally did differ significantly ($P \geq 0.05$) (Fig 9.1). Lowest yield was associated with the unsprayed controls. Also, mean yield did not differ significantly among the untreated controls of both varieties ($P \geq 0.05$) (Fig.9.1). For both cultivars, highest larval infestation/damage, pod and seed damage reduction were obtained by calendar based chemical insecticide sprays, followed by neem applications of the same regime (Table.9.2-9.4). However, both cultivars under scouting based insecticide applications, using only one spray, had a similar level of larval infestation/damage, pod and seed damage (Tables 9.2-9.4). Significantly higher ($P \leq 0.001$) larval infestation/damage was recorded in the scouting based insecticide application resulting in yields from scouting based insecticide spray regime being significantly ($P \geq 0.05$) lower in comparison with those of the calendar based insecticide treatments. However, the highest benefit-cost ratio (Table 9.5) was obtained from nke application on a need basis (scouting). Perfect negative correlation was obtained between yield of cowpea and larval infestation/damage ($R^2 = 0.9212$) (Fig. 9.3).

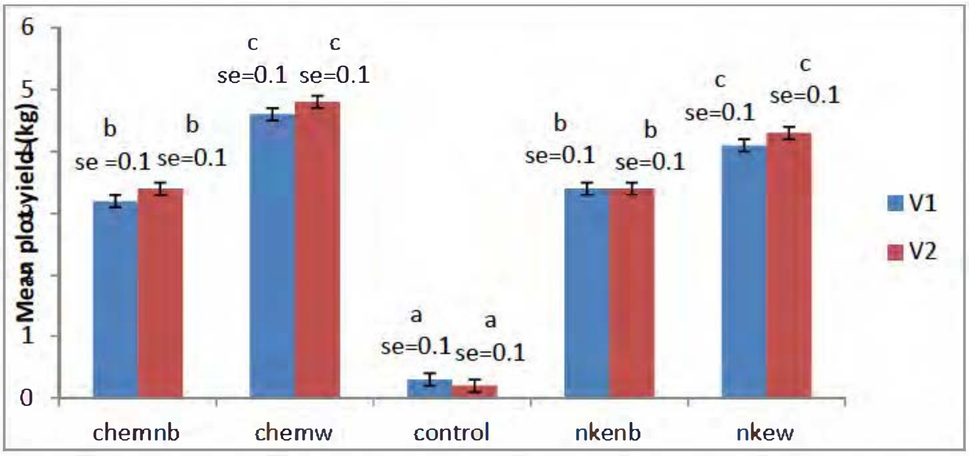

Fig.9.1 Effect of commercial insecticide and neem kernel extract on seed yield of two cowpea varieties Danzafi (V1) and Improved Kanannado (V2). Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$). Plot size = 6m x 6m.

Table 9.1 Percentage yield increase/reduction of two cowpea varieties Danzafi (V1) and Kanannado (V2) under commercial insecticide and neem application

Treatment	% yield increase	
	V1	V2
chemnb	82	89
chemw	88	92
Control(unsprayed)		
nkenb	84	89
nkew	86	91

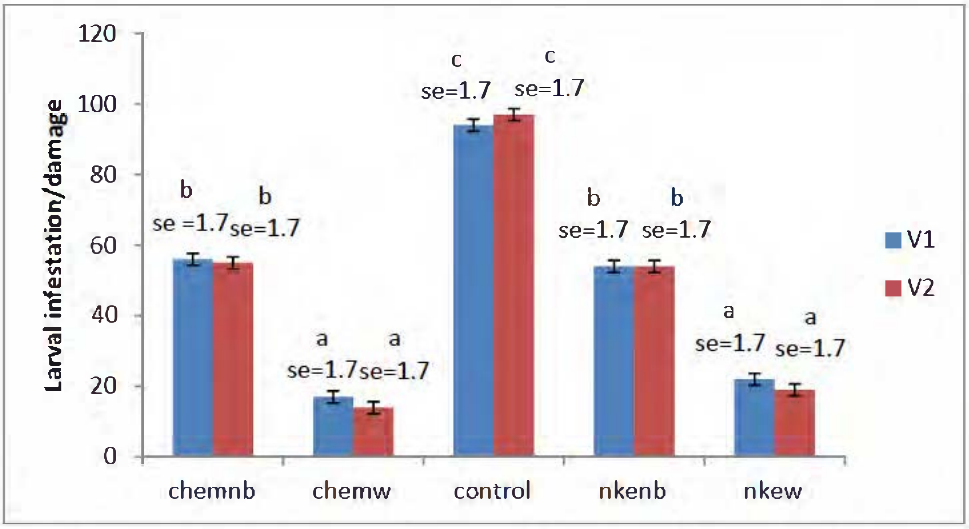

Fig.9.2 Effect of commercial insecticide and neem kernel extract on larval infestation/damage of two cowpea varieties Danzafi (V1) and Improved Kanannado (V2). Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$).

Table 9.2 Percentage larval infestation/damage reduction/increase of two cowpea varieties Danzafi (V1) and Improved Kanannado (V2) under commercial insecticide and neem application

Treatment	% reduction larval infestation/damage	
	V1	V2
chemnb	25	27
chemw	69	76
Control(unsprayed)		
nkenb	27	28
nkew	62	67

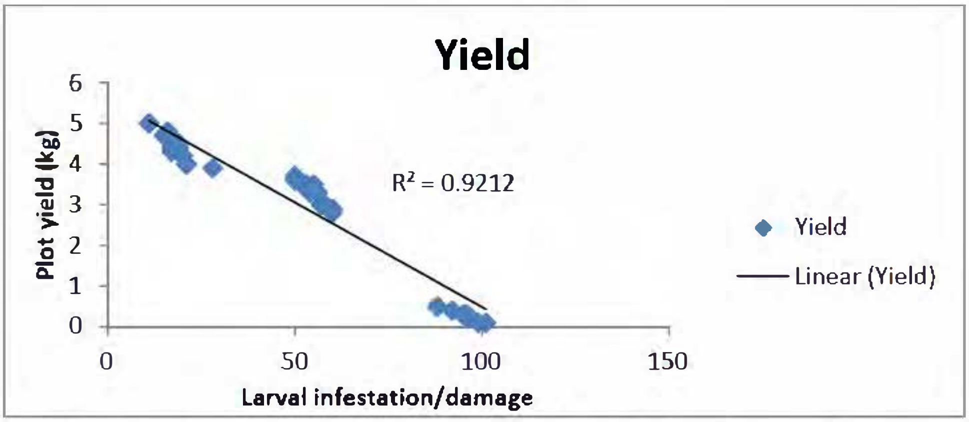

Fig.9.3 Relationship between yield loss and number of cowpea flowers damaged in the second season on-station experiment.

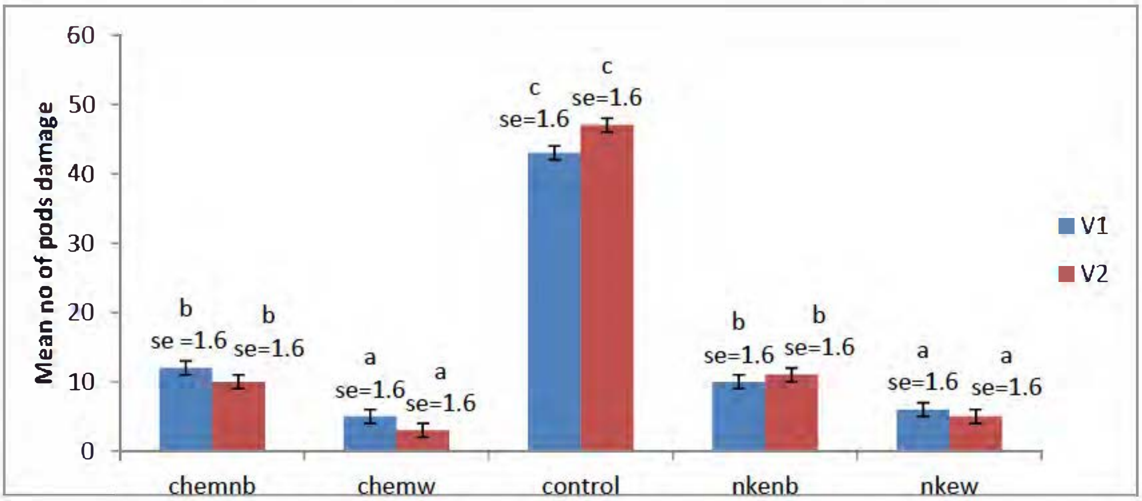

Fig.9.4 Effect of commercial insecticide and neem kernel extract (nke) on pod damage of two cowpea varieties Danzafi (V1) and Improved Kanannado (V2). Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$).

Table 9.3Percentage reduction/increase of pods damage of two cowpea varieties Danzafi (V1) and Improved Kanannado (V2) under commercial insecticide and neem application

Treatment	% reduction of pods damage	
	V1	V2
chemnb	56	65
chemw	78	88
Control(unsprayed)		
nkenb	62	62
nkew	76	81

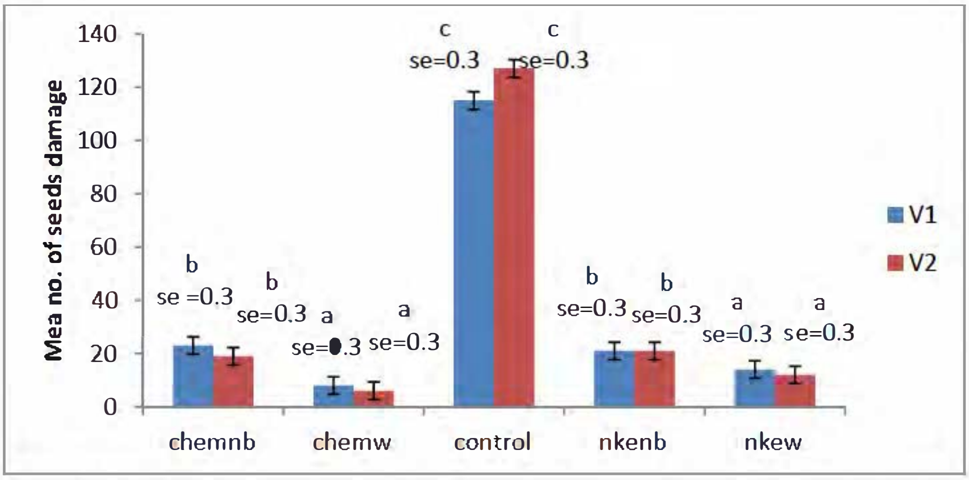

Fig.9.5 Effect of commercial insecticide and neem kernel extract on seeds damage of two cowpea varieties Danzafi (V1) and Improved Kanannado (V2). Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$).

Table 9.4 Percentage reduction/increase of seeds damage of two cowpea varieties Danzafi (V1) and Improved Kanannado (V2) under commercial insecticide and neem application

Treatment	% reduction of seeds damage	
	V1	V2
chemnb	67	74
chemw	87	91
Control(unsprayed)		
nkenb	69	71
nkew	78	83

Table 9.5 Benefit/Cost analysis, of the various control options used in the second year.

item	**nke weekly**	**nke scouting40%**	**nke scouting60%**	**chem. weekly**	**chem.Scouting40%**	**chem. scouting 60%**
	cost	**cost**	**cost**	**cost**	**cost**	**cost**
Seed dressing material (N)	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
Labour for seed dressing (N)	300.00	300.00	300.00	300.00	300.00	300.00
Insecticides	3500.00	1000.00	500.00	10500.00	3000.00	1500.00
Sprayers	1300.00	1300.00	1300.00	1300.00	1300.00	1300.00
Sprayings (N)	7000.00	2000.00	1000.00	7000.00	2000.00	1000.00
Scouting (N)	Nil	3000.00	3000.00	Nil	3000.00	3000.00
Mortar and pestle (N)	95.00	95.00	95.00	Nil	Nil	Nil
Total (N)	13195.00	8695.00	7195.00	20100.00	10600	8100.00
Average yield (kg/ha)	1166.6	1416.6	944.4	1305.5	1374.9	916.6
Yield Increase (kg/ha)	1083.3	1333.3	861.1	1222.2	1291.6	833.3
Value of Yield Increase (N)	216,660.0	266660.00	172,220.00	244,440.00	258320.00	166,660.00
Profit (N)	203,465.0	257,965.00	165,025.0	224,340.00	247,720.00	158,560.00
Benefit/Cost ratio	16.4	30.7	24.0	12.2	24.4	20.5

NB:. nke scouting 40% neem = Projected neem application on scouting basis at 40% flower damage action threshold, chem. scouting 60%= chemical pesticide application at 60% flower damage action threshold Average yield of control plots = 83.3kg.

9.4 DISCUSSION

Weekly chemical pesticide application remains an effective control strategy in view of its effect on yield and pod borer larvae infestation/damage. Earlier studies have shown that calendar-based chemical control has the ability to control *M. vitrata* and increase yield of cowpea by many fold, compared to sprays based on economic threshold (Sharma, 1998; Egho and Emosairue, 2010). However, in view of the negative effects of chemical insecticides on both the farmers' health and environment, including the non-target organisms, chemical pesticide usage especially on calendar basis, is now under strong criticism (Atachi *et al*., 2002).

Although pest control and seed yield were superior with the calendar-based spray regime, the use of neem provided adequate control and was more profitable than using commercial insecticide. The lower cost-benefit ratio sustained by weekly commercial insecticide application was an indication of the wasteful nature of calendar based control strategy. Previous studies such as those of Sharma (1998) have indicated the lack of economic rationale behind calendar based insecticide sprays. Moreover, cowpea has been known to compensate for any early season insect pest damage thereby making any control measure at the vegetative stage to be irrational (Adipala *et al*., 2000).

The ability of nke applications, to obtain yield increase and reduction of *M. vitrata* larval infestation/damage similar to that of the commercial insecticide, was an indication of the potential of neem as a possible alternative control option against *M. vitrata* larval damage in cowpea. In addition to azadirachtin, neem kernel extract has been shown to contain the following biologically active components: gedunin, nimbin, azaridione and epoxy of azaridione, all of which are environmentally safe, making neem suitable for ecologically based crop protection strategies against *M. vitrata* (Sharma, 2005). Higher concentrations of neem extract have been found to provide 100% protection of cowpea against *M. vitrata* larvae attack thereby making it suitable for use in crop protection (Jakai and Oyediran, (1991). It has been documented that neem, when combined with host plant resistance can provide very effective means of *M. vitrata* control (Sharma, 1998). Botanical pesticides such as nke have in many previous research works demonstrated capability for use as an alternative to conventional chemical pesticide in *M. vitrata* larvae control in cowpea and are easy to prepare by the local farmers (Oparaeke, 2005; Adati *et al*., 2008). The low cost-benefit ratio resulting from weekly nke application, in comparison to its application on a scouting basis, was an indication of the uneconomical nature of calendar based insecticide application (Karungi *et al*., 2000). The significantly higher larvae infestations/damage sustained by both the need based treatments of nke and chemical pesticide compared to the calendar applications of the same pesticides was due to the different approach of pest control used by the two types of pesticide applications. In contrast to the calendar method of pesticide application, the need based (scouting) approach relied on an action threshold (AT) allowing larval infestation/damage to build up until reaching a certain predetermined level before any insecticide application is carried out (Afun *et al*., 1991). However, the highest benefit/cost ratio sustained by nke need based sprays followed by need based commercial insecticide sprays (see table 9.6), provided an indication of the profitability of a monitoring based control strategy. Earlier studies such as those of Karungi *et al*., (2000) have already demonstrated the profitable nature of scouting based insecticide application. In view of this profitable outcome of scouting based nke application, its potential as an IPM control strategy for *M. vitrata* on cowpea, has now been demonstrated. The next step was to test the system on farm and assess its appeal to cowpea smallholders and their ability to implement it.

9.5 CONCLUSIONS

Both varieties of cowpea have a similar level of susceptibility to *M. vitrata.* As such the local variety also has the potential for use in IPM. Neem (nke) application on a weekly basis effectively controlled *M. vitrata*, but such calendar application was not economical for farmers to use. The study therefore has validated the effect of nke as a replacement for commercial insecticide in an IPM system for control of *M. vitrata*, if cost can be kept low. Scouting resulted in only one spray being used instead of seven, so although the yield was higher using calendar-based applications, the benefit/cost ratio was greater when scouting was used. Scouting therefore has the potentials for adoption by the resource poor farmers, especially if it incorporates a lower action threshold of, say, 40% infestation/damage.

