# EFFECT OF LEMON GRASS (Cymbopogon citratus stapf) AND BLACK SESAME (Hyptis spicigera Lam.) PRODUCTS ON CALLOSOBRUCHUS MACULATUS FAB. ON STORED COWPEA (Vigna unguiculata L.)

BY

JIJA MUSTAPHA, JAUNI
B.SC. (HONS) AGRIC UNIMAID

A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN CROP PROTECTION

DEPARTMENT OF CROP PROTECTION
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY
ZARIA, NIGERIA

JULY, 1999

## DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

.....
**JIJA MUSTAPHA, JAUNI**

DATE: ...16/7/99...

The above declaration is confirmed.

.....
DR. M. C. DIKE
MAJOR SUPERVISOR

DATE: ...16/7/99...

## CERTIFICATION

This Thesis entitled "Effect of Lemon grass (Cymbopogon citratus stapf and black sesame (Hyptis spicigera Lam) products on callosobruchus maculatus Fab. on stored Cowpea (Vigna unguiculata L)" by JAUNI, JIJA MUSTAPHA meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

.....
DR. M. C. DIKE
CHAIRMAN, SUPERVISORY COMMITTEE DATE: 16/7/99

.....
DR. I. ONU
MEMBER, SUPERVISORY COMMITTEE DATE: 16/7/99

.....
DR. A. D. AKPA
HEAD OF DEPARTMENT DATE: 22.07.99

473385

.....
DEAN, POST-GRADUATE SCHOOL
AHMADU BELLO UNIVERSITY, ZARIA DATE: 26/12/02

**DEDICATION**

My children: Bashir Mustapha

Maryam Mustapha

Jamila Mustapha

Palmata Mustapha

Aishatu Mustapha

Habib Mustapha

My parents:

Late Mallam Hassan Sikta Balami

Mrs. Palmata Hassan Sikta Balami

## ACKNOWLEDGEMENT

I am most grateful to Dr. M.C. Dike (Major Supervisor) for his sense of direction and valuable criticism throughout the duration of this project. For the interest he has taken and in spending no time to go through any portion of this work given to him at any time.

My appreciation to my other supervisors Dr. I.I. Onu and Dr. I.I. Uvah for the interest shown in this work and their time spent in reading the script and making useful corrections and suggestions.

I am also indebted to Late Dr. S.A. Apeji for his advice and suggestions at several points during this work. May I also put on record the cordial manner in which the staff of entomology storage laboratory offered me their advice and assistance during the research period. I am most grateful to Mr. Adakole Adukpe.

My profound gratitude and appreciation to Mr. C.O. Otuagbo, who apart from preparing the hot water extracts of materials used in this project, he has been useful to me while pursuing this study. I must say that your friendly guidance and assistance had contributed immensely towards my completing this project.

My acknowledgement is due to my senior brother, Dr. Dahiru Hassan Balami who has taken much of his time visiting my children and assisting them where necessary while I was away on this course.

I wish to acknowledge my husband for the consent given to me to undertake this study.

My gratitude and appreciation to my niece, Mrs. Jummai Yakubu and my junior sister Mrs. Adama Isa for their assistance towards my successful completion of this project. Thank you for sparing your time to see my children during my absence.

I wish to acknowledge my senior sister Hajiya Fatima's assistance for taking her time to stay with me during my post natal period.

I am indebted to the Deputy Director Horticulture, Mr. F.T. Mshelia, Mr. Y.Y. Balami and Mr. Yakubu Mshelia; I valuled their guidance and counselling. They are among those who inspired and encouraged me to undertake this project. I am most grateful for their financial, friendly and official assistance.

My acknowledgement will be incomplete without mentioning my sister in-law and her husband's contribution during the early part of my stay at Zaria.

I am also grateful to Mallam Musa Samaila and his family for their company during my stay in Zaria. Contributions from Mrs. Ana Malgwi my fellow student and all members of the department are highly acknowledged.

The last but not the least the Computer Technologist Mr. Ayuba Njaja Hildi who typed this manuscripts.

The powders increased ovicidal and larvicidal activities resulting in few emergence of $F_1$ and $F_2$ generations. Low mean numbers of adult emergence were recorded in cowpea treated with 10.0g, 15.0g and 20.0g of lemon grass and black sesame respectively, in this experiment.

In this experiment damage was significantly reduced by the powders with damage ranging from 0.2% - 1.1% with lemon grass and 0.2% - 1.2% with black sesame. Cowpea treated with Hyptis had fewer damaged seeds than lemon grass although the difference was statistically not significant.

Viability of the seeds were affected by the lemon grass germination ranged from 92.2% - 99.4% while black sesame had no effect on seed germination.

Aqueous extracts of the plant materials used had significant effect on adult mortality. Mortality was 72% - 100% apart from the control. Adult mortality increased with increase in concentration.

The powders had no effect on palability of the seeds and attractiveness of the grain remained unchanged. The extracts tinted the cowpea. Seeds treated with extracts changed from white to dirty-white.

## TABLE OF CONTENTS


| | | Page |
|---|---|---|
| Title page .. .. .. .. .. .. .. .. .. .. | | i |
| Declaration .. .. .. .. .. .. .. .. .. .. | | ii |
| Certification .. .. .. .. .. .. .. .. .. .. | | iii |
| Dedication .. .. .. .. .. .. .. .. .. .. | | iv |
| Acknowledgement .. .. .. .. .. .. .. .. .. | | v |
| Abstract .. .. .. .. .. .. .. .. .. .. | | vii |
| Table of Contents .. .. .. .. .. .. .. .. .. | | ix |
| List of Tables .. .. .. .. .. .. .. .. .. | | xi |
| List of Appendices .. .. .. .. .. .. .. .. .. | | xii |
| **CHAPTER ONE** | | |
| General Introduction .. .. .. .. .. .. .. .. .. | | 1 |
| **CHAPTER TWO** | | |
| Literature Review .. .. .. .. .. .. .. .. .. | | 8 |
| 2.1 | Classification and Morphological Description of Callosobruchus "maculatus F. .. .. .. .. .. | 8 |
| 2.2 | Host Range and Distribution .. .. .. .. .. | 8 |
| 2.3 | Life history and behaviour of C. maculatus .. .. .. | 9 |
| 2.4 | Use of Plant and Plant Products .. .. .. .. .. | 14 |
| 2.5 | Use of Chemicals .. .. .. .. .. .. .. | 24 |
| **CHAPTER THREE - MATERIALS AND METHODS** | | |
| 3.1 | Cowpea for Culture .. .. .. .. .. .. .. | 28 |
| 3.2 | Moisture Content Determination for Cowpea .. .. .. | 28 |
| 3.3 | Cowpea for Experiment .. .. .. .. .. .. | 28 |

3.4 Preparation of Lemon Grass and Black Sesame Products .. .. 29
3.2.1 Insect Cultures for the Experiment .. .. .. .. .. 29
3.2.2 Setting up of Experiment .. .. .. .. .. .. 30
3.2.3 Parameters Examined .. .. .. .. .. .. 31
3.2.4 Analysis of Data .. .. .. .. .. .. .. 32

**CHAPTER FOUR**

Results .. .. .. .. .. .. .. .. .. 33

**CHAPTER FIVE**

Results for Analytical comparison between the two Treatment .. .. 39

**CHAPTER SIX - DISCUSSIONS**

6.1 Insecticidal effect on Lemon grass and Black sesame on Adult Insects of C. maculatus .. .. .. .. .. 43

6.2 Insecticidal effect of Lemon grass and Black sesame on Oviposition of C. maculatus .. .. .. .. .. 43

6.3 Insecticidal effect of Lemon grass and Black sesame on emergence of F1 and F2 Generations of C. maculatus .. .. 44

6.4 Insecticidal effect of Lemon grass and Black sesame on Damage of Cowpea Seeds at eight weeks post treatment .. .. 45

6.5 Insecticidal effect of Lemon grass and Black sesame on the Viability of Seeds .. .. .. .. .. .. 45

6.2.1 Effect of Aqueous Extracts of Lemon grass and Black sesame on C. maculatus .. .. .. .. .. 45

6.2.2 Effect of Aqueous Extracts of Lemon grass and Black sesame on Adult Mortality of C. maculatus .. .. .. .. 45

6.2.3 Effect of Aqueous Extracts of Lemon grassand Black sesame on Oviposition of C. maculatus .. .. .. .. .. 46

6.2.4 Effect of Aqueous Extracts of Lemon grass and Black sesame on Emergence of F1 and F2 Generations .. .. .. .. 46

6.2.5 Effect of Aqueous Extracts of lemon grass and black sesame on damage of cowpea seeds at eight weeks post treatment .. 47

6.2.6 Effect of Aqueous Extracts of lemon grass and black sesame on viability of the seeds .. .. .. .. .. .. 47

6.3.1 ON physical Characteristics of the Grains .. .. .. .. 47

**CHAPTER SEVEN**

Summary and Recommendation .. .. .. .. .. .. 48

References .. .. .. .. .. .. .. .. .. 51

## LIST OF TABLES


| | | |
|---|---|---|
| 1. | Effect on Lemon grass powder on C. maculatus .. .. .. | 35 |
| 2. | Effect of Black sesame powder on C. maculatus .. .. .. | 36 |
| 3. | Effect of Aqueous Extract of lemon grass on C. maculatus .. .. | 37 |
| 4. | Effect of Aqueous Extract of black sesame on C. maculatus .. .. | 38 |
| 5. | Result on comparison on lemon grass and black sesame powders on C. maculatus . .. .. .. .. .. .. | 41 |
| 6. | Result on comparison of Acqueous Extracts of lemon grass and black sesame on C. maculatus .. .. .. .. .. | 42 |

## LIST OF APPENDICES


| | | |
|---|---|---|
| 1. | Results of the experiment .. .. .. .. .. .. | 61 |
| 2. | Analysis of variance of plant materials tables .. .. .. | 73 |
| 3. | Analysis of variance for comparison tables .. .. .. | 79 |

# CHAPTER ONE

## INTRODUCTION

Cowpea, Vigna unguiculata (Lam) Walp; is an annual pulse widely cultivated in the tropics and subtropics (Purseglove, 1974, Adjadi: et al., 1985; Singh and Jackai, 1985; Singh et al., 1990 and Gept and Debonck, 1991). It belongs to the family leguminosae and subfamily Papilionaceae (Singh S.R. and Jackai, 1985). Cultivation of cowpea in Africa and Asia has been going on since historic times (Irvine, 1969). In Africa, it is widely cultivated and hence Africa was thought to be a probable home of its domenstication from where it spread to other parts of the World (Purseglove, 1974; Singh and Jackai, 1985).

In Africa the known varieties are dwarf erect, creeping and climbing types. the sizes of seeds are variable often straight or curved. West African varieties are dark brown black or white. The white seeded variety is considered to be the best in quality (Irvine, 1969; Purseglove, 1974; Duke, 1990).

Production areas in Africa are Nigeria, Niger, Burkina Faso, Sierra Leone and Senegal (Singh and Van Emden, 1979; Singh and Jackai, 1985; Singh et al., 1990, Abubakar, 1987). Other production areas include Aisa, Brazil, India and Southern U.S.A. About 2.27 million tonnes were produced world wide from 7.7 million hectares of land (Singh and Jackai, 1985). World production of cowpea has increased from 2.27 to 2.5 million tonnes from 1977 - 1985. Nigeria produces 32% of this total annual world production. In 1985 Nigeria produced 850,000 tonnes. Eighty percent of this, was

produced in the Savanna regions of the country from Borno, Bauchi, Kano, Katsina and Sokoto (Ezedinma, 1960; Singh and Jackai, 1985; Duke, 1990). Annual production in Nigeria in 1978 was at 700 - 800 tonnes. Projected demand and domestic production in 1985 was 1.3 and 1.1 million tonnes respectively (Abubakar, 1987).

Cowpea is an important component of cropping system, cultivated either as a monocrop or in mixed culture with other cereals in the North. It is also cultivated at backyards near small farm house. Cowpea thrives on many kinds of soil from highly acid to neutral. It does well on infertile soils but however, responds to phosphate fertilization. As a black-eye pea, grows well in dry areas along with cereals either millet or sorghum (Singh and Van Emden, 1979; Singh and Jackai, 1985; Jackai and Daoust, 1986; Singh et al., 1990; Duke, 1990; Ansari, 1992).

The leaves and green pods are used as vegetable and soil improver. Cowpea is second only to cereal crops and complements them in feeding the developing world. It provides proteins eaten by most people in the tropics and nitrogen for the soil. In addition to vitamins, minerals and fibres to human, Legumes are the substitute for meat for the poor in the Third World. Cowpea account for over 50% of the protein in local diet together with many essential minerals and vitamins (Anon, 1975; Youdeowei, 1988; Singh et al.; 1990; Duke, 1990; Munro, 1966 and Taylor, 1971).

Hundred of grammes of the elible portion of raw cowpeas provide 11.59g of water, 1408 KJ of food energy, 23.52g of protein (Nx6.25), 1.26g lipid, 60.03g Carbohydrate, 4.58g crude fibre and 3.24g Ash (Bressani and Elias, 1980; Duke, 1990).

During the dry season the leaves and twigs are used as fooder for livestock. Apart from being used as staple food crop many families cultivate it as cash crop.

Like any other crop cowpea is attacked by a wide range of diseases and pests (Irvine, 1969; Purseglove, 1974; Singh and Jackai, 1985; Ansari et al.; 1992; Singh et al.; 1990).

Among the bruchids attacking cowpea in the field, Callosobruchus maculatus is the most important. It starts infestation from the field and is taken to store if it is unchecked. The infestation builds up and great losses can be recorded (Irvine, 1969; Iloba and Osuji, 1986; Abubakar, 1987). The numerous diseases and pests attacking cowpea both in the field and store, constitute a serious constraint to its production (Taylor, 1968; Raheja, 1986; Singh and Jackai, 1985). Serious losses in grain yield and seed quality are recorded. Caswell (1981) reported that more damage is incurred in nothern Nigeria with an average damage level of 30% due to increase in rate of shattering and absence of alternative host. This is compared to the situation of southern Nigeria with only 15% damage. In the absence of pest control upto 90% or more reduction in yield is recorded (Raheja, 1986). Youdeowei, (1988) reported that field infestation of cowpea by C. maculatus results in 2 - 10% loss generally but under favourable environmental conditions upto 30%. When cowpea is stored without effective control measures or protection from pests upto 70% damage losses is recorded within six months.

Damage by the cowpea weevil renders cowpea unsuitable for consumption and viability is reduced. The seeds lose 30% of their weight (Youdeowei, 1988).

With heavy losses encountered in cowpea production, it seems clear that the limiting factor to stable production are insect pests especially the pod sucking and storage insects (Ebong, 1968; Raman et al.; 1987; and Youdeowei, 1988). A number of ways can be employed to halt insect pests as being a major constraint to stable production of cowpea. Among the main technical approaches to reducing storage losses in the context of the constraint commonly faced by the low resource farmer include pre-storage methods such as timely harvest, improved drying, better storage structure, use of appropriate crop varieties, the use of commercial pesticides or locally produced insecticidal materials (Compton et al.; 1993). The use of cowpea varieties that are high yielding and resistant to deterioration in storage would be the ideal solution, but this is not always feasible. New storage structures and grain dryers are the most difficult technologies to promote to the low resource farmers due to their high capital cost. Therefore, most traditional farmers in most parts of the world use local plants and plant products to protect their crop against insect pests before the advent of chemical insecticides (Golob and Webling, 1980; Sowunmi and Akinnusi, 1983). This is because most traditional storage systems are well adapted to their environment and losses are generally low. Five percent loss of grain weight is recorded over a storage season (Compton, 1993). However, with the recent development of chemical insecticides, many farmers abandoned the use of these local storage systems. These chemicals were believed to be effective in all aspects of control. Unfortunately, their use turned out to be hazardous to man. They are also costly inputs and over use contaminates the environment, increases resistance to insecticides and can cause health hazards (Raman et al., 1987; Carson, 1963; Cremlyn,

1978; Anon, 1992). In addition, their detrimental effects on man and livestock due partially to mishandling, residual effects, environmental pollution coupled with high market prices and inaccessibility to the rural populace have resulted in many farmers going back to the traditional system for pest control (Dike and Mbah, 1992; Sowunmi and Akinnusi, 1983; Stoll, 1988; Simmonds et al., 1992). In the light of this, attention is now being given to improvement and local sourcing of raw materials from local plants and plant product found in developing countries for the containment of insect pests (Golob and Webleg, 1980; Sowunmi and Akinnusi, 1983; Stoll, 1988; Simmonds et al.; 1992).

