LABORATORY EVALUATION OF FOUR PLANT POWDERS FOR THE MANAGEMENT OF COWPEA WEEVIL *Callosobruchus maculatus* (F) (COLEOPTERA: Chrysomelidae) IN STORED COWPEA, *Vigna unguiculata* (L) Walp.

BY

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF CROP PROTECTION, FACULTY OF AGRICULTURE, BAYERO UNIVERSITY, KANO IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN CROP PROTECTION

(AGRICULTURAL ENTOMOLOGY)

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DECLARATION

I hereby declare that this work is a product of my research efforts undertaken under the supervision of Prof. A.U. Yusuf and has not been presented anywhere for the award of degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work for this dissertation titled “**Laboratory evaluation of four plant powders for the management of cowpea weevil *Callosobrucus maculatus* (F) (Coleoptera: Chrysomelidae) in stored cowpea, *Vigna unguiculata* (L) Walp.”** and the subsequent write-up by Ali Mohammed Dakasku (SPS/17/MCP/00001) were carried out under my supervision.

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APPROVAL

This dissertation titled 'Laboratory Evaluation of Four Plant Powders for the Management of Cowpea Weevil (*Callosobruchus maculatus* (F.) Coleoptera: Chrysomelidae) in Stored Cowpea (*Vigna unguiculata* (L.)' by Ali Mohammed Dakasku has been examined and approved for the award of Masters in Crop Protection (Agricultural Entomology).

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DEDICATION

I dedicated this research work to my beloved wife Zara A. Hassan and my beloved son Yusuf Ali Mohammed.

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ABSTRACT

A study was conducted in the laboratory of the Department of Crop Protection, Faculty of Agriculture, Bayero University Kano to evaluate the insecticidal effect of leaf powders of four locally available plant namely, Indian jujube (*Ziziphus mauritiana*), Christis thron (*Ziziphus spina Christi*), Camel's foot (*Piliostigma reticulatum)* and Tallow tree (*Detarium senegalense*) against *Callosobruchus maculatus* (cowpea weevils) infesting cowpea seeds (*Vigna unguiculata* L.Walp). Bioassay was done by a direct contact application of the powders using three concentrations (1, 3 and 5g) of each plant power in 100g of cowpea seeds, Permethrin was added at 0.12g (standard check) and untreated seeds to served as control. Treatments were laid out in a completely randomized design (CRD) with three replications. The results show significantly higher mortality (80-83%) of *C. maculatus* at 3g after 7 days exposure to cowpea seeds treated with leaf powers of *Z. mauritiana* and *Z. spina christis* than the untreated control (0.07). Leaf powers of *Z. mauritiana* and *Z. spina christis* at 3g/100g grains was the most effective in reducing oviposition (27.00) thereby bringing about a significant reduction in adult emergence (1.11-0.55), number of emergence holes (0.67) and grains damage (1.11), while it competed favorably with the synthetic insecticides (Permethin). Leaf powders of *P. reticulatum* and *D. senegalense* was not significantly different with the control treatment. All the four plant leaf powders did not exhibit any significant negative effect on viability of the seeds tested. These results have implications for cost effectiveness and safety that even the local farmers can use to protect stored cowpea seeds against the cowpea weevil.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Grain legumes are the most commonly stored durable food commodities in the tropics (Odeyemi and Daramola, 2000). Cowpea grain (*Vigna unguiculata* L) Walp is a pulse crop produced and consumed largely by subsistence farmers in the semi-arid and sub-humid regions of Africa (DeBoer, 2003). It is an important cash and food crop for many poor farmers and also noted for its high nutritional value. It forms a major part of the diets of the people in West and East Africa, Latin America and the Carribean basin (DeBoer, 2003). Cowpea has its origin on the southern African region but has spread and is now cultivated in more than 100 countries between 40°N and 30°S latitudes, most cowpea are grown on the African continent particularly Nigeria and Niger which account for 66% of world cowpea production (FAO, 2012). The Sahel region also contains other major producers such as Barkina Faso, Ghana, Senegal and Mali. Niger is the main exporter and Nigeria the main importers. According to the Food and Agriculture Organization of United Nation, as at 2012, the average cowpea yield in Western Africa was an estimated 483 kilograms per hectare (0.195t/acre), which is still 50% below the estimated potential production yield (Kormawa *et al*., 2002).

Cowpea is mainly used for human and livestock consumption. When fresh, the young leaves, immature pods and peas are used as vegetables, while snacks and main meal dishes are prepared from the dried grain. Cowpea grain matures earlier than cereals, hence becomes a quick source of cash before the maize, millets and cassava are harvested. Cowpea residue after harvest is used for feeding cattle, goats, pigs, sheep and other farm animals (IITA, 2001). Cowpea can be prepared in different ways. In Cameroon, cowpea paste is prepared by soaking the seeds, followed by removal of the testa (Steele *et al*., 1985) and whipping with palm oil and spices then cooked by steaming to make “koki” (Mbofung *et al.*, 1999). In Nigeria, the seeds are processed into “akara” or cooked as porridge (Uguru, 1996). In Ethiopia, cowpeas, locally called “ohota”, “okala” or “neeqayta” are boiled or eaten raw (Engels and Goettsch, 1991).

Cowpea production is affected by insect pests and disease infestations which lead to economic losses. Insect damage is the major constraint to cowpea grain production in most cowpea producing nations (Singh and Van Emden, 1979). The major field insect pests that can cause economic loss are cowpea aphids *(Aphis craccivora)*, leafhoppers *(Empoasca spp)*, thrips (*Megalurothrips sjostedti*—Synonym:*Taeniothrips sjostedti*), flower eating beetles *(Mylabris spp. and Coryna spp.*), blister beetles (*Hycleu slugens*) and green stink bugs (*Nezara viridula*).

The cowpea weevil, *Callosobruchus maculatus*, (F)., (Coleoptera: Bruchidae) is a serious pest of stored grains in sub-Sahara Africa (Al-Moajel and Al-Fuhaid, 2003). Postharvest losses of cowpea 3-4 months in storage caused by *C. maculatus* infestation have been reported as high as 50% in Northern Nigeria (Caswell, 1981) and 60% in Northern Ghana (Tanzubil, 1991). The loss of cowpea is a serious problem in Africa where as much as 20-50% of the grain is damaged by *C. maculatus* (FAO, 2013). The damage of this magnitude is incredibly high and demonstrates the destructive nature of the pest which can threaten food security at both household and national levels. This is a major agricultural problem for farmers in developing countries. Weevil infestation causes weight loss, quality deterioration resulting in overall acceptability problem in markets and impaired germ inability of grains (Keita *et al*., 2001). Infested grains are rendered unfit for consumption and sale.

1.2. PROBLEM STATEMENT

Cowpea is an important edible legume crop in many parts of the world especially in tropical and subtropical regions. Cowpea is one of the most important pulse crops globally. World production of cowpea was estimated to be 2.27 million tons of which Nigeria produces about 850,000 tones (FAO, 2002; Adaji *et al.,* 2007), making it the world's largest producer, followed by Niger (650 000 tonnes) and Mali (110 000 tonnes). Total area grown to cowpea was 9.8 million hectares, about 9.3 million hectares of these in West Africa. World average yield was 337 kg per hectare; average yield in Nigeria was 417 kg per hectare, and in Niger was 171 kg per hectare (IITA, 2003). Production is characterized by limited use of purchased inputs and the crop is traditionally intercropped with cereals such as maize, millets, sorghum and cassava (Singh and van Emdem 1979).

Cowpea production is affected by insect pests and disease infestations which lead to economic losses. Insect damage is the major constraint to cowpea grain production in most cowpea producing nations (Singh & Van Emden I979). The major insect pests that attack cowpea right from the field to the store is cowpea weevil *(Callosobruchus maculatus)* (Coleoptera: Bruchidae). The cowpea weevil, is a cosmopolitan field-to-store pest ranked as the principal post-harvest pest of cowpea in the tropics (Caswell 1981). It causes substantial quantitative and qualitative losses manifested by seed perforation and reductions in weight, market value and germination ability of seeds (Oluwafemi 2012). Consequently, farmers are compelled to sell their products early after harvest when prices are still low partly because of anticipated losses of the grain in storage.