CHAPTER TEN: ON-FARM VALIDATION OF THE IPM SYSTEM FOR THE MANAGEMENT OF *MARUCA vitrata*

10.1 INTRODUCTION

Cowpea cultivation is an integral component of the farming systems of the savannah zones of Northern Nigeria, as a result of the role it plays as a source of protein to the people, as well as nourishing the poor soils with nitrogen (Oso and Falade, 2010) Nigeria is the leading producer of cowpea and the bulk of the production is carried out in the Northern part of the country, where insect pests such as *M. vitrata*, remain the major production constraint. Farmers apply chemical insecticide as many as 8 – 10 times during the season in order to achieve control of the pod borer (Egho, 2010). Massive chemical insecticide usage on a calendar basis has been known to be uneconomical in addition to the hazards caused to farmers' health and to the environment. In Nigeria, insecticides recommended only for cotton have found their way into the hands of cowpea farmers who unknowingly poison the crop for the consumers (CGIAR SP-IPM, 2006). Therefore, farmers need to be introduced to other safe and effective means of control such as the use of Integrated Pest Management (IPM) strategies. According to Munyua (2003: 476) "The process of change must occur at farmers farm and the farmer must understand the farm environment to be fully involved in the implementation of IPM practices". Small scale farmers are hardly involved in the planning and investigations of new farming technologies and unless these farmers are directly involved in the research and development of these new farming technologies, it is unlikely that new technologies will be widely adopted (Andrews *et al.*, 1992; Rajasekaran, 1993). Against this background therefore, this study seeks to use a farmer participatory approach to validate the use of neem (nke) on scouting basis as an alternative IPM strategy for the control of *M. vitrata* in cowpea. The Improve Kanannado cowpea variety was used instead of the local variety in view of its high market value and was the most cultivated cowpea variety.

10.2 MATERIALS AND METHODS

The investigation was carried out in Manga Village of Zuru Local Government Area of Kebbi State of Nigeria between July and December 2012. For details of the materials and methods see general methodology

10.2.1 Data collection

The natural enemies were sampled using sweep net from the two inner rows using 20 strokes per sampling unit and the populations of flying natural enemies caught were recorded on the spot. Natural enemies sampling started on the 2nd of November and ended on the 16th of the same month. Also lady beetles (coccinellids) were counted using visual counting technique. Pitfalls were dug within the inner rows used in the sampling areas in order to catch ground dwelling predators. For more information on flower sampling, pod damage, seed damage and plot yield refer to the general methodology.

10.2.2 Data analysis

Significant differences in natural enemies' abundance between treatments were compared using the Friedman chi-square. The Wilcoxon signed-rank test was used to compare the total number of natural enemies among the treatments. For more details about data analysis for larval infestation/damage and other parameters such as yield see general methodology. Diversity index was calculated by dividing the number of species in a treatment area by the total number of the individual in the area. Relative species abundance was calculated by dividing the number of species in a treatment area by the total number of species in all the treatment areas.

10.3 RESULTS

10.3.1 Larval infestation/damage, yield, pod, and seed damage

Treatments had a significant effect on larval infestation/damage, pod and seed damage and were associated with yield increase (Fig.10.1-10.4). Spraying commercial chemical insecticide and nke, on both a calendar and scouting basis, reduced larvae infestation/damage, pod damage and seed damage, when compared to the unsprayed controls. Highly significant difference was found when the mean of these parameters from the treated plots were compared with those of the unsprayed controls ($P \leq 0.001$) (Fig. 10.1). Lower larval infestations/damage were recorded in plots sprayed on a calendar basis compared to those sprayed on scouting basis but the scouting-based treatment required only two spray applications after pest infestation/damage reached

60%. The larval infestation/damage of the scouting based nke treated plots was significantly ($P \leq 0.001$) higher than those of the calendar based chemical insecticide treated plots Fig. 10.2). Similar result was obtained when the larval infestation/damage of the scouting based commercial insecticide treated plots was compared with that of the calendar based commercial insecticide treated plots (Fig. 10.2). Although a significant difference existed between the larvae infestation/damage of scouting based nke treated plots and those of similar spray regime of commercial insecticide ($P \leq 0.05$) (Fig 10.2), there was no significant difference between those of the calendar based nke treated plots and those of the same spray regime of commercial chemical insecticide ($P \geq 0.05$) (Fig.10.2).

A reduction in pod damage of 70% and 57% below that of the unsprayed controls was obtained from calendar based commercial chemical insecticide and nke applications (Table 10.3). Scouting based application of commercial chemical insecticide and nke, reduced seed damage by 65% and 45% below those of the unsprayed controls respectively (Table 10.4). No significant difference was found in the mean number of pods and seeds damaged between all calendar based spraying of both chemical insecticides and nke, in comparison with those of the scouting based spraying of the same pesticides ($P \geq 0.05$) (Fig 10.3 & 10.4). All spray interventions increased yield above the unsprayed control. A highly significant difference was observed in the mean yield of calendar based commercial insecticide treated plots in comparison with the unsprayed controls ($p \leq 0.001$) (Fig. 10.1). The same result was obtained when the mean yield of the scouting based commercial insecticide treated plots was compared with those of the unsprayed control plots. No significant difference was observed in the mean yield of scouting based nke treated plots when compared with those of the calendar based commercial insecticide treated plots ($P \geq 0.05$) Fig. 10.1). Yield increases over unsprayed control (74% and 68%) were obtained as a result of calendar spraying both commercial chemical insecticide and nke respectively (Table 10.1) while those of scouting based of the commercial chemical insecticide and nke application are 72% and 64% respectively. The benefit-cost ratio (B.C) of the scouting based nke application was superior (19.2 & 25.7 at 40% and 60% action thresholds) to the rest of the treatments (Table 10.5). There was a correlation between flower damage and larval infestation (R^2= 0.5449) (Fig. 10.3).

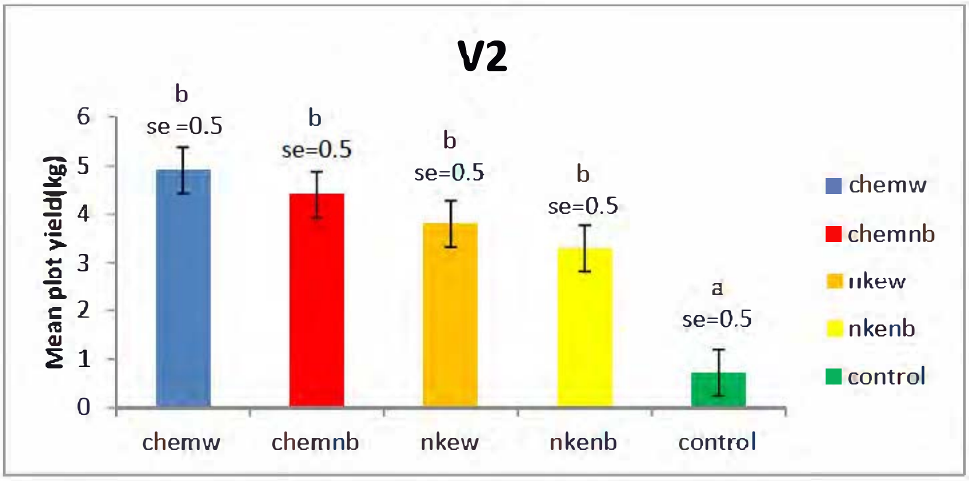

Fig 10.1 Effect of commercial chemical insecticide and neem on seed yield (kg) of Improved Kanannado cowpea variety. Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$). Plot size = 4m x 10m.

Table 10.1 Percentage yield increase/reduction of Improved Kanannado cowpea variety under commercial insecticide and neem application

Treatment	% yield increase
chemnb	72
chemw	74
Control(unsprayed)	
nkenb	64
nkew	68

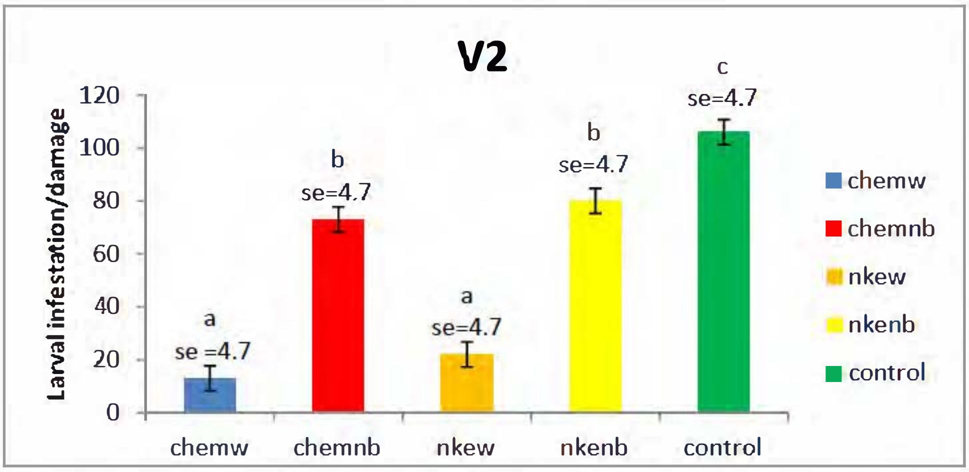

Fig. 10.2 Effect of commercial chemical insecticide and neem on larval infestation/damage of the Improved Kanannado cowpea variety. Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$). (chemw = weekly application of chemical insecticides, chemnb = scouting based chemical insecticide application, nkew = weekly application of neem, nkenb = scouting based neem application and control = unsprayed).

Table 10.2 Percentage reduction/increase of larval infestation/damage the Improved Kanannado cowpea variety, under commercial insecticide and neem application

Treatment	% reduction of larval infestation/damaged
chemnb	19
chemw	78
Control(unsprayed)	
nkenb	14
nkew	66

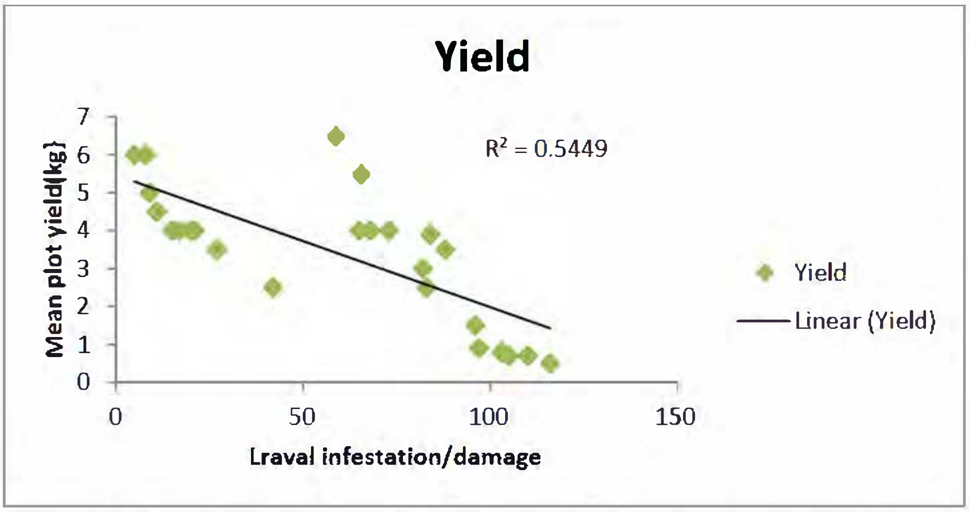

Fig.10.3 Relationship between yield loss and flower damage in the third season on-farm experiment.

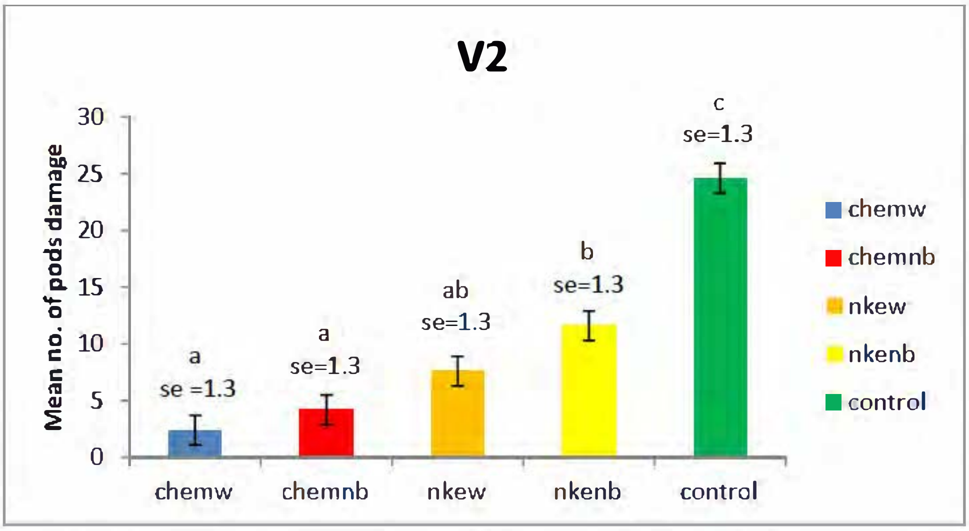

Fig. 10.4 Effect of commercial chemical insecticide and neem on pod damage of the improved Kanannado cowpea variety Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$).

Table 10.3 Percentage reduction/increase of pods damaged of improved Kanannado cowpea variety under commercial insecticide and neem application

Treatment	% reduction of pods damage
chemnb	70
chemw	82
Control(unsprayed)	
nkenb	38
nkew	52

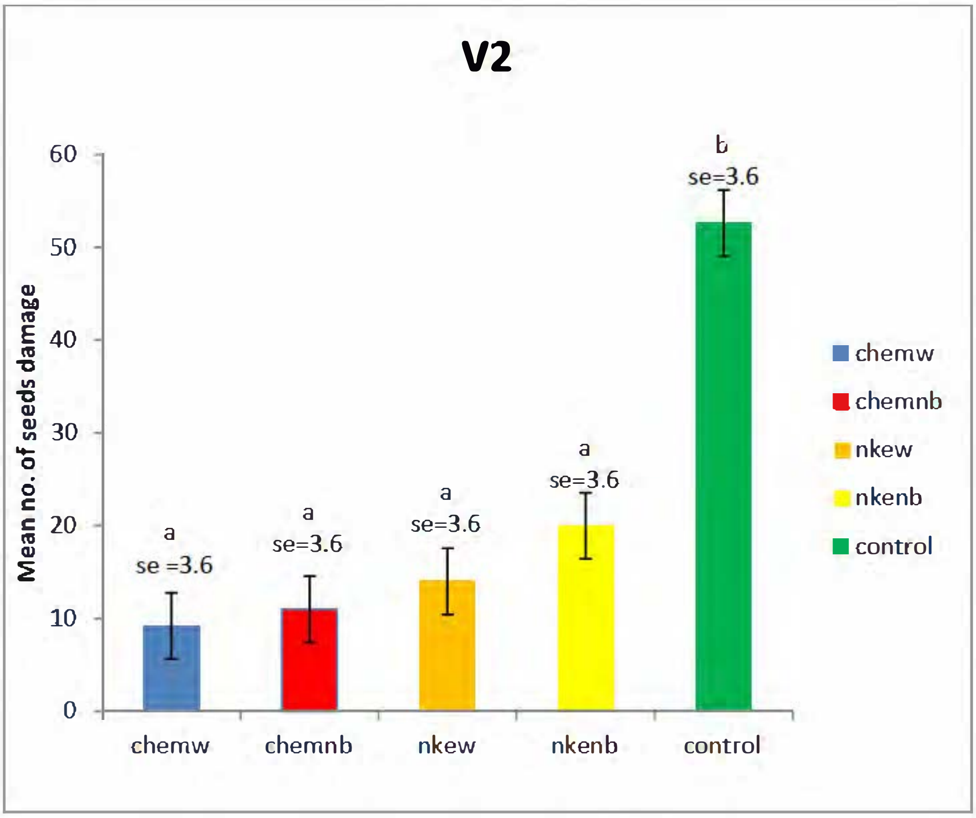

Fig 10.5 Effect of commercial chemical insecticide and neem on seed damage of the Improved Kanannado cowpea variety. Treatments having the same letter or another letter added are not significantly different ($P \geq 0.05$).

