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Bioefficacy of Insecticides against Tur Pod Bug, *Clavigralla gibbosa* (Spinola) on Pigeonpea [*Cajanus cajan* (L.) Millsp.]

Roshan Lal and B L Jat
Department of Entomology, Choudhary Charan Singh Haryana Agricultural University, Hisar, 125 004, Haryana, India

Pod sucking bugs are the key impediments for the low productivity in India. Nymphs and adults of tur pod bug, *Clavigralla gibbosa* (Spinola) suck the cell sap from the pods and cause loss of the grain. Because of its high fecundity and wide host adaptability, it is necessary to check its damage potential. For this purpose, an experiment on bioefficacy of insecticides against this insect was conducted in the laboratory-cum-field conditions on cultivar "Paras" during *kharif* season 2010-11, 2011-12 and 2012-13. Eight insecticides *viz*., endosulfan 35EC, monocrotophos 36SL, chlorpyriphos 20EC, quinalphos 25EC, triazophos 40EC, decamethrin 2.8EC, fenvalerate 20EC and cypermethrin 25EC were selected based on their LC_{50} values against this insect. Among the tested insecticides, cypermethrin proved most toxic (63.94 times) against adults of *C. gibbosa* followed by decamethrin. Quick knock down effect of decamethrin and fenvalerate was recorded in the field conditions. Therefore, the combinations of decamethrin and quinalphos with DDVP (76 EC) were also tested under field conditions. Cypermethrin, decamethrin plus DDVP, decamethrin and monocrotophos were found effective in managing the *C. gibbosa* population upto 10 days after application. None of the insecticides could manage the bug population below ETL after 14 days of their application. Application of cypermethrin @ 188 mL ha^{-1} recorded the highest grain yield, highest net monetary returns and highest incremental cost benefit ratio, followed by decamethrin, fenvalerate and monocrotophos. Either of dimethoate or oxydemeton methyl could also manage the bug population.

Key words: Insecticides, bioefficacy, *Clavigralla gibbosa*, 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 split pulse (*daal*). Pigeonpea is grown in an area of 5.07 m ha with a production of 3.71 m tonnes in Asia. In India, it is grown on 3.63 m ha area, 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, production of 10 thousand tonnes with the yield of 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. Among biotic stresses, it is attacked by more than 250 species of insects worldwide.[2] The flower and pod feeding Lepidopteran, pod sucking Hemipteran, seed feeding Dipteran and Hymenopteran are the four most important groups. The important pests include, the pod borer, *Helicoverpa armigera* (Hübner), spotted pod borer, *Maruca vitrata* (Geyer), pod bug, *Clavigralla gibbosa* (Spinola) and pod fly, *Melanagromyza obtusa* (Malloch) and these cause significant damage to pods. Among the pod damaging insect pests of pigeonpea, next to pod borer, tur pod bug, *Clavigralla* is the most devastating genus attacking on pigeonpea crop and on other host plants throughout tropics and sub-tropics. In Asia, several species and genera of pod-sucking bugs attacking pigeonpea and other legumes have been reported by several workers. Among these, *Clavigralla gibbosa* (Spinola) which is restricted to India and Sri Lanka[3] is the most important pest in India inflicting heavy loss to seed yield. Many species of pod-sucking bugs, mainly in the families of Alydidae, Coreidae and Pentatomidae, feed on pigeonpea.[4] The pod bug causes 25 to 40% damage in pigeonpea and pod and grain weight are reduced by as much as 1/3 to 1/4 at a density of 12 nymphs $plant^{-1}$.[5] Further, they reported an economic threshold of one nymph $plant^{-1}$ and an economic injury level of two nymphs $plant^{-1}$. After the gram pod borer, *Helicoverpa armigera* and pod fly,

*Corresponding author E-mail: roshanhau@yahoo.co.in

Melanagromyza obtusa, tur pod bug is one of the most important pod and flower damaging insects of pigeonpea. Nymphs and adults of this bug feed on flowers, flower-buds and pods causing premature shedding, deformation of pods and shriveling of grains resulting in loss of grain yield and germination of seeds. The affected pods dry up before maturity and damage at milking stage does not allow the grain to develop. Keeping the above facts in view, the present study was formulated to investigate the efficacy of certain insecticides against this pest.