Materials used in this project have been proven by many authors to contain high insecticidal properties capable of killing C. maculatus (Dalziel, 1948; Tiwari et al.; 1966; Akibu et al.; 1984; Sharaby, 1986; Stoll, 1988). However, the trials are still few as to come up with a formulation and dosage optimum for the farmers use. There is also a need for comparative trial to determine the efficacies of these plant materials and recommend the best. Therefore this study aims at investigating the comparative efficacies of Lemon grass and black sesame in controlling C. maculatus on stored cowpea.

Lemon grass, Cymbopogon citratus (Stapf) is a herbaceous perennial grass with narrow leaves and sweet smells, widely grown in Srilanka. It is possibly a native of this land, part of East India and Tropical Asia (Arcander, 1960; Uphof, 1968). It is now cultivated all over the world. The main areas of production are Guatemala, India and China. Other areas of production include Central and South America, parts of Africa,

South East Asia and Indian Ocean Islands (Robbins, 1983). It is locally grown in Nigeria (Dike and Mbah, 1992). Lemon grass is a source of lemon grass oil, and essential oil obtained from steam distillation used for perfuming soap and cosmetics. The oil contains chemical citral which possesses a lemon-like character due to high content of the aldehyde citral which accounts for 75% of the oil constituent. The oil is used in its own right as oil or a source for isolation of citral, ionones and vitamin A and E. It is used as aerosol deodorant; floor polishes; house-hold detergents and a whole range of domestic and industrial products in which a pleasant fresh, fragrance is desired either in its right or as mask for the unpleasant odours of certain active ingredient (Robbins, 1983; Arctander, 1960). It is also used as a source of beverage and as insecticide (Tiwari et al, 1966; Watt and Breyer, 1962; Dalziel, 1948; Sharaby, 1988; Dike and Mbah, 1992). In areas with scarce forage, it is used for grazing and as a source of additives to mollases because of its nutritive quality. The grass is cultivated in some states in Africa for border garden embarkment to check erosion or as decorative grass. The roots are used as chew sticks to clean the teeth. It is used as a herb for cure of malaria and finally the leaves are used to stuff pillows and mattress (Diaziel, 1948).

Another local material used in Nigeria as insecticide is the black sesame, Hyptis spicigera (Lam). This is an annual herb that grows wildly. However, in some parts of central and East Africa and Guinea, it is cultivated like sesame (Dalziel, 1948). In Nigeria the plant is commonly found in most parts of Southern Borno and some Fadama areas of the country. In Sierra Leone the seeds are sown in rooms to get rid of mosquitoes and the plants are placed in a layer below bundles of millet to keep away

termites (Dalziel, 1948). In Guinea, the dried seeds are used to extract oil which yields over 20%. This oil is used in railway workshop in Senegal in place of linseed oil. The seeds are used like sesame for food and when made into pulp are used in stews and gravies by the Sudanese (Dalziel, 1948; Uphof, 1968). It is also used medicinally when the leaves are crushed and applied to the head to relieve cold. Black sesame is generally accepted by agriculturalists as an insecticide, repellent and antifeedant because of its strong pungent pepperish properties (Dalziel, 1948); Lamber et al.; 1987 and Stoll, 1988). The insecticidal property of this herb have been long recognised by farmers in Borno State and where there are used as a source of protection against the cowpea bruchid.

## OBJECTIVES

This project investigates the formulation and dosage values of lemon grass and black sesame as insecticides required for optimum storage of cowpea. This study was aimed at finding simple storage insecticides with less hazards to be recommended to farmers in local communities which form the majority of agricultural sectors in Nigeria. It also seeks to determine the more effective of the two plant materials which can be easily accessible, safe as well as cheap with more biodegradable qualities. Finally, it aims at assessing the forms (extract and powder) which is more effective in controlling C. maculatus on stored cowpea.

KASU

# CHAPTER TWO

## LITERATURE REVIEW

### 2.1 CLASSIFICATION AND MORPHOLOGICAL DESCRIPTION OF CALLOSOBRUCHUS maculatus (Fabrucius).

C. maculatus belongs to the class Insecta, order Coleoptera and family Bruchidae, (Hill, 1975). Apart from C. maculatus, other species in this genus include:

Callosobruchus chinersis (Linnaeus)

" analis (Fabricius)

" phascoli (Gyllenha)

" rehodesianus (Pic)

" theobromae (Linnaeus)

(Haines, 1991).

The body size of C. maculatus varies from 2.5mm - 3.5mm (Southgate, 1958). The weevil is elongate with posterior part of the abdomen not covered completely by the elytra. In males, the elytra is almost brown with small blackish markings while in females the elytra has brown spots which is often strongly marked consisting of two large latral dark patches mid-way along the elytra and smaller patches at the anterior and posterior ends leaving a paler brown cross-shaped area covering the rest of the wing (Anon, 1970; Haines, 1991).

### 2.2 HOST RANGE AND DISTRIBUTION

All insects in the family Bruchidae are grain legume feeders either on the field or in store. Many of them are pests of stored products. However, the predominant pulses attacked by C. maculatus are cowpea, soyabeans, chicken pea and dolichos beans

(Hill, 1975; Anon, 1970). Others include, Phaseolus aurens Rox; Voandzeia subterranea (L) D.G., Sphenostylis stenocarpus Horms; Vigna radiata (Brooker, 1967; Haines, 1991). While most of the host support oviposition, a few do so with poor performance in developmental periods and increased mortality (Credland, 1987). Hill, (1975) reported that in the absence of preferred host, maize could be attacked.

C. maculatus is widely distributed throughout the tropical and subtropical regions of the world. It is cosmopolitan and a successful species throughout the world (Hill, 1975). This is due to its adaptability to high temperatures (Giga and Smith, 1983). C. maculatus breeds poorly in temperature regions where temperatures are below 20°C. Its introduction to other parts of the world was through trade in leguminous seeds and incidentally through imported seeds as aid materials to other countries.

## 2.3 LIFE HISTORY AND BEHAVIOUR OF C. maculatus

Thorough understanding of the life history and behaviour of any pest is valuable, if the recommendation for its control and management are to be sound and efficient. Adults of C. maculatus do not feed on stored products and are short-lived, usually living for not more than 12 days after emergence under favourable optimum conditions (Singh et al.; 1990; Haines, 1991). The female has a mean length of 6.8 days while the male is 6.9 days. The female usually after oviposition die within 10 - 12 days (Booker, 1967; Credland, 1987; Singh et al.; 1990). The female try to avoid males for mating, however the length of life is not affected by mating.

However, infestation begins in the field where eggs are laid and cemented on maturing pods. If this initial infestation is not checked, it is taken into the store where it builds up, (Irvine, 1969; Anon, 1970; Sukprakarn, 1984; Haines, 1991).

Studies by Credland, (1987) showed that C. maculatus usually searched for suitable ovipositional surfaces. Pre-ovipositional period is short. The female are mated within a short time and in about an hour females start ovipositing, which is completed within five to eight days (Singh et al.; 1990 and Singh and Jackai, 1985). C. maculatus lays more than 50% of its eggs in the first three days after emergence with good viability upto the sixth day and thereafter fewer eggs are laid with decreased viability (Booker, 1967). After oviposition the mean length of life in females is 6.8 days. The unmated females lay fewer eggs or non at all and those laid are usually unviable. However, oviposition is depressed and developmental period prolonged when eggs are deposited on non host materials (Credland, 1987). Females will normally look for fresh seeds to oviposit but when all seeds are heavily located with eggs they resort to ovipositing on the same seeds (Haines, 1991). Generally oviposition patterns in C. maculatus involve laying one to few eggs on fresh seeds until all seeds are covered. Then more eggs are laid on the remaining spaces. Even on a preferred host, C. maculatus still looks for seeds which are well filled with smooth coats as large seeded varieties are better hosts than those with rough and wrinkled seeds coats (Booker, 1967; Nwanze et al., 1975; Haines, 1991). Booker, (1967) further stated that smooth surfaced seeds provide for easy attachment and more surface area for ovipositing. For a good population build up large

well filled seeds with smooth testa are preferred as these provide a large surface area for oviposition and greater quality of nutrient for the larvae.

The eggs are spherical in structure with oval flat bases. Newly laid eggs are small shinning white and inconspicuous (Haines, 1991). More than 50% of the eggs are laid within the first three days after emergence with good viability upto the sixth day. Thereafter, fewer egges are laid with decreasing viability (Booker, 1967; Sukprakarn, 1984). Five days after oviposition, the larvae hatch and bite through the base of the egg through the testa of the seed and bore into the under lying cotyledons and incubate for three to six days.

Environmental factors and types of host determine the duration of the life cycle of C. maculatus. Under favourable conditions it ranges from 20 - 35 days (Little, 1972; Hill, 1975; Sukprakarn, 1984; Credland, 1987; Haines, 1991). Generations of six to seven are quite common in many countries while in warm climates more than nine and above is possible (Little, 1972; Hill, 1975).

Temperature and relative humidity govern the oviposition rate. Utida, (1971) reported that the optimum ranges of temperature for oviposition and survival of eggs and larvae are 17 - 18°C. However, other writers reported optimum temperature to be 30°C - 35°C and relative humidity of 70%-100% (Giga and Smith, 1983; Haines, 1991). Anon, (1970) reported that the optimum developmental period is at 10 - 35°C with 70% relative humidity. Booker, (1967) observed that the developmental period is more in the abnormal form of C. maculatus.

RECEIVED
Zaria Nigeria
Ahmadu Bello University



473385

The larvae feed within a single seed excavating a chamber within the cotyledon as they pupate inside the seeds for about three to seven days and grow into adult. On suitable substrate such as cowpea under optimum temperature of 32°C and relative humidity of 90% it takes about 21 days (Booker, 1967; Nwanze, et al., 1975, Haines, 1991). Adult emergence are variable depending on the mean temperature. The peak of adult emergence is at 20°C with the least number of days 21 while at lower temperature emergence is low and takes about 40 days.

There is variation in developmental period and adult emergence in susceptible and resistant cowpea. In susceptible cowpea adult emergence takes about 22 days at 27°C and about 32 days at 22°C. In resistant varieties the two situations are extended by 5 - 10 days respectively. Haines, (1991) observed that the active or flight form of C. maculatus exists, which are apparently more active and more strongly marked with a white pygidium. He further pointed out that their function is not understood but appears as a result of genetic and environmental factors. Taylor and Aludo, (1973) reported that the active forms in Nigeria lived longer and are lower in fecundity. They produced fewer eggs in their late stages of life which mature into adult active forms. The active female infests matured cowpea in the field prior to harvest. They are stronger fliers and are adapted to field conditions. Taylor and Agbase, (1974) further reported that temperature affects flight activity of the adult. However, flying C. maculatus is predominantly the active form, though they are lower in infested cowpea. This is responsible for cross-infestation of adjacent cowpea stores and pre-harvest matured cowpea on nearby farms. Caswell, (1960) observed a high incidence of the active forms

during the months of April and May at the onset of the rainy season. Newly emerged active forms produce fewer eggs or none at all. This behaviour enables it to have more food reserve to prolong life, the food which would have been used for eggs to mature in normal females. Caswell, (1960) further reported that reproductive system of active females do not mature until after a week or more after emergence. Egg laid by them are rarely fertile. Taylor, (1973) observed body weight difference in the normal and active forms of C. maculatus, the active forms being smaller.

Factors influencing the production of active forms of C. maculatus include, high population density during the larval stages. Heat is produced through metabolic activities of the crowded larvae making the condition unfavourable. This results in some insects changing their form and flying away (Taylor, 1974). Photoperiod is another factor which induces the active form of C. maculatus. There is high emergence under two extreme photoperiods i.e. conditions normally 24 hours day and 24 hours darkness. The flight form decreases with change in the photoperiod to the intermediate zone at which emergence of the flight form is almost zero percent (Utida, 1969). Another factor is parental conditions. The percentage of active forms are higher from later developed and old adults in a culture population (Utida, 1968). Utida, (1970) reported that the percentage of emergence of the flight form of C. maculatus decreased gradually from generation to generation in the breeding population. He further said that the flight form was induced phenotypically by the influence of some environmental factors such as high temperature, low content of water in the larval food and high population of larvae. Taylor, (1974) reported that the active form in a large infesting population will disperse

in order to obtain new oviposition sites and for larval development. He further reported that the active forms are produced when a high population density of the larval stage are exposed to high temperature and low water content foods. Nontheless, temperature is the principal factor.

Production of the active forms enable the species an opportunity to facilitate dispersal as population builds up in storage. This results in field infestation which is principally caused by females of the active forms. Inspite of their low fecundity but tendency to produce normal progeny, they still constitute serious preharvest pests (Taylor and Aludo, 1973).

## 2.4 USE OF PLANT AND PLANT PRODUCTS

Most of the insects in the family Bruchidae are controlled successfully with traditional plant products or chemically synthesized insecticides. Traditional farmers in most part of the world use local plants and plant products to control insect pests of stored products (Golob et al.; 1982). This is the traditional way of storage with the low resource farmers. As part of control, the traditional farmer usually heats the harvested cowpea to dryness and initial infestations are taken care of (Irvine 1969). Iloba and Osuji, (1986) reported that the lemal death point of C. maculatus is 51°C when heated for 15 minutes and 47.5°C when exposed to heat for four hours (Golob and Webleg, 1980; Sowmunmi and Akinnusi, 1983). However, with the era of chemical insecticides many farmers abandoned the use of local materials for crop protection against insects in favour of the insecticides. These chemicals were effective in insect pest control but unfortunately their use has turned out to be hazardous to man. They are costly input and

improper use contaminates the environment and can cause health hazards to humans (Cremly, 1978; Carson, 1963; Youdeowei, 1988). With these detrimental effects on man and livestock due partially to mishandling, residual effects, environmental polution coupled with high market prices and inaccessibility to the rural populace, many farmers are going back to the traditional systems for pest control (Sowunmi and Akinnusi, 1983; Boughdad, et al., 1987). Most traditional storage systems are well adapted to their environement and losses are generally low (Rees and Dales, 1993).

Moreover, the general trend now is towards the fourth generation insecticides which are behaviour modifying compounds such as antifeedants and deterents. The products derived from natural plant compounds have been part of each generation of insecticide. The trend is to return to the botannicals not only as source of novel compounds but as products in their own right. The botannical insecticides are not in all safe although unlike synthetic pesticides, natural compounds are usually biodegradable and are potentially environmentally safer than the synthetics (Simmonds, et al., 1992). Plant chemicals with potentials as botannicals contain the following chemicals: terpenoids, flavonoids, phenolics, amines and alkaloids as secondary plant metablolites. There are advances for isolations and analysis of these compounds to control the increase in the number of insect species developing resistance to insecticides available. Thus the agrochemical industries have returned to the plant kingdom to provide them with new leads and ideas. It is most likely that pest management programmes in the year 2000 will benefit from it, especially from plant materials used for centuries by farmers from Africa, Asia and the Americans (Simmonds, et al., 1992). (Naik and Dumber, 1984;

Malik and Muytaba, 1984; Sowunmi and Akinnusi, 1983; Sharaby, 1986 and many other workers have tried various local materials as insect pest protectant of stored products. The botannical insecticides are used in a variety of ways as crude formulations or semi purified or purified extracts that contain compounds active as antifeedant, ovicides, repellent or growth disrupters (Simmonds, et al., 1992).

Tiwari, et al.; (1966) tried the insecticidal, fumigant and repellent properties of lemon grass oil against housefly and mosquito which was successful. He therefore concluded that products of this grass is quite a promising insecticide against insect pests acting as fumigant. Lemon grass has high insecticidal properties as shown in the use of its products. The root stocks of lemon grass is aromatic and repels months (Watt and Breyer, 1962). Products of this grass have been evaluated against insect pests in households, store and field. Tiwari, (1966) reported that the oil has contact toxicity when applied at 7.5ug and 30ug against housefly and mosquito respectively. Sharaby, (1986) further confirmed this insecticidal property when he tried the oil. He reported that 1 - 2% concentration destroyed egg masses and newly hatched larvae of Spodoptera exigna, a cotton pest. Dike and Mbah, (1992) reported that trials with 5g, 10g and 20g lemon grass stem and leaves powder mixed with 100g of cowpea controlled C. maculatus with adult mortality of 88.5%, 97.5% and 100% after four weeks of treatment respectively.

