Pesticide Research Journal Vol. 27(1): 57-62, June 2015

Bioefficacy and Persistence of Insecticides against Blister Beetle, *Mylabris pustulata* (Thunb.) in Pigeonpea, *Cajanus cajan* (L.) Millsp.

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Blister beetle, *Mylabris pustulata* (Thunb.) is a polyphagous pest attacking flowers of pigeonpea (*Cajanus cajan*), cotton (*Gossypium* sp), lady's finger (*Abelmoschus esculentus*), mungbean (*Vigna radiata*), urdbean (*Vigna mungo*), ricebean (*Vigna umbellata*) etc. throughout the country. Because of its polyphagous feeding nature and hard protective adaptation against insecticides, long term management of this pest with a single molecule is difficult. Therefore, field cum laboratory experiments were carried out for three consecutive cropping seasons during *kharif* 2008-09, 2009-10 and 2010-11 to find out the persistence and efficacy of different insecticides. It was found that decamethrin 2.8EC was 3334 times toxic with lowest LC_{50} value (0.0000563) followed by monocrotophos 36SL as compared with endosulfan which was the least toxic with LC_{50} value (0.1877). Insecticides evaluated for their persistent toxicity during 2009-10 revealed that decamethrin and thiodicarb caused cent per cent mortality of adult blister beetle immediately after spray. At 8th days after spraying, decamethrin caused 60 per cent mortality. Insecticides evaluated for their efficacy during the year 2010-11 revealed that the plants were found free from adult blister beetle population in treatments involving decamethrin and cypermethrin even at ten days after spray. Among all the treatments, spraying of thiodicarb 75WP @ 625 g ha^{-1} provided the highest grain yield (18.87 q ha^{-1}). Maximum cost-benefit ratio was observed in monocrotophos 36SL, cypermethrin 25EC and decamethrin 2.8EC.

Key words: Insecticides, bioefficacy, blister beetle, persistence, pigeonpea

Pigeonpea, *Cajanus cajan* (L.) Millspaugh is one of the major pulse crops grown between 30° N and 30° S in the semi-arid tropics. It is an important source of high quality dietary protein and is mostly consumed in the form of pulse (*dal*). Pigeonpea is grown in an area of 5.07 m ha with production of 3.71 m tonnes in Asia. In India, it is grown in an area of 3.63 m ha with 2.76 m tonnes production and 7.60 q ha^{-1} productivity[1]. In Haryana, it is cultivated in an area of 15.1 thousand ha with production of ten thousand tonnes and productivity 10.86 q ha^{-1}. The production and productivity of this crop has remained stagnant over the past three decades largely due to its vulnerability to biotic and abiotic stresses. It is attacked by more than 250 species of insects[2] of which blister beetle, *Mylabris pustulata*, considered as a minor pest in past has recently assumed the state of a major pest. In short duration and determinate cultivars with compact floral clusters of pigeonpea, damage by blister beetle tends to be manifold. The beetle feeds on flowers and flower buds, the economical yield parts of the plant and devours them. Flower shedding and reduced pod setting result in heavy loss in the grain yield of the crop. Blister beetle has wide range of host plants such as blackgram, greengram, cowpea, sesame and clusterbean and is found throughout the world in tropical as well as sub-tropical areas[3]. In Indian sub-continent, *Mylabris pustulata*, *M. thunbergii* Bilberg and *Mylabris* sp. were damaging the pigeonpea flowers with the maximum beetle density of 19.4 beetles plant^{-1} [4]. In view of the havoc caused by this beetle in pigeonpea, the efficacy of different insecticides in controlling it was studied.

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MATERIALS AND METHODS

Field-cum-laboratory evaluation

The field-cum-laboratory experiments were conducted during *kharif* seasons 2008-09, 2009-10 and 2010-11 at Pulses Research Farm, Department of Genetics annd Plant Breeding, CCS Haryana Agricultural University, Hisar. For a particular concentration, 100 flowers were plucked and drenched in different concentrations of insecticide solution and shade dried. The flowers were then divided into three lots at random. For this purpose glass jars of 20 cm x10 cm were used. In each jar 10 field collected adults (pre-starved for 3 h) of the same size were released. The mouth of the jars was covered with muslin cloth, held in position with the help of rubber band, to avoid escape of the beetles. Side by side a control, containing untreated flowers was also run as a check.

