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Research Article

Toxicity of selected insecticides to mealybug parasitoids, *Aenasius bambawalei* Hayat and *Aenasius advena* Compere (Hymenoptera: Encyrtidae)

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ABSTRACT: Safety of selected insecticides to mealybug parasitoids, *Aenasius bambawalei* Hayat and *A. advena* Compere (Hymenoptera: Encyrtidae) was evaluated using dry film method at 1, 3, 6, 12, 18 and 24h after treatment (HAT). Results showed that endosulfan, monocrotophos, profenofos and dimethoate caused 100% mortality within 1h in both *A. bambawalei* and *A. advena*, which was significantly higher than untreated check. Imidacloprid was comparatively safer and caused 100% mortality of both the sexes of the parasitoids after 3h. However, nimbecidine caused 100% mortality only after 24h indicating that it is the safest of all the insecticides tested for both the parasitoids and hence might be the first choice for mealybug management when parasitoid activity is noticed to give a cumulative effect.

KEY WORDS: Insecticides, toxicity, dry film technique, bioassay, *Aenasius bambawalei*, *Aenasius advena*

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INTRODUCTION

Mealybugs, a cosmopolitan group of insects with exceptional powers of dispersal, are major pests on many crops. Mealybugs like *Phenacoccus solenopsis* Tinsley and *Ferrisia virgata* (Cockerell) (Hemiptera: Pseudococcidae) are one of the biggest challenges faced by the agriculture scientists of the country for the past four years along with papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink. Their impact on cotton and horticultural crops has been devastating. Vennila *et al*. (2010) reported that *Aenasius bambawalei* Hayat (Hymenoptera: Encyrtidae) effectively regulates the population of *P. solenopsis* under field conditions. Mani (1992) reported that *Aenasius advena* Compere is a key parasitoid of *F. virgata* in many countries. Manickavasagam (2010) while reporting the primary and secondary parasitoids of major mealybugs, confirmed that *A. bambawalei* is the predominant primary parasitoid on *P. solenopsis* and *A. advena* on *F. virgata*. Insecticides are designed to kill insects, so they are likely to be harmful to one or another group of natural enemies as well. However, their safety to natural enemies is either insufficiently known or scanty (Preetha *et al*., 2009). Therefore, studies on toxicity of certain commonly used insecticides on these encyrtids under laboratory conditions are a pre-requisite for avoiding the insecticides which cause high ecological damage. With this background, the present study focused on the safety of important insecticides (used in cotton and horticultural ecosystems) to *A. bambawalei* and *A. advena*.

MATERIALS AND METHODS

The culturing of *A. bambawalei*, *A. advena, P. solenopsis* and *F. virgata* required for bioassays was carried out during 2010 in the Parasitoid Taxonomy and Biocontrol Laboratory of the Department of Entomology, Faculty of Agriculture, Annamalai University.

Rearing of mealybugs

The cultures of *P. solenopsis* and *F. virgata* were established in the laboratory from individuals collected from the fields of Faculty of Agriculture, Annamalai University. The primary mealybug cultures were maintained on sprouted potatoes in plastic containers covered with khadda cloth for ventilation. Each week 25 potatoes were individually infested with adult females having well formed ovisacs to ensure continuous supply of different instars of mealybugs.

Rearing of parasitoids

The cultures of *A. bambawalei* and *A. advena* were established in the laboratory from the mummies collected from the fields of Faculty of Agriculture, Annamalai

University. The parasitoids emerged were identified and cultured on *P. solenopsis* and *F. virgata*, respectively, on sprouted potatoes. Adult parasitoids (10 females and 10 males) were released into plastic containers containing 10 infested sprouted potatoes supporting second and third instars of *P. solenopsis* and *F. virgata* and removed after 48h of oviposition. Emerged parasitoids were collected 20–25 days after parasitization. One-day-old mated parasitoids were used in the experiments.

Insecticides

The following insecticides used in the present study were obtained as commercially available formulations: imidacloprid 200SL (100ml ha^{-1}), endosulfan 35EC (500ml ha^{-1}), nimbecidine 0.03EC (2500ml ha^{-1}), monocrotophos 36SL (1000ml ha^{-1}), profenofos 50EC (1000ml ha^{-1}), dimethoate 30EC (500ml ha^{-1}), chlorpyriphos 20EC (2000ml ha^{-1}) and untreated check (distilled water). Different concentrations of these insecticides were prepared using distilled water.