MATERIALS AND METHODS

Test insect

Five pairs of *C. gibbosa* were released on pigeonpea twigs having sufficient pods, moistened with cotton swab in a glass jar at 27 ± 1 °C under laboratory condition. Fresh pods were provided daily and maximum eggs were laid on the pigeonpea pods. These pods were separated and kept in Petri plates (20 x 5 cm). Fresh milky stage pods were provided to the first and second nymphal instar to pod bug. So, pod bugs were reared under laboratory condition on natural diets of pigeonpea pods. The size of the males was smaller than female.

Field cum laboratory evaluation

The field-cum-laboratory experiments were conducted during *kharif* 2010-11, 2011-12 and 2012-13 at Pulses Research Farm, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. For a particular concentration, approximately 45-60 pods of pigeonpea were plucked and drenched in insecticide solution and shade dried. The pods were then divided into three lots at random. For this purpose glass jars of 20 x 10 cm were used. In each jar 10 newly emerged adults of *C. gibbosa* of the same size and age were released. The mouths of the jars were covered with muslin cloth, held in position with the help of rubber band, to avoid escape of the bugs. The mortalities were recorded 24 h after the release. Side by side a control, containing untreated pods was also run as a check.

Test insecticides

Proprietary formulations of the respective insecticides were obtained from different sources. Eight insecticides viz. endosulfan (Hysulfan 35EC, M/s. Hyderabad Chemical Supplies Ltd.), monocrotophos (Monostar 36SL, Swal Corporation Ltd.), chlorpyriphos (Lethal 20EC, Insecticides India Ltd.), quinalphos (Ekalux 25EC, M/s Syngenta India Ltd.), triazophos (Hostathion 40EC, Sudarshan Chemicals Ltd.), decamethrin (Decis 2.8EC, Bayer Crop Science Ltd.), fenvalerate (Fenval 20EC, Isagro Agro Chemicals Pvt. Ltd.) and cypermethrin (Root 25EC, Safex Chemicals India Ltd.) were taken and their LC_{50} values against the adults of the test insect determined in laboratory. The mortalities were recorded 24 h after the release. The per cent corrected mortalities were worked out by Abbott's formula[6].

Efficacy of insecticides

To know the efficacy of different insecticides against tur pod bug, *Clavigralla gibbosa*, experiment was conducted under field conditions on cultivar 'Paras' in a Randomized Block Design with three replications in plots of 4.5 x 4 m (18 m^2) each. Eight insecticidal treatments *viz*., decamethrin 2.8 EC @ 538 mL ha^{-1}, monocrotophos 36 WSC @ 750 mL ha^{-1}, quinalphos 25 EC @ 1500 mL ha^{-1}, fenvalerate 20EC @ 300 mL ha^{-1}, cypermethrin 25EC @ 188 mL ha^{-1}, quinalphos 25EC @ 1500 mL + DDVP 76EC @ 750 mL ha^{-1}, decamethrin 2.8EC @ 538 mL + DDVP (Nuvan 76EC, Insecticides India Ltd.) @ 750 mL ha^{-1}, dimethoate (Tafgor 30EC, Rallis India Ltd.) @ 750 mL ha^{-1} and oxydemeton methyl (Metasystox 25EC, United Phosphorus Ltd. India) @ 750 mL ha^{-1} were sprayed once in the year 2011-12 and thrice in the year 2012-13 initiating at 50% flowering stage and repeated at 15 days interval. The data were recorded on number of tur pod bugs per plant. The pre-treatment count of tur pod bug population was also taken and there was a homogenous population of tur pod bug during each year. The cost-benefit ratios of the test insecticides were calculated on the basis of average yield of the two years i.e. 2011-12 and 2012-13.

