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EFFICACY OF NEWER INSECTICIDES AGAINST THE BLACK GRAM, POD BORER COMPLEX

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Black gram [*Vigna mungo* (L.) Hepper] is one of the important pulse crops due to its nutritional and industrial values. In India, preventable yield losses in the range of 7 to 35 % due to pest infestation in black gram have been recorded. The insect spectra that infest the black gram include more than 40 species of insect pests and cause economical damage on black gram Mahalakshmi *et al*. (2016). Overall consumption of pesticides was about 2,167,03 metric tons (MT) in India, of which insecticide included about 96,087 MT, fungicides 72,883 MT, herbicides 41,560 MT, and rodenticides 6,173 MT. Whereas, Tamil Nadu consumes about 1,901 MT and Puducherry consumes about 42 MT of pesticide (DPPQ&S, 2019).

Pod borers cause a considerable damage to buds, flowers and pods and the estimated loss in grain yield was about 60 - 90 per cent (Durairaj, 2006). The spotted pod borer causes serious damage to the crop, leading to huge losses. Larvae feed on webbing of leaves, flowers and pods (Ramu *et al.*, 2018). Pea blue butterfly larvae feed on floral buds, flowers and bore holes in pods of the host plants (Harinath *et al.*, 2015). So it is difficult to kill them due to this typical feeding habit larvae protect from natural enemies and older class of insecticides.

Synthetic organic compounds which include chlorinated hydrocarbons, organo phosphorous and carbamate insecticides have long persistence in the environment as well as in plants, lead to undesirable effects on human health and environment (Damalas and Koutroubas, 2016). Foliar application at frequent intervals during the growing season leads to increased cost of cultivation which in turn reduces the net profits for the pulse growing farmers. The repeated use of older class chemicals results in development of resistance to insecticides. Nowadays, attempts are being focused on safer insecticides to reduce the resistance development and ecofriendly pesticides. Hence, the newer insecticides with relatively low quantities compared to standard insecticides which had long residual properties should be evaluated for effective management of spotted pod borer.

The newer insecticide molecules are less toxic to mammals, birds and fish with high insecticidal potency. Newer insecticides namely, chlorantraniliprole 18.5 SC, flubendiamide 39.35 SC, thiodicarb 75 WP, indaxocarb 14.5 SC, lambda cyhalothrin 5 EC, lufenuron 5.4 EC, *etc.,* are the major insecticides advocated to control pod borer and defoliator pests in black gram (DPPQ&S, 2020). These new molecules are comparatively safer to natural enemies, honeybees, and other pollinators than old generation insecticide molecules (Singh and Kumar, 2012). Considering the above in view, the present investigation was taken up to evaluate the newer insecticides against the pod borer complex in irrigated black gram.

Field experimental trials were carried out in the Eastern farm of PAJANCOA AND RI, Karaikal, U. T. of Puducherry during kharif 2019 and rabi 2019 - 20. The experiment was laid out in a randomized block design (RBD) with nine treatments *viz*., chlorantraniliprole 18.5SC @ 100 ml/ha (T_1), emamectin benzoate 5SG @ 220 g/ha (T2), flubendiamide 20WG @ 125 g/ha (T3), lambda cyhalothrin 2.5EC @ 500 ml/ha (T4), azadirachtin 0.03EC @ 2000 ml/ha (T5), indoxacarb 14.5SC @ 400 ml/ha (T_6), thiodicarb 75WP @ 750 g/ha (T_7), novaluron 10EC @ 750 ml/ha (T_8) and untreated check (Water spray- T_9), which were replicated thrice. The black gram variety VBN (Bg) 5 was sown in the plots (4 x 5 m) with a spacing of 30 x 10 cm. The blanket recommendation of fertilizers of 25: 50: 25 Kg/ha NPK were applied as per the crop production guide (Anonymous, 2019).

Observations on larval and pod borers were recorded on 10 randomly selected plants in each plot at weekly intervals. Based on economic threshold level, two rounds of foliar application of treatments were given with a high-volume sprayer (Hand operated knapsack sprayer) during 35 DAS (flowering stage) and 50 DAS (pod formation stage). ETL for *Maruca* larva was 3 larval webbings/ plant and for pod it was 10 percent damage (TNAU). The data were statistically analyzed as suggested by Panse and Sukhatme (1985). Critical difference values of the experiment were computed using Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

