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Status of sucking insect pests in cashew growing locations of South and Central Zones, Tanzania

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Abstract

Cashew (*Anacardium occidentale* L.) is an economically important cash crop for many rural households in Tanzania. However, its production is constrained by some insect pests and diseases. As a precondition for the development of a more sustainable integrated insect pest management strategy for cashew, information on the incidence and severity of cashew sucking insect pests in a changing environment is required. Field surveys were conducted in the major and minor cashew producing areas of Tanzania in two phases, February to March 2019 during the vegetative season and July to August 2019 during reproduction season. The surveys were conducted in 24 cashew fields in six districts (Liwale, Masasi, Nachingwea, Manyoni, Kongwa and Mpwapwa) in southern and central agricultural research zones in Tanzania. Data on a number of shoots infected by sucking insect pests, i.e. black lesion, leaf damage, dieback level, pest counts and counts of natural enemies were collected from the two zones. Data showed that incidence and diversity of sucking cashew insect pests differed in terms of abundance and distribution within cashew fields in the central and southern zones. Liwale and Kongwa districts recorded higher incidence and severity followed by Mpwapwa, Masasi, Manyoni and Nachingwea districts, respectively. In general, insect pests affecting cashew production in selected locations of southern and central Tanzania have been known in terms of identity (genus level), abundance and distribution; therefore, more efforts on the study should be made on identification to species level to formulate management measures to each specie.

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Introduction

Cashew *Anacardium occidentale* Linnaeus (Sapindales: Anacardiaceae) is native to Brazil and was introduced to Africa by the Portuguese in the 16th Century (McLaughlin *et al.*, 2008). The cashew is now of pan-tropical distribution and is grown commercially in many tropical areas of the world, including East Africa (Mitchell and Mori, 1987; Masawe, 1994). In Tanzania, cashew was initially introduced for soil preservation and reforestation (Mitchell and Mori, 1987; Olotu *et al.*, 2013). Nevertheless, it gradually gained commercial importance in the national Growth Domestic Product (GDP) as important cash crop served as a leading foreign exchange earner for Tanzanians and ranked as the first in the year 2016 (BOT, 2017), producing employment and nutritional benefits (FAOSTAT, 2011; Kilama, 2013; George and Rwegasira, 2017). Also, 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 (NARI, 2008; Kasuga, 2013; Madeni *et al.*, 2017).

Despite its economic importance, cashew productivity in Tanzania has not been optimal due to several factors, including insect pests (Sijaona, 2013; Kasuga, 2013; Malegesi, 2015). Thus, in order to sustain farmers' assurance in engaging in cashew production resulting from Government incentives to cashew farmers, there is the need to reduce and ultimately eliminate huge cashew nut losses in terms of cashew yield and nut qualities, which are caused by major insect pests (Dwomoh *et al.*, 2009; Olotu *et al.*, 2013). In Tanzania, *Helopeltis* sp., and *Pseudotheraptus wayi* are major pests affecting cashew trees (NARI, 2010). *Helopeltis sp.* attack leaves and stalks of the tender vegetative and flowering shoots (Boma *et al.*, 1998; Topper *et al.*, 1998). All tissues above the feeding location of these insects die, and, if an attack takes place early in the growing season, each affected branch produces no leaves or flowers and fruits for the year (Dwomoh *et al.*, 2008). Angular lesions identify the attacked sites due to the insect pest piercing the stalks of the tender shoots (NARI, 2008). At the fruiting stages, *P. wayi* is the key insect pests attacking young nuts, feeds on developing nuts, causing them to shrivel, dry and blacken before them shedding off (Martin *et al.*, 1997). A characteristic sunken spot develops at the site of puncture, and mature kernels show black, sunken spots (Topper *et al.*, 1998).

The infestations can result in more than 75% shoot damage and 98% flower dropping, giving a yield loss of up to 80% (Boma *et al.*, 1998). Secondary infection by fungi may cause dieback of the shoots (Martin *et al.*, 1997) which is characterized by the withering of the shoots, generally starting from the tips and later advancing downwards to the main floral shoots and leaves (NARI, 2008). The increase in sap-sucking pest populations coincides with the main vegetative growth period of the cashew tree, which begins shortly after the end of the long rainy season (Seguni, 1997).

Apart from these common cashew pests, a participatory survey, which was conducted in southern and central zones of Tanzania, revealed that there were more cashew sucking insect pests which were reported for the first time namely *Selenothrips rubrocinctus, Miphetophora sp., Plaesiorrhira sp., Diplognatha gagates*, *Systates sp,* and *Aphis sp.*).

The main management strategy largely relies on calendar-based applications of insecticides, namely lambda-cyhalothrin (Karate 5 EC, Ninja 5 EC, Duduall 450 EC etc.) which are applied during flushing and flowering periods (NARI, 2008). These systemic insecticides have a significant impact on reducing the population of insect pests. However, they also reduce the population of beneficial insects like natural enemies and potential pollinators. Further, increases insect resistance to insecticides, environmental pollution and adverse effects on the health of the farmers, who often lack the necessary protective gear (Hill, 2008; NARI, 2010).

