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Full length Research Paper

Screening of Pesticides against Cotton Mealybug *Phenacoccus solenopsis* Tinsley and its Natural Enemies on Cotton Crop

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A field study was carried out to determine the efficacy of different insecticides against cotton mealybug, *Phenacoccus solenopsis* Tinsley and their toxicity against natural enemies of mealybug at Chaudhery Al-Rahmat Agriculture Farm near to Experimental Field of Central of Agriculture and Biosciences International, South East and West Asia, Modal Farm Mirpur Khas, Sindh, during 2009 on cotton (cv. Bt. 207) variety. The treatments included four pesticides, i.e. Neem oil (repellent), Profenophos, Imidacloprid (SL), imidacloprid (WP) compared with control. Before application of insecticides, the pre treatment observations were taken on mealybug and its natural enemies, while post- treatment observations on mealybug were taken after 24, 48, 72 hrs., 7th and 10th days, where as, the population of predators and parasitoid were recorded after 10th day of application of insecticides. The crop was sprayed five times at 15 days intervals. The results showed that all insecticides were found effective against mealybug. However, imidacloropid showed its effectiveness up to 7 day in most of the sprays. While, prophenophos was next to imidacloropid which retained its effectiveness upto 7 days after application. The activities of natural enemies (Predators and parasitoids) were found maximum in control plot followed by neem oil, imidacloropid and prophenophos indicating that neem oil (repellent) was the least toxic against natural enemies followed by imidacloprid (WP).

Keywords: Cotton, *P. solenopsis*, pesticides, predators and parasitoids.

INTRODUCTION

Cotton, *Gossypium hirsutum* L. is one of the important cash crops of Pakistan providing livelihood to millions of people associated with its cultivation, textile and apparel industries. Pakistan is 4th largest producer of cotton in the world, after China, USA and India (Anonymous, 2007). Different insect pests infest cotton and reduce both yield and quality of cotton. Recently, mealybug, *Phenacoccus solenopsis* Tinsley has invaded cotton crop in Pakistan. It has threatened the cultivation of cotton in Pakistan and caused 14 percent loss of cotton crop during 2005 (Anonymous, 2005) and has become a serious pest of cotton.

Mealybug, *P. solenopsis*, besides cotton is devastating to many other economic crops such as; vegetables, ornamental plants and has been reported infesting 149 plant species (Afzal et al., 2009). Mealybug feed on phloem tissues, suck plant sap and cause leaves to distort and fall (Aheer et al., 2009). Mealybug infestation also produces honey dew which causes sooty mould and hinders with the process of photosynthesis in plants (Saeed et al., 2007). Besides this, ants also feed on honey dew and are one of the major factors in the spread of mealybug infestation and also deter biological control agents playing their role (Cudjoe et al., 1993).

The mealybug, *P. solenopsis* has great reproductive

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potential, during period of pest outbreaks in favorable climatic conditions, its rate of reproduction is very high and the resident natural enemy complex present in crop ecosystem is unable to bring its population below economic injury level. Therefore, in order to contain pest population growth, chemical interventions becomes important to save the crop from complete wrack. Selection of proper insecticides is important for the effective control of this noxious and difficult to control pest, because of its morphology, cottony pouches protecting eggs, crawlers and adults protected with a cuticle composed of hydrophobic wax layer which serves as a barrier to insecticide penetration in to body and cause mortality.

Based on LC_{50} values, spinosad and prophenofos were the most toxic compounds to female *T. exiguum* adults, followed by lamda cyhalothrin, cypermethrin and thiodicarb. Inseceticides field weathered for four to 6d on cotton leaves showed no activity against female *T. exiguum* adults (Charles et al., 2000).

Phenacoccus solenopsis is an invasive polyphagous pest species, first time recorded in Asia (Pakistan) in 2005 (Abbas et al., 2005) and soon afterwards from India. Therefore, its natural enemy fauna is not well established to keep its population under control. It's outbreaks in Pakistan and India has devastated cotton crop and has caused damage worth millions of dollars. In present study, imidacloprid (WP) was comparatively the most effective insecticide followed by profenophos and neem oil in reducing pest population in cotton crop. Neonicotinoids are among the most effective insecticides for the control of sucking insect pests. Their broad spectrum of efficacy, togather with systemic and translaminar action and a unique mode of action make them a favorite class of insecticides. The insecticide, imidacloprid was the first insecticide of this class released in 1991 (Elberty et al., 2008) and is effective against a number of insect pests. imidacloprid has been found efficient against *Planococcus* sp. and other mealybug species in grapevines (Elbert and Nauen, 2004). imidacloprid WP formulation was more effective against mealybug compared with SL formulation and at the same time WP formulation was also less toxic to natural enemies. Various formulations of neonicotinoids have been developed to suit pest control options depending upon pest species and crop (Elbert et al., 2008). Prophenophos had rapid knockdown action against the *P. solenopsis* pest compared with other insecticides in present study. Profenophos has been reported one of the effective insecticides against *P. solenopsis* (Dhawan *et al*. 2009; Bhosle *et al*. 2009; Aheer et al., 2009).

