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Use of the botanical insecticide, neem to control the small rice stinkbug *Oebalus poecilus* (Dallas, 1851) (Hemiptera: Pentatomidae) in Guyana

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Abstract

Sutherland J, Baharally V, Permaul D. 2002. Use of the botanical insecticide, neem to control the small rice stinkbug *Oebalus poecilus* (Dallas, 1851) (Hemiptera: Pentatomidae) in Guyana. Entomotropica 17(1):97-101.

The small rice stinkbug, *Oebalus poecilus* is the principal insect pest of rice in Guyana and many other South American countries. In Guyana, stinkbug control is achieved through spraying with monocrotophos. Research is underway to find cost effective, safer alternatives to monocrotophos. One possibility is the use of products derived from the neem tree, which grows commonly in Guyana. Both bioassays and field tests were used to examine the efficacy of crude neem kernel extracts and several commercially available products. Bioassays revealed that the extracts exhibited a low contact kill as against the commercial products. Antifeedant and ovipositional deterrent tests demonstrated good activity in reducing stinkbug feeding damage but not oviposition. Field-testing of all compounds highlighted that the commercial product showed promise in reducing stinkbug damage when applied at 2.5l ha^{-1}. The prospects for possible inclusion into an integrated pest management programme are discussed.

Additional key words: Antifeedant, *Azadirachta indica*, integrated pest management, IPM.

Resumen

Sutherland J, Baharally V, Permaul D. 2002. Uso del insecticida botánico, neem para el control de la pequeña chinche de la espiga *Oebalus poecilus* (Dallas, 1851) (Hemiptera: Pentatomidae) en Guyana. Entomotropica 17(1):97-101.

La pequeña chinche de la espiga, *Oebalus poecilus* es el principal insecto nocivo para el arroz en Guyana y en muchos otros países sudamericanos. En Guyana, el control de la chinche de la espiga se logra rociando con monocrotophos. Hay trabajos de investigación en curso para encontrar alternativas al monocrotophos seguras y eficaces en costos. Una posibilidad es el uso de productos derivados del árbol neem, el cual crece comúnmente en Guyana. Se utilizaron tanto ensayos biológicos como pruebas de campo para determinar la eficacia de los extractos de semilla cruda de neem y varios productos comerciales. Los bioensayos revelaron que los extractos exhibieron una baja erradicación por contacto contra los productos comerciales. Las pruebas disuasorias antialimentarias y de ovipostura demostraron una buena actividad para reducir los daños por alimentación de la chinche de la espiga pero no los de ovipostura. Las pruebas de campo de todos los compuestos destacó que el producto comercial demostró ser prometedor en la reducción de daños de la chinche de la espiga cuando se aplica a razón de 2.5l ha^{-1}. Se discuten los prospectos para su posible inclusión en un programa de manejo integrado de plagas.

Palabras clave adicionales: Antialimentarias, *Azadirachta indica*, manejo integrado de plagas, MIP.

Introduction

The small rice stinkbug, *Oebalus poecilus* (Dallas, 1851) (Hemiptera: Pentatomidae) and related pentatomids are the most serious pest of rice in Guyana (Kennard 1965; Ralph and Rivas 1993) and other South and Central American countries (Sailer 1944; Halteren 1972; King and Saunders 1984; Pantoja et al. 1995). Both adults and nymphs feed on the grains and the damage caused affects the yield and quality of the harvested paddy (Kennard 1966).

Currently in Guyana and much of South America (Costa and Link 1992), small rice stinkbug control is achieved through the use of monocrotophos, an organophosphate insecticide. In Guyana, 99% of farmers use insecticides and as many as four sprays are applied each season, typically by calendar application (Ralph and Rivas 1993). Approximately 32% of farmers apply insecticide as a preventative measure rather than a targeted spray (Ralph and Rivas 1993), which is not only costly in terms of financial outlay but also has associated ecological and toxicological hazards. Therefore a more balanced and cost effective integrated pest management (IPM) programme must be implemented and adopted by rice farmers.