In the present study, assessment of the incidence and severity of cashew insect pests in the south and

central zones of Tanzania was done. The main objective of this study was to determine damages caused by insect pests (black lesion, leaf damage, and dieback levels) and understand key insect pests to develop ecologically sustainable and economically viable integrated pest management (IPM) strategies for their control.

Materials and methods

Study sites

The surveys were conducted in the cashew producing areas in southern and central zones of Tanzania. In the southern zone, districts were randomly selected namely Nachingwea, Masasi and Liwale whereby purposively sampling was used in the central zone due to a few numbers of districts cultivating cashew and districts were Mpwapwa, Kongwa and Manyoni-Itigi. In each district, four (4) cashew fields were randomly selected where ten (10) trees were assessed (total of 120 cashew trees per zone were assessed). A GARMIN GPS device was used in recording geographical coordinates of each field.

The distribution map of the areas surveyed was drawn using QGIS 3.0 software. The districts, locations and fields under the study are shown in Fig. 1 below.

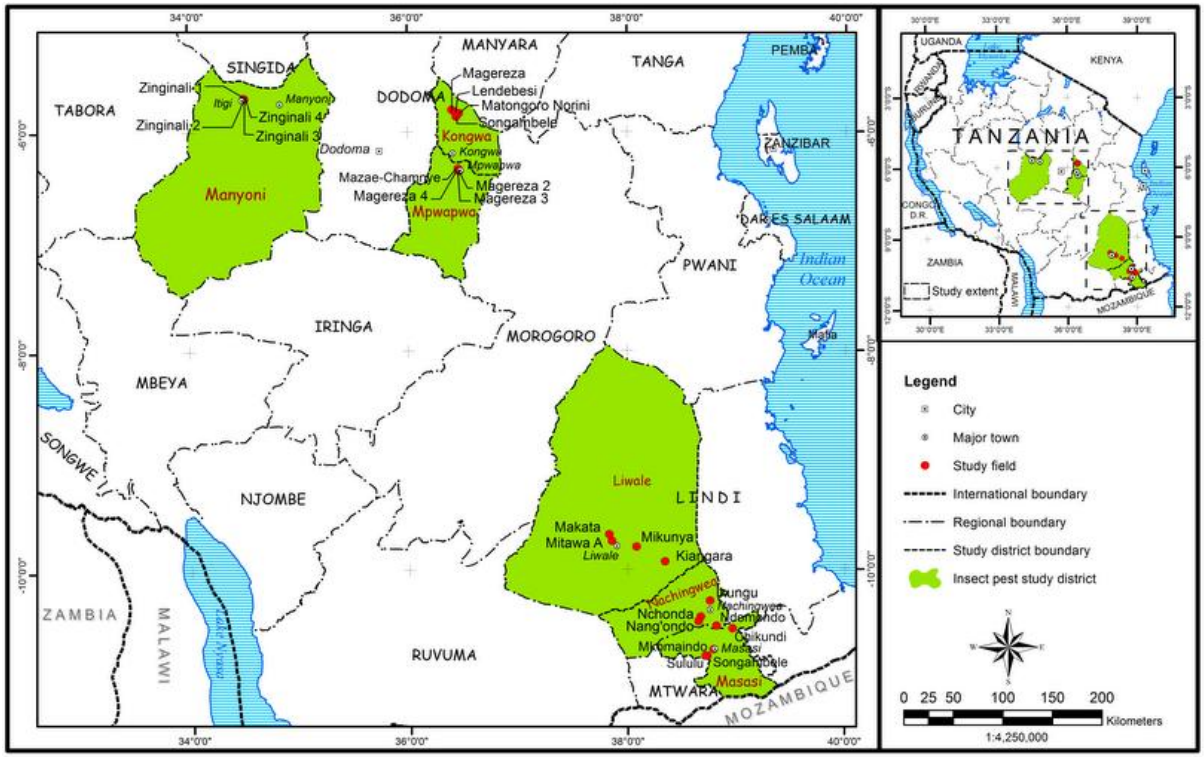

Fig. 1. Insect pests study districts and study fields.

In both zones, field surveys were carried out in two phases; February to March 2019 during the vegetative season (cashew flushing) and July to August 2019 during reproduction season (flower and bear fruit). The surveys covered 24 cashew fields within six (6) districts in the southern and central zones in Tanzania.

A sampling of cashew fields, trees and damage assessments

In each zone, three districts were selected for the study. In each district, four cashew fields were randomly picked for inspection of insect pests whereby ten trees (approximately 7 to 15 years old) were assessed per field. A total of 120 cashew trees per zone was inspected.

The survey transects were drawn across the main cashew-growing areas to include as many cashew plantations as possible for sampling. 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.

On each tree canopy, an assessment of damage to flushing shoots and young nuts and insect pests was conducted on each of the selected cashew trees. A quadrat 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. A leaf and/or panicle was treated as 'damaged' if more than 30% of its surface showed signs of damage and leaves/panicles with less than 30% damage were classified as 'not damaged' (NARI, 2008). Five tender leaves per shoot were inspected, and, if any one of these leaves was affected, the shoot was treated as damaged.

In each quadrat, the total number of shoots (TS), shoots with black lesions (BL), leaf damages (LD), damaged nuts and dieback levels were recorded.

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

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

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

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.