Natural enemies found feeding on mealybug population in cotton crop were: *Aenasiuis bambawalei, Brumus saturalus*, *Menochilus sexmaculantus, Schymnus coccivora, Schymnus saturalus, Chrysoperal carnae,* Spider spp. and ants. Mahmood *et al*. (2011) reported thirteen species of predators found feeding on mealybug *P. solenopsis*. Among them *B. suturalis* was found consistently on all population levels of the pest. The only parasitoid species *A. bambawalei* parasitizing mealybug was recorded first time in August 2008 at Tandojam has established itself well, is an aggressive parasitoid of mealybug with strong searching ability (Mahmood *et al*. 2011, Solangi and Mahmood, 2011). Spiders were found comparatively more sensitive to insecticides in present study. There are many studies reported which support our observation. Spiders tend to be very sensitive to most pesticides (Culin and Yeargan, 1983; Thomas et al., 1992; Whalon and Elsner, 1982; Yardin and Edwards, 1998). In present study insecticides with different modes of action and formulations were tested against mealybug for their effectiveness and their toxicity to natural enemy fauna in cotton ecosystem.

MATERIALS AND METHODS

The field study was conducted at Chaudhery Al-Rahmat Agriculture Farm near to Experimental Field of Central of Agriculture and Biosciences International, South East and West Asia (CABI), unit Mirpur Khas, Sindh, during 2009 to investigate the efficacy of different insecticides against cotton mealybug and their toxicity to parasitoid and predators associated with mealybug. The cotton seed (cv. Bt. 207) was sown on ridges in the direction from North to South in a Randomize Complete Block Design having a treatment size of 100 sq. feet each. There were 5 treatments (Table 1) replicated 5 times. The treatments were: neem oil+Surf® (detergent) = 3 liters and half kg / acre, profenophos = 1000 ml / acre, imidacloprid (SL) = 250 ml / acre, imidacloprid (WP) = 250 g / acre and Control.

The plots were separated from each other by keeping a space of 5 feet between treatments and replications. The distance between ridge to ridge and plant-to-plant was 24" and 6", respectively. All agronomical practices such as thinning and weeding were done manually. The mealybug made their initial appearance sporadically, one month after germination of crop. When the pest populations reached at economic threshhold level, the insecticidal spraying was done. For checking efficacy of different pesticides against mealybug, the cotton crop was sprayed early in the morning to avoid the loss to activity of beneficial insects. Spraying was done with shoulder mounted knapsack sprayer. All the insecticides were applied at the field recommended rate. Neem oil was applied at the rate of 3 liters per acre, before application detergent surf was mixed at the rate of 500 gram per acre to emulsify the solution.

Sampling method

The incidence of cotton mealybug and associated

Table 1. Toxicity of different insecticides against cotton mealybug, *P. solenopsis* Tinsley in field conditions at Chaudhery Al- Rahmat Agriculture Farm near to CABI, Model Farm, Mirpur Khas, Sindh during, 2009

Common name	Company and formulation	*P. solenopsis* population after application of insecticides					
		1st	2nd	3rd	4th	5th	Average
T_1 = **Neem oil** (repellent)	NARC	4.57 BC	4.82 C	4.86 C	5.15 BC	5.97 A	**5.07 B**
T_2 = **Profenophos**	Sygenta 200 SL	3.75 C	4.94 C	5.11 C	7.42 B	2.97 B	**4.84 B**
T_3 = **Imidacloprid**	Bayer 20 SL	5.95 B	7.27 B	7.49 B	6.70 B	4.83 AB	**6.45 B**
T_4= **Imidacloprid**	FMC 25 WP	3.58 C	5.06 C	5.55 C	3.45 C	3.21 B	**4.17 B**
T_5 = **Control**		**7.78 A**	**9.89 A**	**12.47 A**	**10.85 A**	**5.89 A**	**9.38 A**

