Application methods for granular insecticides to control *Heteronyx piceus* Blanchard (Coleoptera: Scarabaeidae) larvae in peanuts in Queensland

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Summary

Between 1980 and 1989 three application methods for granular insecticides were evaluated against the peanut scarab, *Heteronyx piceus* Blanchard (Coleoptera: Scarabaeidae). The application methods were (1) in-furrow application at planting, (2) surface-incorporated bands at planting and (3) post-planting band application. All three application methods were found to be effective for at least some of the chemicals tested.

All chemicals applied at planting, using either surface bands or in-furrow treatments, were effective. The chemicals evaluated were aldicarb, carbofuran, ethoprophos, fensulfothion, isofenphos, phorate and terbufos. The data for carbofuran applied at planting indicate that in-furrow treatments were more effective than surface bands. Post-planting applications appeared to have the least potential for peanut scarab control due to the lack of irrigation and unreliable rainfall patterns. In addition, post-planting application was ineffective for terbufos and phorate. The most product-efficient treatment evaluated in the trials was 0.5 kg ha^{-1} of carbofuran applied in-furrow at planting.

In two trials where crop yields were reported, yield increases from control of the peanut scarab averaged 357 and 450 kg ha^{-1}, respectively.

Introduction

Heteronyx piceus Blanchard is the major scarab pest species associated with peanuts in the South Burnett area of Queensland (Rogers *et al.* in press), comprising approximately 90% of the scarab fauna associated with the crop. *H. rugosipennis* Macleay usually contributes another 5%, with an additional 10 species comprising the remainder of the population (Rogers *et al.* in press).

H. piceus is a univoltine species whose biology is closely tied to the development of the peanut crop. Adults emerge from the soil after early summer storms between mid-October and early December. Females feed on the foliage of the newly emerged peanut seedlings before laying eggs under the crop row. First instar larvae apparently feed on organic matter, as do many young white grubs (Gough and Brown 1988, Wilson 1969), while the second and third instars attack the pegs (incipient pods) and pods. Plants are not killed by *H. piceus* attack. Larvae complete development by the time the crop is mature and overwinter deep in the soil before pupating in spring. After eclosion, adults remain in their pupal cells until early summer storms trigger emergence from the soil. Larval populations of *H. piceus* can reach 24 m^{-1} in commercial crops in the South Burnett region (Rogers *et al.* in press) but densities of 4-10 larvae m^{-1} are more typical. Yield losses from this scarab species are substantial and control of the pest would be warranted on many peanut crops in the region. *H. piceus* is also a minor pest of peanuts on the Atherton Tableland of north Queensland (Gough and Brown 1988).

The relationship between *H. piceus* and the host plant differs from that recorded for other white grub species on peanuts in Australia (Gough and Brown 1988), India (C.P.S. Yadava, personal communication) and Africa (J. Wightman, personal communication). Because control strategies for these other species are of minimal relevance to the chemical control of *H. piceus*, it was important to evaluate general approaches to chemical control of *H. piceus*. This paper reports on three placement strategies for granular insecticides applied for *H. piceus* control: (1) in-furrow application at planting, (2) surface-incorporated band application at planting, and (3) post-planting band application. The paper also presents data on yield losses associated with *H. piceus* infestations in peanuts.

Materials and methods

The experiments were conducted between 1980 and 1989 in areas of the South Burnett region with a history of peanut scarab infestation. The first series of trials (Tables 1-3) evaluated the effect of chemical applications at planting and post-planting "over the row", using a variety of chemicals. The second series of experiments (Tables 4 and 5) evaluated the effects of chemical incorporation in a band over the plant row as well as in-furrow application at planting, using carbofuran as the test chemical.

Ten percent granular formulations of the following pesticides were used in these trials: aldicarb (Temik®), carbofuran (Furadan®), ethoprophos (Mocap®), fensulfothion (Dasanit®), phorate (Thimet® and terbufos (Counter®). A 5% formulation of isofenphos (Oftanol®) was used. Rates of application (active ingredient) are given in the Tables. From 1983, all trials used carbofuran as the standard test chemical as it can control the root-lesion nematode (*Pratylenchus brachyurus* (Godfrey)) (P.C. O'Brien, personal communication) as well as *H. piceus* (Rogers and Brier, unpublished data).