Over the years, the destructive activities and menace of storage pests have been effectively suppressed with synthetic organochlorine and organophosphate compounds like carbon disulphide, phosphine, Malathion, carbaryl, Pirimiphos methyl and Permethrin (Adedire *et al*., 2011). The application of these chemicals as pest control agents is however, associated with problems, such as high persistence of the compounds, resurgence and genetic resistance of pests, negative effects on non-target organisms, poor knowledge of application, direct toxicity to the users, non-availability of the chemicals and increasing costs of application (Berger, 1994; Sharma *et al*., 2006).These drawbacks taken together necessitate the exploration of effective, affordable, safe and environmental-friendly control measures.

1.3 JUSTIFICATION FOR THE STUDY

Callosobruchus maculatus also known as bruchid or cowpea weevil, is the primary pest of stored cowpea. It is polymorphic and has been confused with *C. analis*, which has non serrate antennae, with *C. chinensis* which has a more angular outline and with *C. subinaetatus* which lacks the dark spots on the elytra and is larger (Jurgen, *et. al*., 1977). Eggs are laid by the female bruchids on cowpea seeds or pods and the hatched larvae bore into the seed where the entire immature life is spent. The adults emerge out through circular holes they made leaving the seeds damaged. Under favorable conditions, up to 18 adult bruchids can emerge from a single seed (Credland, and Dick, 1986) and each window left means that one-tenth (1/10) of a seed has been lost (Caswell, 1981). A global conservative estimate puts grain legume losses during storage at between 15-25 percent annually (Samuel, 1980). Damage of up to 40 percent of cowpea in storage has been recorded in several parts of Africa (Tropical Products Institute, 1977), but *C. maculatus* particularly accounts for over 90 percent of the damage (Ahmed, 2010). There is no surprise to this impact of damage because amongst the insect species that attack the pods of cowpeas in the field, only the bruchids survive in the store and among the others; *C. maculatus* remain as the most important

(Onolemhemhen and Oigiangbe, 1991). Infestation of postharvest cowpeas by bruchids also lead to loss in weight and quality of seeds, discoloration, changes of flavor, mould formation, reduced nutritional value due to lowered protein levels and poor germination of seeds due to embryo damage (Okonkwo *et .al*.2017). Another aspect of concern aside from contamination of seeds by dead insects, pupae and larval cocoons is that, their integument has been found to contain various carcinogenic compounds such as ethyl, methyl and methoxy quinines which cannot be denatured by boiling or baking (Ileke, 2012)

. To control the menace of infestation of cowpea in storage, synthetic pesticides remain the most desired tool, but the steady increase in the cost, hazards from chemicals and development of resistance to the pesticides by pests, made it necessary to consider alternative measures of control that are effective, safer and relatively resistant-free. Resistance to pesticides was not serious before the early 1940's when raw plant materials were the principal agents of pest control (Yoshio, 1987). Scientists estimate that pesticides are reducing crop yield by one-third through impaired nitrogen fixation, thus, opined that, pesticides and other contaminants should be substituted by yield enhancing benefit of well-managed, organic farming system (Boakye *et.al.*, 2016).

In many areas of the world locally available materials are widely used to protect stored produce against damage by insects. Small-scale farmers throughout Nigeria are no exception in admixing wood ashes with cereal and pulse grains that they select and store for use as seed. Vegetable oils, leaves and twigs of certain plants and even dried sand and table salt are used for the same purpose. Over 2000 species of plants produce chemicals that have repellent or insecticidal properties (Boakye *et.al.,* 2016). Among other reports, seed oil of rubber plant, coconut, palm kernel and some other essential oils were applied on cowpeas in storage to control *C. maculatus* infestation (Malek and Wilkins, 2014). It is common practice in traditional African communities to use locally available plants for medicinal purposes and in agriculture (Obeng-Ofori *et al*., 2000). In view of the above, the present study was aimed at investigating the insecticidal potential of Camel's foot (*Piliostigma reticulatum),* Tallow tree (*Detarium senegalense*), Indian jujube (*Ziziphus mauritiana*) and Christis thron (*Ziziphus spina Christi*) leave powders against *C. maculatus* on stored cowpea seeds.

1.4 OBJECTIVES OF THE STUDY

The objectives of the study are to:

i. evaluate the insecticidal potentials of four plant leaf powders against the cowpea weevil `*C. maculatus* on stored cowpea.

ii. determine the most effective concentration of the four plant leaf powders for the management of *C. maculatus* on stored cowpea.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ORIGIN AND PRODUCTION OF COWPEA

Cowpea is one of the most ancient crops known to man. Its origin and domestication occurred in Africa near Ethiopia and subsequently was developed mainly in the farms of the African Savannah. (UC SAREP ONLINE). Nowadays it is a legume widely adapted and grown throughout the world (Aeling, 1999).

Of the developed countries, only the United States is a substantial producer and exporter (Imrie, B., 2000). The United States exports around 2000 tons per year of very high quality cowpea. "In a shop anywhere in the world, if there is very large cowpea (> 25 grams per 100 grains) with white testa and very black eyes, it is probably a California product". (Langyintou *et al*., 2003) However, FAO estimates that 3.3 million tonnes of cowpea dry grain were produced worldwide in 2000. (IITA, 2001), but only a small proportion enters international trade. More than 8 million hectares of cowpea are grown in West and Central Africa. Also, it is known that Nigeria is the largest producer with 4 million hectares. Other producers are Niger, Mali, Burkina Faso and Senegal. The largest production is in Africa with Nigeria and Niger predominating, but Brazil, West India, Myanmar, Sri Lanka, Australia, the United States, Bosnia and Herzegovina all have significant production (Quinn, 1999) About 87 percent of that area is in Africa, 10 percent in the Americas and the rest in Europe and Asia. Nigeria alone is accounting for 45 percent of the total, followed by Brazil that produces 17 percent on 1,15 million hectares annually. (Langyintou *et al*., 2003). Around 3.7 millions tonnes of cowpea are produced annually on about 8.7 million hectares, throughout the world.

The production trend of cowpea in Nigeria shows a significant improvement with about 440 percent increase in area planted and 410 percent increase in yield from 1961 to 1995 (Ortiz, 1998). The development within the two decades is attributable to the significant advances made on cowpea seed improvement in the drylands by the IITA. Although Nigeria is the largest producer of cowpea in the world producing about 56 percent of the world production, it is also the largest consumer of cowpea in the world (NAQA, 2001). That is the reason why substantial amounts of cowpea come to Nigeria from neighbouring countries especially Cameroon and Chad. A large proportion of cowpea from Burkina Faso and Mali are sold into Côte d'Ivoire (Lowemberg-DeBoer *et al*., 2003). In Nigeria, the organization of traders in Kano's Dawanau market - the largest cowpea market in the world - differs from other trading organizations.

2.2. USES OF COWPEA

Cowpea is the most economically important indigenous african legume crop. (Langyntuo, *et al.,* 2003)**.** Cowpeas are of vital importance to the livelihood of several millions of people in West and Central Africa. Rural families that make up the larger part of the population of these regions derive from its production, food, animal feed, alongside cash income. The uses and importance of cowpea is highlighted in the following headings.

2.2.1 Commercial Crop

Cowpea grain matures earlier than cereals, hence becomes a quick source of cash before the maize, millets and cassava are harvested. Cowpea residue after harvest can also be sold which is used for feeding cattle, goats, pigs, sheep and other farm animals (IITA, 2001).

2.2.2 Forage

Cowpea can be used as forage, hay, and silage. When used as forage, it should only be lightly grazed after flowering. If there are several buds left after defoliation, the plant will regenerate. When used as silage, it can be mixed with sorghum, maize, or molasses to provide sugar for fermentation (FAO, 2012). In some African countries, several varieties of cowpea has been grown together for both food and feed (Cook *et al.,* 2005).

2.2.3 Cover crop and green manure

Cowpea is a quick growing cover crop that produces 2,500–4,500 lb/acre/yr of dry matter, while providing 100–150 lb/acre of N to the subsequent crop. Its long taproot and wide, vegetative spread make it an excellent plant for erosion prevention and weed suppression. Allelopathic compounds in the plant may help to suppress weeds (Clark, 2007). It has also been used successfully as groundcover in orchards and intercropped with cash crops such as cotton.