Insect pest 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.

Data analysis

The abundance of insect pests and their respective damages from the four sides of the cashew tree canopy were compiled as mean percent scores per district. The obtained mean scores from each zone were graphically presented for visual comparative studies using MS-Excel.

The analysis of variance (ANOVA) was carried out using GenStat software 15th edition statistical package for windows and means separation was done using Fisher's protected LSD at ($P \leq 0.05$).

Results

Diversity and distribution of key insect pests

A total of 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 southern and central zones in 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, and five (*D. gagates, Systates sp., Mithetophora sp., Plaesiorrhira sp.,* and *Aphis sp*) were found only in the central zone of Tanzania. Also, two beneficial species, namely O. *longinoda* and *A. 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.

Table 1. Diversity and distribution of key cashew insect pests in location surveyed in the south and central zones.

Orders	Families	Species	Location/Distribution	Pest status	Tissues infested / parts attacked	Severity
Hemiptera	Miridae	*Helopeltis sp.*	All localities	Harmful	Leaf, shoot, fruit	+++
	Coreidae	*Pseudotheraptus wayi*	All localities	Harmful	Leaf, shoot, fruit	+++
	Aphididae	*Aphis sp.*	All localities	Harmful	Leaf, shoot	++
	Pseudococcidae	*Pseudococcus longispinus*	All localities	Harmful	Leaf, shoot, fruit	+
Coleoptera	Scarabacidae	*Miphetophora sp.*	Mpwapwa and Kongwa	Harmful	Fruit	++
		Diplognatha gagates	Mpwapwa and Kongwa	Harmful	Fruit	++
	Cetoniinae	*Plaesiorrhira sp.*	Mpwapwa and Kongwa	Harmful	Fruit	++
	Curculionidae	*Systates sp.*	Mpwapwa and Kongwa	Harmful	Leaves	+
		Mecocorynus loripes	All localities	Harmful	Stem / Branch	++
	Cerambycidae	*Analeptes trifasciata*	Manyoni - Itigi	Harmful	Stem	++
Thysanoptera	Thripidae	*Selenothrips rubrocinctus*	All localities	Harmful	Leaf, shoot, fruit	++
Hymenoptera	Formicidae	*Oecopylla longinoda*	All localities	Auxiliary/ Predator	Leaf, shoot, fruit, Stem	+
	Apidae	*Apis mellifera*	All localities	Pollinators	Leaf, shoot, fruit	+++

Note: All localities; Liwale, Nachingwea, Masasi, Mpwapwa, Kongwa and Manyoni Districts.

*Severity of occurrence; + Light; ++ Medium; +++ Severe.

Incidence and severity of cashew insect pests in southern and central Tanzania

Figs 2 - 7 present results on pest damages in the form of percentage black lesion (BL), leaf damage (LD) and pest counts (*Helopeltis sp, P. wayi, Miphetophora sp., D. gagates, Plaesiorrhira sp.,* and *Systates sp.* etc.) at six sites, for trials conducted in 2019 in vegetative and reproduction seasons. The sites were at Liwale, Masasi, Nachingwea, Mpwapwa, Kongwa and Manyoni- Itigi districts. Table 2 represents result covering mean percent pest damages and pests counts. There were significant differences at ($P < 0.05$) in pest damages and pest counts between districts surveyed. Liwale ranked the first followed by Kongwa districts.

Mpwapwa district took the third position, Masasi and Nachingwea districts took fourth and fifth positions respectively whereby Manyoni-Itigi was the last district in terms of pest damages and pest counts.

Table 2. Mean percent damages and pest counts (percent black lesion, leaf damage and Pest counts) of selected sites in southern and central zones.

Sites	Vegetative season			Reproduction season				
	Percent black lesion	Percent leaf damage	Pest counts	Percent black lesion	Percent leaf damage	Pest counts	Mean rank	Overall rank
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 ($P < 0.05$).

*Numbers within parenthesis shows rank order down the columns.

Percent shoot damages caused by insect pests observed as black lesions and leaf damages were high in all districts surveyed. The maximum percentage of black lesions (46.7%) was recorded in Liwale District. Manyoni-Itigi district had the lowest percentage of black lesions (3.5%). The maximum leaf damages (51.7%) were recorded in Kongwa district, and a minimum average of 2.2% was observed in Manyoni-Itigi district. Pest counts were fluctuating across surveyed sites in terms of species and abundance as portrayed in Figs (2 - 7). Results representing severity levels of six sites in southern and central Tanzania are

shown in Table 3. The results portrayed slightly 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 Nachingwea and Kongwa sites. 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. 8).

Table 3. Dieback levels of selected sites in southern and central zones.

Sites	Vegetative season	Reproduction season		
	Severity	Severity	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)

*Numbers within parenthesis shows rank order down the columns.

Also, during reproduction, all-districts surveyed have an average severity of 13% (level 1) with the exception in Masasi district with severity level zero and one field in Liwale which have severity level 2 (Fig. 9).

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.