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Assessment of larvae was made by counting number of *Maruca* larvae present inside the web per plant on ten randomly selected plants per plot. Assessment of green pods with bore hole symptoms caused by the larvae of pea blue butterfly *(Lampides boeticus*) and bore holes in buds, flowers and pods infested parts with webbed shoots and pods caused by the larvae of spotted pod borer (*Maruca vitrata*) were made on ten randomly selected plants per plot. The percentage damage was worked out by using the formula. The mean of each foliar spray was recorded before and after treatments

$$\text{Per cent pod damage} = \frac{\text{Total number of damaged pods}}{\text{Total number of examined pods}} \times 100$$

Kumar *et al*. (2013)

The yield of back gram from each plot was recorded separately for both the seasons. The total yields obtained from different treatments were calculated and computed per hectare. Based on the yield data, the gross returns and net returns were calculated for each treatment. The benefit cost ratio (BCR) was determined by dividing the additional returns with the additional cost of imposing the respective treatments on hectare basis (Sarao and Kaur, 2014).

The overall mean value presented in Table 1, 2 and 3 revealed that all the treatments were found significantly superior when compared to untreated check for the management of pod borer complex in black gram. The overall mean value exhibited that *Maruca* population of 1st and 2nd foliar application ranged from 1.48 to 7.02, 1.39 to 12.89 larvae/ plants and 2.02 to 6.24, 1.16 to 9.68 larvae/plant. The lowest larval populations were recorded in chlorantraniliprole 18.5 SC at 100 ml/ha (1.44 and 1.59), followed by flubendiamide 20 WG at 125 g/ha (1.66 and 1.83) compared to untreated check (9.96 and 7.96) during kharif 2019 and rabi 2019 – 2020.

Among the treatments, chlorantraniliprole 18.5SC @ 100 ml/ha recorded the lowest pod damage of 5.79 and 6.29 %, followed by flubendiamide 20WG @ 125 g/ha (6.65 and 6.73 % damage**)**, for management of *M. vitrata*. Similar trend was repeated in pea blue butterfly, *L. boeticus.* Chlorantraniliprole 18.5SC @ 100 ml/ha recorded the least number of pod damage with 6.06

Table 1. Bioefficacy of newer insecticides against *M. vitrata* larval population *in* black gram during kharif 2019 and rabi 2019-2020

Treatments (T)	**Conc. ml/g per ha**	**Mean number of *M. vitrata*/ plant**									
		***kharif* 2019**					***rabi* 2019-2020**				
		PTC	**1st Foliar spray#**	**2nd Foliar spray#**	**Overall mean**	**Per cent reduction over control**	**PTC**	**1st Foliar spray#**	**2nd Foliar spray#**	**Overall mean**	**Per cent reduction over control**
T_1	100	3.07 (1.75)	1.48 (1.21)^{a}	1.39 (1.17)^{a}	1.44	85.59	3.60 (1.89)	2.02 (1.42)^{a}	1.16 (1.07)^{a}	1.59	80.03
T_2	220	3.00 (1.73)	2.08 (1.44)^{e}	2.14 (1.46)^{e}	2.11	78.80	3.57 (1.88)	3.03 (1.74)^{e}	2.01 (1.41)^{e}	2.52	68.34
T_3	125	3.13 (1.76)	1.65 (1.28)^{b}	1.66 (1.28)^{b}	1.66	83.38	3.57 (1.88)	2.27 (1.50)^{b}	1.39 (1.71)^{b}	1.83	77.02
T_4	500	3.17 (1.77)	1.83 (1.35)^{c}	1.85 (1.36)^{c}	1.84	81.52	3.50 (1.87)	2.50 (1.58)^{c}	1.64 (1.28)^{c}	2.07	74.02
T_5	2000	3.13 (1.76)	1.99 (1.40)^{d}	2.08 (1.44)^{d}	2.04	79.56	3.50 (1.87)	2.73 (1.65)^{d}	1.78 (1.33)^{d}	2.25	71.69
T_6	400	3.20 (1.78)	2.42 (1.55)^{g}	2.50 (1.58)^{g}	2.46	75.29	3.53 (1.86)	3.46 (1.85)^{g}	2.40 (1.54)^{g}	2.93	63.22
T_7	750 750	3.00 (1.73)	2.24 (1.49)^{f}	2.31 (1.52)^{f}	2.28	77.15	3.60 (1.89)	3.25 (1.80)^{f}	2.18 (1.47)^{f}	2.72	65.88
T_8		3.30 (1.81)	4.39 (1.61)^{h}	2.74 (1.65)^{h}	3.57	64.19	3.67 (1.91)	3.78 (1.94)^{h}	2.79 (1.66)^{h}	3.29	58.72
T_9	-	3.13 (1.76)	7.02 (2.64)^{i}	12.89 (3.59)^{i}	9.96		3.63 (1.90)	6.24 (2.49)^{i}	9.68 (3.11)^{i}	7.96	
S.Ed.		0.33	0.25	0.19	-		0.32	0.24	0.12	-	
C.D.(P=0.05)		NS	0.11*	0.10*			NS	0.14*	0.02*		

