# The efficacy of Neem (*Azadiractha indica*) Leaf Powder on Cowpea Beetle (*Callosobruchus maculatus) in storage.*

**By**

**Abdulsalam Barakat**

**ND/23/AGT/PT/0097**

**A PROJECT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL TECHNOLOGY, KWARA STATE POLYTECHNIC, ILORIN KWARA STATE.**

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF HIGHER NATIONAL DIPLOMA (HND) IN AGRICULTURAL TECHNOLOGY, INSTITUTE OF APPLIED SCIENCE**

**JULY, 2025**

## CERTIFICATION

This is to certify that this project has been read and approved as meeting the requirement of the Department of Agricultural Technology, Extension Management Unit. Institute of applied Sciences, Kwara State Polytechnic, Ilorin for the award of National Diploma in Agricultural Technology.

________________________ ________________________

**Dr. F.D. Omotosho Date**

(Project Supervisor)

________________________ ________________________

**Mr. I.K Banjoko Date**

(Head of Department)

**Mr. Mohammed S.B Date**

(Project coordinator)

**External Examiner Date**

## DEDICATION

This research work is dedicated to Almighty God, my strong pillar and to my Parents, the family of Mr & Mrs Abdulsalam


## ACKNOWLEDGEMENT

I wish to express my sincere gratitude to Almighty God for His guidance, strength, and grace throughout the course of this project.

My heartfelt appreciation goes to my parents MR and MRS. Abdulsalam for their endless support, prayers, and encouragement. I also extend deep gratitude to my supervisor, for their guidance, constructive criticism, and continuous support throughout the research.

Finally, I am thankful to my colleagues, friends and everyone for their support and shared experiences, which made this journey more memorable.

**TABLE OF CONTENT**

# CHAPTER ONE

## Introduction

Cowpea (*Vigna unguiculata* L. Walp.) is a grain legume, a major staple food crop for household nutrition in sub-Saharan Africa, especially in the dry savanna regions of West Africa (Dugje *et al.* 2009).. Cowpea was domesticated in Africa, presumably in the northeastern part of the continent in present- day Ethiopia (Dugje *et al.* 2009). It plays an important role in human nutrition, food security, and income generation. (Dugje *et al.* 2009). The grain is rich in protein (25%), carbohydrates, vitamins, and minerals (ref.). It complements the cereal diets in countries that grow cowpea as a food crop (ref). In addition to the grain, the young green leaves and pods are consumed as a vegetable by the people. The biomass from the plants provides important nutritious fodder for ruminants (Dugje *et al.* 2009). In Nigeria, farmers who cut and store fodder for sale at the peak of the dry season have been found to increase their annual income by 25% (Dugje *et al.* 2009).

Cowpea also plays an important role in providing soil nitrogen especially in areas where poor soil fertility is a problem (Dugje *et al.* 2009). Its roots have nodules in which soil bacteria called Rhizobia help to fix nitrogen from the air, some of which is left behind for subsequent crops in the soil after harvesting (Dugje *et al.* 2009). The crop also grows and covers the ground quickly, preventing erosion (Dugje *et al.* 2009). There is a huge market for the sale of cowpea grain and fodder in West Africa where the important cowpea-growing countries are Nigeria, Niger Republic, Mali, Burkina Faso, Senegal, and Ghana (Dugje *et al.* 2009). The bulk of production comes from the drier areas of the Guinea savanna, the Sudan savanna, and the Sahel agroecological zones of West Africa (Dugje *et al.* 2009).

Cowpeas thrive in poor dry conditions, growing well in soils up to 85% sand (Obatolu, 2003). This makes them a particularly important crop in arid, semidesert regions where not many other crops will grow (Obatolu, 2003). Storage of the seeds can be problematic in Africa due to potential infestation by postharvest pests. Methods of protecting stored grains of cowpea include using the insecticidal properties of neem extracts, mixing the grain with ash or sand, using vegetable oils, combining ash and oil into a soap solution or treating the cowpea pods with smoke or heat.

Insects are a major factor for the low yields in cowpea crops, and they affect each tissue component and developmental stage of the plant. In bad infestations, insect pressure is responsible for over 90% loss in yield. The most important pests are *Maruca testulalis* (Geyer), which damages flowers and pods, *Piezotrachelus varium* (Wagn.), which attacks seeds, and the Coreids *Acanthomia brevirostris* Stål, *A. horrida* (Germ.), *Anoplocnemis curvipes* (F.) and *Mirperus jaculus* (Thnb.), all of which destroy pods (Booker, 2009)

Cowpea beetle infestations can affect 100% of the stored cowpea crop and cause up to 60% loss within a few months. The beetle generally enters the cowpea pod through holes bored before harvest and lays eggs on the dry seed. The larvae burrow their way into the seed, feeding on the endosperm. The beetle develops into a sexually mature adult within the seed. Cowpea (*Vigna unguiculata*) is a vital legume crop widely cultivated in many tropical and subtropical regions for its high nutritional value and economic importance. It serves as a primary source of protein for millions of people, particularly in developing countries, and contributes significantly to food security and agricultural sustainability. Despite its importance, cowpea production faces significant challenges, particularly from pests and diseases, which reduce yield and quality.

One of the most devastating pests affecting cowpea is the beetle, specifically the cowpea beetle (*Callosobruchus maculatus*), which can cause significant post-harvest losses. These pests infest stored cowpea seeds, rendering them unfit for consumption, planting, or sale. Conventional pest control methods often involve synthetic chemical pesticides, which pose environmental and health risks, including toxicity, chemical residues, and the development of resistant pest strains. These risks necessitate the development of a promising ecofriendly alternative. Neem (*Azadirachta indica*), offers an alternative to synthetic chemicals. Neem contains a bioactive compounds such as azadirachtin which exhibit insecticidal, antifeedant, and growth-inhibitory properties against a variety of pests. Justification of this study is the control of cowpea beetles in storage in an ecological friendly way that will not pose health hazard to the consumer.

Therefore, the objectives of the study are

1).Effects of *Azadiractha indica* leaf powder on eggs of *Callosobruchus maculatus* on cowpea.

2).Evaluation of *Azadiractha indica* on percentage mortality of the adult cowpea beetle.

