Management of the coconut bug in avocados

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ABSTRACT
For effective control it is important to define the most vulnerable stage(s) in the life cycle of the target insect, use the most appropriate control measures, as well as optimise any biological control factor that could add to the eventual control of the target insect. Previous research indicated that avocado fruit became susceptible to the coconut bug when the fruit reached ±87% moisture. During a follow up trial in the Limpopo Province, this observation was confirmed on 'Pinkerton' and 'Hass' fruit. Observations indicating that infestation tends to be confined to the perimeter of orchards early in the season, were confirmed. It would appear that insects used inter row spaces as alleyways whereby they gained access deep into the orchards. Follow-up work is required to confirm this observation; general recommendations regarding early season perimeter spraying cannot be provided at the moment. A fogging machine was acquired to study the population dynamics of the bugs in avocado orchards. Early results indicate that, similarly to macadamias, a complex of stink bugs exploit avocados throughout the season. Damage symptoms of *Nezara viridula*, *Nezara pallidoconspera*, *Nezara prunasis*, as well as *Bathycoelia natalicola*, are presented. The woolly stink bug, *Atelocera raptoria*, which is very common in avocado orchards, did not survive on avocado fruit and should therefore not be considered as a threat. Previous results proved that the effect of synthetic pyrethroids to control the coconut bug is limited to a few days post application. During the late season, immigration of the coconut bug into the orchards occurs at a near exponential rate. Clearly two options exist: (1) Increase the spray frequency; (2) use insecticides with longer residual actions. Due to environmental as well as food safety concerns, clearly both these options are unacceptable. The only logical solution to this conundrum will be to intensively study the migration patterns of this insect between various commercial and non-commercial hosts and to disrupt these patterns at certain critical times with strategic usage of pesticides.

INTRODUCTION

Very little knowledge is currently available in South Africa regarding the immigration and distribution patterns of stink bugs into subtropical crops. Information regarding vertical distribution of this pest is envisaged to facilitate spray operations in the orchard, while knowledge regarding immigration patterns could facilitate more environmentally friendly spraying practices (spot spraying or perimeter spraying as opposed to spraying the entire orchard).

Previous reports (Schoeman *et al*., 2010; Schoeman *et al*., 2012) indicate that stink bug damage increase exponentially during the mid-season and reach a peak at main harvest. However, Bruwer (1996) and Van den Berg *et al*. (2000) indicated that the coconut bug population in avocados reached a peak early in the season (Nov/Dec and Sept/Oct respectively). Population surveys conducted by Bruwer (1996) and Van den Berg *et al*. (2000) were based on direct insect counts, while the surveys conducted by Schoeman *et al*. (2010 & 2012) were based on fruit damage. This conundrum could be explained by the following two scenarios:

a) Coconut bug occur early in the season, but the symptoms only manifest later. Studies with caged bugs contradict this possibility, as the characteristic water soaked feeding lesions are nearly immediately evident after a feeding event.
b) Other stink bugs could be involved, which could explain the wide range of external damage symptoms typically present on the fruit.

Both assumptions will be tested during the new production season with the help of thermal fogging machines and the following studies must therefore be regarded as a first step in this process.

MATERIALS AND METHODS

Chemical trial

This trial was conducted to determine the most effective spray frequency in a severely infested orchard. All trees were sprayed with Lambda-cyhalothrin 50 g/L CS (Karate with Zeon Tech) @ 10 ml/10 L of water. This chemical was selected because of the anticipated long residual action due to micro-encapsulation and not because registration of the product was intended.

The trial was conducted on mature, severely infested 'Pinkerton' fruit at the Agricultural Research Council – Institute for Tropical and Subtropical Crops (ARC-ITSC) in Nelspruit. This orchard is surrounded by alternative commercial host plants, and coconut bug infestation levels ranging up to 50% was not uncommon in the past. The following treatments were applied (application dates):

- Single spray December (6 Dec)
- Single spray January (6 Jan)
- Single spray February (30 Jan)
- Program spray December/January (6 Dec & 6 Jan)
- Program spray December/January/February (6 Dec, 6 Jan & 30 Jan)
- Program spray January/February (6 Jan & 30 Jan)
- Untreated control.