Treatment procedure

Dry film coating technique was followed to assess the toxicity of insecticides to *A. bambawalei* and *A. advena* as per Plapp and Vinson (1977). Different concentrations of insecticide solutions were prepared using distilled water and used for bioassay. Each replication had ten pairs of parasitoids and there were three replications in each treatment.

Glass containers of 9.0 cm height and 8.5cm diameter were used. The glass containers were cleaned by soaking overnight in soap water, cleaned, rinsed with distilled water and air-dried for at least 4 h before use. The glass containers were coated evenly with 2 ml of the prepared insecticide solutions (listed in Table 1), allowed to dry thoroughly and covered with muslin cloth dipped in the same insecticide solutions and dried. For the untreated control, 2ml of distilled water was used. The respective encyrtids were released into the containers and a fine streak of honey was placed inside. Mortality of the encyrtids was checked at 1, 3, 6, 12 and 24 hours after treatment (HAT). Natural mortality was corrected using Abbott's formula (Abbott, 1925). The data were subjected to completely randomized block design (CRD) and analysed using IRRISTAT.

RESULTS AND DISCUSSION

The data on per cent corrected mortality of *A. bambawalei* and *A. advena* due to various insecticides are presented in Table 1 and Table 2, respectively. In

Table 1. Evaluation of different insecticides for their safety against *Aenasius bambawalei*

Treatments	Corrected Mortality % of *A. bambawalei* after*									
	1h		3h		6h		12h		24h	
	F	M	F	M	F	M	F	M	F	M
Imidacloprid 200SL (100ml ha^{-1})	60.00 (51.15)	80.00 (63.44)	73.33 (59.21)	86.67 (71.74)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Endosulfan 35EC (500ml ha^{-1})	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Nimbecidine 0.03 EC (2500ml ha^{-1})	53.33 (46.92)	73.33 (59.21)	60.00 (51.15)	73.33 (59.21)	66.67 (54.99)	93.33 (80.04)	80.00 (63.44)	93.33 (80.04)	100.00 (88.35)	100.00 (88.35)
Monocrotophos 36SL (1000ml ha^{-1})	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Profenofos 50 EC (1000ml ha^{-1})	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Dimethoate 30 EC (500ml ha^{-1})	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Chlorpyriphos 20EC (2000ml ha^{-1})	86.67 (71.74)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Untreated check (distilled water)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)
SEd	5.76	2.11	4.08	4.66	2.11	4.15	0.00	3.33	0.00	0.00
CD (P = 0.05)	12.21	4.48	8.65	9.87	4.48	8.80	0.00	7.07	0.00	0.00

*Mean of three replications; F = female; M = male; data in parentheses are arc sine transformed values

Table 2. Evaluation of different insecticides for their safety against *Aenasius advena*

Treatments	Corrected Mortality % of *A. bambawalei* after*									
	1h		3h		6h		12h		24h	
	F	M	F	M	F	M	F	M	F	M
Imidacloprid 200SL (100ml ha^{-1})	73.33 (59.21)	86.67 (71.74)	73.33 (59.21)	93.33 (80.04)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Endosulfan 35EC (500ml ha^{-1})	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Nimbecidine 0.03EC (2500ml ha^{-1})	53.33 (49.92)	73.33 (59.21)	66.67 (54.99)	73.33 (59.21)	73.33 (59.21)	80.00 (63.44)	86.67 (71.74)	93.33 (80.04)	100.00 100.00	100.00 100.00
Monocrotophos 36SL (1000ml ha^{-1})	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 100.00	100.00 100.00
Profenofos 50EC (1000ml ha^{-1})	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Dimethoate 30EC (500ml ha^{-1})	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Chlorpyriphos 20EC (2000ml ha^{-1})	86.67 (71.74)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Untreated check (distilled water)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)
SEd	5.04	4.66	2.99	4.66	2.11	0.00	4.15	4.15	0.00	0.00
CD (P = 0.05)	10.68	9.87	6.33	9.87	4.48	0.00	8.80	8.80	0.00	0.00

*Mean of three replications; F = female; M = male; data in parentheses are arc sine transformed values