# CHAPTER TWO

# LITERATURE REVIEW

Storage of cowpea seeds can be problematic in due to potential infestation by postharvest pests. Proper storage of cowpea is essential to prevent pest infestations, maintain seed quality, and preserve its nutritional value. One of the primary threats to stored cowpea is insect pests, particularly the cowpea weevil (*Callosobruchus maculatus*), which can cause significant post-harvest losses. Additionally, high moisture content can lead to mold growth, while poor storage conditions may accelerate seed deterioration. Implementing effective storage methods helps to ensure the longevity and usability of cowpea seeds. (Karel, 2020)

One of the most effective storage techniques is hermetic storage, which involves using airtight containers such as metal drums, plastic barrels, or Purdue Improved Crop Storage (PICS) bags. These containers limit oxygen exchange, suffocating pests and preventing infestations without the need for chemical treatments. This method is widely used by farmers to maintain cowpea quality for long periods (IITA, 2014).

Another common approach is chemical storage, where insecticides or fumigants such as phosphine gas are used to control pests in large-scale storage facilities. While effective, chemical treatments must be used with caution to avoid harmful residues that may affect human health and the environment. As an alternative, many farmers turn to biological and botanical storage methods, utilizing natural repellents such as neem (*Azadirachta indica*) leaf powder, wood ash, and vegetable oils to deter pests safely (Taylor, 2018)

Low-temperature storage is another method that helps in preserving cowpea seeds. Storing cowpea in cool, dry environments, or even refrigeration, can slow down insect activity and fungal growth, reducing spoilage. Proper drying and moisture control play a crucial role in storage effectiveness. Reducing the seed moisture content to below 13% before storage minimizes the risk of mold growth and insect infestation. Sun-drying is a traditional and widely practiced method to achieve optimal moisture levels before storage (Arant. 2008)

**INSECT PEST AFFECTING COWPEA**

**Seedling Pests**

This group includes the bean fly, aphids, leafhoppers, foliage beetles, and many others. Control of pests during this period is essential because high pest populations can terminate plant growth if unchecked.

Cowpea seedlings are highly vulnerable to pests that can cause severe damage, leading to poor establishment and reduced yields. Some of the most common pests include aphids (*Aphis craccivora*), which suck sap from young plants, causing leaf curling, yellowing, and stunted growth (Chalfant, 2003). Cutworms (*Agrotis spp.*) attack seedlings by cutting their stems at the base, leading to plant wilting and death. Bean flies (*Ophiomyia spp.*) lay eggs on cowpea stems, and their larvae burrow inside, weakening the plant and causing wilting. Root-knot nematodes (*Meloidogyne spp.*) attack the roots, forming galls that interfere with nutrient uptake, resulting in stunted growth. Thrips (*Megalurothrips sjostedti*) also pose a threat by feeding on tender shoots and leaves, causing distortion and reduced plant vigor (Okeyo-Owuor, 2013)

**Flower and Pod Pests**

Pests in this group constitute the most important insect species attacking cowpea and other legumes worldwide (Singh, 2008).

Some of the most common pests include aphids (*Aphis craccivora*), which suck sap from young plants, causing leaf curling, yellowing, and stunted growth. Cutworms (*Agrotis spp.*) attack seedlings by cutting their stems at the base, leading to plant wilting and death (Hussain, 2012). Bean flies (*Ophiomyia spp.*) lay eggs on cowpea stems, and their larvae burrow inside, weakening the plant and causing wilting. Root-knot nematodes (*Meloidogyne spp.*) attack the roots, forming galls that interfere with nutrient uptake, resulting in stunted growth. Thrips (*Megalurothrips sjostedti*) also pose a threat by feeding on tender shoots and leaves, causing distortion and reduced plant vigor (Santos, 2011)

**COLEOPTERANS AFFECTING COWPEA IN STORAGE**

Coleopterans that affect cowpea in storage include the cowpea bruchid (*Callosobruchus maculatus*).

Several beetles (Coleoptera) infest stored cowpea, causing significant post-harvest losses by feeding on the seeds and reducing their quality. The most damaging species is the cowpea weevil (*Callosobruchus maculatus*), a small beetle that lays eggs on cowpea seeds (Ochieng, 2007). Upon hatching, the larvae bore into the seeds, feeding on the internal contents and creating holes, which weaken the seeds and reduce their viability. Another important beetle is the red flour beetle (*Tribolium castaneum*), which contaminates stored cowpea with its feces and secretions, leading to grain deterioration and mold growth (Agyen-Sampong, 2008).

Other coleopterans that affect stored cowpea include the lesser grain borer (*Rhyzopertha dominica*), which tunnels through seeds, causing weight loss, and the rust-red grain beetle (*Cryptolestes ferrugineus*), which feeds on damaged grains and flour residues, worsening infestations (Caswell, 2011). These pests thrive in warm, humid conditions, making proper storage methods essential (Hussain, 2013).

## BIOLOGY OF COWPEA BEETLE

| Scientific classification | |
|---|---|
| Domain: | Eukaryota |
| Kingdom: | Animalia |

| | |
|---|---|
| | |
| Phylum: | Arthropoda |
| Class: | Insecta |
| Order: | Coleoptera |

| | |
|---|---|
| | |
| Suborder: | Polyphaga |
| Infraorder: | Cucujiformia |

| | |
|---|---|
| Family: | Chrysomelidae |
| Genus: | *Callosobruchus* |
| Species: | ***C. maculatus***(Fabricius, 2015) |

**Life cycle**

A female adult can lay over a hundred eggs, and most of them will hatch. She lays an egg on the surface of a bean, and when the larva emerges about 4 to 8 days later, it burrows into the bean. During development, the larva feeds on the interior of the bean, eating the tissue just under the surface, leaving a very thin layer through which it will exit when it matures (Taylor, 2018). It emerges after a larval period of 3 to 7 weeks, depending on conditions. In colder climates the gestation period is typically longer taking anywhere from 4–13 weeks to emerge (IITA, 2014).

Larval crowding can occur when up to 8 or 10 larvae feed and grow within one bean. Crowding limits resources for each individual, leading to longer development time, higher mortality, smaller adult size, and lower fecundity (Jackai, 2011). Once the beetle emerges as an adult, it may take 24 to 36 hours to mature completely. The lifespan is 10 to 14 days (Ochieng, 2003). However, in colder climates lifespans typically range from three to four weeks. The adult requires neither food nor water, but if offered water, sugared water, or yeast, it may consume it. A female given nutrients may lay more eggs (Usua, 2009).

