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EFFECT OF DIFFERENT INSECTICIDES ON SOLENOPSIS MEALYBUG PARASITOID, *A. BAMBAWALEI* (HAYAT)

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ABSTRACT

Inspite of the success of the biological control, chemical control is still being largely used as an important component of integrated pest management (IPM) and is used in conjunction with the biological control. But pesticides when used along with natural enemies may limit the efficacy of these biocontrol agents and have deleterious effects on parasitoids such as *A. bambawalei*. Although all pesticides may not have a specific site of action on the beneficial organisms, but they can induce sub lethal effects on reproduction and other biological functions (Manzoni *et al*., 2006; Junior *et al.*, 2008). Results of augmentative releases of parasitoids have been variable and atleast some of the variability has been attributed to the use of broad spectrum insecticides (Stinner *et al.*, 1974). Hence, any pesticide applied during the crop growing season has the potential to disrupt biological control. The efficacy of parasitoids is also influenced greatly by the insecticide spray schedule before and after the parasitoid release. Pesticides may also interfere with the searching behaviour by acting as repellent, feeding inhibitor or even reducing the olfactory capacity in addition to resulting in direct mortality of the parasitoid (Desneux *et al.*, 2007). The conservation and inoculative release of the parasitoid is considered as an economically feasible and environmentally safe option for the control of *P. solenopsis.*

KEYWORDS: Insecticides, Solenopsis Mealybug Parasitoid

INTRODUCTION

Biological control is an important component of IPM, hence, the integration of biological and chemical control tactics require a thorough understanding of how pesticides affect biocontrol agents. In recent years, emphasis has been laid on the use of selective pesticides which have little or no effect on the natural enemies but effective against the target pests. Laboratory evaluation of the reduction in the beneficial capacity of the biocontrol agent due to pesticides can serve as a relevant parameter for evaluation of their safety. Residual toxicity of the insecticides has great influence on dispersal and searching ability of the parasitoid. The results of such programmes would help the plant protection advisors in the development of rational control programmes, after determining safe waiting periods for release of bioagents. Therefore, necessary studies about the associated use of pesticides with parasitoids (Pratissoli *et al.*, 2003) and predators (Zanuncio *et al.*, 1998) are important and may help in the decision making in IPM. Hence, keeping this in view the present article has been proposed to integrate the investigations of different workers to find effect of different insecticides, recommended for insect-pests control in cotton crop, on solenopsis mealybug parasitoid, *A. bambawalei* and to identify safer insecticides that can be used when parasitoids are available in the field.

TOXICITY OF INSECTICIDES TO DIFFERENT STAGES OF THE PARASITOIDS

Toxicity of some insecticides to mealybug parasitoid, *A. bambawalei* and *A. advena* adults, was tested by Nalini and Manickavasagam (2011) and they found that monocrotophos, profenophos, endosulfan and dimethoate caused 100 per

cent mortality within one hour while imidacloprid and nimbecidine were found safer. Dinotefuran was extremely detrimental to the adults of *Leptomastix dactylopii* Howard, at the label rate with 100 per cent mortality after 24h. Buprofezin, pyriproxyfen and flonicamid were not harmful when applied at the label rate. At four times the recommended label rate, dinotefuran, acetamprid and clothianidin were all harmful to the parasitoid with 100 per cent mortality 72h after application (Cloyd and Dickinson, 2006). Mgocheki and Addison (2009) reported that fipronil and a-cypermethrin caused significant acute toxicity of *Anagyrus* sp. and *Coccidoxenoides perininutus*.

Organophosphate and carbamate insecticides were highly toxic to the parasitoid, *Colpoclypeus florus* in topical applications, Imidacloprid and abamectin were highly toxic when applied topically. Insect growth regulators did not cause mortality however, dibenzuron caused severe sublethal effects, completely blocking the production of *C. florus* offspring. Biorational pesticides, such as soap, oil, and *B. thuringiensis* products, caused no toxicity to *C. florus* (Brunner *et al*., 2001).

Kheradmand *et al.* (2012) reported that pirimicarb, imidaclopride and dimethoate killed all treated parasitoid adults of *Diaeretiella rapae* (McIntosh) at their field application rates. Furthermore, pymetrozine caused 27 per cent mortality in adult stage and significantly reduced parasitoid's life table parameters in comparison to the control. Acute contact toxicity tests indicated that chlorpyriphos had the highest toxicity to the *Anagrus nilaparvatae* (Pang *et* Wang), requiring the least chemical to achieve 50 per cent mortality. Imidacloprid was the second most toxic insecticide, while insect growth regulators (IGRs) had the lowest toxicity. Results of oral toxicity tests of 14 pesticides showed that dichlorvos was the most toxic, which generated 100 per cent mortality only 2h after treatment. Isoprocarb, imidacloprid, and thiamethoxam were the second most toxic insecticides and killed all wasps in a 4h period. IGRs showed very low contact toxicity, but exhibited certain chronic effects of oral toxicity on longevity, fecundity, and offspring emergence (Wang *et al.*, 2008).