2.2.4 Human consumption

Cowpea is of major importance to the livelihoods of millions of relatively poor people in less developed countries of the tropics (FAO, 2002). Islam *et al.* (2006) emphasized that all parts of the plant used as food are nutritious providing protein and vitamins, immature pods and peas are used as vegetables while several snacks and main dishes are prepared from the grains (Duke, 1981; Bittenbender *et al.*, 1984). Egho (2009) reported that Nigeria is the second greatest consumer of cowpea in the whole world. Among the legumes, cowpea is the most extensively grown, distributed and traded food crop consumed, (Philips and McWalters, 1991; Ogbo, 2009: Agbogidi, 2010). This is because the crop is of considerable nutritional and of health value to man and livestock (Agbogidi, 2010). They form a major staple in the diet in Africa and Asian continents (Awe, 2008). The seeds make up the largest contributor to the overall protein intake of several rural and urban families hence Agbogidi (2010) regarded cowpea as the poor man's major source of protein. Their amino acid complements those of cereals (Fashokin and Ojo, 1988; Fashokin andFansaya, 1988; Asumugha, 2002). Their mineral contents: calcium and iron are higher than that of meat, fish and egg and the iron content equates that of milk; the vitamins- thiamin, riboflavin, niacin (water soluble) and their levels compare with that found in lean meat and fish (Platt, 1962; Adams, 1984; Rachie *et al*., 1985; Achuba, 2006) which make them very useful in blood cholesterol reduction (Johnson *et al*., 1983; Anderson, 1985). Many researchers including Anderson (1983), Adaji *et al*. (2007) have showed that daily consumption of 100– 135gm of dry beans reduces serum cholesterol level by 20% thereby, reducing the risk for coronary heart diseases by 40% (Anderson, 1985; Ofuya, 1993). Besides its health related benefits, beans are inexpensive, considerably cheaper than rice or any other dietary fibre type (Ayenlere *et al*., 2012).

2.3. PRODUCTION CONSTRAINTS

Particularly in African continent and in developing countries cowpea production constraint are part of a broad chain of problems and limitants occurring in three following broad areas:

• **Abiotic:** erratic rainfall, high soil temperatures, low soil fertility and degradated fragile soils;

• **Biotic:** insect pests, parasitic weed, diseases induced by fungi, viruses and nematodes;

• **Socio-economic**: resource-poor farmers are extremely risk-averse, farmer capacity to produce inputs is limited and input delivery systems function poorly.

The major field insect pests that can cause economic loss are cowpea aphids *(Aphis craccivora)*, leafhoppers *(Empoasca spp)*, thrips (*Megalurothrips sjostedti*—Synonym:*Taeniothrips sjostedti*), flower eating beetles *(Mylabris spp. and Coryna spp.*), blister beetles (*Hycleu slugens*) and green stink bugs (*Nezara viridula*) (IPM CRSP, 2000).

The cowpea weevil, *Callosobruchus maculatus*, F., (Coleoptera: chrysomelidae) is a serious pest of stored cowpea grains in sub-Sahara Africa (Al-Moajel and Al-Fuhaid, 2003). Postharvest losses of cowpea 3-4 months in storage caused by *C. maculatus* infestation have been reported as high as 50% in Northern Nigeria (Caswell, 1981) and 60% in Northern Ghana (Tanzubil, 1991). The loss of cowpea is a serious problem in Africa where as much as 20-50% of the grain is damaged by *C. maculatus* (FAO, 2013). The damage of this magnitude is incredibly high and demonstrates the destructive nature of the pest which can threaten food security at both household and national levels. This is a major agricultural problem for farmers in developing countries. Weevil infestation causes weight loss, quality deterioration resulting in overall acceptability problem in markets and impaired germinability of grains (Keita *et al.*, 2001). Infested grains are rendered unfit for consumption and sale.

2.3.1 <u>Pest status of *C. maculatus*</u>

Cowpe bruchid weevil is a cosmopolitan pest of stored legume seeds (Credland, 1986) They are widespread throughout the temperate and tropical world. Several species are agricultural pests that have the potential to destroy stores of legumes. One species in particular, the cowpea weevil, *C. maculatus*, is a cosmopolitan pest that causes considerable economic damage. (Profit, 1997). Bruchids are major pests on cowpea in Africa. Where it attacks dried cowpeas and other related stored seeds. They are mainly found on cowpea grains in storage and may be the main constraint to increased cowpea production.

2.3.2 Description of *C. maculatus*

The cowpea weevil lacks the "snout" of a true weevil. It is more elongated in shape than other members of the leaf beetle family. It is reddish-brown overall, with black and gray elytra marked with two central black spots. The last segment of the abdomen extends out from under the short elytra, and also has two black spots. (Tran and Credland, 1995) The beetle is sexually dimorphic and males are easily distinguished from females. The females are sometimes larger than males, but this is not true of all strains. Females are darker overall, while males are brown. The plate covering the end of the abdomen is large and dark in color along the sides in females, and smaller without the dark areas in males. (Fox and Reed, 2010) .There are two morphs of *C. maculatus*, a flightless form and a flying form. The flying form is more common in beetles that developed in conditions of high larval density and high temperatures. The flying form has a longer lifespan and lower fecundity, and the sexes are less dimorphic and can be more difficult to tell apart (Fox and Reed, 2010). The egg is clear, shiny, oval to spindle-shaped, and about 0.75 millimeters long. The larva is whitish in color.

2.3.3 Life cycle of *C. maculatus*

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. (Raina, 1970). 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. (Tran and Credland, 1995). It emerges after a larval period of 3 to 7 weeks, depending on conditions (Edvardsson and Tregenza, 2005). Once the beetle emerges as an adult, it may take 24 to 36 hours to mature completely. The lifespan is 10 to 14 days. 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 (Raina, 1970). The adult lives longer at 81% to 90% relative humidity (Schoof, 1941). In another experiment, temperatures of 17°C and 37°C with a constant humidity stressed the beetle, and the ideal temperature range was 24 to 28°C (Fox and Reed, 2011).

2.3.4. Damage caused by *C. maculatus*

The primary insect pest causing losses to stored cowpeas in West Africa is the cowpea weevil, *Callosobruchus maculatus.* Infestation begins in the field at low levels. After the crop is placed in storage, the insect population continues to grow until there is an obvious, severe infestation (Ntoukam *et al*., 2000). Damaged grains are full of small holes and dead beetles may be found inside the grains. The white eggs are glued to the outside of cowpea grains and are clearly visible as small white dots on the grain. Damage and weight loss in stored seeds is caused by larvae, which develop within the grain, consuming the seed (New Agriculturist on line). Infestation of postharvest cowpeas by bruchids also lead to loss in weight and quality of seeds, discoloration, changes of flavor, mould formation, reduced nutritional value due to lowered protein levels and poor germination of seeds due to embryo damage (Okonkwo, *et .al*.2017). Another aspect of concern aside from contamination of seeds by dead insects, pupae and larval cocoons is that, their integument has been found to contain various carcinogenic compounds such as ethyl, methyl and methoxy quinines which cannot be denatured by boiling or baking (Ileke, 2012)

2.4. CONTROL OF *C. maculatus*

2.4.1 Prophylactic control.

Good hygiene is an essential part of insect control in stored grain. Other options for pest control include: cooling grain with aeration, drying, treating grain by mixing dryacide or residual chemicals, treating infested grain with dichlorvos,fumigation (bombing) with phosphine, or controlled atmosphere treatment (e.g. carbon dioxide), treating storages and equipment with dryacide or residual chemicals.

A combination of good hygiene, aeration, drying, treating storages and equipment, and mixing chemicals or Dryacide with the grain is effective to prevent or reduce the chance of infestations developing. If insects are found, grain could be treated with dichlorvos, fumigate with phosphine, or apply a controlled atmosphere treatment. Insecticides, especially the dust form and the gas form are recommended for short-term storage. The product Actellic (2%) or Actellic Super and Phostoxin gas are very helpful to the farmer. However, insecticides are expensive and may not be available in all areas. Phostoxin is a fumigant that can kill humans and animals (Ntoukam *et al*., 2000). Problems, such as high persistence of the compounds, resurgence and genetic resistance of pests, negative effects on non-target organisms, poor knowledge of application, direct toxicity to the users, non-availability of the chemicals and increasing costs of application (Berger, 1994; Sharma *et al*., 2006).These drawbacks taken together necessitate the exploration of effective, affordable, safe and environmental-friendly control measures.