Table 10.4 Percentage reduction/increase of seeds damaged of Improved Kanannado cowpea variety under commercial insecticide and neem application

Treatment	% reduction of seeds damage
chemnb	65
chemw	70
Control(unsprayed)	
nkenb	45
nkew	57

Table 10.5 Benefit/Cost analysis, of the various control options used in the on-farm experiment.

item	nke weekly costs	nke scouting 40% costs	nke scouting 60% costs	chem. weekly costs	Chem.Scouting40% costs	chem. scouting60% costs
Seed dressing material (N)	300.00	300.00	300.00	300.00	300.00	300.00
Labour for seed dressing (N)	200.00	200.00	200.00	200.00	200.00	200.00
Insecticides/nke	6300.00	2700.00	1800.00	17500.00	7500.00	5000.00
Sprayers (N)	1700.00	1700.00	1700.00	1700.00	1700.00	1700.00
Sprayings (N)	490.00	210.00	140.00	490.00	210.00	140.00
Scouting (N)	Nil	3000.00	3000.00	Nil	3000.00	3000.00
Mortar and pestle (N)	145.00	145.00	145.00	Nil	Nil	Nil
Total costs (N)	9135.00	8255.00	6785.00	20190.00	12910.00	10840.00
Average Yield (kg/ha)	950	1237.5	825	1225	1650	1100
Yield Increase (kg/ha)	775	1062.5	650	1050	1475	925
Value of yield (N) increase	155,000.00	212,500.00	130,000.00	210,000.00	295,000.00	185,000.00
Profit (N)	140,865.00	204,245.00	123,215.00	189,810.00	282,090.00	174,160.00
Benefit/Cost ratio	17.0	25.7	19.2	10.4	22.9	17.1

NB: chem. scouting 60% = chemical pesticide application at 60% flower damage action threshold, nke scouting 40% = Projected neem application at 40% flower damage action threshold, Average plot yield = 175kg/ha. For other details see general methodology.

10.3.2 Predator abundance in relation to time

Coccinellidae spp. (Ladybugs) were the only Coleopteran predators caught during the sampling exercise (Plates 25 and 26) and they constitute 16% of the total Predators/Parasites caught. They appeared in the first week and continued to increase in the second and third week of sampling. The Dipteran predators/parasites constituted 41% of beneficial insects trapped (Fig. 10.5) and were the majority of the predators sampled. Members of this Order such as the Asilidae spp. (Robber flies) (Plate 21) were not present during the first week, but appeared in the second week and increased in number in the third week. They constituted the majority of the Dipterans caught (Table 10.6). The Tachinidae spp. (Tachinid flies) were absent for most of the time and were only caught during the third week in small numbers (3%). The Syrphidae spp. (Hover flies) (Plate 19) were present on each sampling date but their populations were observed to be high in the first week, decreased in the second week and rose to its peak in the third week (Table 10.6). They were the second largest group within their Order (19%). The Hymenopterans (Wasps) constitute 21% of the total predators/ parasites sampled and the majority (15%) were the *Polistes* spp. (Plate 20) whose number was highest during the first week but began to decline during the second and the third week (Table 6.7). The Ichneumonidae spp. (Plate 17) only appeared in the third week and their numbers were low (2.4%). Other Hymenopterans caught were the *Vespula* spp. (Plate 18), whose appearance was noticed in the first week and reduced in number in the second week then disappeared in the third week. The Anisopterae spp. (Dragon flies) (Plate 22) made their appearance in the second week and increased in number in the third week, as did the Mantidae spp. and the Anisopterae spp.

10.3.3 Effect of insecticide treatments on the abundance of predator/parasites

There were significant differences in the number of the beneficial insects between the treatments (Table 10.9). Spraying insecticides greatly decreased the number of beneficial insects relative to the unsprayed control plots and this effect was greater for chemical insecticide than for neem and was more pronounced in the calendar-based spray treatments. (Fig.10.8). Application of chemical insecticide and nke on calendar basis did not favour the proliferation of beneficials, as shown by the cluster 1 (Fig. 10.8). Where fewer neen sprays were applied due to scouting, the numbers of the beneficial insects were similar to the unsprayed plots (Table 10.8). Generally, fewer Coccinellidae were observed in the commercial chemical insecticides treated plots in comparison with the botanical insecticide. However, the unsprayed controls had the highest number of these predators, followed by the scouting based nke treated plot (Table 10.8). The highest number of the Asilidae spp. was caught in the scouting based nke treated plots, followed by those of calendar based nke treatment. The lowest number of these predators was found in the calendar based commercial insecticide treated plots. All the Tachinidae spp. sampled were from the unsprayed controls (Table 10.8). The Syrphidae spp. were present in all the treatment plots but their number was higher in the unsprayed control plots, followed by the scouting based nke treated plots then the calendar based nke treated plots. Both the calendar and scouting based commercial insecticide treated plots sustained few but equal number of these predator. The entire Ichneumonidae spp. were caught in the unsprayed control plots. The highest number of the Vespidae spp. (*Polistes* spp. and *Vespula* spp.) were caught in the nke scouting based treated plots, followed by the unsprayed controls. Among these predators only *Polistes* spp. were caught in the chemical insecticide treated plots. The Anisopterae were caught mostly in the unsprayed controls, followed by the calendar and scouting based nke treated plots. Only one was caught in the calendar based commercial insecticide treated plots (Table 10.8) As for the Mantidae, most of them were caught in the unsprayed controls followed by nke scouting based treated plots and none was caught in the chemical insecticide treated plots (Table 10.8)

Plate 17 Vespidae: Ichineumonidae sp.

Plate 18 Vespidae: Vespula sp.

Plate 19 Syrphidae sp.

Plate 20 Vespidae: Polistes sp.

Plate 21 Asilidae sp.

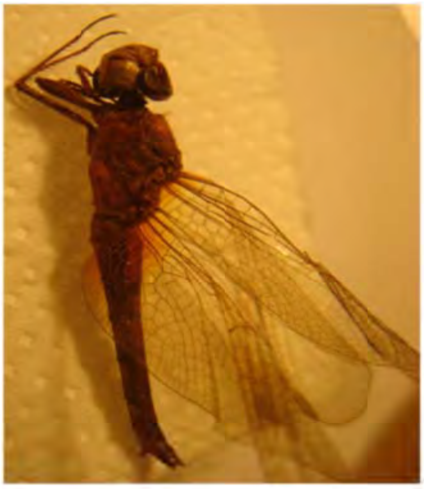

Plate 22 Anisoptera sp.

Plate 23 Mantidae: *Mantis* sp.
(Brown)

Plate 24 Mantidae: *Mantis* sp.

Plate 25 Sampling of predators in IPM plots

Plate 26 Assessment of larval infestation/damage with IPM farmers

Fig. 10.6 Relative percentage of the various insects sampled using scoop net in Zuru.

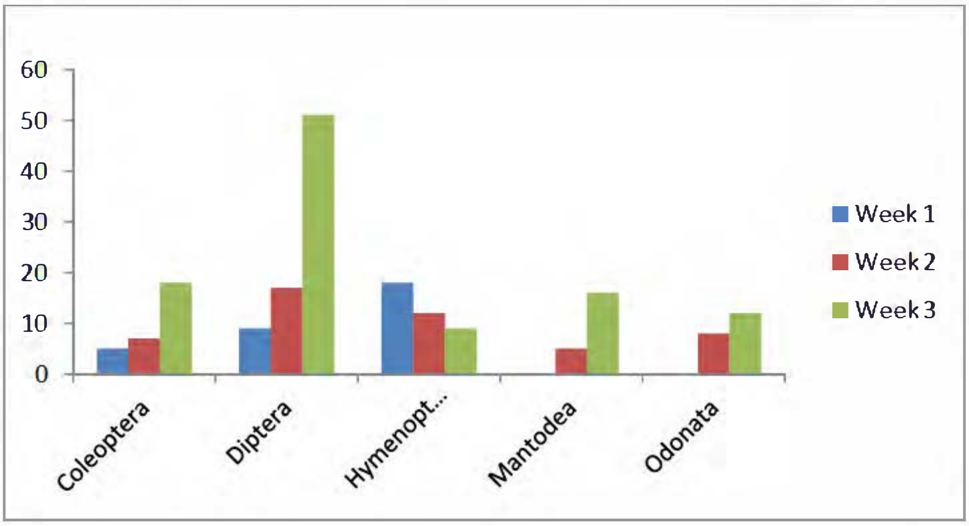

Fig. 10.7 Effect of time on the abundance of predator/parasites sampled using a scoop net.

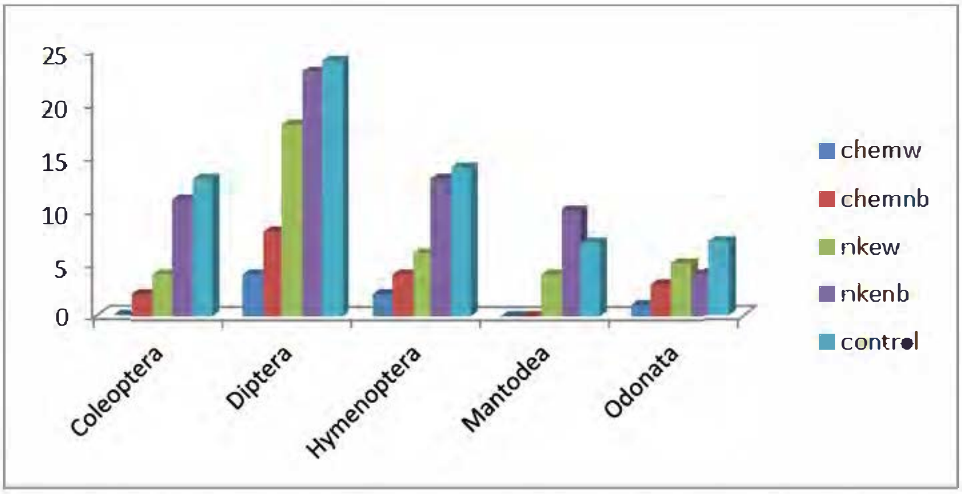

Fig. 10.8 Effect of insecticide sprays on the abundance predator/parasites sampled using a scoop net.

Table 10.6 Predators/parasites total numbers in relation to time of sampling

insect	weekly catch			total	%
	1	2	3		
Coleoptera:Coccinellidae sp.	5	7	18	30	16.0
Diptera					
Asilidae sp.	Nil	10	30	40	21.4
Tachinidae sp.	Nil	Nil	5	5	2.7
Syrphidae sp.	9	7	16	32	17.1
Hymenoptera					
Ichneumonidae sp.	Nil	Nil	4	4	2.1
Vespidae:					
Polistes sp.	10	9	5	24	12.8
Vespula sp.	8	3	Nil	11	6.0
Mantodea					
Mantidae:*Mantis* sp.	Nil	5	16	21	11.2
Odonata: Anisoptera sp.	Nil	8	12	20	10.7
Grand Total				187	

Table 10.7 Wilcoxon signed rank test comparison for total number of predators/parasite between the various treatments

s/n	type of comparison	p-value
1	control-chemw	0.0091**
2	control-chemnb	0.0088**
3	control-nkew	0.0320*
4	control-nkenb	0.8830ns
5	chemnb-chemw	0.0201*
6	nkenb-chemnb	0.0140*

Significance codes 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05, ns = not significant

Table 10.8 Predator/parasites total numbers trapped in the various treatment plots

insect	population in the various treatment plots					total
	chemw	chemnb	nkew	nkenb	control	
Coleoptera						
Coccinellidae sp.	Nil	2	4	11	13	30
Diptera						
Asilidae sp.	1	5	11	14	9	40
Tachinidae sp.	Nil	Nil	1	1	3	5
Syrphidae sp.	3	3	6	8	12	32
Hymenoptera						
Ichneumonidae sp.	Nil	Nil	Nil	Nil	4	4
Vespidae:						
Polistes sp.	2	4	6	7	5	24
Vespula sp.	Nil	Nil	Nil	6	5	11
Mantodea						
Mantidae:	Nil	Nil	4	10	7	21
Mantis sp.						
Odonata						
Anisoptera sp.	1	3	5	4	7	20
Total	7	17	37	61	65	
Diversity index	0.57	0.29	0.19	0.13	0.14	
Abundance index	0.12	0.15	0.21	0.24	0.27	

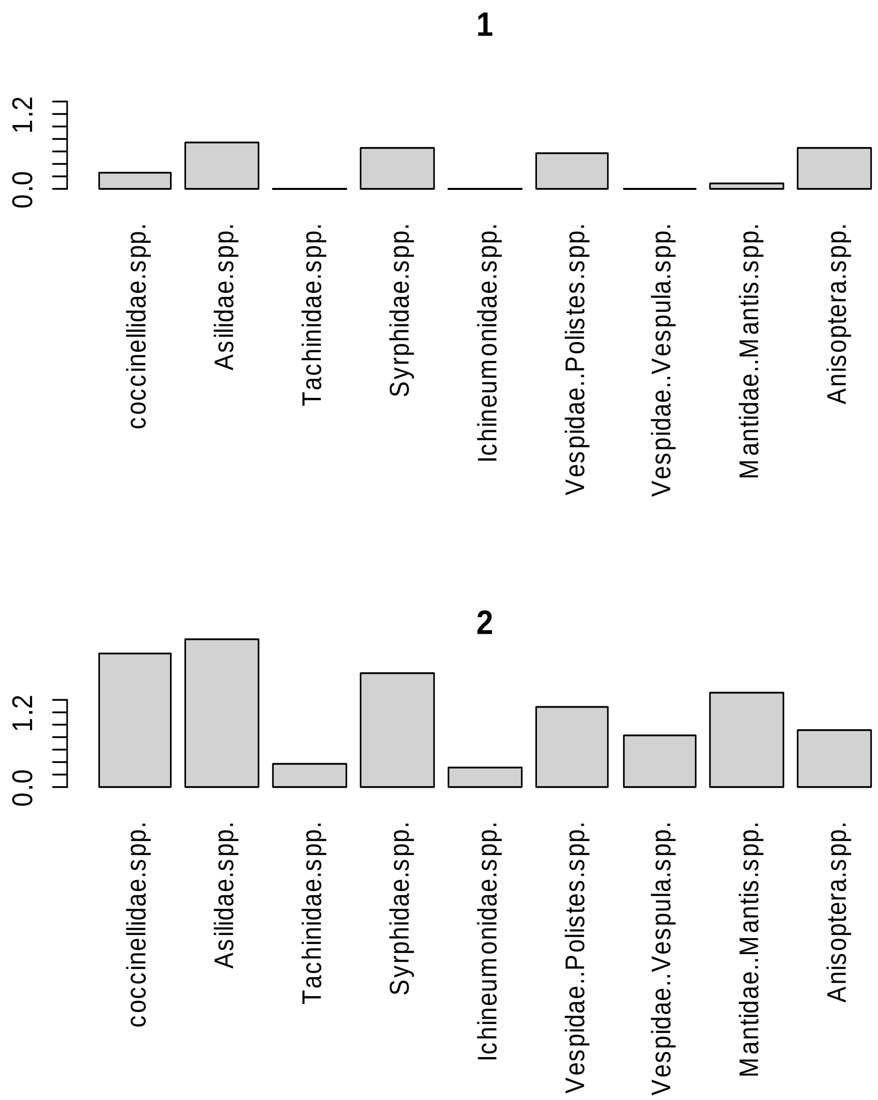

Fig. 10.9 Relationship between treatments and the predator/parasites abundance (Cluster 1= all chemical treatments and part of the calendar based nke treatments. Cluster 2= unsprayed controls, the scouting based nke treatments & part of the calendar based nke treatments). The scale showed that the average number of insects per specie in the two clusters was 1.2. The difference in the species distribution between the two clusters in highly significant ($P \leq 0.001$). Also see appendix 3.3.5 for significance test.

