# STATUS AND EFFECTS OF INSECT PESTS ON THE CASHEW (*Anacardium occidentale* L.) IN SOUTHERN AND CENTRAL ZONES, TANZANIA

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**A Dissertation Submitted in Partial Fulfillment of the Requirement for the Degree of Masters in Life Sciences of the Nelson Mandela African Institution of Science and Technology**

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## ABSTRACT

This study was conducted from February to March and July to August 2019 in twenty-four (24) cashew fields located in the southern and central zones of Tanzania. In each zone, three districts were selected based on cashew production reports, and in each district, four farms were selected. In each farm, ten fully-grown cashew nut trees were randomly selected and assessed for infestation by sucking insect pests. The insect pests were assessed within quadrants of one-meter length placed at the north and south of the canopy of the cashew tree. The total number of insect pests, susceptible shoots and nuts, both clean and damaged were recorded. Insect samples were collected and identified at the Tropical Pesticides Research Institute, Arusha Tanzania. Twenty-seven (27) key informant farmers were interviewed using questionnaires and farmers group discussions in both zones. The study revealed a number of both known and first recorded insect pest's attacks that cashew nut. The commonly known insect pests identified include *Helopeltis sp, Pseudotheraptus wayi, Selenothrips rubrocinctus and Mecocorynus loripes*, and newly recorded were *Miphetophora sp., Plaesiorrhira sp., Diplognatha gagates, Systates sp,* and *Aphis sp*. The incidence and diversity of these cashew sucking insect pests differed in terms of abundance and distribution within cashew fields. Most abundant insect pests were *Helopeltis sp*. with incidences of 46.7%. Further research is required in studying biology, ecology population dynamics and abundance of first reported and identified insect pests to determine specific periods for intervention and develop methods (species-specific) for effective pest management in Tanzania.

## DECLARATION

I, Bobnoel Boniface Assenga do hereby declare to the Senate of Nelson Mandela African Institution of Science and Technology that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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The above declaration is confirmed

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## CERTIFICATION

The undersigned certify that they have read the dissertation titled "Status and effects of insect pests on the cashew (*Anacardium occidentale* L.) in southern and central zones, Tanzania" and recommend for examination in fulfilment of the requirements for the degree of Masters in Life Sciences with specialization in Sustainable Agriculture of the Nelson Mandela African Institution of Science and Technology (NM-AIST).

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## DEDICATION

This work is dedicated to my beloved wife Paschalina Marko Bura and my lovely son Brighton as well as my daughters Lightness, Irene and Careen Assenga for their inspiration and the encouragement.

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## LIST OF ABBREVIATIONS AND SYMBOLS

| | |
|---|---|
| % | Percentage |
| ≤ | Less than or equal to |
| AC4 | Anacardium Ceylon 4 |
| ANOVA | Analysis of Variance |
| AZA 17 | Anacardium Zanzibar 17 |
| AZA 2 | Anacardium Zanzibar 2 |
| BL | Black Lesions |
| CBT | Cashewnut Board of Tanzania |
| CV | Coefficient of Variation |
| FAO | Food and Agriculture Organization |
| FGD | Farmers Group Discussion |
| GenStat | General Statistics |
| GPS | Global Positioning System |
| ha | Hectare |
| LD | Leaf Damage |
| LSD | Least Significant Different |
| mls | Milliliters |
| N | North |
| NARI | Naliendele Agricultural Research Institute |
| NM-AIST | Nelson Mandela African Institution of Science and Technology |
| ºC | Degrees Celsius |
| P | Probability |
| QGIS | Quantum Geographic Information System |
| S | South |
| sp. | Species |
| SPSS | Statistical Package for Social Science |
| TARI | Tanzania Agricultural Research Institute |
| TPRI | Tropical Pesticides Research Institute |
| TS | Total Shoots |

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background of the problem

Cashew (*Anacardium occidentale* L.) is a tree, native of South and Central America currently grown in many tropical countries worldwide as a nut-producing cash crop (Johnson, 1973; Masawe, 2006; Nair, 2010; Ohler, 1979; Zhongrum & Masawe, 2014). Cashew was introduced to East Africa by the Portuguese in the 16$^{th}$ century, and it is now widely cultivated, especially in Tanzania (Masawe, 1994). The crop was introduced for afforestation and control of soil erosion along with the coastal areas of Tanzania, Kenya, Mozambique and Nigeria (Mitchell & Mori, 1987; Olotu *et al.*, 2013). In Tanzania, cashew is grown in southern and eastern zones, but recently the government has scaled up the production into new growth areas in the central and western zones of the country particularly Dodoma, Singida and Tabora regions (NARI, 2018).

In south-eastern Tanzania, farmers are engaged in both cash and food crop production whereby cashew nut is the main cash crop and the leading source of income for over 300 000 households (Madeni *et al.*, 2017; NARI, 2008). The leading regions with many producers of cashew nut in Tanzania are Mtwara (70%), Lindi (18%), Ruvuma (8%) in Coast region (Kasuga, 2013). Other regions, which account for remained 4% were Tanga, Dodoma and Singida (CBT, 2018).

Cashew nut contributed about 497.4 billion Tanzanian shillings to the economy equivalent to 10.97% from export in 2015, (Msoka *et al.*, 2017). In 2016, cashew nut was the leading foreign exchange earner as a cash crop (BOT, 2017), creating employment and nutritional benefits (FAOSTAT, 2011; George & Rwegasira, 2017; Kilama, 2013; Msoka *et al.*, 2017).

Despite its importance, cashew production in Tanzania faces several challenges including high production costs caused by increased spraying regimes targeted on managing sucking insect pests and diseases, droughts and decreasing soil fertility status (George & Rwegasira, 2017; Kasuga, 2013). Of the challenges, the infestation of cashew by insect pests particularly still Mirids (*Helopeltis anacardii* Miller) and Coreid bug (*Pseudotheraptus wayi* Brown) (Boma *et al.*, 1998; Martin *et al.*, 1997; NARI, 2010) have been cited to be the most

important insect pest species. However, in the central zone of Tanzania, there have been reports of new unknown insect pests on the cashew (Kapinga, personal communication). Reports on such unknown insect species prompted the establishment of the current research specifically on determining their identity and effect on cashew.

Those sucking insect pests, attack the leaf and floral flushing shoots and cause early abortion of young developing nuts and fruits and this creates rooms by fungal infestation mainly (*Phomopsis anacardii*) leading to cashew dieback disease, consequently causing substantial yield loss (Seguni *et al.*, 2011). Cashew tree with massive infestation by both insects pests and fungus appears as if it has been burned by fire (Sijaona, 2013). The symptoms of fungal infestation start at treetop shoots and spreading downwards (Zhongrum & Masawe, 2014).

The typical management of the insect pests by farmers usually involve use of synthetic insecticides such as Lambda-cyhalothrin 50 g/L, Cypermethrin 150 g/L + Chlorpyrifos 300 g/L (Karate 5 EC, Ninja 5 EC, Duduall 450 EC) which are applied during flowering (NARI, 2008; Peng *et al.*, 2014). However, the reliance on synthetic insecticides is expensive and also carries a risk of polluting the environment, increase possibilities for resistance development by the pest and its effects extends to non-target organisms (Gitonga, 2009; Varela *et al.*, 2012). Thus, alternative approaches to pest control, such as biological control and botanicals, have been recommended (Nene *et al.*, 2017; Olotu *et al.*, 2013). Nevertheless, before embarking to developing management options, accurate identification of the type of insects that attack cashew, especially under the current new insect pest status as previously described, was needed. Thus, this study aimed at identifying sucking insect pests associated with cashew and dieback disease and assessing farmers based management strategies against the insect pests in southern and central Tanzania.

### 1.2 Statement of the problem

Sucking insect pests are a threat to cashew nut production in Tanzania (NARI, 2010). Difficulties in the management of sucking insect pests by farmers have been associated with a buildup of *Phomopsis* fungal pathogens that cause cashew dieback disease (Sijaona, 2013; Zhongrum & Masawe, 2014). Of the insect that creates rooms for fungal infestation resulting in dieback disease, cashew bugs (*Helopeltis sp.,)* and Palm coreid bug (*Pseudotheraptus wayi*) have been reported to be the main agents (Intini & Sijaona, 1983; Martin *et al.*, 1997;

Punithalingam & Holliday, 1972). The dieback disease symptoms appear as angular lesions on leaves that have been thought to be due to the injection of toxic saliva (that also create room for fungal growth) by the insects into the stalks of the tender shoots (NARI, 2010). The withering of the shoots also characterizes the symptoms of the dieback disease, generally starting from the tips and later advancing downwards to the main floral shoots and leaves (Sijaona, 2013). A complex insect force towards cashew also involves the strategic nut-targeting insect such as *Pseudotheraptus wayi* that feeds on developing nuts, causing them to shrivel, dry and blacken before they shed (Boma & Topper, 1998). A characteristic sunken spot develops at the site of puncture, and mature kernels show black, sunken spots (Topper *et al.*, 1998). The increase in sap-sucking pest populations coincides with the main growth period of the tree crop, which begins shortly after the end of the long rainy season ( Sporleder & Rapp, 1998). This condition has been reported to result in reduced quality, quantity of cashew nuts and severe economic loss to cashew growing farmers.

Moreover, damages by the insects to new growing shoots can severely stunt or kill grafted seedlings leaving only unimproved rootstock shoots to grow (Intini & Sijaona, 1983). This situation is common in Masasi, Nachingwea and Tunduru (Martin *et al.*, 1997; NARI, 2008).

In general, the pests cause yield loss of 60 - 75% in Tanzania (Agboton *et al.*, 2013). Taking into account the contribution of cashew to the economy of Tanzania, serious measures are needed, particularly on managing the pests. With reports on new pests in central Tanzania, more focus should be targeted into identification the pests to know how to start developing management options. It was based on the foundation that this study was needed particularly on status and effects of sucking insect pests in the cashew nut growing areas of southern and central zones of Tanzania.

### 1.3 Rationale of the study

Cashew is a leading foreign exchange earner as a cash crop in Tanzania; then the emerging of these new insect pests will lead decline in production. Therefore, this study aimed at identifying present and new sucking insect pests associated with cashew and make basic foundation study in developing strategies to species-specific management strategies in Tanzania.

## 1.4 Objectives

### 1.4.1 General objective

The general objective of this study was to investigate cashew sucking insect pest status and effects on cashew yields and generate information useful in designing species-specific management strategies in southern and central zone in Tanzania.

### 1.4.2 Specific objectives

(i) To determine the infestation status of cashew insect pests in the southern and central zones of Tanzania.
(ii) To assess the effects and map the distribution of sucking insect pests on cashew in the study area.
(iii) To identify common management practices used by farmers in managing sucking insect pests in the study area.

## 1.5 Research hypothesis

### 1.5.1 Null hypotheses ($H_0$)

There exists a vast diversity of insect pests that affect cashew growing in southern and central Tanzania.

### 1.5.2 Alternative hypotheses ($H_a$)

There exists no diversity of insect pests in cashew growing in southern and central Tanzania.

## 1.6 Significance of the research study

This study has offered a clear picture of the identity of insect pests attacking cashew in southern and central Tanzania. The information provided here is useful for developing appropriate pest management strategic actions.

## 1.7 Delineation of the study

The study focused on status and effects of cashew insect pests in southern and central zones, Tanzania as a foundation study in developing strategies to species-specific management strategies specifically for discovered insect's pests in the south and central zones.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Cashew nut production trend in Tanzania

Raw cashew nut production in Tanzania has been ranked the eighth position in the world and third in Africa after Mozambique and Ivory Coast (CBT, 2018). Cashew production from 1945s to 2018/19 fluctuates due to different reasons such as insect pests and disease infestation, abandoned cashew fields, old age of the trees, poor agronomic practices, price fluctuation and drought. Nevertheless, the production is currently increasing possibly due to increased acreage of production, planting of new materials, strengthening of the cashew research programme and proper education given to cashew farmers. The cashew raw nut production trend from 1945 to 2018/19 is as summarized in Fig. 1 below.

