Integrated management of avocado pests with special reference to the coconut bug *Pseudotheraptus wayi* (Hemiptera: Coreidae)

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ABSTRACT

The main aims of this project were to investigate alternative management techniques for the coconut bug as well as to determine the pest status of thrips in avocados by conducting a spray trial. Alternative environmentally friendly management techniques for the coconut bug are important because numbers of this insect increase nearly exponentially towards the end of the fruit maturation stage each year. Not only does spraying during this time increase the risk for exceedance of MRL levels, repeated applications of contact insecticides may also lead to flare ups of secondary pests which may be more difficult to manage. Two *Beauveria bassiana* isolates were obtained from the National Mycological Collection at ARC-PPRI in Pretoria. Both strains were originally isolated from the insect Order: Heteroptera (stink bugs) and each isolate was subsequently cultured in the laboratory to obtain sufficient material for a laboratory bio-assay. These strains were then compared to two commercially available products containing *B. bassiana* and mortalities of stink bugs were then monitored every 3 days up to 21 days post application. Broadband outperformed the other three products statistically significantly, but all four products induced high mortalities, which indicate that this approach has considerable merit. This will not completely solve the fundamental problem of repeated applications of pesticides, therefore a more innovative solution to control this pest is still required. Using defensive compounds of other stink bugs to deter the coconut bug may be such an option. These chemicals are unfortunately very expensive and it was decided after consulting with research partners that a laboratory bio-assay be conducted first. This work is currently in progress and results will be given through to growers as soon as it becomes available.

It was decided to evaluate a single application of two products against thrips prior to flowering (3 August). The trial was evaluated during mid-January 2018 for the first time and both treatments differed statistically significantly from the untreated control in terms of the often ill-defined carapace/mechanical/wind damage symptoms. This early evaluation only focussed on the presence/absence of damage and during a subsequent evaluation, a damage index value revealed a similar trend, indicating that an early treatment could decrease superficial damage often associated with thrips.

INTRODUCTION

Due to their high mobility, their adaptability as well as their generalist nature, stink bugs and particularly the coconut bug *Pseudotheraptus wayi* (Hemiptera: Coreidae) are not easy to control. They are generally K-selected, which means they produce relative low numbers of progeny but the likelihood of offspring to reach adulthood is high. They are also strong competitors, normally have bigger body sizes and may also have relatively longer life expectancies than other insects.

The coconut bug also prefers apical tree portions, which is very similar to the distribution pattern of *Bathycoelia distincta* (Schoeman, 2014). When invading an empty niche, the coconut bug initially settles along the edges of the orchards (Schoeman, 2014) but subsequent research indicate that some individuals may settle deeper into the orchards, which negates the possibility of treating orchard perimeters only in an attempt to decrease pesticide usage (Schoeman, 2017).

Smaller fruit are generally not preferred and infestations in the orchards follow a typical sigmoidal pattern with a near exponential increase in population numbers of *P. wayi* and/or fruit damage from December onwards (Schoeman, 2016). This corroborates the findings of Bruwer (1992), who found that in macadamias, *P. wayi* normally reach its annual relative abundance peak in April.

Although natural host plants of this pest have not been found yet, orchards bordering riparian vegetation are traditionally more severely affected than orchards that are further away from watercourses. Strong edge effects next to riparian vegetation/avocado interfaces indicate that this habitat is the likely source of infestation. The question that immediately arise is: can we treat these watercourses chemically. After consultation with various ecologists at various universities the unanimous answer was no. These areas must act as islands of biodiversity and should act as important refugia for natural enemies that will control insect pests in the respective orchards.

The big conundrum for growers is that immigration of bugs into susceptible orchards between December and April/May is continuous. Although current registered pesticides will control *P. wayi*, field weathered residues are unfortunately ephemeral and should control stink bugs only 4 – 7 days post application (Schoeman, 2010). This essentially leaves the avocado industry with the following two options to ponder:

1. Increase spraying frequency of various pesticides. By doing this, production costs will increase but it will also have negative spin offs in terms of ecological problems and acceptability of South African fruit on export markets.
2. Adopt a strategy where the habitat in the avocado ecosystem is managed in a more natural way. This includes the environmentally friendly control of avocado pests where such options exist as well as exploiting ecological processes and behavioural patterns of insects in such a way that the grower will derive a nett benefit.