Other plant products tried for their insecticidal properties include the Black sesame, Hyptis spicigera (Lam). This plant is used as protectant of stored produce against insect pests due to its insecticidal, repelling and antifeedant properties (Dalziel,

1948; Akibu et al., 1984; Lambert, et al., 1985). Dalziel, (1984) reported that the seeds are sown in rooms to get rid of mosquitoes, and the plants are laid in layers below bundles of millet to keep away termites. This is due to its repelling and antifeedant qualities. Evaluation trials by Ajayi, et al., (1987) showed that when pieces of the leaves and wigs weighing 10g plus 3g of ground chilli pepper were added to 300g of pearl millet it gave good control of Rhizopertha dominica on millet for seven weeks. They however said that this plant material is quite promising as an insecticide, nonetheless more work needs to be done on the rates and prestorage treatment inorder to enhance and prolong its efficacy. Studies by Lambert, et al., (1985) showed that ethanol extract of Hyptis spicigera and Cassia nigricans applied at low rates with E.C. 50 between 0.3 - 14ml/grams of cowpea reduced oviposition and hatching of the cowpea weevil. In Burkina Faso, the leaves of Hyptis spicigera are used to control bean weevil Acanthoscelides obtectus. The leaves are laid between the beans stored in their pods. Dried leaf powder reduced hatching of larvae in proportion to the quantity used. At 3gm/kg of cowpea, hatching was reduced by 78%. Hyptis spicigera leaf powder protected millet against termites when scattered throughout the grains (Stoll, 1988). The extract reduced egg deposit at a concentration of 3ml/kg of seed and gave good control of the insect.

Many other local plants and plant products have been tried against C. maculatus. This insect was readily controlled by mixing 5ml groundnut oil with one kilogramme of cowpea which control the bruchid for 6 - 8 months (Singh, et al., 1977); Boughdad, et al., 1987; Raman, et al., 1987; Feeroza et al.; 1988; Singal and Singh, 1990). It is

generally recommended that vegetable oils at rates of 5 - 10ml/kg of grain is effective against the bruchids attack (Jackai and Daoust, 1986). The oil mode of action is by providing a physical barrier to insect respiration and many contain insecticidal or repellent compounds including fatty acid and others produced by chemical breakdown of the oil after application (Credland, 1992; Rees and Dales, 1993). Hill and Schoonhoven, (1981) reported that the insecticidal effectiveness is due to triglyceride fraction and oleic acid present. The ovicidal effect is due to blockage of insect trachea which hinders larval activity (Kumar and Okonronkwo, 1991; Schoonhoven, 1978). In study trials to compare the efficacy of vegetable oils, palm oil with pepper and ash by Akibu, et al., 1984 it was observed that palm oil was highly effective in controlling C. maculatus as compared to pepper and ash. In India, locally extracted oils were used against the bruchid attack and vegetable oil screened protected cowpea and bambara groundnut against C. maculatus by reducing oviposition and egg hatching or both. Other oils used by Asian villagers include peanut oil and soyabean oil to protect cowpea in storage against weevil attack. Both oils suppressed weevil reproduction in stored mungbean at rates of 1 - 3ml/kg. Best results were obtained with 2ml/kg and it is the minimal recommendation for five months (Anon, 1975). Pereira, (1983) reported that when 3ml and 1ml oil of neem kernel were mixed with one kilogramme of cowpea and bambara groundnut respectively there was effective control of cowpea weevil for six months by reducing oviposition, egg hatching and death of larvae. Neem seed oil caused 100% mortality of bruchid females and all insects died within five days with 3ml/kg seeds. The seeds treated with neem seed oil suffered less than 4% damage (Ivbijaro, 1990).

Dennetlin tripetala oil is also effective against C. maculatus. When used at the rate of 1ml/kg it protected cowpea for more than 14 weeks. The essential oil of Mentha spicata at rates of 10ml in 90ml of water 1.0% emulsion completely suppressed the hatching of eggs when infested seeds were deeped into it (Stoll, 1988). Su, et al., (1976) investigated the insecticidal property of lemon oil and concluded that a single component was highly toxic to C. maculatus at LD50 concentration when applied topically after 24 hours; average mortality rate were 16.4 and 4.73 for C. maculatus. Hellen, et al., (1972) reported that oils from lemon, grapefruit, lime, kumquat and tangerine were highly toxic to cowpea weevils. Lypohilized lemon oil at the rate of 12.5ug/insect gave 100% mortality of the insects within 24 hours. Echendu, (1991) reported that cashew nut oil significantly reduced the number of eggs laid by C. maculatus and adult emergency. Olaifa and Erhun, (1988) further observed that even the volatile oil Piper guineense at 0.02% gave complete suppression of oviposition and even at lower concentration there was significant reduction in oviposition and death of adult insects. The Piper seed oil was most effective in reducing oviposition substantially to an average of 7.5 and 15.5 eggs at concentrations of 2ml/kg and 3ml/kg seeds. Oils from seed of Piper at both concentrations caused 100% mortality of bruchid female within 24 hours. High mortality rate was observed as all insects died within five days. No damage was observed in seed treated with Piper oil (Ivbijaro, 1990). Naik and Dumber, (1984) tried non edible and edible oils and concluded that non-edible oils such as neem, castor, karanj and undi were more effective in preventing adult emergence and progeny development with increase in doses resulting in reduced oviposition. Neem provided the largest

reduction in oviposition and was superior to others at 1% as shown by its allowing no oviposition. Other oils tried against the bruchids included essential oils of Mentha arvensis; Eucalyptus globulus, Cymbopogon minterianus and C. martinii against Callosobruchus chinesis on red gram. Cymbopogon martinii was the most effective in preventing oviposition giving only 18.66 eggs/adult, 90 days after insect release. Mentha arvensis was effecctive at 0.2% and gave complete control of oviposition while M. arvensis, C. martinii at 0.2% and Eucalyptus globulus and C. minterianus at 0.4% was successful in controlling of C. chinensis on red gram (Srivastava, et al., 1988). Don Pedro, (1988) further reported that oils exert lethal action slowly by drastically reducing respiratory activity and direct toxic effect that possibly penetrate the eggs and therefore concluded that complete spread of an oil film over the surface of a commodity is vital for successful utilization of fixed oils as stored product protectants. Babu, et al., (1989) in evaluation trials with edible and non-edible oils on development of the pulse beetle, viability and yield of mungbean concluded that treatment with karanj oil (5ml and 10ml/kg) and Castor oil (10ml/kg) effectively reduced oviposition under artificial infestation conditions for over 18 months of storage.

Most of the materials used in storage are used as powders. Ivbijaro, (1983) observed that admixture of 1 - 3g dry ground neem seeds with 20g cowpea afforded protection from damage by C. maculatus for more than four months by reducing fecundity, prolonging pre-emarginal development period and reducing emergence of progeny with 82% viability. Texture, colour and attractiveness of seeds remained unaffected. Sowunmi and Akinnusi, (1983) reported that 1% and 2% neem kernel

admixture with cowpea provided effective preservation for eight months against C. maculatus. Yadava and Bhatnagar (1987) reported that leaf powder of neem, Datura alba and oak Calotropis procea, garlic powder and shell and seed powder of soapnut, Sapindus trifoliatus treated at three doses on cowpea gave initial low mortality rates which increases with time. These chemicals compete favourably with 2.2g malation. Saxena, (1987) reported that after 12 months of treatment of lentil seeds with neem seed powder, no progeny developed from released adult of C. maculatus and C. chinensis. Similarly, no damage occured after 12 months treatment with 2% neem kernel powder mixed with gram and pigeon pea seeds weight per weight (wt/wt). The effectiveness of this was due to inhibition of oviposition in the weevil. The neem seed powder significantly reduced the rate of oviposition of Dermestes maculatus at rates of 0.5g, 1.0g/25g dried fish and 2.0g/25g of cowpea seed as in C. maculatus. It prolonged incubation period and larvicidal activity was 93% of D. maculatus (Tonye, et al., 1990). The powder of neem seed kernel or leaves have been used in stores and ware houses to reduce infestation and damage to grains during three to twelve months storage periods (Saxena, 1988; Makanjuola, 1989; Simmonds, et al., 1990; Echendu, 1991). Olaifa and Erhun, (1989) reviewed the use of Pipper guineense powder and observed that 42% of the total product used gave complete suppression of oviposition in C. maculatus. The fruit and roots contain amide alkaloids which exhibit anti-insect activity. The guineensine constituent have paralysing effect on the eggs and adult cowpea weevil. In stored cowpea, the piperine is very effective against C. maculatus (Baldwin, et al., 1991).



473285

Other indigenous plants tried as powder for their definite repellent, antifeedant and insecticidal properties include Saussurea lappa (P) and Chenopodium ambrosioides (Malik and Muytaba, 1984). C. maculatus is controlled with Mentha spicata (spearmint), the leaves dried and crushed into powder and applied at rates of 2.5g, 5g and 10g produced death rates of 88.8%, 88.8% and 96.3% respectively within 24 hours of introduction into infested cowpea (Stoll, 1988). The rhizome of turmeric, (Curcuma domestica) is insecticidal, reppellent and effective against many storage and field pests. Acetone extract of the dried rhizome grated and diluted with five parts of water or the shredded roots with cow urine added and diluted with water in proportions between 1:2 and 1:6 spray on produce will protect it against the following insects armyworm, caterpillar, cowpea weevil, grain borer, Sitophilus granarius; lesser grain borer Rhizopertha dominica, mites and rice flour beetle, Tribolium spp (Stoll, 1988). The powder of the rhizome of sweet flag, Acorus calamus is used at 50kg grain per one kilogramme of rice for control of rice weevils. The essential oil obtained from steam distillation is made into emulsion by adding 2ml oil + 2ml alcohol in 100ml water. Seeds dressed with 2% or 4% emulsion in water preserve stored products for at least four months (Stoll, 1988). The leaves of Ocimum canum sinu and Chenopodium procerum Hochst are toxic to the bruchids (Kayitare and Ntezurbanza, 1991). The plant products of the following plant species are effective against stored pests including C. maculatus, Borreria, verticellatus, Hexalobus monopetalus, Khaya senegalensis, Annona squamosa, Clevatis hirsuta and Afrormosia laxiflora. When applied to cowpea they can preserve it for one to two years (Olufade, 1985).

The by-product of oranges and grape fruits were also tried. Taylor, (1975) reported that organge and grape fruit peel powders tried at various doses, showed that orange peel powders was toxic to C. maculatus at 100,000 and 50,000 ppm by significantly depressing oviposition and progeny emergence. Don Pedro, (1985) reported that 4.0g of ground orange (peel)/ 100g cowpea killed Dermestes maculatus. He further reported that 5.82g of ground grape fruit at LD50 was effective on adult Dermestes maculatus.

*At high doses orange peel depressed progeny development. Trials with sorptive* dust showed that sorptive dust has repelling and killing action against the cowpea weevil with its desiccating effect against the bruchids soft body wax which is responsible for the fast mortality rate. Other materials of the same effect are hydrated lime (Ebeling, 1971). Covering cowpea with a layer of hydrated lime to a depth of 1.25cm or mixing the lime with small quantities of cowpea at the rate of 1:4 part by weight protected it against attach by cowpea weevil (Evans, 1939). Prevett, (1962) observed that when cowpea is stored in rumbu with Lantana snulvifolia Jacq, it is safe against insect pests attack because of its sage-like odour which repells the insect. He further said that a mixture of sand and ashes reduces spaces between the seeds thereby reducing infestation. Parkin and Bills, (1955) reported that treatment of cowpea with heavy doses of admixed clays, ashes, hydrated lime or with inert dust such as silicate, magnesite, bentonite, and rock phosphate which are smaller in particle size have a physical action on the insect thereby controlling ifestation with recommended dosage rates of 0.5 - 2% by weight.

Ginger rhizome powder significantly reduced number of eggs laid and adult emergency of C. maculatus (Echendu, 1991). Onolemhemhen, (1990) reported that rubber oil had adverse effect on the survival of adult C. maculatus and gave 100% mortality. Within four days, 5 - 10ml/kg gave 57.49 - 73% death rate. It is both ovicidal and larvicidal.

## 2.5 THE USE OF CHEMICALS

Pesticides are considered as one of the major inputs in the production of food, raw materials and in correcting the imbalance in agro-ecosystem when necessary. They played a key role in pest management despite their undesirable side effects. They are necessary for increased production and maintenance of high quality produce (Anon, 1992). In the light of these, many chemicals have been tried to control the cowpea weevil in comparative terms with traditional insecticides and singly as insect pest protectants of stored products.

For the legumes - cowpea in particular, a high yielding and resistant variety to deterioration in storage, would be an ideal solution, but this is not always feasible. The new storage structures and grain dryers are the most difficult technologies to promote to the low resource farmers due to their high capital cost. Therefore pesticides are probably the most successful storage technology to date (Singh et al., 1990; Rees and Dales, 1993). They are easy to incoporate into most types of storage systems and when correctly used can give high returns to the farmers investment (Rees and Dales, 1993). Evans, (1939) observed that fumigation of cowpea with cyanogas (Calcium cyanide) gave satisfactory control under winter conditions. Caswell and Akibu, (1980) further reported

that treatment of cowpea seeds with pirimiphos methyl concentration at 7.5 ppm - 15 ppm gave protection for 12 months without any appreciable damage to stored cowpea when store in pods. Fumigation of pigeon pea and hericot beans with dilute formulation of pirimiphos - methyl and permethrin at rates between 2.5 - 10mg/kg gave adequate control C. maculatus and C. chinensis (Taylor and Evans, 1980). Further trials with pirimiphos methyl on cowpea by Sowunmi and Fetuga, (1982) showed that pirimiphos-methyl was effective against cowpea weevil. However, this is subject to rapid degration occasioned by humid conditions of the tropics which required higher initial dose to achieve acceptable protection over a longer period. Olufade, (1985) further reported that pirimiphos-methyl and phostoxin are effective against cowpea storgage pests. Ajayi, et al., (1987) tried pirimiphos-methyl on storage pests and observed that it gave 100% mortality of Rhizopertha dominica, Tribolium castaneum and Trogoderma granarium on millet and maize. Taylor, (1971) reported that pirimiphos-methyl and phostoxin are effective against cowpea and sorghum storage pests respectively. Mohammed et al, (1988) reported that pirimiphos-methyl is more effective than the synthetic pyrethroid sumicidin. The following organophosphate insecticides: pirimiphos-methyl, chlorpyriphos methyl and fenitrothion are highly effective against bruchids in storage (Rees and Dales, 1993). Singh et al.; (1990) reported that malathion, permethrin as dust application in storage structures are effective against C. maculatus. Fumigation with phostoxin is effective against the eggs in air tight containers and currently storage of dry food commodities employs the flow through fumigants such as phosphine (PHs) gas using processess as the SIRO FLO (Whitten, 1992). Other fumigation processes include spot

fumigation carried out in polythene bags or polythene sheets using ethylenedibromide, ethylene dichloride and carbontetrachloride, 5cc per 2 cwt (51kg bags). Fumigation is also used for rapid disinfestation of commodities in store as an emergence measures. Control with contact insecticides like malathion at 1% dust at a dosage of 8 ppm is very effective against coleoptera. Allotey, (1991) reported that Methacrifos, chloropyrites - methyl Deltamethrin, Fenvalerate, Bioresmethrin and Carbaryl are effective for storage pest management of locally produced food grains.

