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Toxicity of Biological and Chemical Insecticides on Spiders

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ABSTRACT

Spiders being voracious predators, acting as natural control of pests are facing the brunt of indiscriminate application of chemical pesticides. Therefore, objective of the present investigation is to analyze the toxicity of pesticides on predominant spider *Pardosapsuedo annulata* in laboratory and percent reduction of spider population due to pesticide in the field conditions. Among the five insecticides evaluated in laboratory, the insecticides from biological origin (biopesticides) i.e., *Bacillus thuringiensis* (16000 IU/mg) and Nuclear polyhedrosis virus (NPV) ($1^{x}10^{9}$ Polyhedral Inclusion Bodies, PIBs/ml) as compared to synthetic insecticides viz., imidacloprid (17.8% Soluble concentrates, SL), Chlorpyriphos (20% Emulsifiable concentrates, EC) and cypermethrin (10% EC) were relatively less harmful. NPV being species specific caused negligible mortality. Among synthetic insecticides, imidacloprid (17.8% SL) was more harmful as compared to Chorpyriphos (20% EC) and Cypermethrin (10% EC) causing 80.0, 16.5 and 4.8 percent, respectively. In field experiments, none of the insecticides was found safe to spiders when sprayed in green gram (*Cicer arietinum*, Variety RSG-44), pearl millet (*Pennisetumglaucum,* Variety Pioneer 86M86) and cabbage (*Brassica oleracea* L. var. *capitata*, Variety Golden Acre) crops. Both the first and second spray of insecticides viz., Chlorpyriphos (20% EC), Monocrotophos (36% SL) and Imidacloprid (17.8% SL) reduced the spider population significantly over control.

Key words: Spiders, *Bacillus thuringiensis*, *Nuclear Polyhedrosis Virus (NPV), Imidacloprid, Chlorpyriphos, Cypermethrin, Monocrotophos*

INTRODUCTION

Spiders are documented as a polyphagous predator of insects including Odonata, Orthoptera, Homoptera, Lepidoptera, Diptera, Hymenoptera and other Aranae (Jackson and Macnab, 1989; Wise, 1993; Holland *et al*., 2004 and Tahir and Butt, 2009). Therefore, 48374 species of spider belonging to 4152 Genera and 120 Families (World Spider Catalogue, 2019) play an important role in agro-ecosystem by limiting the growth of insect pests (Chatterjee *et al*., 2009; Venturino *et al*., 2008).

Use of pesticides has become intensive and widespread in modern agriculture. A case study of Tijara Tehsil, Alwar, Rajasthan by (Yadav and Dutta, 2019) revealed that 78.2 % of farmers were aware of harmful effects of pesticide usage but not ready to adopt alternative of pesticide practices. They also reported that 76.2% farmers not even read labels on pesticide containers. This injudicious and indiscriminate application of pesticides are reported to affect adversely not only to human health and environment but also on the population of natural enemies viz., spiders (Hanna and Hanna, 2013 and Albin, *et al*., 2014), lady bird beetles (Ba M'hamed and Chemseddine, 2002 and Ahmad *et al*., 2011) and lacewings (Giolo *et al*., 2009, Cole *et al*., 2010, Fernandes *et al*., 2010, Marko *et al*., 2009 and Evans *et al*., 2010) described that extensive use of pesticides affect either by direct contact or spray drift. As spiders are found to be more susceptible to insecticides than other insect predators (Toft and Jensen,1998), use of pesticides tend to decrease the population of spiders in the fields (Dinter and Poehling, 1995). Therefore, the toxicity of

commonly used chemical pesticides (Imidacloprid, 17.8% SL; Chlorpyriophos, 20% EC and Cypermethrin, 10% EC) and biological pesticides (Nuclear Polyhedrosis Virus and *Bacillus thuringiensis*) were assessed in the present study against predominant spider *Pardosa psuedo annulata* in the laboratory. Likewise, in the field experiments the effect of locally used conventional pesticides (Chlorpyriphos, 20% EC; Monocrotophos, 36% SL and Imidacloprid, 17.8% SL) was assessed on the populations of spiders in the present study.

MATERIAL AND METHODS

Toxicity of pesticides on spider in laboratory condition:

P. pseudo annulata collected from the fields near Jaipur, Rajasthan were reared individually in separate glass cage to prevent cannibalism under simulated laboratory conditions at Department of Zoology, University of Rajasthan, Jaipur, Rajasthan and culture was maintained at 27±1˚C temperature and 80±5% relative humidity (RH) using BOD incubator (Kumari *et al.,* 2016). Culture of *Drosophila melanogaster* was maintained in laboratory as continuous diet source for rearing spider species. Spider was reared in each glass cage which was made by a lantern chimney put over a petridish with sterilized and moist sand and covered by a piece of muslin cloth. Marked male and female individuals were placed together in the glass cage for mating during which the larvae of *D. melanogaster* were provided as food in adequate number to prevent cannibalism. After three days both were separated and kept in another glass cages for egg laying by female. For the laboratory experiments, spiderlings with the 1.4–1.7mm length of the carapace from the stock culture of *P. pseudo annulata* maintained in the laboratory, were chosen because according to (Rezac *et al*., 2010), when insecticides are applied in the field the spiders are at this stage. Five commercial formulations of insecticides were used (Table 1). The insecticide formulations were used according to the manufacturer's recommended concentrations.