In a column mean followed by common letters are significantly different by DMRT (p=0.05); values in parentheses are transformed values;
* - significant at p=0.05 # - observed on pretreatment, 3, 5, 7, 10 and 14 DAT PTC – Pre-Treatment Count DAT – Days After Treatment

and 7.59 %, followed by flubendiamide 20WG @ 125 g/ha (6.71 and 8.05 % damage) compared to untreated check for control of pod borers in both the kharif 2019 and rabi 2019 – 2020.

Natural enemies including ladybird beetles, *Telamonia dimidiate, Olios millet, Neoscona theisi, Cheilomenes sexmaculata, Harmonia octomaculata, Micraspis discolour*, and *Propylea dissecta* were seen in all of the experimental plots during the trial periods in Kharif 2019 and Rabi 2019-2020, respectively. Regarding the number of natural enemies, there were no appreciable variations across the treatments. chlorantraniliprole 18.5 SC at 100 ml/ha and Flubendiamide 20 WG at 125 g/ha in contrast to other treatments, had no negative effects on the population's natural enemies. This indicates that there were no differences between the treatments regarding the incidence of natural enemies.

Satpute and Barkhade (2012) expressed that Rynaxypyr 20SC @ 30 and 40 g/ha was found to be effective in reducing pod damage as well as the population of pod borer in pigeon pea. Mahalakshmi *et al*. (2013) reported that coragen 20SC @ 20 g a.i./ha was found to be effective in reducing the larval incidence on black gram compared to the different doses of coragen 20SC @ 30, 25 and 20 g/ha. Sambathkumar *et al.* (2015) stated that chlorantraniliprole 18.5SC @ 30 g/ha recorded the least incidence of *M. vitrata* larval (3.1 webbings/10 plants) with per cent reduction of 87.7% of larval infestation in red gram, respectively. Jakhar *et al*. (2016) stated that chlorantraniliprole at 18.5SC @ 0.15 ml/l recorded the maximum control of pod borers (3.33 %) in pigeon pea. Karthikeyan (2017) stated that chlorantraniliprole 0.4G @ 10 kg/ha were found to be most effective treatment against rice yellow stem borer. Patange and Chiranjeevi (2017) stated that Rynaxypyr 18.5SP @ 30 g a.i./ha was most effective insecticide in minimizing the larval population of pigeon pea pod borers *viz*., gram pod borer, *H. armigera,* plume moth, *Exelastis atomosa* and pod fly, *Melanagromyza obtusa* (5.59 %). Prajapati *et al.* (2018) reported that chlorantraniliprole 18.5SC @ 0.0006 % was found to be effective in reducing larval population (1.75 larvae/20 twigs), bud damage (2.37 %), flower damage (1.91 %) and pod damage (0.87 %) against blue butterfly, *Euchrysops cnejus* in pigeon pea. When compared

Table 2. Bioefficacy of newer insecticides against *M. vitrata, L. boeticus,* yield and benefit cost ratio of black gram during kharif 2019