2.4.2 Biological control

The predators of *C. maculatus* include several parasitoid wasps. *Anisopteromalus calandrae*, *Uscana mukerjii*, and *Dinarmus* wasps specifically target *Callosobruchus* species

(Soundarajan, *et al.*, 2012). *Dinarmus basalis* parasitizes small larvae and halts their development. This limits the damage they can do to beans, but their presence still makes the beans unfit for human consumption and usually make them unfit for sowing, as well (Soundarajan, *et al.*, 2012). *Uscana mukerjii* is an egg parasite which prevents the egg from hatching, thereby preventing damage to the legume (Kapila and Agarwal, 1995).

2.4.3 Hermetic storage

Hermetic storage technologies like the use of Metal drums, plastic sheets and plastic bags have also proven successful in controlling *C. maculatus*. These technologies work by separating the container environment from the surrounding air and forcing the insects inside to deplete the available oxygen inside the container. Not only does this ultimately kill the insects, but it also reduces the level of damage they inflict as active feeding ceases below a certain threshold of oxygen (Murdock, *et al.*, 2000)

2.4.4 Low Temperature

In developed countries, one alternative is the use of cold storage. Johnson and Valero (2000) found that exposures to -18 ^{o}C for 6 to 24 hours reduced pest numbers by more than 99 percent. Freezing the whole storage area will also control *C. maculatus*. A period of 6 to 24 hours at -18°C kills all the adults and larvae. If the cooling is slow, the beetle can acclimatize, so longer freezing is required (Johnson and Valero, 2000).

2.4 5 Use of Botanical

In many areas of the world, locally available materials are widely used to protect stored produce against damage by insect infestation. Small-scale farmers throughout Nigeria are no exception in admixing wood ashes with cereal and pulse grains that they select and store for use as seed. Vegetable oils, leaves and twigs of certain plants and even dried sand and table salt are used for the same purpose. Over 2000 species of plants produce chemicals that have repellent or controlling properties (Boakye, *et.al* 2016). In developing countries, small-scale farmers mix the crushed leaves of *Cassia occidentalis* into bean stores to deter the beetle (Lienard, *et al*. 1993). The powdered leaves are effective, and a warm-water extract and the essential oil from the seeds are better (Lienard, *et al.* 1993). (Kestenholz *et al.* 2007). The seed oil does not stop oviposition, but it increases the mortality of the eggs and the first-instar larvae. The warm-water extract deters the adult female from ovipositing (Kestenholz, *et al*. 2007). Other botanical pest control agents tested include nishinda (*Vitex negundo*), Tasmanian blue gum (*Eucalyptus globulus*), bankalmi (*Ipomoea sepiaria*), neem (*Azadirachta indica*), safflower (*Carthamus tinctorius*), sesame (*Sesamum indicum*), and gum arabic (*Acacia nilotica* syn. *Acacia arabica*) (Rahman, and Talukder. 2006). Among other reports, seed oil of rubber plant, coconut, palm kernel and some other essential oils were applied on cowpeas in storage to control *C. maculatus* infestation (Malek and Wilkins, 2014). It is common practice in traditional African communities to use locally available plants for medicinal purposes and in agriculture (Obeng-Ofori *et al*., 2000).

In view of the above, the present study was aimed at investiging the insecticidal potential of Indian jujube (*Ziziphus mauritiana*), Christis thron (*Ziziphus spina Christi*), Camel's foot (*Piliostigma reticulatum)* and Tallow tree (*Detarium senegalense*), leave powders against *C. maculatus* on stored cowpea seeds.

2.5. Indian Jujube (*Ziziphus mauritiana*)

Ziziphus mauritiana, a member from the family *Rhamnaceae* with local name Ber, in Hausa (Magarya), is a fruit tree which grows in tropical and sub-tropical regions of the world. Different parts of this plant have been used in the traditional medicine for the treatment of different ailments such as asthma, allergies, depression and ulcers (Marwat *et al*., 2009). Nevertheless, some studies so far have also investigated the phenolics composition of the leaves of *Z. mauritiana* and illustrated the scientific basis for the uses of different parts of this plant for the treatment of diabetes, ulcer and inflammation (Bhatia & Mishra, 2010; Cisse *et al*., 2000; Gupta *et al*., 2012; Memon *et al*., 2012; Siddharth *et al*., 2010).

Plants based phenolic antioxidants, due to their unique structural features and multiple biological actions, play a promising role in the treatment of certain cancer and infectious diseases (Prasad *et al*., 2012; He *et al*., 2011; Miyasaki *et al.*, 2013; Bhalodia and Shukla, 2011). Due to the revival of interest in the use of plants as a source of food and medicine, currently the researchers are largely engaged in exploring and studying the bioactives composition and biological principles of many more plants (Elless *et al*., 2000; Lucock, 2004; Liu *et al.*, 2008).

2.6. Christis thron (*Ziziphus spina Christi*)

Ziziphus spina-christi belongs to genus *Ziziphus*, which are indigenous plants commonly found in Northern part of Nigeria and populalarly known as "Kurna" in hausa language. The stems, roots, leave and fruits extracts have been employed in the traditional health system for the treatment of various diseases and ailments (Pawlowska *et al*., 2009). However, the fruits are eaten directly or processed into snacks, dried candied and sometimes serve with a coffee and other soft drinks (Azam *et al*., 2006; Adekunle and Adenike, 2012). Therefore, this work is aimed at investigating the phytochemical and elemental compositions of the leaves which could be beneficial to rural populace who have closer access to the plant. Several researchers have found out that ethanolic edible fruits extracts of *Z. spina-christi* were found be gummy/oily in texture and appeared deep-brown in colour. This indicates the effect of ethanol in extracting organic compounds in the plant (Wendakoon *et al*., 2012). The phytochemical investigations revealed the presence of important secondary metabolites such as tannins, flavonoids, steroids, alkaloids and saponins. The presence of secondary metabolites in plants are essential and synthesized mainly for environmental adaptation and defence mechanism (Bourgaud *et al*., 2001). Plants containing important secondary metabolites have been utilized by mankind for their medicinal significance many years ago (Wink, 1988), this could support the use of *Z. spina-christi* edible fruits in the traditional health system among the people in the rural areas of Northern Nigeria. They have been using the fruit's tonic solutions as relief for people suffering from mental illness, which attributes to the presence of saponins and flavonoids in the fruits extracts and is in accordance with the finding of Jiang *et al*. (2007) where they reported the sedative effects of saponins and flavonoids isolated from the seeds of *Ziziphus* species. Tannins have been reported to poses antimicrobial and antioxidant activities (Rivière *et al*., 2009). Current reports show that tannins have potential value as cytotoxic and antineoplastic agents (Aguinaldo *et al*., 2005). Plant steroids have been investigated to possess anti-inflammatory, antimicrobial, analgesic and insecticidal properties (Argal 2006; Akindele, 2007).

2.7. Camel's Foot (*Piliostigma reticulatum*)

Is a plant that occurs in the Sahelo-Sudanian region of Africa from Senegal, Mauritania to Sudan and has been introduced to Mozambique (Fibres,1846). The plant is a dioeciously shrub or small tree up to 10–15 meters tall, bole short, rarely straight, up to 30 cm in diameter. In northern Nigeria the plant is locally known as "Kargo" and is widely used for many purposes. In Africa the plant is used as a traditional medicine for the treatment of many diseases, such as malaria, tuberculosis, and diarrhea (Dosso *et al*,. (2011). *Piliostigma* *reticulatum* is used in traditional medicine in Cameron to treat epilepsy, anxiety, and agitation. In fact, the results of a study conducted in Cameron suggested that it possesses anxiolytic and antipyretic properties in mice and could really be helpful in the treatment of anxiety (Sidiki *et al*. 2013). The leaf extract from the plant was found to exhibit anti-microbial activity against some bacteria and fungi such as *Staphylococcus aureus* (NCTC 6571, *Escherichia coli* (NCTC 10418), *Bacillus subtilis* (NCTC 8236), *Proteus vulgaris* (NCTC 4175), *Aspergillus niger* (ATCC 10578), and *Candida albicans* (NCTC 10231) (Olalekan and Babajide, *et al.*, 2008). Vibriocidal action of *P. reticulatum* among other medicinal plants was studied and proved to be effective in killing *Vibrio spp*. (Akinsinde, and Olukoya, 1995). In Nuba mountains in Sudan, the plant is widely used. The young leaves with their acidic taste are eaten. The fruits after maturation and drying is also eaten for its sweet taste and nowadays used for preparation of juice. The fresh bark of the plant is used for fresh wound dressing as it coagulates blood and is believed to enhance healing of the wound by keeping it clean. In the old days before the introduction of primary healthcare and midwifery facilities, the inner soft bark of *P. reticulatum* was widely used after delivery to cover the episiotomy wound (based on personal observation, one of the authors being part of the Nuba community).