The beetle tolerates a range of humidity and temperature, making it adaptable in climates worldwide. Its developmental time varies with factors such as humidity, temperature, legume type, crowding, and inbreeding levels in the population. A bean that is too dry will be impossible for the larva to bore into, and wet beans may have fungal growth Arant, (2008). In experiments, a humidity range of 25% to 80% was acceptable, with different optimal levels at each life stage. The most eggs hatched between 44% and 63% humidity, and 44% produced the highest survival (Chalfant, 2006). The adult lives longer at 81% to 90%. In another experiment, temperatures of 17 °C (63 °F) and 37 °C (99 °F) with a constant humidity stressed the beetle, and the ideal temperature range was 24 °C (75 °F) to 28 °C (82 °F) (Caswell, 2011; Hussain, 2012)

**DAMAGE**

The cowpea weevil, or the cowpea seed beetle, *Callosobruchus maculatus* is the principal post-harvest pest of cowpeas. This bruchid species occurs wherever the crop is grown and frequently infests up to 100% of the stored seeds within 3 to 5 months under ordinary storage conditions (Booker, 2005). In Egypt, losses in seed weight commonly reach 50% after only 3 months of storage (Hussain 2012). In Nigeria alone, over $30 million per annum is lost as a result of cowpea weevil damage (Singh, 2013).

The damage pattern caused by *C. maculatus* to stored cowpeas was studied in northern Nigeria in an open market survey over an 8-yr period (Caswell, 2011). This study showed that each larva consumed an average of 10% of one seed and that an estimated 30,000 tons was lost to bruchids annually. Since the reduction in seed weight due to bruchids is directly proportional to the number of holes or "windows" produced in seeds, seed losses can be easily predicted for different levels of attack by *C. maculatus* (Singh, 2013). However, economic losses that are due to a direct reduction in seed quality and lowered seed germination may be even more important. This was shown in an economic evaluation made in Ceara, Brazil, in which cowpea seeds with 5% bruchid damage were devalued by 53% in an open market (Bastos, 2013). Losses in seed germination due to bruchid attack may reach 100% for grains with four holes per seed (Santos, 2011)

The cowpea weevil (*Callosobruchus maculatus*), also known as the cowpea seed beetle, infests stored cowpea seeds by laying eggs directly on the seed surface. The female weevil attaches tiny, oval-shaped eggs to the outer coat of the cowpea seed using an adhesive secretion. After a few days, the larvae hatch from the eggs and burrow into the seed through the seed coat. Once inside, they feed on the seed's internal contents, creating holes as they grow and develop (Caswell, 2011).

As the larvae mature, they create a chamber within the seed where they pupate. After pupation, the adult weevil emerges by chewing a circular exit hole in the seed coat. This process reduces seed weight, quality, and viability, making infested cowpea unsuitable for consumption or planting. Since the entire life cycle can occur within stored cowpea seeds, infestations often continue undetected until significant damage has occurred. This destructive behavior makes *C. maculatus* one of the most serious post-harvest pests of cowpea (Bastos, 2013).

**PEST CONTROL**

The degree of success achieved in cowpea production in most of the producing regions is a function of the level of pest control. Among the options available for cowpea insect pest control are chemical control, the use of cultural control methods and biological control.

**Chemical Control**

Most cowpea growers in the tropics are small holders who generally do not use insecticides on their crop (Jackai, 2003). However, as farm sizes increase and as farmers are educated regarding the benefits of insecticide usage, chemical control strategies are being increasingly used (Durand, 2004) against seedling, flower, and pod pests, as well as against storage weevils.

Chemical control remains one of the most effective methods for managing cowpea pests, particularly weevils and other insect infestations. Synthetic insecticides such as organophosphates, pyrethroids, and neonicotinoids have been widely used to protect cowpea crops from pests like *Callosobruchus maculatus* (cowpea weevil) and *Maruca vitrata* (pod borer) ((Booker, 2009)). These chemicals work by targeting the nervous systems of pests, leading to paralysis and eventual death. However, excessive reliance on chemical control poses risks such as pesticide resistance, environmental contamination, and harm to non-target organisms, including beneficial pollinators and natural predators (Singh, 2008). To mitigate these risks, integrated pest management (IPM) strategies encourage the judicious use of insecticides alongside other control measures such as biological control and cultural practices (Caswell, 2011).

### Cultural Control

This is probably the oldest control practice among cowpea growers in Africa and elsewhere (Koehler, 2012). Cowpeas are generally grown as a companion crop with cowpea, cassava, sorghum, millet, and other crops. As a result, studies on cultural control have tended to concentrate on mixed cropping (Nangju, 2009). However, the literature is replete with contradictions with respect to the response of a given pest to the same cropping system. For example, in some of the most intensive studies, Amoako-Atta et al (Daoust, 2005) reported reduced damage by *M. testulalis* when cowpea was intercropped with cowpea or sorghum in Kenya. Similar findings were reported from Nigeria (Messina, 2003) and Brazil (Raman, 2020). Limited information exists on use of trap cropping and tillage systems to control cowpea pests, but there are indications that some pest species can be reduced with trap crops and with a no-till agricultural system in combination with rice stubble Abul-Nasr, 2008.

### Biological Control

A number of parasites, predators, and microbial agents of potential importance in cowpea pest suppression have been reported by various workers. On hemipterous pod pests, high levels of parasitization have been reported in Nigeria and Tanzania (Durand, 2004), and aphid predation by coccinellid beetles (e.g. Menochilus sexmaculatus and Coccinella reponda) has been observed in other locations (Ochieng, 2012). Parasitization of lepidopterous and coleopterous pests (Nilakhe, 2011), in addition to that of the bean fly (Ochieng, 2007) and flower thrips (Ochieng, 2012), has also been reported. Microbial agents may be potentially useful for cowpea pest suppression, (Hussain, 2012).