Leaf-dip method (Immaraju *et al*., 1990) was employed in which 25mm diameter sized lime leaves were cut and dipped separately in different concentrations of five pesticides for 30 seconds. Leaves were then air dried for 2h or until dry and placed singly at the bottom of each petridish. To each petridish a single spiderling was added and fed with larvae of *D. melanogaster* and covered with plastic lid. The control was dipped simultaneously in deionized water for all pesticides except Imidacloprid, Chlorpyrifos and Cypermethrin for which control was dipped in acetone was used as a control (Amalin *et al.,* 2000). Each treatment were replicated thirty times and kept in an incubator at 27±1°C and 80±5% RH. The spider mortality was regularly observed for 72 h after the treatment. Data so obtained were corrected using Abbott's formula, (1925).

Effect of pesticides on diversity and distribution of spiders in field experiments:

The area selected for the study was Ramgarh, Jaipur, Rajasthan. The green gram (*Cicer arietinum*, Variety RSG-44), pearl millet (*Pennisetum glaucum,* Variety Pioneer 86M86) and cabbage (*Brassica oleracea* L. var. *capitata*, Variety Golden Acre) fields during November 2015 to March 2016, August 2016 to October 2016 and October 2016 to January 2017,

respectively were selected. Lethal 20% EC (Chlorpyriphos), Monocil 36% SL (Monocrotophos) and Confidor 17.8% SL (Imidacloprid) pesticides were used and normal cultural practices were followed in fields by the farmers. In each field, twelve plots one acre each in a randomized block design were randomly selected for field assays.

Observations of spider population in green gram, pearl millet and cabbage fields were recorded one day before spraying (treated as control) and three, eight and twelve days after treatment with insecticides. The total population of spider in each replication was recorded. The results were expressed in percent reduction of spider population over control and were calculated by the formula given by (Henderson and Tilton, 1955)

$$\text{Percentage reduction} = \left[1 - \frac{T_a \times C_b}{T_b \times C_a}\right] \times 100$$

Where,

T_a = Population of spider in treatment after spray.

T_b = Population of spider in treatment before spray.

C_a = Population of spider in control after spray.

C_b= Population of spider in control before spray.

Data so generated were analyzed for analysis of variance (ANOVA) using INDO-STAT software. Means were separated by applying CD test (critical difference) at 5% level of significance.

Table 1. List of insecticides used in the study

Trade Name	Active ingredients	Manufacturer	Type	Concentration tested
Victor	Imidacloprid	Insecticides (India) Limited	Systemic Insecticide	17.8% SL
Lethal EC	Chlorpyriophos	Insecticides (India) Limited	Organophosphate	20% EC
Cypermil	Cypermethrin	Insecticides (India) Limited	Synthetic Pyrethroids	10% EC
Biovirus-S	Nuclear Polyhedrosis Virus	Biotech International India Ltd.	Virus (Pathogen)	$1^{x}10^{9}$ PIBs/ml
Biolep	*Bacillus thuringiensis kurstaki*	Biotech International India Ltd.	Bacteria (Pathogen)	16000 IU/mg

Table 2. Mortality (S.E- Standard Error) of *Pardosapseudo annulata* after exposure to five insecticides in laboratory experiments

Treatment	n	Mortality (%)
Control	20	0.0 (0.0)
Imidacloprid (17.8% SL)	25	80.0 (8.0)
Chlorpyriphos (20% EC)	25	16.5 (7.6)
Cypermethrin (10% EC)	22	4.8 (4.7)
Nuclear Polyhedrosis Virus (1^{x} 10^{9} POBs/ml)	24	0.0 (0.0)
Bacillus thuringiensiskurstaki(16000 IU/mg)	21	7.4 (5.0)

Table 3. Percent reduction of spider population over control in gram, Pearl millet and cabbage fields due to the action of insecticides spray

Sampling period		Percent reduction of spider population over control					
		Gram field		Pearl millet field		Cabbage field	
		Untreated control	Treated	Untreated control	Treated	Untreated control	Treated
First spray	3 DAS	0 (4.05)	68.26 (55.98)	0 (4.05)	69.2 (56.74)	0 (4.05)	67.32 (55.23)
	7 DAS	0 (4.05)	51.49 (45.84)	0 (4.05)	45.43 (42.35)	0 (4.05)	57.56 (49.36)
	12 DAS	0 (4.05)	37.95 (37.05)	0 (4.05)	32.73 (34.82)	0 (4.05)	43.17 (41.05)
Second Spray	3 DAS	0 (4.05)	72.93 (58.81)	0 (4.05)	76.69 (61.26)	0 (4.05)	69.18 (56.36)
	7 DAS	0 (4.05)	50.91 (45.53)	0 (4.05)	48.96 (44.4)	0 (4.05)	52.87 (46.67)
	12 DAS	0 (4.05)	42.15 (40.18)	0 (4.05)	39.15 (38.66)	0 (4.05)	45.15 (42.18)
S. E m±		-	2.53	-	1.92	-	1.18
C. D at 5%		-	7.51	-	5.76	-	3.40