2.8. Tallow Tree (*Detarium senegalense*)

Detarium senegalense is a leguminous tree in the subfamily Detarioideae. Unlike most members of the family, it produces globular fruits (Adenkunle, *et. al*, 2011). Its common names include ditax, ditakh, detar, taura and tallow tree. The tree is of value for several reasons: it produces nutritious fruits, (NRC, 2008) and is locally prominent in folk medicine (Akah, *et. al*., 2012) is a source of quality timber (El-Kamali 2011). It could contribute to food security, sustainable land care, and rural development. As its Linnaean name indicates, it is native to Senegal and the surrounding countries of West Africa. Several parts of the *Detarium senegalense* tree are utilized for a variety of purposes, but mainly for folk medicine. The bark of the tree is most widely used in preparations for: the expulsion of the placenta after birth and treatment of anaemia (Adenkunle, *et.al.,* 2011) wounds, skin problems, bronchitis, pneumonia, stomach ache and digestive disorders (Akah *et.al.*, 2012) tuberculosis and cases of heavy blood loss. Root decoctions are used to treat marasmus, debility, intestinal complaints, and convulsions (Akah, *et.al.,* 2012). Leaf and shoot mixtures have been used in the treatment of dysentery, conjunctivitis, arthritis, fractures, and boils (El-Kamali 2011) Seeds have been applied to control blood-glucose levels in diabetic individuals, for the treatment of mosquito bites (Cisse, *et.al.*, 2010) and as an antidote against arrow poison and snake bite (Akah, *et.al.*, 2012). Leaves from the trees have demonstrated antiviral activity - against a number of human and animal viruses and the bark has shown antibacterial activity against many pathogenic bacteria, justifying the medicinal properties of the plant (El-Kamali , 2011).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3. 1 EXPERIMENTAL SITE

The experiment was conducted in Entomology Laboratory of the Department of Crop Protection of Faculty of Agriculture, Bayero University Kano, during the months of October – November 2019.

3.2 SOURCE OF INSECTS

The initial cultures of *C. maculatus* were obtained from already infested cowpea seeds in the laboratory and were used to establish new cultures on cowpea. The stock cultures of *C. maculatus* were raised by placing 100 unsexed adults in two-liter jar half full of disinfected kanannado cowpea seeds. Before infestation, the cowpea seeds were spread on a polythene bag under the sun for three days in order to disinfest the cowpea. Muslin cloth was used to cover the top of the jars so that cowpea weevils could not escape. This was allowed for mating and oviposition for further multiplication of the insect until the required numbers were obtained. The parent stocks were sieved out and the seeds containing eggs (subsequent) F1 progenies from the cultures were used for the experiment (Plate 1).

Plate I: Highly infested cowpea seeds

3.3. SOURCE OF COWPEA SEEDS

A local cowpea variety (Kanannado) was purchased from Dawanau International Grains Market at Dawakin Tofa local government area of Kano State, and the seeds were visually checked to ensure that they were not infested. Furthermore, the seeds were placed in freezer for 3 days to ensure that all stages of insects present were destroyed by the cold.

3.4. SOURCE AND PREPARATIONS OF PLANT LEAVES

The four plant products, Viz: Camels foot (*Piliostigma reticulatum),* Tallow tree (*Detarium senegalense*), Indian jujube (*Ziziphus mauritiana*) *and* Christis thorn (*Ziziphus spina christi*) (Plate II) used as treatments in this study were collected from the vicinity of Bayero University Kano (New site campus). Each plant material was washed and dried under shade for seven days in the laboratory and ground to a fine powder using electric blender, the powders were further sieved to pass through 1 mm^2 perforation. The powdered materials were kept in air-tight containers, labeled, and stored at room temperature until need for the experiment

Plate II: Preparation of Botanical leaf powders

3.5. EXPERIMENTAL TEST PROCEDURES

Experiment 1: A Study on the Evaluation of Insecticidal Potential of the Botanicals

Hundreds grams' seeds of cowpea were placed in a glass jar and then thoroughly mixed with the various plant leaf powders at three (3) dosage/concentration levels (1,3 and 5g/100g of cowpea seeds), while synthetic insecticides (Permethrin) at 0.12g/100 seeds as standard check, and untreated cowpea seed was served as control. Five (5) pairs of newly emerged adults are then introduced in each container of cowpea using entomological aspirator, then containers were closed by muslin cloth and tightly rubber band. Each treatment was replicated three times, labeled and arranged in Completely Randomized Design (CRD) on laboratory bench for eight weeks.

Experiment 2: A Study on Residual Toxicity of the Botanicals

A total of 30 seeds that contained eggs of the F1 generation were selected and placed into a new plastic container containing treated uninfested cowpea seeds, dead insect (adult, pupae and larvae) from the F2 progeny were counted.

3.6 DATA COLLECTION

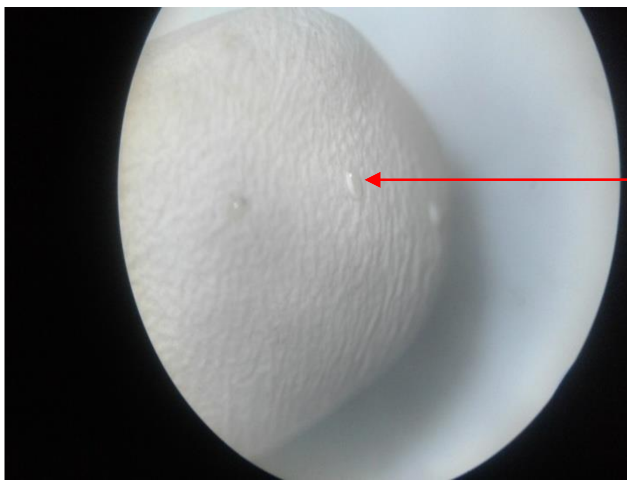
3.6. 1. Mortality rate

Number of dead insects in each treatment and replicates was removed, counted and recorded at seven (7) days after infestation. Insect were probed three (3) times with a tip of pen to confirm mortality (Yusuf *et al*., 2009). Mortality rate was calculated using the formula:

$$\text{Mortality rate} = \frac{\text{Number of dead } C.\ maculatus}{\text{Total number of } C.\ maculatus}$$

3.6.2 Fecundity of *C. maculatus*

The insects were allowed to mate and oviposit for 10 days, after which the number of seed with eggs and number of eggs deposited on the seeds (Plate III) were counted with the aid of dissecting microscope and recorded from each of the experiment unit, while the seeds from each treatment were examined individually (Arong *et al.*, 2011)



Egg of *C .maculatus*

Plate III: Egg laid on cowpea by *C. maculatus*

3.6.3 Egg Hatchability and Progeny Development of *C maculatus*

At 10 days oviposition, 30 seeds that contain eggs were selected and placed into a new plastic container containing clean un-infested treated *V. unguculata* seeds. Adult that emerged were recorded at 30 days after the exposure (Musa, 2013).

Percentage adult emergence was calculated from each of the treatments and replicates, using the formula:

$$\% \text{ Adult emergence} = \frac{\text{Number of adult emerged}}{\text{Number of eggs laid}} \times 100$$

3.6.4 Number of holes per grains

At the end of the experiment 60 days, the number of exit holes was assessed by counting the number of holes which appeared on each seed with the aid of dissecting needle. The seeds were turned upside down and from side to side to ensure that no hole was left uncounted.