Other chemicals used include gamma BHC dust which is used for external treatment of sacks of cowpea at ranges from 0.25 - 12.5 ppm. This gave considerable reduction of losses by insect infestation (Parkin and Bills, 1955). Subatti and Blackith, (1956) observed that peas and cowpea are safe against insect pests in store when treated with methyl bromide at moisture content as high as 19%. Bastos, (1974) reported that cowpea seeds infested with cowpea weevil at 5 - 6, 10 - 11 and 20 - 21 days after egg laying were 100% controlled with methyl bromide treatment. He further said that comphostoxin gave same result with same age of insect. El-Rafie et al., (1974) evaluated the comparative toxicity of some insecticides and concluded that malathion was proven to be the most toxic insecticide with increasing efficiency on cowpea weevil with LC50 in the following values 0.45, 0.64 and 6.5 ppm. Other trials with organophosphate insecticides by Allotey, (1991) showed that chlorphysifo methyl gave excellent and good knock down of C. maculatus and other pests of stored products while phostoxin caused knock down of all species tested including C. maculatus. At higher dosages of bromophos, C. maculatus and other species were killed. Allotey, (1991) reported that

C. maculatus was controlled when fumigated with aluminium phosphide tablets. Trials with chemicals and local products for insect pests control conducted by Chipeta and Roberts, (1974) showed that only malation controlled the pests and produced palatable seeds. In evaluation trials of some secondary plant compounds, 2, 5 - dihydroxy methyl - 3 - diphdrozcypyrro lidine (DMDA) and analogue of B - fractofuranose were found to be lethal to the larvae of cowpea pests (Evans et al., 1985). He further reported that at higher levels greater than 0.03%, DMDA was lethal to larvae of C. maculatus in artificial diet. Abdel-a'al et al., (1983) tried the efficacy of althosid diet on egg viability of C. maculatus and reported that treating the eggs with altosid significantly reduced adult emergence and were more effective on newly laid eggs with higher concentrations. The chemicals were persistent for two weeks of treatment at concentrations of 800 - 1600 ppm. Therefore declines in protection activity as observed. Uvah, (1991) reported that treatment of cowpea weevil with methylbromide and aluminium phosphide gave good control of C. maculatus.

With pesticides being considered as a major input and playing a key role in pest management in agricultural production, despite their detrimental effect, it has become imperative that improvement methods are necessary to reduce their hazards. To overcome and meet this demand a specially formulated detergent called ACRI - N was developed to wash out pesticide residues on agro-products. This chemical is a water soluble liquid consisting of edible surfactants, salts of organic acid and preservatives. It was tried with fenitrothion EC sprayed on strawberries and washing with 0.5% solution of ACRI - N and rinsing twice with tap water gave 97% removal of the surface residue, (Anon, 1992).

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1 COWPEA FOR CULTURE

Kanannado white cultivar obtained from the market was used after thorough cleaning and fumigating to eliminate any existing infestation. This was used to breed Callosobruchus maculatus in a 1000ml Raven Head Kilner jar. Two cultures were maintained under laboratory conditions. The moisture content of the cowpea was determined prior to the start of the experiment using the oven dry method (Pixton, 1967).

## 3.2 MOISTURE CONTENT DETERMINATION OF COWPEA

*Some cowpea grain was ground using a mechanical blender. Out of the cowpea* powder, 5g was weighed into an aluminium dish and this was repeated three times. Initial weight of each dish plus the sample was recorded then placed in an oven set at 100°C. This was allowed to stand for four hours after which the oven was switched off and allowed to cool for thirty minutes. The oven - dried samples and dishes were then weighed again and recorded. This was substracted from the initial weight to give weight of water loss. Percentage moisture content was calculated as follows:

$$\% \text{ Moisture content} = \frac{\text{Initial sample weight - final}}{\text{Initial sample weight.}} \times 100$$

## 3.3 COWPEA FOR EXPERIMENT

Fifteen kilogrames of cowpea variety, Kanannado white cultivar, was used in this experiment. This is a moderately resistant cultivar common in Bauchi, Gombe, Zaria and parts of Borno State. The pod structure is curled like a ram's horn and makes a

1.5mm circle. The seeds are large and white in colour with brown eye colour. It is a late maaturing cultivar with a postrate growth habit (Singh and Jackai, 1985). The cowpea were thoroughly cleaned by removing all damaged and holed seeds as well as dirts. This was put into a polythene bag and fumigated with phostoxin tablet kept in a Gallenkamp Cool incubator set at 10°C for two weeks. The essence of this was to check existing infestation in the sample. This treatment made the seeds ready for the start of the experiment.

### 3.4 PREPARATION OF LEMON GRASS AND BLACK SESAME PRODUCTS

The leaves and stems of lemon grass were cut from fresh growing stock behind the Department of Crop Protection building Samaru, Zaria and sun dried for two weeks. This was then ground using motar and pistle. The same procedure was followed to obtain the powder of leaves and twigs of black sesame, obtained from Fadama area in Samaru, Zaria. These powders from lemon grass and black sesame were store in an incubator at 30°C.

Extracts from Lemon grass and black sesame powders were obtained by hot extraction using steam distillation apparatus (Uphof, 1968). Extraction was carried out using distilled water. Twenty grams of each sample was dissolved in 100ml of distilled water extracted for sixh hours. This treatment allowed all water soluble components to be extracted.

#### 3.2.1 INSECT CULTURES FOR THE EXPERIMENT

Culture of adult C. maculatus was maintained in a large stock of infested cowpea contained in a 11 Raven head Kilner jar under open laboratory conditions. Before setting

up the experiment adult insects from this culture were used to raise fresh cultures. Insects from this subculture were used for the experiment. Insects were sieved daily for start of the experiment.

### 3.2.2 SETTING UP OF EXPERIMENT

The experiment was set in the Entomology Storage Laboratory of the Department of Crop Protection. One hundred grammes of cowpea seeds were weighed into all the jars. Thirty clean sterile Kilner jars were used for lemon grass products (leaves and stem), black sesame products (leaves and twigs) treatments as well as the control. All measurements were carried out using a Mettler Balance PE200. These jars were appropriately labelled so as not to create a mix-up about their contained materials. 5g, 10g, 15g and 20g of lemon grass or black sesame powder were weighed into their respective jars which were replicated six times. Each jar was shaken vigorously to have a uniform admixture of each treatment. These were allowed to settle for five minutes. Five pairs of freshy emerged adult C. maculatus were introduced gently into the kilner jars without injuring insects.

The same procedure was employed to set up the experiment with the extracts from lemon grass and black sesame. The levels used were 1.0ml, 1.5ml, 2.0ml, 2.5ml. However, after the admixture the contents were emptied and allowed to dry for five minutes before returning it into its jar. This was to allow the seeds to dry in order to check wetness and prevent mould growth. Five pairs of freshly emerged adult insects were introduced and the jars arranged in a completely randomized design on laboratory bench.

The laboratory condition was assessed using a Cole - Parmer Hygrothermograph for temperature and relative humidity for the period of the experiment.

### 3.2.3 PARAMETERS EXAMINED

**1. Adult Mortality Rate**

The death of the insects was assessed by emptying the content of each jar after the day of introduction on a daily basis. This was then sieved with a large laboratory test sieve of mesh size of 40mm; record of life and dead insects were taken. This was done very carefully, taking care not to lose the material and that no insect escaped. This was repeated daily until all the insects in the experiment died. The jars and their contents were returned to their respective positions on the bench.

**2. Oviposition Rate**

After ten days of oviposition, thirty seeds were randomly selected from each jar and observed under a hand lens for counts of the eggs laid.

**3. Emergence of $F_1$ Generation**

At four weeks post-treatment, the contents of each jar was sieved for counts of progeny development (F1). All insects, life and dead were counted and records taken.

**4. Emergence of F2 Generation**

At eight weeks post-treatment, the contents of each jar were sieved for counts of F2 progeny development. All insects, life and dead were counted and records taken.

**5. Damage Assessment**

For damage assessment, all damaged seeds were selected from each jar and emergence holes on them were counted.

6. **Viability Test**

The viability test was carried out based on thirty seeds randomly selected from each jar and plated in a petri-dish which was watered daily and germinated seeds counted after four days and records taken.

7. **Palatability Test**

For palatability test, 100g of seeds were weighed from each of the lemon grass and black sesame treatment, respectively, and the control. These seeds were washed thoroughly and cooked. Then served on three different plates for tasting.

8. **Colour and Texture**

At the end of the experiment, the seeds were observed carefully to check for any change in colour or texture due to treatment materials. The observations were recorded.

### 3.2.4 ANALYSIS OF DATA

One-way and combine analysis of variance were used to analyse the data obtained.

## CHAPTER FOUR

## RESULTS

The relative efficacies of lemon grass and black sesame powders as surface protectants of cowpea seeds against Callosobruchus maculatus was conducted during the dry cold season from December to February, 1993. The laboratory temperature and relative humidity were 15.5°C - 17.0°C and 47% - 51% respectively.

The lemon grass powder caused significant effect on adult mortality of C. maculatus (Table 1). Most insects in the treatments died within five days of introduction. Lemon grass dosage of 5.0g, 10.0g and 20.0g gave higher significant death means than 15.0g and control. Adult mortality were 93%, 98% and 98% respectively (Table 1).

The powder significantly reduced oviposition by C. maculatus. Statistically 15.0g and 20.0g gave low figures of 4.8 and 5.0 eggs laid which were better than control, 5.0g and 10.0g. Lemon grass powder caused significant reduction in emergence of F1. Apart from control with the highest mean 6.7 (Table 1). The result from emergence of F2 generation at eight weeks of post-treatment showed significant difference among all treatments. 15.0g dose gave few adult emerged of 6.0 (Table 1). Lemon grass protected the cowpea from damage as treatment of 10.0g, 15.0g and 20.0g showed significant effect when compared with control and 5.0g. The least mean number of damage seeds of 7.0 was recorded in 15.0g dose (Table 1). Germination of the seed was significantly affected and 10.0g gave the least mean number 27.7 seeds (Table 1).

Black sesame powder had significant effect on adult mortality of C. maculatus insects in most treatment died within five to six days of the treatment. At 15.0g and 20.0g dosage adult mortality was significantly higher than control. Adult mortality was 95% (Table 2). Oviposition was not significantly reduced by the powder. The black

sesame powder also significantly reduced emergence of F1 adult insects. Treated cowpea seed did not differ significantly from one another in retarding emergence of F1, (Table 2). Statistical analysis showed significant effect on emergence of F2 generation with the highest emergence in control. Treatment at 20.0g gave the least mean number of adult insect emerged. The cowpea seeds were significantly protected from damage by the black sesame powder. Concentration levels of 20.0g gave the least number of damage seeds of 5.5. Seed germination was not significantly affected by the powder.

Aqueous extracts of lemon grass and black sesame were tried for their insecticidal activities on Callosobruchus maculatus on stored cowpea during the warm season temperature 18°C - 21°C and relative humidity 65% - 70% respectively. The aqueous extract of lemon grass caused significant effect on adult mortality. Most insects died within five days of treatment. The aqueous extract of lemon grass at 2.0ml and 2.5ml gave 100% adult mortality which were significantly higher than control, (Table 3). Oviposition was significantly reduced. This treatment caused delay in adult emergence of F1. Concentration level of 2.0ml gave the least mean number of 3.0 adult insect. However, emergence of F2 was not significantly reduced (Table 3). The aqueous extract of lemon grass did not protect the cowpea seed from damage. Seed germination was significantly reduced by the aqueous extract of lemon grass (table 3).

The aqueous extract of black sesame had significant effect on adult mortality of C. maculatus. Concentrations of 2.0ml and 2.5ml per 100g of cowpea gave 100% mortality (Table 4). Oviposition was not significantly affected. However, there was a significant reduction in F1 generation (Table 4). Emergence of F2 generation and damage were not significantly reduced by the treatment (Table 4). Seed germination was unaffected by aqueous extract of black sesame.

473385

## RESULT

Table 1:EFFECT OF LEMON GRASS POWDER ON C. MACULATUS FAB

| VARIABLE | LEMON GRASS POWDER TREATMENT | | | | | LEVEL OF SIGNIFICANT LSD (P=0.05) |
|---|---|---|---|---|---|---|
| | 0.0g/100 | 5.0g/100 | 10.0g/100 | 15.0g/100 | 20.0g/100 | |
| Adult Mortality | 5.6 | 9.3 | 9.8 | 8.0 | 9.8 | 1.41*** |
| % Mortality | 56 | 93 | 98 | 80 | 98 | - |
| Oviposition | 11.0 | 9.2 | 6.3 | 4.8 | 5.0 | 3.91* |
| F1 Generation | 6.7 | 1.7 | 1.2 | 1.0 | 1.2 | 1.38*** |
| F2 Generation | 31 | 18.5 | 8.5 | 6.0 | 11.0 | 3.91** |
| Damage | 37.7 | 20.2 | 9.7 | 7.0 | 12.0 | 11.79*** |
| % Damage | 1.1 | 0.6 | 0.3 | 0.2 | 0.4 | - |
| Germination | 29.8 | 28.5 | 27.7 | 28.3 | 28.5 | 1.38 |
| % Germination | 99.4 | 95.0 | 92.2 | 94.4 | 95.0 | - |

TABLE 2: EFFECT OF BLACK SESAME POWDER ON C. MACULATUS FAB

| VARIABLE | BLACK SESAME POWDER TREATMENT | | | | | LEVEL OF SIGNIFICANT LSD (P=0.05) |
|---|---|---|---|---|---|---|
| | 0.0g/100 | 5.0g/100 | 10.0g/100 | 15.0g/100 | 20.0g/100 | |
| Adult Mortality | 5.5 | 9.3 | 9.3 | 9.5 | 9.5 | 1.16*** |
| % Mortality | 55 | 93 | 93 | 95 | 95 | - |
| Oviposition | 12.0 | 8.3 | 9.8 | 7.5 | 5.7 | $4.82^{ns}$ |
| F1 Generation | 8.0 | 1.0 | 1.3 | 1.2 | 1.3 | 1.16*** |
| F2 Generation | 33 | 7.8 | 9.7 | 7.0 | 4.20 | 7.83*** |
| Damage | 41.0 | 8.8 | 11.0 | 8.2 | 5.5 | 8.419*** |
| % Damage | 1.2 | 0.3 | 0.3 | 0.2 | 0.2 | - |
| Germination | 29.8 | 29.3 | 28.3 | 29.5 | 29.2 | 1.17 |
| % Germination | 99.4 | 97.8 | 94.4 | 98.3 | 97.2 | - |

TABLE 3: EFFECT OF AQUEOUS EXTRACT OF LEMON GRASS ON C. MACULATUS FAB

| VARIABLE | AQUEOUS EXTRACT OF LEMON GRASS TREATMENTS | | | | | LEVEL OF SIGNIFICANT LSD (P=0.05) |
|---|---|---|---|---|---|---|
| | 0.0g/100 | 5.0g/100 | 10.0g/100 | 15.0g/100 | 20.0g/100 | |
| Adult Mortality | 7.2 | 9.2 | 9.8 | 10.0 | 10.0 | 1.14*** |
| % Mortality | 72 | 92 | 98 | 100 | 100 | - |
| Oviposition | 15.8 | 13.2 | 12.0 | 7.0 | 11.7 | 5.61* |
| F1 Generation | 10.0 | 4.7 | 7.3 | 3.0 | 5.7 | 4.46* |
| F2 Generation | 40.5 | 19.0 | 36.8 | 10.8 | 26.2 | $29.26^{ns}$ |
| Damage | 50.8 | 23.7 | 44.2 | 13.8 | 31.8 | $33.31^{ns}$ |
| % Damage | 1.5 | 0.7 | 1.3 | 0.4 | 0.9 | - |
| Germination | 29.5 | 27.7 | 26.3 | 26.7 | 28.5 | 2.35* |
| % Germination | 98.3 | 92.2 | 87.7 | 88.9 | 95.0 | - |

TABLE 4: EFFECT OF AQUEOUS EXTRACT ON BLACK SESAME ON C. MACULATUS FAB

| VARIABLE | AQUEOUS EXTRACT OF BLACK SESAME TREATMENTS | | | | | LEVEL OF SIGNIFICANT LSD (P=0.05) |
|---|---|---|---|---|---|---|
| | 0.0g/100 | 5.0g/100 | 10.0g/100 | 15.0g/100 | 20.0g/100 | |
| Adult Mortality | 6.3 | 7.8 | 9.8 | 10.0 | 10.0 | 0.96*** |
| % Mortality | 63 | 78 | 98 | 100 | 100 | - |
| Oviposition | 16.8 | 16.2 | 13.2 | 14.3 | 11.2 | $6.18^{ns}$ |
| F1 Generation | 10.5 | 4.7 | 3.8 | 6.0 | 5.0 | 3.96* |
| F2 Generation | 42.0 | 29.8 | 12.3 | 49.3 | 28.3 | $35.17^{ns}$ |
| Damage | 52.5 | 34.5 | 16.2 | 55.3 | 33.2 | $38.05^{ns}$ |
| % Damage | 1.5 | 1.0 | 0.5 | 1.6 | 1.0 | - |
| Germination | 29.5 | 28.0 | 27.8 | 28.3 | 27.8 | $3.14^{ns}$ |
| % Germination | 98.3 | 93.3 | 92.8 | 94.4 | 92.8 | - |

## CHAPTER FIVE

### ANALYTICAL COMPARISON BETWEEN THE TWO PLANT MATERIALS

When the means were compared, means from lemon grass treatments of 10.0g and 20.0g gave higher siginificant difference than controls and 15.0g of black sesame. Other treatment did not differ significantly from one another. Lemon grass gave a better kill of the adult insects, (Table 5). Oviposition was retarded significantly by lemon grass dosage of 15.0g which gave the least mean number of eggs laid. Lemon grass performed better in reducing the number of eggs laid by the insects (Table 5). The two plant materials had highly significant effect in retarding the emergence of F1 compared to the control. While lemon grass at 20.0g gave one emergence black sesame gave same one emergence but at a low concentration of 5.0g.