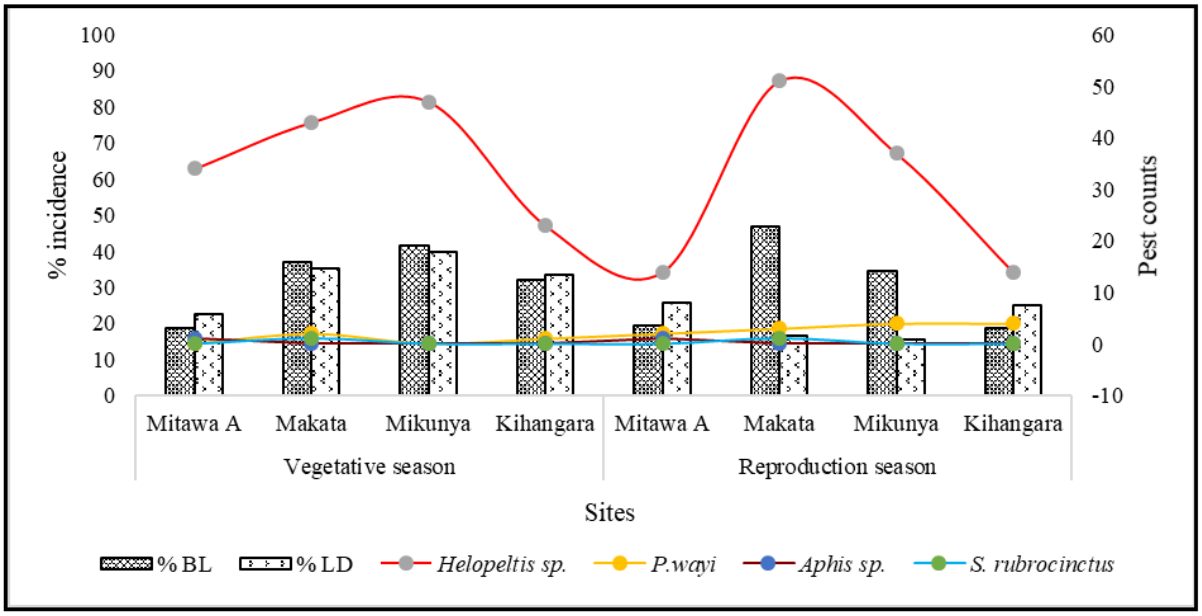

Fig. 2. Percent Black lesions (BL), Leaf damage (LD) and Pest counts at Liwale district.

Discussion

Considering survey conducted in cashew growing locations of south and central in Tanzania, it had shown, physical damages on cashew shoot done by insect pests as exhibited by observed black lesions, and leaf damages were present in all the surveyed sites. Maximum insect pest infestation on cashew fields was high during flushing stage (vegetative season) where there were many tender shoots for sucking and in the reproduction season where there were tender cashew nuts.

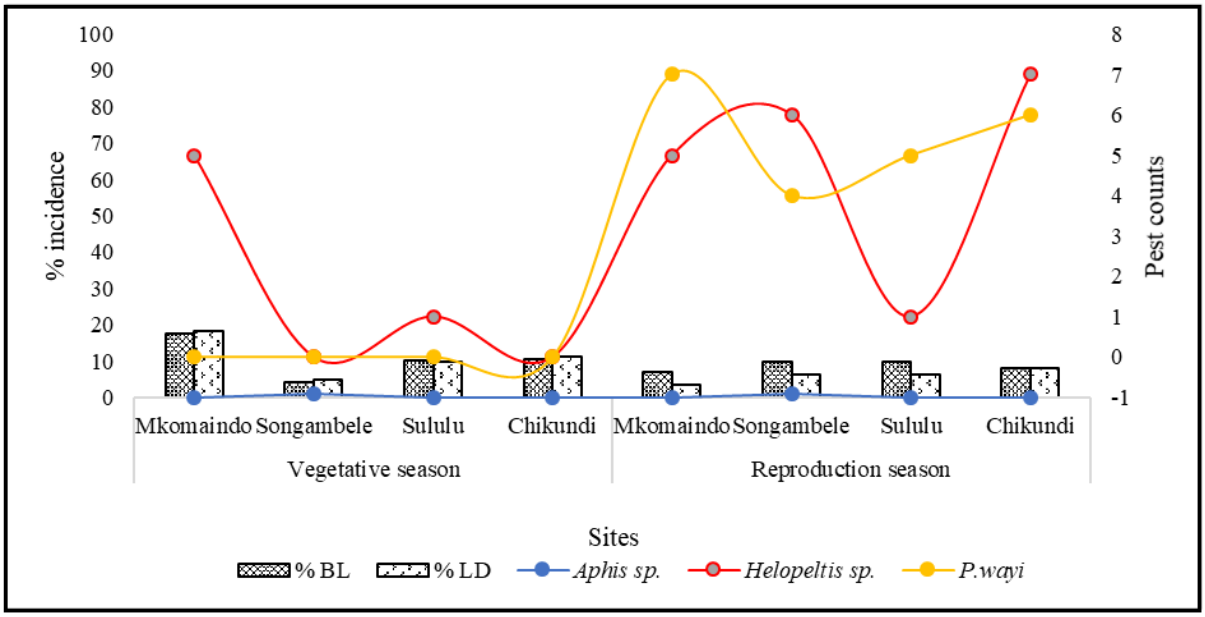

Fig. 3. Percent Black lesions (BL), Leaf damage (LD) and Pest counts at Masasi district.