Table 10.9Friedman Chi-squared test for significant difference in predators/parasites among treatments

x^2	df	p-value
26.9565	4	2.029e-05

10.4 DISCUSSION

Commercial chemical insecticide sprays applied on a calendar basis outperformed all the other insecticide applications in decreasing the *M. vitrata* larvae infestation/damage on the cowpea variety tested (Improved Kanannado). Similar findings were also documented by Afun and co-workers, (1991). Egho (2011) whose work using cypermethrin on both calendar (7 days interval) and monitored sprays, also showed highly significant difference between the two spray regimes (calendar and scouting) in terms of larvae infestation/damage. Previous works such as those of Dzemo (2010) obtained better control (69% reduction) of the pod borer larvae infestation with calendar sprays which was started at the seedling stage (5 sprays at 7days interval) compared to 44% larvae reduction obtained by 3 sprays of chemical insecticide which was started at the flower budding stage. However, using pheromones as a monitoring device, application of synthetic insecticides was found to be more effective in reducing *M. vitrata* larvae infestation/damage in cowpea, compared to spraying based on crop growth stage (Calendar) (Downham, 2003). Although the concealed feeding nature of the larvae sometimes makes it difficult for farmers to achieve full control with minimal or monitored insecticide applications, such intensive use of chemical insecticide as done on the calendar based sprays, is known to adversely affect the natural enemies' population thereby promoting pest resurgence. In addition to the long term effect on the farmers' health and that of the consumers, this type of spraying is known to be uneconomical and makes food production expensive (Jeyanthi and Kombairaju, 2005). Also, it has been observed that in many instances, the economic cost of this type of multiple sprays can even be greater than the cost of damage done to crop by pests (Symondson *et al.*, 2002).

Foliar insect damage is only sporadic in the savannah zones in Nigeria and more than 70% of total loss in yield of cowpea occurs at the reproductive stage, making any spray at the vegetative state (36 days after planting) as is done on calendar basis, unwarranted (Asante, 2001). Generally nke application on both calendar and scouting had a positive effect in the reduction of the larvae infestation/damage. Kanhere and co-workers (2012) also demonstrated that the use of nke at 5% concentration could give good control of larvae infestation/damage in cowpea as a result of its inflicting 85% mortality on the pest populations. However the work of Egho (2012) goes contrary to the findings of this research work due its inability to detect any significant difference between treatment and controls in terms of larvae infestations/damage when nke at 5%

concentration was used. This could have possibly been caused by low pest pressure in Egbo's study (Bottenberg and Singh, 1996). Although both chemical pesticide and nke applications on scouting basis did reduce larvae infestation/damage below the level obtained in the unsprayed controls, the relatively higher pest infestation/damage in comparison with the calendar based counterparts, could have occurred due to the delayed nature of the scouting based spray regimes until the infestation reached the 60% action threshold.

Although both larval infestation/damage and the number of pods damaged with the calendar and scouting based commercial chemical insecticide treatments were significantly lower than those of the scouting based nke treatments, this did not result in any significant difference in seed damage and grain yield. Yield was not affected possibly due to the use of manure and the indeterminate nature of the varieties used. Animal manure contains phosphorus (PureAg, 2011), which according to Asiwe (2009) is known to enhance speedy crop recovery after insect damage. This enhanced crop recovery coupled with the staggered flowering nature of the cultivars and some measure of insecticide protection given could have caused yield to be less affected in the scouting experiment. The result however goes contrary to the findings of Oparaeke (2006) who found that application of 5% nke solutions adequately protected cowpea pods from damage by *M. vitrata* larvae but application of synthetic insecticide (Mixture of cypermethrin and dimethoate) gave significantly higher reduction of seed damage and higher yields. The differences between nke and synthetic insecticides detected by Oparaeke could have occurred due weather conditions such as rainfall and sunlight that could reduce the efficacy of nke. It has been reported that nke is liable to photo degradation due to non-standardization (Kavoski *et al.*, 2011). The result of this research work is also in conflict with the findings of Downham (2003) that the use of botanical insecticides (neem inclusive) combined with monitoring using pheromones, proved inferior to the conventional farmers calendar spraying of synthetic insecticides in protecting the yield of cowpea. However, pheromone catches can be reduced by many factors, such as faulty trap design or female moths out-competing the traps. These factors may lead to the under estimation of moth populations thereby causing delay in the application of insecticides which in turn will cause more damage to the crop and higher yield reduction in the monitored farms.

The highest cost-benefit from spraying was obtained by the scouting based nke application. This is also in agreement with the work of Badii and co-workers (2008) whose study using different concentration of nke and a synthetic insecticide (25g/L lamda-cyhalothrin) against the major insect pest of cowpea, showed that the best cost-benefit ratio was obtained by 5% nke application. Costs in using neem-based sprays are kept to a minimum by using locally available materials and family labour.

The presence of a large number of Coccinellidae spp. in the third week of sampling was due to the abundance of aphids present at that time which coincided with near end of the reproductive stage of the cowpea crop. In Nigeria aphids are known to be migratory in nature and affect mostly the late season cowpea (Egho, 2012). The Coccillenidae are known to prefer soft bodied insects and both the adult and the larvae have an insatiable appetite for aphids (University of Florida Institute of Food and Agricultural Sciences, 2012). An adult of these predators can consume more than 100 aphids per day (Roos, 2006). Their absence in the calendar based commercial insecticide treated plots is an indication of the negative impact this type of spray regime can have on these beneficial insects. Moreover, the type of chemical insecticide used in this study contained an organophosphate compound (dimethoate) whose damaging effect on Coccillenidae has been documented (Amin Jalali *et al.,* 2009). Chemical insecticides are known to affect them through ingestion of contaminated food, direct contact with the droplets, contaminated plant surfaces and the resultant effect is manifested in various ways such as the immediate disruption in the predatory behaviour, including a reduction in efficiency in locating and capturing of prey (El-Wakil *et al.,* 2013). Their presence in both the unsprayed plots and those of the botanical insecticide plots is an indication of the relative harmlessness of this type of insecticide on them. This result is in agreement with the work of Abdullahi and co-workers (2004) whose work found no effect of neem on the predatory activities of Coccinellidae spp. on *N. viridula* eggs and suggested neem as an important component of IPM on this particular insect pest. However, the observed harmlessness of nke on Coccinellidae spp. as shown in this study is in conflict with the findings of Kraiss and McCullen (2008) who showed that neem in both powder and oil applications, adversely affect the fecundity of coccinellid *Harmonia axyridis* larvae and adult under laboratory test. El-Wakil and co-workers (2012) also indicated that application of nke at 10% concentration resulted in 72% loss of fecundity and 73% mortality of coccinellid *Adonia variegata* (Goeze). All the works of these two authors are laboratory tests which may not necessarily be the reality under field conditions where environmental factors such as degradation and plant architecture could affect the pesticide-pest natural enemy interaction, thereby making field performance of insecticide different from laboratory observations (Cloyd, 2012). Also the concentrations of nke in the solutions sprayed were higher than used in the present study.

The Asilidae spp. occurrence mainly in the second and the third week, could possibly be due to availability of many different types of flower and pod insects especially bees, wasps, and grass hoppers which are an important food source to these predators (Dennis *et al.,* 2008; University of Carlifornia 2008). This period corresponds with up to 70% flowering of the cowpea crop which attracts large numbers of different insects that are ambushed and captured by these predators. Experiments in China showed that the larvae of an asilid *Promachus yesonicus* Bigot significantly reduced white grubs populations between 21 – 99% in wheat and reduced damage by 68 – 96% (Symondson *et al.,* 2002). Although these predators were present in all the treatment plots, their numbers in the nke treated and control plots were higher in comparison to other chemically insecticide treated plots. The finding of this study is in agreement with those of Pounce and co-workers (2011) who reported 20% increase in asilids abundance in organic fields compared to the conventional farming fields (which use chemical pesticides). Apart from repelling both adult and larvae, disrupting their development processes including sterility, nke is known to affect insect pests in various other ways such as causing confusion (immobilization) in the behaviour of adults (Abdullahi, 2004). The effect of this is to enhance predation as the prey becomes easier to capture.

The Syrphidae spp. presence at each sampling date may suggest they have a wide range of arthropod food and their preference of the unsprayed control plots and the nke treated plots seemed to indicate that there is little or no detrimental effect of the botanical on them. It has been observed that some Syrphidae species are important flower pollinators and the immature of many species are predators of aphids and other plant bugs and could cause significant reduction in aphids colony where they operate (Ghahari *et al.,* 2008: AlMohammad *et al.,* 2010). This may explain why they were mostly in abundance in the third week of sampling, corresponding to the period of availability of flowers and flower insects as well as aphids. Application of broad spectrum chemical insecticides is the main cause of population demise of these important predators. However, it has been observed that neem products especially the oil when spayed directly on these predators is known to have negative effect on them (POD, 2013). Neem oil has been documented to have stronger side effect on natural enemies in comparison to oil free preparations and so the use of oil based preparation should be avoided or minimised where natural control is taking place (Infonet-biovision, 2011). In another instance it has been reported that neem oil affects only the insects that feed on the crop foliage by ingestion therefore has no any effect on the natural enemies that feed on insects alone (Sutherland, 2010). The presence of Mantises in the second and third week may have been due to the presence of many foliage and flower insect such as grasshoppers, butterflies and moths which are important food source for the adults, while the young ones feed on aphids (Johnson, 2012). All these sources of Mantis food were observed to be plentiful on the crop especially at the third week. However, Zinat (2005) noted that Mantises are easily killed by chemical insecticides especially the broad spectrum types, and this may explain why their presence is only noticeable in both nke treated plots and the unsprayed controls.

The Hymenopteran *Polistes* spp. appearances in all the weeks of sampling and most especially in the first week, could suggest that they mainly prefer to prey on the remaining foliage beetles whose abundance was observed in the second week. Their scarcity in the third week could be due to the heavy presence of Anisoptera spp. at that time which are known attack and eat many insects including bees and wasps. The *Vespula* spp. which are known to be the most dangerous among the Hymenopterans whose sting can even be life-threatening in man (University of Carlifornia, 2001) and whose appearance in the third week of sampling could possibly due to the abundance of flower and flower insects in that particular week. These wasps also known as yellow jackets, have mouth parts that are well developed for capturing insects and sucking of nectar and fruit juices using their long tongue. They are known to feed voraciously on both insect and caterpillars (University of Carlifornia, 2001). Organophospahtes are toxic to Hymenopterans and few were found in the plots sprayed with commercial insecticide. Dimethoate is one of the constituents of the type of insecticide used, and in a contact toxicity test of many insecticides such as indoxacarb, endosulfan and dimethoate and three others on two beneficial insects one of which was a wasp (*Aphidius colemani* Viereck), dimethoate was found to be the most toxic (Bostanian and Alakachi, 2004). Hymenopterans were abundant in the neem treated plots, especially where only two sprays were applied. This, may be due to the fact that neem has systemic, repellent and antifeedant insecticidal activity that is devoid of lethal toxins and has little negative effect on wasps and bees (Jack and Nancy, 2000). Both the unsprayed controls and the scouting based nke treated plots seemed to provide safe haven to the predators as shown in the cluster 2 of the result section of this study

10.5 CONCLUSIONS

Although sprays with chemical insecticide applied on a calendar basis provided the greatest reduction in numbers of *M. vitrata* larval infestation/damage, beneficial insects were greatly decreased by spraying with chemical insecticide. Neem on a calendar basis also provided effective control of *M. vitrata* larval infestation/damage and beneficial insects were less affected by neem sprays than by chemical insecticide, especially when spray frequency was decreased by scouting. There was less difference between chemical insecticide and neem with respect to their effect on crop damage and seed yield than there was on pest infestation. Economic returns were better when using neem for control of *M. vitrata* than using calendar based chemical insecticide, especially if neem applications were based on scouting using a suggested action threshold of 40% flower infestation/damage (a lower threshold than the 60% level tested in the experiemnts). Thus neem can be considered as a safe and better alternative to chemical control. Scouting can be used to decrease the number of sprays applied but results in less effective control of *M. vitrata* larval infestation/damage than calendar-based spraying.

CHAPTER ELEVEN: GENERAL DISCUSSION

11.1 INTRODUCTION

The legume pod borer *Maruca vitrata* is a serious insect pest of cowpea in both tropical and subtropical regions of the world. The larvae of this insect pest attack cowpea at the reproductive stage causing extensive damage to the reproductive structures (Abdullahi and Shepard, 2003). In Nigeria cowpea yield losses of about 80% have been reported as a result of the larvae feeding on cowpea (Oparaeke*, et al.*, 2005). Farmers in Nigeria apply chemical insecticides for the control of this insect pest. Many of these farmers cannot afford the recommended insecticides, due their high cost, so resort to the use of cheap but highly toxic cotton insecticides and other dangerous chemical insecticides. This misuse of insecticide has been known to have caused many deaths and other important health problems in West Africa (Coulibaly *et al.,* 2008), especially in Nigeria and Zuru in particular. It is therefore, the objective of this research work, to offer farmers in Zuru, a safe means of control by developing an Integrated Pest Management (IPM) strategy using neem application on scouting basis which will replace their calendar based broad spectrum chemical insecticides applications. The study utilized farmers survey and focus group interview to investigate the farmers' cultivation practices, their perceptions on pests and pesticides, as well as the economics of their cowpea cultivations. Both on-station and on-farm experiments were used to develop and validate a sustainable, environmentally friendly and farmer acceptable, IPM controls strategy against *M. vitrata*.

11.2 FARMERS SURVEY ON COWPEA CULTIVATION PRACTICES

Farmers use commercial chemical insecticides purchased from the merchants in the local market for the control of the various insect pests of cowpea. The most commonly used insecticide was the mixture of cypermethrin and dimethoate which they applied up to 7 times on a calendar basis for the control of *M. vitrata larvae* and other insect pests. Farmers complained of the reduced effectiveness of this insecticide which suggested the possibility of the development of resistance by *M. vitrata* against this particular chemical insecticide due to improper application. Onstad and co-workers,

(2012) reported that the use of chemical insecticides by farmers in West Africa for the control of this insect pest is now not the best tactic, due partly to the evolution of resistance by *M. vitrata* to insecticides such as cypermethrin and dimethoate. Studies on insect resistance in field populations of *M. vitrata* in two locations (Shika and Samaru villages) in Nigeria, found a resistance ratio range of 17-53 for cypermethrin and 27-92 for dimethoate (Ekesi, 1999). Resistance ratios are calculated based on LC_{50} data. The LC_{50} of field obtained strains divided by the LC_{50} derived under the laboratory bioassay of the same strains gives the resistance ratio and both strains should be tested under same conditions. A resistance ratio > 10 indicates a genetically acquired decreased susceptibility to insecticide (Tabashnik *et al.,* 2009). In addition, under such massive chemical insecticide sprays, the health of the farmers and the environment is in jeopardy.

The massive use of broad spectrum chemical insecticides as farmers were doing in the end may not be without some negative consequences both in the short and long term. Pesticides used in agriculture contaminate the environment and have other non-target effects. Through rainfall they migrate to streams and lakes from where they enter the tissues of aquatic organisms. Spray operators are also at risk. In a survey, of over 2000 agricultural workers in Africa, Asia and Latin America, through exposure 47-59% were found to have encountered acute pesticides poisoning such as convulsion and nausea (Blacksmith Institute, 2013). Pesticides may disrupt the agro ecosystem through their negative impact on the beneficial insects (The World Bank, 2011). The need to have a strategy to minimise pesticide use, such as the adoption of IPM principles, is particularly apparent in Nigeria, where contamination with chemical pesticides has been reported to be the most prevalent and serious occupational hazard facing farmers in the country. In only two states (Akwa Ibom and Cross River) of the country, more than 600,000 farming households experienced various pesticide poisoning effects, due the use and exposure of the agro-chemicals (Augustine and Comfort, 2011). The future of farming profession in the study area is in jeopardy due to lack of young people in the farming enterprise, as the average age of majority of the farmers surveyed indicated that they were not young. The consequence of such a trend to the country has been reported by Samuel (2012) whose work noted that Nigeria is facing a looming food security threat, due to dwindling arable land, climate change and an ageing farming population. It has been observed that most young people in the country have failed to see agriculture as a profitable venture and a means of self-employment (Faralu, 2011). Consequently un-unemployment is on the increase and is resulting in youth restiveness, armed robbery and kidnapping (Ajaegbu, 2012). In the year 2012 the Federal Government of Nigeria disbursed the sum of N1billion to each of the 36 states of the Federation, to help attract and boost young peoples' participation in farming (Sanni, 2012). It is good that the Nigerian policy planners are now beginning to understand that certain factors that make young Nigerians shun agriculture. It has been observed that lack of incentives and the necessary infrastructures tend to make farming unattractive to the today's young Nigerians (Hargrave, 2012). The negative attitude of the Nigerian youths towards agriculture can be linked: 1 lack of awareness of the diverse opportunities associated with agricultural enterprise, 2 difficulties in having access to key inputs such as land, finance and market information, 3 risks associated with agriculture (Faralu, 2011). The massive use of external inputs such as chemical insecticides and fertilizers contributes to the high cost of commercial farming. Properly implemented IPM systems can help to make farming safer and more profitable.

