Economic Evaluation of Insect Pests Management in Cashew Productionin Mtwara, Tanzania

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Abstract: *Cashew production is severely constrained by sucking insect pests such as coconut bugs, cashew mosquito bugs and thrips. They damage flushing foliar, floral shoots and developing nuts. Weaver ants (Oecophyllalonginoda) have for long been considered as effective biological control agents against pests. Before changing from one production method to another, farmers need to consider costs and incomes resulting from the change. This paper evaluated economic benefits of managing cashew insects using weaver ant, Karate and control. The experiment was conducted in a Randomized Complete Block Design with four replications in, Mtwara during 2012-13 and 2013-14. The statistically significant treatments were subjected to economic analysis using the partial budget and MRR. Discounted financial indicators (NPV, BCR and IRR) were used. The study revealed that damage caused by each pest was significantly lower* $(P < 0.0001)$ *on trees with weaver ants and in the plots treated with Karate® than was the case on the control trees. There was no significant difference* $(P > 0.05)$ *in the damage between O. longinoda and Karate® treated trees suggesting that the two treatments are equally effective. The difference in the damage levels was directly reflected in the mean cashew yield. Switching to weaver ants was feasible due topositive net change in benefits. MRR was highest forweaver ants at 235% in 2012/13 and 405% in 2013/14 seasons. Weaver ant indicated highest NPV (TZS 32 640), BCR (2.5:1) and IRR (57%). The use of weaver ants was economically feasible management strategy to be adopted by farmers and was recommended.*

Key words: cashew, crop damage, biological control; economic analysis, weaver ants

1.0 INTRODUCTION

Cashew nut (*Anacardiumoccidentale*) production is continually gaining recognition as a major income generating activity for both small and large-scale farmers in Tanzania, creating job opportunities and improving diet by providing essential micronutrients and vitamins (FAOSTAT, 2011; UNIDO, 2011; Kilama, 2013). The production of the crop is considered to be below its potential as a result of the ever increasing production costs and the reduction of the quality and quantity of marketable produce (UNIDO, 2011). Cashew nut is constrained by heavy infestations of a range of insect

pests (NARI, 2010). In Tanzania, two potentially serious pests in cashew sub-sector are the mirids (*Helopeltisanacardii*) and coreid bug (*Pseudotheraptuswayi*) (NARI, 2010) (Figure 1).

These pests, attack leaf and floral flushing shoots and cause early abortion of young developing nuts and fruits and substantial loss of yield (Segun*iet al*., 2011). Their wide distribution, fast proliferation and polyphagous nature (feeding on multiple host crops) make it difficult to control because insecticides in form of dust or sprays cannot reach them (NARI, 2010; Peng *et al*., 2010).

In some cashew-based farming systems, current agricultural practices don't involve pest control methods. That is the tree crops are left untreated which results in decline in yields and quality (Figure 2) due to insect pests which in turn causes significant economic loss (NARI, 2010; Gudila*et al*., 2013).

Other smallholder farmers rely on synthetic pesticides spray such as Karate for most of their pest management (Christian *et al*., 2011; Peng and Christian, 2014) as indicated in Figure 3(i). However, the increased use of pesticides for pest control has led to the rise of production costsdue to the high costs of insecticides, equipment and labour during application four to five times a season (NARI, 2010). Smallholder farmers continue to rely on insecticides because cost-effective and environment friendly alternative control measures are not available to them (Gitonga, 2009; Varela *et al*., 2012).

In the absence of natural enemies as biological control agents, insect pest populations are menace such that sometimes, damage is high (Peng *at al*., 2010). Smallholder farmers are seeking alternative technologies by use of the weaver ants (*Oecophyllasp*) that reduce production costs and/or increase yields.The use of Asian weaver ants, *O. smaragdina* (green ants) *as* biological control agents in Asia, South Pacific Islands and Northern Territory of Australia has been found to be superior to pesticides in insect pest control (Peng *et al*., 2010). More than 50 insect pest species belonging to 18 families are effectively controlled by *Oecophylla* in eight tropical tree crops and some forest trees (Peng and Christian, 2009). They reduce infestation through: predation as shown in Figure 4 (iii)of adult insect pests, predation of third-stage larvae and the repulsive effect of "pheromones" left by the weaver ants on nuts and fruits so that insect pests are discouraged from laying eggs in them (Olutu*et al*., 2013). However, little is known about the economic benefits of using African weaver ants, *Oecophyllalonginoda* (red ants) in

production. Before changing from one production method to another, farmers need to consider costs and incomes resulting from the change. This paper evaluated economic benefits of managing cashew insects using weaver ant-based protection, chemical (Karate) and control (neither weaver ants nor Karate).