Treatments (T)	Conc. ml/g per ha	Mean % pod damage during kharif 2019										Grain yield (kg/ha)	BCR
		M. vitrata					*L. boeticus*						
		PTC	1st Foliar spray#	2nd Foliar spray#	Overall mean	Per cent reduction over control	PTC	1st Foliar spray#	2nd Foliar spray#	Overall mean	Per cent reduction over control		
T$_1$	100	11.33 (19.66)	8.26 (16.71)^{a}	5.04 (12.97)^{a}	5.79	74.38	11.64 (19.91)	7.72 (16.12)^{a}	4.41 (12.12)^{a}	6.06	72.23	635.00^{a}	1: 2.31
T$_2$	220	12.95 (21.08)	10.79 (19.15)^{e}	8.60 (17.05)^{e}	9.38	58.50	11.25 (19.58)	10.14 (18.56)^{e}	7.18 (15.54)^{e}	8.66	60.35	406.00^{d}	1: 1.47
T$_3$	125	11.61 (19.91)	8.98 (17.41)^{b}	5.89 (14.04)^{b}	6.65	70.60	10.44 (18.51)	8.13 (16.56)^{b}	5.29 (13.30)^{b}	6.71	69.28	537.00^{b}	1: 1.96
T$_4$	500	11.67 (19.96)	9.52 (17.97)^{c}	6.95 (15.29)^{c}	7.62	66.29	10.84 (19.22)	8.80 (17.25)^{c}	5.94 (14.10)^{c}	7.37	66.24	457.00^{c}	1: 1.67
T$_5$	2000	11.74 (20.03)	9.94 (18.37)^{d}	7.75 (16.16)^{d}	8.46	62.60	12.98 (21.10)	9.77 (18.21)^{d}	6.63 (14.92)^{d}	8.20	62.46	309.67^{f}	1: 1.13
T$_6$	400	12.44 (20.64)	11.17 (19.53)^{g}	10.27 (18.69)^{g}	11.09	50.94	12.67 (20.33)	11.73 (20.02)^{g}	8.87 (17.32)^{g}	10.30	52.84	279.50^{g}	1: 1.02
T$_7$	750	12.12 (20.36)	11.01 (19.37)^{f}	9.40 (17.86)^{f}	10.18	54.97	12.99 (21.03)	11.10 (19.45)^{f}	7.97 (16.39)^{f}	9.54	56.33	356.17^{e}	1:1.29
T$_8$	750	12.03 (20.29)	11.53 (19.84)^{h}	11.21 (19.56)^{h}	12.22	45.96	10.78 (19.16)	12.29 (20.52)^{h}	10.09 (18.52)^{h}	11.19	48.76	273.83^{h}	1:1.00
T$_9$	-	11.86 (20.13)	18.22 (25.72)^{i}	25.55 (30.36)^{i}	22.61	-	11.98 (20.21)	12.43 (21.11)^{i}	12.78 (21.76)^{i}	21.84	-	174.17^{i}	
S.Ed.		0.53	0.11	0.03	-		1.05	0.22	0.01	-		-	-
C.D.(P=0.05)		NS	0.02*	0.10*			NS	0.47*	0.11*			19.24*	

In a column mean followed by common letters are significantly different by DMRT (p=0.05); values in parentheses are arc sine transformed values; * - significant at p=0.05 # - observed on pretreatment, 3, 5, 7, 10 and 14 DAT PTC – Pre-Treatment Count DAT – Days After Treatment

Table 3. Bioefficacy of newer insecticides against *M. vitrata, L. boeticus,* yield and benefit cost ratio of black gram during rabi 2019-20

Treatments (T)	Conc. ml/g per ha	Mean % pod damage during rabi 2019- 2020										Grain yield (kg/ha)	BCR
		M. vitrata					*L. boeticus*						
		PTC	1st Foliar spray#	2nd Foliar spray#	Overall mean	Per cent reduction over control	PTC	1st Foliar spray#	2nd Foliar spray#	Overall mean	Per cent reduction over control		
T_1	100	12.17 (20.40)	7.74 (16.15)^{a}	6.45 (14.71)^{a}	6.29	74.52	11.30 (19.63)	7.75 (16.25)^{a}	7.42 (15.80)^{a}	7.59	73.93	721.67^{a}	1: 2.63
T_2	220	10.21 (18.62)	8.36 (17.20)^{e}	8.20 (16.64)^{e}	7.88	68.09	10.00 (18.43)	8.98 (17.22)^{e}	8.80 (17.25)^{e}	8.89	69.44	461.50^{d}	1: 1.67
T_3	125	12.16 (20.35)	7.91 (16.41)^{b}	6.80 (15.12)^{b}	6.73	72.76	11.87 (20.13)	8.35 (16.79)^{b}	7.74 (16.15)^{b}	8.05	72.35	545.00^{b}	1: 1.98
T_4	500	10.93 (19.30)	7.98 (16.67)^{c}	7.33 (15.71)^{c}	7.11	71.23	11.85 (20.11)	8.42 (17.03)^{c}	8.06 (16.49)^{c}	8.24	71.67	500.00^{c}	1: 1.83
T_5	2000	11.72 (19.96)	8.84 (16.89)^{d}	7.70 (16.11)^{d}	7.53	69.50	11.17 (19.52)	8.68 (17.16)^{d}	8.37 (16.81)^{d}	8.52	70.70	357.00^{f}	1: 1.30
T_6	400	10.67 (19.05)	8.90 (17.76)^{g}	9.06 (17.52)^{g}	8.78	64.46	12.74 (20.89)	9.59 (18.32)^{g}	9.43 (17.81)^{g}	9.51	67.32	310.00^{g}	1: 1.13
T_7	750	12.20 (20.41)	9.23 (18.04)^{f}	8.54 (16.99)^{f}	8.53	65.47	10.57 (18.96)	9.24 (17.63)^{f}	9.13 (17.59)^{f}	9.18	68.43	409.83^{e}	1: 1.49
T_8	750	11.86 (20.10)	10.05 (18.48)^{h}	9.62 (18.07)^{h}	9.57	61.24	11.28 (19.62)	10.16 (18.59)^{h}	9.96 (18.39)^{h}	10.06	65.43	279.50^{h}	1: 1.02
T_9	-	11.85 (20/11)	19.91 (24.28)^{i}	31.23 (33.97)^{i}	24.70	-	10.90 (19.27)	11.58 (19.52)^{i}	12.00 (19.98)^{i}	29.09	-	217.50^{i}	
S.Ed.		1.19	0.23	0.02	-		0.68	0.13	0.17	-		-	
C.D.(P=0.05)		NS	0.25*	0.10*			NS	0.29*	0.14*			26.09*	-