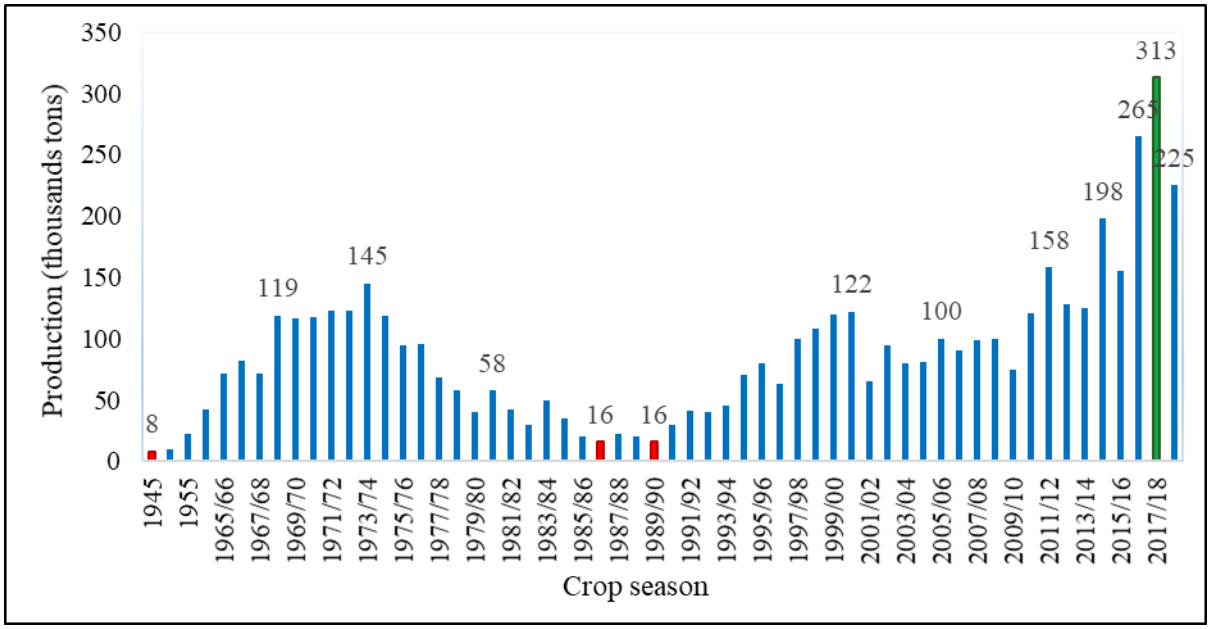


**Figure 1: Cashew raw nuts production in Tanzania from 1945 to 2018/19 (CBT, 2018/19)**

## 2.2 Problems associated with cashew production

Cashew production in Tanzania is facing several challenges, which result in low yields (Martin *et al.*, 1997). Among them is drought, decreasing soil fertility, poor agronomic practices, insect pests and diseases damage and losses (Agboton *et al.*, 2013; Azamali & Judge, 2001; Masawe, 2006). These pests, attack leaf and floral flushing shoots and cause

early abortion of young developing nuts and fruits and substantial loss of yield (Boma *et al.*, 1998; NARI, 2010; Seguni *et al.*, 2011). There are several insect-pests attacking cashew, but the most important ones are Helopeltis and the coreid bugs (Boma *et al.*, 1998; Martin *et al.*, 1997; Topper *et al.*, 1998). Sucking pests can cause complete yield loss in cashew, and the intensity of their attack varies with locality and with seasons (Agboton *et al.*, 2013; NARI, 2010; Sijaona, 2013). Other insect pests include the Cashew weevil/stem borer (*Mecocorynus loripes* Chevrolat), Thrips (*Selenothrips rubocinctus* Giard), Mealybug (*Pseudococcus longispinus* Targ), Aphids (*Aphis sp.*) and Leafminer (*Acrocercops syngramma* Meyrick).

### 2.2.1 Cashew Helopeltis bugs (*Helopeltis sp.*)

Mirid bugs, namely *Helopeltis schoutedeni* and *H. anacardii*. *Helopeltis schoutedeni* Reuter, commonly known as "Cotton Helopeltis" has a black head, antennae and wings (Boma *et al.*, 1998). Females have a blood-red body. Both adults and nymphs have a pin-like projection on the thorax. *H. anacardii* Miller commonly referred to, as "Cashew Helopeltis" are orange-brown coloured (Topper *et al.*, 1998). Nymph and adults have knobby hair-like projection stinking up from the thorax.

Damage to cashew is caused by the sucking effect of nymphs and adults through injection of toxic saliva in the process of feeding. Symptoms are characterized by brown to a black lesion on shoots, leaves, flowers, apples and nuts (Maruthadurai *et al.*, 2012). Brownish and watery lesions appear on the recently damaged tissue. The lesions darken with time and become necrotic. Severely attached leaves and flowers may exhibit dieback and scorched appearance. Attacked young nuts shrivel, dry and blacken before they fall off. The feeding points on developing nuts become sunken, circular or oval spots that may go deep into the kernel. Damaged apples exhibit black scars and become deformed. Besides, *Helopeltis sp.* are referred to as predisposing agents to dieback disease. The different methods used to control *Helopeltis sp*., are chemical methods with the active ingredients Lambda-cyhalothrin 50g/L (5ml/l), (Zhongrum & Masawe, 2014) and biological method, the use weaver ants, *Oecopylla longinoda* (Seguni *et al.*, 2011).

### 2.2.2 Coreid bugs (*Pseudotheraptus wayi* Brown)

The coreid bug is serious cashew and coconut pest. The adult and its nymphs have a reddish-brown colour on the dorsal and greenish abdomen (Boma *et al.*, 1998). Both adult and nymph

suck the developing nuts, which shrivel and blacken before they fall (Agboton *et al.*, 2013). On the advanced nuts, the damage shows deeper and elongated sunken spots at points of attack, which lowers the value of nuts, also, the bugs may feed on young shoot causing dieback (Boma & Topper, 1998). The female measures between 14 and 15 mm long, while the male is slightly shorter (Topper *et al.*, 1998). The lifespan of the adult bug in captivity is often more than 60 days, during which the female lays up to 75 eggs. The life cycle takes up to 40 days in which they are five nymphal instars. Control methods are similar to that of cashew Helopeltis bugs.

### 2.2.3 Cashew weevil/stem borer (*Mecocorynus loripes* Chevrolat)

Adult cashew stem borer has a dark-grey colour measuring about 2 cm long. The larvae are typical weevil grubs with the curled, whitish body, wrinkled skin and dark brown head. The pest attack mature trees only. The primary damage caused by the pest occurs on the trunk and main branches of the tree (Maruthadurai *et al.*, 2012). The larvae are the damaging stage. They feed beneath the bark before tunnelling into the wood of the trunk where pupation occurs.

Eggs laid singly in small holes. Larvae hatching from the eggs tunnel down just beneath the bark, eating the sapwood of the tree in the process (Asogwa *et al.*, 2008). The development cycle lasts approximately six months. A hollow sound produced when the affected part knocked. Heavily infested trees may die within a short time after which the adult weevil moves to the next tree. Currently, the control measures are through removing barks of the affected cashew tree by a sharp knife and in a severe situation, burn the affected tree completely without transferring outside the cashew field.

### 2.2.4 Foliage thrips (*Selenothrips rubrocinctus* Giard)

These are common sporadic pests on cashew. Symptoms of attack by Thrips include a patchy dirty silver appearance on leaves mainly along the main veins, causing yellowing which later changes into greyish-brown (Asogwa *et al.*, 2008). Cashew affected leaves later dry and fall prematurely, both adults and nymphs attack mature leaves by scraping the underside. However, they also attack young leaves, shoots and inflorescence. Heavily infested flowers may not open for fertilization, become stunted, thus lowering nut yields drastically. Thrips attack is serious in hot, dry weather; however, damage appears more in abandoned

plantations (Maruthadurai *et al.*, 2012). The cultural method includes improvement of the light condition in cashew field to reduce shade and weed clearing (Navik *et al.*, 2016). Chemical methods include spraying of insecticides with active ingredients like Chlorpyrifos 50% + Cypermethrin 10% EC (3 ml/1), or Imidacloprid 5% EC (1ml/ 1-2 l).

### 2.2.5 Cashew mealybugs (*Pseudococcus longispinus* Targ.)

Mealybugs attack tender parts of the plants by sucking sap from leaves, flowers and fruits, often-injecting toxic saliva and spread plant pathogens. Many species produce copious honeydew that coats the host-plant and develop a layer of sooty mould. The mould prevents light from reaching the leave, thus restricting gaseous exchange and photosynthesis. Attacked flowers wilt thus hindering pollination, while leaves dehydrate and fall precociously. Later infestations during nut swell may result in the void or under grade nuts.

The snow-white appearance quickly identifies canopy attacked by mealybugs. Later stages of severe infestations exhibit dripping honeydew and increased number of symbiotic ants. These ants are attracted by honeydew and usually protect the mealybugs and scales from their natural enemies. The body of the mealybug is broadly oval with the caudal filaments extremely long. The female lays 50 to 500 eggs behind or under its body. The active first instar (crawler) disperses passively by the wind drifts, birds, insects and even men. The use of chemicals with active ingredient Profenofos 720 g/l or Chlorpyrifos 500 g/l +Cypermethrin 50g/l (7.1 ml/l) is more effective in controlling mealy bugs.

### 2.2.6 Aphids (*Aphis sp.*)

Nymphs and adults are soft-bodied, ovate and brown. Adults may be winged or wingless. Both adults and nymphs of aphids suck sap from tender shoots, inflorescence, apples and nuts (Ambethgar, 2011). The aphid infests cashew tree and colonizes on the underside of tender leaves along the central veins, terminal buds, flower shoots and developing tender nuts (Ambethgar, 2011). Both adult and nymphs of aphids impede the plant performance by sucking cell sap (Godse, 2002). The affected plant parts are disfigured. The aphids also excrete copious amounts of honeydew on which sooty mould develops, interfering with the regular photosynthetic activity of plants, which reduces the plant vigour and subsequently its fruit-bearing capacity (Biradar & Shaila, 2004). This kind of insects pests are controlled with

natural enemies like ladybugs and lacewing; also chemicals can be used in tender shoots, leaves and fruits with active ingredient Imidacloprid 5% (1 ml/1-2 l).

### 2.2.7 Leaf miner (*Acrocercops syngramma* Meyrick)

Leaf miner is one of the important pests of cashew. The larvae were hatched from the eggs and start mining the epidermal layer on the upper surface of the tender cashew leaves as well as tender shoots (Asogwa *et al.,* 2008). Because of feeding, the affected area form blistered patches of greyish white colour. As the infested leaves mature, the damage manifest as big holes (Vanitha *et al.,* 2015). This kind of pest attacks younger cashew plants. During the developmental period, leaf miner larvae are dull white and turn pinkish before pupation (Maruthadurai *et al.,* 2012). After full development, the larvae fall off to the soil where they pupate and emerge after 7-9 days (Kanhar *et al.,* 2016). The adult is a silvery grey moth, lays eggs on tender leaves. Control measures are through natural enemies like *Cirrospillus sp*. and Chemical control with the use of Deltamethrin 2.5% (1ml/4-6 litres), (Zhongrum & Masawe, 2014).

### 2.2.8 Dieback disease (*Phomopsis anacardii*)

Dieback disease is the severe results of sucking pests attacks on petioles or black angular spots on the leaf surface on the stem in form of leaf damage or black lesions, it appears as an elongated, black necrotic area or lesion around the point of entry of the labial stylet into the plant tissue (Topper *et al.,* 1998). The damage typically called “Dieback” involves withering of the inflorescence or shoot, followed by progressive dieback, starting from the tip and advancing downwards to the central floral shoots and leaves; shoots progressively turn brown/black, and frit or new shoot formation is arrested (NARI, 2008). In severe cases, the entire tree looks burnt (Boma & Topper, 1998), (Plate 2).