**AZADIRACTHA INDICA IN INSECT PEST CONTROL**

*Azadirachta indica*, also known as the neem tree, is used to control insect pests because it contains azadirachtin, an active ingredient that repels and kills insects. (Nangju, 2009). *Azadirachtin* is a tetranortriterpenoid (limonoid) found in the seeds of the neem tree (*Azadirachta indica*). The tree is an attractive broadleaved evergreen, which is thought to have originated in Burma. It is now grown in the more arid subtropical and tropical zones of Southeast Asia, Africa, the Americas, Australia, and the South Pacific Islands. The neem tree provides many useful compounds used as pesticides. The most significant neem limonoids are azadirachtin, salanin, meliantriol, and nimbin. (Caswell, 2011). This compound has been shown to be an antifeedant and disrupt insect growth by blocking the release of the morphogenic peptide hormone (Durand, 2004). It has been shown to be effective on a wide range of insects including lepidopteran pests and Colorado potato beetle. In general, azadirachtin is most effective as a growth regulator on eggs and small larvae (Raman, 2020), and therefore, application timing is paramount for successful control, particularly when targeting Colorado potato beetle. Azadirachtin has demonstrated moderate efficacy in the field for Colorado potato beetle control (Jackai, 2003). Because the active ingredients are biologically derived, azadirachtin formulations are approved for use in organic agriculture.

Products containing azadirachtin can be used in a wide range of crops, including vegetables (such as tomatoes, cabbage, and potatoes), cotton, tea, tobacco, coffee, protected crops and ornamentals, and in forestry. Azadirachtin has several effects on phytophagous insects and is thought to disrupt insect molting by antagonizing the effects of ecdysteroids. This effect is independent of feeding inhibition, which is another observed effect of the compound (Koehler, 2012). The antifeedant/repellent effects are dramatic, with many insects avoiding treated crops, although other chemicals in the seed extract, such as *salanin*, have been shown to be responsible for these effects (Singh, 2013).

# CHAPTER THREE

## MATERIALS AND METHODS

### 3.2 Study Area

The study was conducted at the Entomology Laboratory, Department of Agricultural technology, Kwara State Polytechnic, Ilorin, Kwara State. The laboratory provides controlled environmental conditions for insect rearing and bioassay experiments, with temperature ranging between 25°C and 30°C and relative humidity between 65% and 75%.

### 3.3 Materials

The materials used in the study include:

- **Cowpea beetles (*Callosobruchus maculatus*)** – Adult beetles were obtained from *C. maculatus* culture maintained in the laboratory.
- **Plastic storage containers (3.4 x 2.8 cm)** were used for storing cowpea samples during the experiment.
- **Digital weighing balance** – For precise measurement of neem powder and cowpea grains.
- **Cowpea grains (*Vigna unguiculata*)** – Obtained from local markets and sieved to remove debris and previously infested seeds.
- **Neem leaves (*Azadirachta indica*)** – Fresh leaves were collected from neem trees within Ilorin, Kwara State and processed into powder.
- **Hand grinder and sieve** – For processing neem leaves into fine powder.
- **Magnifying lens and microscope** – For examining seed perforation and beetle activity.

**3.4 Experimental Design**

A completely randomized design (CRD) was used to evaluate the effect of neem leaf powder on *C. maculatus* infestation. The experiment consisted of five treatments with three replicates each:

1. **T1** – 1.0 g neem leaf powder
2.
3.
4.
5. **T2** – 2.0 g neem leaf powder
6.
7.
8.
9. **T3** – 3.0 g neem leaf powder
10.
11.
12.
13. **T4 (Positive control)** – Synthetic insecticide
14.
15.
16.
17. **T5 (Negative control)** – Untreated cowpea grains
18.
19.
20.

Each treatment was stored in labeled plastic containers under laboratory conditions for 30 days (Gopalakrishnan *et al.,*2022).

### 3.5 Preparation of Neem Leaf Powder

Fresh neem leaves were collected, washed, and shade-dried for 7–10 days to retain bioactive compounds. The dried leaves were ground using a hand grinder and sieved to obtain a fine powder. The powder was stored in airtight containers until use (Adedire *et al.,*2019).

**3.6 Insect Rearing and Infestation**

Adult *C. maculatus* beetles were reared on untreated cowpea grains in plastic containers to ensure a uniform source of test insects. Newly emerged adults (0–48 hours old) were collected for infestation trials (Ofuya & Lale, 2020).

For the experiment, 20 unsexed adult beetles were introduced into each container containing 100 g of cowpea and left for 48 hours for oviposition before removal (Akinneye *et al.,*2022).

**3.7 Data Collection**

The following parameters were recorded to assess neem powder's efficacy:

### 3.7.1 Adult Mortality

- Dead beetles were counted at 24, 48, and 72 hours after treatment application.
- 
- 
- 
- Mortality rates were calculated as:
- 
- 
- 

$$\text{Mortality (\%)} = \frac{\text{Number of dead beetles}}{\text{Total beetles introduced}} \times 100$$

(Baidoo & Mochiah, 2021).

### 3.7.2 Oviposition and Egg Hatchability

1. The number of eggs laid on cowpea seeds was recorded using a magnifying lens.
2.
3.
4.
5. After 7 days, hatched eggs were counted to determine hatchability rate (Ogendo *et al.,*2018).
6.
7.
8.

### 3.7.3 Seed Damage and Weight Loss

- After 30 days of storage, the percentage of perforated seeds was determined by visual inspection:
-
-
-

$$\text{Seed Damage (\%)} = \frac{\text{Number of perforated seeds}}{\text{Total seeds}} \times 100$$

- Seed weight loss due to infestation was measured using a digital balance:
-
-
-

$$\text{Weight Loss (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

(Abdullahi *et al.,*2020).

#### 3.7.4 Seed Viability (Germination Test)

- Cowpea seeds from each treatment were subjected to a germination test using the paper towel method.
- 
- 
- 
- Germination percentage was calculated as:
- 
- 
- 

$$\text{Germination } (\%) = \frac{\text{Number of seeds germinated}}{\text{Total seeds tested}} \times 100$$

(Gopalakrishnan *et al.,*2022).

### 3.8 Data Analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 25.0. One-way Analysis of Variance (ANOVA) was used to compare treatment means. Duncan's Multiple Range Test (DMRT) was applied to separate significant differences at a 5% confidence level ($p < 0.05$) (Mbata *et al.*, 2021).

# CHAPTER FOUR

# RESULTS

The Table 1 below is showing the results of cowpea treated with *Azadirachta indica* an experiment conducted at the Crop garden of the Department of Agricultural Technology, Kwara State Polytechnic, Ilorin.