Test insecticides

Proprietary formulations of the respective insecticides were obtained from different sources. Eight insecticides i.e. quinalphos (Ekalux 25EC, M/s Syngenta India Ltd.); decamethrin (Decis 2.8EC, Bayer Crop Science Ltd.); chlorpyriphos (Lethal 20EC, Insecticides India Ltd.); thiodicarb (Larvin 75WP, Bayer Crop Science Ltd.); triazophos (Hostathion 40EC, Sudershan Chemical Industries Ltd.); monocrotophos (Monostar 36SL, Swal Corporation Ltd.); profenophos (Carina 50EC, P.I. Industries Ltd.) and endosulfan (Hysulfn 35EC, Hyerabad Chemical Supplies Ltd.) were tested after preparation of different concentrations. The relative toxicity was calculated based on LC_{50} values, taking LC_{50} of endosulfan as unity.

Efficacy of insecticides

To evaluate the efficacy of insecticides, different concentrations of the test insecticides in distilled water were tried, so as to get 20-90 per cent kill of the pest. Three replications of each concentration were kept. The mortalities were recorded 24 h after the release. The per cent corrected mortalities were worked out by using Abbott's formula[5], if there was any mortality in control.

Persistence of insecticides

The persistence of different insecticides against blister beetle (adults) was tested. The insecticides were sprayed on pigeonpea separately in the field. After draining and drying of the insecticides, the flowers from each treatment were plucked and brought to laboratory and taken in jars. In each jar 10 field collected adults of the same size were released daily. The flowers were plucked at 0, 1, 2, 3, 4, 5, 6, 7 and 8th day after spraying. The mortalities were recorded 24 h after the release and per cent mortality worked out.

Field efficacy

An experiment was carried out on pigeonpea crop sown in *kharif* 2010-11 in a randomized block design with three replications in plots of 4.5×4 m (18 sq. m) each. Eight insecticides *viz*., decamethrin 2.8EC @ 538 mL ha^{-1}, monocrotophos 36SL @ 750 mL ha^{-1}, thiodicarb 75WP @ 625 g ha^{-1}, quinalphos 25EC @ 1500 mL ha^{-1}, fenvalerate (Fenval 20EC, Isagro Agrochemicals Pvt. Ltd.) @ 300 mL ha^{-1}, cypermethrin (Root 25EC, Safex Chemicals India Ltd.) @ 188 mL ha^{-1}, endosulfan 35EC @ 1500 mL ha^{-1} and oxydemeton methyl (Metasystox 25EC, United Phosphorus India Ltd.) @ 750 mL ha^{-1} were sprayed twice at 50% flowering stage and repeated after15 days. Data were recorded on number of adult blister beetle, *Mylabris pustulata* per plot.

RESULTS AND DISCUSSION

Relative toxicity of insecticides

The regression equations and data on LC_{50} values, fiducial limits and relative toxicities of different insecticides are presented in Table 1. The LC_{50} values of decamethrin, monocrotophos, thiodicarb, quinalphos, chlorpyriphos, triazophos, profenophos and endosulfan were 0.0000563, 0.000528, 0.00226, 0.00389, 0.00462, 0.00657, 0.0537 and 0.1877 per cent, respectively. The relative toxicities of these insecticides in decreasing order taking endosulfan as unit were 3333.93, 355.48, 83.05, 48.25, 40.63, 28.57 and 3.50 times for decamethrin, monocrotophos, thiodicarb, quinalphos, chlorpyriphos, triazophos and profenophos, respectively. It is clear that decamethrin was 3334 times as toxic as endosulfan and the next best toxic was monocrotophos which was 355 times as toxic as endosulfan, though about 9.4 times less toxic as compared to decamethrin. Since the LC_{50} value of endosulfan (0.1877%) was much higher than its general application dose at 0.07 per cent, its failure to exercise any control in the field was justified. Keeping in view the rationality of this data, decamethrin should be the first choice followed by monocrotophos for the control of *M. pustulata* in the field conditions. Decamethrin (0.025%) and monocrotophos (0.05%) have been earlier reported to give good control of *Mylabris* spp. on okra[6]. Differing results on the management of blister beetles involved the application of cypermethrin 10EC @ 0.01%, chlorpyriphos 50EC + cypermethrin 5EC @ 0.1375% and lambda cyhalothrin 2.5EC @ 0.00375% as the most effective insecticides in minimizing the adult beetles abundance, translating in higher grain yield of 9.8, 9.6 and 9.4 q ha^{-1}, respectively[7].