The following three trials were initiated in an attempt to get this initiative started:

1. Quantification of the effect of thrip damage on avocados (Spinetoram) as well as to determine if thrips can be controlled with an environmentally friendly product (Agrispray).
2. Determining the efficacy of commercially available fungal entomopathogens in comparison with *Beauveria bassiana* isolates obtained from PPRI in terms of stink bug control.
3. Understanding the role of stress pheromones in population dynamics of stink bugs – a preliminary study.

MATERIALS AND METHODS

Thrip trial

This trial was conducted on a commercial avocado estate ±15 km West of Nelspruit on mature avocados cv. Fuerte (25°24′ 25.92S; 30°55′ 32.36E). Husbandry practices in this orchard did not differ from the surrounding orchards and all normal orchard activities and tasks took place. This trial site was selected because it had high carapace/wind/thrips/mechanical damage during the previous season. The following treatments were applied with an experimental spraying rig mounted on a LDV on the 3rd of August 2017:

1. Spinetoram 250 WG @ 10 g/100 L
2. PNS Agrispray @ 300 ml/100 L & ViBacSan Wettersticker @ 50 ml/100 L
3. Untreated control.

The product was applied with a MT trigger gun equipped with a 2 mm nozzle at a pressure of 16 Bar. The orchard was planted at a tree spacing of 8 m × 6 m (208 trees/ha). Both products were applied at a rate of ±2 500 L/ha (12 L/tree). The trial was laid out as a complete randomized block and each treatment was replicated five times. Each replicate consisted of three trees and data was only taken from the centre tree of each replicate.

The efficacy of the treatments was quantified during mid-January by inspecting 50 fruit/replicate for the presence/absence of typical superficial webbing symptoms commonly associated with thrip damage. The second evaluation was done ±2 weeks later by placing fruits into three damage classes (Severe damage, moderate damage and no damage). A damage index value according to the method of Wheeler (1963) was then calculated for each replicate. Means were compared with an analysis of variance and data was analysed with the statistical program Genstat (2003).

Pathogen trial

Fungal isolates and preparation

Beauveria bassiana isolates PPRI 12514, PPRI 12515, PPRI 5339 and Eco-Bb were evaluated for this study. Isolates PPRI 12514 and PPRI 12515 were obtained as dry aerial conidia, provided by the National Collection of Fungi - Agricultural Research Council - Plant Protection Research, Pretoria. PPRI 5339 (BroadBand, an emulsifiable spore concentrate formulation) was supplied by BASF and Eco-Bb (wettable powder formulation) was supplied by Plant Health Products (PHP) respectively.

For isolates PPRI 12514 and 12515, aerial spores were grown on potato dextrose agar (PDA) for 30 days. Conidial suspensions were then harvested by gently scraping the surface of the dried medium using a scalpel blade and filtering the suspension through a sieve to separate conidia from mycelial mats. A Neubauer hemocytometer (0.1 mm depth) was used to determine conidial concentrations and the conidial concentrations were adjusted to a final minimum concentration of 1×10^7.

Experimental/bioassay procedures

For reliable statistical comparison, each isolate was replicated five times and each replicate consisted of five recently eclosed adult two spotted bugs (*Bathycoelia distincta*) (in total, 125 stink bugs were treated). *B. distincta* was used as an indicator organism because they were relatively easy to collect. Occurrence of the coconut bug is extremely seasonal and catching sufficient quantities of individuals could have compromised the timely execution of the trial. All isolates were applied with a micropipette to the stink bugs dorsally. Pathogen deposits on the surfaces of the stink bugs were allowed to air dry before placing them into rearing cages.