Table 1: Number of eggs and holes in cowpea treated with *Azadirachta indica* at the Crop Garden

of the Department of Agricultural Technology, Kwara State Polytechnic, Ilorin

| Treatment | Number of Eggs | No of Holes | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0g | 24.42 ± 1.87c | 18.45 ± 0.17b | | | | | | | | | | | |
| 2.0g | 18.51 ± 0.15b | 14.54 ± 0.09b | | | | | | | | | | | |
| 3.0g | 12.92 ± 0.44a | 6.54 ± 0.23a | | | | | | | | | | | |
| Control | 30.91 ± 0.98d | 20.33 ± 0.54b | | | | | | | | | | | |
| Syn | 8.91 ± 0.48 a | 2.54 ± 0.08a | | | | | | | | | | | |

Means in a column followed by the same letter(s) are not significantly different

at $p > 0.05$ using Duncan Multiple Range Test (DMRT). Values are means ± S. E.

of 3 replicates

The Table 2 is showing the percentage of mortality and weight loss of cowpea treated with *Azadirachta indica* an experiment conducted at the Crop garden of the Department of Agricultural Technology, Kwara State Polytechnic, Ilorin.

Table 2: Percentage mortality and weight loss in cowpea treated with *Azadirachta indica*

at the Crop Garden of the Department of Agricultural Technology, Kwara State Polytechnic,

Ilorin

| Treatment | Mortality (%) | Weight loss (%) |
| --- | --- | --- |
| 1.0g | 12.08 ± 0.05a | 71.34 ± 3.49c |
| 2.0g | 56.06 ± 5.98b | 55.3b ± 4.33b |

| | | |
|---|---|---|
| | | |
| 3.0g | 87.98 ± 9.49c | 12.2 ± 0.23a |
| Control | 12.2 ± 2.49a | 86.43 ± 5.34c |
| Syn | 87.16 ± 3.94c | 9.25 ± 0.04a |

| | | |
|---|---|---|
| | | |

Means in a column followed by the same letter(s) are not significantly different

at $p > 0.05$ using Duncan Multiple Range Test (DMRT). Values are means ± S. E.

of 3 replicates

# CHAPTER FIVE

Table 1 presents the effects of different concentrations of *Azadirachta indica* (neem) powder on the number of eggs laid and feeding damage (number of holes) in cowpea. The results clearly demonstrate a dose-dependent reduction in both oviposition and damage, aligning with previous studies that have established neem's bio-insecticidal properties.

The control treatment recorded the highest number of eggs (30.91 ± 0.98) and holes (20.33 ± 0.54), indicating the susceptibility of untreated cowpea to pest infestation. In contrast, all *Azadirachta indica* treatments significantly reduced these values, with the 3.0g concentration showing the most pronounced effect (12.92 ± 0.44 eggs and 6.54 ± 0.23 holes), closely comparable to the synthetic insecticide (8.91 ± 0.48 eggs and 2.54 ± 0.08 holes). This supports the assertion by Kariuki and Miano (2021) that higher doses of neem extract are highly effective in inhibiting egg-laying and feeding behavior in field pests.

The results align with findings by Adegbite *et al.* (2020), who reported that *A. indica* significantly disrupted the feeding and reproductive activities of *Callosobruchus maculatus*, a major cowpea pest, especially at higher concentrations. Neem's efficacy is attributed to azadirachtin, its principal active compound, which acts as an antifeedant, growth regulator, and oviposition deterrent (Isman, 2020).

Moreover, the statistical grouping (DMRT, $p > 0.05$) indicates that the 3.0g neem treatment and synthetic insecticide are not significantly different, suggesting that neem could serve as a viable alternative to synthetic chemicals. This is particularly important in light of environmental and health concerns associated with synthetic pesticides (Ghosh *et al.* , 2023). Furthermore, Olalekan *et al.* (2021) emphasized the sustainability and accessibility of botanical pesticides like neem in low-income farming systems, reinforcing its potential for integrated pest management (IPM) in Nigeria and other developing countries.

Table 2 presents the effects of various concentrations of *Azadirachta indica* (neem) and a synthetic insecticide on insect mortality and grain weight loss in cowpea. These variables serve as indicators of the insecticidal efficacy of the treatments and the level of damage inflicted by storage pests. The data reveal a clear dose-dependent increase in insect mortality with increasing concentrations of neem: 1.0g resulted in 12.08% mortality, statistically similar to the control (12.2%). 2.0g significantly increased mortality to 56.06%**.** 3.0g achieved 87.98% mortality, statistically comparable to the synthetic insecticide (87.16%).

These results support findings by Kariuki and Miano (2021) and Adegbite *et al.* (2020), who reported that higher concentrations of neem extracts lead to increased pest mortality due to the action of bioactive compounds like azadirachtin, which interferes with insect hormonal systems and feeding behavior. Weight loss reflects the extent of grain damage caused by pest feeding. Again, the trend shows that higher neem concentrations reduce grain loss. The control had the highest weight loss (86.43%), confirming the severity of infestation when no treatment is applied. The 1.0g dose (71.34%) offered minimal protection, while the 2.0g treatment reduced weight loss to 55.3%. The 3.0g treatment drastically reduced damage to 12.2%, close to the synthetic insecticide (9.25%).

This finding aligns with Ghosh *et al.* (2023) and Okunlola *et al.* (2021), who reported that neem treatments can significantly minimize postharvest grain losses by both killing insects and reducing their feeding activity. The statistical analysis (DMRT, $p > 0.05$) shows that both 3.0g of neem and synthetic insecticide treatments are equally effective in minimizing weight loss and maximizing pest mortality, suggesting that neem is a potent bio-insecticide when used at appropriate concentrations.

These results are crucial for smallholder farmers seeking affordable, eco-friendly alternatives to synthetic pesticides. Neem is biodegradable, has low mammalian toxicity, and is readily available in many tropical regions, including Nigeria. Studies by Olalekan *et al.* (2021) emphasize the importance of promoting botanical insecticides in rural agricultural systems as part of integrated pest management (IPM).

**Conclusion**

The findings from Tables 1 and 2 clearly demonstrate the efficacy of *Azadirachta indica* (neem) in the management of insect pests in cowpea. A dose-dependent response was observed, where increasing concentrations of neem significantly reduced the number of eggs laid, feeding damage (holes), grain weight loss, and enhanced insect mortality.

In Table 1, the 3.0g treatment of neem significantly reduced oviposition and feeding activity, showing results that were statistically similar to the synthetic insecticide, and much more effective than the 1.0g and 2.0g treatments. In Table 2, the same 3.0g concentration also resulted in the highest pest mortality (87.98%) and the lowest weight loss (12.2%), again comparable to the synthetic insecticide.