The results suggest that population levels of sucking pests continue to be a problem in all cashew-growing areas, and actual physical damages on the cashew tissues were indicated on the surveyed sites. However, it is extensive in certain localities in the southern zone. The infestation of insect pests varied within two zones and between the seasons. During the vegetative season, *Helopeltis sp., P. wayi*, and *Aphis sp*. were the key insect pest species encountered in the southern zone. In the reproduction season, *Helopeltis sp.,* and *P.wayi* continues to remain the most important insect pests affecting cashew production in all sites due to low knowledge and difficulties on insect pest's management.

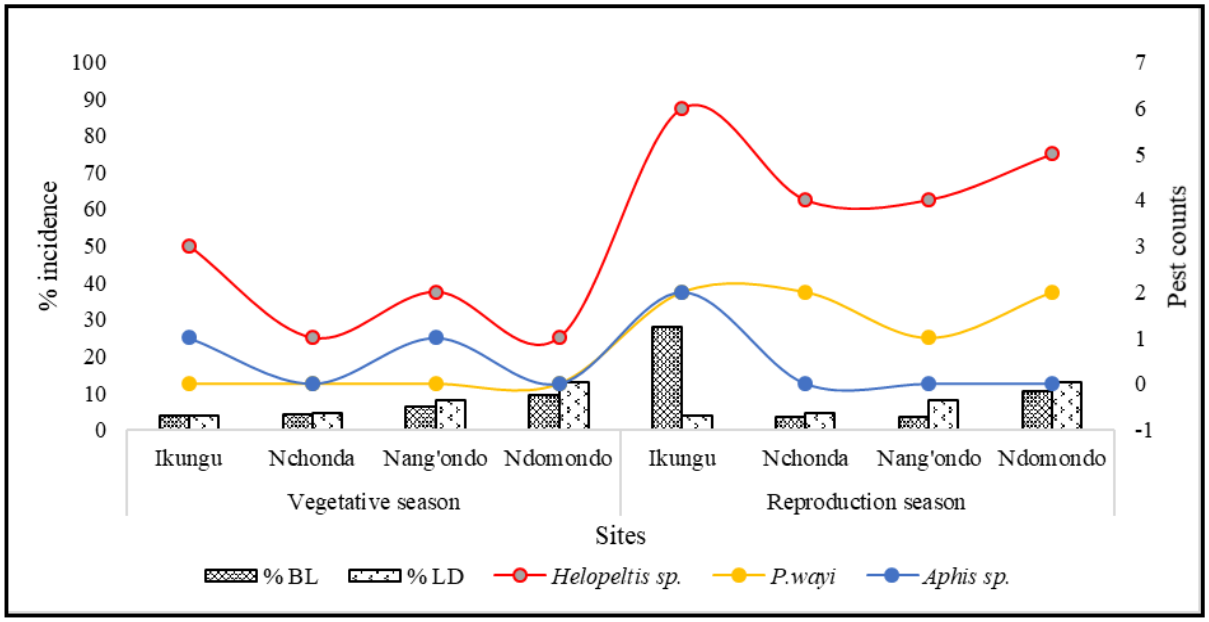

Fig. 4. Percent Black lesions (BL), Leaf damage (LD) and Pest counts at Nachingwea district.

Apart from *Helopeltis sp.,* and *P.wayi*, there were new sucking insect pests recorded for the first time to attack cashew trees in Tanzania, and these were *Miphetophora sp., Diplognatha gagates, Plaesiorrhira sp.,* and *Systates sp.* recorded in Mpwapwa and Kongwa sites.