Each treatment was replicated four times and each replicate consisted of three trees. Approximately 6 L spray mixture was applied/tree. Calculated at 667 trees/ha the spray volume was therefore ±4 000 L/ha. The chemical was applied with an LDV mounted experimental spraying unit equipped with hand held lances. No precipitation was recorded 24 hours after each of the applications. Damage assessments were made on the 20th of January, the 3rd of February, the 21st of February and the 26th of March. Approximately 30 fruit were selected from the center tree of each application and were subsequently rated *in situ* for coconut bug damage. Data was analysed using the statistical program Genstat (2003) and Fisher's protected least significant difference test was done to quantify differences among the various treatments.

Vertical distribution of damage levels

This trial was conducted on mature Pinkerton trees (3 to 4 m high) in an unsprayed variety orchard at the ARC-ITSC in Nelspruit. Assessments were done during February 2013 when considerable damage was caused by the coconut bug.

Five groups of trees consisting of ±5 trees each were randomly selected along the perimeter of the orchard where high damage levels were expected. The trees were divided into three vertical strata, namely lower than one metre, between one and two metres and higher than two metres. Fifty fruit from each stratum from tree cluster were externally examined for coconut bug damage. Results were expressed as a percentage damaged fruit and means were subsequently compared with a Fisher's protected least significant difference test.

Immigration patterns

Immigration patterns of the coconut stink bug (*Pseudotherathus wayi*) were studied in the Stads River Valley near Nelspruit. Movement of these bugs from an adjoining macadamia orchard into a commercially managed Pinkerton orchard was studied every fortnight from December 2012 to February 2013.