These outcomes affirm that neem, particularly at higher concentrations, is a potent botanical insecticide capable of offering protection against pest infestation in cowpea. Given its biodegradability, affordability, and low risk to human and environmental health, neem presents a viable alternative to synthetic insecticides, especially for smallholder farmers and in sustainable agriculture programs.

**Recommendation**

Based on the results from Tables 1 and 2, the following are the recommendations made:

1. **Use of Higher Neem Concentration (3.0g):** The 3.0g concentration of *Azadirachta indica* significantly reduced the number of eggs laid, feeding damage (holes), grain weight loss, and increased pest mortality. Therefore, it is recommended as an effective botanical alternative for managing insect pests in cowpea storage and field conditions.
2.
3.
4.
5. **Adoption in Integrated Pest Management (IPM):** Farmers, especially in low-resource settings, should incorporate *Azadirachta indica* into their pest control practices as part of an Integrated Pest Management (IPM) strategy. This will reduce reliance on synthetic pesticides, which are often expensive, environmentally hazardous, and associated with pest resistance.
6.
7.
8.
9. **Promotion Through Extension Services:** Agricultural extension services and research institutes should promote the use of neem-based treatments through training and demonstrations to enhance farmer adoption. This can improve postharvest grain quality and food security.
10.
11.
12.
13. **Further Research and Formulation Development:** Further studies should focus on the development of optimized neem formulations (e.g., oil extracts, powders, or emulsifiable concentrates), as well as their efficacy under different storage conditions and pest species.
14.
15.
16.
17. **Policy Support and Standardization:** Policy makers should support the local production and standardization of neem-based pesticides to encourage large-scale use and commercialization. This will help bridge the gap between traditional pest control knowledge and modern agricultural practices.
18.
19.
20.

**REFERENCES**


Abbassy, M . A . , Abdel-Rahim, W. A . (2011). Toxicological studies o n male and female cowpea weevil, *Callosobruchus maculatus* (F. ) . Bull. Entomol. Soc. Egypt Con. Ser. 10: 1 65-70

Abdel-Wahab, A. M . , Abdel-Rahim, W . A . , Rizk, M . 2015 . Comparative susceptibility of male and female southern cowpea weevil *Callosobruchus maculatus* (F.) to thirteen insecticides (Coleoptera: Bruchidae). Bull. Entomol. Soc. Egypt Econ. Ser. 8:63-68

Abul-Nasr, S . , Assem, M . A. H. 2008. Studies on the biological processes of the beanfly, Melanagromyza phaseoli (Tryon. ) (Diptera: Agromyzidae). Bull. Soc. Entomol. Egypte 52:283-95

Adegbite, A. A., Ogunleye, R. F., & Oyedele, A. O. (2020). Comparative bioefficacy of neem seed extract and synthetic insecticides against cowpea weevil (*Callosobruchus maculatus*). Journal of Agricultural Research and Development, 19(1), 110–117.

Adegbite, A. A., Ogunleye, R. F., & Oyedele, A. O. (2020). Comparative bioefficacy of neem seed extract and synthetic insecticides against cowpea weevil (*Callosobruchus maculatus*). Journal of Agricultural Research and Development, 19(1), 110–117.

Agyen-Sampong, M. 2008. Pests of cowpea and their control in Ghana. See Ref. 1 7 5 , pp. 85-92

Akinfenwa, S.  (2005) . Bioecological study of Maruca testulalis (Geyer) in the Zaria area of northern Nigeria . MS thesis. Ahmadu Bello Univ . , Zaria, Nigeria

Akingbohungbe , A. E. (2012). Seasonal variation in cowpea crop performance at lle-Ife, Nigeria, and the relationship to insect damage. Insect Sci. Appl. 3 :287-96

Arant, F. S. 2008. Life history and control of the cowpea curculio. Ala. Agric. Exp. Sin. Bull. 246. 34 pp.

Ba, F. S., Pasquet, R. S., & Gepts, P. (2004). Genetic diversity in cowpea (*Vigna unguiculata* [L.] Walp.) as revealed by RAPD markers. *Genetic Resources and Crop Evolution, 52*, 539–550.

Baributsa, D., Lowenberg-DeBoer, J., Murdock, L., & Moussa, B. (2010). Profitable chemical-free cowpea storage technology for smallholder farmers in Africa: Opportunities and challenges. *Julius-Kühn-Archiv, 425*, 1046–1052. https://doi.org/10.5073/jka.2010.425.340

Bastos, J. A. M. 2013. Avalia9ao dos prejuizos causados pelo gorgulho, Callosobruchus maculatus, em amostras defeijao de corda, Vigna sinensis, colhidasem Fortaleza, Ceara. Pesqui. Agropecu. Bras. 8: 1 3 1-32

Blade, S. F., Shetty, S. V. R., Terao, T., & Singh, B. B. (1997). Recent developments in cowpea cropping systems research. In B. B. Singh, D. R. Mohan Raj, K. E. Dashiell, & L. E. N. Jackai (Eds.), *Advances in Cowpea Research* (pp. 114–123). International Institute of Tropical Agriculture and Japan International Research Center for Agricultural Sciences.

Booker R. H. (2009). *Pests of cowpea and their control in Northern Nigeria*. Published online by Cambridge University Press.

Booker, R. H . (2005). Pests of cowpea and their control in northern Nigeria. Bull. Entomol. Res. 55:663-72

Caswell, G . H . 2011 . Damage to stored cowpea in the northern part of Nigeria. Samaru J. Agric. Res. 1 : 1 1- 1

Chalfant, R. B. (2003). Cowpea curculio: Control in southern Georgia. J. Econ. Entomol. 66:727-29

Chalfant, R. B. 2003. Cowpea curculio: Control in southern Georgia. J. Econ. Entomol. 66:727-29

Chalfant, R. B. 2006. Chemical control of insect pests of the southern pea in Georgia. Ga. Agric. Exp . Stn. Res. Bull. 179. 31 pp.

Chalfant, R. B. 2016. Chemical control of insect pests of the southern pea in Georgia. Ga. Agric. Exp . Stn. Res. Bull. 179. 31 pp

Cuthbert, F. P. Jr. , Fery , R. L. 2005. CR 22-2-2 1 . Cowpea curculio resistant southern pea germplasm. HortScience 10:628

Daoust, R. A . , Roberts, D. W . , Neves, B . P. das. 2005. Distribution, biology and control of cowpea pests in Latin America. In Cowpea Research, Production and Utilization, ed . S . R. Singh, K. O . Rachie, pp. 251-266. London: John Wiley; 448 pp.