Black sesame gave the least mean of F2 generation emerged of 4.2 while lemon grass at the same level gave a higher value. This was highly significant when compared to controls. Concentration of 20.0g significantly retarded adult emerged which is not significantly different compared to 20.0g treatment of lemon grass. Black sesame significantly protected the cowpea seed when compared to control but non significant to other treatments of lemon grass, (Table 5). Lemon grass reduced germination as compared to black sesame which was significant compared to control.

The aqueous extracts were also compared for significance. Both plant materials gave significant effect on adult mortality when the means were compared statistically concentrations of 2.0ml and 2.5ml of both materials showed significant effect on adult mortality when compared with controls. Oviposition was not significant when compared statistically, (Table 6). Two plant materials had significant effect on emergence of F1. However, lemon grass treatment at 2.0ml

gave the least mean number of 3.0. All other means are statistically non significant (Table 6). Emergence of F2 generation, Damage and Germination were not significantly reduced by treatment of both plant materials, (Table 6).

TABLE 5: Result on Comparison of Lemon grass and Black sesame Powders on C. maculatus

| VARIABLES | DOSAGE OF PLANT MATERIALS PER 100g COWPEA | | | | | LEVEL OF SIGNIFICANT LSD (P=0.05) |
|---|---|---|---|---|---|---|
| | 0.0g/100 | 5.0g/100 | 10.0g/100 | 15.0g/100 | 20.0g/100 | |
| Adult mortality | | | | | | |
| | $PM_1$ 5.6 | 9.3 | 9.8 | 8.0 | 9.8 | |
| | $PM_2$ 5.5 | 9.3 | 9.3 | 9.5 | 9.5 | 1.42*** |
| Oviposition | | | | | | |
| | $PM_1$ 11.0 | 9.2 | 6.3 | 4.8 | 5.0 | |
| | $PM_2$ 12.0 | 8.3 | 9.8 | 7.5 | 5.7 | 4.70* |
| **F1 Generation** | | | | | | |
| | $PM_1$ 6.7 | 1.7 | 1.2 | 1.0 | 1.2 | |
| | $PM_2$ 8.0 | 1.0 | 1.3 | 1.2 | 1.3 | 1.16*** |
| **F2 Generation** | | | | | | |
| | $PM_1$ 31.0 | 18.5 | 8.5 | 6.0 | 11.0 | |
| | $PM_2$ 33.0 | 7.8 | 9.7 | 7.0 | 4.2 | 8.93*** |
| **Damage** | | | | | | |
| | $PM_1$ 37.7 | 20.2 | 9.7 | 7.0 | 12.0 | |
| | $PM_2$ 41.0 | 8.8 | 11.0 | 8.2 | 5.5 | 9.43*** |
| **Germination** | | | | | | |
| | $PM_1$ 29.8 | 28.5 | 27.7 | 28.3 | 28.5 | |
| | $PM_2$ 29.8 | 29.3 | 28.3 | 29.5 | 29.2 | 1.18*** |

TABLE 6: Result on Comparison of Aqueous Extracts of Lemon grass and Black sesame on C. maculatus

| VARIABLES | DOSAGE OF PLANT MATERIALS PER 100g COWPEA | | | | | LEVEL OF SIGNIFICANT LSD (P=0.05) |
|---|---|---|---|---|---|---|
| | 0.0ml/100g | 1.0ml/100g | 1.5ml/100g | 2.0ml/100g | 2.5ml/100g | |
| Adult mortality | | | | | | |
| | $PM_1$ 7.2 | 9.2 | 9.8 | 10.0 | 10.0 | |
| | $Pm_2$ 6.3 | 7.8 | 9.8 | 10.0 | 10.0 | 0.97*** |
| Oviposition | | | | | | |
| | $PM_1$ 15.8 | 13.2 | 12.0 | 7.0 | 11.7 | |
| | $PM_2$ 16.8 | 16.2 | 13.2 | 14.3 | 11.2 | $6.01^{ns}$ |
| F1 Generation | | | | | | |
| | $PM_1$ 10.0 | 4.7 | 7.3 | 3.0 | 5.7 | |
| | $PM_2$ 10.5 | 4.7 | 3.8 | 6.0 | 5.0 | 3.92** |
| F2 Generation | | | | | | |
| | $PM_1$ 40.5 | 19.0 | 36.8 | 10.8 | 26.2 | |
| | $PM_2$ 42.0 | 29.8 | 12.3 | 49.3 | 28.3 | $30.62^{ns}$ |
| Damage | | | | | | |
| | $PM_1$ 50.8 | 23.7 | 44.2 | 13.8 | 31.8 | |
| | $PM_2$ 52.5 | 34.5 | 16.2 | 55.3 | 33.2 | $33.83^{ns}$ |
| Germination | | | | | | |
| | $PM_1$ 29.5 | 27.7 | 26.3 | 26.7 | 28.5 | |
| | $PM_2$ 29.5 | 28.0 | 27.8 | 28.3 | 27.8 | $2.37^{ns}$ |

# CHAPTER SIX

# DISCUSSION

## 6.1 INSECTICIDAL EFFECT OF LEMON GRASS AND BLACK SESAME ON ADULT INSECT OF C. MACULATUS

The powder of lemon grass or black sesame had significant effect on adult mortality. Most insects in treated cowpea died within five days apart from those in control. Increased concentration of either plant material caused higher death in adult insects. However, adult mortality in 15.0g lemon grass was low, as insects took more days to die. The reason for this insect activity is not clear. Application rates of 20.0g of the two plant materials gave highest death of adult insects. Adult mortality were 98% and 95% respectively. When the two plant materials were compared statistically they performed significantly in killing adult insects. With the highest mean of 9.8 from lemon grass (Table 5). Dike and Mbah (1992) reported similar result of high death with lemon grass powder. The findings in this experiment were similar to those of Lambert et al., 1985; Ajayi et al.; 1987 and Stoll, 1988.

## 6.2 INSECTICIDAL EFFECT OF LEMON GRASS AND BLACK SESAME ON OVIPOSITION C. MACULATUS

Lemon grass caused significant effect on oviposition. Low mean number of eggs 4.8 were laid on cowpea treated with 15.0g. Even though insects in this dose did not die within short time, they were unable to lay more eggs. The reasons for this is not known. The decrease in oviposition was due probably to the fumigating and repelling property of lemon grass which resulted in interference with the insect physiological activity and consequently did not allow them full potential of oviposition. Black sesame powder did

not significantly reduced oviposition. Naturally some Hyptis depending on their growth environment performed better than others (Lamber et al., 1985; Baldwin et al., 1992). Statistical comparison between the two plant materials showed significant different, with lemon grass being more effective in reducing the number of eggs laid by C. maculatus.

## 6.3 INSECTICIDAL EFFECT OF LEMON GRASS AND BLACK SESAME ON EMERGENCE OF F1 AND F2 GENERATIONS OF C. MACULATUS

The powder of lemon grass or black sesame caused highly significant effect on emergence of C. maculatus. Low mean number of 1.0 was recorded with 15.0g dose while the same value was recorded with 5.0g dose of black sesame. Apart from the insecticidal effect, the powder of black sesame was oily in nature which probably contributed to the killing of larvae. When the two plant material were compared statistically there was significant effect in reducing F1 generation as compared to control. They performed equaly good in delaying adult emerged. Similarly, F2 generation was highly reduced by either of the powder. Either of the powder prolonged the development period increased larval mortality and decreased number of adult emerged. Reports in Burkina Faso and Upper Volta by Lamber et al., 1985; Stoll, 1988 and Watt and Brayer, 1962; Tiwari et al., 1966 respectively confirmed the insecticidal activity of these either of the powders. Statistical comparison of the two plant materials showed highly significant effect on emergence of F2 generation with black sesame powder being more effective in reducing the number of adult emerged.

## 6.4 INSECTICIDAL EFFECT OF LEMON GRASS AND BLACK SESAME ON DAMAGE OF COWPEA SEEDS AT EIGHT WEEKS POST TREATMENT

Either of the powder highly significantly protected cowpea seed from damage. Apart from control damage percentage was less than one, over a period of two months. When the two plant materials were compared, damage was highly significant with the least mean number of 5.5 from 20.0g dose of black sesame powder. The black sesame powder is superior in protecting the cowpea from damage.

## 6.5 INSECTICIDAL EFFECT OF LEMON GRASS AND BLACK SESAME ON VIABILITY OF SEEDS

Seed viability was significantly reduced with lemon grass treatment. However, it was not affected by black sesame powder. When they were compared statistically viability was significantly reduced with lemon grass being inferior in reducing seed viability.

### 6.2.1 EFFECT OF AQUEOUS EXTRACTS OF LEMON GRASS AND BLACK SESAME ON C. MACULATUS

Botannical insecticides are used in a variety of ways as crude formulation or semi or purified extracts that contain active compounds such as antifeedant, ovicides, repellent or growth disrupters Simomonds et al., (1992). Usually, the formulation process requires high technologies which are beyond the reach of the ordinary farmers. In the light of this simple method which involves local processing such as boiling was used in this experiment.

### 6.2.2. EFFECT OF AQUEOUS EXTRACTS OF LEMON GRASS AND BLACK SESAME ON ADULT MORTALITY OF C. MACULATUS

The aqueous extract of lemon grass or black sesame caused highly significant effect on adult mortality of adult insects. 2.0ml and 2.5ml of either plant material gave 100% adult mortality. Similar report by Asari and Thomas 1976, Tiwari et al.,

1966 and Sharaby 1986 while working with the purified oil. Dalziel, (1948) and Stoll, (1988) reported black sesame to be of high insecticidal effect on insects. Statistically when the two plant materials were compared they gave highly siginicant effect on adult mortality. They equally performed good in killing the adult insects.

### 6.2.3 EFFECT OF AQUEOUS EXTRACT OF LEMON GRASS AND BLACK SESAME ON OVIPOSITION OF C. MACULATUS

The extract of lemon grass significantly reduced the number of eggs that were laid by adult insects. Dosage of 2.0ml gave the least mean number of 7.0. Sharaby in 1986 reported that 2% lemon grass oil inhibited oviposition in Spodoptera exigna. Aqueous extract of black sesame had no significant effect on the number of eggs laid. When the means of the two plant materials were statistically compared there was no significant difference.

### 6.2.4 EFFECT OF AQUEOUS EXTRACT OF LEMON GRASS AND BLACK SESAME ON EMERGENCE OF F1 AND F2 GENERATIONS OF C. MACULATUS

The aqueous extract of either plant material significantly reduced emergence of F1 generation. Lemon grass at 2.0ml gave only 3.0 while black sesame gave at 1.5ml, gave 3.8 mean adult emerged. The aqueous extracts had insecticidal activity on the eggs therefore leading to low emergence. When they were statistically compared the treatment showed significant effect with lemon grass being superior in reducing the number of adult that emerged. The extracts did not showed any significant effect in reducing the number of F2 generations. Even when compared they show non significant effect.

### 6.2.5 EFFECT OF AQUEOUS EXTRACTS OF LEMON GRASS AND BLACK SESAME ON DAMAGE OF COWPEA SEEDS AT EIGHT WEEKS POST TREATMENT

Damage was not significantly reduced by the plant materials. Even when compared the result show non-significant difference. Treatment with the aqueous extract did not protected the cowpea from damage. Damage figures were very high and variable among the various concentrations.

### 6.2.6 EFFECT OF AQUEOUS EXTRACTS OF LEMON GRASS AND BLACK *SESAME ON VIABILITY OF THE SEEDS*

Lemon grass extract significantly reduced germination of the seeds. While black sesame had no effect on germination. When compared statistically the plant materials showed non significant effect on germination.

### 6.3.1 ON PHYSICAL CHARACTERISTICS OF THE GRAINS

Treatment with the powders had no side effect on palatability and physical attractiveness of the seeds remained unchanged. However, the aqueous extracts though had no bad taste on the grains did changed the colour from white to dirty-white.

## CHAPTER SEVEN

## SUMMARY AND RECOMMENDATION

Considerable damage and loss encountered in stored grains due to insect pest infestation necessitates a study of insecticidal materials both in natural plants and minerals. The problems associated with use and over use of chemical insecticides such as contamination of environment; increased resistance to insecticides; toxic residual effects on man and livestock; hazard in handling; broad insecticidal effect on non-target and occasional scarcity to rural populace demands a substitute from indigenous plants which are less hazardous; with high insecticidal property and easy to handle. Locally available plant materials used as grain protectants by traditional farmers need to be improved upon in order to provide simple storage insecticides with less hazard and lower cost of application.

The essence of the present study is to investigate the optimum level and the most effective forms (powders or aqueous extracts) of the plant materials that can be used for control of C. maculatus. Therefore the relative efficacies of lemon grass and black sesame as surface protectant of stored cowpea were evaluated. Powders of lemon grass (leaves and stem) and black sesame (twigs and leaves) at four levels 5.0g, 10.0g, 15.0g and 20.0g were used. The aqueous extracts were obtained by continuous hot extraction using steam distillation apparatus, the soxlet fat extractor system.

The powders of lemon grass and black sesame had significant effect on adult mortality. Insects died within four to five days of introduction. The effect of the treatment shortened the longevity of the adult insects by seven days. Lemon grass

powder gave 98% adult mortality each at 10.0g and 20.0g per 100g seed respectively. Hyptis powder at 20.0g per 100g seed gave 95% adult mortality. Oviposition was significantly reduced by all treatments used. The powders constituted a physical barrier coupled with their insecticidal effect on the insect which resulted in low number of eggs laid. Oviposition decreased with increase in concentration. Few eggs were recorded on cowpea treated with 10.0g, 15.0g and 20.0g per 100g seeds of both powders. The developmental period of insects were prolonged and there was one adult emergence of $F_1$ generation at four weeks. At eight weeks fewer numbers of $F_2$ generation emerged in the following concentrations; 10.0g, 15.0g and 20.0g per 100g seeds respectively. The powders were effective as ovicides, larvicides and insecticides, resulting in significant reduction in adult emergence.

The damage was significantly reduced by all treatment apart from the control. Damage ranged from 1.1 - 0.2%. Viability of the seeds were affected by treatments as germination percentage was 92.2% - 99.4%. However, black sesame treatment had no effect on germination of the seeds.

The aqueous extracts of both plants gave significant effect mortality. The aqueous extract had significant effect on oviposition, emergence of $F_1$ adult insects, however, $F_2$ and damage were not significantly reduced. The aqueous extracts did not impart any taste on the grains unlike the neem which had bitter taste on grains after treatment. With the aqueous extracts, even though there was no bad taste imparted on the grains the liquid affected the colour of the grains. The seed coat after treatment turned dirty-white when compared with untreated grains.