The insecticidal properties of neem, *Azadirachta indica* A. Juss. (Meliaceae) were first observed in 1959 when it was noticed that neem trees in Africa were undamaged during a plague of locusts (Schmutterer 1990). The trees produce yellow oval shaped fruits once or twice per year. The seeds contain most of the principal active ingredient azadirachtin, but the leaves and other parts of the tree also contain significant amounts.

Throughout Asia, azadirachtin has been used successfully against a variety of rice pests, including brown planthopper, *Nilaparvata lugens* (Stål) (Homoptera: Delphacidae) (Rao and Rao 1979; Saxena and Khan 1985), white-backed planthopper, *Sogatella furcifera* (Horváth) (Homoptera: Delphacidae) (Shukla et al. 1991), green leafhopper, *Nephotettix virescens* (Distant) (Homoptera: Cicadellidae) (Mariappan and Saxena 1983) and rice water weevil, *Lissorhoptrus oryzophilus* Kuschel (Coleoptera: Curculionidae) (Mochizuki 1993). Some attempts to use azadirachtin in pest management have been made both in Africa and South America (see Dreyer and Hellpap 1991) but these have been limited. The use of natural and easily biodegradable crop protection inputs such as azadirachtin could be a useful component of an IPM strategy, as neem is known for its low toxicity against beneficial insects.

Various commercial azadirachtin formulations and crude neem seed extracts were screened in the laboratory for their efficacy against the small rice stinkbug. Standardized bioassays and choice tests were performed to test the efficacy of several azadirachtin formulations against *O. poecilus.* All products were then further field tested to confirm their activity.

Materials and Methods

Contact kill bioassays of four neem-derived formulations. Three panicles of *Echinochloa colona* (Linnaeus) Link were placed inside conical flasks with a filter paper placed in the base. Fifteen field-collected adult *O. poecilus* were placed into each conical flask. Bugs were contained with mesh at the mouth of the flask. The following azadirachtin treatments were tested in bioassays: NEEMACTIN 0.15% ai (Wockhardt Ltd., Mumbai, India), (recommended rate (RR) = 12.5ml l^{-1}), AGRONEEM 0.15% ai (Nitrac NV., Suriname) (RR = 12.5ml l^{-1}), NEEM-X 0.4% ai (Marketing Arm International, Florida, USA) (RR = 12.5ml l^{-1}), neem kernel extract (RR = 50g l^{-1}). Neem kernel extract was produced by collecting neem fruits from trees and sun drying for 24h. The pulp was removed from the seeds and the testae removed to yield the kernel. 500g of kernel was crushed in a laboratory blender to give an oily brown powder. This was added to 10l of water, agitated vigorously and left for 12h in a dark place. The solution was filtered through a 0.5mm mesh to remove suspended particles which might otherwise have blocked spray equipment. The solution was kept for 3 days. Replicates were sprayed with a manual microsprayer with 1ml of the following range of concentrations; 0% (control), 12.5% of the RR, 25% of the RR, 50% of the RR and 100% of the RR. Mortality of *O. poecilus* was recorded after 24h in each of the replicates and treatments. Mortality was corrected using Abbott's Formula $P_T = (P_O - P_C / 100 - P_C) \times 100$, where P_O is observed mortality and P_C is control mortality (Abbott 1925).

Persistence of the azadirachtin formulation, NIMBECIDINE. Fifteen potted rice plants (cv Rustic) were sprayed with equal volumes (10ml) of NIMBECIDINE 0.03% ai (T. Stanes and Co. Ltd., India) applied at the following rates: 5ml l^{-1}, 8ml l^{-1} and 10ml l^{-1}. Five rice plants were left untreated and all plants were placed in a screened field cage (3m x 3m x 2m). 24 h after treatment ten adult *O. poecilus* were released into mesh cages (10cm diameter, 25cm height) attached to the fifteen treated and five control rice plants. Mortality was recorded 24h after introduction of the bugs. This was repeated daily until 120h after spraying.