The possibility of successful mechanizing of cowpea production in Zuru is remote, due the fragmented nature of farm sizes which are mostly below 3ha and intercropped with cereals. Intercropping is the predominant farming system in the savannah zones of Nigeria and is a means of maximising the use of the small size farm lands cultivated in this region (Jirgi *et al.,* 2010). It is a form crop diversification which provides households with an insurance against crop failure (Beets, 1990). Although recent progress in research has shown that it may be compatible with agricultural mechanization, most especially for small resource-poor farms, cowpea intercropping is not convenient for mechanization in the agriculture of the developed countries (Itulya *et al.,* 1997). However, mechanization is known to cut down cost of crop production through efficient use of resources which in turn increases farming income (Brian and Josef, 2006). Intercropping on the other hand is also known to have the advantage of efficient use of resources and higher productivity which increases farmer income (Lithourgidis, 2011). The IPM systems developed are compatible with intercropping. Regarding the fragmented nature of the cowpea farms in Zuru, studies have shown that the effect of farm size on profitability of farming has always been a matter of debate among agricultural economics. Profitability is more influenced by the farmers' management decisions rather than the farms scale (Kern and Poulson, 2011). Using a sample of 226 cash grain farms in the lake state-corn belt of USA, Studies have shown that pesticide dependence increased with the increase of farm size (Whittaker *et al.,* 1995). Studies in Uganda have shown that IPM is farm scale neutral. This implies that the smallness of the farm sizes in Zuru, will not affect IPM adoption.

11.3 FARMERS' PERCEPTION ON PESTS AND PESTICIDES

Farmers showed a good knowledge of the various insect pests attacking their crop. For example farmers have a local name for pod sucking bugs which they called "Maikaho" meaning insect with horns. Altieri (1993) also reported that in Philippines, farmers had local names in various dialects for most of the pests attacking rice, corn and grain legumes. The traditional faming systems in the developing countries are characterized by high biodiversity and a wealth of indigenous knowledge which is especially important in pest management (Altieri, 1993). Sometimes this farmer's indigenous knowledge can form the bedrock of IPM strategies.

The interviewed farmers were inappropriately applying the mixture of cypermethrin and dimethoate with a high frequency of application of these broad spectrum chemical insecticides. Such massive usage of non-selective chemical insecticide is known to disrupt the natural control process (Verkerk, 2001). This could possibly help to explain why most of the farmers indicated that *M. vitrata* was their most damaging insect pest of cowpea. The use of non-selective chemical insecticide at such frequencies has implications for the abundance of the natural enemies and the need for IPM adoption in the study area. Among the beneficial insects that have a demonstrated ability to control *M. vitrata* in West Africa is a locally available egg parasitoid *Trichogramma eldanae* Viggiani (Hymenoptera, Trichogrammatidae)(Tamo *et al.*, 2003). This parasitoid is a wasp and all wasps and bees are known to be liable to destruction by the application of organophosphate insecticides typical of the type used by the farmers in Zuru. Conservation of the parasites and predators is an integral part of IPM philosophy and which is currently not being done by the farmers due to their ignorance of the role played by these organisms.

Biological control has the potential to increase production and save the country its hard earned foreign reserve. A typical example is that the country is now reaping the reward of biological control of cassava mealy bug (using a wasp *Apoanagyrus lopezi*). This project is now giving a return of at least $150 to the farmers for every $1 spent on the control project, and making Nigeria the world's highest cassava producer (IITA, 2012). Possibly, conservation of the natural enemies of *M. vitrata* by cowpea farmers in Zuru will give similar rewards. Farmers have inherited traditional methods of control of insect pests of cowpea such as the use of *Ficus spp*. for the control of *C. maculatus* in store. This technology is now abandoned in favour of the use of chemical insecticides. Studies have shown that botanical insecticides used for storage pests are also effective against field pests (Ba *et al.,* 2009). This traditional method could save the farmers unnecessary purchase of chemical insecticides. Such a trend of farmers abandoning their traditional insect pest control method in favour of chemical insecticides has also been observed by Bottenberg (1995). However, the availability of such effective cowpea storage pest control plant material in Zuru is a resource area for IPM to explore for potential for field applications.

Farmers were ignorant of the consequence of pesticide exposure on their health. This was indicated by their reluctance to use protective clothing while spraying and cases of skin burns due to insecticide leakage were only treated with locally available materials such as shea butter. Organophosphate insecticides such as the type used by the farmers are known to be readily absorbed through the skin and cause symptoms such as loss of appetite, loss in weight and general feeling of unwell as a result of chronic exposure (Cornell University, 2012). In view of this, unless IPM strategies are used, this repetitive unprotected farmer's exposure to chemical insecticide will in the long run jeopardize farmers' health and consequently that of the sustainability of farming in the study area. Pesticide trade in Zuru is a source of farmer exploitation by the merchants as merchants take advantage of the scarcity of insecticide to extort more money from the farmers than the usual price of the product. This kind of trade deserves the intervention of the authorities in Zuru. Farmers had difficulty in gaining access to the subsidized products which forces them to patronise the merchants in the market for the supply of insecticides. Since these farmers had no formal education, they could not read labels to find whether the type of insecticides with reduced effectiveness sold to them are expired ones or not.

11.4 ECONOMICS OF COWPEA CULTIVATION IN ZURU

Farmers lack the knowledge of the appropriate type of fertilizer to use on cowpea. This was indicted by their application rate of NPK fertilizer (50kg/ha). NPK is recommended on cowpea at the rate of 20kg/ha, the most beneficial fertilizer is Superphosphate at the rate of 40kg/ha (Dugie 2009). Excess application of NPK, as the farmers were applying, usually results in to delay of the maturity of the crop, prolonging the period over which insect control is required. It also causes the crop to produce more foliage at the expense of yield (Dugie, 2009). However, it has been reported that chemical fertilizers, apart from supplying the needed nutrients for plant growth, also pollute ground water soil and air through the accumulation of heavy metals in plants (Savci, 20012). Manure on the other hand is an alternative to the chemical fertilizer; it increases soil fertility, water retention capacity, bulk density and biological properties (Augusstin and Rahman, 2010). Manure has been known to be the corner stone of sustainable soil fertility management (Harris, 2002). Use of manure which is plentiful and can be given free by the nomadic Fulani in Zuru, will cut down farmers' expenditure and increase profit. IPM strategies stress the use of low external inputs such as manure in order to maximise profit.

Potentials exist for seed contamination due non usage of certified seeds and seed dressing by most of the farmers. Various seedling diseases capable of reducing yield of cowpea are known to be seed borne. Cowpea Anthracnose and brown blotch diseases caused by *Colletotrichum* spp. causing yield loss between 46-74% in Nigeria are known to be seed borne (Adegbiti and Amusa, 2008). The use of certified seeds and seed dressing are important IPM preventive cultural control measures (Edward and Williams, 2013), which are lacking by most farmers in Zuru. Insecticides and labour costs were the most important profit limiting factors in cowpea cultivation in Zuru. Insecticides are used to control those factors that limit cowpea productivity and as imported inputs, their prices are going higher in a dramatic manner in Nigeria. Famers in Nigeria are faced with the decision on how to adjust to this skyrocketing cost of chemical insecticides (Omolehin, *et al.,* 2011).

Farmers experience was not a factor in profit making in cowpea farming in Zuru, rather it was the type of management given by the farmer that determined profit. In a farmer's resource use study in Nigeria, Omonona and co-workers (2010) also noted that farm size, farmers experience and affiliation to a cooperative society, are factors enhancing productivity and profitability of cowpea, not experience alone. This result implies that lack of experience is not necessarily a barrier to the adoption new technologies such as IPM.

It has been observed that efficiency and profitability of cowpea production at small holder level can greatly be enhanced when farmers use family labour and less hired labour (Jirgi *et al.,* 2010). In view of the high proportion of the farm budget consumed by labour and insecticides, the challenge to IPM is to increase profitability of cowpea production at small holder level, using locally available alternatives to the costly chemical insecticides. IPM also faces a challenge in devising means of increasing labour efficiency in such a manner that its overall cost is reduced and profit increased. Poor road conditions affected the cowpea profitability in Zuru. It has been reported that in Nigeria the neglect of rural infrastructure such as the feeder roads severely affect the profitability of Agricultural production (IFAD, 2012). In many rural areas of Nigeria where motorable roads exist, in most cases are full of pot holes and depressions. The low quality level of rural roads and the long average travel time associated with them usually result into high transaction cost for the sales of agricultural commodities and inputs there by limiting agricultural production and growth (Tunde and Adeniyi, 2012). The challenge to IPM with regards the poor rural road network is to enlighten farmers on the need for collective responsibility through communal labour to maintain rural roads so as to limit transport expenses which affect the profitability of their produce.

Cowpea production in Zuru is still profitable against numerous odds, such as high cost of labour and insecticides. However, considering the increase in profit that resulted from replacing commercial insecticide with neem, especially if farmers were able to scout, adoption of IPM strategies will eliminate or greatly increase the profitability of cowpea in a sustainable manner in Zuru.

11.5 USE OF PHEROMONE TRAPS FOR MONITORING AND FORECASTING OF *M. vitrata* POPULATIONS DYNAMICS IN COWPEA IN ZURU

Pheromone traps using the three blend lures were not effective in catching sufficient number of adult *M. vitrata* so as to be a useful monitoring device. Throughout the year 2008 cropping season, only three moths were caught. Although the three blend lures were effective in trapping the moths in the neighbouring Benin republic and Ghana, they were not effective in Northern Nigeria as shown by the multi season work of Downham and co-workers (2003). The work of Hassan (2007) threw more light on this issue after discovering that the moth responses to pheromone lures was dependent upon the geographical locations and single blend lures were more effective in Nigeria and Burkina Faso than the three blend lures. However, in view of the limited time available, further investigations on the reasons for the low pheromone trap catch was not possible. Instead a scouting-based Action Threshold (AT) as provided in the literature was adopted. The use of AT on cowpea flower infestation by *M. vitrata* has been known to reduce chemical insecticide application (Afun, 1991). Further research would be required to develop effective pheromone combinations for northern Nigeria, if pheromone trapping is to play a role there in cowpea IPM.

11.6 FIRST YEAR ON-STATION TESTING OF THE EFFICACY OF IPM COMPONENT TECHNOLOGIES

Throughout the first year (2008) experiment, scouting showed that pest infestations/damage never reached the action threshold of 60% so no insecticides were applied in all the scouting based experiments. However, the calendar based applications of insecticides were continued despite the low pest infestations. Thus, scouting has been demonstrated to be an effective tool in preventing unnecessary sprays of insecticide. This result implies some substantial saving a farmer stands to gain by adopting IPM scouting technique. It has been reported that scouting enables more efficient application of insecticides, lowers the pesticide expenses and helps preserve the natural enemies (Geoff Menzies *et al.,* 2013). Neem has proven to be an alternative to chemical pesticide in view of the high cost-benefit sustained by the weekly application of the botanical. Use of neem and other botanicals such as papaya are already an integral part of the indigenous *M. vitrata* control in Benin republic (Downham, 2003).

Crude seed extract of neem application on bean plants has been shown to result in significant reduction in flower damage when compared to the untreated controls (Rauf and Sardar, 2011). Tanzubil (2008) reported that the application of 5% concentration of nke effectively reduced damage due to other reproductive pests of cowpea (*Megalurothrips sjostedti* and Pod sucking bugs) and increased the yield of the crop. This confirms that neem has the potential for use as an IPM component. The second cowpea variety tested (Danzafi) has the potential as a source of genetic material in view of its ability to compete favourably in yield with the improved Kanannado whose tolerance to drought, resistance to striga and some field pest have been documented by various research works. Farmers in Zuru grow the local cultivar Danzafi due to its ability to give fair yield even without insecticide application. However since both the improved variety and the local variety did not show any significant difference in larval infestation/damage is an indication Danzafi could also be used in cowpea IPM strategies.

11.7 SECOND YEAR ON-STATION VALIDATION OF THE IPM SYSTEM FOR THE MANAGEMENT OF M. *vitrata*

Generally during the second year (2012) experiments, calendar based applications of insecticides gave the highest yield in comparison with scouting based application which resulted in a single application of insecticides. The cost/benefit ratio of scouting which resulted in a single application of insecticide as a result of pest infestation/damage reaching 60% and which was higher than the calendar based insecticide application. Calendar based insecticide application starting at the vegetative state 8 weeks after planting, is known to increase cowpea yield, but such insecticide application is wasteful since cowpea with re-growth can compensate for early season damage (Adipala, 2000). Scouting on the other hand is known to reduce un-necessary insecticide application and will make farming profitable and sustainable, through cost saving and minimising the negative effects of insecticides to the beneficial organisms and the environment at large. Calendar based neem application effectively controlled *M. vitrata* but it was not economical. The efficacy of neem in controlling *M. vitrata* in cowpea has also been documented by Sharma (1998) whose work reported that neem, especially when combined with host plant resistance can provide effective means of *M. vitrata* control. However, the uneconomical side of its application on calendar basis could possibly be due the need for its repetitive preparations due to its poor shelf life. Labour for neem preparations is one of the drawbacks hindering its use by the farmers (Downham, 2003). This implies that the use of neem on scouting basis holds the promise as an effective and economical alternative for use as an IPM control option, since only two sprays were required even in a season of high pest pressure

11.8 ON-FARM VALIDATION OF THE IPM SYSTEM FOR THE MANAGEMENT OF M. *vitrata*

Insecticide application on a calendar basis gave the highest reduction in the *M. vitrata* larvae infestation/damage but there was little difference in yield, pod damage and seed damage between neem applications and chemical insecticide applications. The highest economic returns were obtained by neem application, particularly the scouting-based applications in comparison to the use chemical insecticides. Natural enemy populations were less affected by neem application than by commercial insecticide, especially when used on a scouting basis. This result is contrary to the findings of

Baidoo and co-workers (2012), whose work on the effect of neem on aphis and its natural enemy (*Harmonia axyridis*), showed that neem application at 5% concentration reduced aphid numbers but caused a decrease in the coccinellids population compared to the unsprayed control. However, this may have been due to lack of aphids which the ladybirds preyed on, rather than a direct effect of the neem. Mumuni *et al.,* (2004) reported that neem had no effect on the predation by coccinellids on the eggs of *Nezera viridula.*

Nigeria is spending N35billion ($350, 000000.00) annually due to importation of agrochemical insecticides which puts a lot of pressure to the country's foreign reserve (Olanrewaju, 2012). This implies that the use of neem especially on scouting basis as an IPM alternative control strategy of *M. vitrata* will be of great importance, considering the huge expenses that will be saved by the farmers and the Nigerian state.

11.9 WHAT CONSITITUTED THE IPM PACKAGE

The followings are the components of the IPM package:

1) Use of a resistant variety of cowpea.
2) Use of neem (neem kernel extract) at 5% concentration as an insecticide.
3) Use of scouting when 50% flowering stage is reached.
4) Use of 60% or 40% flower infestation/damage as action threshold.