parasitoid, *Aenasius bambawalei* mummies and predators were recorded per leaf / plant. Twenty plants were selected at random and tagged for taking observations. Observations were taken for pest and predators / parasitoid mummies by counting the numbers of individuals per treatment. The plants were observed thoroughly. After the spray, the data were collected 24, 48, 72 hours, 7th day and 10th day of spraying. Natural enemies population was recorded after 10 days of every spray. Thus the data collected were subjected to analysis of variance and mean values were compared with LSD test using Analytical Statistics Package 8.1 software (USA).

RESULTS AND DISCUSSION

The results (Table-1) showed that the mealybug population decreased significantly after application of insecticides (DF= 4, 16; F= 15.92, P>0.01). All the pesticides were found effective up to 72 hours after application however, imidacloprid (WP) and profenophos proved more effective until day 7 after application. During 2nd spray the pesticides applied behaved similarly as 1st spray and their effectiveness differed significantly (DF= 4, 16; F= 25.51, P>0.01). Further the results showed little variation in effectiveness of pesticides, during 3rd spray. Prophenophos effectively reduced mealybug population up to 7th day after application. The significant differences were observed in effectiveness of pesticides (DF= 4, 16; F= 83.07, P>0.01). During 4th application, imidacloprid (WP) and neem oil (repellent) behaved similarly and reduces maelybug population up to 7th day of their application. However, significant difference was observed among insecticides (DF= 4, 16; F= 24.72, P>0.01). During 5th spray significant difference (DF= 4, 16; F= 4.93, P>0.01) was also recorded in the effectiveness of insecticides against maelybug population. Prophenophos was the only insecticides which retained its effectiveness up to day 7 after application. Mealy bug population in control plots was found increasing as compared to the plots in which insecticides were applied.

During all sprays throughout post application intervals, predators and parasitoids such as; *Aenasiuis bambawalei, Brumus saturalus, Menochilus sexmaculantus, Schymnus coccivora, Schymnus saturalus, Chrysoperal carnae* and Spider spp. were found active against mealybug. Their activities were found significantly (DF= 4, 16; F= 7.89, P>0.01) affected as compared to control plots during post application period after all sprays. However, Neem oil (repellent) to mealybug and found the safest insecticide which was followed by imidacloprid (WP) and prophenophos. Whereas, imidacloprid (SL) was found comparatively the most toxic to the activities of natural enemies up to 10 days after application of insecticides (Table 2).

Application of insecticides had some toxic effect on ant population but it was not significant. However, neem oil was almost non toxic to ants as the difference between population of ants in neem oil treated and control was very little and insignificant (Table-2).

In present study *A. bambawalei* was found one of the dominant species of natural enemies with the highest population per leaf compared with other natural enemies (Table-2). The populations of different natural enemies were significantly different (DF= 4, 16; F= 7.89, P>0.01) from each. Mealybug parasitoid, *A. bambawalei* was most abundant natural enemy with the highest population followed by spiders. Application of insecticides significantly (DF= 4, 7; F= 9.85, P>0.01) reduced the population of natural enemies compared with control. Neem oil was comparatively less toxic, followed by imidacloprid (WP) against natural enemies than other insecticides tested in this study (Table 2).

Table 2. Toxicity of different insecticides against cotton mealybug, *P. solenopsis* parasitoid and predators in field conditions at Chaudhery Al- Rahmat Agriculture Farm near to CABI, Model Farm, Mirpur Khas, Sindh during, 2009

Common name	*Aenasiuis Bambawalei*	*Brumus saturalus*	*Menochilus sexmaculatus*	*Schymnus coccivora*	*Schymnus Saturalus*	*Chrysoperla Carnea*	Spiders	Ants	Average
T_1 = **Neem oil** (repellent)	2.07 AB	1.17 AB	0.37 B	0.89 A	0.73 B	1.32 AB	1.27 B	3.40 A	**1.40**
T_2 = **Profenophos**	1.24 BC	0.77 BC	0.41 B	0.67 A	0.62 B	0.95 B	1.09 B	1.87 A	**0.95**
T_3 = **Imidacloprid**	0.45 C	0.70 C	0.44 B	0.63 A	0.43 B	0.74 B	0.44 B	1.91 A	**0.72**
T_4= **Imidacloprid**	1.92 B	1.05 BC	0.84 A	0.85 A	0.81 B	0.98 B	0.96 B	1.91 A	**1.17**
T_5 = **Control**	3.29 A	2.24 A	1.08 A	1.26 A	2.19 A	2.06 A	3.00 A	3.71 A	**2.35**
Average	**1.79 B**	**1.19 C**	**0.63 D**	**0.86 CD**	**0.96 CD**	**1.21 C**	**1.35 BC**	**2.56 A**	**1.32**