The conidial suspension (10 µl) was applied using a micro-pipette onto the dorsal side of the thorax of the stink bug. Sterilized distilled water (10 µl) with 0.1% Tween 20 was inoculated in the same way onto control adults. Insects from each replicate were transferred into a sterile cage (3 L plastic tub, 40×40×19 cm, with breathable mesh inserts). Freshly cut macadamia leaves, as well as green nuts, were used to sustain stink bugs for the duration of the trial and all plant material was changed once a week. Moist cotton wool was placed in each cage to provide humidity. Mortality assessments were done at 3-day intervals for up to 30 days post treatment. Dead stink bugs were examined, counted and recorded. Means were compared with an analysis of variance and data was analysed with the statistical program Genstat (2003).

RESULTS

Thrip trial

Some confusion currently exists regarding the economic significance of thrips. Although this study was by no means comprehensive, the fruit depicted in Figure 1 should clarify matters somewhat. This fruit was obtained from an avocado/macadamia interface where thrips were known to be main economic problems. Most of the fruit had these type of symptoms and the assumption was therefore made that these insects highly likely also caused this damage. If the image is carefully scrutinized, one can see that the damage is initially superficial and it would appear as if damage originated from underneath the calyx when the fruit was still young. This concurs with typical damage symptoms observed by Gilbert & Bedford (1998) in citrus.

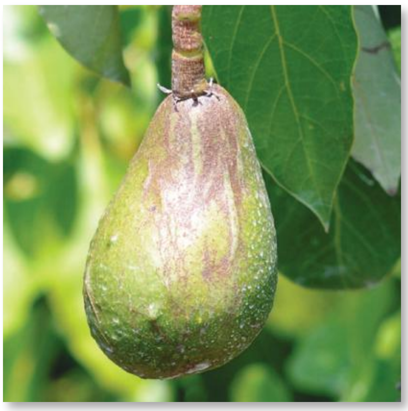

Figure 1: Suspected thrip damage on avocados that were collected from an avocado/macadamia orchard interface.

The orchard where the spray trial was done flowered continuously throughout spring but according to Figure 2 both treatments had significantly less damage than the control, indicating that typical carapace webbing damage (Fig. 1) may at least in part be caused by thrips.

When damage symptoms were evaluated two weeks later according to the damage index method of Wheeler (1963), a similar pattern emerged although the damage between Agrispray and control were longer statistically significantly different (Fig. 3).

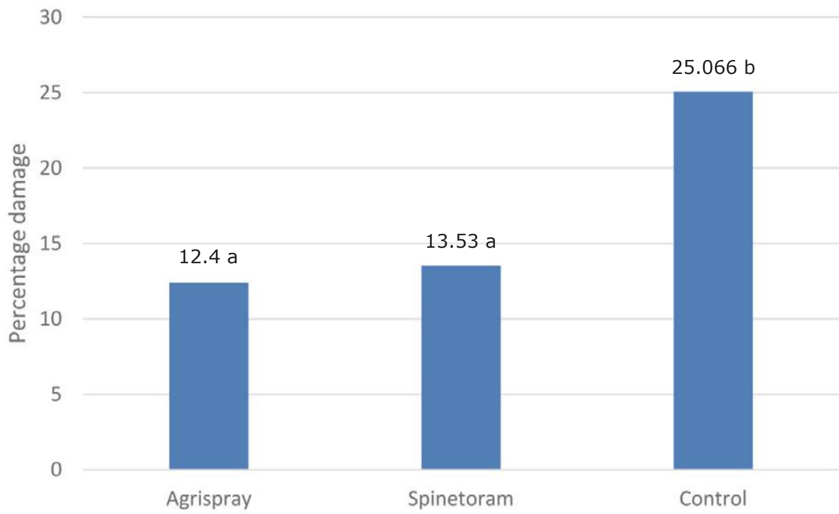

Figure 2: The effect of two pesticides on typical carapace/wind/mechanical damage on avocados evaluated in terms of absence/presence of any lesions. (P<0.012 & CV% = 35.8)