3.6.5 Percentage Seed Damage

At the end of the experiment, 30 seeds were randomly selected from the sample bottles and the seeds were separated into damaged and undamaged categories and each was counted thus percentage seed damage was calculated as described by Sibakwe and Donga (2015),

$$\% \text{ Seed damage} = \frac{\text{Number of seed damage}}{\text{Total number of seeds}} \times 100$$

3.6.6 Grains Weight loss

At the end of the experiment, all dead insects and other debris in the cowpea seeds were removed and the seeds were weighed to obtained the final seed weight of the samples. Percentage seed weight loss was calculated as follows. (Sibakwe and Donga 2015)

$$\% \text{ weight loss} = \frac{\text{Initial Weight-Final weight}}{\text{Initial weight}} \times 100$$

3.6.7 Germination percentage

At the end of the experiment, ten (10) seeds were randomly picked from each jar for all the treatment and replicates, and placed in a Petri dishes lined with moistened filter paper. These were left on the laboratory bench at ambient temperature and relative humidity for seven (7) days after which germination percentage was calculated using the formula: (Olisa *et.al.*,2010)

$$\% \text{ Germination} = \frac{\text{Number of germinated seed}}{\text{Total number of seed planted}} \times 100$$

Plate IV: Cowpea seeds germination test

3.7 RESIDUAL TOXICITY

Data on residual toxicity was collected by counting the number of dead insects from the F_2 progeny reproduced by the parents that was introduced into the treated seeds. These data were recorded at 60 days after treatment as discribed by Abduljalal *et al.*, (2011).

3.7.1 Larval Mortality

Larval mortality was obtained by opening the seeds with a scalpe and a pair of forceps at the end of adult emergence and dead larvae inside the seeds were counted and express as percentage of the seed examined (Arong *et al.*, 2011).

3.7.2 Pupal Mortality

Similarly, pupal mortality was obtained at the end of adult emergence and dead pupae within the seeds were counted and recorded (Arong *et al.*, 20011)

3.8 DATA ANALYSIS

Data collected were subjected to analysis of variance (ANOVA) using Genstat 17th Edition computer software. Significant treatment means were separated using Student Newman Keuls (SNK) test at 5% level of probability.

CHAPTER FOUR

4.0 RESULTS

4.1: EFFECT OF SOME BIO-PESTICIDES LEAF POWDERS ON ADULT MORTALITY, OF *C. maculatus* ON STORED COWPEA SEEDS

Table 1 clearly shows that the synthetic chemical cased significantly higher adult mortality (0.9) rate, which was statistically similar with Cowpea seed treated with *Zizphus mauritiana* and *Ziziphus spina christis* leave powders at 3 and 5gram concentrations (0.8). The lowest mortality was recorded in the untreated control (0.07) which was not significantly different from the mortalities recorded in grains treated with *P. reticulatum* and *D. senegalense*, irrespective of the rate of application.

4.2: EFFECT OF SOME BIO-PESTICIDES LEAF POWDERS ON FECUNDITY OF *C. maculatus* ON STORED COWPEA SEEDS

Results presented in Table 2 show that all the tested materials affected the numbers of eggs laid by *C. maculatus*. Cowpea seed treated with *Z. mauritiana* and *Z. spina christis* leaf powders at 3 and 5 gram concentrations had higher number of eggs (26.67- 28.0) but not significantly different from that of synthetic chemical, (25.33). The untreated control had significantly highest number of eggs (100.67) than all other treatments.

Table 1: Adult mortality of *C. maculatus* at seven days after exposure to cowpea seeds treated with plant leaf powders

Treatment	Amount used (g/100g)	Number of Insects Introduced	Mean Mortality (Rate)
Z. mauritiana	1	10	0.37b
	3	10	0.80a
	5	10	0.83a
Z. spina christis	1	10	0.33bc
	3	10	0.83a
	5	10	0.83a
P. reticulatum	1	10	0.17d
	3	10	0.23cd
	5	10	0.17d
D. senegalense	1	10	0.10d
	3	10	0.20cd
	5	10	0.10d
Permethrin	0.12	10	0.9a
Control	0.00	10	0.07d
SE+	-	-	0.0398

Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

Table 2**:** Effect of plant leaf powders on fecundity of *C. maculatus* infesting treated cowpea seeds.

Treatment	Amount used (g/100g)	Number of Insects Introduced	Number of eggs laid
Z. mauritiana	1	10	63.67d
	3	10	27.00e
	5	10	26.67e
Z. spina christis	1	10	62.00d
	3	10	28.00e
	5	10	27.67e
P. reticulatum	1	10	77.33c
	3	10	80.33bc
	5	10	84.33b
D. senegalense	1	10	81.00bc
	3	10	80.33bc
	5	10	81.00bc
Permethrine	0.12	10	25.33e
Control	0.00	10	100.67a
SE+	-	-	1.373

Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

4.3: EFFECT OF SOME BIO-PESTICIDES LEAF POWDERS ON ADULT EMERGENCE OF *C. maculatus* ON STORED COWPEA SEEDS

All the plant leaf powders and their concentrations significantly affected adult emergence of *C. maculatus* 30 days after treatment (Table 3). *Z. mauritiana* and *Z. spina christis* leave powders at 3 and 5 gram concentrations recorded the lowest adult emergence (0.55) which did not differ significantly with the chemical control which recorded (0.33). The untreated control recorded significantly highest number of adult emergence (36.11) than all other treatments.

4.4: EFFECT OF SOME BIO-PESTICIDES LEAF POWDERS ON SEED PERFORATION, CAUSED BY *C. maculatus* ON STORED COWPEA SEEDS

Table 4 shows the effected of plant materials on numbers of holed seed caused by *C. maculatus*. Lowest seed perforation (0.33-0.67) was recorded at concentration 3 and 5g treated seed with *Z. mauritiana* and *Z. spina christis* leaf powders, which were comparable with permethrin powder. The highest seeds perforation was recorded in untreated control seeds (79.00) which was significantly ($P<0.05$) higher than perforations recorded in all other treatments.

4.5: PERCENTAGE SEED DAMAGE CAUSED BY ADULT *C. maculatus* ON COWPEA SEEDS TREATED WITH SOME PLANT LEAF POWDER.

Table 5 indicateds that there was significant difference ($P<0.05$), in % seed damage among all the treatment compared with the untreated control. Seeds treated with *Z. mauritiana* and *Z. spina christis* leaf powders at 3 and 5g concentrations recorded the lowest seed damage of (0.00 - 1.11), followed by *P. reticulatum* and *D. senegalense*. However there was significant difference between the treated seeds and the untreated control which sustained the highest seed damage (43.33).

Table 3: Mean percentage adult emergence of *C. maculatus* on cowpea seeds thirty days after exposure to plant leaf powders

Treatment	Amount used (g/100g)	Number of Insects Introduced	Number of Seed Sample	% Adult Emergency
Z. mauritiana	1	10	30	10.00c
	3	10	30	1.11d
	5	10	30	0.55d
Z. spina christis	1	10	30	11.11c
	3	10	30	0.00d
	5	10	30	0.55d
P. reticulatum	1	10	30	29.44b
	3	10	30	29.44b
	5	10	30	30.55b
D. senegalense	1	10	30	30.55b
	3	10	30	30.00b
	5	10	30	31.77b
Permethrin	0.12	10	30	0.33d
Control	0.00	10	30	36.11a
SE+	-	-	-	0.855

Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

Table 4: Mean percentage of seed perforation caused by adult *C. maculatus* on cowpea seeds treated with four plant leaf powders

Treatment	Amount used (g/100g)	Number of Insect Introduced	Number of holed cowpea seeds
Z. mauritiana	1	10	19.00e
	3	10	0.67f
	5	10	0.33f
Z. spina christis	1	10	19.00e
	3	10	0.67f
	5	10	0.67f
P. reticulatum	1	10	62.67d
	3	10	64.00cd
	5	10	63.67cd
D. senegalense	1	10	67.67b
	3	10	67.00b
	5	10	65.67c
Permethrine	0.12	10	0.00f
Control	0.00	10	76.00a
SE+	-	-	0.638

Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

Table 5: Percentage seed damage caused by adult *C. maculatus* on cowpea seeds treated with some plant leaf powders

Treatment	**Amount used (g/100g)**	**Number of Insects Introduced**	**% Cowpea seed damage**
Z. mauritiana	1	10	20.00d
	3	10	1.11e
	5	10	0.00e
Z. spina christis	1	10	26.66c
	3	10	1.11e
	5	10	1.11e
P. reticulatum	1	10	36.66b
	3	10	35.55b
	5	10	36.66b
D. senegalense	1	10	36.66b
	3	10	36.66b
	5	10	36.66b
Permethrine	0.12	10	0.00e
Control	0.00	10	43.33a
SE+	-	-	1.784

Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

4.6: EFFECT OF PLANT LEAF POWDERS ON PERCENTAGE SEED WEIGHT LOSS CAUSED BY ADULT *C. maculatus*

Data presented in Table 6 shows percentage seed weight loss caused by adult *C. maculatus* on cowpea seeds treated with plant leaf powders. Minimum weight loss (0.33%) was recorded in seed treated with *Z. mauritiana* and *Z. spina christis* leaf powders at 3 and 5g concentrations, followed by *P. raticulatum* and *D. segegalense* which recorded (28.00%) at 3 and 5g concentrations respectively. The synthetic chemical completely prevented seed weight loss (0.00) and was significantly different (P.0.05) from the untreated control (32.33%) and seeds treated with 1g of *Z.mauritiana* and *Z. spina christi* .