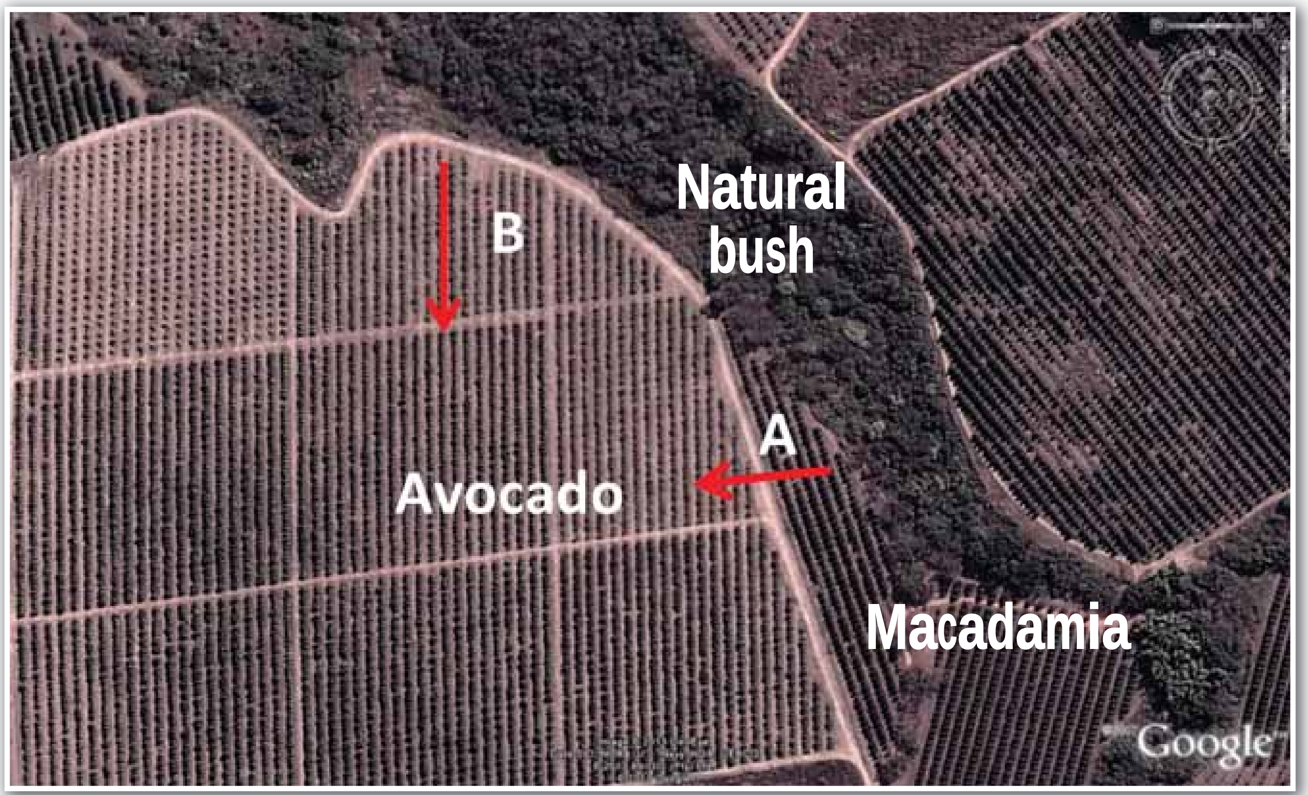

Figure 1. Layout of trials to determine migration patterns of the coconut bug into avocado orchards A: where rows are planted parallel to alternative host plants; B: where rows are planted at right angles to riverine forest.

Two separate trials were conducted to study the movement of these insects. The first trial was conducted in trees where the rows were situated parallel to an adjoining macadamia orchard (Fig. 1). This trial was done to determine if the first few rows acted as a barrier that prevented migration of the bugs deeper into the orchard. Fifty fruit from five randomly selected trees were examined in each of the following rows: the perimeter row, 2nd, 3rd, 4th and 5th row away from the avocado macadamia interface.

The second trial (Fig. 1B) was conducted where rows were situated at right angles to riverine forest. The aim of this trial was to determine if the coconut bug merely settled on the perimeter of the orchard, or if the insects used inter row spaces as alleyways to infest trees deeper into the orchard. Fifty fruit on trees grown along the perimeter were examined from five randomly selected rows. A further fifty fruit were then examined on the 5th, 10th, 15th and 20th tree in every row (Fig. 1B).

Damage studies of other heteropterans previously recorded in avocados

A number of other bugs belonging to the suborder Heteroptera have previously been recorded on avocados by Van den Berg *et al*. (2000). Five stink bug species (*Atelocera raptoria*, *Nezara viridula*, *Nezara pallidoconspersa*, *Bathycoelia natalicola* and *Nezara prunasis*) were collected from a nearby unsprayed mixed cultivar macadamia orchard, as well as a stand of castor oil (*Ricinus communis*).

All collected insects were confined to avocado fruit (cv. 'Pinkerton') in screen cages for seven days whereupon the cages were shifted to other fruit. Because it was suspected that some of these insects may be obligate bark feeders, care was taken to select only undamaged fruit as well as to exclude leaves or twigs/branches in the cages. After a further 14 days the fruit were picked, examined for any external signs of damage and subsequently peeled. All damage symptoms were photographed