A. bambawalei, after 1h exposure, the lowest mortality (53.3%) was observed in nimbecidine treatment but moderate mortality (60.0%) was caused by imidacloprid in females. In nimbecidine and imidacloprid treatments, mortality of females ranged 53.3–100.0 and 60.0–100.0, but in the case of males, the range was 73.3–100.0 and 80.0–100.0 per cent during 24h of exposure, respectively. This is in agreement with the previous findings of Hewa-Kapuge *et al*. (2003) who found that imidacloprid, emamectin and tau-fluvalinate were toxic, caused ≥97 per cent mortality in adults of *Trichogramma* nr. *brassicae* 1h after direct application and in residue assays they caused 23-64 per cent mortality during the first 24h.

In *A. advena*, after 1h exposure, the lowest mortality (53.33%) was observed in nimbecidine followed by moderate mortality (73.33%) in imidacloprid for females. In nimbecidine and imidacloprid treatments, the per cent mortality of females ranged from 53.3–100.0 and 73.3–100.0 and in the case of males, the range was 73.3–100.0 and 86.7–100.0 during 24h of exposure, respectively. Jalali *et al*. (2009) also indicated that pest management programmes in agricultural crops using dimethoate, lambda-cyhalothrin and, to a lesser degree, imidacloprid, are detrimental to two-spotted ladybird beetle, *Adalia bipunctata* (L.)

Endosulfan, monocrotophos, profenofos and dimethoate caused 100% mortality within 1h in both the sexes of *A. bambawalei* and *A. advena* (Table 2). This is in conformity with the reports of Consoli *et al*. (1998) who found that organophosphates such as naled can have toxic effects on immature stages of *Trichogramma* Westwood and Olszak (1999) also stated that an organophosphate (phosalone) proved to be the most toxic on *A. bipunctata*. Chlorpyriphos (organochlorine insecticide) caused 86.67% mortality (females) during 1h and it reached 100 per cent after 3h of exposure in both *A. bambawalei* and *A. advena* which was significantly higher than untreated check. Alexander *et al*. (2006) also reported that endosulfan and chlorpyriphos caused highest per cent mortality of adult *Trichogramma chilonis* at 24, 48 and 72h after treatment.

Nimbecidine caused 100% mortality only after 24h in both the sexes of the parasitoids. This is in agreement with the reports of Lowery and Isman (1995), Naumann and Isman (1996) and Tang *et al*. (2002) who also confirmed that neem formulations have minimal toxicity to non-target organisms and negative effect on parasitoid survival and emergence.

There was significant difference between imidacloprid and nimbecidine treatments on the behaviour of the parasitoids. After 1h, parasitoids in imidacloprid treated glass containers could not even walk, but in nimbecidine treatment, parasitoids were able to fly. This is similar to the reports of Nagata *et al*. (1997) and Bloomquist (2001) who

observed that imidacloprid induced overstimulation of the synapses, which resulted in hypertension, convulsions, paralysis, and death. Only after 6h, parasitoids in nimbecidine treated containers were unable to move, but their appendages made slight movements, i.e. they became moribund. In contrast, parasitoids in water sprayed containers (untreated check) were alive for 24h.

The lower per cent corrected mortality due to imidacloprid and nimbecidine in *A. bambawalei* females than *A. advena* females might be because the former is larger in size which enables it to endure the toxicity of insecticides for longer time. But per cent corrected mortality of males of both the species is similar probably due to their similar size.

Overall the results are in agreement with Srinivasa babu and Sharma (2003) who stated that neem oil was the safest chemical and imidacloprid was also relatively safer than conventional organophosphates to coccinellids.

On direct exposure, endosulfan, monocrotophos, profenofos and dimethoate were highly toxic to both adult wasps. This might be because the chances of picking up a lethal dose are much higher in a closed environment than under field conditions, where the parasitoid might move away from the treated area and possibilities of escape are more as stated by Studebaker and Kring (2003).

Both the parasitoids are specific to mealybugs, especially in cotton and horticultural ecosystems. Among the chemicals tested, imidacloprid is commonly used and has comparatively less toxicity to parasitoids. Hence, it is concluded that whenever the activity of these parasitoids are observed, it is better to recommend nimbecidine as both will have their cumulative effect together. If no parasitoid activity is observed, then imidacloprid is the best choice, because it is more effective against mealybugs.

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