## 2.3 Management of cashew sucking insect pests

There are several management practices like the use of resistant cashew variety (Sijaona, 2013), biological control (Abdulla *et al.*, 2015; Dwomoh *et al.*, 2009; Nene *et al.*, 2015; Olotu *et al.,* 2013), synthetic chemicals (Sijaona, 2013; Zhongrum & Masawe, 2014), botanical pesticides (Nene *et al.,* 2017), and ecological management strategies (Sijaona,

2013). There is limited information on the major insect pests that affect the crop and management practices of cashew farming community.

### 2.3.1 Cultural control method

Cashew has different insect pest hosts. Farmers are advised not cultivating cashew together with pigeon peas (*Cajanus cajan*), castor oil plants (*Ricinus communis*) and cowpeas (*Vigna unguiculata*) which act as an alternative host for sucking insect pests (Martin *et al.*, 1997; NARI, 2010). Tall crops that last more than four months, like castor oil plants, should be avoided (NARI, 2008). Prediction and forecast of cashew insect pests should be done as early as possible, which is very important for control (NARI, 2018). Management of alternative host plants like pigeon peas and weeds in cashew fields should be done.

### 2.3.2 Chemical control method

Chemical control with active ingredients namely Lambda-cyhalothrin, Alpha-cypermethrin, Profenofos, Chlorpyrifos etc. are applied to the tender leaves and shoots, panicles and which are applied during flushing, flowering fruit and nut setting stages are highly recommended in Tanzania (NARI, 2018; Sijaona, 2013; Zhongrum & Masawe, 2014).

### 2.3.3 Biocontrol method

Natural enemies like weaver ants *Oecopylla longinoda* Latreille (Hymenoptera: Formicidae) can protect several tropical crops against more than 40 species of pests (Anato *et al.*, 2015; Mele, 2008) because the ants prey on and deter other insects (Nene *et al.*, 2015). It has estimated that worker ants from 12 weaver ant nests captured 45 000 insects per year and studies have shown that semi chemicals deposited by the ants may also deter pests (Adandonon *et al.*, 2009; Ativor *et al.*, 2012; Offenberg *et al.*, 2004). For example, pest control by weaver ants has been observed in cashew plantations to benefit from the presence of weaver ants. In Tanzania (Olotu *et al.*, 2013) and Ghana (Dwomoh *et al.*, 2009) and *O. longinoda* provides efficient protection against sap-sucking bugs (Abdulla *et al.*, 2017).

In some settings, weaver ants may not be sufficient for managing the insect pest complex attacking cashew. In such cases, control by weaver ants should be integrated with other compatible methods (Abdulla *et al.*, 2015). For example, Peng and Christian (2005) reported that weaver ants used in integrated pest management (IPM) programme with soft chemicals

(white oil and potassium soap) proved to be more profitable than using the weaver ants alone because the ants were unable to reduce scale insect populations (Peng & Christian, 2005).

Therefore, the combination of farmer's knowledge and results from research conducted, aids in the formation of an ecologically sustainable and economically viable integrated pest management strategies and detailed understanding of the bioecology of important cashew pests. Furthermore, information obtained during the survey and farmer's group discussion will help to identify, develop and recommend measures, which could take to enhance the adoption of insect pest control in cashew.

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1 Description of the study sites

The study was conducted in the cashew production areas of Tanzania in two cashew growing zones, namely southern and central Tanzania. In the southern zone, three districts were randomly selected whereby purposively sampling was used in the central zone due to a few numbers of districts cultivating cashew. Four cashew fields were sampled in each district, and the locations for the fields are displayed in Fig. 2. Cashew plantations of age group at most 20 years disseminated across the zones were sampled due to its potential production at this stage. The survey was conducted in two consecutive seasons: February to March 2019 and July to August 2019, corresponding to seasons when cashew trees flush, flower and bear fruits. Surveyed districts in the southern and central zone are shown in Fig. 2 below:-

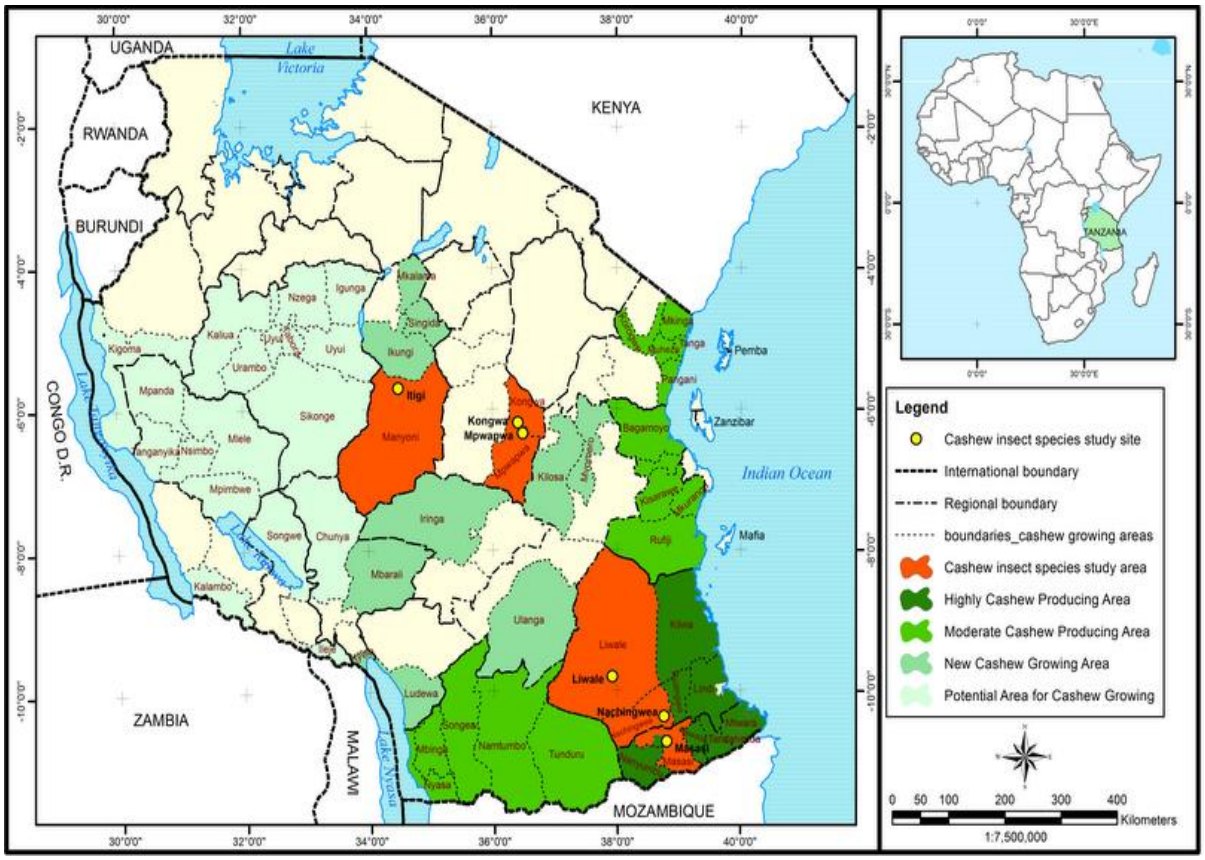


**Figure 2: Cashew insect pests in surveyed sites**

### 3.2 Sampling of fields and trees

Three districts were selected per zone, three (3) and four cashew fields were randomly selected where ten trees were assessed (total of 120 cashew trees per zone) using a one-meter quadrat square (as sampling units) on two sides of each cashew tree. The quadrants were set up on two sides (shade and sunny side, roughly north and south poles of the trees) of each tree following the movement of the sun.

The selection criteria of the study field were first based on the age of the cashew trees. The tree was to be at most 20 years based on the farmer's history and cashew research experience on cashew trees. The second criterion was that the size of the selected field should exceed one (1) hectare, therefore having at about 100 cashew trees. Cashew trees in the fields were assessed diagonally from north to south (transects) to obtain homogenous data and cashew plantations were visited at a distance of 5 - 20 km in each district within the zone. Where cashew plantations were sparse, the sampling distance was about 10 - 40 km.

The longitudes and latitudes were recorded for each sampled locations using the GPS handset (GARMIN-GPS 60). Pictures were taken using a CANON photographic camera (PowerShot SX540 HS 20.3). The distribution map of the areas surveyed was drawn using QGIS 3.0 software.

### 3.3 Data collection

#### 3.3.1 Shoot and nut damages

On each canopy, an assessment of damage to flushing shoots and young nuts was conducted on each of the selected cashew trees. A quadrant of one-meter length was placed over the shoots approximately 1 m above the tree base, the flushing shoots and nuts within each quadrat were carefully inspected, and the numbers of shoots and nuts damaged were recorded separately. The quadrat was set up on two sides of the cashew tree canopy (shade and sunny side, roughly north and south sides) of each tree following the movement of the sun close to the equator. The position of the quadrat was maintained throughout the study. Five tender leaves per shoot were inspected, and, if any one of these leaves was affected, the shoot was treated as damaged. Evaluation of damage to tender shoots and young nuts by the sap-sucking pests was done. A leaf was treated as ‘damaged’ if more than 30% of its surface

showed signs of damage leaves with less than 30% damage were classified as ‘not damaged’ (NARI, 2008). The severe results of sucking pests attacks on petioles or black angular spots on the leaf surface on the stem in the form of leaf damage or black lesions are what called dieback disease (Plate 2).

**Plate 1: Symptoms of leaf damage on cashew shoot**

**Plate 2: Dieback disease on cashew shoot after sucking of insect pests**

The percentage of shoots damaged per quadrat was calculated as follows:-

(i) $$\frac{\text{Total number of damaged shoots per quadrat}}{\text{Total number of shoots counted within the quadrat}} \times 100$$

(ii) The percentage of shoots damaged per tree was calculated as the average of the percentage of shoots damaged in the two quadrats.

A similar procedure was used to calculate the percentage of damaged nuts per tree. Data collected were total shoots (TS), shoots with black lesions (BL), leaf damages (LD) and pest populations were collected (Plate 1).

Insect pests and their respective damages from the two sides or points of the assessed tree canopy were compiled as mean percent scores (TARI Entomologist Protocol, 2016). These data collected was used to calculate levels of insect pest infestation in terms of incidence and severity. Mean scores for each field in every district was graphically presented for visual comparative.

### 3.3.2 Insect pests counts

Insect species, including pests and suspected beneficial insects, were counted and recorded around the cashew canopy. Presence of other pests within the assessed field was recorded. Forty cashew trees were assessed in each district, which will make up one hundred and twenty cashew trees per zone. The same procedures were repeated in the other zone.

### 3.3.3 Insect pests collection and identification

Insect collection and capturing was physically done by hand or/ and using sweep nets. The samples were collected from three developmental stages of the cashew trees, and these were young leaf flushes, flowering panicles and young fruits. The samples of the cashew insect pests were collected from the tree canopies and put in conservation kit using ethanol 70% concentration. A visual examination technique was carried out where 40 cashew trees in each district were inspected around the canopy while knocking to observe the presence of various insect pests and extent of damage done. Samples of cashew insect pests were collected for identification in the laboratory. Identification of the insects, which were collected, was done

at Tropical Pesticides Research Institute, Arusha using an identification guide with the aid of binocular microscope Euromex (Holland) Model BMK 31162.