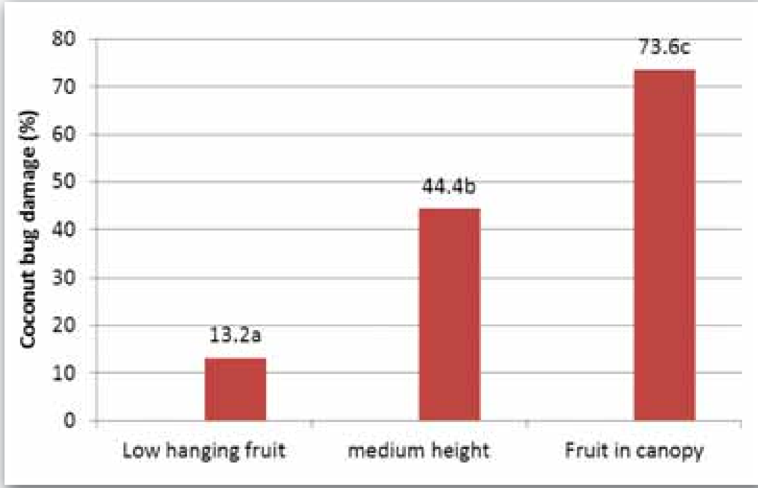

Figure 2. Effect of vertical distribution of fruit in mature avocado trees cv. 'Pinkerton' on the percentage coconut bug damage (P <0.001; LSD = 11.1 & CV% = 18.4).

Table 1. The effect of various applications of Lambda-cyhalothrin 50 g/L CS applied from December onwards on fruit damage (cv. 'Pinkerton').

Spray regime	Undamaged fruit ± SD (%)			
	Evaluation dates			
	20 January	3 February	21 February	26 March
December	97.5a±2.76	92.5a±4.93	60.83a±15.16	90.00a
January	85.83a±13.82	91.67a±7.64	82.29a±9.81	71.33b
February	80.83a±22.03	79.17a±16.05	87.33a±8.45	87.2ab
Dec/Jan	98.34a±1.67	92.5a±2.76	83.34a±7.82	78.33ab
Dec/Jan/Feb	94.17a±4.93	93.34a±4.08	94.17a±2.77	83.33ab
Jan/Feb	86.67a±7.45	90a±5.27	80.84a±12.77	88.33ab
Control	70.83a±17.06	59.17b±12.99	56.67a±32.23	43.33c
CV%	5.8	3.5	8	8.33
LSD		15.89		17.65
P	0.135	0.002	0.145	0.01

Various assessment dates were analysed separately
Means per row followed by the same letter do not differ statistically
CV – Coefficient of variation

and characterised.

Approximately 25 recently aborted fruit (cv. 'Pinkerton') were also picked up from the ground and a further 25 fruit were randomly harvested. All fruit were peeled and examined for the presence of any stink bug damage.

RESULTS

Chemical trial

According to Table 1 the December spray was able to significantly reduce damage recorded during all four monitoring periods. Applications during the late season did not reduce the damage considerably, which was contrary to what was expected. Although some variation was observed among the treatments, damage in the untreated control increased during each period of monitoring.

Vertical distribution of damage levels

Coconut bug damage was consistently higher in the tops of the trees. External examination of the fruit indicated that damage in the top of the trees ranged from 66 to 86%, fruit damage examined in the middle portion ranged from 32 to 56%, while damage in low hanging fruit ranged from 8 to 20% (Fig. 2).

Immigration patterns

According to Figs. 3 & 4 stink bugs appear to concentrate along the three outermost rows of the trial orchard. However, during the early season, fruit damage in trees growing along the macadamia/avocado interface (Fig. 1A) was not statistically significantly higher, when damage was compared with fruit deeper in the orchard. (Perimeter fruit damage % = 2.00 ± 2.82; damage deep inside the orchard = 1.00 ± 2.11; t9 = 0.77; P = 0.46). Although damage

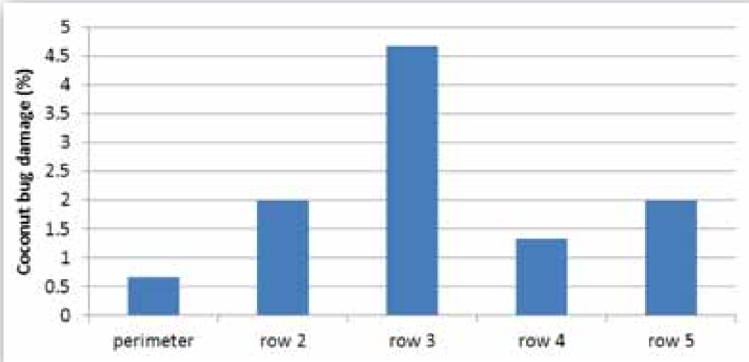

Figure 3. Percentage avocado fruit damaged by the coconut bug where tree rows were situated parallel to an important alternative host (N = 1 350 fruit).