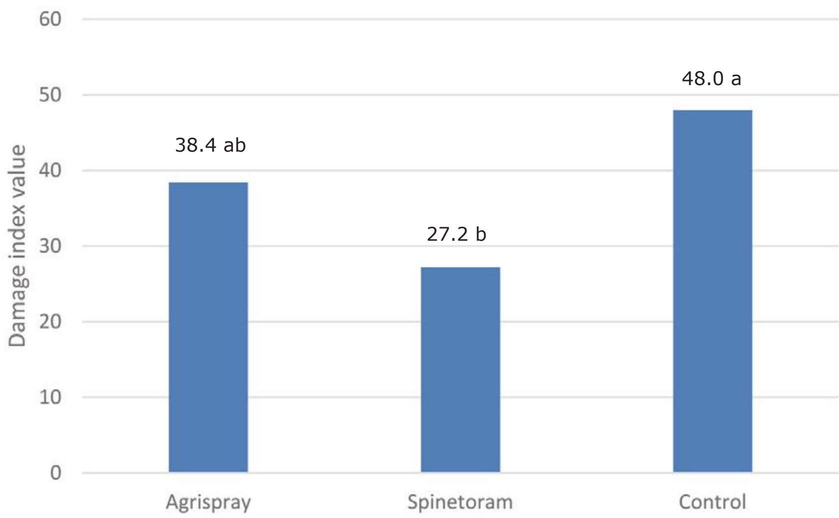

Figure 3: The effect of two pesticides on typical carapace/wind/mechanical damage on avocados evaluated in terms of the severity of any lesions according to the index value method of Wheeler (1963). (P<0.037 & CV% = 29.4)

Table 1: Cumulative mortality (%) of an indicator organism (*Bathycoelia distincta*) after treatment with various isolates of *Beauveria bassiana.*

Treatments	Days after treatment						
	3	6	9	12	15	18	21
Broadband PPRI5339	72 bcdefghi	100a	100a	100a	100a	100a	100a
Eco BB	0q	16oq	36lmnop	72defg	76acdef	92abc	96ab
PPRI 12515	0q	16opq	44jlmn	64dfghijk	72bcdefghi	76abcdef	84abcde
PPRI 12514	8q	36mno	48giklm	56fghijkl	68cdefghij	72bcdefgh	84abcd
Control	4q	8q	16opq	20nopq	20nopq	20nopq	20nopq

Percentage values followed by the same letter did not differ statistically significantly at P<0.001 (CV% = 30.9)

Pathogen trial

According to Table 1, Broadband had a high initial knock out effect but by day 15 the other products induced similar mortality levels. Broadband was initially developed as a cooperative project between ARC-TSC and Biological Control Products (BCP) against the banana weevil *Cosmopolites sordidus* (Coleoptera: Curculionidae) and had a higher conidial concentration than the other three products. This probably explains the rapid knock out effect. The two other PPRI products induced similar levels of mortality than Eco-Bb, highlighting the potential virulence of these products as well as the likelihood that entomopathogens may be effectively used as commercially acceptable biological control agents.

CONCLUSIONS

Damage depicted in Figure 1 could be decreased by a single spray during flowering but before fruit set. According to Figures 2 and 3, both treatments still had significant damage which seems to indicate that the protracted flowering period probably necessitated more than one application. Both treatments were initially nearly equally effective, which is fortunate as it would provide growers with a number of options to use in an anti-resistance campaign. This trial should be expanded during the next production season to include other products as well as multiple sprays. Product selection should be done with circumspection in order not to compromise the ecological balance in the orchards and to prevent any negative effect on pollinators.

Although pathogens normally do not have a quick knock down effect, Broadband appears to the exception, as 72% of treated individuals were dead after just 3 days. Whether this is related to formulation or concentration differences or not, is unclear now but it certainly provides growers with another option for coconut bug control that can be used closer to harvest without any risk of accidentally exceeding maximum residue limits (MRL).

Research with stress pheromones as a deterrent for the coconut bug is in progress and results are still very preliminary. Growers will be informed during the new production season regarding progress.

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