Virginia Bunch peanuts were planted in 91 cm rows at commercial plant densities between mid-November and mid-December of each year, the normal planting period. The trials were laid out in randomized block designs with four to eight replications, depending on the number of treatments. Plots were four rows wide and 10 to 20 m long.

In the 1980/81 and 1981/82 seasons, granules were preweighed for each plot and applied using a modified coneplanter. From 1983, Gandy® granule application equipment was used for all insecticide applications. In-furrow treatments were applied through the planting tyne with the seed. The granules were distributed in a band approximately 3 cm wide and at the same depth as the seed. At-planting band applications were applied to the soil surface immediately in front of the planting tyne. Soil movement created by this tyne incorporated the granules into the soil surface. Band widths between 15 cm and 35 cm were tested in the trials. Post-planting band applications (1980/81) were applied 27 days after planting by dropping granules over the plant row in a 20 cm wide band, with most of the granules concentrated in the central 8 cm of the treated area. Only a few granules were trapped in foliage. Almost all applied granules in post-planting applications reached the soil surface where they were covered immediately using an inter-row tyne cultivator.

Data were collected from the central two rows of each plot. At crop maturity, *H. piceus* larval populations were assessed by dry sieving the soil from randomly selected sites within each plot. In 1980/81, four single plants/plot were sampled while in all other trials either four (1981/82) or six 0.5 m sections of row were sampled per plot. Larvae were preserved in KAA(2) fixative (Carne 1951) and speciated according to the criteria listed by Rogers *et al.* (in press). Pods from sampled plants were assessed for larval feeding damage, typically a hole eaten into the distal end of the pod.

In 1981/82, some phytotoxicity was apparent and plant density (28 days post-planting) and plant canopy width (63 days post-planting) were recorded in each plot. In 1987/88, yield data were obtained from 27 m of row harvested with commercial harvesting equipment. In 1988/89, crop yield was calculated from the six 0.5 m samples. Preplanting soil samples of the 1987/88 and 1988/89 trial sites indicated that root-lesion nematode populations were too low to affect crop yield.

Results

Granule placement affected terbufos efficacy against *H. piceus* (Table 1). In 1980/81, an in-furrow treatment was highly effective against the pest but a post-planting band application caused almost no larval mortality and did not reduce crop damage. In 1981/82 an additional trial with in-furrow terbufos applications (Table 1) established that there was no significant difference in efficacy in the 1–3 kg a.i. ha^{-1} rate range. These trials established that in-furrow applications at planting have potential for the control of *H. piceus* at moderate chemical application rates.

The cultivation treatment associated with the post-planting chemical applications (Table 2) had no effect on white grub numbers or damage. Of the chemicals tested, phorate and terbufos were ineffective while ethoprophos, fensulfothion and isofenphos significantly reduced larval numbers and crop damage.

The 1981/82 trial (Table 3) confirmed the efficacy of 3 kg a.i. ha^{-1} terbufos and also showed that aldicarb, ethoprophos, fensulfothion, isofenphos and phorate control the peanut scarab when applied in the furrow at planting. However the trial found that at least one of these chemicals, ethoprophos, can cause significant phytotoxicity when applied in this manner, reducing plant density and the size of the surviving plants.

The effect of at-planting surface-incorporated bands (15 and 35 cm wide) of carbofuran were investigated during 1983/84 (Table 4). Within both band widths, *H. piceus* larval density and damage declined as carbofuran rate increased. Band width did not affect the level of *H. piceus* control at either the 0.4 kg ha^{-1} or 0.8 kg ha^{-1} rates. In this experiment, at least 0.8 kg ha^{-1} carbofuran was required for satisfactory control of peanut scarab.

The final trials (Table 5) compared in-furrow and banded carbofuran applications in two successive years. In 1987/88, all treatments significantly reduced larval populations and damage and significantly increased crop yield. In this trial, carbofuran treatment increased yield by an average of 450 kg ha^{-1}, a 72 % increase over the untreated control. At the 1 kg ha^{-1} rate, the in-furrow treatment produced a level of scarab control equivalent to the band application but had significantly fewer damaged nuts. The 0.5 kg ha^{-1} in-furrow treatment produced control not significantly different from the 1 kg ha^{-1} band treatment. However, the level of control from the 0.25 kg ha^{-1} in-furrow application was significantly lower than the 1 kg ha^{-1} treatment, both banded and in-furrow. It also had significantly more damaged nuts than the 0.5 kg and 1.0 kg in-furrow treatments.