### 3.3.4 Farmer's awareness and knowledge on cashew insect pests

Samples were drawn from the population of farmers using purposive and simple random sampling techniques. Out of 66 registered villages, only eight (8) villages (12%) were randomly selected in four districts, namely Liwale, Mpwapwa, Kongwa and Manyoni. Twenty-seven (27) key informant farmers were drawn from a group of farmers growing cashew and interviewed following a transect walk technique (Kothari, 2004). Twenty key informant farmers (20) were randomly selected from Liwale district whereby seven (7) were purposively selected from the three districts as follows: four (4) farmers from Kongwa, two (2) from Mpwapwa and one (1) from Manyoni districts respectively. The criteria of selection for the key informant farmers in the southern zone were based on the influence of other farmers on adopting new technologies, must own the field of cashew and practicing different agronomic practices. However, in the central zone, there were fewer farmers; hence purposive selection was made for those how cultivating cashew. Qualitative and quantitative data was collected using questionnaires and focused group discussions (FGD) were used as tools for the data collection on various aspects such as socio-demographic and family/household characteristics, and management production constraints.

## 3.4 Statistical analysis and presentation

GenStat® 15 Edition (VSN International, Hemel Hempstead, UK) was used to perform analysis of variance (ANOVA). Differences between means of significant differences were separated using a Fisher's protected at 5% level of significance. Normality test was performed before subjecting to the ANOVA. Primary data was coded and analyzed using IBM Statistical Package for Social Sciences (SPSS 20.0 for windows) computer software. The obtained mean scores from each site were graphically presented for visual comparative studies using MS-Excel. Secondary information was collected from various sources, including TARI annual reports, proceedings, review of published papers and official reports, and online information.

# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.1 Status, distribution and effects of cashew insect pests in the selected location of southern and central Tanzania

Eleven (11) insect pest species, namely *Helopeltis sp., Pseudotheraptus wayi, Pseudococcus longispinus, Selenothrips rubrocinctus, Mecocorynus loripes, Diplognatha gagates, Systates sp., Mithetophora sp., Plaesiorrhira sp., Analeptes trifasciata* and *Aphis sp.* were recorded in cashew fields surveyed in the southern and central zone of Tanzania. Of these six (6) cashew insect pests (*Helopeltis sp., P. wayi, P. longispinus, S. rubrocinctus, M. loripes and A. trifasciata*) were found in both survey zones (Table 1) and five (*D. gagates, Systates sp., Mithetophora sp., Plaesiorrhira sp.,* and *Aphis sp.*) were found only in the central zone of Tanzania (Table 2). Also, two beneficial species, namely *Oecopylla longinoda* and *Apis mellifera* were recorded as either pollinators or predators in both zones. The distribution of these insect pests and damage in the two zones is shown in Table 1 and 2. These insects had several effects on the cashew trees, parts attacked and damaged caused (Table 3).

**Table 1: Diversity and distribution of cashew insect pests found in both southern and central zones**

| Insect species | Location/ Distribution | Pest status | Tissues infested / parts attacked | Level of infestation (Severity) |
|---|---|---|---|---|
| *Helopeltis sp.* | All localities | Harmful | Leaf, shoot, fruit | +++ |
| *Pseudotheraptus wayi* | All localities | Harmful | Leaf, shoot, fruit | +++ |
| *Aphis sp.* | All localities | Harmful | Leaf, shoot | ++ |
| *Pseudococcus longispinus* | All localities | Harmful | Leaf, shoot, fruit | + |
| *Mecocorynus loripes* | All localities | Harmful | Stem / Branch | ++ |
| *Selenothrips rubrocinctus* | All localities | Harmful | Leaf, shoot, fruit | ++ |
| *Oecopylla longinoda* | All localities | Auxiliary/ Predator | Leaf, shoot, fruit, stem | + |
| *Apis mellifera* | All localities | Pollinators | Leaf, shoot, fruit | +++ |

**Table2: Diversity and distribution of new cashew insect pests found in the central zone**

| Insect species | Location/ Distribution | Pest status | Tissues infested / parts attacked | Level of infestation (Severity) |
|---|---|---|---|---|
| *Miphetophora sp.* | Mpwapwa and Kongwa | Harmful | Fruit | ++ |
| *Diplognatha gagates* | Mpwapwa and Kongwa | Harmful | Fruit | ++ |
| *Plaesiorrhira sp.* | Mpwapwa and Kongwa | Harmful | Fruit | ++ |
| *Systates sp.* | Mpwapwa and Kongwa | Harmful | Leaves | + |
| *Analeptes trifasciata* | Manyoni - Itigi | Harmful | Stem | ++ |

Note: **All localities;** Liwale, Nachingwea, Masasi, Mpwapwa, Kongwa and Manyoni Districts. * **Level of infestation;** + Light; ++ Medium; +++ Severe

**Table 3: Insects and insect pests species associated with cashew, plant part attacked and nature of damage in southern and central zones of Tanzania**

| Species | Parts attacked and damage caused |
|---|---|
| *Helopeltis sp.* | Found on both young and mature trees. Adults and nymphs suck sap and juice from shoots, young apples and nuts. Points of stylet insertion develop necrotic lesions that appear as black, sunken, elongated spots on the epidermal tissue (Plate 3a) |
| *Pseudotheraptus wayi* | Found on both young and mature trees. Attack and damage similar to those of *Helopeltis sp.* (Plate 3b) |
| *Aphis sp.* | Found on mature trees. Sapsuckers. Live on terminal shoots and fruits |
| *Miphetophora* sp. | Found on mature trees. Adults feed on young and mature apples (Plate 3g) |
| *Diplognatha gagates* | Found on mature trees. Adults feed on young and mature apples |
| *Plaesiorrhira* sp. | Found on mature trees. Adults feed on young and mature apples |
| *Systates* sp. | Found on both young and mature trees. Foliage feeder |
| *Selenothrips rubrocinctus* | Found on both young and mature trees. Both nymphs and adults suck and scrape the abaxial surface of leaves, mainly along the main veins. Initial yellowish patches turn grey to give a silvery appearance to the adaxial surfaces of leaves. |
| *Mecocorynus loripes* | Larvae bore into cashew trunk and the tunnel upwards, leading to the withering of twigs and branches, and dying up of the trunk in serious cases (Plate 3f) |
| *Analeptes trifasciata* | Girdle tree trunks and branches (Plate 3d) |
| *Pseudococcus longispinus* | Mealybugs attack tender parts of the plants by sucking sap from leaves, flowers and fruits, often-injecting toxic saliva and spread plant pathogens |
| *Oecopylla longinoda* | Found on mature trees. Predators and scavengers |
| *Apis mellifera* | Found on mature trees. Pollinators of cashew inflorescence |

<table>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>a) Shoot damage by Helopeltis sp.</td><td>b) Nut damaged by P. wayi</td><td>c) Leaves attacked by S.rubrocinctus</td></tr>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td colspan="2">d) Analeptes trifasciata and its damage on young cashew stem</td><td>e) Mecocorynus loripes</td></tr>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>f) Cashew stem affected with M. loripes</td><td colspan="2">g) Plaesiorrhira sp. and its infestation on cashew apple</td></tr>
</table>

**Plate 3: Damages of cashew plant parts by different insect pests in the southern and central zones cashew fields of Tanzania in 2019**

## 4.2 Identification and mapping of sucking insect pest on cashew

Eleven (11) insect species (Table 1 and 2) were recorded, comprising of four (4) Coleoptera, three (3) Hemiptera, two (2) Hymenoptera and one (1) Thysanoptera in which five of them were recorded for the first time in the cashew farming in Tanzania. All of the total collections were identified to genus level. The identified specimens are presented in Plate 4.

These Hemiptera, Coleoptera and Thysanoptera pests belong to the families Miridae (damage to the annual flush), Coreidae (damage to nuts and apples), Cerambycidae and Curculionidae (damage to branches and trunks), and Thripidae and Aphididae (damage to leaves); they cause cashew nut losses each year in Tanzania and severely penalizing the growers involved in cashew production.

| | | |
|---|---|---|
|  |  |  |
| a) *Helopeltis sp.* | b) *Pseudotheraptus wayi* | c) *Aphis sp.* |
|  |  |  |
| d) *Mithetophora sp.* | | e) *Plaesiorrhira sp.* |
|  |  |  |
| f) *Diplognatha gagates* | | g) *Systates sp.* |

| | | |
|---|---|---|
|  |  |  |
| h) *Selenothrips rubrocinctus* | i) *Oecopylla longinoda* | j) *Apis mellifera* |

**Plate 4: Insects collected and identified in 24 cashew fields in the southern and central zones of Tanzania in season 2019**

### 4.3 Infestation status of cashew insect pests in southern and central Tanzania

Figure 3 - 5 represents on the pest damages in the form of percentage black lesion (BL), leaf damage (LD) and pest counts (*Helopeltis sp, Pseudotheraptus wayi, Aphis sp.,* and *S. rubrocinctus*) at three districts (Liwale, Masasi and Nachingwea) in the southern zone, for trials conducted in 2019 in vegetative and reproduction seasons. The infestation of insect pests varied within three sites and between the seasons. During vegetative and reproduction seasons *Helopeltis sp., P. wayi* and *Apis sp*. were the key insect pest species encountered in all sites, *Helopeltis sp. and P. wayi* continues to remain the most important insect pest affecting cashew production in all sites (Fig. 3 - 5). Makata site in Liwale district recorded the highest incidence of 46.7% and Nang'ondo site in Nachingwea district showed the lowest incidence of 3.3% during reproduction season on cashew fields respectively. Cashew insect pests count *Helopeltis sp.* accurately, took the first position with an average of 51 insect pests counts per site in Liwale district (Fig. 3) followed by *P. wayi* (with an average of 7 insect pests counts per site) in Masasi district. Other insect pests *Aphis sp.* and *S. rubrocinctus* were found to cause minor damage.

Besides, Fig. 6 - 8 shows the pest damages in the form of percentage black lesion (BL), leaf damage (LD) and pest counts (*Helopeltis sp, Pseudotheraptus wayi, Miphetophora sp., Diplognatha gagates, Analeptes trifasciata, Plaesiorrhira sp. and Systates sp*.) at three districts (Mpwapwa, Kongwa and Manyoni- Itigi) in the central zone. The infestation of insect pests varied within three sites and between the seasons. During vegetative and reproduction seasons *Helopeltis sp.* was the key insect pest specie come across in all sites (Fig. 6 - 8). The highest incidence was recorded in Lendebesi site in Kongwa district, and Zinginali 3 recorded the lowest incidence of 2.2% in Manyoni district. Furthermore,

*Helopeltis sp.* continues to be devastating insect pests in the central zone with the highest count of 30 per site in Kongwa district due to their damage potential and their wide distribution on both zones. This confirmed the findings reported earlier in this study on the effect of agro-ecological zones on infestation by insect pests (Agboton *et al.*, 2013; Boma *et al.*, 1998; NARI, 2018).

The differences in terms of incidence and pests counts in surveyed zones were accredited to the climatic condition, effects of landscape, insecticides use and intercropping systems. Furthermore, climatic conditions, insecticides use, and intercropping systems constitute main factors that could explain the variation that may occur in consecutive surveys (vegetative and reproduction seasons). In southern zone farmers practicing intercropping system pigeon peas with cashew (*Cajanus cajan*), Castor beans (*Ricinus communis*) which act as alternative host plants. Whereas in central zone farmers cultivating cashew have low knowledge on managing insect pests in terms of insecticides use (types of insecticides, types of active ingredients, dosage rates) and insects pests identification since they were new in cashew production. More surprisingly, there were new insects pests, which were not reported previously in the cashew production industry in Tanzania.

