

Trap crop management strategies to control stink bug in avocado orchards with emphasis on *Pseudotheraptus wayi* brown (Hemiptera: coreidae)

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ABSTRACT

Very little knowledge is currently available in South Africa regarding the immigration and distribution patterns of stink bugs into subtropical crops. Stink bugs are polyphagous insects that inflict economic damage on many crop species. *Pseudotheraptus wayi* brown (Hemiptera: coreidae) is of particular concern in the South African avocado industry. This is because the control of this insect pest in South Africa relies heavily on insecticides which are disruptive to natural enemies of arthropods, and as such have undesirable residual effects. Presently the avocado growers are not spraying extensively to control this pest, as is the case with the macadamia growers. This tendency needs to be maintained. The main objective of this study was to investigate the use of trap crops to monitor stink bug outbreak in avocado orchards. Four different trap crops were planted between the orchard and natural bush in a randomised complete block design replicated four times. Visual line-transect method was applied in all trap crops to monitor and scout for different stink bugs. The results showed no significant differences among host crops for the coconut stink bug (*P. wayi*). Significant difference for *P. wayi* were only recorded in insect counts between two growth stages (flowering and fruiting stage). Other significant differences were recorded between the four trap crops for *Nezara viridula*, *Bathycoelia natalicola*, *Bathycoelia rhodaini* and *Nezara pallidoconspersa*, as well as a number of unidentified pentatomids. It was therefore concluded that trap crops can solve the current stink bug monitoring dilemma, while other monitoring techniques are being developed.

INTRODUCTION

The subtropical fruit crop industry in South Africa is still battling with low fruit production due to production losses caused by various indigenous stink bugs. According to Mizell *et al.* (2008), fruit phenology (maturity) is directly related to severity of damage caused by the coconut stink bug. Coconut stink bug is one of the damaging pests of subtropical crops – affecting a range of horticultural crops from macadamias to avocados and litchi, causing millions of rand in crop damage each year (Schoeman, 2011). The big concern is that avocado fruit become more susceptible to the coconut bug closer to harvest time. This limits the usage of broad spectrum long acting chemicals, since it might not be possible to adhere to prescribed post-harvest interval times. Pyrethroids have a very short residual activity under field conditions and once the chemicals are inactive, bugs simply re-infest the

crop. This will make absolute reliance on chemicals very expensive, as an orchard will have to be sprayed repeatedly. This situation has then made it necessary to investigate the use of trap crops to monitor stink bug outbreaks in avocado orchards. The potential of using trap crops as means of reducing stink bug population levels in the orchard is believed to offer exciting possibilities that could be considered for avocado crop protection in future. Previous trap crop research has tested a number of plant species. According to Mizell *et al.* (2008), small plantings of species such as triticale, sunflower, sorghum, millet, buckwheat, soybean, field peas and okra, provide superior food plants for the bugs, while also attracting their natural enemies. Natural enemies of arthropods that can help to reduce the infestation level in the orchard, falls into three major categories: predators, parasitoids, and pathogens (Altieri *et al.*, 2005; Mahr



et al., 2008). To maximise the benefit of this natural enemies in orchards, chemicals should only be applied when absolutely necessary (Joubert, 2001). This study aims to provide growers with practical alternatives to current monitoring techniques, which will then enhance financial and environmental sustainability of current control options.

MATERIALS AND METHODS

Description of the trial

Field trials were conducted to assess the potential of trap crops as an alternative stink bug monitoring device in both macadamia and avocado orchards. Field experiments were chosen because of their aptness and greater reliability. Identification and control of environmental variables expected to influence the results, were considered carefully and measured. Four different trap crops; *Crotalaria capensis* (jacq) (rattle pod), *Crotalaria juncea* (L.) (sunhemp) *Helianthus annuus* (L.) (sunflower) and *Vigna unguiculata* L (Walp) (cowpea) were evaluated for the purpose of the study. Treatments were replicated four times in a randomised complete block design to meet statistical requirements and for adequate representation. The trial was planted during November 2011 at Dick Graham Farm in the Tzaneen area of the Limpopo Province. It was bordered on two sides by natural bush and by avocado orchards on the remainder. Trap crop replicates were planted three meters apart, in an alleyway between natural bushes and an unsprayed avocado orchard. Standard agronomic practices such as irrigation and weeding were conducted up to a flower emergence stage, where it was decided to discontinue weeding, as it increase the functional bio-diversity in trap crops which was expected to increase the number of phytophagous insect species.