11.10 THE NOVELTY IN THE DEVELOPED IPM STRATEGY

The IPM strategy is a three in one flexible type which for the first time allows the farmers to apply neem insecticide as they have been applying chemical insecticides, or they can delay the application until 50% flowering stage is reached and continue application onwards according to the farmers' wish, or use scouting at 50% flower stage plus an action threshold of 60% or 40% flower infestation as the basis of neem insecticide application. Whichever one the farmers chose, there is safety to the farmers' health, the environment and the beneficial organisms, therefore sustainable.

11.11 SOME POSSIBLE BARRIERS TO THE ADOPTION OF THE IPM STRATEGY

Lack of effective extension services has resulted in farmers developing a strong relationship with pesticide merchants who are more likely to persuade them to continue with chemical protection. This strong relationship was manifested during the focus group interview where farmer were reluctant to seek the advice of the extension workers on the issue of insecticide application, due to friendlier nature of the merchants as well as being more knowledgeable with regards to insecticides. The availability of smuggled cheap but toxic cotton insecticides could possibly make the farmers revert to insecticide usage because of the labour required to prepare the neem extract. High market value of improved Kanannado grains coupled with the grain merchants having zero tolerance to insect damaged grains, are also a threat to the sustainability of the IPM strategy. These factors can influence farmers to drive for high quality grains which can make them revert to chemical usage. Farmers and many consumers lack the knowledge of long term effect of chemical pesticides, so there is no challenge to the issue of maximum residues which could compel farmers to use safe alternatives to chemical insecticides. Farmers also have no environmental awareness therefore, may not take necessary steps to adopt safer alternatives. However, a reassuring point to make on the sustainability of the IPM control strategy is that even at minimum insecticide applications, as shown in both on-station and on-farm experiments, use of neem still gave greater benefit-cost which is likely to persuade the farmers to continue with the strategy. Farmers have seen the benefit of scouting in the reduction of spray cost without affecting yield and have developed enthusiasm on IPM as there was no complain on health due to use of neem as such are likely to continue with the strategy. Farmers have now become experts in pest scouting and are doing the job by themselves which greatly helps to cut down farming costs and other values associated with scouting.

11.12 MAIN CONCLUSSIONS

Farmers inappropriately use chemical fertilizer and the commercial growers misuse broad spectrum chemical insecticides for the control of *C. maculatus*. This could negatively affect the control exerted by the natural enemies (parasitoids and predators). Farmers stand the risks of long term effects of chemical pesticide exposure manifested by serious diseases such as Parkinson disease especially, due to lack of use of personal protection equipment. In the absence of effective pheromone monitoring system, scouting based on an action threshold, can provide reasonable basis of *M. vitrata* control decisions. More research is required to develop a reliable pheromone trap and to understand the factors influencing low trap catch of *M. vitrata* in Zuru. Scouting that was continued with, using of an action threshold of 60% infested flowers, although considered high and, a lower action threshold will be practical for smallholders to implement. Further research is required on both the 50% flowering for the initiation of scouting and the 60% infection as an action threshold. Therefore, adoption of scouting neem application by farmers could reduce their spray cost, their risks of long term effects of chemical insecticides exposure and afford them with better environmental quality.

Use of neem has proved to have potential as an IPM control strategy against *M. vitrata*. Neem as alternative to chemical insecticide will conserve the natural enemies and is therefore a vital IPM tool. As a simple and self- made insecticide, neem has proved effective against *M. vitrata* and less costly than purchased insecticide. Nigeria at large stands to benefit through increase of the country's foreign reserve, currently under pressure as a result of massive chemical pesticides import. Scouting proved to improve the targeting and decrease costs of *M. vitrata* control with both purchased insecticide and neem. Therefore, the main benefit of scouting with regards to neem is that it decreases the number of sprays required [zero in a season of low pest pressure], thus decreasing the labour required for neem preparation. However, insect control was considerably decreased in the scouting based treatment using neem and this may be caused by the action threshold that was set too high. This is why further research on action threshold is required, No evidence was found to support the view that *H. spicegera* has insecticidal properties against *M. vitrata* although studies have shown the plant has proven insecticidal effect on some arthropod species. Cowpea farming is profitable in Zuru but, returns can be considerably increased by better management techniques and the adoption of IPM. Better management techniques such as efficient use of labour, use of cheap or free manure and use animal drawn row crop weeder for weeding operations, will increase the profitability of cowpea farming. Provision of good rural feeder roads by the government will reduce transport cost increase profitability of cowpea farming and make food cheap. Traditional farming system in Zuru, most especially that of cowpea needs to be mechanized so that it is made attractive to young people who most likely shun the profession due to its lack of modernity.

11.13 RECOMMENDATIONS

1) Farmers need to be educated on the various preventive measures they can use such as use of clean certified seeds of resistant varieties which will eventually reduce their pest protection needs in the later growth stage of the crop.
2) Education on appropriate pesticide usage including personal protection is needed on the part of the farmers and, this will include knowledge of the role of the natural enemies in control of the various insect pests of cowpea and how their present chemical method of control is harming these organisms.
3) Authorities have to monitor the chemical insecticide trade in Zuru so as to prevent merchants from further exploitation of the farmers. There is the need for effective government intervention in the farmers' access to non-selective chemical insecticides.
4) Further work on *M. vitrata* population dynamics in Zuru through the use of different pheromone blends is needed.
5) The savings farmers obtained from reduced insecticide applications should be ploughed back into the farm business to cultivate extra hectares of cowpea so as to reduce Nigeria's cowpea grains import.
6) Famers need to be educated to become researchers on alternative to chemical pesticide such as neem and to conserve their inherited traditional botanical methods of cowpea insect pest control.
7) As contributors to the farmers' massive insecticide usage through ill advising of the farmers, pesticide merchants need to be made to pay some extra taxes for environmental damage. This will compel them to support the search for alternatives through IPM. Pesticide merchants also have to be trained in the use of chemical insecticides, safety precautions and the negative effects of pesticides both in the short and long term. They should also participate in the training and search for safer alternatives to chemical insecticides.
8) More research effort is needed to reduce the drudgery in aqueous neem seed kernel extract preparation so as to make its use more attractive.

9) Farmers' need to be organised into volunteer groups for the maintenance of the rural feeder roads so as to ease their transport problems which will increase their profit.
10) Government has to put more incentives into farming to revolutionize the traditional farming system so as to make it attractive to young people.
11) An impact assessment research is need to deterrmine whether farmers are continuing to use the neem, whether farmers can still recognise the beneficial insects and take measures to protect these organism as well as whether they are continuing with spraying insecticides based on action threshold.

11.14 SUGGESTIONS FOR FUTURE RESEARCH

The IPM Strategy developed for the control of *M. vitrata* in cowpea in Zuru is still in embryo stage and in future needs to be broadened to encompass other reproductive insect pests such as the pod sucking bugs mentioned by the farmers as second most damaging insects of cowpea in order to ensure its sustainability. In this direction, a compound action threshold involving these insect pests needs to be put in place.

An evaluation might be needed in future to determine the extent of adoption and overall sustainability of the program. Future research work will have to consider use of lower actions threshold such as 50% larval infestation/damage. In broader sense the whole cowpea farmers in Zuru local government area have to be involved in the IPM strategy. Evidence of the success of the IPM strategy from the pioneer farmers can be used to solicit government's backing and goodwill to provide sound pesticide policy which will encourage use of alternatives to chemical insecticides and limit their free circulation especially the non- selective ones among farmers.

Government is expected to provide trainings of extension personnel and the pesticide merchants on the IPM strategy and they will subsequently educate more farmers. As a result, more neem seedlings are expected to be planted by the government under is afforestation programme which apart from the benefit of halting desert encroachment, the neem trees will continue to provide the raw materials for neem pesticide (nke) preparation.

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APPENDICES

Appendix 1 field Experiment pictures

1.1 Flower damage assessments

1.2 Sampled pods ready for damage assessment

APPENDIX 2 FIELD LAYOUT OF THE VARIOUS FIELD EXPERIMENTS

2.1Field layout of calendar and need based application of commercial chemical insecticide on the two cowpea varieties Danzafi (V1) and Kanannado (V2)(+ = Pheromone traps)

Chemnb:V2 +	Chemw:V2	Control:V2	Chemnb:V2 +
Chemw:V1	Control:V1	Chemnb:V1	Chemw:V2
Control:V2 +	Chemnb:V1	Control:V2	Chemw:V1 +

Chemnb:V1	Control:V1	Chemnb:V2	Chemnb:V1
Control:V2	Chemnb:V2	Chemw:V2	Control:V1
Chemw:V2 +	Chemw:V1	Control:V2	Chemw:V1 +

2.2Layout of calendar based (weekly) Neem application on the two cowpea varieties Danzafi (V1) and Kanannado (V2)

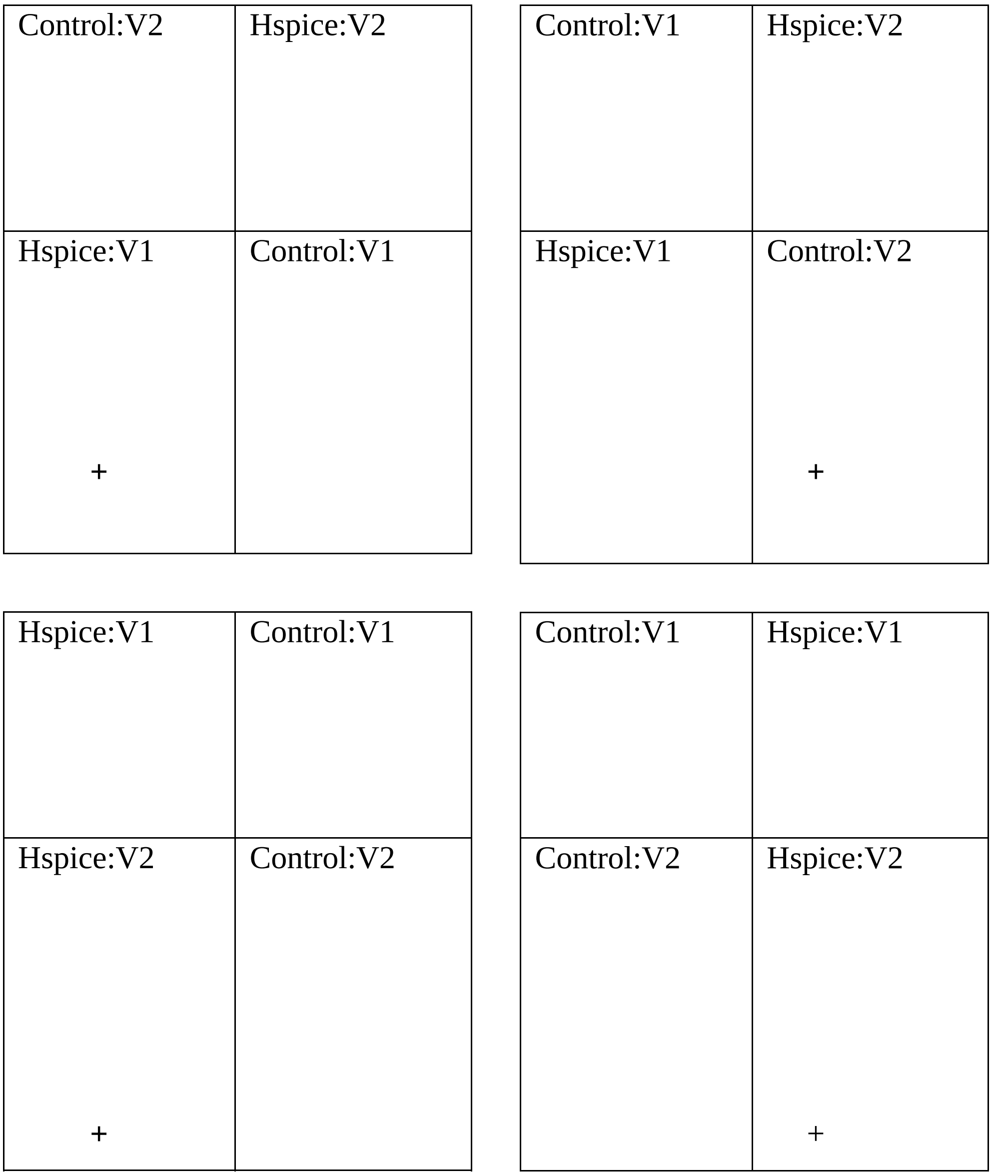
Nkew:V1	Nkew:V2
Control:V2 +	Control:V1

Control:V2	Nkew:V1
Nkew:V2	Control:V1 +

Nkew:V1	Nkew:V2
Control:V2 +	Control:V1

Control:V1	Nkew:V2
Control:V2	Nkew:V1 +

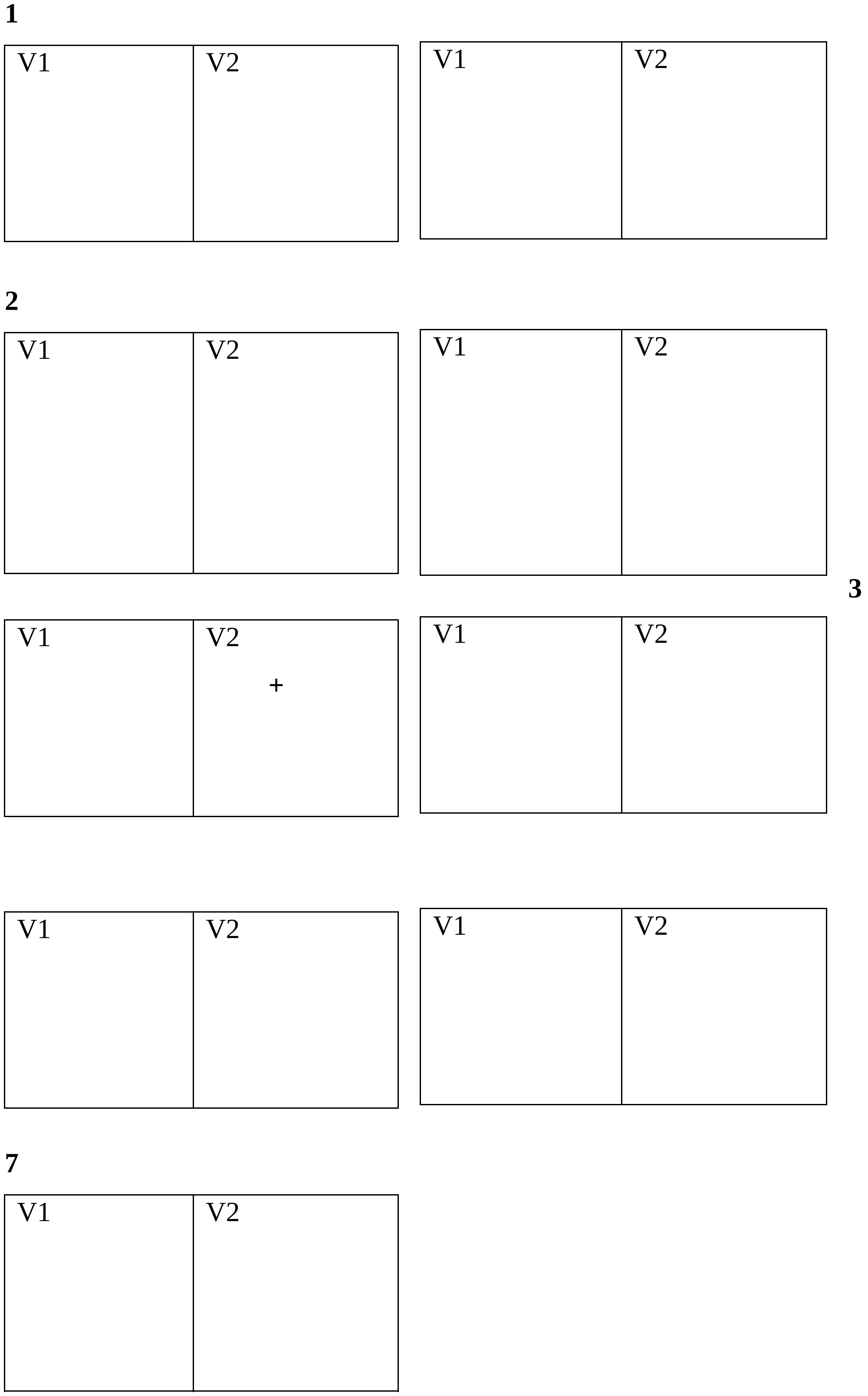
2.3Layout of *H. spicegera* interplanting with the two cowpea varieties Danzafi (V1) and Kanannado (V2)



NOTE:

+ = PHEROMONE TRAPS

2.4Layout of resistance trial of the two cowpea varieties Danzafi (V1) and Kanannado (V2)



2.5Layout of second year on-station experimental plots

Rep. 1

Chemw:V2	Nkew:V1	Control:V1	Nkenb:V1	Chemw:V1
Chemnb:V1	Control:V2	Nkew:V2	Chemnb:V2	Nkenb:V2

Rep.2

Chemw:V2	Control:V2	Nkew:V2	Chemnb:V1	Nkenb:V1
Nkenb:V2	Control:V1	Nkew:V1	Chemnb:V2	Chemw:V1

Rep.3

Control:V2	Chemnb:V2	Control:V1	Nkew:V1	Hkew:V2
Chemw:V1	Chemnb:V1	Chemw:V2	Nkenb:V1	Nkenb:V2

Rep.4

Nkenb:V2	Chemw:V1	Nkew:V2	Chemw:V2	Chemnb:V2
Nkenb:V1	Chemnb:V1	Control:V2	Control:V1	Nkew:V1

2.6 Layout of the third year on-farm experiment

Rep1

Nkenb
Chemnb
Nkew
Chemw
Control

Rep. 2

Nkenb
Chemnb
Control
Chemw
Nkew

Rep.3

Control
Nkenb
Chemw
Chemnb
Nkew

Rep. 4

Nkew
Control
Chemw
Nkenb
Chemnb

Rep. 5

Nkenb
Chemnb
Nkew
Chemw
Control

APPENDIX 3 ANOVA TABLES OF THE VARIOUS FIELD EXPERIMENTS

3.1First year on-station anova tables

Table 3.1.1 Analysis of variance table of mean yield of two cowpea varieties Danzafi V1 and Kanannado V2 under each of five IPM component treatment effects.