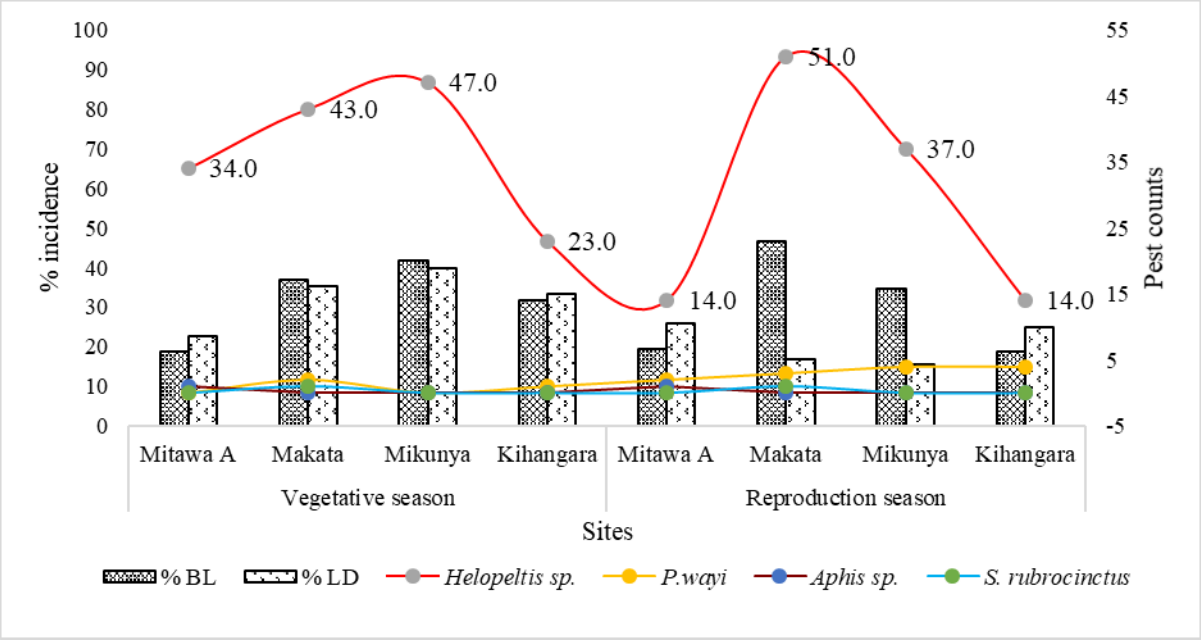


**Figure 3: Percent black lesions (BL), leaf damage (LD) and pest counts at Liwale district**

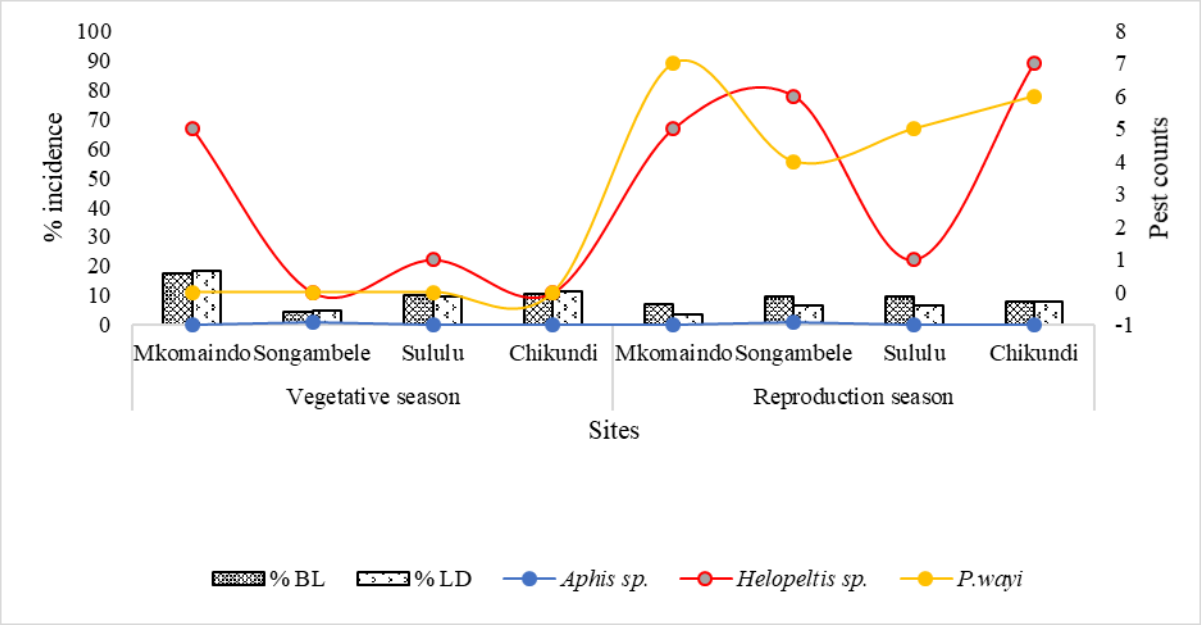


**Figure 4: Percent black lesions (BL), leaf damage (LD) and pest counts at Masasi district**

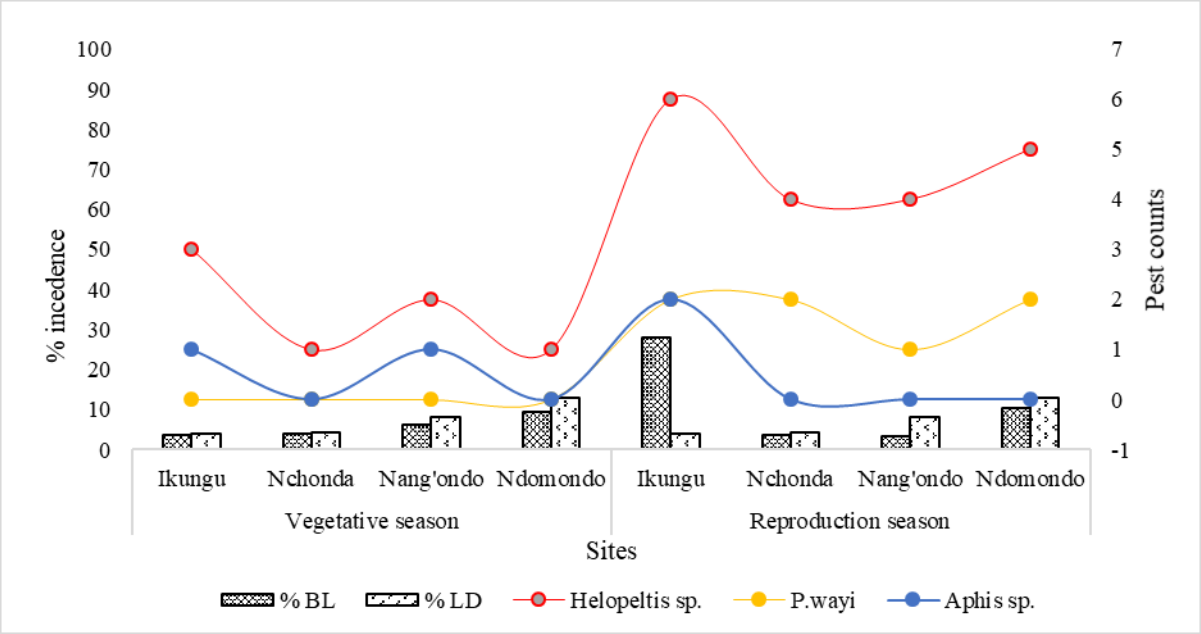


**Figure 5: Percent black lesions (BL), leaf damage (LD) and pest counts at Nachingwea district**

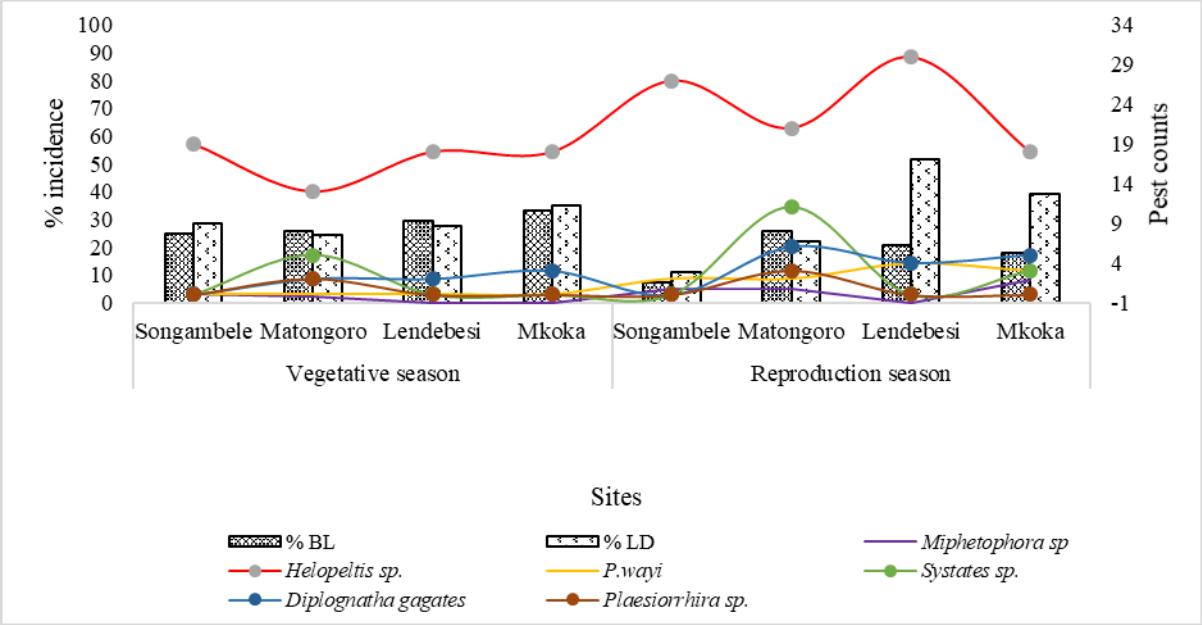


**Figure 6: Percent black lesions (BL), leaf damage (LD) and pest counts at Kongwa district**

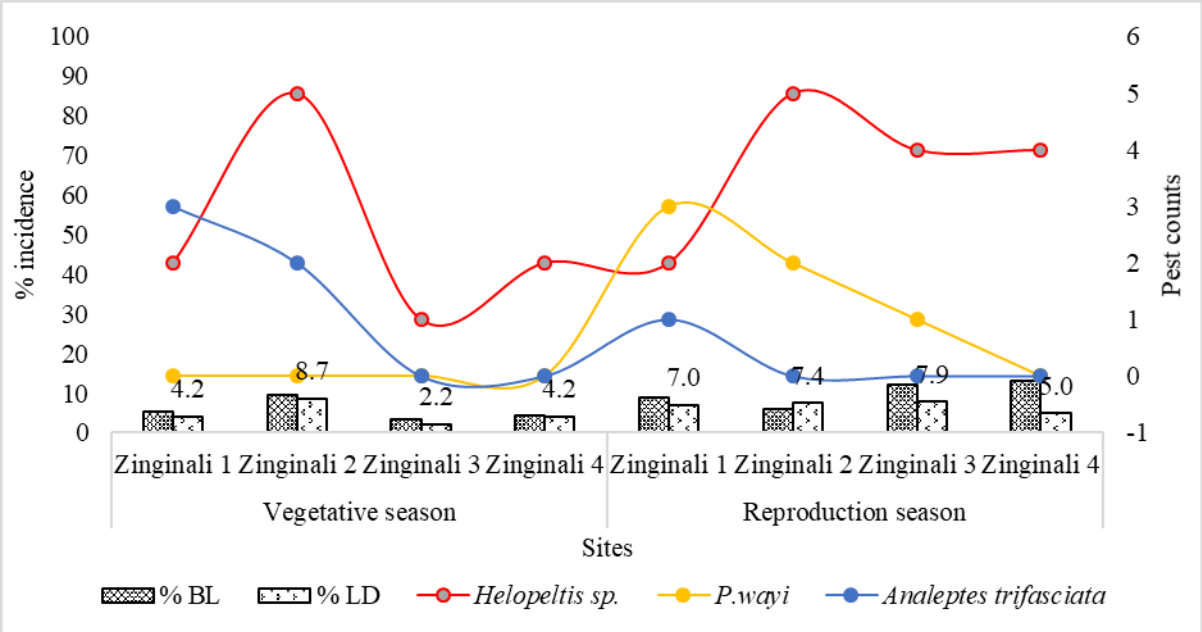


**Figure 7: Percent black lesions (BL), leaf damage (LD) and pest counts at Manyoni-Itigi district**

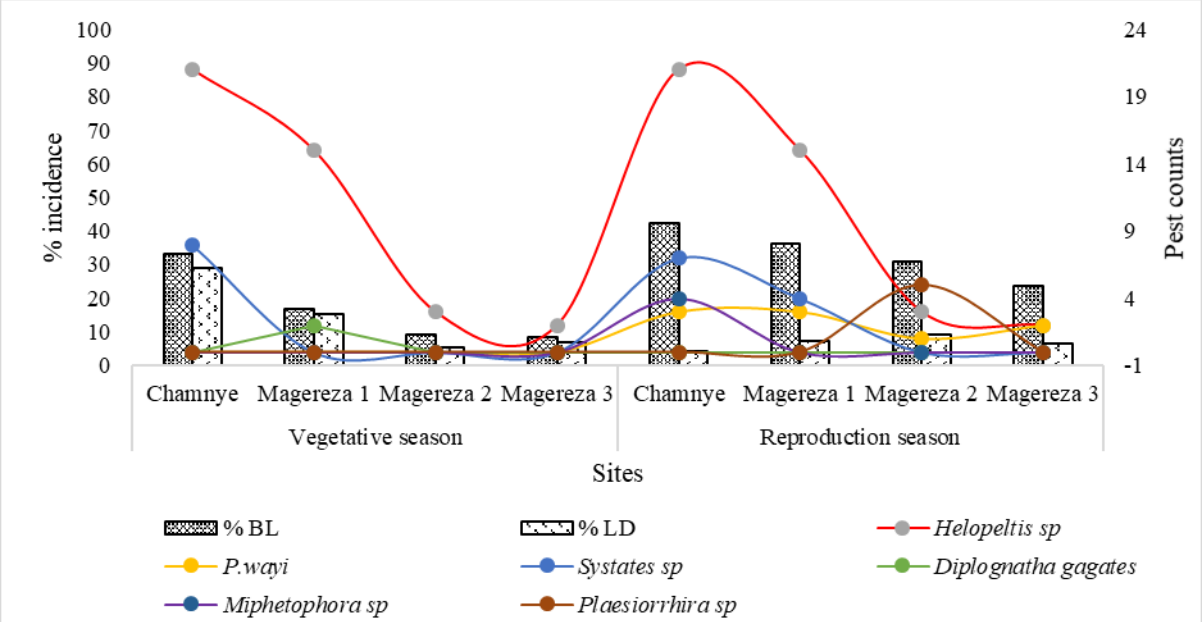


**Figure 8: Percent black lesions (BL), leaf damage (LD) and pest counts at Mpwapwa district**

The results in Table 4 and 5 shows the coverage of pest damages, pest counts population and dieback levels. There were significant differences ($P < 0.05$) in pest damages, pest counts population and dieback levels in all six surveyed sites (Liwale, Masasi, Nachingwea, Mpwapwa, Kongwa and Manyoni – Itigi districts). The results further indicated that Liwale ranked the first, followed by Kongwa sites in terms of percent incidences. Mpwapwa and Masasi ranked the third and fourth position respectively. Nachingwea took the fifth position while Manyoni was the last in all sites.

Furthermore, *Miphetophora sp., Diplognatha gagates, Plaesiorrhira sp. and Systates sp.* were recorded in Mpwapwa and Kongwa sites, and *Analeptes trifasciata* was only recorded in Manyoni district in the central zone (Table 3). The incidence was low in all fields of Mpwapwa and Kongwa but had a significantly destructive effect on the cashew apples. *Analeptes trifasciata* has more effect on young cashew stems planted in Manyoni district. The presence of *Analeptes trifasciata* or its damage on newly and formerly girdled stems or twigs belted suspended or fallen branches were noted.

Table 4 represents results from six sites in southern and central Tanzania. The results portrayed significant differences ($P < 0.05$) in severity levels (dieback) in all sites and between zones. However, there is no significant difference ($P < 0.05$) between the Nachingwea and Kongwa site (Table 5). During survey Liwale and Kongwa districts have

severity level 2 (average 38%) and other sites (Masasi, Nachingwea, Mpwapwa and Kongwa districts) ranging in severity level 1 (average 13%) during the vegetative season (Fig. 9). Also, during reproduction season, all-district surveyed have an average severity of 13% (level 1) with the exception in Masasi district with severity level zero and one field of Liwale which have severity level 2 (Fig. 10).

Generally, the highest overall incidences and severities were recorded in Liwale (32.28%, 2.20%) and the lowest in Manyoni (4.80%, 0.25%) districts respectively.