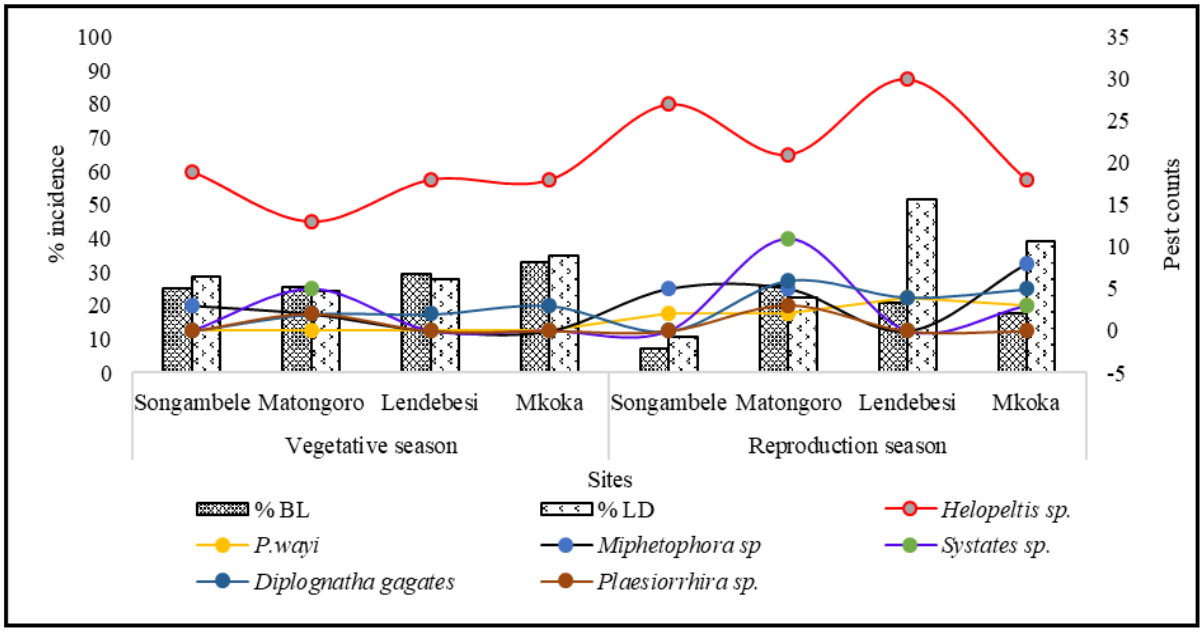

Fig. 5. Percent Black lesions (BL), Leaf damage (LD) and Pest counts at Kongwa district.

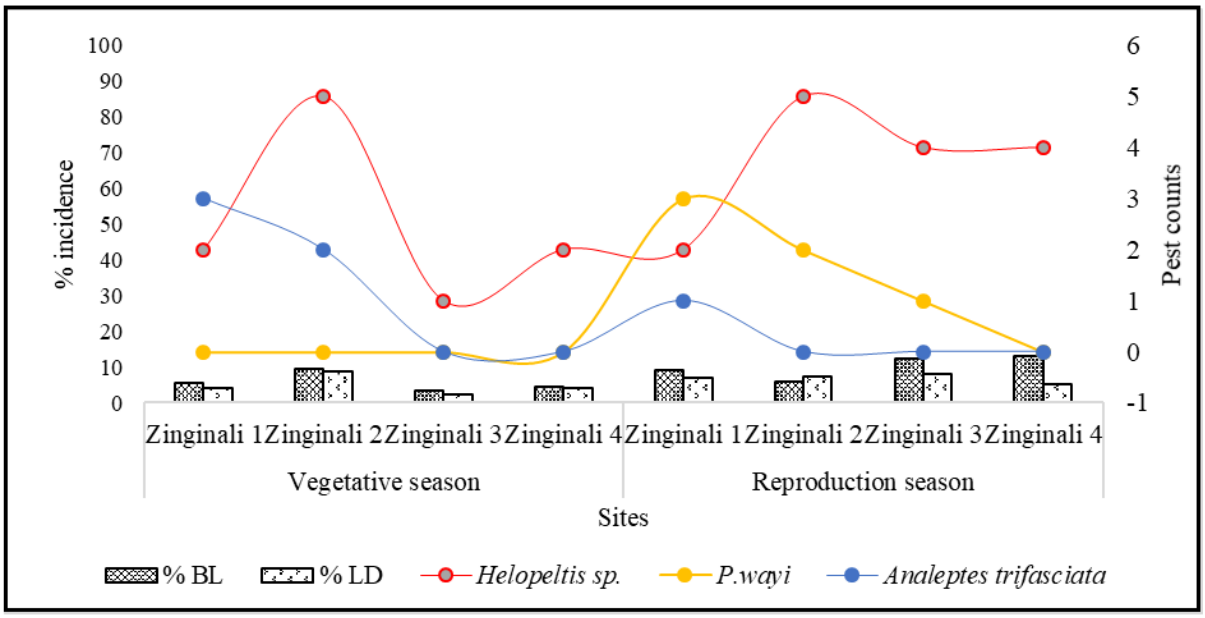

Fig. 6. Percent Black lesions (BL), Leaf damage (LD) and Pest counts at Manyoni- Itigi district.

In contrast, *Analeptes trifasciata* was only recorded in Manyoni district in the central zone. The incidence of these newly recorded insect-pests was low in all fields of Mpwapwa and Kongwa but had a significantly destructive effect on the cashew apples. *Analeptes trifasciata* had more effect on the stems of young planted cashew trees in Manyoni district.

The incidence of the sucking insect pests in the surveyed districts was high in both seasons. The adults of both species feed on tender shoots, inflorescences, immature nuts, and apples, causing the drying-off of tender shoots, blighting of inflorescences, and fall-off of immature nuts. Damaged raw cashew nuts as results of insect pests feeding are of low quality and sold at a low price after grading.

Their damages are most severe and noticeable during the flushing and flowering season. Both *Helopeltis sp.* and *P.wayi* are dominant in the southern and central zone of Tanzania (e.g., Liwale and Kongwa districts).