Investigation of antifeedant and oviposition-deterrent properties of azadirachtin formulations. Five panicles of rice (cv BR 444) were placed in each of three separate conical flasks filled with water. Panicles were sprayed with equal volumes (10ml) of the following neem treatments: Control (water), NEEMACTIN 0.15% at 12.5ml l^{-1} and NEEM-X 0.4% at12.5ml l^{-1}. Treatments were assigned to random positions in the bottom of a mesh cage (55cm x 55cm x 65cm) in the laboratory. Lighting (12h day: 12h night), was provided by cool fluorescent tubing (2 x 20W Phillips tubes) and ambient temperature and humidity conditions were utilized (i.e. mean temperature was 28.9 ^{o}C ± 3 ^{o}C and the mean relative humidity was 78.3%). Approximately 150 - 200 field-collected adult *O. poecilus* were introduced into the cage and permitted to make choices concerning which panicles they would feed from and oviposit on. After 72h, treatments were removed from the cage and numbers of eggs were counted and the percentage of damaged rice grains was assessed by counting the total number of grains and

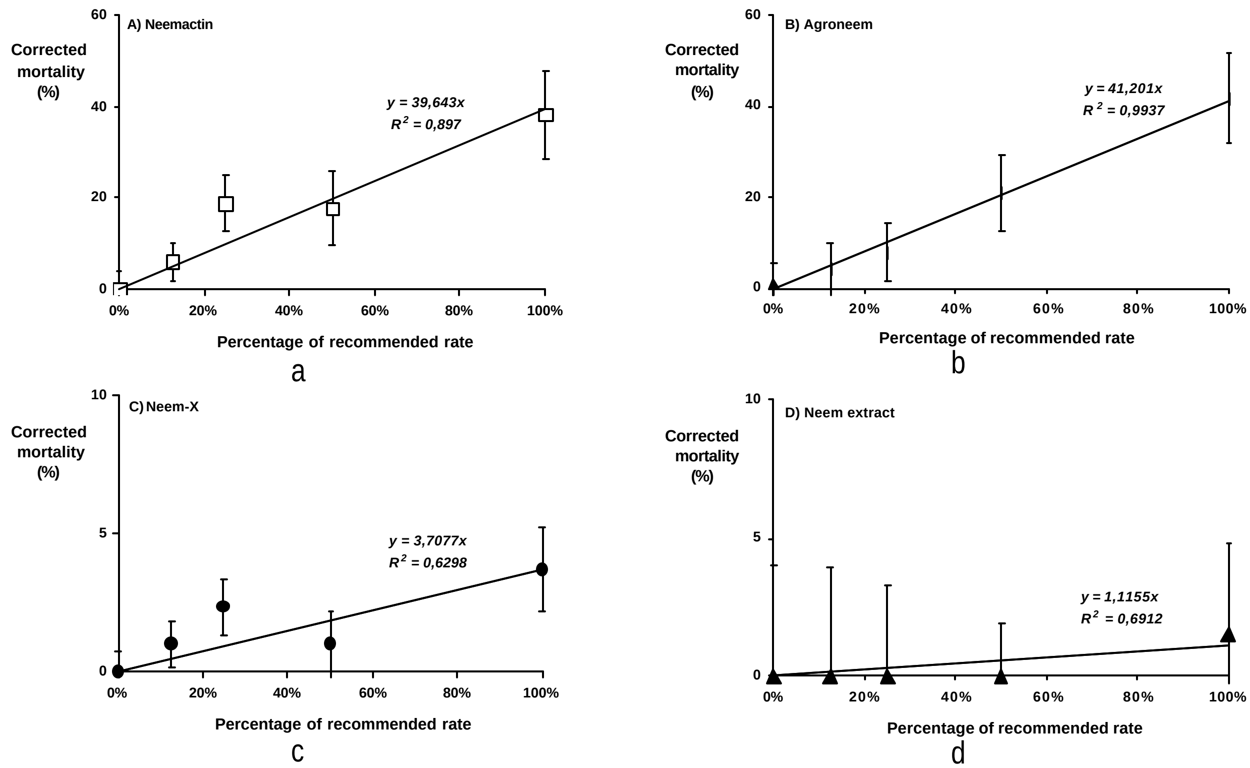

FIGURE 1. Mortality of the small rice stinkbug, *Oebalus poecilus* at a range of concentrations of **a)** NEEMACTIN, **b)** AGRONEEM, **c)** NEEM-X and **d)** neem seed kernel. Mortality is corrected using Abbott's Formula $P_T = (P_O - P_C / 100 - P_C) \times 100$, where P_O is observed mortality and P_C is control mortality.

then evaluating which had stylet puncture wounds (discoloured brown spots on the shell of the grain).