RESULTS AND DISCUSSION

Relative toxicity of insecticides

The regression equations and data on LC_{50} values, fiducial limits and relative toxicities of different test insecticides are presented in Table 1. In increasing order of the LC_{50} values, cypermethrin, decamethrin, monocrotophos, chlorpyriphos, endosulfan, quinalphos, fenvalerate and triazophos gave values 0.001057, 0.001678, 0.002887, 0.004156, 0.010064, 0.01363, 0.01461 and 0.06758 per cent, respectively. The relative toxicities in decreasing order taking triazophos as

Table 1. Relative toxicity of test insecticides against tur pod bug, *Cravigralla gibbosa* on pigeonpea during 2010-11

Insecticide	Heterogeneity* χ^2 (df)	Regression equation (Y =)	LC_{50} (%)	Fiducial limits	Relative toxicity
Endosulfan 35EC	(5) = 12.3074	3.4163X-1.8424	0.010064	0.009306-0.010878	6.72
Monocrotophos 36SL	(4) = 3.2739	2.04028X+0.4993	0.002887	0.0022436-0.0037145	23.41
Chlorpyriphos 20EC	(4) = 4.5282	4.7692X-2.7198	0.004156	0.003686-0.0044686	16.21
Quinalphos 25EC	(3) = 3.08369	1.9452X+0.8483	0.01363	0.008911-0.02083	4.96
Triazophos 40EC	(3) = 1.1781	2.1388X+1.0864	0.06758	0.04526-0.1004	1.00
Decamethrin 2.8EC	(3) = 5.1513	3.1237X-1.457.8	0.001678	0.009806-0.01391	40.27
Fenvalerate 20EC	(3) = 1.1519	1.8981X+2.7891	0.01461	0.009775-0.01284	4.63
Cypermethrin 25EC	(5) = 10.3735	1.7016X-1.5557	0.001057	0.007737-0.01445	63.94

* In none of these insecticides, the data were significantly heterogeneous at P = 0.05; Y = Probit kill; X = Conc. X $10^{5;}$ LC_{50} = Concentration calculated to give 50 per cent mortality

unit were 63.94, 40.27, 23.41, 16.21, 6.72, 4.96 and 4.63 times more for cypermethrin, decamethrin, monocrotophos, chlorpyriphos, endosulfan, quinalphos and fenvalerate, respectively. From the values it is clear that cypermethrin was 63.94 times as toxic as triazophos and the next best toxic insecticide was decamethrin which was 40.27 times toxic than triazophos, however, it was about 1.59 times less toxic as compared to cypermethrin. The LC_{50} of triazophos (0.06758%) was much higher than its general application value of 0.04 per cent; hence its failure to exercise any control in the field was justified. Keeping in view the rationality of this data, cypermethrin should be the first choice, followed by decamethrin, for the control of *C. gibbosa* in the field. Similar results were obtained from synthetic insecticides in reducing the bug population in pigeonpea[7]. Synthetic pyrethroids were found more effective against pod bug as compared to other insecticides[8-11]. In another study, methomyl 40 SP @ 1.0 g L^{-1} was found significantly superior followed by chlorpyriphos 20 EC @ 2.5 mL L^{-1} and acephate 75 SP @ 1.0 g L^{-1} in suppressing the pod bug population[12]. The mean per cent population reduction from spinosad ranged from 89.85 to 94.49% after first spray[13]. Four rounds of endosulfan 35 EC at 35 g a.i. ha^{-1} recorded less damage compared with untreated control[14].