One way and combine analysis of ANOVA was used to test the significant differences in the concentration, and the relative efficacies of the materials used. The result of the analysis revealed the following: All concentrations used as powders: 5.0g; 10.0g; 15.0g; 20.0g and as aqueous extracts: 1.0ml; 1.5ml; 2.0ml and 2.5ml were significant in knocking down adult insects on 100g of cowpea. Powders of lemon grass, and black sesame competed equally in killing adult insects, reducing oviposition, adult emergence and cowpea damage. Statistical analysis showed non significant difference between the treatments in controlling C. maculatus. Concentrations at 10.0g, 15.0g and 20.0g per 100g seed gave better results for the parameters investigated in this experiment. The extracts were only good at knocking down adult insects but ineffective at reducing other insect activity leading to high damage. Based on this finding the aqueous extracts of both plant materials are not recommended for cowpea protection.

From this research finding, 10 - 20g powders of lemon grass and black sesame per 100 cowpea are highly recommended for controlling C. maculatus. At the farmer's level 10 - 20kg of the powders are recommended for 100kg bag. All other parameters like oviposition, emergence of $F_1$ and $F_2$ progeny, reduction of damage were statistically significant. Where these plant materials are available, it is highly recommended that farmers use them instead of chemical insecticides which has side effects on man and his environment. However, five percent of the active ingredient is recommended. Therefore, I suggest that low levels of the concentrations given in this project should be tried.

## REFERENCES


Abdel-a'al, Y.A.I. and Hussein, M.H. (1983): Adult emergence and survival of the cowpea seed beetle, Callosobruchs maculatus (Fab) exposed as eggs to the harmoid altosid. Cowpea Abstract of World Lit. Vol. V 19983 - 1985, P. 117.

Abubakar, S. Ishaku, (1987): Effect of Spartial Pattern on Abundance of Insect Pest in a cereal - cowpea Mixture M.Sc. Thesis Ahmadu Bello University, Zaria. 27pp.

Adjadi, O., Singh, B.B. and Singh, S.R. (1985): Inheritance of Bruchid Resistance in Cowpea. Crop Science 25: (5) 740 - 742.

Ajayi, O., Arokoyo, J.T., Nezan, J.T.; Olayinka O.: NdirmbulaB.M and Kannike O.A. (1987). Laboratory assessment the efficacy of some Local Plant materials for the control of stored insect pests. Samaru Journal Agricultural Research 5:81 - 85.

Akibu, S.; Nezan, J.T.; Ajayi, O. and Arokoyo, J.O. (1984): A preliminary study of the use of locally plant derived materials in the control of storage pests. AERLS Newsletter 10(1): 11 - 24.

Allotey, J. (1991):Storage Insect Pests of Cereals in small scale farming community and their control. Insect Sci. Appli. 12 (5/6): 679 - 693.

Anonymous, (1970): World food programme Food storage mannual Rome. 45pp.

Anonymous, (1975): Asian Vegetable Research & Development Centre. Mungbean Report. Shanhua, Taiwan Rep. China p 45.

Anonymous, (1992): Neem: A tree for solving Global Problems National Academy Press, Washington DC. 141pp.

Anonymous (1992): Annual Research Report for 1992 Rural DevelopmentAdministration, Republic of Korea, p.177 - 193.

Ansari, A.K.; Van Emden, H.F. and Singh, S. R. (1992): Varietal resistance of cowpea to cowpea aphid Aphis craccivora koch. Insect Sci. Applic. 13(2): 129 - 203.

Arctanders, S. (1960): Perfume and Falvour Materials of Natural Origin Elizabeth New Jersey USA pp. 352 - 364.

Asari, P.A.R. and Thomas, M.I. (1976): On the use of the lemon grass leaf infusion for control of brinj-al aphid. Journal of Agricultural Research 12:77 - 81.

Babu, T.R.; Reddy, V.S.; Hussaini,S.H. (1989): Effect of edible land nonedible oils on the development of the pulse beetle, Callosobruchus chinensis and on viability and yield of mungbean, Vigna radiata (L) Wilczek. Tropical science 29 (3): 215 - 220.

Baldmyn Torto, Ivan, Addae - Mensah and Lambert Moreka, (1992): Antifeedant Activity of Piper guineense Schum & Stem borer, Chilo partellus (Swinhoe). Insect Sci. Applic. 13(5): 705 - 708.

Bastos, J.A.M., (1974): Control of the cowpea weevil, Callosobruchus maculatus F. with methylbromide - Turniolba, 241(2): 230 - 232.

Booker, R.H. (1967): *Observations on three bruchids associated with cowpea in Northern* Nigeria. J. Store Prod. Res. 3(1): 1 - 15.

Boughidad, Gillon, Y. and Gagnepain, C. (1987): Effect of Archis hypogaea seed fats on the larval Development of Callosobruchus maculatus F. Coleoptera: Bruchidae. J. Stored Prod. Res. 23(2): 99 - 103.

Bressani, R. and Elias, L.G., (1980): Nutritional value of legume crops for human and Animals Advances in legume Science Kew, Royal Botanic Gardens. pp 135 - 155.

Carson, R. (1963): Silent Spring Hamish Hamilton London 243pp

Caswell, G.H. (1981): Damage of stored cowpea in the Northern part of Nigeria. Samaru J. Agric Res. 1(1): 11 - 19.

Caswell, G.H. (1960): Observations on abnormal forms of Callosobruchus maculatus. Bull of Entomol Res. Vol. 50 part 4pp. 671 - 699

Caswell G.H. and Akibu, S. (1980): The use of Pirimiphos ethyl to control Bruchids attacking selected varieties of stored cowpea. Tropical Grain Legume Bulletin p.9.

Chipeta, F.M. and Roberts, M.J. (1974): A preliminary evaluation of storage method for cowpea. Cowpeas (Vigna unginculata L. Walp) Abstracts of World Literature Vol. III, 1974 - 1980 p. 304.

Compton, J.A.F., Tyler P.S., Hindmarsh, P.S., Golob, P. Boxall, R.A. and Haines, C.P. (1993): Reducing losses in small farm grain storage in the tropics. Tropical Science 33(3): 283 - 318

Credland, P.E. (1992): The structure of bruchid eggs may explain the ovicidal effect of oils. J. Stored Prod. Res. 28:1 - 9.

Credland, P.E. (1987): Effect of host change on the fecundity and Development of an usual strain of Callosobruchus maculatus (Coleoptera: Bruchidae). J. Stored Prod. Res. 23: 91 - 98.

Cremlyn, R. J. (1978): Pesticides: Preparation and mode of action Presticides in the Environment. John Wiley, 240 pp.

Dalziel, J.M. (1948): Useful plants of West Africa London Crown Agents P. 460 - 461.

Dike, M.C, and Mbah, O.I. (1992): Evaluation of the lemon grass (Cymbopogon citratus Stapf) products in the control of Callosobruchus maculatus F. (Coleoptera: Bruchidae) on stored cowpea. Niger. J. Pl. Prot. 14: 88 - 19.

Don - Pedro, K.N. (1989): Mode of action of fixed oils againsts eggs of Callosobruchus maculatus (F). Pesticide Science 26(2): 107 - 115.

Duke, J.A. (1990): Introduction to food legumes insect pests of food legumes Edited by S.R. Singh 1990. John Wiley & Sons Ltd P.1- 10

Ebeling, W. (1971): Soptive dust for pest control. Ann. Rev. Entomol. 16: 123 - 158

Ebong, U.U. (1968): Cowpea production in Nigeria Nigerian J. Science 2(2): 67 - 72

Echendu, T.N.C. (1991): Ginger, cashew and neem as surface protectants of cowpeas against infestation and damage by Callosobruchus maculatus (Fab), Tropical Science 31(2): 209.

El-Rafie, M.S.; Sclim, M.S. and Sobeiha, A.M. (1974): Evaluation of the comparative toxicity of Bio allerthrin, Malathion and sevin on the Southern Cowpea weevil (Coleoptera: Bruchidae) Bull. Ent. Soc. Egypt Econ. Scr., VIII: 187.

Evans, S.V. (1939): Solving the union's pasture crop and insect problem. Farming S. Africa Report. No. 117

Evans, S.V.; Gatehouse M.R.; and Fellows L.E. (1985): Deterimental effects of 2,5 - dihydroxy methyl 3,4 - dihydroxy pyrolidine in some tropical legume seeds on larvae of the Bruchid Callosobruchus maculatus. Entomologia Experimentalis et Applicata 37(3): 257 - 261.

Ezedinma, F.O.C. (1960): Research on cowpea (Vigna Spp.) in Nigeria before 1960. Memorandum No. 68.

Feeroza, Khalique Khalique; Ahmed, Muhammed Afzalt; Bashir, Ahmed Malik and Mohammed, Raiz Malik (1988): Protection of stored chickpea Cicer arietinum L. from attack of Callosobruchus chinensis (Coleoptera: Bruchidae). Tropical Pest Management 34(3): 333 - 334.

Gepts, P. and Debonck, D. (1991): Origin, Domestication and evolution of the common bean, Phaseolus vulgaris L. Common Beans Research for Crop Improvement P. 8 - 10

Giga, D.P. and Smith, R.H. (1983): Comparative life history studies offourCallosobruchus Spp infesting cowpea with special reference to C. rhodesianus (Pic) (Coleoptera: Bruchidae). J. Stored Prod. Res. 19(4): 189 - 198.

Golob, J. Mmambula, Mhango, V. and Ngulde, F. (1982): The use of locally available materials as protectants or maize grain against insect infestation during storage in Malawi. Journal Stored Prod Res. 18:67 - 74.

Golob, P. and Webleg, D.J. (1980): The use of plants and minerals as traditional protectants of stored products. Bulletin of Stored Products information p. 32.

Haines, C.P. (1991): Insects and Arachinds of Tropical stored products, their biology and identification. A training mannual Natural Resources Institute. p. 32.

Hanson, N.W. (1973): Official standardised and recommended methods of analysis 3rd Edition London 897 pp.

Hill, D.S. (1975): Agricultural insect pests of the Tropics and their control Cambridge: C.U.P. 516 pp.

Hill, D. and Schoonhoven, A. V. (1981): Effectiveness of vegetable oil fractions in controlling the Mexican bean weevil on stored beans. J.Econ. Ent. 474:478 - 479.

Iloba, B.N. and Osuji, F.N.C. (1986): Outlines of stored products Entomology for the tropics. Nigeria Journal of Ent. 7: 18 - 23.

Irvine, F.R. (1969): West African Crops Oxford University Press, 72 pp.

Ivbijaro, M.F. (1990): The efficacy of seed oils of Azadirachta indica A. Juss and Piper guineense Schum and Thonn on the control of Callosobruchus maculatus F. Insect Sci. Applic. 11(2): 149 - 152.

Ivbijaro, M.F. (1983): Preservation of cowpea Vigna unguiculatu L. Walp with the neem seed Azadirachta indica A. Juss. Protection Ecology 5(2): 177 - 182.

Jackai, L.E.N. and Daoust, R.A. (1986):Insect Pests of cowpea Ann Rev. of Entomology 31: 95 - 119.

Kayitare, J. et I. Ntezurubanza, (1991): Evaluation de La toxicite et de l'effet upulsit de certaines plants du Ruwanda contre les bruches du hari-cot Acanthoscelides obectus say et zabrotes subfasciatus Bohewan. Insect Sci. Applic. 12(5/5): 679 - 693.

Kumar, A. and Okoronkwo, N.O. (1991): Effectiveness of plant oils against some Bostrychids infesting cereals in storage. Insect Sci. Applic. 12:77 - 85.

Lamber,J.D.H., Gale, J.; Arnaso, J.T. and Philogene, B.J.R. (1985): Bruchid Control with traditionally used insecticidal plants Hyptis spicigera and cassia nigrican. Insect Sci. Applic.. 6(2): 167 - 170.

Little, Van Allen, (1972): General and Applied Entomology. Harper and Raw, Publishers. New York Evanston San Francisco London. p.217 - 218.

Makanjuola, W.A. (1989): Evaluation of extracts of neem (Azadirachta indica A. Juss). Journal of Stored Product Research 25:231 - 237.

Malik, M.M. and Muytaba, S.H. (1984): Screening of some indigenous plants as repellents or antifeedants for stored grain insects. J.Stored Prod. Res. 20: 41 - 44.

Mohammed, A.K. and Al Jabery, I.R. (1988): Comparative toxicity of some insecticides in the laboratory to the southern cowpea weevil Callosobruchus maculatus (F) and the parasite Anisoptheromalus calandrae (How). Post Harvest News and Information 1(1): 70

Munro, J.W. (1966): The bean weevil pest of stored products, Hatchinson & Co. Ltd. London. p. 112 - 114.

473385
SB
608 C85

Naik, R.L., Dumbre, R.B. (1984): Effect of some vegetable oils used in protecting stored cowpea on Biology of pulse beetle, Callosobruchus maculatus (F) (Coleopthra: Bruchidae). Bulletin of Grain Technology 22(1): 25 - 32.

Nwanze, K.F.; Horber, E. and Pitts, C.W. (1975): Evidence for ovipositional preference of Callosobruchus maculatus for cowpea varieties. Environmental Entomol 4(3): 409.

Ofuya, T.I. (1987): Growth and development of Callosobruchus maculatus (F) (Coleoptera: Bruchidae) on some wild and cultivated cowpeas. Review of Applied Entomology (Series A) 76(6): 423

Olaifa, J.T. and Erhun, W.O. (1988): Laboratory evaluation of Piper guineense for the protection of cowpea against Callosobruchus maculatus. Insect Sci. Applic. 9(1): 55 - 58.

Olufade, A.O. (1985): Plants used in traditional storage. Paper presented at the 1985 AERLS Conference Hall A.B.U. Zaria 5pp.

Onolemhemhen, O.P. (1990): Control of cowpea weevil C. maculatus (Fab) (Coleoptera: Bruchidae) in stored cowpea with Rubber seed oil. Nigeria Agric J. 25:87 - 93.

Parkin, E.A and Bills, G.T. (1955): Insecticidal dust for protection of stored peas and beans against Bruchid infestation. Bull of Ent. Res. 46(3):626 - 641.

Pereira, J. (1983): The effectiveness of six vegetable oils as protectants of cowpea and bambara groundnut against infestation by Callosobruchus maculatus F. (Coleoptera: Bruchidae). J. Stored Prod. Res. 19(2): 57 - 62.

Pixton, S.W. (1967): Moisture content - its significance and measurement in stored products. J. of stored Prod. Res. 3:35 - 47.

Prevett, P.F. (1962): The reduction of bruchid infestation of cowpeas by Post-harvest storage methods. West African stored product Res. Unit Pp 1 - 5

Purseglove, J.W. (1974): Tropical crops: Dicotyledons Third Edition, Longman Ltd London 718 pp.

Raheja, A.K. (1986): *Problems and prospects of cowpea in the Nigerian Savannas* Tropical Grain Legume 32: 78 - 87.

Raheja, A.K. (1976): Assessment of losses caused by insects pests to cowpea in Northern Nigeria. Pest Article & News Summaries 22(2):229 - 233.

Raman, R.V.; Booth, R.H. and Palacios, M. (1987): Interprated pest management for tropical root and tuber crops P.95 - 107 International Institute of Tropical Agriculture. Ibadan, Nigeria.

Rees, D.P. and Dales, M.J. (1993): Alternative methods for the control of stored product insect pests. A Bibliographic Data base Chatham: Natural Resources Institute. Tropical Science 33(3): 283 - 318.

Robbins, S.R.J. (1983): Selected markets for the essential oils of lemon grass citronella and eucalytis. Tropical Products Institute 90pp.

Saxena, R.C. (1989): Insecticides from Neem. In: Insecticides of plant origin (Eds *Arnaso, J.T. Philogene, B.J.R. and Morand, P.) P.110 - 135 ACS 387* Washington.

Schoonhoven, A.V. (1987): Use of vegetable oils to protect stored beans from Bruchid attack. J. of Econ. Entomol 71(2): 254 - 56

Sharaby, A. (1986): Anti-insect properties of essential oil of lemon grass, Cymbopogon citratus against the lesser cotton leaf worm Spodoptera exigua (Hbn) Insect Sci. Applic 9(1): 77 - 80.

Simmonds, M.S.J.; Evans, H.C. and Blaney, W.M. (1992): Pesticides for the year 2000. Mycochemicals and Botannicals. Pest Management and the Environment in 2000 P. 127. C.A.B. International Wallingford.

Singal, S.K. and Singh, Z. (1990): Studies of plant oils as surface protectants against pulse beetle Callosobruchus chinensis L. in chick pea Cicer arietinum L. in India. Tropical Pest Management 36(3): 314 - 316.