Field trial of the efficacy of azadirachtin formulations. The field site was located in experimental fields at the Rice Research Station, Burma, East Coast Demerara, Guyana, South America (lat 6°27'50"N, long 57°45'25"W). Plots (5m x 15m) were laid out in a randomized block design with cv BR 444. Plots were sprayed with the azadirachtin formulations and insecticide check using a Guanary 20l knapsack sprayer fitted with blue flat fan nozzle, leaving a 1m wide "buffer zone" between plots, so as to limit spray drift from entering adjoining plots. Treatments included NEEMACTIN at 2.5l ha^{-1}, AGRONEEM at 2.5l ha^{-1}, NEEM-X at 2.5l ha^{-1}, neem kernel extract at 10kg ha^{-1}, monocrotophos 600SC (NUVACRON) at 700ml ha^{-1} and water (control). All were sprayed at an equivalent rate of 200l ha^{-1}. Bug populations were monitored twice weekly from 70 days after sowing (DAS) through to harvest. A 30cm diameter sweep net was used to assess the population, making 25 complete sweeps in each plot. Samples of grain were also taken from each plot immediately prior to harvest to calculate percent damaged grains. All data were square root transformed to normalize the data.

Results and Discussion

Contact kill bioassays of four neem-derived formulations. Initial contact mortality of *O. poecilus* after 24h exposure to a range of concentrations of azadirachtin formulations is shown in Figure 1. It is evident that only NEEMACTIN and AGRONEEM at the highest rates (12.5ml l^{-1} or 2.5l ha^{-1}) gave significant stinkbug mortality and this was only between 35 and 40%. The reason for the very poor performance of NEEM-X, which contains a higher concentration of the active ingredient, azadirachtin, is unknown. Much of the activity of NEEMACTIN and AGRONEEM could be attributed to the adjuvants and solvents in the formulation rather than the active ingredient. This result is to be expected, as azadirachtin is not generally known for its ability to kill insects outright and may take well in excess of three days to do so. Neem is more regarded for its sublethal and chronic effects on pests (Schmutterer 1988; Schmutterer 1990).

Persistence of the azadirachtin formulation, NIMBECIDINE. Figure 2 shows that the persistence of the neem-formulation NIMBECIDINE lasts for approximately three days. From persistence testing, at the highest concentrations only a moderate mortality

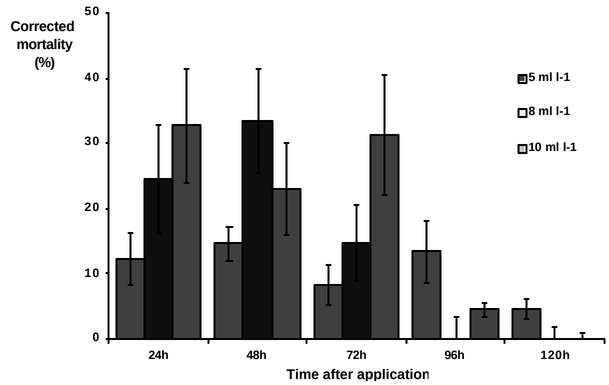

FIGURE 2. Mortality of the small rice stinkbug, *Oebalus poecilus* at a range of concentrations of NIMBECIDINE after introduction at 24, 48, 72, 96 and 120h. Mortality is corrected using Abbott's Formula $P_T = (P_O - P_C / 100 - P_C) \times 100$, where P_O is observed mortality and P_C is control mortality.

TABLE 1. Mean number of *Oebalus poecilus* eggs laid in 72h and damaged rice grains after 72h (± standard error). An ANOVA on $\log_{10}$ transformed data revealed significant differences between the means (P < 0.05) for damaged grains only. Different letters after the means indicate a significant difference (Fisher's LSD test, P £ 0.05).