Source of variation	Df	Sum Sq	Mean Sq	F value	Pr (>F)
treat	5	26.1204	5.2241	96.9884	<2e-16***
Var	1	0.0173	0.0173	0.3209	0.5732
Treat:var	5	0.0441	0.0058	0.1639	0.9748
Residuals	58	3.1240	0.539		

Signif. Codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ‘ 1

Table 3.1.2 Analysis of variance tables for *M. vitrata* larval infestation/damage count of two cowpea varieties Danzafi V1 and Kanannado V2 under each of five IPM components treatment effects.

Source of variation	Df	Sum Sq	Mean Sq	F value	Pr (>F)
Treat	5	11318.3	2263.65	37.9458	<2e-16***
Var	1	0.1	0.06	0.0010	0.9754
Treat:var	5	117.6	23.53	0.3944	0.8507
Residuals	58	3460.0	59.65		

Signif. Codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table3.1.3 Analysis of variance table for mean pods damage number of two cowpea varieties Improved Kanannado and Danzafi under of five IPM component treatment effects.

Source of variation	Df	Sum Sq	Mean Sq	F Value	Pr (>F)
treat	5	5237.9	1047.57	39.9278	<2e-16***
Var	1	0.7	0.70	0.0267	0.8708
Treat:var	5	93.5	18.70	0.7127	0.6164
Residuals	58	1521.7	26.24		

Signif. Codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 3.1.4 Analysis of variance table of mean number of seeds damage of two cowpea varieties Danzafi V1 and Improved Kanannado V2 under each of five IPM component treatment effects.

Source of variation	Df	Sum Sq	Mean Sq	F Value	Pr (>F)
treat	5	35445	7089.0	34.0107	4.677e-16***
Var	1	103	103.2	0.4952	0.4844
Treat:var	5	618	123.6	0.5952	0.70
Residuals	58	12089	208.4		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

3.2 Second year on-station anova tables

Table 3.2.1. Analysis of variance table of the mean plot yield of two cowpea varieties Danzafi V1 and Improved Kanannado V2 under commercial insecticide neem kernel exract treatment effects in the second year.

Source of variation	Df	Sum Sq	Mean Sq	F value	Pr (>F)
Treat	4	94.264	23.5659	336.6554	<2e-16***
Var	1	0.100	0.100	1.4286	0.2414
Treat:var	4	0.213	0.0531	0.7589	0.5602
Residuals	30	2.100	0.0700		

Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 3.2.2 Analysis of variance table of the mean larvae infestation count of two cowpea varieties Danzafi V1 and Improved Kanannado V2 under commercial insecticide and neem kernel extract treatment effects.

Source of variation	Df	Sum Sq	Mean Sq	F value	Pr (>F)
treat	4	33243	8310.7	336.6554	<2e-16***
Var	1	17	16.9	1.4286	0.2414
Treat:var	4	53	13.3	0.7586	0.5602
Residuals	30	346	11.5		

Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 3.2.3 Analysis of variance tables of the mean number of pods damage of two cowpea varieties Improved Kanannado and Danzafi under commercial insecticide and neem kernel extract treatment effects.

Source of variation	Df	Sum Sq	Mean Sq	F Value	Pr (>F)
treat	4	9211.8	2302.96	233.6057	<2e-16***
Var	1	0.0	0.02	0.0025	0.9602
Treat:var	4	53.4	13.34	1.3529	0.2736
Residuals	30	295.7	9.86		

Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 3.2.4.Analysis of variance table of the mean number of seeds damage of two cowpea varieties Danzafi V1 and Improved Kanannado V2 under commercial insecticide and neem kernel extract treatment effects.

Source of variation	Df	Sum Sq	Mean Sq	F Value	Pr (>F)
treat	4	72378	18094.6	404.4236	<2e-16***
Var	1	9	9.0	0.2017	0.6566
Treat:var	4	366	91.6	2.0470	0.1129
Residuals	30	1342	44.7		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

3.3On-farm anova

Table3.3.1 analysis of variance tables for the mean number of pods damage of cowpea variety Improved Kanannado under various treatment effects.

Source of variation	Df	Sum of sqrs	Mean sqrs	F- value	Pr(>F)
Treat	4	1556.6	389.14	45.674	8.759e-10***
Residuals	20	170.4	8.52		

Significance codes 0 '***' 0.001 '**' 0.01 '*' 0.05

Table 3.3.2.analysis of variance tables for the mean larvae infestation of cowpea variety Kanannado under various treatment effects.

Source of variation	Df	Sum of sqrs	Mean sqrs	F- value	Pr(>F)
Treat	4	31720	7930.1	71.263	1.518e-11***
Residuals	20	2226	111.3		

Significance codes 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05

Table 3.3.3. analysis of variance tables for the mean number of seeds damage of cowpea variety Kanannado under various treatment effects.

Source of variation	Df	Sum of sqrs	Mean sqrs	F- value	Pr(>F)
Treat	4	6435.8	1608.9	25.338	1..383e-07***
Residuals	20	1270.0	63.5		

Significance codes 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05

Table 3.3.4. analysis of variance tables for the mean yield of cowpea variety Improved Kanannado under various treatment effects.

Source of variation	Df	Sum of sqrs	Mean sqrs	F- value	Pr(>F)
Treat	4	52.804	13.2010	11.643	4.789e-05***
Residuals	20	22.676	1.1338		

Significance codes 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05

Table 3.3.5 Chi square test for significance in species distribution between clusters

	Df	Deviance	Mean sqrs	F- value	Pr(>Chi)
NULL			224	352.02	4.789e-05***
Spp.	8	68.225	216	263.79	1.108e-11***
Cluscodes	1	67.505	215	216.29	<2.2e-16***
Spp:Cluscodes	8	21.071	207	195.22	0.006962**

Significance codes 0 '***' 0.001 '**' 0.01 '*' 0.05

APPENDIX 4 SPREAD SHEET FOR THE FIRST YEAR TABLE OF TOTALS

Rep	Subplot	Var	Treat	Larvaeinfest	Yield	Pods	Seeds
1	1	V1	Control	68	2.3	40	93
1	3	V1	Hspice	76	1.7	45	101
1	2	V2	Control	62	2.3	34	86
1	4	V2	Hspice	60	2	34	91
2	3	V1	Control	72	2	41	98
2	1	V1	Hspice	58	2.5	32	88
2	4	V2	Control	55	2.4	31	86
2	2	V2	Hspice	65	2.3	35	91
3	1	V1	Control	66	2.1	39	93
3	2	V1	Hspice	71	2.1	41	96
3	4	V2	Control	71	2	37	94
3	3	V2	Hspice	71	2.2	37	93
4	1	V1	Control	61	2.3	37	92
4	3	V1	Hspice	61	2.2	38	91
4	2	V2	Control	66	2.2	39	91
4	4	V2	Hspice	51	2.3	31	83
1	4	V1	Control	76	2	20	42
1	1	V1	Nkew	38	3.5	12	36
1	2	V2	Control	80	2	24	45
1	3	V2	Nkew	42	3.2	14	37
2	4	V1	Control	83	1.8	24	48
2	1	V1	Nkew	39	3.3	13	32
2	2	V2	Control	83	1.9	26	47
2	3	V2	Nkew	40	3.4	13	38
3	4	V1	Control	80	2	24	47
3	3	V1	Nkew	41	3.2	14	37
3	1	V2	Control	70	2.2	21	38
3	2	V2	Nkew	37	3.5	13	34
4	1	V1	Control	77	2.1	22	41
4	4	V1	Nkew	40	3.3	14	33
4	2	V2	Control	82	1.9	25	45

4	3	V2	Nkew	36	3.6	11	33
1	5	V1	Control	61	2.6	23	54
1	2	V1	Chemw	40	3.5	14	25
1	6	V1	Chemnb	69	2.3	26	70
1	3	V2	Control	64	2.5	29	83
1	4	V2	Chemw	33	3.9	12	23
1	1	V2	Chemnb	71	2.4	31	85
2	1	V1	Control	57	2.3	23	63
2	6	V1	Chemw	39	3.6	11	24
2	2	V1	Chemnb	52	2.9	20	49
2	3	V2	Control	67	2.4	30	69
2	5	V2	Chemw	38	3.7	13	25
2	4	V2	Chemnb	59	2.4	25	75
3	4	V1	Control	65	2.6	21	66
3	6	V1	Chemw	32	3.9	11	24
3	1	V1	Chemnb	57	2.4	24	60
3	2	V2	Control	74	1.9	32	88
3	3	V2	Chemw	37	3.7	14	26
3	5	V2	Chemnb	58	2.8	21	64
4	5	V1	Control	71	1.8	26	72
4	6	V1	Chemw	33	3.7	12	23
4	4	V1	Chemnb	70	1.9	28	73
4	3	V2	Control	71	2.5	27	82
4	2	V2	Chemw	32	3.8	11	23
4	1	V2	Chemnb	83	1.9	38	96
1	1	V1	Resistance	58	2	32	80
1	2	V2	Resistance	67	1.8	36	90
2	1	V1	Resistance	72	1.9	41	103
2	2	V2	Resistance	63	1.9	33	83
3	1	V1	Resistance	58	2	35	88
3	2	V2	Resistance	68	1.9	37	93
4	1	V1	Resistance	79	1.7	42	105
4	2	V2	Resistance	62	1.9	36	90
5	1	V1	Resistance	51	2.2	32	80

5	2	V2	Resistance	70	2	37	93
6	1	V1	Resistance	72	1.9	39	98
6	2	V2	Resistance	54	2	33	83
7	1	V1	Resistance	62	2	33	83
7	2	V2	Resistance	65	1.9	36	90

APPENDIX5: SPREAD SHEET ON-STATION SECOND YEAR TABLE OF TOTALS

Rep	Subplot	Var	Treat	Larvae infest	Yield	Pods	Seeds
1	3	V1	control	101	0.1	53	136
1	5	V1	chemw	16	4.8	3	6
1	6	V1	chemnb	54	3.3	9	20
1	2	V1	nkew	21	4	5	12
1	4	V1	nkenb	55	3.4	10	21
1	7	V2	control	95	0.3	45	125
1	1	V2	chemw	17	4.5	4	8
1	9	V2	chemnb	53	3.4	9	18
1	8	V2	nkew	20	4.2	5	9
1	10	V2	nkenb	50	3.6	9	19
2	7	V1	control	88	0.5	35	96
2	10	V1	chemw	17	4.3	6	12
2	4	V1	chemnb	60	2.9	14	25
2	8	V1	nkew	28	3.9	9	20
2	5	V1	nkenb	50	3.7	8	18
2	2	V2	control	96	0.3	47	128
2	1	V2	chemw	11	5	3	5
2	9	V2	chemnb	53	3.5	8	19
2	3	V2	nkew	21	4	7	17
2	6	V2	nkenb	52	3.5	9	20
3	3	V1	control	92	0.4	38	102
3	6	V1	chemw	19	4.4	4	9
3	7	V1	chemnb	50	3.7	8	17
3	4	V1	nkew	21	4	6	15
3	9	V1	nkenb	53	3.5	9	21
3	1	V2	control	96	0.2	46	126
3	8	V2	chemw	11	5	2	4
3	2	V2	chemnb	57	3	12	22

3	5	V2	nkew	17	4.4	5	11
3	10	V2	nkenb	57	3	11	22
4	9	V1	control	95	0.3	45	124
4	2	V1	chemw	16	4.7	5	6
4	7	V1	chemnb	60	2.8	15	29
4	10	V1	nkew	19	4.5	5	8
4	6	V1	nkenb	58	3	12	23
4	8	V2	control	99	0.1	50	130
4	4	V2	chemw	15	4.7	2	5
4	5	V2	chemnb	55	3.5	9	18
4	3	V2	nkew	16	4.7	4	9
4	1	V2	nkenb	56	3.3	13	24

APPENDIX 6 SPREAD SHEET FOR THIRD YEAR ON-FARM TABLE OF TOTALS

rep	subplot	Treat	larvae infest	Pods	Seeds	Yield
1	d	chemw	8	1	7	6
	a	nkenb	66	5	11	5.5
	b	chemnb	59	2	8	6.5
	e	control	110	25	52	0.7
	c	nkew	15	6	10	4
2	a	nkenb	73	11	17	4
	d	chemw	5	2	5	6
	b	chemnb	84	6	12	3.9
	e	nkew	9	4	9	5
	c	control	105	23	60	0.7
3	c	chemw	20	4	12	4
	e	nkew	27	8	18	3.5
	a	control	116	28	74	0.5
	b	nkenb	82	7	20	3
	d	chemnb	88	4	14	3.5
4	e	chemnb	68	4	10	4
	c	chemw	11	2	9	4.5
	b	control	97	23	37	0.9
	d	nkenb	96	17	29	1.5
	a	nkew	42	12	21	2.5
5	b	chemnb	65	5	11	4
	e	control	103	24	40	0.8
	a	nkenb	83	15	23	2.5
	d	chemw	21	3	13	4
	c	nkew	17	8	12	4

APPENDIX 7 QUESTIONNAIRE AND CHECK LIST

Development of an integrated pest management strategy (IPM) against the post flowering insect pest of cowpea *Maruca vitrata* in Zuru local government area of Kebbi State of Nigeria.

Dear Respondent,

The researcher is an Mphil/PhD student of the Greenwich University UK conducting a research in the use of IPM strategy to control *Maruca vitrata* a flowering insect pest of cowpea in Zuru local government area. This survey is part of the research project and any information you give will be highly appreciated and shall be treated with confidentiality.

Thanks

Abdullahi Maikai M.

SECTION 1: THE QUESTIONNAIRE

Part A: Respondent Background

(1) Name of Respondent---

(2) Respondent Gender Male [   ] Female [   ]

(3) Age---

(4) Marital Status   Single [   ] Married [   ] Divorcee[   ] Others [   ]

Part B: Cultivation Practices

(5) What is the total size of your of your farm land? **---**

(6) What size of your available farm land did you devote to cowpea cultivation during the last years cropping season? ---

(7) For how long have you been in cowpea cultivation? --

(8) What type of cultivar do you use?