The 1988/89 experiment included two band widths (15 cm and 25 cm) at planting as well as in-furrow treatments. As in 1987/88, all carbofuran treatments significantly reduced larval numbers and damage and significantly increased crop yield. The yield increase averaged 357 kg ha^{-1} across the seven carbofuran treatments. For the banded applications at planting, band width had no significant effect on efficacy as there were no significant differences in pest numbers or damage between band widths for either application rate. However in the 25 cm band, the level of control from 0.5 kg ha^{-1} was significantly worse than that from 1.0 kg ha^{-1}. This significant difference in efficacy was not detected in the 15 cm band width. For the in-furrow treatments, scarab control, damage and crop yield were equivalent across the rate range from 0.25 to 1.0 kg ha^{-1}. In-furrow treatments down to 0.25 kg ha^{-1} were equivalent to 1.0 kg ha^{-1} in either band width, on the basis of crop yield, pest numbers and damage. This is in contrast to the 1987/88 trial, where the 0.25 kg ha^{-1} in-furrow treatment gave a significantly lower level of control to 1 kg ha^{-1}, banded or in-furrow.

Table 1. Control of *Heteronyx piceus* with in-furrow and post-planting applications of terbufos.

Application Method	Terbufos Rate (kg ha^{-1})	Larval Density*	Damaged Nuts (%)
1980/81			
Control	–	26.4a	22.1a
At-planting in-furrow	3	3.1c	2.6b
Post-planting band (20 cm)	3	17.4b	19.9a
1981/82			
Control	–	6.9a	5.5a
At-planting in-furrow	1	1.6b	1.7b
At-planting in-furrow	2	1.6b	1.4b
At-planting in-furrow	3	0.4b	1.4b

Within experiments, means followed by the same letter are not significantly different. (P=0.05, Fisher's LSD test).
*Larvae per four plants in 1980/81, larvae per metre in 1981/82.

Table 2. Control of *Heteronyx piceus* with a post-planting over-the-row application of granular insecticides (3 kg a.i. ha^{-1}) 1980/81.

Treatment	Larvae/4 plants	Damaged Nuts (%)
Uncultivated control	14.8a	16.5a
Cultivated control	12.5ab	16.4a
Ethoprophos	4.5c	3.6b
Fensulfothion	1.3c	2.4b
Isofenphos	3.0c	5.2b
Phorate	11.8ab	19.3a
Terbufos	9.5b	15.6a

Means followed by the same letter are not significantly different (P=0.05, Fisher's LSD test).

Table 3. Control of *Heteronyx piceus* with an in-furrow application at planting of granular insecticides (3 kg a.i. ha^{-1}) 1981/82.

Treatment	Larvae/m	Damaged Nuts (%)	Plant Density* (pl/m) (28 d post-planting)	Plant Width* (cm) (63 d post-planting)
Control	4.8a	7.0a	6.2a	65.0ab
Aldicarb	1.0b	2.5b	6.3a	68.1a
Ethoprophos	1.3b	1.1c	4.8b	51.7c
Fensulfothion	0.5b	1.2c	6.0a	63.3b
Isofenphos	0b	1.1c	6.3a	66.1ab
Phorate	0.8b	1.3bc	6.2a	63.2b
Terbufos	0.6b	1.0c	6.3a	66.9ab

Means followed by the same letter are not significantly different (P=0.05, Fisher's LSD test).
*Square root transformation before analysis. Equivalent means are presented.

Discussion

These experiments show that granular insecticides can be used to control the peanut scarab, *H. piceus*, when applied in the planting furrow, as surface-banded applications and as post-planting over-the-row treatments. However, for two of the chemicals tested, phorate and terbufos, at-planting treatments were effective against the pest while post-planting applications were not.

In the post-planting trial (Table 2), 101 mm of rainfall was received in 5 falls between 4 and 10 days after chemical application. Rainfall, or irrigation, is known to be important in determining efficacy of products such as ethoprophos when applied as post-planting treatments (Allsopp and Hitchcock 1985). Peanuts in the region are grown without irrigation and early summer rainfall is unpredictable. Consequently, the post-planting applications trialled here may not have wide commercial application if applied with the techniques used in this experiment.