Monitoring and scouting technique

The visual line-transect method was applied in all trap crops due to the current lack of proper stink bug monitoring techniques (Southwood, 1978; Sutherland, 1996). Movement and activities of stink bug into the orchard was monitored through visual search along each of the predetermined transects. This was done every week before 10:00, just before the insects became too active. Monitoring only took place from flowering onwards. Scouting was intensified during the fruiting stage by examining green, mature fruits and apical shoots for damage, as well as egg masses. It was assumed that the layout of this trial would alleviate the effects of heterogeneous distribution patterns and gradients of infestation level due to the proximity of alternative host plants. Since it was possible to count and identify all the insects found in trap crops, it was also necessary to have estimates of the population levels of stink bugs by means of comparing the number of stink bugs in the orchards with the counts in the trap crops. The estimates were considered to have the highest accuracy commensurate, considering the amount of work and time expended. The distribution patterns and number of stink bugs

collected were recorded together with the time and cost of each round of monitoring. Cost was measured using the man hours required to monitor and collect, as well as the time spent moving from one block to the next.

Monitoring and scouting natural bushes

According to Mizell *et al.* (2008), stink bugs respond strongly to indigenous vegetation and do not like to cross open areas where they are more exposed to natural enemies. It was for this reason that the natural vegetation bordering the trial site was scrutinised to quantify natural feeding behaviour of the heteropteran insects. Prior to this study there was no published information available regarding the distribution patterns and host plants of the indigenous stink bug complex. Similarly, migration from natural vegetation into the orchards is also poorly studied. It was important to study these aspects, because the nature of these distribution patterns was envisaged to influence the accuracy of insect monitoring. Sweep netting was the only alternative method evaluated, but with no success. Several pod bearing plants were subsequently visually monitored twice per week. This was done by means of examining green to mature fruit, leaves and stem terminals for damage and egg masses. This work will be repeated this season (2012/13) with the thermal fogging machine. The information of each plant, regarding the phenological stage of growth at the time of monitoring, will be recorded.

Statistical procedures

Data from the trial was subjected to a two way analysis of variance (ANOVA) for a randomised, complete block design with appropriate transformation for non-normal data. Growth stage of trap crops was included as a sub-plot factor in the analysis of variance (ANOVA). The experiment was repeated over two years (2010/11 and 2011/12 growing seasons). The data of the two years were tested for homogeneity of variances using Levene's test (Levene, 1960). For all species the variability in the observations of the two years was of comparable magnitude and an analysis of the combination of the two years' observations were subsequently carried out (John & Que-nouille, 1977). Student's t-Least Significant Differences were calculated at the 5% level to compare treatment means of significant effects (Snedecor & Cochran, 1980). All analyses were done using SAS v9.2 statistical software (SAS, 1999). Means of significant effects are presented in Tables 1 and 2.

RESULTS AND DISCUSSION

Stink bugs were recovered from all four trap crops, although no crop seems to be a good host for the coconut stink bug. However, since the completion of this trial, an alternative host was located. This new potential host will be evaluated during 2012/13 for its efficacy as a host of the coconut stink bug. Significant differences in terms of incidence on each of the four trap crops were recorded for *Nezara viridu-*



la, *Bathycoelia natalicola*, *Bathycoelia rhodaini* and *Nezara pallidoconspersa* as well as a number of unidentified pentatomids (Table 1). Significant differences for *P. wayi* were only evident in terms of comparative abundance for the two growth stages (flowering and fruiting). There was also a significant interaction between trap crop and growth stage for *Nezara viridula* as well as the unidentified pentatomids (Table 2). It is clear from Table 1 that *Helianthus annuus* was generally a very attractive trap crop when compared to the other crops.