METHODOLOGY

Study areas

The experiments were conducted in a Randomized Complete Block Design (RCBD) with four replications at Naliendele Research Institute (NARI) ($10^{o}22'S$ and $40^{o}10'E$) in Mtwara in 2012 and 2013 seasons. The area receives a mean annual rainfall of about 1160 mm (unimodal) which falls mainly between November and April. A plot measuring 324m x 196m, with a cashew variety (AC4) was used.

Experimental treatment

Three treatments were used namely; control, *O. longinoda*, and Karate. Each treatment was applied to a total of 72 trees that were fortnightly assessed for damage by the *P. wayi*, *Helopeltis* species thrips damages and yields per tree.

(a) Control

Control treatment (neither *O. longinoda* nor Karate) was used for comparisons. Sulphur dusting was applied at a rate of 0.25 kg per tree at 14-days intervals after panicle emergence and continued at two-week intervals throughout the flowering period. Sulphur was used in this treatment because according to NARI (2010) cashew PMD is believed to destroy the harvest if not controlled using Sulphur.

(b) Karate

The Karate® 5ECwas applied at a rate of 0.005 litres per tree four to five times per season using a motorized backpack sprayer (M 225-20 Motor-Rückensprühgerät). The entire experiment was prophylactically protected against powdery mildew by spraying sulphur (falcon dust) fortnightly at a rate of 250 g $tree^{-1}$(Olotu*et al.*, 2013). Sulphur dusting was appliedat a rate of 0.25 kg per tree at 14-days intervals after panicle emergence and continued at two-week intervals throughout the flowering period. Additional spray of a systemic fungicide Bayfidan, (triadimenol 250 g $litre^{-1}$) was applied at 3-weeks intervals at a rate of 0.015 litres per tree four rounds to control powdery mildew disease (PMD), (*Oidiumanacardii*).

(c) *O. longinoda*

In the *O. longinoda* treatments, weaver ant colonies were identified and collected/harvested using picking pole from neighboring villages and were transplanted/released onto the experimental plots (Figure 1).

Assessment of nut yields and revenues

Yields of individual trees were assessed by counting and weighing fully ripened and dropped nuts collected under the tree canopy. Collection of the nuts started in late August and ended in November in each cropping season. Transplantation of weaver ant colonies covers the labor involved in identifying ant colonies and transporting them into the plantationas presented in Figure 4 (i)). Plastic bags were used to carry the ant nests that were transplanted into the plantationas shown in Figure 4 (ii). The weaver ants were released by hanging the plastic bags on a tree at a shade to allow them establish their new nests indicated in Figure (iii). Nylon rope was used to connect trees within ant colonies to ease their migration between treesas presented in Figure 4 (iv). Selling prices of cashew were based on the price that smallholders could obtain by selling their produce to local farmer cooperatives. The average price used in the analysis for cashew nuts protected using Karate was obtained by interviewing 12 representatives from five farmer cooperatives in Mtwara region. This premium price for organic cashew was given by the Masasi Cooperative for organically grown nuts which were subsequently exported to Netherlands.

Data analysis

Analysis of variance was used to test the effect of treatments on yields for each season. The statistically significant treatments of this experiment were subjected to economic analysis using the partial budget procedure and Marginal Rate of Return (MRR) involving dominance analysis. In order to perform dominance analysis, insect pest management practices (treatments) were arranged in order of increasing variable costs. A treatment was dominated if its variable costs were higher than the proceeding treatments but its net benefit was lower. Such a treatment was termed as dominated treatment and was donated by 'D'. In addition, three important discounted financial indicators (NPV, BCR and IRR) were used in the study.

RESULTS AND DISCUSSION

Damages by majors pests

Damage caused by *P. wayi* and *Helpeltisspp*were significantly lower $(P < 0.0001)$ on trees with *O. longionoda*and in the plots treated with

Karate® than was the case on the control trees in 2012 and 2013 seasons (Table 1). There was no significant difference $(P > 0.05)$ in the damage between *O. longinoda* and Karate® treated trees suggesting that the two treatments are equally effective. The difference in the damage levels was directly reflected in the mean cashew yield. The comparable effectiveness of ants and chemicals in Vietnamese citrus protection is also lent support by a study by Offenberg&Wiwatwitaya (2010) in which costs and yields were compared between orchards with abundant *O. smaragdina*ants and orchards with fewer ants.

Crop Budget

Yields in cashew were not significantly different between the Karate and *O. longinoda* treatments but these treatments were all significantly higher than the control (Table 2). The use of *O. longinoda* reduced total variable costs by 19% and 22% in the first and second season, respectively, as compared to the use of Karate, and the use of *O. longinoda* increased costs by 37% and 24% in the two seasons, compared to the control group.