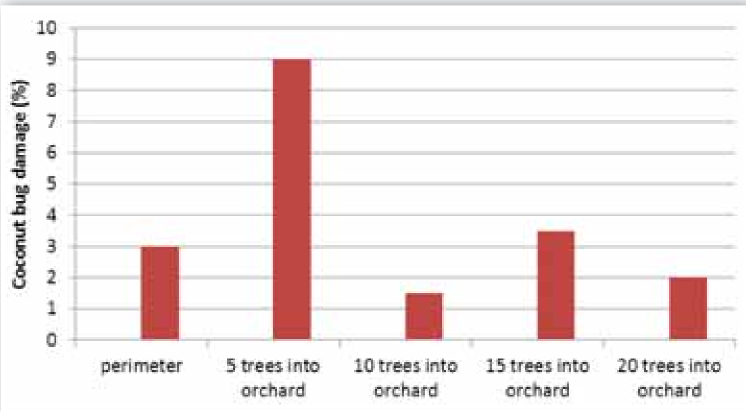

Figure 4. Percentage avocado fruit damaged by the coconut bug where tree rows were situated at right angles to riverine woodland (N = 1 000 fruit).

Table 2. Percentage fruit with stink bug lesions recovered from unsprayed 'Pinkerton' avocados at the ARC-ITSC in Nelspruit.

Location of fruit	Type of damage (%)			
	Undamaged	Coconut bug	Pentatomid bugs	Coconut & pentatomid bugs
Aborted (on ground)	1 (4)	10 (40)	4 (16)	10 (40)
In tree	3 (12)	8 (32)	0 (0)	14 (32)
Total	4 (8)	18 (36)	4 (8)	24 (48)

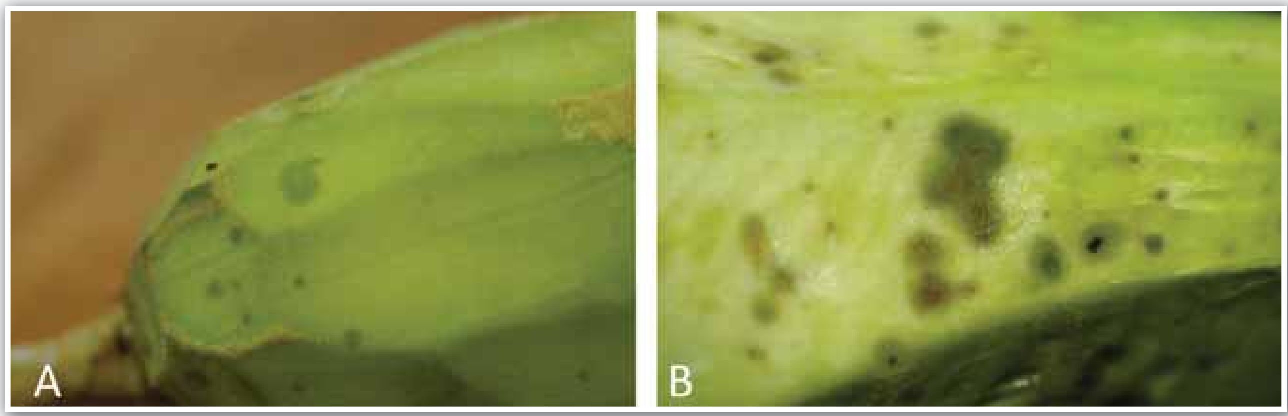

Figure 5. A: Shallow water soaked lesions indicative of *N. pallidoconspersa* and *N. viridula infestation*. B: Deep lesions indicative of *B. natalicola* feeding damage.

increased inside the orchard later during the season (Feb – March), no significant differences were observed (Perimeter fruit damage % = 3.33 ± 5.44; damage deep inside the orchard = 6.5 ± 6.69; t9 = 1.06; P = 0.316).