The result also shows that *V. unguiculata* was effective in trapping the two-spotted bug when mature pods became available (Table 2). Two-spotted bug (*B. natalicola*) eggs were also observed on the upper part of the leaves of this plant. Species identification was confirmed by incubating eggs in captivity. It took seven days for the eggs to hatch. No oviposition for *P. wayi* was observed on any of the plants, although some host plants had significant stink bug damage. It was also observed that seasonal stink bug population fluctuates according to the phenological stages of the crop as outlined in Fig. 1. Population densities generally increased during flower-set and near exponential increases were observed up to fruit maturity. This observation is in line with that of Jones and Follett (1997), who reported that stink bug populations also increase dramatically once weeds set seeds. Stink bugs are believed to fly into the orchard from the outside and when conditions become unfavourable in the orchards, they simply move to other commercial host plants or natural bush (Fig. 1). It is therefore important to ensure that trap crops are always in the

preferred stage to provide food source for this insects. *C. capensis* seems to be a promising host plant for coconut bug. Cowpea (*Vigna unguiculata*) also seems to be a good host for both coconut and two-spotted bugs. *C. juncea* is a good host for two-spotted and green vegetable bugs, but the attractiveness of each host plant still needs to be verified using the thermal fogging machine to ensure a more accurate estimation of the population dynamics of both bugs. Scouting and daily temperature monitoring for various phenological stages will still have to be studied on individual plants. The coconut stink bug (*P. wayi*) is polyphagous and if conditions become unsuitable on one host, they simply move to the next and may be regarded as the main pest of litchis, macadamia and avocado crops, as outlined in Fig. 1. The coconut stink bug is very difficult to monitor, due to its ability to move away from any perceived source of danger. This has resulted in a vast underestimation of the economic importance of this insect. They are agile and unobtrusive fliers. Because of their mobility and discriminative feeding preferences, these insects are able to alternate between various host plants (Fig. 1).

CONCLUSION

Although no significant differences were recorded in the number of stink bugs per trap crop, it is still believed that trap crops are a cost effective, short to medium term alternative that could solve the current stink bug monitoring dilemma. Coordination of trap crop phenological development and orchard development could go a long way in monitoring both species

Table 1. Stink bugs associated with various trap crops at the research farm of the ARC-ITSC in Levubu.

Trap crop	<i>Nezara viridula</i>	<i>B. natalicola</i>	<i>P. wayi</i>	<i>B. rhodaini</i>	<i>N. pallidoconspersa</i>	Unidentified pentatomids
<i>H. annuus</i>	5.0000 ^a	4.3750 ^a	0.1250 ^a	1.7500 ^a	3.3750 ^a	4.5000 ^a
<i>C. capensis</i>	3.3750 ^b	2.8750 ^b	0.2500 ^a	1.0000 ^b	1.6875 ^{bc}	2.9375 ^b
<i>V. unguiculata</i>	3.1875 ^b	2.3750 ^{bc}	0.5000 ^a	1.2500 ^{ab}	2.875 ^{ab}	3.2500 ^{ab}
<i>C. juncea</i>	0.5000 ^c	1.1875 ^c	0.6875 ^a	0.1875 ^c	0.6250 ^c	1.8750 ^b
LSD	1.1811	1.4955	n/a	0.6866	1.2870	1.4219

LSD = Least Significant Difference at the 5% significance level

Means per column followed by the same letter are not significantly different at the 5% level

Table 2. Trap crops and growth stage interaction means in relation to the population trends of heteropteran insects.