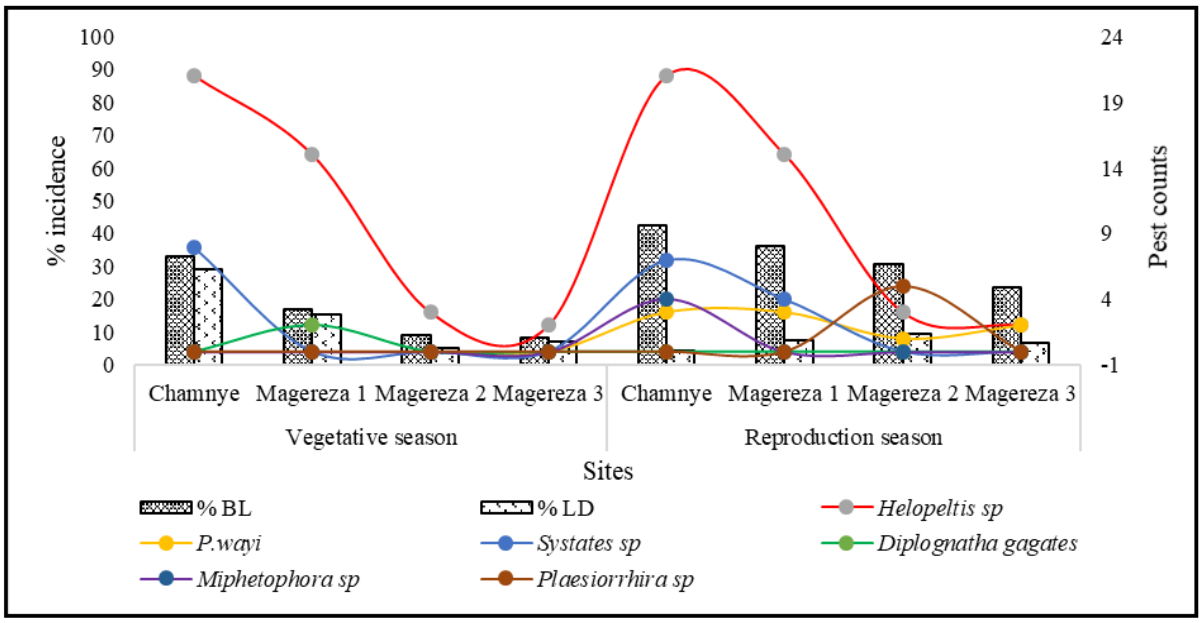

Fig. 7. Percent Black lesions (BL), Leaf damage (LD) and Pest counts at Mpwapwa district.

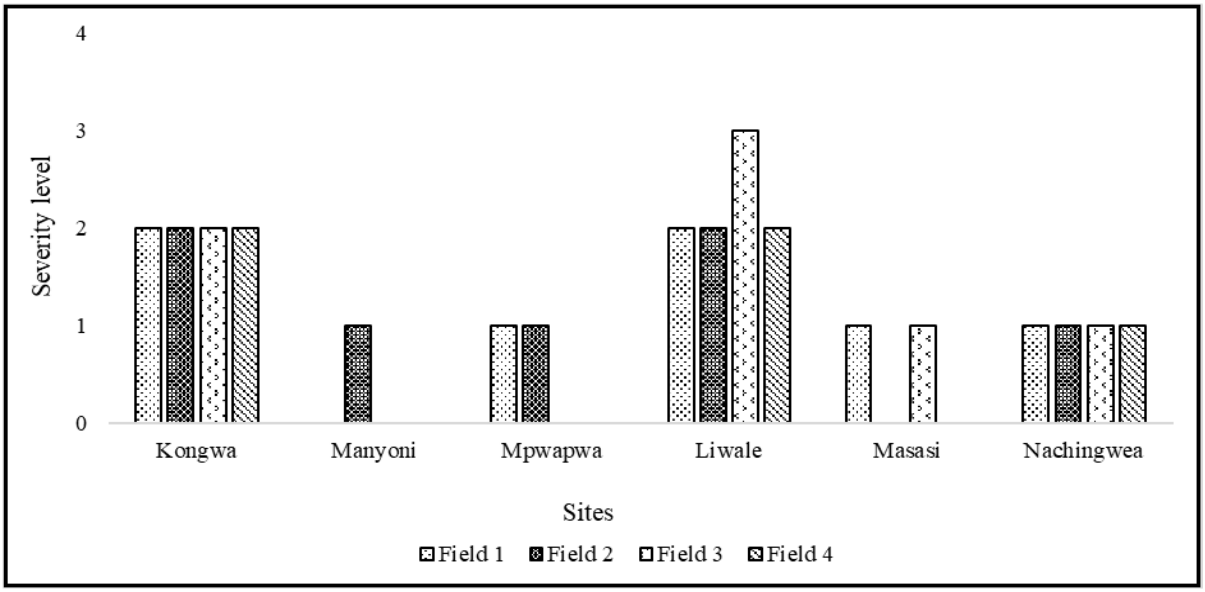

Fig. 8. Severity levels at different districts during the vegetative season.

Surveyed cashew trees were observed around the canopy and assigned a score reflecting the overall proportion of dieback disease levels on a 0-4 scale, where level 0 = 0%; level 1= 1 – 25%; level 2 = 26 – 50%; level 3 = 51 – 75% and level 4 = 76 – 100% disease severity as described by TARI Pathologists Protocol (2012). Severity levels in the surveyed sites varied according to the population of cashew sucking insect pests, farming system and farmer's knowledge and awareness on the control of cashew insect pests. Districts like Liwale and Nachingwea had higher severity levels among surveyed districts due to intercropping farming system with pigeon peas, castrol beans and cowpeas, which act as alternative hosts plants for these sucking insect pests.