A pairwise statistical comparison was performed between the three treatments under study (Table 3). Results show that there was no significantly different $(P < 0.0001)$of the mean yields obtained in tree protected by O. longinoda and Karate with *O. longionoda*and was signigicantly different when compared to control trees in both seasons.

ECONOMIC ANALYSIS

Partial Budgeting Analysis (PBA)

The results of the partial budget analysis are shown in Table 4. Using the 2012 and 2013 crop budgets, the adoption of *O. longinoda*will increase income (positive net change in benefits) in both seasons. This implies that the incremental benefits in farming with *O. longinoda* exceed the incremental costs and suggesting that using *O. longinoda*is an economically feasible management practice. Evans (2015) pointed out that if a technology is relatively new, requiring some new skills, higher benefits associated with less costs may be appropriate to a farmer to change or shift from his/her old technology.

Dominance Analysis

The dominance analyses of theresults are presented in Table 5. The results showedthat Karate wasdominated by *O. longinoda* and control indicating that Karate was less profitable in both seasons. Since there were two profitable treatments so Marginal Rate of Return (MRR) was calculated. According to the economicanalysis, *O. longinoda*proved to be the

bestbecause MRR was highest at 235% in 2012 and 405% in 2013 seasons. Hence, *O. longinoda*that was superior and economically betteralternative. These results agree with findings of Das *et al*. (2010) who concluded that rational farmers adopt a new innovation that has a comparatively higher MRR.

Cost benefit analysis (CBA)

On per tree basis, all the evaluation criteria used in this study NPV, BCR and IRR (Table 6) recorded highest for *O. longinoda*. This was followed by Control and Karate recorded the lowest. This suggests *O. longinoda* was feasible for adoption. Low cost for *O. longinoda*compared to Karate proved advantageous to give the highest BCR. Van Den Berg (2010) found highly cost effective biological control of the spiny blackfly in Switzerland with a benefit-cost ratio of 199:1.

CONCLUSIONS

This research was conducted to evaluate economic benefits of using *O. longinoda*to manage insect pest in cashew orchards compared with Karate and control. The observed increase in cashew nuts yields and reduction in damage by sucking insect pests explains effectiveness and ability of *O. longinoda* to prey on any insect attending their territory. Switching from either Karate or control to *O. longinoda* gave positive and higher net change in benefits. Furthermore, MRR for switching from control to *O. longionoda* was highest suggesting that it was feasible to be adopted by cashew smallholder farmers. All the evaluation criteria recorded highest for *O. longinoda* indicating that it financially feasible to be adopted by cashew smallholder farmers. Switching to *O. longinoda* was recommended for adoption by smallholder farmers in cashew. The experimental trials focused only on cashew. An idea for future experiment is to conduct trials on other tree crops such as citrus, etc.

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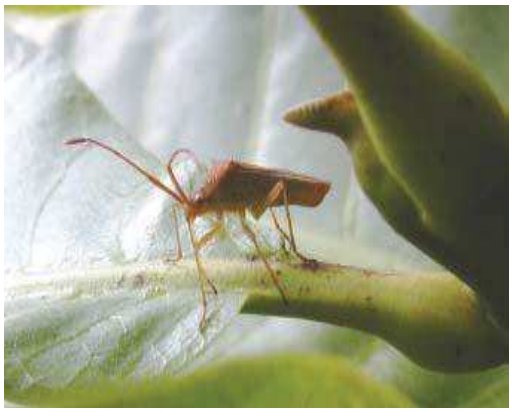
Appendix 1: Figures

Cashew mosquito bugs (*Helopeltisanacardii*)

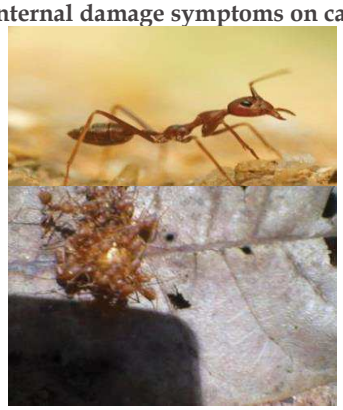


Coreid bugs (*Pseudotheraptuswayi*) in cashew

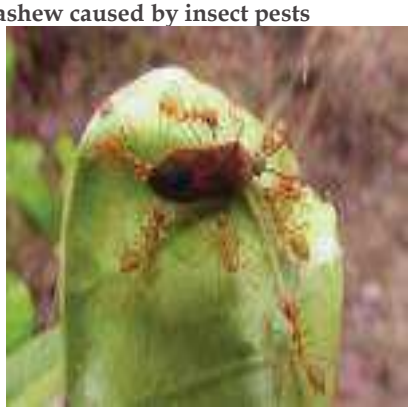
Figure 1: Major insect pests in cashew of economic importance in Tanzania