A. bambawali, B. suturalis and *C. carnea* seemed to be a little more tolerant to insecticides compared with remaining natural enemies. *C. carnea* is one the most common predator in agroecosystem and is exposed to insecticide applications resulting in enhanced tolerance to insecticides (Sayyad, *et al.* 2010). Spider populations were significantly depressed by pesticide (Men *et al.* 2004) probably due to a direct contact effect of insecticides. Moreover, insecticides could also kill spiders by accumulating on their webs and poisoning them directly on the webs or repelling them from the webs, thereby exposing them to predation and contaminated leaf surfaces (Samu, *et al*. 1992).

Neem oil and neem based insecticides have been tested against different insects pests and are reported comparatively less toxic against natural enemies. Roger *et al.* (2009) evaluated toxicity of neem extracts compared with malathion and predation efficacy of *Coleomegilla maculata lengi* Timp. Adult mortality rate after 72h was 100% for malathion treatment. Only one dose of neem oil (10%) resulted in significantly greater mortality than control group. The aqueous suspension of ground neem seeds caused a 50 % reduction in the number of aphid consumed. Rao *et al*. (2007) reported toxic effects of neem on soil inhabiting and aerial natural enemies in chickpea to an extent of 41 and 20 % population reduction respectively, compared with 63 and 52 % when using conventional insecticides (endosulfan). Neem also affected the parasitization of *Helicoverpa armigera* larvae by *Campoletis chlorideae* Uchida up to 20 %. Tavares *et al.* (2010) reported larval mortality of predator, *Eriopis connexa* (Coleoptera: Coccinelidae) was lower with neem oil (25.0±0.33%) than with lufenuron (91.66±1.22%).

A diverse group of arthropods such as, Lacewings, mites, ladybird beetles, plant bugs and spiders varied in their susceptibility to imidacloprid (James and Vogele, 2001). Mizell and Sconyers, (1992) reported that spiders and predatory mites being less susceptible to imidacloprid than the predaceous insects. Similarly, under laboratory conditions, imidacloprid was toxic to the adults of *Deraeocoris nebulosus* (Uhler), *Hippodamia convergens* (Guerin - Meneville), *Geocoris punctipes* (Say) and *Chrysoperla rufilabris* (Burmeister), although mortality was dependent on the concentration of imidcloprid applied. The toxic effects of Imidacloprid may be dependent on the development stage, length of exposure and properties of the product, such as formulation and concentration of active ingredient (Elbert, *et al*. 1998; Lucas, *et al*. 2004). Medina *et al.* (2007) reported that direct applications of imidacloprid were not harmful to the endoparasitoid *Hyposoter didymator* (Thunberg), although adult emergence was reduced from the larvae of *Spodoptera littoralis* (Boisduval) that had ingested residues of Imidacloprid which is associated with the fact that developing parasitoid endoparasitoids may be exposed to the active ingredient of body. Acetamiprid, clothianidin and dinotefuran were shown to be harmful to the citrus mealybug, *Planococcus citri* Risso, parasitoid, *Leptomastix dactylopii* Howard, 24h after exposure (Cloyd and Dickinson, 2006).

Pofenophos was found effective against mealybug but at the same time it was found toxic against natural enemies of mealybug present in cotton crop in present study. Profenophos has been found toxic to natural enemies in many studies reported. Profenofos resulted in 100% morality for *C. marginiventris* in direct contact study and in the residual studies (Ruberson *et al*. 1993); Wilkinson *et al.* 1979). This insecticide and sulprofos were highly toxic to *C. marginiventris* and *H. convergens* (Wilkinson *et al*. 1979), *M. croceipes* and *C. nigriceps* (Tillman 1995), and *C. carnea* larvae (Plapp and Bull 1978), but less toxic to *G. punctipes* (Wilkinson *et al.* 1979, McCutheon and DuRant 1993) in residual toxicity tests.

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