Efficacy of insecticides

During the year 2011-12, all the insecticidal treatments were significantly superior over untreated control except cypermethrin 25EC in which the bug population was maximum (4.7 bugs $plant^{-1}$) at one day after spray. The minimum population of tur pod bug (1.0 bug $plant^{-1}$) was recorded in decamethrin 2.8EC (Table 2) and it was statistically on par with fenvalerate 20EC (1.1 bugs $plant^{-1}$). Observations recorded at 3 days after spray revealed that minimum population (1.2 bugs $plant^{-1}$) was in decamethrin 2.8EC + DDVP 76EC and fenvalerate 20EC, and these treatments were statistically on par with cypermethrin 25EC and monocrotophos 36SL (1.3 bugs $plant^{-1}$). At 7 days after spray, minimum bugs population (1.6 bugs $plant^{-1}$) was recorded in monocrotophos 36 SL and it was statistically on par with decamethrin 2.8EC (1.9 bugs $plant^{-1}$), fenvalerate 20EC (2.4 bugs $plant^{-1}$), cypermethrin 25EC (2.3 bugs $plant^{-1}$), quinalphos 25EC (3.0 bugs $plant^{-1}$) and quinalphos 25 EC + DDVP 76EC (2.9 bugs $plant^{-1}$), respectively. None of the insecticides was found effective in suppressing the bugs population at 14 days after spray. Similar results were obtained from some synthetic pyrethroids against pod bug infesting pigeonpea cv. UPAS-120[15]. The order of efficacy was cypermethrin (0.006%) > fenvalerate (0.02%) > deltamethrin (0.004%) > control. Present findings are strengthened by the finding that pyrethroids were found most effective as compared to botanicals and bio-agents[9-11,16]. Whereas the order of efficacy in case of pod bug infesting pigeonpea was monocrotophos > endosulfan > cypermethrin > fenvalerate > deltamethrin > carbaryl and malathion, respectively[17]. A significant difference in per cent population reduction at every observation day and the mean percentage population reduction from spinosad ranged from 89.85 after first spray to 94.49% after the second spray[13].

During 2012-13, all the insecticidal treatments were found equally effective in reducing the bug population at 1, 3 and 7 days after spray application (Table 3). Significant difference in bugs population was recorded at 10 days after first spraying. Minimum population was recorded in

Table 2. Efficacy of test insecticides against tur pod bug, *Cravigralla gibbosa* on pigeonpea during 2011-12

Treatment	Dosage (mL ha^{-1})	Number of bugs per plant					
		Pre-treatment	1 DAS*	3 DAS	7 DAS	10 DAS	14 DAS
Decamethrin 2.8EC	538	5.1 (2.42)	1.0 (1.41)	3.5 (2.12)	1.9 (1.70)	2.0 (1.72)	15.0 (4.00)
Fenvalerate 20EC	300	4.7 (2.37)	1.1 (1.45)	1.2 (1.48)	2.4 (1.84)	7.0 (2.83)	13.8 (3.82)
Cypermethrin 25EC	188	4.5 (2.34)	4.7 (2.38)	1.3 (1.52)	2.3 (1.72)	3.8 (2.18)	9.0 (3.16)
Monocrotophos 36SL	750	6.0 (2.64)	2.1 (1.75)	1.3 (1.52)	1.6 (1.58)	3.0 (1.98)	8.0 (2.98)
Quinalphos 25EC	1500	3.0 (2.00)	2.5 (1.86)	2.8 (1.94)	3.0 (1.98)	6.4 (2.72)	16.1 (4.13)
Quinalphos 25EC + DDVP 76EC	1500 750	4.2 (2.24)	1.9 (1.69)	2.9 (1.96)	2.9 (1.97)	9.0 (3.16)	8.1 (3.02)
Oxydemeton methyl 25EC	750	4.2 (2.27)	1.9 (1.70)	4.0 (2.24)	4.7 (2.39)	4.6 (2.34)	14.0 (3.87)
Decamethrin 2.8EC + DDVP 76EC	538 750	4.3 (2.31)	2.2 (1.79)	1.2 (1.49)	4.2 (2.27)	12.2 (3.63)	11.4 (3.52)
Untreated control	-	3.7 (2.16)	4.1 (2.25)	3.8 (2.15)	5.3 (2.25)	13.0 (3.73)	17.1 (4.25)
SEm±	-	N.S.	(0.12)	(0.17)	(0.19)	(0.19)	(0.18)
CD at 5%	-	-	(0.26)	(0.37)	(0.41)	(0.40)	(0.39)

*Figures in parentheses are √n+1; DAS: Days after spray

cypermethrin 25EC sprayed plots (1.8 bugs plant^{-1}) and it was statistically on par with quinalphos 25EC, decamethrin 2.8EC, decamethrin 2.8EC + DDVP 76EC and monocrotophos 36SL recording 2.0, 2.1, 2.3 and 2.4 bugs plant^{-1}, respectively. Quinalphos 0.025% showed highest mortality of eggs (86.6%), and nymphs and adults (100%), and decamethrin 0.002%, cypermethrin 0.005% and polytrin (A 6341 B) resulted in 50.0 to 53.3 per cent egg mortality[18].