Damage in perimeter trees of rows growing at right angles to natural bush were, however, significantly different when compared to trees deeper inside the orchard during the early season (perimeter fruit damage % = 5.67 ± 8.42; damage deep inside the orchard = 1.11 ± 2.41; t14 = 2.16; P = 0.48). However, later during the season (Feb – March) no statistically significant differences were observed (perimeter fruit damage % = 11.5 ± 15.46; damage deep inside the orchard = 7.04 ± 5.32; t14 = 0.92; P = 0.38), which indicates that the insect probably migrated deeper into orchard and became established.

Damage studies of other heteropterans previously recorded in avocados

Atelocera raptoria was the most prolific stink bug recovered from avocado during the initial population surveys. When caged on mature avocados, nymphs of this species did not survive and no damage symptoms were observed. According to Van den Berg *et al*. (1999) this species probably feed on the bark and some *Atelocera* genera may also be facultative predators.

Although *N. prunasis* was the 3rd most numerous pentatomid stink bug recorded by Van den Berg *et al.* (2000), adults did also not survive on mature avocados. Van den Berg *et al*. (2000) mentioned that insects feed on succulent plant tissue as well as young fruit.

N. viridula and *N. pallidoconspersa* did feed on the fruit, but no offspring was produced. Shallow lesions with a water soaked appearance were evident just under the skin of the fruit (Fig. 5A).

B. natalicola was able to survive on the fruit for long periods of time but produced no offspring. The lesions resemble those of *N. viridula* and *N. pallidoconspersa* but coalesce deeper in the fruit into large water soaked lesions (±5 – 7 mm) (Fig. 5B).

When fruit in the orchard was evaluated for alternative damage symptoms, Table 2 reveals that a large proportion of fruit had damage symptoms associated with shield stink bugs (Pentatomidae).

CONCLUSIONS AND RECOMMENDATIONS

1) Coconut bugs prefer to feed on avocado fruit that occur in the canopy of the trees. The ecological advantage of this phenomenon is unclear, but is possibly linked to thermoregulation. Because these insects are cold blooded they have to sun themselves in the mornings to become active. If they feed on lower hanging fruit which are normally overshadowed by adjacent trees, it will take much longer for them to become active and this could possibly predispose them to higher rates of predation/parasitism.

2) Coconut bugs did not settle along the outside perimeter of the orchard, but concentrated on the first rows just inside the orchard. This trial will have to be repeated to confirm these observations. Additionally, it is also suggested to expand the trial in order to include areas deeper in the centre of the orchard as well.

3) If these results can be repeated, perimeter spraying or using attract and kill technology on the outside few rows could be a viable option that will limit incursions of this pest into the orchards during the early season. This will in turn have a limited effect on beneficial insects which should increase the levels of natural control. No general recommendations in this regard can be provided yet, as significant variation was observed in preliminary trials.

4) A single spray during December was as effective as a program spray, while single sprays during January and February was not as effective as expected. Damage in the control treatment increased from ±29% during 20 January to 57% during the 26th of March, indicating that all sprays were able to reduce damage. Variation in this trial

was high and this trial should probably be repeated in accordance with the population survey.

5) More stink bugs than only the coconut bug are causing damage to the fruit. Species recorded thus far include: *A. raptoria*, *Coenomorpha nervosa* Dallas and *Anolcus campestris* Bergroth. Quantification of damage caused by each species is a research priority and feedback will be provided to growers as soon as results become available.

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