Table 1. Relative toxicity of insecticides against blister beetle, *M. pustulata* adults on pigeonpea during 2008-09

S. no.	Insecticide	Heterogeneity χ^2 (df)	Regression equation (Y=)	LC_{50} (%)	Fiducial limits	Relative toxicity*
1.	Decamethrin 2.8EC	2=3.353	2.1988X+1.1503	0.0000563	0.0000363 0.0000875	3333.93
2.	Monocrotophos 36SL	2=4.098	4.981X-3.5807	0.000528	0.000431 0.000646	355.48
3.	Thiodicarb 75WP	2=0.228	4.3565X-0.0903	0.00226	0.00165 0.00309	83.05
4.	Quinalphos 25EC	3=0.587	4.9454X-2.0846	0.00389	0.00328 0.00452	48.25
5.	Chlorpyriphos 20EC	3=0.114	7.9484X-8.2292	0.00462	0.00313 0.00681	40.63
6.	Triazophos 40EC	2=0.261	5.4615X-4.9258	0.00657	0.00543 0.00794	28.57
7.	Profenophos 50EC	2=0.226	6.3830X-6.0135	0.0537	0.0831 0.0853	3.50
8.	Endosulfan 35EC	3=2.436	3.0672X+1.0943	0.1877	0.1419 0.2480	1.00

Y = Probit kill; X = Log concentration; LC_{50} = Concentration calculated to give 50% mortality; df = Degrees of freedom
*Relative to endosulfan

Persistence of insecticides

Data on persistence of different insecticides against blister beetle presented in Table 2 revealed that cent per cent mortality of the blister beetle adults was recorded in decamethrin 2.8EC and thiodicarb 75WP, when beetles were released immediately after treatment application, while mortality was least in the treatment profenophos 50EC at this interval. In observations recorded after one day of spray, 90 per cent mortality of adult blister beetle was observed in treatment decamethrin 2.8EC followed by thiodicarb 75WP and triazophos 40EC (80%) and quinalphos 25EC (65%). Upto three days after spray, the treatment decamethrin 2.8EC caused 90 per cent mortality. In observations on the mortality of adult blister beetle at 4^{th} and 5^{th} days after spray application, decamethrin 2.8EC maintained its persistence and caused 80 per cent mortality. All the other treatments proved less effective. Decamethrin 2.8EC @ 538 mL ha^{-1} caused 35 per cent mortality of blister beetle adults upto 8^{th} day after spray and proved superior over the other treatments. Treatments profenophos 50EC @ 1500 mL ha^{-1} and monocrotophos 36SL @ 750 mL ha^{-1} were inferior at all the days after spray application than decamethrin. Similar trend with decamethrin was reported in studies from Uttar Pradesh[6]. Effectiveness of synthetic pyrethroids against blister beetle, *M. pustulata*[8] and *M. mecilenta*[9] has been reported. The highest persistent toxicity of pyrethroids fenvalerate, cypermethrin and deltamethrin was also reported against three *Mylabris* spp. on chrysanthemum[10]. In contrast, more field toxicity of carbaryl (0.12%) as compared to cypermethrin (0.008%), fenvalerate (0.02%) and deltamethrin (0.06%) has been reported against *M. pustulata* on pigeonpea[11].

Field bioefficacy

All the test insecticides were found equally effective in suppressing the population of blister beetle one day after spraying of insecticides (Table 3). Population of the beetle adults recorded 3 days after insecticide application recorded the least number of adults in decamethrin 2.8EC and thiodicarb 75WP (0.3 adults $plot^{-1}$) and these were statistically at par with fenvalerate (0.7 adults $plot^{-1}$), cypermethrin (0.7 adults $plot^{-1}$), monocrotophos (0.7 adults $plot^{-1}$) and quinalphos 0.8 adults $plot^{-1}$). All the insecticides were found superior over untreated control. At 10 days after spray application of insecticides, no blister beetle adult was observed in treatments decamethrin and cypermethrin and these were statistically on par with fenvalerate and quinalphos (1.0 adult $plot^{-1}$) and monocrotophos and thiodicarb (0.7 adult $plot^{-1}$). Treatments endosulfan and oxydemeton methyl were found ineffective in suppressing the adult blister beetle population (2.7 adults $plot^{-1}$). The present findings corroborated the efficacy of cypermethrin

Table 2. Persistence of different insecticides against blister beetle, *M. pustulata* on pigeonpea during 2009-10