Singh, S.R., Luse A.R.; Leuschner, K. and Nangju, D. (1977): Groundnut oil treatment for the control of Callosobruchus maculatus during cowpea storage. J. Stored Prod. Res. 14(2/3): 77 - 80.

Singh, S.R. and Jackai, L.E.N. (1985): Insect pests of cowpea in Africa: Their life cycle, economic importance and potential for control. In Cowpea Research, Production and Utilization P. 230 Edited by Singh, S.R. and K.O. Rachie; John Willey and Sons Ltd Chichester, U.S.A.

Singh, S.R.; Jackai, L.E.N. Don Santos, J.H.R. and Adalla, C.B.; (1990): Insect pests of cowpea Insects Pests of Food legumes P.43 - 64. John Willey and Sons Ltd Chichester, U.S.A.

Singh, B.B.; Singh, S.R. and Adjadi, O. (1985): Bruchid Resistance in cowpea. Crop Science 25(5): 736-739

Singh, S.R. and Van Emden, H.F. (1979): Insect Pests of grain legumes. Ann Rev. Entomol 24:255-278

Southage, B.J. (1958): Systematic Notes on Spp. of Callosobruchus maculatus of economic importance. Bulletin of Ent. Res. 49(3): 591-599

Sowunmi, O. (1980): The effect of insect infestation on cowpea Vigna unguiculata Walp Rep: Nigerian Stored Pro. Inst. Tech. Report No. 4, P. 43.

Sowunmi, O. (1981): Phosphine Residue on cowpeas Fumigatedwith phostoxin tablet. Rep: Nigerian Stored Prod. Res. Inst. Technical Report No. 8, P.75.

Sowunmi, O.E. and Akinnusi, O.A. (1983): Studies on the use of Neem Kernel in the control of stored cowpea beetle C. maculatus F. Tropical grain legume Bulletin 27: 28 - 31.

Sowunmi, O.E. and Fetuga, B.L. (1982): Loss of Pirimiphos methyl Applied to Stored Cowpea under Tropical Conditions. Tropical Grain Legume Bulletin 24:16 - 17.

Srivastava, S.; Guto, K.C. and Agrawal, A. (1988): Effect of plant products on Callosobruchus chinensis infestation on red gram seed. Post Harvest News and Information 1990 1(1): 66.

Stoll, G. (1988): Natural Crop Protection in the Tropics. Margrate Publishers Scientific Books F.R. Germany. 188 pp.

Su, C.H.F. (1977): Insecticidal properties of black peper to rice weevil and cowpea weevil J. Econ. Ent. 70: 18 - 21.

Su, Helen, C.F. Speirs Roy, D. and Mahany Patrick, G. (1972): Citrus oils as protectants of black - eyed peas against cowpea weevils: Laboratory Evaluation. J. Econ. Entomology 65(5): 1422 - 1436.

Subatti, O.F. and Blackith; R.E. (1956): Fumigation of Agric. Products Treatment of Peas and Beans with methyl bromide. Journal of the Science of Food and Agric. 5: 343 - 348.

Taylor, T.A. (1968): Effect of Insecticide Applications on Insect Damage and Performance of Cowpea in Southern Nigeria. Nigerian Agric J. 5(1): 29 - 37.

Taylor, T.A. (1970): On the incidence of the Active form of Callosobruchus maculatus (F) on matured cowpea in the field. Niger. Ent. mag. 2:66 - 69.

Taylor, T.A. (1971): Insect Pest of Tropical Grain Legumes. Ford Foundation IRAT/IITA Seminar on Plant Protect of Tropical Food Crops. Ibadan, Nigeria 19 pp.

Taylor, T.A. and Aludo, J.I.S. (1973): Further notes on the incidence of Active females of Callosobruchus maculatus on mature cowpea in the field in Nigeria. J. Stored Prod. Res. 2:123 - 125.

Taylor, T.A. (1974): Observation on the effect of initial population densities in culture and humidity on the production of active females of Callosobruchus maculatus (Coleoptera: Bruchidae). J. of Stored Prod. Res. 10(2): 113 - 125.

Taylor, T.A. and Agbase L.A. (1974): Flight activity in normal and active forms of Callosobruchus maculatus (F) in a store in Nigeria. J. Stored Prod. Res. 10:9 - 16.

Taylor T.A. (1975): Effect of orange and grape fruit peels on Callosobruchus maculatus infestation of cowpea. Ghana J. of Agric. Sc. 8(2): 169 - 172.

Taylor, T.A. and Evans, N.J. (1980): Laboratory evaluation of Pirimiphos methyl and permethrin dilute dust for control of bruchid beetles attacking stored pulse. Inst. Pest Control - September/October 1980 issue.

Tiwari, B.K.; Bajpai, V.N. and Agrawal, A (1966): Evaluation of Insecticidal, Fumigant and Repellent properties of lemon grass oil. Indian J. Exp. Biol 4:128

Tonye, G.O.; Siyanbola, O.O. and Ebochuo, V.O. (1990): Neem seed powder, as a protectant for Dried Tilaphia fish against Dermestes maculatus Degger Infestation. Insect Sci. Applic. 11(2):153 - 157.

Uphof, J.C.T.H. (1968): Dictionary of Economic Plants. 2nd Edition. J. Cramer, 3301 Lehve, Germany 597 pp.

Utida, S. (1968): The influence of the parental condition on the production of flight forms in the population of Callosobruchus maculatus. Jap. J. Ecol. 18:246 - 249.

Utida, S. (1969): Photoperiod as a factor including the flight form of the southern cowpea weevil, Callosobruchus maculatus. Jap. J. Appl. Ent. Zool. 13:129 - 134.

Utida, S. (1970): Secular change of percentage emergence of flight form in the population of southern cowpea weevil. Callosobruchus maculatus. Jap. J. appl. Ent. Zool. 14:71 - 78.

Utida, S. (1971): Influence of temperature on the number of eggs, mortality and development of several spp. of Bruchid infesting stored bean. Jap. J. appl. Ent. Zool. 15:23 - 30.

Uvah, I.I. and Ishaya, A.T. (1992): Effect of some vegetable oils on emergence, oviposition and longevity of the bean weevil, Callosobruchus maculatus (F). Tropical Pest Management.

Uvah, I.I. (1991): Major insect pests of stored products in Nigeria and their control. Noma News Magazine. 9:6 - 10.

Watt, J.M. and Breyer, B. (1962): The Medicinal and Poisonous Plants of Southern and Eastern Africa. E & S Livingstone, Pp. 1469.

Whitten, M.J. (1990): What we might learn from the twentieth century Pest Management in 2000. Pest Management and the Environment in 2000, P. 9 C.A.B. International Wallingford.

William, J.O. (1980): Notes on Bruchidae Associated with Stored Products in Nigeria. Tropical Grain Legume Bulletin. 21:5 - 10.

Wilson, K. (1988): Egg laying decisions by the bean weevil, Callosobruchus maculatus Review of Applied Entomology (Series A) 76(6):720.

Yadava, S.R.S. and Bhatnagar, K.N. (1989): A preliminary study on the protection of stored cowpea grains against pulse beetle by indigenous plant products. Pesticide 21(8): 25 - 29.

Youdeowei, A. (1988): Major Arthropod Pests of food and Industrial Crops of Africa and their Economic Importance. Biological control. A sustainable solution to crop pest problems in Africa.

International Institute of Tropical Agric. Ibadan, Nigeria. 31pp.

## RESULTS OF EXPERIMENT

Table 1: Effect of lemon grass powder on Adult mortality of C. maculatus.

| Dosage | Number of Insects in each replicate | | | | | | Total | Mean | %Mortality |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| 0.0g | 6 | 4 | 7 | 5 | 8 | 4 | 34 | 5.6 | 56.7 |
| 5.0g | 9 | 10 | 10 | 7 | 10 | 10 | 56 | 9.3 | 93.3 |
| 10.0g | 10 | 10 | 10 | 9 | 10 | 10 | 59 | 9.8 | 98.3 |
| 15.0g | 7 | 8 | 6 | 10 | 9 | 8 | 48 | 8.0 | 80.0 |
| 20.0g | 10 | 10 | 10 | 10 | 9 | 10 | 59 | 9.8 | 98.3 |

Table 2: Effect of Lemon grass powder on oviposition of C. maculatus

| Dosage | No. of eggs laid per 30 seeds in each replicate | | | | | | Total | Mean |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0.0g | 8 | 9 | 14 | 13 | 11 | 11 | 66 | 11.0 |
| 5.0g | 6 | 6 | 3 | 12 | 12 | 16 | 55 | 9.2 |
| 10.0g | 3 | 6 | 7 | 10 | 1 | 11 | 38 | 6.3 |
| 15.0g | 1 | 4 | 3 | 4 | 10 | 7 | 25 | 4.8 |
| 20.0g | 3 | 1 | 7 | 11 | 6 | 2 | 30 | 5.0 |

Table 3: Effect of lemon grass powder on emergence of F1 generation of C. maculatus

| Dosage | No.of F1 generation emerged in replicate | | | | | | Total | Mean |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0.0g | 4 | 5 | 7 | 10 | 6 | 8 | 40 | 6.7 |
| 5.0g | 1 | 1 | 1 | 1 | 2 | 4 | 10 | 1.7 |
| 10.0g | 1 | 2 | 1 | 1 | 1 | 1 | 7 | 1.2 |
| 15.0g | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1.0 |
| 20.0g | 1 | 2 | 1 | 1 | 1 | 1 | 7 | 1.2 |

Table 4: Effect of lemon grass powder on emergence of F2 generation of C. maculatus

| Dosage | Number of F2 generation emerged in replicate | | | | | | Total | Mean |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0.0g | 28 | 25 | 28 | 37 | 40 | 28 | 186 | 31 |
| 5.0g | 7 | 24 | 6 | 7 | 24 | 43 | 111 | 18.5 |
| 10.0g | 10 | 16 | 4 | 6 | 5 | 10 | 51 | 8.5 |
| 15.0g | 4 | 14 | 4 | 30 | 7 | 4 | 36 | 6.0 |
| 20.0g | 7 | 5 | 22 | 24 | 6 | 2 | 66 | 11.0 |

Table 5: Effect of lemon grass on damage of cowpea seeds at eight weeks post-treatment.

| Dosage | Number of holed seeds in each replicate | | | | | | Total | Mean | %Damage |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| 0.0g | 32 | 30 | 35 | 47 | 46 | 36 | 226 | 37.7 | 1.1 |
| 5.0g | 8 | 25 | 7 | 8 | 26 | 47 | 121 | 20.2 | 0.6 |
| 10.0g | 11 | 18 | 5 | 7 | 6 | 11 | 58 | 9.7 | 0.3 |
| 15.0g | 5 | 15 | 5 | 4 | 8 | 5 | 42 | 7.0 | 0.2 |
| 20.0g | 8 | 1 | 23 | 24 | 7 | 3 | 72 | 12.0 | 0.4 |

Table 6: Effect of lemon grass powder on viability of cowpea seeds at eight weeks post-treatment.

| Dosage | Number of viable seeds in replicate | | | | | | Total | Mean | %Damage |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| 0.0g | 30 | 30 | 30 | 30 | 29 | 30 | 179 | 29.8 | 99.4 |
| 5.0g | 28 | 29 | 28 | 29 | 29 | 28 | 171 | 28.5 | 95.0 |
| 10.0g | 29 | 28 | 28 | 25 | 29 | 27 | 166 | 27.7 | 92.2 |
| 15.0g | 28 | 26 | 29 | 29 | 28 | 30 | 170 | 28.3 | 94.4 |
| 20.0g | 30 | 29 | 27 | 28 | 29 | 28 | 171 | 28.5 | 95.0 |

Table 7: Effect of black sesame powder on Adult mortality of C. maculatus.

| Dosage | Number of insect dead in each replicate | | | | | | Total | Mean | % Damage |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| 0.0g | 6 | 5 | 7 | 4 | 8 | 3 | 33 | 5.5 | 55 |
| 5.0g | 10 | 9 | 9 | 9 | 10 | 9 | 56 | 9.3 | 93 |
| 10.0g | 8 | 10 | 10 | 10 | 10 | 8 | 56 | 9.3 | 93 |
| 15.0g | 9 | 9 | 9 | 10 | 10 | 10 | 57 | 9.5 | 95 |
| 20.0g | 10 | 10 | 9 | 9 | 10 | 9 | 57 | 9.5 | 95 |

Table 8: Effect of black sesame powder on oviposition of C. maculatus.

| Dosage | No. of eggs laid per 30 seed in each replicate | | | | | | Total | Mean |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0.0g | 14 | 17 | 8 | 14 | 13 | 11 | 72 | 12.0 |
| 5.0g | 19 | 10 | 9 | 6 | 4 | 2 | 50 | 8.3 |
| 10.0g | 15 | 7 | 7 | 9 | 8 | 13 | 59 | 9.8 |
| 15.0g | 13 | 10 | 7 | 4 | 5 | 6 | 45 | 7.5 |
| 20.0g | 2 | 12 | 1 | 1 | 12 | 6 | 34 | 5.7 |

Table 9: Effect of black sesame on emergence of F1 generation of C. maculatus.

| Dosage | Number of F1 generation emerged in each replicate | | | | | | Total | Mean |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0.0g | 8 | 7 | 5 | 11 | 8 | 9 | 48 | 8.0 |
| 5.0g | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1.0 |
| 10.0g | 1 | 2 | 1 | 1 | 1 | 2 | 8 | 1.3 |
| 15.0g | 1 | 1 | 1 | 1 | 1 | 2 | 7 | 1.2 |
| 20.0g | 2 | 1 | 1 | 1 | 2 | 1 | 8 | 1.3 |

Table 10. Effect of black sesame powder on emergence of F2 generation of C. maculatus.

| Dosage | No. of F2 generation emerged in each replicate | | | | | | Total | Mean |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0.0g | 29 | 29 | 29 | 44 | 29 | 38 | 198 | 33.0 |
| 5.0g | 27 | 1 | 4 | 8 | 4 | 3 | 47 | 7.8 |
| 10.0g | 2 | 21 | 7 | 10 | 5 | 13 | 58 | 9.7 |
| 15.0g | 10 | 6 | 1 | 11 | 9 | 5 | 42 | 7.0 |
| 20.0g | 10 | 8 | 2 | 1 | 1 | 3 | 25 | 4.2 |

Table 11. Effect of black sesame powder on damaged of cowpea seeds at eight weeks post-treatment.

| Dosage | Number of holed seeds in each replicate | | | | | | Total | Mean | %Damage |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| 0.0g | 37 | 36 | 34 | 55 | 37 | 47 | 246 | 41.0 | 1.2 |
| 5.0g | 28 | 2 | 5 | 9 | 5 | 4 | 531 | 8.8 | 0.3 |
| 10.0g | 3 | 23 | 8 | 11 | 6 | 15 | 66 | 11 | 0.3 |
| 15.0g | 11 | 7 | 2 | 12 | 10 | 7 | 49 | 8.2 | 0.2 |
| 20.0g | 12 | 9 | 3 | 2 | 3 | 4 | 33 | 5.5 | 0.2 |

Table 12. Effect of black sesame powder on viability of cowpea seeds at eight weeks post-treatment.

| Dosage | Number of viable seeds in eac replicate | | | | | | Total | Mean | %Damage |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| 0.0g | 30 | 29 | 30 | 30 | 30 | 30 | 179 | 29.8 | 99.4 |
| 5.0g | 30 | 30 | 28 | 30 | 28 | 30 | 176 | 29.3 | 97.8 |
| 10.0g | 29 | 30 | 30 | 27 | 26 | 28 | 170 | 28.3 | 94.4 |
| 15.0g | 30 | 30 | 29 | 29 | 30 | 29 | 177 | 29.5 | 98.3 |
| 20.0g | 29 | 30 | 30 | 29 | 29 | 28 | 175 | 29.2 | 97.2 |

Table 13. Effect of aqueous extract of lemon grass on adult mortality of C. maculatus.