Table 1: IOBC Categorization of Insecticides with Regard to Safety to the Adults of Parasitoid on the Basis of Per Cent Adult Mortality within 24h after Exposure

Class	Description	Adult Mortality
1	Harmless	(<30%)
2	Slightly harmful	(30-79%)
3	Moderately harmful	(80-99%)
4	Harmful	(>99%)

EFFECT OF INSECTICIDES ON HOST PARASITIZATION BY THE PARASITOIDS

Ramesh and Manickavasagam (2006) evaluated the effects of chemical insecticides, namely, monocrotophos, endosulfan, phosphamidon and cypermethrin and biopesticides, namely, Achook, Nimbecidine and Dipel on adult parasitism and emergence of *Trichogramma chilonis* from the eggs of *Corcyra cephalonica*. The results revealed that biopesticides recorded higher parasitism than chemical insecticides, but significantly lower than control. Among the chemical insecticides, cypermethrin recorded the least parasitism followed by phosphamidon and monocrotophos while endosulfan recorded higher parasitism and was on par with biopesticides. Irrespective of treatments, emergence rate was on par except for cypermethrin. Khattak and Rashid (2006) observed neem oil at 2.0 per cent and neem seed water extract at 3.0 per cent significantly affected the egg parasitization of the parasitoid but did not show any negative effect on the adult emergence of *T. chilonis* from two hosts, *Earias vitella* Fabricius and *Helicoverpa armigera* Hubner.

Bayram *et al.* (2010) investigated the possible integration of synthetic pyrethroids with biological control of

Sesamia nonagrioides Lefebvre by the egg parasitoid *Telenomus busseolae* Gahan. Parasitoid females exposed to cyfluthrin (LC25) parasitized significantly fewer eggs than untreated females, whereas neither the level of emergence from parasitized eggs nor the sex ratio of the offspring was affected by the insecticides. None of the above biological parameters were significantly affected by deltamethrin (LC25). Both insecticide treatments reduced the longevity of the parasitoids.

Singh and Gupta (2001) observed maximum parasitization (84.66%) in 50 ppm dose of acephate and maximum adult emergence of *T. chilonis* from *C. cephalonica* eggs in all treatments of acephate whereas minimum adult emergence (1.66%) was found in fenvalerate at higher concentration of 1000 ppm. Among the tested insecticides, acephate was found to be the least toxic and fenvalerate the most in respect of LC_{50} value, parasitization and adult emergence.

Table 2: IOBC Categorization of Insecticides with Regard to Safety to the Parasitoid on the Basis of Reduction in Parasitization/Adult Emergence (%)

Category	Description	Reduction in Parasitization /Adult Emergence (%)
I	Harmless	(< 30)
II	Slightly harmful	(30-79)
III	Moderately harmful	(80-99)
IV	Harmful	(> 99)

Preetha *et al.* (2012) conducted a study to compare the toxicity of imidacloprid on parasitoids. Imidacloprid was tested against three beneficial insects *viz*., an egg parasitoid, egg larval parasitoid and a larval parasitoid representing two families of order Hymenoptera *i.e* Trichogrammatidae (*T. chilonis*) and Braconidae (*Chelonus blackburni* Cameron; *Bracon hebetor* Say) that attack insect pests of cotton. The toxicity of imidacloprid to parasitoids was compared with another neonicotinoid, named thiamethoxam, and a standard check, methyldemeton. Imidacloprid 17.8 SL did not cause any adverse effects on the adult emergence and parasitization of *T. chilonis*. At the recommended dose of imidacloprid (25g active substance /ha), 90.67 and 85.32 per cent adult emergence and parasitization, respectively, was recorded. The recommended dose of imidacloprid caused 56 per cent mortality and was found to have moderate impact on the adults of *C. blackburni*. On the other hand, it was found to be toxic to the parasitoid *B. hebetor*, causing 70 per cent mortality at 48 hours after treatment.

RESIDUAL TOXICITY OF DIFFERENT INSECTICIDES TO THE PARASITOID ADULTS

Newman *et al.* (2004) investigated that residues of buprofezin, emamectin benzoate, lufenuron, tebufenozide and thiacloprid were harmless (<30% mortality) to *Dolichogenidea tasmanica* adults 7 days after treatment. Indoxacarb and lime sulphur residues were moderately harmful (80-99% mortality), while carbaryl, diazinon and spinosad residues were harmful (>99% mortality). Residual toxicity results indicated that imidacloprid was the most persistent insecticide and it retained residual toxicity (80.7% mortality) on rice leaves up to 7 days after treatment. Thiamethoxam, triazophos, and fipronil also had long residual toxicity to the wasps with 7 days mortalities as 66.8, 54.6, and 50.0 per cent, respectively. IGRs showed very low contact and residual toxicity, but exhibited certain chronic effects of oral toxicity on longevity, fecundity, and offspring emergence (Wang *et al.*, 2008).