In a column mean followed by a common letter are significantly different by DMRT (p=0.05); values in parentheses are arc sine transformed values;
* - significant at p=0.05 # - observed on pretreatment, 3, 5, 7, 10 and 14 DAT PTC – Pre-Treatment Count DAT – Days After Treatmen

to untreated check, Coragen 20 SC at 125 ml/ha and 150 ml/ha caused the greatest percent reduction in larval population over control and had the highest BCR during the kharifs of 2018 (6.29, 4.21) and 2019 (5.95, 5.64). The five Bt isolates that were tested exhibited compatibility with Coragen 20 SC, meaning that Bt growth wasn't suppressed in nutrient agar that included a field dose of Coragen 20 SC (Sujayanand *et al.,* 2021). The above results are in consonance with the present findings.

The treatments can be arranged according to the decline order, chlorantraniliprole 18.5SC @ 100 ml/ha > flubendiamide 20WG @ 125 g/ha > lambda cyhalothrin 2.5EC @ 500 ml/ha > azadirachtin 0.03EC @ 2000 ml/ha > emamectin benzoate 5SG @ 220 g/ha > thiodicarb 75WP @750 g/ha > indoxacarb 14.5SC @ 400 ml/ha > novaluron 10EC @ 750 ml/ha.

Yield and benefit coat ratio (BC Ratio)

The highest yield of 635.00 and 721.67 kg/ ha was recorded in chlorantraniliprole 18.5SC @ 100 ml/ha, followed by flubendiamide 20WG @ 125 g/ha (537.00 and 545.00 kg/ha). It was found that chlorantraniliprole 18.5SC @ 100 ml/ha was superior among the treatments. All the treatments was found to be superior than the untreated check. The maximum benefit cost ratio recorded in chlorantraniliprole 18.5SC @ 100 ml/ha with 1: 2.31 and 1: 2.63, followed by flubendiamide 20WG @ 125 g/ha (1: 1.96 and 1: 1.98) (Table 1 and 2).

Mahalakshmi *et al.* (2013) reported that coragen 20SC @ 30 g a.i./ha recorded the highest yield with 858 and 890 kg/ha in 2008-2009 and 2009-2010 at par with coragen 20SC @ 25 g a.i./ha, whereas coragen @ 10 and 15 g a.i./ha recorded seed yield more than 550 kg/ha. All the treatments were found significantly superior over the untreated check with lowest seed yield (265 to 290 kg/ha) in black gram. Patel and Patel (2013) reported that chlorantraniliprole 18.5SC @ 30 g/ha recorded highest yield of 1354.67 kg/ha than the untreated check which recorded the lowest yield of 876.33 kg/ha in pigeon pea. Sreekanth *et al.* (2014) stated that highest pod yield was recorded in chlorantraniliprole 20SC @ 0.3 ml/lit (686.1 kg/ha), followed by flubendiamide 480SC @ 0.2 ml/lit (595.8 kg/ha) over untreated check (301.6 kg/ha). The cost effectiveness of chlorantraniliprole and flubendiamide was also high and very favorable with incremental cost-benefit ratio of 1: 4.64 and 1: 4.50 respectively in pigeon pea. Patange and Chiranjeevi (2017) reported that rynaxypyr 18.5SP @ 30 g a.i./ha recorded maximum cost benefit ratio of 1:1.72, respectively, in pigeon pea. The above reports are in support with the present findings.

It was concluded that among the various newer insecticides evaluated, chlorantraniliprole 18.5SC @ 100 ml/ha and flubendiamide 20WG @ 125 g/ha can be included in IPM to manage pod borer complex in black gram.

Authors' contribution

Conceptualization of research work and designing of experiments (RP, MK); Execution of field/lab experiments and data collection (RP); Analysis of data and interpretation (RP); Preparation of manuscript (RP, MK)

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