Figures in parenthesis indicate angular transformed values
DAS- Days after spraying
S. E m± - Standard error of mean
C. D- critical difference

RESULTS AND DISCUSSION

Among the five insecticides, biopesticides i.e., *Bacillus thuringiensis* and Nuclear Polyhedrosis Virus (NPV) with 7.4±5.0 and 0.00±0.0 percent mortality, respectively, were less harmful to spider as compared to synthetic insecticides viz., Imidacloprid (17.8% SL), Chlorpyriphos (20% EC) and Cypermethrin (10% EC) with 80±8.0, 16.5±7.6 and 4.8±4.7 percent mortality, respectively. The results are in corroboration with (Pekar and Haddad, 2005) who reported that neither fresh nor 1-day-old residues of phosalone or *Bt* caused significant mortality to *Clubiona* spp., *Pardosa* spp., *Phildromus* spp., *Xysticus* spp., *Dictyna* spp. and *Therdion* spp. Similarly, (Amalin *et al*., 2000, Bajwa and Aliniazee, 2001) described that formulations of *B. thuringiensis* had no direct detrimental effect on spiders either in the laboratory or in the field because this formulation acts as a stomach poison. NPV being species specific caused negligible mortality (0.0±0.0 percent) as shown in table 2. Similarly, Ghosh, (2013) reported that *Polygonum hydropiper* floral part extract, *Beauveria bassiana* (Bals.) *Vuillemin* and *Bacillus thuringiensis* Berliner) were less harmful (killing percentage was less than 30) to spiders when compared with synthetic ones (profenophos and methomyl) where killing percentage was more than 52. Present results are also in accordance with Schoonover and Larson, (1995) where no mortality was recorded in *Coccinella* when fed on spinosad treated

aphids. Whereas, 42.18% (Mudassir *et al*., 2015) and 33.23% (Ahmad *et al*., 2015) reduction in spider's population due to spinosad; 19% mortality after 12 days in larvae of *Chrysoperlacarnia* when exposed to spinosad (Cisneros *et al*., 2002) and 24.50% reduction of tetragnathid spider population due to Azadirachtin (Joseph *et al*., 2010) were reported.

Among synthetic insecticides, Imidacloprid with 80.0±8.0 percent mortality, was more harmful as compared to chorpyriphos and cypermethrin with 16.5±7.6 and 4.8±4.7 percent mortality, respectively. Likewise, Phosalone and permethrin were found detrimental to spiders both in the laboratory by Pekar, (1999) and in the field experiments by Huusela-Veistola *et al*. (1994). Pekar and Haddad, 2005 also reported that the phosalone and permethrin had higher detrimental effect than biopesticides as they have a contact mode of action. Similarly, during laboratory experiments by Sherawat *et al*., (2015), Buctril-M was reported to be less toxic as compared to Confidor for *Lycosa terrestris* and *Oxyopes javanus* causing 22 and 35 percent mortality, respectively.

It was revealed that all the insecticides used in field experiment (Table 3) altered the spider population. Three days after first spray, the percent reduction in spider population over control was 68.25, 69.2 and 67.32 in gram, pearl millet and cabbage fields, respectively. Similarly, the application of insecticides was also reported to decrease both the abundance and diversity of spiders (Vickerman and Sunderland, 1977; Culin and Yeargan, 1983; Niehoff *et al*., 1994; Devotto *et al*., 2007 and Park *et al*., 2007). The results are also in consonance with Joseph *et al*. (2010) who reported 64.78 and 46.79 % mortality in spider due to triazophos (0.05% conc.) and quinalphos (0.05% conc.), respectively. Marko *et al*. (2009) suggested that change in spider community after the pesticide application was due to combined effect or interaction of several factors viz., structure of community, timings and frequency of insecticide applications and size of the field. Similarly, Pekar (2012) described that a contact of spider with chemical pesticides could vary greatly being exposed to spray droplets or to residues on surfaces or to contaminated prey or to all at the same time in the worst case. In the present study, 12 days after first spraying the percent reduction of spider population over control was much lower with 37.95, 32.73 and 43.17 in gram, pearl millet and cabbage fields, respectively. Similarly, after second spray of insecticides reduced the spider population significantly over control. The decline in mortality of *Lycosa terrestris* and *Oxyopesjavanus* with the increase in time after pesticide (Confidor and Buctril-M) spray were also reported by Sherawat *et al*. (2015). The results are in agreement with Ahmad *et al*. (2015) and Mudassir *et al*. (2015) where percentage reduction of population with passage of time was reported to be decreased.

CONCLUSION

The present study is an important step in understanding laboratory as well as field studies are important to understand at what extent natural control agents provided by nature are affected by the indiscriminate use of pesticides. Bio-pesticides (*Btkurstaki* and NPV) being less harmful to spiders can be incorporated in IPM programs under the field conditions. It might also be promising to use common pesticides at lower

concentration as lower application rates might be safer to spiders which provide added control of pests.

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