(9) Which of the followings is your reason for the use of the cultivar   [A] Due to its high yield, [B] For home consumption. [C] Gives acceptable yield even without protection, [D] Ease of getting seeds, [E] High market price, [F] Others specify? --

(10) How do you obtain the seeds of your chosen cultivar? ---

(11) Do you carry out land preparation before planting cowpea? Yes [   ] No [   ]

(12) If yes which method of land preparation do you use and if no why? ---

(13) Do you carry out seed dressing before planting? Yes [   ] No [   ]

(14) If yes what type of seed dressing material do you use and if no why? --

(15) Which of the following is your method of cultivating cowpea? A [Sole cropping] B. [Intercropping] C. [Others specify]

(16) Do you carry out weeding operations? Yes [   ] No [   ]

(17) If yes which of the following methods of weed control do you use and why? [A] Hand hoeing + hand picking, [B] Use of herbicides + hand picking, [C] Use of aninal drawn row crop weeder, [D] Others specify --

(18) Do you apply chemical fertilizer/manure on your cowpea farm? Yes [   ] No [   ]

(19) If yes what type of chemical fertilizer/manure do you use? --

(20) How many times do you apply the chemical fertilizer/manure? -------------------------------------

(21) Do you protect cowpea from field insect pest? Yes [   ] No [   ]

(22) If yes what type of control option do you use and why? ---

(23) If the control options you use are chemical or botanical pesticide application, which chemical or botanical pesticide do you normally use? ---------
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(24) Which particular insect pest do you spray against? --------------------------
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(25) What dosage of the insecticide do you normally use? -----------------------
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(26) How many times do apply the insecticide in the cropping season and why ? ---
----
----

(27) Do you have any problem or with regards to the insecticide you are using? Yes [ ] No [ ]

(28) If yes what is this problem that you are encountering with regards to the insecticide you are using? ---
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----

(29) What was the average output of cowpea grains/hay obtained from your farm during the last year cropping season? --
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SECTION 2: Focus Group Discussion Check List
Part A: Background Information

(1) Name of the Participants

i. --
ii. --
iii. --
iv. --
v. --
vi. --
vii. --
viii. --
ix. --
x. --
xi. ....,
xii. …………………………………………………………………….

(2) Date of the Interview ---

(3) Location of the Interview –Manga village---

(4) Interviewer Maikai Abdullahi Murana --

Part B: Economics of Cowpea Cultivation

(1) What is the total size of your farm land? **---**

(2) What size of your available farm land did you devote to cowpea cultivation during the last year cropping season? **--**

(3) What quantity of cowpea seeds do you normally use for the given size of your farm? ---

(4) What is the price per kg of your chosen seeds at both planting and harvest times? --

(5) If you do carry out seed dressing, what is the total cost of the seed dressing material that you use? --

(6) If you do carry out land preparation using hired labour how much do you pay daily for the job and for how long does the operation lasts or if using family labour how long does it last? --

(7) If you use hired labour or other means to plant your cowpea how much do you pay daily for the job and how long does it lasts, or if you use family labour how long does it lasts? ---
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(8) If you do use hired labour for weeding how much do you pay daily for the job and for how long, or if you use family labour for your weeding operation for how long? --
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(9) If you do use chemical fertilizers/manure on your cowpea farm, what is the estimated cost of the fertilizer used?...
....

(10) If you do hire labour for the fertilizer application how much do you pay daily and for how long or if you use family labour then for how long? ------------
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(11) If you do use insecticide spray to protect cowpea from field insect pest how much do you pay to procure your chosen insecticide? --------------------------
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(12) If you do hire labour to do the spraying how much do you pay daily and for how long or if you use farmer labour for the sprays, then for how long? ------
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(13) If you do hire labour or other means for harvesting your cowpea how much do you pay daily and for how long, or if you use family labour then for how long? --
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(14) If you do hire labour for the threshing of cowpea how much do you pay or if you use family labour then how long? --
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(15) What was the estimated output of grain yield obtained from your farm during the last year cropping season? ---
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(16) What was the estimated market price of your cowpea grains at the harvest time during the last year cropping season? ------------------------------------
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(17) What do you do with the grains after harvest? --------------------------------
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(18) If you do sell your cowpea grains how do you find buyers of your farm produce? ---

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(19) How do you transport your produce to the market? ---

(20) How much do you pay to transport your produce to the market? -----------------------------------

(21) What problem do you normally encounter in terms of transporting your farm products to the market? --

(22) What quality of cowpea do the buyers of your produce prefer? --

Part C: Farmers Perception on Field Insect Pest of Cowpea and Pesticides

(23) Among the numerous cowpea production constraints which one do you consider as your single most important production constraint? ---

(24) How will you rank the various insect pests in terms of severity of damage to the cowpea crop? ---

(25) How will you recognise the damage symptoms due to these insects activity in cowpea? --

(26) How will quantify crop losses due to these insect pests?---

(27) Do you use insecticides to control these insect pests? ---

(28) If yes which insecticide do you normally use and why? ---

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(29) What dosage do you normally apply and why? -------------------------------
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(30) How many times do you apply the insecticide? -------------------------------
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(31) What are the incidences of pesticides poisoning have you or any member of your family got? --
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(32) If you have had such incidences and you have referred to the hospital, for how long have you been hospitalised? ---
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(33) If you have not referred to the hospital but took other remedial action, what are they and how effective did you find them? ----------------------------------
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(34) How much per person have been spent during the hospitalisation? --------
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(35) Apart from cases of poisoning, what other problem have you got with regards to the insecticide you are using? --
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Appendix 8 Questions and farmers responses on economics of cowpea production

S/N	Question	Response
1	What is the total size of your farm land?	"All and all I have farm lands measuring 10 *kadada* (ha) when added together", "My total farm size is 6 *kadada* (ha)", "I have no precise measurement but it can reach up to 11 *kadada*" and "Although my farms were scattered around, but when added together they can reach up to 5 *kadada*". *Kadada* is what farmers in the study area used in measuring farm size and is equivalent to one hectare.
2	What size of your available farm land did you devote to cowpea cultivation during the last year cropping season?	"For cowpea cultivation, last season I used the whole of my six hectare farm" and "Out of my ten hectare farms I cultivated seven hectares of cowpea".
3	What quantity of cowpea seeds do you normally use for the given size of your farm?	"I used to plant nine *mudus* (kg) per hectare" and "During the time of planting I used 11 *mudus* per hectare"
	Did you consult the extension officers about the recommended seed rate?	"No I have not" and "It is not worth seeing the officers".
	Do you know that you are under sowing the crop at the seed rate you said?	"Cowpea was not the only crop I grew on the farm", "You know I cannot rely on only one type of crop on my farm", and "I do grew cowpea with sorghum on my farm".
4	What is the price per kg of your chosen seeds?	"Presently cowpea is sold at N200.00 per kg for Improved Kanannado and N150.00 for Danzafi" at harvest time and "At the time of Planting the price of kg of cowpea used to rise and can reach between N300

		– N500.00”.
	Do you use certified seeds?	“I do not know where to get the *ingantace iri* (certified seeds)” and “I have never seen them”
	How do you obtain your seeds?	“If you are cultivating such large farms like ours, you know purchasing seed is not the best option”
5	If you do carry out seed dressing, what is the total cost of the seed dressing material that you use?	“I do not know what it is used for”, “not using seed dressing has no any effect on my crop” , “I feel what is more important is the control of those insect that destroy the whole flower, not those that even if they attack, cannot destroy the whole farm” and “Yes, I used to carry out seed dressing” and “I always dress my seeds before planting.”
	What quantity and cost of seed dressing material did you use	“I used five sachets of ’Force’ this year and each costs N200.00” , “I also used a total of six sachets of Force last season and the price is the same as he told you” and “I used the same chemical that these people told you, only that my farm consumed a total of three sachets last year”
6	If you do carry out land preparation using hired labour how much do you pay daily for the job and for how long does the operation lasts or if using family labour how long does it last?	“I used to contract people with animal drawn plough to do the job” , “I hired the services of people with animal drawn plough during my land preparations”, “It was quiet expensive because they charged between N6500 to N7000.00” , “Generally two bulls can cover 1ha in 1-1/2 days” ,“You know you cannot expect the animals to work like machine you have to allow them to graze and rest from

		time to time" and "Generally labour for land preparation was contracted at the rate of seven thousand Naira (N7000.00) per ha unless if the farmer had some discount".
	Do you own the bulls and how much do they cost?	"Yes I do have them", "I have four of such work bulls" , "I have just added two more to my existing two", "with such farm lands like ours you cannot afford to rely on hiring, rather we own them and after finishing our work we did for the other people and they paid us" ,"I do not have the bulls for the ploughing" , "I am yet to have the animals but I will definitely obtain them" ,"Yes I do have them", "I have four of such work bulls" and "I have just added two more to my existing two", "owning two bulls with plough can cost up to N200, 000.00","Even because of the hardship I used to encounter before getting my land prepared in good time, I must get my own animals" and "you know if you are left behind in land preparation then, you are also left behind in yield".
7	If you use hired labour or other means to plant your cowpea how much do you pay daily for the job and how long does it lasts, or if you use family labour how long does it lasts?	"I used family labour", "I and members of my family did the job", "It was just a day's work so even I and my three children could handle it without any worries", "if you say every small farm work like planting you have to pay then, at the end you will not make anything out of your small farm" ,"hired labour for planting cost N500.00 per worker per

		day", "we used contract labour when it came to planting of cowpea" "It usually cost between N2000-2500.00 per ha depending upon your bargaining power" and "It all depended upon the number of people used but generally about four people were needed to plant one hectare of cowpea per day"
	Why did you use hired labour for planting instead of family labour?	"At the time of planting there used to be many secondary school boys looking for money to travel home for their holidays which in most cases coincided with the time cowpea was planted so I helped them with the job for planting cowpea on my farm" and "My grown up male children went out with the animals to work on other farmers' field and the money obtained was what I used to pay for hired labour for planting".
8	If you do use hired labour for weeding how much do you pay daily for the job and for how long, or if you use family labour for your weeding operation for how long?	"I used contract labour during weeding" "When it was time for weeding I contracted labour so as have quick weed control", "We used family labour during weeding time", "Charges for weeding were in two categories, the first weeding was charged N 700.00 per worker per day while the second and third weeding were charged N500.00 per worker per day" and "Contract labour for weeding had a flat rate N 7000.00 per hectare".
	Why did you use hired/family labour for weeding?	"As we have told you earlier we did commercial land preparation for other farmers who did not have animals so that the money we realized we use it for

		subsequent farm works like weeding", "As for me I did not have the animals but the pepper which I grew in the cowpea farm gave me the money which I used to contract labour for all the weeding works", "you know if you have large farm like mine and you did not hire enough people to do the weeding fast, then you know you have already lost in the race for yield of cowpea and that was why I did not use family labour", "I engaged my family for the first weeding because labour used to be scarce by then, but during the time of the second and third weeding I hired labour because of its cheapness and abundance at that time", "I use Roundup (glyphosate) herbicide for my first weeding which just after planting and before the crop emerged then the second weeding I engaged my family and it took us just a day" and "It had not prevented my crops emergence"
9	If you do use chemical fertilizers/manure on your cowpea farm, what is the estimated cost of the fertilizer used?	"How can you apply fertilizer on cowpea?", "Does cowpea need fertilizer?", "Yes I used to apply NPK on my crop" , "Of course I used NPK on my cowpea", "I used to apply one bag for every *kadada* (ha)" and "For one *kadada* I applied one bag of NPK" and "In the market a bag of NPK costs N5000.00".
11	If you do hire labour for the fertilizer application how much do you pay daily and for how long or if you use family labour then for how long?	

12	If you do use insecticide spray to protect cowpea from field insect pest how much do you pay to procure your chosen insecticide	"How can you plant cowpea and say you do not spray","Yes you yourself know that we have to protect our crop from insect pests with insecticide", "I purchased insecticides worth N40,000.00 last season" , "The season that passed, I spend N35,000.00 on insecticides", "My cowpea farm consumed insecticides worth N14, 400.00 last season" and "On an estimate I spent N21, 600.00 last season on insecticides alone".
13	If you do hire labour to do the spraying how much do you pay daily and for how long or if you use farmer labour for the sprays, then for how long?	"I used to hired labour when it came to spraying insecticides" , "I hired labour at the time for spraying insecticide" "Unless if you were the one that did the spray, otherwise if you hired labour then you would pay N70.00 per spraying of one knapsack load".
	Why did you use hired labour/family labour for spraying insecticide?	"It is very important to spray as quickly as possible when the weather permits otherwise for such large farm like mine then any delay will give insects the chance to establish and destroy the crop", "As we have told you earlier whatever you think we spent due to various farm labours we regained it when we disposed our grains at the time prices have gone up so we would not worry about hiring labour for spraying and others", "We used family labour during spraying" and "Why I used family labour for spraying was that I felt doing the spraying myself and my family would be better in terms of proper coverage and

		control of the insects”.
14	If you do hire labour or other means for harvesting your cowpea how much do you pay daily and for how long, or if you use family labour then for how long?	“I engaged my family during the harvesting operation”, “All members of my household have to take part during the harvest”, “I organised *Mseve* during my harvest” , “*Mseve* was what I used during the harvest period”, “A week before your harvest you send an invitation to your friends and neighbours and they come to assist you then, when it is their turn you also go and assist them (*Mseve*)”, “I used contract labour during my farm harvest”, “I relied on contract labour for my cowpea harvest”. “You know at the harvest time we had almost exhausted our pockets and delaying harvesting would mean risking your produce to theft, so we did not pay labour for harvesting with cash but with grains”,“We settled the labourers in the following manner for every five bags of threshed grains we gave them one bag as payment of their labour”, “you know we did not sell our produce at harvest time until sometimes around June when prices had almost doubled so that whatever you might think we had lost to labour we regained it” and “In the labour market labour for harvest was charged on daily basis at the rate of N 500.00 per person per day”.
15	If you do hire labour for the threshing of cowpea how much do you pay or if you use family labour then how long?	“sometimes its charge is included in harvest cost” “ If you have done the harvest yourself then hiring labour for threshing cost N500.00 per worker daily”

		and "It all depends upon the farm out- put for that year. It took five people two days to thresh my harvested cowpea".
16	What was the estimated output of grain yield obtained from your farm during the last year cropping season?	"Everything went right, I obtained up to 47 bags (2350kg) last season" , "My farm output of cowpea amounted up to 40bags (2000kg) last season", "the season was good for me I obtained up to18 bags (900kg)" , "Last season it was 20bags (1000kg) "At the last harvest time I took home about six and a half bags (325kg)" and "I obtained up to three bags (150kg)".
17	What do you do with the grains after harvest?	"We reserved some for our household consumption then we store the rest and sell when prices have jumped", "I consumed all my grains" and "My cowpea harvest could not even meet my household consumption".
18	If you do sell your cowpea grains how do you find buyers of your farm produce?	"I took my threshed grains to the market for sell" , "I sold my produce in the market"and "I did not support that idea because, when you call buyers they will think you are in problem and they will tend to give you lower price but when you take your grains to the market you have vast number of buyers with different prices".
19	What was the estimated market price of your cowpea grains at the harvest time during the last year cropping season?	"At harvest time one mudu (1kg) of Improved Kanannado grains can cost N200.00" and "We used to sell Kanannado at N200.00 for one mudu".
20	How do you transport your produce to the market?	"I hired a pickup to carry my produce to the market" , "I called people with tractors for the transportation on my produce to

		the market" and "I used my motorcycle to transport my produce to the market".
21	How much do you pay to transport your produce to the market?	"Initially we did not pay until we disposed the produce so the transporter financed everything. Then when we have sold the produce the transporter charged N5000.00 for every 10 bags (500kg) and we paid".
22	What problem do you normally encounter in terms of transporting your farm products to the market?	"The only problem is the nature of the road that is in deplorable condition" , "Our biggest transport problem was the road" and "Two years back we paid N3000.00 for every 10 bags (500kg) transported but, because of the present deplorable condition of the road, this year drivers charged N5000.00 to transport the same quantity of grains".
23	What quality of cowpea do the buyers of your produce prefer	"The moment your grains have holes and insects then you have lost the market" ,"Sometimes grain size did not matter to some buyers all they wanted want to see was white clean grains without insects" "Buyers preferred Improved Kanannado because its seeds are white and large. Even with that you should not allow the grains to have insect holes".