**Table 4: Percent damages and pest counts of selected sites in the southern and central zones**

| Sites | Vegetative season | | | Reproduction season | | | Mean rank | Overall rank |
|---|---|---|---|---|---|---|---|---|
| | Percent black lesion | Percent leaf damage | Pest counts | Percent black lesion | Percent leaf damage | Pest counts | | |
| Liwale | 32.28a(1) | 32.78a(1) | 15.00a(1) | 26.30b(3) | 22.64b(2) | 12.00a(1) | 1.50 | 1 |
| Masasi | 10.69c(4) | 11.10bc(4) | 0.80c(5) | 11.20c(4) | 9.82c(3) | 2.00bc(4) | 4.00 | 4 |
| Nachingwea | 5.87c(5) | 7.31cd(5) | 0.60c(6) | 10.32c(5) | 7.28c(4) | 1.00c(6) | 5.17 | 5 |
| Mpwapwa | 16.78b(3) | 14.11b(3) | 4.40bc(3) | 33.26a(1) | 6.88c(5) | 4.40b(3) | 3.00 | 3 |
| Kongwa | 28.19a(2) | 28.84a(2) | 7.00b(2) | 28.64ab(2) | 31.08a(1) | 9.80a(2) | 1.83 | 2 |
| Manyoni | 5.72c(6) | 4.80d(6) | 1.20c(4) | 10.08c(6) | 6.84c(6) | 1.80bc(5) | 5.50 | 6 |
| Grand Mean | 16.60 | 16.50 | 4.80 | 30.00 | 14.10 | 5.20 | | |
| LSD | 5.38 | 5.04 | 3.87 | 5.04 | 3.97 | 2.60 | | |
| P - Value | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | | |

**Means with the same letter(s) in the same column are not significantly different at ($P < 0.05$) and numbers within parenthesis shows rank order down the columns**

**Table 5: Severity levels of selected sites in the southern and central zones**

| Sites | Vegetative season | Reproduction season | Mean rank | Overall rank |
|---|---|---|---|---|
| Liwale | 2.25a(1) | 1.25a(1) | 1.0 | 1 |
| Masasi | 0.50bc(4) | 0.25b(6) | 5.0 | 5 |
| Nachingwea | 1.00b(3) | 0.75ab(2) | 2.5 | 2 |
| Mpwapwa | 0.50bc(5) | 0.50b(4) | 4.5 | 4 |
| Kongwa | 2.00a(2) | 0.50b(3) | 2.5 | 2 |
| Manyoni | 0.25c(6) | 0.25b(5) | 5.5 | 6 |
| Grand Mean | 1.08 | 0.58 | | |
| LSD | 0.67 | 0.57 | | |
| P - Value | < 0.001 | < 0.018 | | |

**Means with the same letter(s) in the same column are not significantly different at ($P < 0.05$) and numbers within parenthesis shows rank order down the columns**

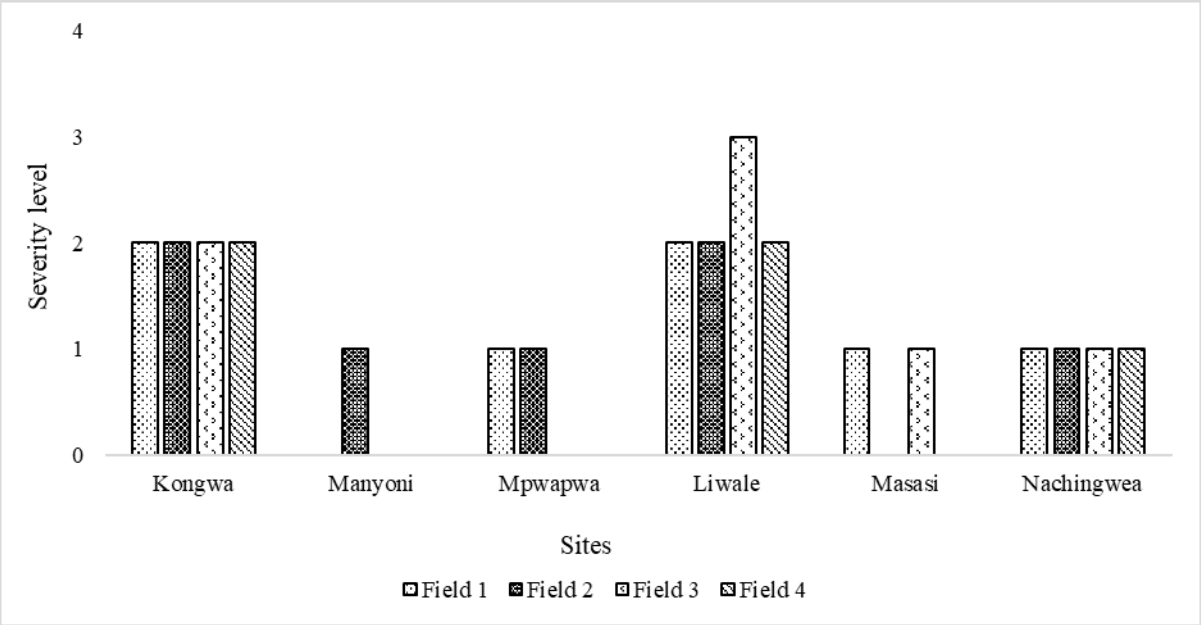


**Figure 9: Severity levels at different districts during the vegetative season**

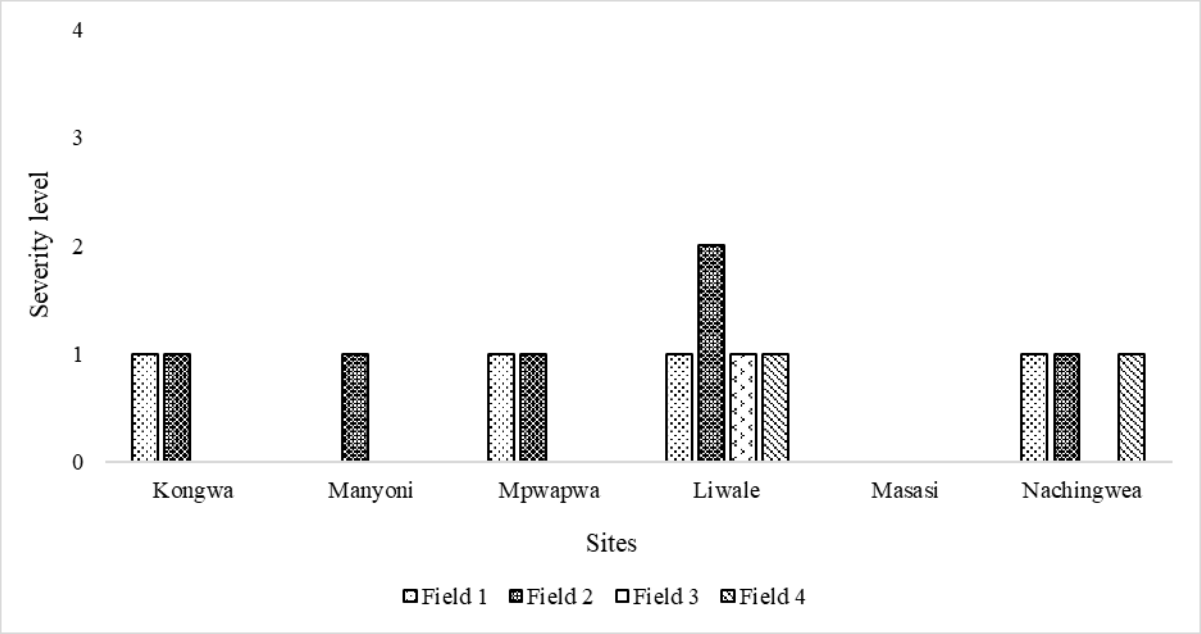


**Figure 10: Severity levels at different districts during the reproduction season**

## 4.4 Farmers common management practices in managing sucking insect pests

### 4.4.1 Farmer profile

Table 6 summarizes the socio-economic profile of the key informant interviewed. About Seventy-seven (77.8%) of the respondents were males and 22.2% were females. Slightly 14.8% of the farmers were older than 46 years; the majority of the respondents (66.7%) were aged between 31-45 years, and few (18.5%) were in 19-30 years. Since the majority of the farmers were ranging from 31-45 years aged, and most of them were males (77.8%); hence they were capable of performing farming operations in the cashew fields.