4.7: GERMINATION PERCENTAGE OF COWPEA SEED TREATED WITH SOME PLANT LEAVES POWDER.

Table 7 shows the germination of cowpea seeds treated with various leaf powders. Seeds treated with *Z. mauritiana* and *Z. spina christis* leaf powders at 3 and 5g recorded the highest germination percentage of 96.67%, which were not significantly different from the chemical control which recorded 99.67%. Untreated seeds recorded the lowest germination percentage

Table 6: Percentage weight loss caused by adult *C. maculatus* on cowpea seeds treated with some plant leaf powders

Treatment	Amount used (g/100g)	Number of Insects Introduced	% Cowpea weight loss
Z. mauritiana	1	10	5.00c
	3	10	0.33d
	5	10	0.33d
Z. spina christis	1	10	5.33c
	3	10	0.33d
	5	10	0.33d
P. reticulatum	1	10	29.00b
	3	10	28.00b
	5	10	28.67b
D. senegalense	1	10	28.67b
	3	10	28.00b
	5	10	28.00b
Permethrine	0.12	10	0.00d
Control	0.00	10	32.33a
SE+	-	-	0.512

Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test

Table 7: Mean germination Percentage of cowpea seeds treated with some plant leaf powders

Treatment	Amount used (g/100g)	Number of Seeds Planted	% Seeds Germination
Z. mauritiana	1	10	63.33b
	3	10	93.33a
	5	10	96.67a
Z. spina christis	1	10	66.67b
	3	10	96.67a
	5	10	96.67a
P. reticulatum	1	10	16.67c
	3	10	13.33c
	5	10	6.67c
D. senegalense	1	10	13.33c
	3	10	10.00c
	5	10	10.00c
Permethrine	0.12	10	96.67a
Control	0.00	10	6.67c
SE+	-	-	3.87

Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

4.8: EFFECT OF PLANT LEAF POWDERS ON THE MORTALITY OF F_2 GENERATION, LARVAE AND PUPAE OF *C. maculatus* SIXTY DAYS AFTER TREATMENT.

Results in Table 8 shows that pupal, larval and F_2 generation mortality of *C. maculatus* has been affected by all the plant leaf powders, and there were significant ($P<0.05$) differences among the treatments. Seeds treated with *Z. spina* Christis leaf powder caused the highest adult mortality (7.33) at 3g/100g seeds, followed by *Z. Mauritian* at 3 and 5g/100g seeds which was significantly different with Permethrin and untreated check.

Similarly seeds treated with *Z. mauritiana* leaf powder at 3 and 5g/100g seeds recorded high pupal mortality (4.00) and (3.00) respectively, compared to Permethrin and control. Lower larval mortality was achieved on seed treat with *P. reticulatum* leaf powder (0.00), which was statistically similar with other leaf powders and significantly different from the control.

Table 8: Mean mortality of adult, pupal and larvae of *C. maculatus* (F_2 generation) sixty days after treatment with leaf powders

			Residual Toxicity	
Treatment	**Amount used (g/100g seeds)**	**Adult Mortality**	**Pupal Mortality**	**Larva Mortality**
Z. mauritiana	1	2.67bc	1.00c	0.67bc
	3	6.67a	4.00a	0.67bc
	5	6.67a	3.00ab	0.67bc
Z. spina christis	1	2.33bc	1.33c	0.33bc
	3	7.33a	3.00ab	0.67bc
	5	6.67a	2.00bc	1.00ab
P. reticulatum	1	1.00ef	0.33c	1.00ab
	3	1.67cd	0.76c	0.00c
	5	0.67eg	0.33c	0.33bc
D. senegalense	1	0.33g	0.33c	0.33bc
	3	1.67cd	0.67c	0.67bc
	5	1.00ef	0.33c	0.33bc
Permethrine	0.12	0.33g	0.33c	0.33bc
Control	0.00	3.33b	2.00bc	2.33a
SE+	-	0.384	0.385	0.351

Means followed by same letter(s) within same column are not significantly different at P=0.05 according to SNK test.

CHAPTER FIVE

5.0 DISCUSSION

From the results obtained, it can be seen that the plant leaf powders of *Z. mauritiana* and *Z. spina christis* used in this research showed significant (P < 0.05) effect on the mortality and fecundity of adult *C. maculatus* as well as damage caused on cowpea seeds. Both of the leaf powders were observed to have affected the mortality of *C. maculatus* at varying concentrations applied.

The results of this study are in conformity with the report of previous workers (Opareke and Dike, 2005, Adedire *et al*. 2011, Mukanga *et al*. 2010, Ileke .and Oni 2011), who observed that certain botanicals were effectively toxic against storage insect pests including *C. maculatus*. The resultant mortality rates of *C. maculatus* in this investigation could be attributed to the insecticidal effects of the chemicals in the tested plant species.

Z. mauritiana and *Z. spina christis* leaf powders exhibited the strongest insecticidal effect due to the presence of secondary metabolites like alkaloid, phenolic and terpenoid (Bourgaud *et al*., 2001), The high toxicity of *Z. mauritiana* and *Z. spina christis* could be attributed to phenolic and alkaloid metabolites which act as insecticides, repellants and antifeedants against insects (Argal 2006; Akindele, 2007). Result of the present study are in line with the findings of (Devi and Bora, 2017) who reported the effect of phenolic extracts of *Ziziphus jujuba* leaves on *Aedes aegypti* (Diptera:Culicidae). Earlier *Z. jujuba* has been reported to be effective against *Culex pipiens* larvae in which the petroleum ether extract and oil had caused pathological effect on pupa and adult (El Husseiny *et al.,* 2014).

Several researchers have worked on plants and naturally derived pesticides that are non toxic to human and other animals (Makur *et al,* 2008). This serve as useful tool for the development of a safer, effective, sustainable and environmentally friendly bruchids control tactics. Promising results obtained in this study showed the insecticidal effect of *Z. mauritiana* and *Z. spina christis* against *C. maculatus.* The identified compounds (Secondary metabolites) which are naturally occurring in most plant materials are known to be pesticidal, bactericidal and fungicidal in nature thus conferring the pesticidal activity to plants (Aqil *et al*, 2006). The presence of some these compounds has been demonstrated previously by other researchers.

The present study confirms plant leaf powders of *Z. mauritiana* and *Z. spina christis* had relatively caused high mortality of *C. maculatus* on stored cowpea seeds. However, the findings of Bhagat and Tripatri (1989) and Lucy *et al*, (2016) contrasted with this study as they reported an increasing efficacy of neem leaf powder as concentration increased from 1-3g/100g seeds. On the other hand, the plant extracts might have interfered with the normal embryonic development by suppressing hormonal and biochemical processes. Similar physiological interferences were observed by Ofuya *et al*. (2002) and Jeyakumar *et al.* (2003). Similarly, oviposition and adult emergence are suppressed in grains treated *Z. mauritiana* and *Z. spina christis* leaf powders, which is similar with the findings of Yusuf and Ahmed (2007), who reported that the ground parts of some plants (Neem, Chinaberry, Eucalyptus and Chilli) were effective in suppressing the emergence of the maize weevils *Sitophilus. zeamais* on stored maize grains

All the treatments with the exception of the control (untreated grains) prove effective in reducing the number of emergence holes suggesting low amount of bruchid perforated grains on seeds treated with *Z. mauritiana* and *Z. spina christis* leaf powders. This agrees with earlier findings of Asawalaam and Emosairue (2006), who found the powdered form of *Piper guineese* and pirimiphos-methyl were effective in controlling weevil perforation caused by *S.*

*zeamai*s, on stored maize grains. Damage caused by bruchids on cowpea seeds was highly reduced in all the treatments. The leaf powders of *Z. mauritiana* and *Z. spina christis* appeared to be more promising as they compared favorably with the synthetic insecticide (Permethrin) treatment. These findings collaborates with that of Dike and Mshelia (1997) who reported that phenolics are well known to be directly involved in protection of grains by insects through antixenosis and antibiosis mechanisms.