Figure 2: External and internal damage symptoms on cashew caused by insect pests

Spraying Karate at NARI, Mtwara

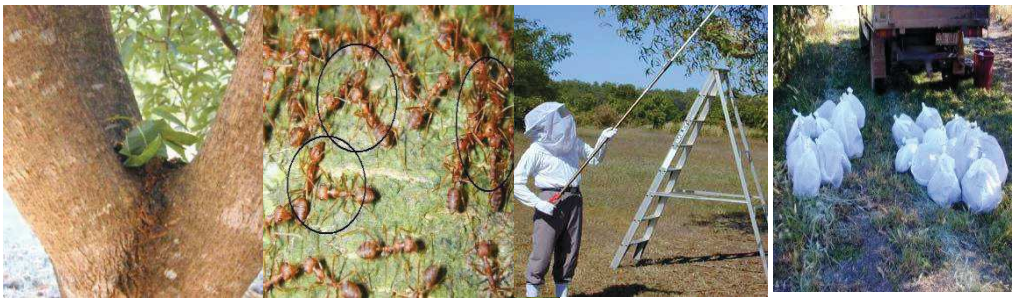


(i) African weaver ant (*O. longinoda*) and queen protected by workers



O. longinoda predating *P.wayi*in orchard at NARI

Figure 3: Alternative management practices in cashew orchard to control insect pests



(i) Determine colonies boundary by placing a nest containing ant workers adjacent other tree with ants. The ants of different colonies fight each other

(ii) Harvesting ant nests using picking pole and collecting ant of the same colony using plastic bags for transplanting.

(iii) Hanging the plastic bags in the tree to release workers and the queen and immediately they make new nets.

(iv) Connecting tree of the same colonies using a rope (4mm) to increase territory in the canopy

Figure 4: Activities during implementation of weaver ant technology in cashew orchard

Appendix 2: Tables

Table 1: Pairwise statistical comparisons of treatments on damage caused by major cashew pests

Pests	Treatment comparisons	P value 2012	P value 2013
P. wayi	*O. longinoda*vs Karate	0.223	0.208
	*O. longinoda*vs Control	< 0.0001	< 0.0001
	Karate vs Control	< 0.0001	< 0.0001
Helopeltis species	*O. longinoda*vs Karate	0.181	0.103
	*O. longinoda*vs Control	< 0.0001	< 0.0001
	Karate vs Control	< 0.0001	< 0.0001

Table 2: Comparisons of variable costs (TZS/Kg), yields, Benefits (TZS/tree) and Net benefits for each treatment

Particulars	O. longinoda		Karate		Control	
	2012	**2013**	**2012**	**2013**	**2012**	2013
Total costs	12092	13695	15008	17505	8857	11042
Yields	1.03	1.20	0.98	1.21	0.65	0.73
Prices	28500	28500	23000	23000	28500	28500
Gross benefits	29355	34200	22540	27830	18525	20805
Net benefits						

Table 3: Pairwise statistical comparisons of treatments on cashew yields

Treatments comparisons	P-value 2012	P-value 2013
*O. longinoda*Vs Karate	0.9896	0.9902
*O. longinoda*Vs Control	<0.0007	<0.0001
KarateVs Control	<0.0001	<0.0001

Table 4: Partial budget (TZS/tree) of African weaver ants on cashew in two seasons

Particulars	Based on 2012 crop budget		Based on 2013 crop budget	
	Switching from Karate to *O. longinoda*	Switching from Control to *O. longinoda*	Switching from Karate to *O. longinoda*	Switching from Control to *O. longinoda*
Incremental benefits				
Reduced costs	3815	10830	9790	16815
Additional benefits	6815	0	4306	0
Total incremental benefits	9630	10830	14096	16815
Incremental costs				
Additional costs	899	839	193	193
Reduced revenue	0	0	0	0
Total incremental costs	899	839	193	193
Net change in benefits	8731	9991	13903	16622

Table 5: Dominance analysis of different insect management practices in cashew orchards

Treatments	Costs that vary (TZS/tree)		Net Benefits (TZS/tree)	
	2012	2013	2012	2013
Control	8857	11042	9668	9763
O. longinoda	12092	13695	17263	20505
Karate	15008	17506	7532 **D**	10325 **D**
MRR (%)			235 > 100	405 > 100

Table 6: NPV (TZS/tree), BCR and IRR (%) analyses of treatments in cashew and mango production

Particulars	Treatments		
	O. longinoda	Karate	Control
Present Value of Benefits	54951	43491	34035
Present Value of Cost	22311	28111	17177
Net present value	32640	15380	16858
Benefit-Cost Ratio	2.5:1	1.5:1	2.0:1
Internal rate of return	57	24	41
Raking based on NPV	1	4	3
Raking based on BCR	1	4	3
Ranking based on IRR	1	4	3