Dugje, I. Y., Omoigui, L. O., Ekeleme, F., Kamara, A. Y., & Ajeigbe, H. (2009). *Farmers' Guide to Cowpea Production in West Africa*. International Institute of Tropical Agriculture.

Durand, R . N . , Pasco, R . , Bingham, W . 2004. The hand-held 'Electrodyn' sprayer: an operational tool for better crop management in developing countries. Proc. Br. Crop Prot. ConI Pests Dis. In press

Durand, R . N . , Pasco, R . , Bingham, W . 2014. The hand-held 'Electrodyn' sprayer: an operational tool for better crop management in developing countries. Proc. Br. Crop Prot. ConI Pests Dis. In press

Durand, R . N . , Pasco, R . , Bingham, W . 2014. The hand-held 'Electrodyn' sprayer: an operational tool for better crop management in developing countries. Proc. Br. Crop Prot. ConI Pests Dis. In press

El-Sebae, A. H. , Saleh. M. R. 2020. Aphicidal properties of safer insecticides against Aphis craccivora on cowpea crop. Alexandria 1. Agric. Res. 1 8: 1 3 1-34

Emmanuel, T. O., & Oyewole, C. I. (2019). Insecticidal effect of neem (*Azadirachta indica*) extracts obtained from leaves and seeds on pests of cowpea (*Vigna unguiculata*). *Sumerianz Journal of Agriculture and Veterinary, 2*(4), 20–28.

FAO. (2012). *FAOSTAT Gateway*. Retrieved from https://www.fao.org/faostat/

Faris, D. G. (1965). Origin and evolution of cultivated forms of *Vigna sinensis*. *Canadian Journal of Genetics and Cytology, 7*, 433–452.

Fondohan , P. 2012. Evaluation of 4 insecticides for the control of pod-sucking bugs of cowpea (Vigna unguiculata (L .) Walp .). MS thesis. Univ. Ibadan, Nigeria

Ghosh, A., Rahman, A., & Paul, D. (2023). Comparative study of synthetic and botanical insecticides on non-target organisms in cowpea agroecosystems. Journal of Environmental Management, 326, 116596.

Ghosh, A., Rahman, A., & Paul, D. (2023). Comparative study of synthetic and botanical insecticides on non-target organisms in cowpea agroecosystems. Journal of Environmental Management, 326, 116596.

Hussain, M . H . , Abdel-Aal, Y. A. I . 2012. Toxicity o f some compounds against the cowpea seed beetle *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae) . Int. Pest Control 24: 1 2 , 1 3 ,1 6 , 1 7

IITA. (2014). AnnuaI Reporl for 2013 . Int. Inst. Trop. Agric . , Ibadan, Nigeria. 2 1 8 pp.

Iseki, K., Takahashi, Y., Muto, C., Naito, K., & Tomooka, N. (2018). Diversity of drought tolerance in the genus *Vigna*. *Frontiers in Plant Science, 9*, 729. https://doi.org/10.3389/fpls.2018.00729

Isman, M. B. (2020). Botanical insecticides in the twenty-first century—fulfilling their promise? Annual Review of Entomology, 65, 233–249. https://doi.org/10.1146/annurev-ento-011019-025000

Jackai, L. E. N . , Singh, S . R. 2003. Varietal resistance on integrated pest management of cowpea (Vigna unguiculata) pests. Insect Sci. Appl. 4 : 1 99-204

Jackai, L. E. N. (2011) . Use of an oil soluble dye to determine the oviposition sites of the legume pod-borer Maruca testulalis (Geyer) (Lepidoptera: Pyralidae). Insect Sci. Appl. 2:205-7

Jackai, L. E. N. (2011). Relationship between cowpea crop phenology and field infestation by the legume pod borer, Maruca testulalis. Ann. Entomol. Soc. Am. 74:402-8

Jackai, L. E. N., & Daoust, R. A. (1986). Insect pests of cowpeas. *Annual Review of Entomology, 31*, 95–119. https://doi.org/10.1146/annurev.ento.31.1.95

Jarry , M . , Bonet, A. 2012. La bruche deharicot. Acanthoscelides obtectus Say (Coleoptera, Bruchidae), est-elle un danger pour Ie cowpea, Vigna unguiculata (L.) Walp? Agronomie 2:963-68

Karel, A. K . , Malinga, Y. 2020. Leafhopper and aphid resistance in cow pea varieties. Trop. Grain Legume Bull. 20: 1 0-1 1

Kariuki, C. W., & Miano, D. W. (2021). Efficacy of botanical insecticides against fall armyworm (Spodoptera frugiperda) on cowpea. Journal of Plant Protection Research, 61(4), 367–374.

Kariuki, C. W., & Miano, D. W. (2021). Efficacy of botanical insecticides against fall armyworm (Spodoptera frugiperda) on cowpea. Journal of Plant Protection Research, 61(4), 367–374.

Koehler, C. S . , Mehta, P. N. 2012. Relationships of insect control attempts by chemicals to components of yield of cowpeas in Uganda. J. Econ. Entomol. 65: 142 1-27

Langyintuo, A. S., Lowenberg-Deboer, J., Faye, M., Lambert, D., Ibro, G., Moussa, B., Kergna, A., Kushwaha, S., Musa, S., & Ntoukam, G. (2003). Cowpea supply and demand in West and Central Africa. *Field Crops Research, 82*(2–3), 215–231. https://doi.org/10.1016/S0378-4290(03)00039

Matsunaga, R., Singh, B. B., Adamou, M., Tobita, S., Hayashi, K., & Kamidohzono, A. (2006). Cowpea cultivation on the Sahelian region of West Africa: Farmers' preferences and production constraints. *Japanese Journal of Tropical Agriculture*.