### 4.4.2 Cashew fields

About 51.8% of the farmers own cashew fields ranging from 2.1- 4 hectares with nearly 87% under mono-crop. Of those fields under mixed cropping, 64% were cashew mixed with Pigeon peas (*Cajanus cajan*), 20% with *Mucuna sp.* Dominant cashew clones covered in our survey were local, polyclonal and improved varieties like AC4, AZA 2, and AZA 17 etc. About two-thirds of the farmers bought seedlings and seeds from TARI Naliendele and nurseries nearby Cashew Development Centers (CDC's).

**Table 6: Socio economic characteristics of respondents**

| Demographic category | | Sites | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Liwale** | **Zinginali** | **Magereza-Mpwapwa** | **Mazae Chamnye** | **Magereza-Kongwa** | **Matongoro-Norini** | **Lendebesi** | **Songambele** | **Total** |
| | | Percent (%) | | | | | | | | |
| Gender | Female | 22.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 30.0 |
| | Male | 51.9 | 3.7 | 3.7 | 3.7 | 3.7 | 3.7 | 3.7 | 3.7 | 70.0 |
| Age (years) | 19-30 | 11.1 | 0.0 | 0.0 | 3.7 | 0.0 | 0.0 | 0.0 | 3.7 | 18.5 |
| | 31-45 | 55.6 | 3.7 | 0.0 | 0.0 | 0.0 | 3.7 | 3.7 | 0.0 | 66.7 |
| | >46 | 7.4 | 0.0 | 3.7 | 0.0 | 3.7 | 0.0 | 0.0 | 0.0 | 14.8 |
| Education level | Primary | 66.7 | 0.0 | 0.0 | 3.7 | 0.0 | 0.0 | 3.7 | 3.7 | 77.8 |
| | Secondary | 7.4 | 3.7 | 0.0 | 0.0 | 0.0 | 3.7 | 0.0 | 0.0 | 14.8 |
| | Collage | 0.0 | 0.0 | 3.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.7 |
| | University | 0.0 | 0.0 | 0.0 | 0.0 | 3.7 | 0.0 | 0.0 | 0.0 | 3.7 |
| Farm size cultivated (ha) | Small scale 0.1 – 2 | 14.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.7 | 18.5 |
| | Medium scale 2.1 – 4.0 | 37.0 | 3.7 | 0.0 | 3.7 | 0.0 | 3.7 | 3.7 | 0.0 | 51.8 |
| | Large scale ≥ 4.1 | 22.2 | 0.0 | 3.7 | 0.0 | 3.7 | 0.0 | 0.0 | 0.0 | 29.6 |

### 4.4.3 Farmer's knowledge and perception of pests and natural enemies

In response to the questions concerning the major insect pests in their field, farmers on average mentioned eleven (11) different species. They described pests mostly as related to a particular symptom or by the plant part under attack. The majority had a higher knowledge of sucking insect pests, the mosquito bugs *Helopeltis sp.*, (Hemiptera: Miridae), was mentioned by 87% of the farmers. Coconut bugs, *Pseudotheraptus wayi* (Hemiptera: Coreidae), were reported by 62% and Stem borer, *Mecocorynus loripes* (Coleoptera: Curculionidae) species, by 43% of the farmers. Thirty-four percent and 20% of the farmers mentioned leaf, shoot and fruit-feeding insects, Mealybugs, *Pseudococcus longispinus* (Hemiptera: Pseudococcidae) and Foliage thrips, *Selenothrips rubrocinctus* (Thysanoptera: Thripidae) respectively. About 15% of the farmers reported problems with the Aphids, *Aphis sp.*, (Hemiptera: Aphididae), *Miphetophora sp.* and *Diplognatha gagates* (Coleoptera: Scarabacidae), *Plaesiorrhira sp.*, (Coleoptera: Cetoniinae) and *Systates sp.*, (Coleoptera: Curculionidae) was only mentioned by farmers in Mpwapwa and Kongwa Districts (25.5%) and the Girdlers, *Analeptes trifasciata* (Coleoptera: Cerambycidae) almost only by farmers in Manyoni District (3.7%). Only around 20% of the farmers knew natural enemies, all of which were either predators or pollinators. When asked how they knew about them, the only answer was that they had learned through their observations and in different training conducted every year organized by Tanzania Agricultural Research Institute – Naliendele and facilitated by Cashew Board of Tanzania (CBT) before the starting of the cashew production season. The training was conducted in terms of cashew agro-ecological zones (southern, eastern and central); farmers gather and receive training in all aspects regarding cashew husbandry, including insect pests. Four (14.8%) farmers mentioned bees, *Apis mellifera*, (Hymenoptera: Apidae) and twenty-three (85.2%) mentioned the weaver ant *Oecopylla longinoda* (Hymenoptera: Formicidae) as the most predators of cashew insect pests.

### 4.4.4 Pests management practices

Seventy-nine percent (79%) of farmers interviewed used chemical control method (insecticides) and about 16% used cultural methods such as sanitation and pruning, while 5% used biological methods with the use of weaver ants (Fig. 11). About two-thirds of the farmers possessed motorized blower machines for spraying application in the fields.

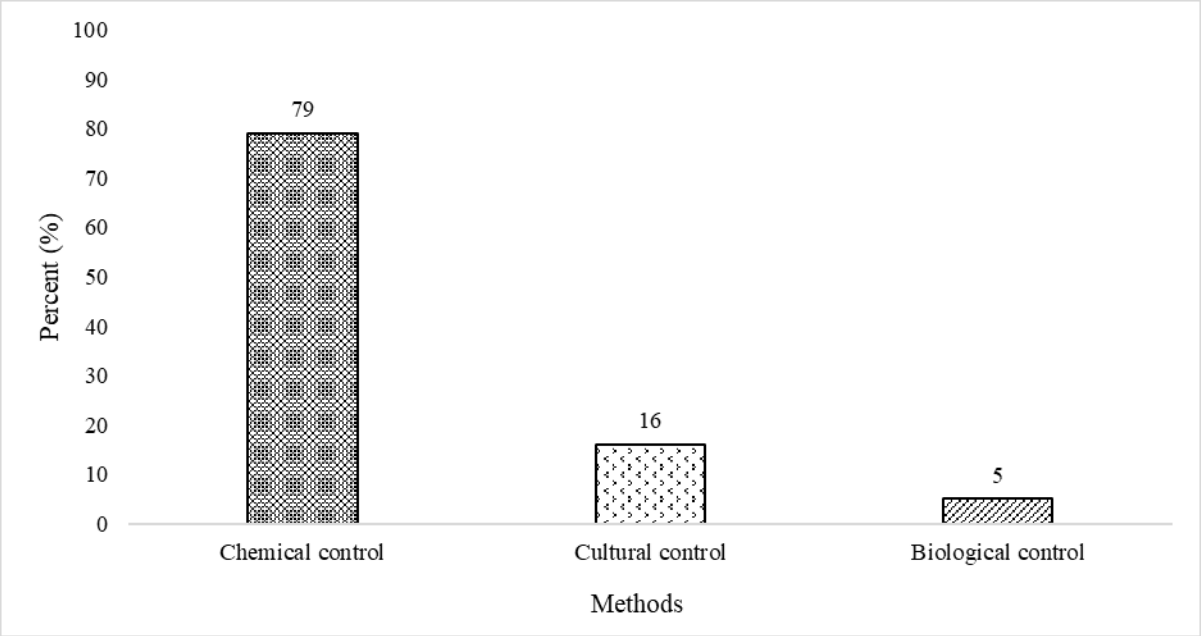


**Figure 11: Insect pests control methods**

### 4.4.5 Timing and frequency of insecticide applications

Insecticides were used at an average of 2-4 rounds of sprays per season. Most sprays applied from a few weeks after flushing (May / June) and after nut setting (August/September). Most of the farmers (57%) sprayed insecticides in 3 weeks interval, mainly to protect shoots and nuts from cashew sucking insect pest's infestation. The number of rounds for insecticides application also varied from one respondent to another depending on the incidence of insect pests and income levels. However, timing and frequency of insecticide applications, insecticide use in terms of active ingredients to use and application rates, and cost of inputs such as motorized blowers are major factors that constrain adoption of recommended technologies in some of the cashew growing areas in Tanzania, especially in the central zone.

### 4.4.6 Insecticide use and application rates

Insecticides use varied among the respondent; thus affect their appropriate use. Farmers showed that have little knowledge regarding insecticides and insecticides use, including the types of insect's controlled and active ingredient, dosage rates and rounds of application. Sixteen (16) different insecticides with five (5) different active ingredients, Lambda-cyhalothrin, Cypermethrin, Chlorpyrifos, Profenofos and Fenitrothion were used. Only 63% of farmers knew the appropriate insecticides application rates.

### 4.4.7 Information transfer and awareness level

The low level of awareness expressed by respondents was due to limited contact with the Village Agricultural Extension Officer (43%), while limited exposure and opportunities accounted for 19%. Other factors were low priority given to cashew farming 21%, and weak interaction with other farmers 7% and only 10% have information from more than one source (Fig. 12). Awareness of the respondents was still in a progress situation due to the low number of trainees attending training due to limited resources, few numbers of village extension officers per district, emerging of new insects pests and new types of insecticides registered every year with different active ingredients.

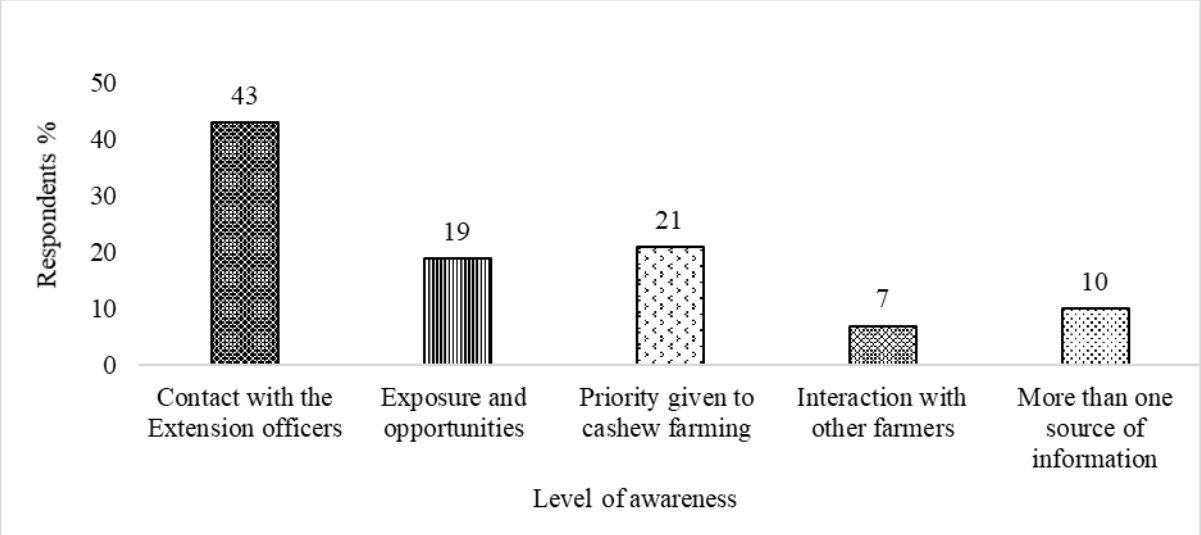


**Figure 12:**

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusion

The present study demonstrated thirteen (13) species belonging to eleven (11) families and four (4) orders. Hemiptera, Coleoptera and Thysanoptera were the orders consist of insects pests attacking cashew tree organs (Leaf, shoot, fruit and stem) in surveyed sites. The *A. mellifera* and *O. longinoda* were only natural enemies recorded belong to the order Hymenoptera. Six (6) insect pest's species (*Helopeltis sp., P. wayi, P. longispinus, S. rubrocinctus, M. loripes and A. trifasciata*) were found in both zones whereas five (5) insect pests (*D. gagates, Systates sp., Mithetophora sp., Plaesiorrhira sp.,* and *Aphis sp.*) were first recorded and identified in the central zone of Tanzania. Moreover, the present study has shown that *Helopeltis sp*. and *Pseudotheraptus wayi* were the main cashew insect pests in the surveyed zones.