On the other hand, grains treated with *Z. mauritiana* and *Z. spina christis* leaf powders showed no significant effect on loss in grain weight. This is similar to the findings of Yusuf (2009), who reported the ground form of five plant materials (neem, chinaberry, eucalyptus, chilli and mahogany wood ash) were effective in reducing grain damage and loss in grain weight caused by *S. zeamais* on stored maize grains. Application of *Z. mauritiana* and *Z. spina christis* leaf powders as treatments showed no significant effect on the germination of the seed after 60 days. These are similar to the findings of Obeng-Ofori and Dankwah (2002) who showed that neem leaf powder and Actellic 25EC did not affect the germination of Bambara nut seed after 60 days of treatments. In a similar study Mariappan *et al.* (2013), reported that seeds protected with *Jatropha curcas* pelleted with pungan leaf powder and *Pongamia pinna* seeds pelleted with neem leaf gave high germination percentage due to effective protection from fungal and insects attacks, thus increasing percent germination of the treated seeds.

Pesticides are also adulterated by unscrupulous traders, which have resulted in development of resistance by several species of storage insects in Uganda and elsewhere (Pereira *et al,* 2008). Chemical grain dusts are also usually very expensive, not readily available to farmers and prone to human and environmental toxicity (Dugje *et al.,* 2009).

Cultural methods such as sun-drying of seeds to reduce moisture and pest damage are alternative options that have been used in the past with little pest management success (Kestenholz, 2002). Plants such as neem (*Azadirachta indica*), chili pepper (*Capsium annuum*), clove (*Syzygium aromaticum*), Ethiopian pepper (*Xylopia aethiopica*), etc. possess secondasry metabolites which act as antifeedants, oviposition deterrents, larvicidal and insect growth regulators (Asawalam and Anaeto, 2014). These plants are known to repel insects and the products from these plants have been reported to be toxic to insects (Adesina *et al.,* 2015). Application of products of such plants, fresh or dried materials, extracts or oil to stored products have been shown to effectively protect stored products against *C. maculatus* infestation (Kashere *et al.,* 2015). Oparaeke and Dike (2005), recorded success using plant oils from calabash nutmeg (*Monodora myristica*) and Onion (*Allium cepa*) as protectants against *C. maculatus* infesting stored cowpea seeds.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

The study was conducted in the laboratory of the Department of Crop Protection, Faculty of Agriculture, Bayero University Kano during the months of October to November to determine the efficacy of plant derived pesticides on stored cowpea seed for the management of *Callosobruchus maculatus*. Leaves powder of Indian jujube (*Ziziphus mauritiana*), Christis thron (*Ziziphus spina Christi*) Camel's foot (*Piliostigma reticulatum)* and Tallow tree (*Detarium senegalense*) at three concentration/dosage levels each, permethrin as (standard check) and control (untreated seeds) were laid out in a completely randomized design (CRD) and replicated three times.

Results showed significant increase in mortality of C. maculatus after seven days exposure to Indian jujube (*Ziziphus mauritiana*) and Christis thron (*Ziziphus spina Christi*) leaf powders while Camel's foot (*Piliostigma reticulatum)* and Tallow tree (*Detarium senegalense*) was statistically similar with untreated control. The number of eggs laid had reduced on both *Z. mauritiana and Z. spina christis* leaf powder treated seeds, however, the untreated control recorded the highest number of eggs laid and number of emergence of *C. maculatus*. More so, the percentage grain damage, seed perforation and grain weight loss were significantly lowered by both the leaf powders, and all had no adverse effects on seeds germination. Findings of this study showed that leaves of *Z. mauritiana and Z. spina christis* were effective against *C. maculatus* infestation.

6.2 CONCLUSION

Ziziphus. mauritiana and Ziziphus. spina christis leaf powders performed better than Camel's foot (*Piliostigma reticulatum)* and Tallow tree (*Detarium senegalense*) irrespective of their concentrations and statistically similar to the synthetic chemical (permethrin). However, among the leaf powders concentrations, better protection of cowpea seeds was achieved with *Z. mauritiana and Z. spina christis* at 3 and 5g dosage rate. Higher adult mortality of *C. maculatus*, reduction in oviposition, seed damage and weight loss, inhibition of progeny emergence were achieved by using both the *Z. mauritiana and Z. spina christis* leaf powders.

6.3 RECOMMENDATIONS

Therefore, based on the present results of this research work, the following recommendations are made:

I. The use of *Z. mauritiana and Z. spina christis* leaf powders at 3g/100g seeds could be use for the management of *C. maculatus* on stored cowpea

II. It is recommended that similar investigation on different parts of the tested plants species be carried out to further evaluate their efficacy against the *C. maculatus* and other storage insect pests.

III. Further investigation to determine the substances responsible for the insecticidal activity are also recommended.

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APPENDICES

Appendix I

Analysis of variance for Adult Mortality of *C. maculatus* at seven days after exposure to cowpea seeds treated with four plant leaf powders.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications stratum	2	0.036190	0.018095	3.80	
Replications.*Units* stratum					
Treatments	13	4.316190	0.332015	69.72	<.001
Residual	26	0.123810	0.004762		
Total	41	4.476190			

Appendix II

Analysis of variance for effect of plant leaf powders on fecundity of C. maculatus

Source of variation	d.f.	s.s	m.s.	v.r	F pr.
Replications stratum	2	12.905	6.452	1.14	
Replications.*Units* stratum					
Treatments	13	29225.905	2248.147	397.37	<.001
Residual	26	147.095	5.658		
Total	41	29385.905			

Appendix III

Analysis of variance for percentage progeny emergence of C. maculatus at thirty days after exposure to cowpea seeds treated with plant leaf powders.

Source of variation	d.f	s.s.	m.s	v.r.	Fpr.
Replications stratum	2	0.197	0.098	0.04	
Replications.*Units* stratum					
Treatments	13	8617.262	662.866	302.02	<.001
Residual	26	57.065	2.195		
Total	41	8674.523			

Appendix IV

Analysis of variance for Mean percentage of seed perforation caused by adult of C. maculatus on cowpea seeds treated with plant leaf powders.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications stratum	2	5.571	2.786	2.28	
Replications.*Units* stratum					
Treatments	13	41526.952	3194.381	2614.89	<.001
Residual	26	31.762	1.222		
Total	41	41564.286			

Appendix V

Analysis of variance for percentage of seed damage caused by adult of C. maculatus on cowpea seeds treated with plant leaf powders.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications stratum	2	11.098	5.549	0.58	
Replications.*Units* stratum					
Treatments	13	11868.118	912.932	95.67	<.001
Residual	26	248.109	9.543		
Total	41	12127.326			

Appendix V I

Analysis of variance for percentage weight loss caused by adult of C. maculatus on cowpea seeds treated with plant leaf powders.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications stratum	2	0.9048	0.4524	0.58	
Replications.*Units* stratum					
Treatments	13	7963.6429	612.5879	779.66	<.001
Residual	26	20.4286	0.7857		
Total	41	7984.9762			

Appendix VI I

Analysis of variance for Germination percentage of cowpea seeds treated with plant leaf powders.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replications stratum	2	33.33	16.67	0.37	
Replications.*Units* stratum					
Treatments	13	65361.90	5027.84	112.05	<.001
Residual	26	1166.67	44.87		
Total	41	66561.90			

Appendix VIII

How the treatments were infested with newly emerged *C. maculatus*

Appendix IV

Application of leaf powders at different concentration