At 14 days after first spray, decamethrin 2.8EC recorded minimum (2.1 bugs plant^{-1}) as compared to the other treatments and was found superior over rest of the treatments. Quinalphos 25EC + DDVP 76EC was found least effective in reduction of bug population (3.8 bugs plant^{-1}). Non-significant difference was observed among all the treatments in reducing the bug population after second spray. The significant difference in the tur pod bug population was observed after 7 days of third spray. The minimum bug population was recorded in cypermethrin 25EC (2.4 bugs plant^{-1}) and it was statistically on par with fenvalerate 20EC (4.9 bugs plant^{-1}), monocrotophos 36SL (4.6 bugs plant^{-1}), quinalphos 25EC + DDVP 76EC (4.3 bugs plant^{-1}) and decamethrin 2.8EC + DDVP 76EC (4.1 bugs plant^{-1}), respectively. None of the insecticides could manage the bug population after 10 days of the third application of the insecticides and in all the treatments bug population was more than 10 bugs plant^{-1}. The present findings did not corroborate with the results that decamethrin, carbosulfan 0.01%, cypermethrin 0.005%. fomesafen 0.002% and monocrotophos 0.04% showed cumulative mortality of 96.66 to 100 per cent against nymphs and adults 72 h after treatment[18]. Results also disagreed with the minimum per cent pod damage observed in lufenuron 5EC + profenophos 50EC treated plots[19]. Methomyl 40SP @ 1.0 g L^{-1} has been reported as effective in suppressing the pod bug population followed by chlorpyriphos 20EC and acephate 75SP[12].

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

The data on grain yield, net monetary return and cost-benefit ratio of two years suggests that except the treatment at S. no. 8, the insecticide treated plots gave higher yield as compared to untreated control (Table 4). Application of cypermethrin 25EC @ 188 mL ha^{-1} recorded the highest grain yield (14.83 q ha^{-1}) and it was statistically on par with the treatments fenvalerate 20EC @ 300 mL ha^{-1} (14.35 q ha^{-1}), decamethrin 2.8EC @ 538 (14.23 q ha^{-1}), decamethrin

Table 3. Efficacy of test insecticides against tur pod bug, *Cravigrolla gibbosa* in pigeonpea during 2012-13