The differences observed between the zones, districts and sites were attributed to climatic condition, effects of landscape, insecticides use and intercropping systems, including cashew intercropped with pigeon peas, castor beans (alternative host) that affect cashew production by increasing the population of sucking insect pest's species that are harmful to the cashew production areas, especially in Liwale, Masasi and Nachingwea districts.

Farmers in the central zone they have little knowledge on the integrated pest management (IPM) especially on timing and frequency of insecticide applications, insecticide use in terms of active ingredients to use and application rates were major factors that constrain to cashew.

Hence, through this study, the identity, abundance and distribution were known therefore, the information provided here is necessary for a way forward towards developing appropriate pest management measures.

## 5.2 Recommendations

In correspondence to the findings and conclusion, the following are recommended:-

(i) Farmers of the southern zone should not intercrop pigeon peas, castor beans together with cashew fields, which acts as alternative host crops or managing (chemical control) both crops at the same time to reduce the pest population and damages.

(ii) It would be desirable to conduct demonstration plots, farmer's field days as well as training on managing cashew insect pests so as establish common understanding and trust among farmers.

(iii) Further research is required in studying biology, ecology population dynamics and abundance of (*D. gagates*, *Systates sp.*, *Mithetophora sp.*, *Plaesiorrhira sp.*, and *Aphis sp.*) first reported and identified insect pests to determine specific periods for intervention and develop methods (species-specific) for effective pest management.

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## APPENDICES

**Appendix 1:**

| | |
|---|---|
|  | **DISEASE LEVEL 0**<br>▪ Leaf symptoms:<br>▪ No, any disease symptom<br>▪ 0% of disease severity |
|  | **DISEASE LEVEL 1**<br>▪ Leaf symptoms:<br>▪ Disease percentage; 1 – 25 (Average 13%) |
|  | **DISEASE LEVEL 2**<br>▪ Leaf symptoms:<br>▪ Disease percentage; 26 – 50 (Average 38%) |
|  | **DISEASE LEVEL 3**<br>▪ Leaf symptoms:<br>▪ Disease percentage; 51 – 75 (Average 63%) |

| | |
|---|---|
|  | **DISEASE LEVEL 4**<br>▪ Leaf symptoms:<br>▪ Disease percentage; 76 – 100 (Average 88%) |

**Appendix 2:**

| Zones | Districts | Sites/Field names | Latitudes ( ° ) | Longitudes ( ° ) |
|---|---|---|---|---|
| Southern | Liwale | Makata-Mitawa A | -9.743611 | 37.857500 |
| | | Makata-Makata | -9.683056 | 37.832778 |
| | | LiwaleB-Mikunya | -9.796667 | 38.084444 |
| | | Kihangara-Kihangara | -9.931944 | 38.346667 |
| | Masasi | Mkomaindo | -10.736667 | 38.793056 |
| | | Sululu-Songambele | -10.795556 | 38.733889 |
| | | Sululu-Sululu | -10.793889 | 38.719444 |
| | | Chikundi-Chikundi | -10.545000 | 38.966667 |
| | Nachingwea | Ikungu | -10.290833 | 38.760000 |
| | | Naipingo-Nchonda | -10.437222 | 38.673611 |
| | | Nang'ondo-Nang'ondo | -10.478889 | 38.655278 |
| | | Naipanga-Ndomondo | -10.520833 | 38.819167 |
| Central | Mpwapwa | Mazae-Chamnye | -6.337448 | 36.461910 |
| | | Magereza 2 | -6.359692 | 36.472438 |
| | | Magereza 3 | -6.357575 | 36.467380 |
| | | Magereza 4 | -6.357003 | 36.466750 |
| | Kongwa | Mkoka-Songambele | -5.862610 | 36.446667 |
| | | Mkoka-Matongoro | -5.829862 | 36.470665 |
| | | Mkoka-Lenebesi | -5.799215 | 36.405113 |
| | | Mkoka-Magereza | -5.828133 | 36.438327 |
| | Manyoni-Itigi | Majengo-Zinginali 1 | -5.696588 | 34.515463 |
| | | Majengo-Zinginali 2 | -5.697910 | 34.515275 |
| | | Majengo-Zinginali 3 | -5.694843 | 34.514527 |
| | | Majengo-Zinginali 4 | -5.691233 | 34.513392 |

**Appendix 3:**

1. Name of respondent …….
2. Age
    a) 25-30 years' old
    b) 31-45 years' old
    c) > 46 years' old
    d) Don`t know their age

3. Gender.....
4. Education level
    a) Primary
    b) Secondary
    c) Collage
    d) University
5. Cashew farm acreage ……

6. Did you experience crop loss/wastage during production season?
    a) Yes [ ]
    b) No [ ]
7. If yes, what were the causes /nature of the crop loss?
    a) ……..
    b) ……
    c) ……

8. Do you experience insect pest in cashew production?
    a) Yes [ ]
    b) No [ ]
9. Do you know any insect pest of cashew?
    a) Yes [ ]
    b) No [ ]

10. If yes; list type of insect pests identified infesting cashew in your cashew farm
    a) ……
    b) …….
    c) …….

11. What is the nature of their attack?
    a. Piercing and sucking
    b. Cutting and chewing
    c. Boring
12. What part (tissue) of the tree is most attacked?

a. New emerging shoots and leaves
b. Flowers
c. Fruits
d. Apple
e. All the above

13. What are signs/symptoms to the attacked area?
    a) ……
    b) ……
    c) ……

14. What is the most destructive stage of insect pest?
    i. Egg
    ii. Larvae
    iii. Pupa
    iv. Adult

15. At what time of the year do you notice insect attack/damage to your cashew trees?
    a) …….
    b) …….
    c) …….

16. On which month the attack is most severe ?
    a) ……..
    b) ……..
    c) ……..

17. At what time the damage occurs?
    i. During the night
    ii. During the morning
    iii. During the afternoon
    iv. Any time of the day
    v. I don't know

18. Do you control them?
    a) Yes [ ]
    b) No [ ]

19. If you did not use any chemical to control insect pests in cashew, what were the reasons?
    (i) ……..
    (ii) ……..

20. If yes, what method did you use to control them?
    a) Chemicals [ ]
    b) Cultural control [ ]
    c) Biological control [ ]

d) Both Chemical and cultural [ ]

e) Combination of all 1, 2 3 & 4 [ ]

21. What indicators/factors determine decision when to start spraying against insect pests?
    a) ……..
    b) ……..
    c) ……..…

22. If chemicals were used, specify which insecticides

    a) ……

    b) ……

    c) ……

23. Did you get the (input) insecticides at the right time?
    a) Yes
    b) No

24. Was the input sold at the subsidized price?
    a) Yes
    b) No

25. What was the price of the pesticides? Tshs……

26. What was the number of insecticides obtained?
    a) Less than the amount required
    b) The right amount required
    c) More than the amount required

27. What were the sources of those chemicals?
    a) NGOs
    b) Extension services
    c) Cooperative society
    d) CBOs/ Agencies
    e) Business people (stockiest/input dealers)
    f) Others

28. Were the insecticides applied at the right time?
    a) Yes
    b) No

29. Did spraying of insecticides start on time?
    a) Yes
    b) No

30. If spraying did not start on time, what were the reasons for the delay?
    a) ……
    b) ……..……..

31. What was the spraying interval of insecticide per season?
    a) 21 days
    b) Less than 21 days
    c) More than 21 days

32. Were you able to maintain spraying interval?
    a) Yes
    b) No

33. If no, explain why spraying interval was not followed?
    (i) ……
    (ii)……

34. Were chemicals applied according to recommendations given (ml/water)?
    a) Yes [ ]
    b) No [ ]

35. If not, explain why the recommended rate was not achieved
    i. ……..
    ii. ……
    iii. …….

36. Are you able to follow the spraying recommendations (Time to start spraying, spraying interval, recommended dose rate/rounds)?.
    a) Yes
    b) No

37. If yes, mention the sources of knowledge on the use of insecticides.
    a) ……..
    b) …….
    c) ……..

38. How do you evaluate the effectiveness of the insecticides used in controlling insect?
    a) Very effective
    b) Somehow effective
    c) Not effective

39. Do you own a motorized/blower machine?
    a) 1. Yes [ ]
    b) 2. No [ ]

40. If you do not own a blower machine, where do you obtain spraying services?
    a) ……..
    b) ……..

41. What is the cost of service charge per tree/round? .....

42. Have you ever participated in training/workshop about any topic related to pesticides use? 1. Yes, 2. No

43. If yes, indicate year and venue and possibly organizer /facilitator

44. Since when did you start to use insecticides in your cashew farm?

45. Have you ever noticed side effect (negative impact) after use insecticides in your cashew farm? 1. Yes, 2. No

46. If yes, explain them
    a) ……..
    b) ……
    c) ……

47. How do you evaluate the yield trend before and after the use of insecticides?
    a) Increasing
    b) Decreasing
    c) No change

48. In your opinion, what are the most challenges in the use of insecticides?
    a) ……
    b) ……
    c) ……

**Appendix 4:**

| INSECT PESTS SCORING SHEET | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone: | | | | | | | | | | | |
| District: | | | | | | | | | | | |
| Field Name: | | | | | | | | | | | |
| Scorer Name | | | | | | | | | | | |
| Score Date: | | | | | | | | | | | |
| GPS Coordinates: | | | | | | | | | | | |
| **Field #** | **Tree #** | **Tree side** | **Total shoots** | **Shoots with** | | **Dieback** | **Pest counts** | | | **Nuts counts** | |
| | | | | BL | LD | (0-4) | Helo | Pw | Others | Total Nuts | Nut infected |
| | 1 | N | | | | | | | | | |
| | | S | | | | | | | | | |
| | 2 | N | | | | | | | | | |
| | | S | | | | | | | | | |
| | 3 | N | | | | | | | | | |
| | | S | | | | | | | | | |
| | 4 | N | | | | | | | | | |
| | | S | | | | | | | | | |
| | 5 | N | | | | | | | | | |
| | | S | | | | | | | | | |
| | 6 | N | | | | | | | | | |
| | | S | | | | | | | | | |
| | 7 | N | | | | | | | | | |
| | | S | | | | | | | | | |
| | 8 | N | | | | | | | | | |
| | | S | | | | | | | | | |
| | 9 | N | | | | | | | | | |
| | | S | | | | | | | | | |
| | 10 | N | | | | | | | | | |
| | | S | | | | | | | | | |