Equally, Kongwa district had high severity level due to low knowledge and awareness on the control of insect pests in terms of the type of insecticides to be used (active ingredients), rate of application, the timing of application, and intervals of application and the round of insecticides applications. Other sites were ranked, and most of the districts were in severity level 1.

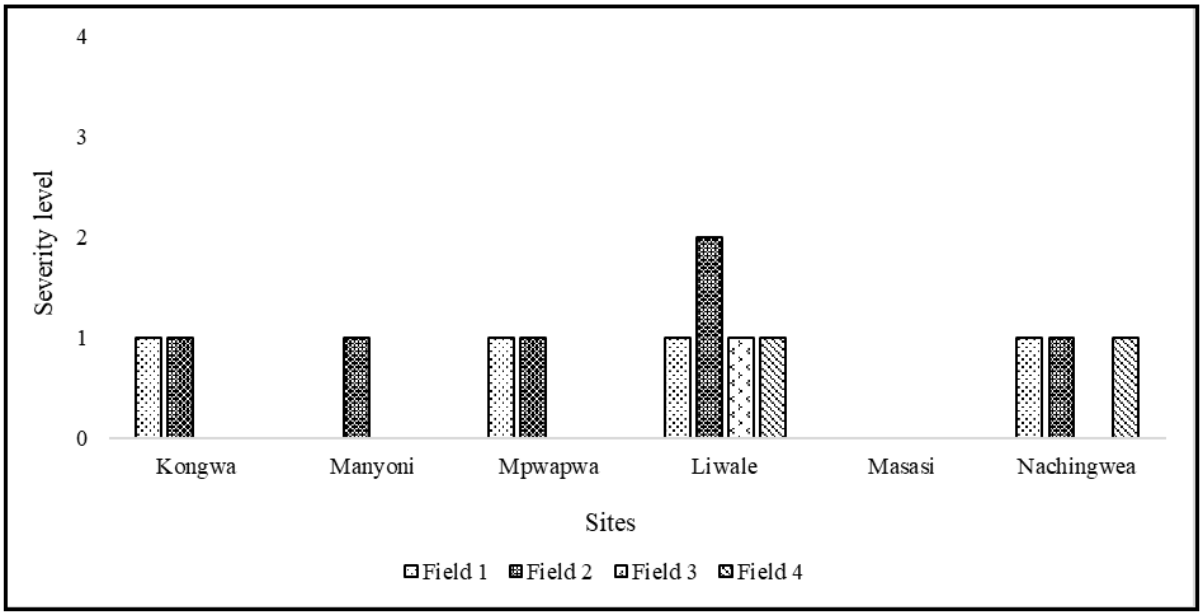

Fig. 9. Severity levels at different districts during the reproduction season.

This study shows that *Helopeltis sp*. represents the most important insect pest species across the major cashew grown zones of Tanzania, confirming previous reports (Martin *et al.,* 1997; Boma *et al.,* 1998; Topper *et al.,* 1998; NARI 2008; Agboton *et al.,* 2013).

Conclusion

In conclusion, thirteen (13) species belonging to eleven (11) families and four (4) orders were recorded in this study. Among these species, others were auxiliary/predator and pollinator pests. Hemiptera, Coleoptera and Thysanoptera were the orders attacking cashew tree organs (Leaf, shoot, fruit and stem) in surveyed sites. These results indicated that major insect-pests that attack cashew in the studied sites included commonly known species namely *Helopeltis sp, P. wayi, S. rubrocinctus, M. loripes* and *A. trifasciata* and only provide an overview of the first recorded insect pests namely *Miphetophora sp., Plaesiorrhira sp., Diplognatha gagates, Systates sp* and *Aphis sp*. The *A. mellifera* and *O. longinoda* were only natural enemies recorded belong to the order Hymenoptera.

The two surveyed zones had differences in incidence and severity due to variations in cashew insect pests. Highly significant differences in the incidence and severity were observed in different cashew sites from the two zones. Incidence and severity variations in southern and central zones could further be attributed to the effects of landscape, agrochemical use and intercropping systems. Furthermore, climatic conditions constitute one of the main factors that could explain the variation that may occur in consecutive surveys. In general, Liwale district presented higher incidences and severity levels than the rest of surveyed sites in both zones. These high levels of infestations are observed on cashew fields that are not well managed in terms of insecticides spraying and intercropped with annual crops like pigeon peas, castrol beans and cowpeas, which shares pests and act as an alternative host.

Therefore, there is a need for training and seminars to farmers to know and understand the appropriate measures of managing cashew insect pests affecting the cashew industry. Further research on population dynamics and abundance of the insect-pests and identification of insects to species level is recommended to aid in designing intervention and effective management approaches against the insect pests in Tanzania.

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Abbreviations

BOT -Bank of Tanzania
DAICO's- District Agriculture, Irrigation and Cooperative Officer (s)
FAOSTAT- Food and Agriculture Organization Statistics
Gen Stat- General Statistics
GPS- Global Positioning System
LSD- Least Significant Difference
M- Meter
NARI- Naliendele Agricultural Research Institute
NM-AIST Nelson Mandela African Institution of Science and Technology
QGIS- Quantum Geographic Information System
TARI- Tanzania Agricultural Research Institute