Treatment	Dosage (mL or g ha^{-1})	Number of bugs per plant															
		Pre-treatment	First spray					Second spray					Third spray				
			1 DAS*	3 DAS	7 DAS	10 DAS	14 DAS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS
Decamethrin 2.8EC	538	0.2 (1.09)	1.0 (1.41)	0.8 (1.32)	3.1 (2.02)	2.1 (1.76)	2.1 (1.76)	1.8 (1.67)	2.1 (1.76)	4.1 (2.27)	3.8 (2.18)	7.6 (2.92)	5.3 (2.53)	6.7 (2.76)	5.7 (2.58)	11.3 (3.50)	10.4 (3.37)
Fenvalerate 20EC	300	0.7 (1.27)	0.9 (1.37)	0.9 (1.37)	2.9 (1.97)	2.9 (1.97)	3.6 (2.14)	2.7 (1.91)	1.4 (1.55)	5.4 (2.53)	5.8 (2.58)	7.6 (2.92)	3.3 (2.06)	5.9 (2.59)	4.9 (2.41)	11.3 (3.51)	11.7 (3.56)
Cypermethrin 25EC	188	0.9 (1.34)	1.2 (1.49)	0.5 (1.56)	2.1 (1.76)	1.8 (1.66)	3.3 (2.08)	2.1 (1.75)	1.8 (1.66)	4.8 (2.40)	5.6 (2.49)	5.8 (2.60)	4.1 (2.27)	6.3 (2.70)	2.4 (1.84)	12.2 (3.63)	14.0 (3.84)
Monocrotophos 36SL	750	0.5 (1.22)	0.8 (1.34)	0.6 (1.24)	2.1 (1.76)	2.4 (1.85)	3.7 (2.14)	2.1 (1.75)	1.8 (1.65)	4.6 (2.35)	5.3 (2.51)	6.6 (2.75)	4.1 (2.26)	5.5 (2.53)	4.6 (2.35)	11.8 (3.57)	9.9 (3.29)
Quinalphos 25EC	1500	0.8 (1.31)	0.6 (1.25)	1.0 (1.39)	2.8 (1.94)	2.0 (1.73)	3.1 (2.01)	2.7 (1.91)	1.6 (1.60)	5.9 (2.63)	5.6 (2.56)	7.1 (2.83)	4.0 (2.23)	7.0 (2.83)	8.9 (3.14)	10.9 (3.45)	12.9 (3.71)
Quinalphos 25EC + DDVP 76EC	1500+750	0.9 (1.34)	0.7 (1.28)	1.1 (1.43)	2.2 (1.79)	2.7 (1.92)	3.8 (2.16)	1.0 (1.41)	1.9 (1.70)	4.7 (2.36)	5.8 (2.59)	7.7 (2.94)	5.2 (2.50)	6.2 (2.69)	4.3 (2.29)	12.8 (3.71)	14.2 (3.87)
Decamethrin 2.8EC + DDVP 76EC	538+750	0.7 (1.30)	1.3 (1.49)	1.5 (1.59)	2.1 (1.75)	2.3 (1.82)	2.2 (1.79)	2.2 (1.79)	1.5 (1.56)	4.9 (2.43)	5.8 (2.60)	9.1 (3.17)	3.2 (2.05)	7.7 (2.94)	4.1 (2.17)	10.7 (3.42)	16.2 (4.11)
Dimethoate 30EC	750	0.7 (1.28)	0.7 (1.28)	1.4 (1.55)	1.9 (1.69)	3.3 (2.08)	3.3 (2.08)	2.2 (1.79)	2.0 (1.73)	5.0 (2.44)	6.2 (2.69)	8.0 (2.98)	3.4 (2.08)	6.5 (2.73)	5.5 (2.50)	11.1 (3.48)	13.6 (3.80)
Untreated control	-	0.7 (1.28)	1.1 (1.45)	2.0 (1.73)	2.4 (1.85)	3.1 (2.02)	4.6 (2.34)	2.0 (1.71)	2.6 (1.88)	5.2 (2.50)	6.2 (2.68)	8.4 (2.69)	3.7 (2.04)	5.3 (2.52)	5.7 (2.52)	11.9 (3.59)	11.6 (3.54)
SEm±	-	NS	NS	NS	NS	(0.11)	NS	NS	NS	NS	NS	NS	NS	NS	(0.31)	NS	NS
CD at 5%	-	-	-	-	-	(0.23)	-	-	-	-	-	-	-	-	(0.66)	-	-

* Figures in parentheses are √n+1; DAS: Days after spray

Table 4. Effect of different insecticides on yield of pigeonpea, net profit and their cost benefit ratio

Treatment	Av. yield (q ha^{-1})	Increased yield over control (q ha^{-1})	Value of the additional grain yield (Rs ha^{-1})	Cost of treatment (Rs ha^{-1})	Net profit (Rs ha^{-1})	Cost benefit ratio
Decamethrin 2.8EC	14.23	3.36	10080	1089.28	8990.72	1:8.25
Fenvalerate 20EC	14.35	3.28	9840	628	9212	1:14.66
Cypermethrin 25EC	14.83	3.76	11280	355.28	10924.72	1:30.74
Monocrotophos 36SL	13.73	2.66	7980	880	7100	1:8.06
Quinalphos 25EC	13.27	2.20	6600	2117.5	4482.25	1:2.11
Quinalphos 25EC + DDVP 76EC	13.55	2.48	7440	2905	4535	1:1.56
Decamethrin 2.8EC + DDVP 76EC	14.03	2.96	8880	1876.78	7003.22	1:3.73
Dimethoate 30EC/ Oxydemeton methyl 25EC	11.21	0.14	420	1487.5	-1067.5	1:0.71
Untreated control	11.07	-	-	-	-	-
SEm±	0.90	-	-	-	-	-
CD at 5%	1.92	-	-	-	-	-