S. no.	Treatment	Dose (mL g^{-1} ha^{-1})	Per cent mortality of adults at									Yield (q ha^{-1})
			0 DAS*	1 DAS	2 DAS	3 DAS	4 DAS	5 DAS	6 DAS	7 DAS	8 DAS	
1.	Decamethrin 2.8EC	538	100.0 (90)	90.0 (71.52)	90.0 (71.07)	90.0 (71.74)	80.0 (63.43)	80.0 (63.58)	70.0 (56.83)	60.0 (50.71)	35.0 (36.60)	7.04
2.	Thiodicarb 75WP	625	100.0 (90)	80.0 (63.70)	55.0 (47.64)	40.0 (39.38)	25.0 (29.91)	10.00 (18.27)	10.0 (18.56)	0.0 (1.81)	0.0 (1.81)	7.82
3.	Quinalphos 25EC	1500	65.0 (53.93)	65.0 (53.68)	50.0 (44.78)	20.0 (26.49)	20.0 (26.65)	15.0 (23.05)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	6.12
4.	Triazophos 40EC	1500	95.0 (77.52)	80.0 (63.58)	70.0 (57.56)	10.0 (18.62)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	6.84
5.	Chlorpyriphos 20EC	2500	30.0 (33.37)	15.0 (22.87)	5.0 (34.86)	5.0 (12.87)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	5.98
6.	Profenophos 50EC	1500	10.0 (18.37)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	5.44
7.	Monocrotophos 36SL	750	90.0 (71.58)	55.0 (47.89)	40.0 (39.28)	10.0 (18.47)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	5.20
8.	Control	-	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	0.0 (1.81)	2.13
SEm±		-	0.09	0.07	0.16	0.09	0.06	1.07	0.08	0.01	0.06	0.75
CD at 5%		-	0.29	0.23	0.51	0.29	0.20	3.26	0.27	0.04	0.19	1.60

*DAS: Days after spray

Figures in parentheses are angular transformed values

Table 3. Efficacy of insecticides against blister beetle, *M. pustulata* on pigeonpea in field during 2010-11

S. no.	Treatment	Dose (mL g^{-1} ha^{-1})	Number of blister beetle adults plot^{-1*}				Yield (q ha^{-1})
			Pre-treatment count	1 Day after spray	3 Days after spray	10 Days after spray	
1.	Decamethrin 2.8EC	538	2.3 (1.73)	0.7 (1.24)	0.3 (1.14)	0.0 (1.00)	17.85
2.	Fenvalerate 20EC	300	2.0 (1.71)	0.7 (1.27)	0.7 (1.27)	1.0 (1.38)	13.98
3.	Cypermethrin 25EC	188	1.0 (1.38)	0.3 (1.14)	0.7 (1.27)	0.0 (1.00)	16.06
4.	Endosulfan 35EC	1500	1.0 (1.38)	1.8 (1.67)	1.0 (1.41)	2.7 (1.91)	15.40
5.	Monocrotophos 36SL	750	1.0 (1.38)	0.3 (1.14)	0.7 (1.24)	0.7 (1.27)	18.20
6.	Quinalphos 25EC	1500	2.0 (1.72)	1.0 (1.41)	0.8 (1.33)	1.0 (1.38)	15.97
7.	Thiodicarb 75WP	625	1.7 (1.62)	0.3 (1.14)	0.3 (1.14)	0.7 (1.27)	18.87
8.	Oxydemeton methyl 25EC	750	1.7 (1.64)	1.0 (1.38)	1.0 (1.40)	2.7 (1.91)	11.41
9.	Untreated control		2.0 (1.73)	1.3 (1.52)	1.8 (1.66)	4.5 (2.36)	10.03
	SEm±		NS	NS	(0.09)	(0.25)	0.65
	CD at 5%		-	-	(0.21)	(0.53)	1.38

*Figures in parentheses are $\sqrt{n+1}$

Table 4. Effect of different insecticidal treatments on yield of pigeonpea, net profit and their cost benefit ratio during 2010-11