Table 3: IOBC Insecticide Persistency Ranking

Class	Description	Persistence Class
A	Short lived	<5 days
B	Slightly persistent	5-15 days
C	Moderately persistent	16-30 days
D	Persistent	>30 days

Pirimicarb, pyriproxifen, paraffinic oil, abamectin, chlorpyriphos, and lambda-cyhalothrin were studied for their persistence over time. Most of these products reduced their negative effect on adults of *A. melinus* between one and six weeks after treatment, although lambdacyhalothrin was still harmful to parasitoids 11 weeks after application (Zamora *et al.,* 2013). Persistence toxicity showed dimethoate, dichlorvos and endosulfan to be least persistence, losing their toxicity against *C. plutellae*, one day after treatment. However, toxic residual activity of chlorpyriphos was observed up to 28 days after treatment. All the remaining insecticides (phosphamidon, cartap hydrochloride, quinalphos, monocrotophos and methyl parathion) proved non toxic, seven days after treatment (Mani *et al*., 1995).

For all tested insecticides, longevity of *M. croceipes* females that fed on nectar from cotton was affected for at least 10 days after plants were treated with insecticides. Moreover, the parasitoid's host foraging ability was severely affected for periods ranging from 2 days (imidacloprid) to 18 days (aldicarb) after insecticide application (Stapel *et al.*, 2000). Suh *et al.* (2000) investigated that adult survival of *T. exiguum* on day zero after spray was less than five per cent for thiodicarb, profenofos and spinosad and it ranged from 4 to 16 per cent for lambda-cyhalothrin and cypermethrin. Three days after spraying, spinosad was on par with control and by day four adult survival was similar among all treatments and control. Insecticides were tested at three levels of concentration *viz*., low, recommended and high. The results revealed that all concentrations of imidacloprid, carbosulfan, methamidophos and thiodicarb were toxic to the adult parasitoid, *T. chilonis*. Lower concentrations of acetamiprid and thiamethoxam were slightly harmful, while recommended and higher concentrations were found moderately harmful and harmful, respectively. All concentrations of buprofezin remained harmless. All insecticides were found toxic after 48 h except buprofezin (Nasreen *et al.*, 2004). In contact toxicity tests, all the neem formulations (botanicals) resulted in significantly high adult mortality of egg parasitoid, *T. chilonis* ranging from 20.64 to 37.70 per cent over untreated check (0%) and endosulfan (67.59%). Among the microbials; spinosad and their combinations caused 100 per cent mortality while spicturin and HaNPV alone resulted in 23.61 and 8.05 per cent mortality, respectively (Boomathi *et al*., 2005).

Mahdavi (2013) investigated that all pesticide treatments had significant differences compared to the control treatment. The results also showed that synthetic and biorational pesticides had lower toxicity to *Habrobracon hebetor* than conventional pesticides. They demonstrated that imidacloprid and thiacloprid had lower adverse effects on the parasitoid and could be used as compatible chemical materials with the parasitoid in IPM programmes.

CONCLUSIONS

Perusal of literature showed that different insecticides have different degrees of toxicity to various biological parameters of the parasitoids. It also revealed that the toxicity varies with the type of parasitoid species, developmental stage of the parasitoid, factitious host and the concentration and formulation of the insecticides used. Newer insecticides are being recommended every year for the control of insect pests in different crops. Hence, the present studies were undertaken to study the effect of commonly recommended insecticides in cotton crop on *A. bambawalei.*

- Among all the insecticides, nimbecidine was harmless (<30% mortality) while imidacloprid, novaluron and spinosad were slightly harmful (30-79% mortality) and profenophos, quinalphos and thiodicab were harmful (>99% mortality) to the adults of *A. bambawalei.*
- Novaluron and imidacloprid were found safe to the larval stage (in two days old parasitised mealybugs) as the number of mummies formed were at par with control while in all other treatments significantly less number of

mummies were formed.

- Novaluron was also categorized as harmless (<30%) on the basis of reduction in adult emergence over control from treated larval stage (in two days old parasitised mealybugs) while nimbecidine and thiodicarb as slightly harmful (30-79%), spinosad as moderately harmful (80-99%), profenophos and quinalphos as harmful (>99%).
- On the basis of reduction in adult emergence over control from insecticide sprayed host mummies (pupal stage of the parasitoid), imidacloprid, novaluron and nimbecidine were categorized as harmless (<30%) while thiodicarb as slightly harmful (30-79%) and spinosad, quinalphos and profenophos as harmful (>99%) to the pupal stage of the parasitoid.
- There was no effect on the sex of emerging adults of the parasitoids from the treated host mummies (pupal stage of the parasitoid).
- On the basis of residue persistence, novaluron and nimbecidine were classified as short lived (<5 days) while all other insecticides were classified as slightly persistent (5-15 days).

Based on the reduction in mealybug parasitisation over control, profenophos, quinalphos and spinosad were categorized as moderately harmful (80-99%), nimbecidine, thiodicarb and imidacloprid as slightly harmful (30-79%) while novaluron alone was categorized as harmless (<30%).

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