While bands and in-furrow applications at planting can both control peanut scarab damage, the data suggest that lower chemical rates can be used for in-furrow applications. However, at-planting banded applications of chemicals such as carbofuran can be used to provide simultaneous control of the root-lesion nematode (P.C. O'Brien, personal communication) and the peanut scarab. Where *H. piceus* alone is present, the in-furrow application would be the preferred option. Some phytotoxicity was detected with this application method with ethoprophos (Table 3) at the application rate of 3 kg a.i. ha^{-1}. This problem would not be expected from any of the chemicals tested at lower, commercial, application rates.

White grub population density varied widely from year to year because early season weather patterns, especially rainfall, were more suitable for adult flights and activity in some years than others. Where good early season rains (mid-October to early November) fell, adult activity occurred over a longer period than usual, leading to higher adult infestation levels and, as a result, higher larval populations. Early-planted crops (mid-October to early November) also tend to have higher larval populations as they are subject to adult infestation over a longer period of time.

The percent of damaged nuts, relative to larval populations, also showed wide variation from year to year. In 1988/89, 7 larvae/metre damaged 30.5% of nuts while in 1987/88, 18.4 larvae/metre damaged 22.6% of nuts. This variation occurred because of interactions between insect development and crop phenology under the dryland growing conditions. The degree of damage in any one year is dependent on planting date, the cropping history of the area and rainfall patterns. The most damage appears to occur when third instar larvae are present from early pod set. This can occur (a) through delayed planting, (b) in areas where peanuts have been double cropped and where a *H. piceus* population has become established on self-set plants prior to planting, and (c) where a prolonged dry period has markedly delayed flowering and pod set. All of these situations lead to the presence of third instar larvae from early in the podding period and result in increased pod damage.

An in-furrow application of 0.5 kg ha^{-1} of carbofuran was the most product-efficient treatment identified. This requires an at-planting application of pesticide prior to there being detectable adult activity. For this reason, control decisions for *H. piceus* would require an evaluation of larval populations prior to the harvest of the previous crop. Grower experience over the last 30 years has shown that if scarab damage occurs in a crop, it will also occur in any crops grown in the succeeding year on the same land or adjacent areas. This management strategy, if applied on a whole-farm basis over a number of years, will reduce *H. piceus* populations to a low level and prevent the recurrence of the persistent high populations observed in peanut-growing areas of the South Burnett over the last 30 years.

Table 4. Control of *Heteronyx piceus* with surface-incorporated carbofuran applications at planting (1983/84).

Band Width (cm)	Carbofuran Rate (kg a.i. ha^{-1})	Larvae/m	Damaged Nuts (%)
Control	–	18.9a	23.9a
15	0.2	12.2b	13.9b
	0.4	11.9b	13.4b
	0.8	3.3cd	6.5bc
35	0.4	8.1bc	10.0bc
	0.8	5.1cd	5.1bc
	1.5	1.2d	3.0c

Means followed by the same letter are not significantly different (P=0.05, Fisher's LSD test).

Table 5. Control of *Heteronyx piceus* with in-furrow and surface-incorporated applications of carbofuran at planting.

Application Method	Carbofuran Rate (kg a.i. ha^{-1})	Larvae/m	Damaged Nuts (%)	Yield (kg ha^{-1})
1987/88 experiment				
Control	–	18.4a	22.6a	622a
Band (35 cm)	1.0	5.6c	9.1bc	1047b
In-furrow	0.25	12.0b	12.3b	1007b
	0.5	7.7bc	4.8cd	1141b
	1.0	4.4c	3.6d	1094b
1988/89 experiment				
Control	–	7.0a	30.5a	1632a
Band (25cm)	0.5	4.5b	15.3b	1867b
	1.0	1.3c	1.9c	1976bc
Band (15cm)	0.5	3.8bc	4.1bc	1966bc
	1.0	1.7c	2.8c	1944bc
In-furrow	0.25	3.4bc	8.1bc	2119c
	0.5	2.3bc	7.2bc	2044bc
	1.0	3.2bc	6.3bc	2006bc

Within experiments, means followed by the same letter are not significantly different (P=0.05, Fisher's LSD test).

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