Treatment	Mean number of eggs	Mean % damaged grains
Control	117.7 ± 43.9 ns	9.44 ± 1.5 b
NEEMACTIN	75.8 ± 20.9 ns	5.29 ± 0.5 a
NEEM-X	95.9 ± 25.9 ns	5.6 ± 1.1 a

(25 - 30%) was achieved up to 72h after treatmen. This is less than that quoted by Schmutterer (1990), who stated that a foliar spray application of most commercial neem formulations persists for 5 to 7 days under field conditions. This does indicate, that as suspected the active ingredient in neem formulations has a low persistence and are readily broken down. This has obvious implications and advantages for an IPM programme, although it would mean that repeat sprays may be required to effectively manage the pest population.

Investigation of antifeedant and oviposition-deterrent properties of azadirachtin formulations. There were no significant differences between the number of eggs laid on treated plants ($F_{2,27}$ = 0.86, P = 0.44) although Table 1 does indicate lower numbers of eggs on treated plants. Reduction in fecundity and reproduction has previously been induced by azadirachtin in *N. virescens* by Vonderheyde et al. (1985), but actual oviposition is rarely influenced (Schmutterer 1990). There were significant differences between the percentage of damaged grains in treatments ($F_{2,27}$ = 5.36, P = 0.01) (see Table 1), indicating a marked reduction in feeding by *O. poecilus* on those panicles treated with azadirachtin. The antifeedant properties of azadirachtin on rice pests have been well documented. Much of this has been in Asian homopteran rice pests, for example *N. lugens* (Rao and Rao 1979; Saxena and Khan 1985), *S. furcifera* (Shukla et al. 1991) and *N. virescens* (Mariappan and Saxena 1983; Saxena and Khan 1986). One case of activity of azadirachtin against a pentatomid was reported by Seymour et al. (1995), where feeding damage by *Nezara viridula* Linnaeus (Heteroptera: Pentatomidae) on pecans was significantly reduced. It appears as though we have found a similar effect on rice grain feeding bugs for the first time.

TABLE 2. Numbers of *Oebalus poecilus* sweep-netted in field plots treated with neem formulations. An ANOVA on square root transformed data revealed significant differences between the means (P < 0.05). Different letters after means indicate a significant difference between the means (Fisher's LSD test, P £ 0.05).

	Mean bugs per plot (per 25 sweeps)		Damaged
Treatment	24h post-treatment	96h post-treatment	grains (%)
NEEMACTIN	1.2 b	5.8 c	3.2 abc
AGRONEEM	1.5 b	2.2 ab	3.8 c
NEEM-X	2.2 b	5.0 bc	2.5 a
Crude neem extract	1.5 b	7.5 c	2.7 ab
NUVACRON	0.0 a	0.8 a	2.9 abc
Control	3.2 b	7.2 c	3.4 bc

Field trial of the efficacy of azadirachtin formulations. Table 2 shows the effect of application of the several azadirachtin formulations and monocrotophos on the small rice stinkbug. There were significant differences between stinkbug numbers in treatments 24h after spraying ($F_{5,15}$ = 3.38, P = 0.03) and at 96h after spraying ($F_{5,15}$ = 7.44, P = 0.001). A priori testing (Fisher's LSD) revealed that at 24h, only monocrotophos was significantly different to all azadirachtin treatments and the control. At 96h, both monocrotophos and AGRONEEM had a slightly lower bug population than other treatments. However, *O. poecilus* numbers were extremely low in treated plots and perhaps too low for statistical consideration. With assessment of the damaged grains data, although significant differences were observed ($F_{5,15}$ = 3.00, P = 0.04), one would question the validity of the results because of the late application of the sprays (90 DAS). The direct effects of neem on a pest such as a heteropteran bug are difficult to assess in the field, as azadirachtin has complex sublethal effects on the pest

(Schmutterer 1988), so it is important to realize that this is by no means a negative result.

To conclude, azadirachtin is an ideal candidate substance for inclusion into an IPM programme for small rice stinkbug (Pluke et al. 1999) predominantly because of its low toxicity to natural enemies (Schmutterer 1990; although see Bottrell 1996). With this in mind, further research is needed in the future to investigate the chronic antifeedant and antioviposition effects of azadirachtin on the small rice stinkbug, particularly on the nymphal instars.

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