Input	Cost (Rs)
Decamethrin 2.8EC	520 L^{-1}
Fenvalerate 20EC	420 L^{-1}
Cypermethrin 25EC	560 L^{-1}
Monocrotophos 36SL	280 L^{-1}
Quinalphos 25EC	415 L^{-1}
DDVP 76EC	350 L^{-1}
Dimethoate 30EC	300 L^{-1}
Oxydemeton methyl 25EC	300 L^{-1}
Pigeonpea grain	3000 q^{-1}
Labour charges	250 $labour^{-1}$ ha^{-1}

2.8EC + DDVP 76EC @ 538 and 750 mL ha^{-1} (14.03 q ha^{-1}), monocrotophos 36SL @ 750 mL ha^{-1} (13.73 q ha^{-1}), quinalphos 25EC + DDVP 76EC @ 1500 and 750 mL ha^{-1} (13.55 q ha^{-1}) and quinalphos 25EC @ 1500 mL ha^{-1} (13.27 q ha^{-1}), respectively. Treatment oxydemeton methyl 25EC @ 750 or dimethoate 30EC @ 750 mL ha^{-1} was found inferior, registering grain yield of 11.21 q ha^{-1}.

Data on net monetary returns revealed that treatment cypermethrin 25EC @ 188 mL ha^{-1} registered highest return of Rs. 10924.72. It was followed by fenvalerate 20EC @ 300 mL ha^{-1} (Rs 9212) and decamethrin 2.8EC @ 538 mL ha^{-1} (Rs 8990.72). Other treatments can be arranged in descending order as monocrotophos 25EC @ 750 mL ha^{-1} (Rs 7100), decamethrin 2.8EC @ 538 mL ha^{-1} + DDVP 76EC @ 750 mL ha^{-1} (Rs 7003.22), quinalphos 25EC @ 1500 mL ha^{-1} + DDVP 76EC @ 750 mL ha^{-1} (Rs 4535) and quinalphos 25EC @ 1500 mL ha^{-1} (Rs 4482.25), respectively. Whereas, the application of either of dimethoate 30EC @ 750 mL ha^{-1} or oxydemeton methyl 25EC 750 mL ha^{-1} caused loss of Rs 1067.5.

Similarly, incremental cost-benefit ratio of different insecticides revealed that treatment cypermethrin 25EC @ 188 mL ha^{-1} again proved excellent by registering the highest incremental cost-benefit ratio of 1: 30.74 and it was followed by the treatment fenvalerate 20EC @ 300 mL ha^{-1}, decamethrin 2.8EC @ 538 mL ha^{-1} and monocrotophos 25EC @ 750 mL ha^{-1} recording ICBR of 1: 14.66, 1: 8.25 and 1: 8.06, respectively. The least ICBR of 1: 3.73, 1: 2.11 and 1: 1.56 was obtained in treatment decamethrin 2.8EC + DDVP 76EC, quinalphos 25EC and quinalphos 25EC + DDVP 76EC. Spraying either of dimethoate 30EC or oxydemeton methyl 25EC provided loss in cost benefit ratio (ICBR 1:0.71).

Contrasting results of seed yield have been reported and realized in case of monocrotophos treated plots[17,20]. The application of dimethoate 30EC[19] provided the highest grain yield (14.2 q ha^{-1}), highest net profit (Rs 8451.0 ha^{-1}) and highest cost benefit ratio of 1: 7.45. Methomyl 40SP reportedly registered the highest grain yield (11.10 q ha^{-1}) with the highest net return (Rs 27686 ha^{-1}) and B : C ratio

(1:4.54) of pigeonpea[12]. Endosulfan[21] treated plots gave maximum yield of 19.4 q ha^{-1} and maximum net return in phosphomidon treated plots. Highest incremental benefit cost ratio and net income of 13.23 and Rs 21597 ha^{-1} were recorded in case of spinosad 45% SC[13].

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