| Dosage | Number of insect dead in each replicate | | | | | | Total | Mean | % Mortality |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| 0.0ml | 7 | 5 | 9 | 8 | 8 | 6 | 43 | 7.2 | 72 |
| 1.0ml | 8 | 10 | 10 | 10 | 7 | 10 | 55 | 9.2 | 92 |
| 1.5ml | 10 | 10 | 10 | 9 | 10 | 10 | 59 | 9.8 | 98 |
| 2.0ml | 10 | 10 | 10 | 10 | 10 | 10 | 60 | 10 | 100 |
| 2.5ml | 10 | 10 | 10 | 10 | 10 | 10 | 60 | 10 | 100 |

Table 14. Effect of aqueous extract of lemon grass on oviposition of C. maculatus.

| Dosage | Number of insect dead in each replicate | | | | | | Total | Mean |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0.0ml | 21 | 11 | 13 | 10 | 18 | 22 | 95 | 15.8 |
| 1.0ml | 15 | 11 | 90 | 7 | 15 | 22 | 79 | 13.2 |
| 1.5ml | 6 | 6 | 23 | 9 | 9 | 19 | 72 | 12.0 |
| 2.0ml | 4 | 7 | 5 | 9 | 9 | 8 | 42 | 7.0 |
| 2.5ml | 7 | 12 | 17 | 9 | 15 | 10 | 70 | 11.7 |

Table 15. Effect of aqueous extract of lemon grass on emergence of F1 generation of C. maculatus.

| Dosage | Number of F1 emerged in each replicate | | | | | | Total | Mean |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0.0ml | 8 | 5 | 13 | 10 | 15 | 9 | 60 | 10.0 |
| 1.0ml | 3 | 7 | 2 | 6 | 6 | 4 | 28 | 4.7 |
| 1.5ml | 4 | 5 | 7 | 8 | 4 | 16 | 44 | 7.3 |
| 2.0ml | 1 | 2 | 2 | 6 | 3 | 4 | 18 | 3.0 |
| 2.5ml | 5 | 13 | 8 | 1 | 5 | 2 | 34 | 5.7 |

Table 16. Effect of aqueous extract of lemon grass on emergence of F2 generation of C. maculatus.

| Dosage | Number of F2 emerged in each replicate | | | | | | Total | Mean |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0.0ml | 29 | 24 | 37 | 47 | 52 | 54 | 243 | 40.5 |
| 1.0ml | 7 | 26 | 3 | 30 | 25 | 23 | 114 | 19.0 |
| 1.5ml | 11 | 25 | 37 | 47 | 2 | 99 | 221 | 36.8 |
| 2.0ml | 25 | 3 | 1 | 20 | 14 | 2 | 65 | 10.8 |
| 2.5ml | 28 | 81 | 42 | 2 | 3 | 1 | 157 | 26.2 |

Table 17. Effect of aqueous extract of lemon grass on damage of cowpea seeds at eight weeks post-treatment.

| Dosage | Number of holed seeds in each replicate | | | | | | Total | Mean | % Damage |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| 0.0ml | 37 | 29 | 50 | 57 | 69 | 63 | 305 | 50.8 | 1.5 |
| 1.0ml | 10 | 33 | 5 | 36 | 31 | 27 | 142 | 23.7 | 0.7 |
| 1.5ml | 15 | 30 | 44 | 55 | 6 | 115 | 265 | 44.2 | 1.3 |
| 2.0ml | 26 | 5 | 3 | 26 | 17 | 265 | 83 | 13.8 | 0.4 |
| 2.5ml | 33 | 94 | 50 | 3 | 8 | 3 | 191 | 31.8 | 0.9 |

Table 18. Effect of aqueous extract of lemon grass on viability of cowpea seeds at eight weeks of post-treatment.

| Dosage | Number of viable seeds in each replicate | | | | | | Total | Mean | % Germination |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| 0.0ml | 29 | 29 | 30 | 30 | 30 | 30 | 177 | 29.5 | 98.3 |
| 1.0ml | 29 | 25 | 27 | 27 | 27 | 29 | 166 | 27.7 | 92.2 |
| 1.5ml | 28 | 27 | 24 | 30 | 25 | 24 | 158 | 26.3 | 87.7 |
| 2.0ml | 24 | 29 | 27 | 24 | 27 | 29 | 160 | 26.7 | 88.9 |
| 2.5ml | 28 | 26 | 27 | 30 | 30 | 30 | 171 | 28.5 | 95.0 |

Table 19. Effect of aqueous extract of black sesame on adult mortality of C. maculatus.

| Dosage | Number of insect dead in each replicate | | | | | | Total | Mean | % Mortality |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| 0.0ml | 6 | 5 | 8 | 7 | 8 | 4 | 38 | 6.3 | 63 |
| 1.0ml | 10 | 9 | 10 | 10 | 10 | 8 | 47 | 7.8 | 78 |
| 1.5ml | 10 | 10 | 10 | 9 | 10 | 10 | 59 | 9.8 | 98 |
| 2.0ml | 10 | 10 | 10 | 10 | 10 | 10 | 60 | 10.0 | 100 |
| 2.5ml | 10 | 10 | 10 | 10 | 10 | 10 | 60 | 10.0 | 100 |

Table 20. Effect of aqueous extract of black sesame on oviposition of C. maculatus.

| Dosage | No. of eggs laid per 30 seed in each replicate | | | | | | Total | Mean |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0.0ml | 21 | 14 | 13 | 22 | 21 | 10 | 101 | 16.8 |
| 1.0ml | 8 | 19 | 11 | 22 | 17 | 20 | 97 | 16.2 |
| 1.5ml | 16 | 24 | 10 | 11 | 10 | 8 | 79 | 13.2 |
| 2.0ml | 19 | 19 | 13 | 13 | 14 | 8 | 86 | 14.3 |
| 2.5ml | 4 | 17 | 7 | 9 | 12 | 18 | 67 | 11.2 |

Table 21. Effect of aqueous extract of black sesame on emergence of F1 generation of C. maculatus.

| Dosage | Number of F1 emerged in each replicate | | | | | | Total | Mean |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0.0ml | 7 | 7 | 12 | 9 | 18 | 10 | 63 | 10.5 |
| 1.0ml | 1 | 11 | 2 | 4 | 8 | 2 | 28 | 4.7 |
| 1.5ml | 6 | 1 | 3 | 6 | 2 | 5 | 23 | 3.8 |
| 2.0ml | 4 | 2 | 10 | 6 | 13 | 1 | 36 | 6.0 |
| 2.5ml | 4 | 2 | 8 | 5 | 7 | 4 | 30 | 5.0 |

Table 22. Effect of aqueous extract of black sesame on emergence of F2 generation of C. maculatus.

| Dosage | Number of F2 emerged in each replicate | | | | | | Total | Mean |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 0.0ml | 29 | 27 | 37 | 55 | 56 | 48 | 252 | 42.0 |
| 1.0ml | 19 | 81 | 20 | 3 | 44 | 12 | 179 | 29.8 |
| 1.5ml | 9 | 11 | 1 | 46 | 1 | 6 | 74 | 12.3 |
| 2.0ml | 43 | 20 | 72 | 14 | 137 | 10 | 296 | 49.3 |
| 2.5ml | 6 | 5 | 70 | 43 | 33 | 13 | 170 | 28.3 |

Table 23. Effect of aqueous extract of black sesame on damage of cowpea seeds at eight weeks post-treatment

| Dosage | Number of holed seeds in each replicate | | | | | | Total | Mean | % Damage |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| 0.0ml | 36 | 34 | 49 | 64 | 74 | 58 | 315 | 52.5 | 1.5 |
| 1.0ml | 20 | 92 | 22 | 7 | 52 | 14 | 207 | 34.5 | 1.0 |
| 1.5ml | 15 | 12 | 4 | 52 | 3 | 11 | 97 | 16.2 | 0.5 |
| 2.0ml | 47 | 22 | 82 | 20 | 150 | 11 | 332 | 55.3 | 1.6 |
| 2.5ml | 10 | 7 | 77 | 48 | 40 | 17 | 199 | 33.2 | 1.0 |

Table 24. Effect of aqueous extract of black sesame on viability of cowpea seeds at eight weeks post-treatment.

| Dosage | Number of viable seeds in each replicate | | | | | | Total | Mean | % Germination |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| 0.0ml | 29 | 30 | 30 | 30 | 29 | 29 | 177 | 29.5 | 98.3 |
| 1.0ml | 29 | 30 | 27 | 29 | 24 | 29 | 168 | 28.0 | 93.3 |
| 1.5ml | 30 | 29 | 30 | 20 | 29 | 29 | 167 | 27.8 | 92.8 |
| 2.0ml | 28 | 29 | 29 | 29 | 26 | 29 | 170 | 28.3 | 94.4 |
| 2.5ml | 28 | 29 | 29 | 28 | 24 | 29 | 167 | 27.8 | 92.8 |

**ANALYSIS OF VARIANCE 1-WAY**

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 4.6667 | 0.9333 | | |
| TREATMENT | 4 | 75.1333 | 18.7833 | 13.578 | (P<0.0001) |
| ERROR | 20 | 27.6667 | 1.3833 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 132.2667 | 26.4533 | | |
| TREATMENT | 4 | 176.8667 | 44.2167 | 4.1968 | (P=0.0125) |
| ERROR | 20 | 210.7333 | 10.5367 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 6.2667 | 1.2533 | | |
| TREATMENT | 4 | 142.3333 | 35.5833 | 27.302 | (P<0.0001) |
| EROR | 20 | 26.0667 | 1.3033 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 152.0000 | 30.4000 | | |
| TREATMENT | 4 | 2445.000 | 611.2500 | 7.014 | (P=0.0010) |
| ERROR | 20 | 1743.0000 | 87.1500 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 201.1000 | 40.2200 | | |
| TREATMENT | 4 | 3692.8000 | 923.2000 | 9.635 | (P=0.0001) |
| ERROR | 20 | 1916.4000 | 95.8200 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 2.1667 | 0.4333 | | |
| TREATMENT | 4 | 14.8667 | 3.7167 | 2.823 | (P=0.0524) |
| ERROR | 20 | 26.3333 | 1.3167 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 8.5667 | 1.7133 | | |
| TREATMENT | 4 | 73.800 | 18.4500 | 19.839 | (P<0.0001) |
| ERROR | 20 | 18.6000 | 0.9300 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 138.2667 | 27.6533 | | |
| TREATMENT | 4 | 137.6667 | 34.4167 | 2.146 | (P=0.1125) |
| ERROR | 20 | 320.7333 | 16.0367 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 4.9667 | 0.9933 | | |
| TREATMENT | 4 | 221.8667 | 55.4667 | 59.856 | (P<0.0001) |
| ERROR | 20 | 18.5333 | 0.9267 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 193.0667 | 38.6133 | | |
| TREATMENT | 4 | 3297.6667 | 824.4167 | 19.264 | (P<0.0001) |
| ERROR | 20 | 855.9333 | 42.2967 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 236.7000 | 47.3400 | | |
| TREATMENT | 4 | 5201.5333 | 1300.3833 | 26.689 | (P<0.0001) |
| ERROR | 20 | 974.4667 | 48.7233 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 4.9667 | 0.9933 | | |
| TREATMENT | 4 | 7.5333 | 1.8833 | 1.996 | (P=0.1338) |
| ERROR | 20 | 18.8667 | 0.9433 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 2.5667 | 0.5133 | | |
| TREATMENT | 4 | 34.8667 | 8.7167 | 9.721 | (P=0.0001) |
| ERROR | 20 | 17.9333 | 0.8967 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 199.8667 | 39.9733 | | |
| TREATMENT | 4 | 246.8667 | 61.7167 | 2.850 | (P=0.0509) |
| ERROR | 20 | 433.1333 | 21.6567 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 24.2667 | 4.8533 | | |
| TREATMENT | 4 | 171.4667 | 42.8667 | 3.1326 | (P=0.0374) |
| ERROR | 20 | 273.7333 | 13.6867 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 1117.4667 | 223.4933 | | |
| TREATMENT | 4 | 3626.6667 | 906.6667 | 1.5356 | (P=0.2301) |
| ERROR | 20 | 11812.5333 | 590.6267 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 1261.2000 | 252.2400 | | |
| TREATMENT | 4 | 4992.1333 | 1248.0333 | 1.632 | (P=0.2053) |
| ERROR | 20 | 15295.4667 | 764.7733 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 8.6667 | 1.7333 | | |
| TREATMENT | 4 | 40.8667 | 10.2167 | 2.677 | (P=0.0616) |
| ERROR | 20 | 76.3333 | 3.8167 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 5.0667 | 1.0133 | | |
| TREATMENT | 4 | 59.8000 | 14.9500 | 23.730 | (P<0.0001) |
| ERROR | 20 | 12.600 | 0.6300 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 174.6667 | 34.9333 | | |
| TREATMENT | 4 | 126.000 | 31.5000 | 1.198 | (P=0.3424) |
| ERROR | 20 | 526.000 | 26.3000 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 105.2000 | 21.0400 | | |
| TREATMENT | 4 | 166.3333 | 41.5833 | 3.842 | * (P=0.0178) |
| ERROR | 20 | 216.4667 | 10.8233 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 4422.9667 | 884.5933 | | |
| TREATMENT | 4 | 4828.1333 | 1207.0333 | 1.415 | (P=0.2651) |
| ERROR | 20 | 17057.8667 | 852.8933 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 5835.0667 | 1167.0133 | | |
| TREATMENT | 4 | 6134.6667 | 1533.6667 | 1.537 | (P=0.2297 |
| ERROR | 20 | 19960.9333 | 998.0467 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 36.3000 | 7.2600 | | |
| TREATMENT | 4 | 11.8000 | 2.9500 | 0.654 | (P=0.6307) |
| ERROR | 20 | 90.2000 | 4.5100 | | |

KASHIM IBRAHIM LIBRARY

**ANALYSIS OF VARIANCE FOR COMPARISON TABLES**

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 13.000 | 2.6000 | | |
| TREATMENT | 9 | 145.3333 | 16.1481 | 10.283 | (P<0.0001) |
| ERROR | 45 | 70.6667 | 1.5704 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 26.5333 | 5.3067 | | |
| TREATMENT | 9 | 343.9333 | 38.2148 | 2.218 | (P=0.0431) |
| ERROR | 45 | 775.4667 | 17.2326 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 8.5500 | 1.7100 | | |
| TREATMENT | 9 | 365.0167 | 40.5574 | 38.599 | (P<0.0001) |
| ERROR | 45 | 47.2833 | 1.0507 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 144.1333 | 28.8267 | | |
| TREATMENT | 9 | 5849.3333 | 649.9259 | 10.446 | (P<0.0001) |
| ERROR | 45 | 2799.8667 | 62.2193 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 201.0000 | 40.2000 | | |
| TREATMENT | 9 | 8980.7333 | 997.8593 | 14.357 | (P<0.0001) |
| EEROR | 45 | 3127.6667 | 69.5037 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 3.4000 | 0.6800 | | |
| TREATMENT | 9 | 29.0667 | 3.2296 | 2.970 | (P=0.0087) |
| ERROR | 45 | 48.9333 | 1.0874 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 5.2833 | 1.0567 | | |
| TREATMENT | 9 | 94.8167 | 10.5352 | 14.417 | (P<0.0001) |
| ERROR | 45 | 32.8833 | 0.7307 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 65.7333 | 13.1467 | | |
| TREATMENT | 9 | 459.2667 | 51.0296 | 1.811 | (P=0.1014) |
| ERROR | 45 | 1267.9333 | 28.1763 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 81.1333 | 16.2267 | | |
| TREATMENT | 9 | 338.0667 | 37.5630 | 3.139 | (P=0.0061) |
| ERROR | 45 | 538.5333 | 11.9674 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 1466.6833 | 293.3367 | | |
| TREATMENT | 9 | 8942.1500 | 993.5722 | 1.357 | (P=0.2509) |
| ERROR | 45 | 32944.1500 | 732.0922 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 2229.4000 | 445.8800 | | |
| TREATMENT | 9 | 11973.7333 | 1330.4148 | 1.488 | (P=0.1948) |
| ERROR | 45 | 40223.2667 | 893.8504 | | |

| SOURCE OF VARIANCE | DF | SS | MS | F | PROB |
|---|---|---|---|---|---|
| REPLICATION | 5 | 14.6833 | 2.9367 | | |
| TREATMENT | 9 | 57.4833 | 6.3870 | 1.460 | (P=0.2058) |
| ERROR | 45 | 196.8167 | 4.3737 | | |