Trap crop	<i>Nezara viridula</i>	<i>B. natalicola</i>	<i>P. wayi</i>	<i>B. rhodaini</i>	<i>N. pallidoconspersa</i>	Unidentified pentatomids
<i>H. annuus</i> x F	5.0000 ^a	4.3750 ^a	0.1250 ^b	1.7500 ^a	3.3750 ^a	4.5000 ^a
<i>C. capensis</i> x F	3.8750 ^{ab}	2.6250 ^b	0.0000 ^b	1.1250 ^{ab}	1.8750 ^b	3.1250 ^{ab}
<i>C. capensis</i> x M	2.8750 ^{bc}	3.1250 ^b	0.5000 ^{ab}	0.8750 ^{ab}	1.5000 ^{bc}	2.7500 ^{bc}
<i>V. unguiculata</i> x F	2.0000 ^{cd}	2.2500 ^{bc}	0.0000 ^b	1.0000 ^{ab}	2.3750 ^{ab}	2.0000 ^{bc}
<i>V. unguiculata</i> x M	4.3750 ^a	2.5000 ^b	1.0000 ^a	1.5000 ^a	3.3750 ^a	4.5000 ^a
<i>C. juncea</i> x F	0.3750 ^e	1.0000 ^d	0.5000 ^{ab}	0.1250 ^b	0.5000 ^c	2.2500 ^{bc}
<i>C. juncea</i> x M	0.6250 ^{de}	1.3750 ^{cd}	0.8750 ^a	0.2500 ^b	0.7500 ^c	1.5000 ^c
LSD	1.3758	1.0969	0.6609	1.0246	1.0685	1.3979

LSD = Least Significant Difference at the 5% significance level

Means per column followed by the same letter are not significantly different at the 5% level

F=Flowering, M=Maturity



of stink bugs. It should be timed in such a way that the more attractive and irresistible stage of the trap crop coincides with the flowering and fruiting stage of the orchard, so to avoid fruit damage that could lead to poor fruit quality. The distance between trap crops and orchards also need to be scrutinised, because it might jeopardise the overall objective of trap crops.

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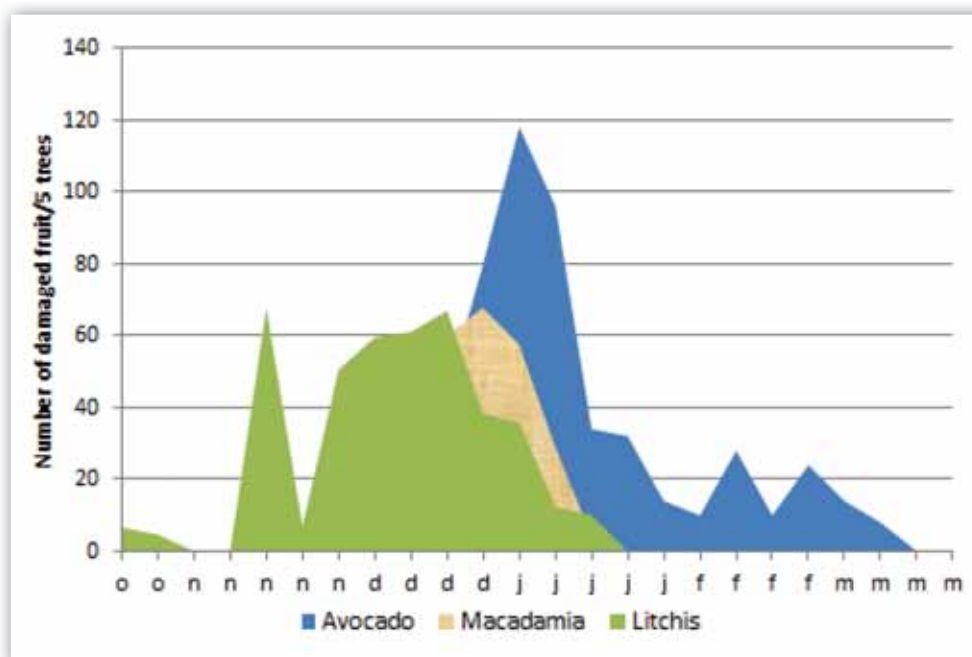


Figure 1. Host interchanging behaviour of coconut stink bug in the subtropical growing regions of South Africa.