S. no.	Treatment	Yield (q ha^{-1})	Increase over control (q ha^{-1})	Cost of increase over control (₹ ha^{-1})	Cost of treatment (₹ ha^{-1})	Net profit (₹)	Cost benefit ratio
1.	Decamethrin	17.85	7.82	19550	479.76	19070.24	1:39.74
2.	Fenvalerate	13.98	3.95	9875	326.00	9549.00	1:29.29
3.	Cypermethrin	16.06	6.03	15075	305.00	14770.00	1:48.42
4.	Endosulfan	15.40	5.37	13425	770.00	12655.00	1:16.43
5.	Monocrotophos	18.21	8.18	20450	410.00	20040.00	1:48.87
6.	Quinalphos	15.97	5.94	14850	822.50	14027.50	1:17.05
7.	Thiodicarb	18.87	8.84	22100	2025.00	20075.00	1:9.91
8.	Oxydemeton methyl	11.41	1.38	3450	425.00	3025.00	1:7.11
9.	Untreated control	10.03	-	-	-	-	-
SEm±		0.65	-	-	-	-	-
CD at 5%		1.38	-	-	-	-	-

Input	Cost (₹)
Decamethrin	520 L^{-1}
Fenvalerate	420 L^{-1}
Cypermethrin	560 L^{-1}
Endosulfan	380 L^{-1}
Monocrotophos	280 L^{-1}
Quinalphos	415 L^{-1}
Thiodicarb	2920 kg^{-1}
Oxydemeton methyl	300 L^{-1}
Triazophos	300 L^{-1}
Chlorpyriphos	300 L^{-1}
Profenophos	450 L^{-1}
Pigeonpea grain	2500 q^{-1}
Labour charges	200 $labour^{-1}$ ha^{-1}

(1 mL L^{-1}) at flowering phase for effective management of blister beetles on greengram[12]. Results also supported that pyrethroids *viz*., cypermethrin (0.002%) and deltamethrin (0.002%) were superior option in comparison to other insecticides[9]. On rajmah, the application of cypermethrin restricted blister beetle activity till 20 days after spraying. Similar observations were reported about cypermethrin @ 30 g ai ha^{-1} at flowering stage on frenchbean[13]. The mortality of blister beetle, *Mylabris pustulata* was 100 per cent after 6 h in fenvalerate 0.02% and cypermethrin 0.025% on pigeonpea at Tamil Nadu[14]. Most of the insecticides are not very effective against these beetles, but synthetic pyrethroids such as cypermethrin 10EC @ 1 mL L^{-1} or lambda cyhalothrin 5EC @ 1 mL L^{-1} worked reasonably well[15], which strengthens findings of the present study. Contrasting results were reported with endosulfan, monocrotophos and dimethoate, each at 0.05 per cent concentration which proved to be the most effective giving 87.9 to 80.7 per cent reduction of blister beetle upto 14 days after spraying[16].

Effect on yield attributes, net profit and cost-benefit ratio

Data in Table 4 revealed that highest seed yield (18.87 q ha^{-1}) and net monetary return (Rs 20075 ha^{-1}) of pigeonpea was realized due to the application of thiodicarb during 2010-11. Treatments monocrotophos, 18.21 q ha^{-1}, Rs 20040 ha^{-1} and decamethrin, 17.85 q ha^{-1} and Rs 19070 ha^{-1}, were at par with the thiodicarb treatment. Next effective treatment was cypermethrin with grain yield level and net monetary returns of 16.06 q ha^{-1} and Rs 14770 ha^{-1}. It was followed by quinalphos and endosulfan with grain yield and net profit of 15.97 q ha^{-1}, Rs 14027 ha^{-1} and 15.40 q ha^{-1}, Rs 12655 ha^{-1}, respectively. The application of fenvalerate and oxydemeton methyl secured the lowest grain yields (13.98 q ha^{-1} and 11.41 q ha^{-1}) and net profit return (Rs 9549 ha^{-1} and Rs 3025 ha^{-1}).

Data on incremental cost-benefit ratio revealed cost effectiveness of monocrotophos with highest ICBR of 1:48.87. It was followed by cypermethrin (ICBR 1:48.42) and decamethrin (ICBR 1:39.74). Lowest ICBR was estimated in application of oxydemeton methyl (1:7.11). Other promising treatments can be arranged in descending order of cost effectiveness as fenvalerate (1: 29.29), quinalphos (1: 17.05), endosulfan (1:16.43) and thiodicarb (1: 9.91). The results disagreed with[12] who reported higher ICBR of 1: 15.4 for cypermethrin (1 mL L^{-1}) and 1: 6.6 for methyl parathion 2% dust, and higher ICBR for lambda cyhalothrin 0.025% (1: 23.3) and fenvalerate 0.02% (1: 16.18) in pigeonpea[17].

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Manuscript No. PRJ/09/14-04
Received 2 November, 2014; Accepted 24 February, 2015