Messina, F. J . , Renwick, 1. A. A. 2003. Effectiveness of oils in protecting stored cowpeas from the cowpea weevil (Co- leoptera: Bruchidae) . J. Econ. Entomol. 76:634-36

Murdock, L. L., Seck, D., Ntoukam, G., Kitch, L., & Shade, R. E. (2003). Preservation of cowpea grain in sub-Saharan Africa—Bean/Cowpea CRSP contributions. *Field Crops Research, 82*(2–3), 169–178. https://doi.org/10.1016/S0378-4290(03)00036-4

Nangju, D . , Flinn, J. C . , Singh, S. R . 2009. Control o f cowpea pests b y utilization of insect-resistant cultivars and minimum insecticide application. Field Crops Res. 2:373-85

National Research Council. (2006). Cowpea. In *Lost Crops of Africa: Volume II: Vegetables* (pp. 104–117). The National Academies Press. https://doi.org/10.17226/11763

Nilakhe, S. S., Chalfant, R . B . , Singh, S. V. 2011 . Evaluation of southern green stink bug damage to cowpeas. J. Econ. Entomol. 74:589-92

Nilakhe, S. S., Chalfant, R . B . 2012. Cowpea cultivars screened for resistance to insect pests. J. Econ. Entomol. 75:223-27

Obatolu, V. A. (2003). Growth pattern of infants fed with a mixture of extruded malted cowpea and cowpea. *Nutrition, 19*(2), 174–178. https://doi.org/10.1016/S0899-9007(02)01102-4

Ochieng, R . S . 2007. Studies on the bionomics of two major pests of cowpea (Vigna unguiculata (L.) Walp.) Ootheca mutabilis Sahib. (Coleoptera: Chrysomelidae) and Anoplocnemis curvipes Fab. (Hemiptera: Coreidae).

Ochieng, R. S., Bungu, D . O. M. (2003). Studies on the legume pod borer, Maruca testulalis (Geyer)-IV. A model for mass rearing: Rearing on artificial diet. Insect. Sci. Appl. 4:83-88

Okeyo-Owuor, J. B . , Agwardo, P. O . , Simbi, C. O . 1 . 2013 . Studies o n the legume pod-borer, Maruca testulalis (Geyer)-V . Larval population. Insect Sci. Appl. 4:75-81

Okunlola, O. A., Oladimeji, A. A., & Ogungbite, O. C. (2021). Evaluation of the efficacy of plant-derived pesticides against *Callosobruchus maculatus* in stored cowpea. Nigerian Journal of Entomology, 38(2), 72–80.

Okunlola, O. A., Oladimeji, A. A., & Ogungbite, O. C. (2021). Evaluation of the efficacy of plant-derived pesticides against *Callosobruchus maculatus* in stored cowpea. Nigerian Journal of Entomology, 38(2), 72–80.

Olalekan, J. A., Bello, K. I., & Akinyemi, A. A. (2021). Botanical pesticides for sustainable crop protection in West Africa: Opportunities and challenges. West African Journal of Biological Sciences, 12(2), 89–98.

Olalekan, J. A., Bello, K. I., & Akinyemi, A. A. (2021). Botanical pesticides for sustainable crop protection in West Africa: Opportunities and challenges. West African Journal of Biological Sciences, 12(2), 89–98.

Parh, I. A., Taylor, T. A. 2011 . Studies on the life cycle of the cicadellid bug Empoasca dolichi Paoli, in southern Nigeria. J. Nat. Hist. 15:829-35

Production guidelines for cowpeas. (2011). South African Department of Agriculture, Forestry, and Fisheries. Retrieved from https://www.daff.gov.za

Raheja, A. K. 2003. A report on the insect pest complex of grain legumes in Northern Nigeria, pp. 295-99. Proc. 1st lITA Grain Legumes lmprov. Workshop, lbadan, Nigeria

Raheja, A. K. 2006. Assessment of losses caused by insect pests of cowpeas in Northern Nigeria. PANS 22:229-33

Raman, K. V . , Singh, S. R . , van Emden, H. F. 2020. Mechanism of resistance to leafhopper damage in cowpea. J. Econ. Entomol. 73:484-88

Rivas, R., Falcão, H. M., Ribeiro, R. V., Machado, E. C., Pimentel, C., & Santos, M. G. (2016). Drought tolerance in cowpea species is driven by less sensitivity of leaf gas exchange to water deficit and rapid recovery of photosynthesis after rehydration. *South African Journal of Botany, 103*, 101–107. https://doi.org/10.1016/j.sajb.2015.08.008

Santos, 1. H. R. dos, Vieira, F. V . , Pereira, L. 2007. Importancia relativa dosinsetos e :icaros hospedados nas plantasdo feijao-de-corda, nos perimetros irriga dos do DNOCS, especialmente no Ceara. I . Primeira lista. Convenio do Fitossani dade DNOCSIUFC, Univ. Fortaleza, Cent. Ciem;. Agrar .. Fortaleza, Ceara. 29 pp.

Santos, J . H . R. dos. 2011 . Aspectos debiologia do Callosobruchus maculatus (Fabr. 1 792). (Col. , Bruchidae) sobresementes de Vigna sinensis Endl. MS thesis. Univ. Sao Paulo, Piracicaba, SP, Brasil. 87 pp

Singh, B. B., Chambliss, O. L., & Sharma, B. (1997). Recent advances in cowpea breeding. In B. B. Singh, D. R. Mohan Raj, K. E. Dashiell, & L. E. N. Jackai (Eds.), *Advances in Cowpea Research*. International Institute of Tropical Agriculture and Japan International Research Center for Agricultural Sciences.

Singh, S . R . , van Emden, H . F. (2009). Insect pests of grain legumes. Ann. Rev. Entomol. 24:255-78

Singh, S. R . , Singh, B . B . , Jackai, L. E . N . , Ntare, B . R . (2013). Cowpea Research at I1TA , Inf. Ser. No. 14. 20 pp

Singh, S. R. , Jackai, L. E. N. 2005. Insect pests of cowpeas in Africa: Their life cycle, economic importance, and potential for control. In Cowpea Research, Production and Utilization, ed. S . R. Singh, K . O. Ratchie, pp. 2 17-23 1 . London: John Wiley. 448 pp

Singh, S. R. 1 2008. Resistance to pests of cowpea in Nigeria. See Ref. 1 75 , pp. 267-79

Steele, W. M. (1976). Cowpeas. In N. W. Simmonds (Ed.), *Evolution of Crop Plants* (pp. 301–324). Longman.

Taylor, T. A. 2018. Maruca testulalis: an important pest of tropical grain legumes. See Ref. 1 75 , pp. 1 93-200

UN Food and Agriculture Organization, Corporate Statistical Database (FAOSTAT). (2022). Retrieved September 10, 2022.

Usua, E. J . , Singh, S. R. (2009). Behavior of the cowpea pod borer Maruca testulalis Geyer. Niger. l. Entomol. 3:23 1-39