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Bio efficacy of insecticides against gram pod borer, *Helicoverpa armigera* in Redgram

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Abstract
The present investigation was carried out to explore the bio efficacy of Insecticides against Gram pod borer, *Helicoverpa armigera* in redgram during *Kharif*, 2016 and 2017 at Agricultural Research Station, Garikapadu. Seven treatments including untreated control were evaluated for their relative efficacy towards suppression of larval population and reduction of percent pod damage. The insecticides *viz*., Emamectin benzoate 5SG, Flubendamide 20WG, Chlorantraniliprole 20 SC, Thiodicarb 75% WP, Indoxacarb 14.5 SC, Novaluron 10 EC were applied three times during the crop season *viz*., 50% flowering, pod initiation and 50% pod formation stage. Among all the insecticides, larval population of *H.armigera* infesting redgram was proven to be significantly lower in plots treated with chlorantraniliprole 20 SC (0.62 larvae/plant) and flubendamide 20 WG (1.04 larvae/plant) exhibiting 76.36 and 69.09 percent reduction over control respectively. Similar trend was also observed with respect to percent reduction of pod damage over control, where chlorantraniliprole 20 SC and flubendamide 20 WG exhibited 63.65 and 59.57 percent control respectively. Yield increase over control was recorded to be higher in plots treated with chlorantraniliprole 20 SC (60.78%) and flubendamide 20 WG (54.93%). The other treatments in order of yield efficacy were indoxacarb 14.5 SC (46.73%) > emamectin benzoate 5SG (43.68%)> thiodicarb 75% WP (42.45%)> novaluron 10 EC (27.37%).

Keywords: Redgram, Insecticides, *Helicoverpa*

Introduction
In India Redgram (*Cajanus cajan* L.) is considered as most important pulse crop next to Bengal gram. The ability of red gram to produce high economic yields under soil moisture deficit makes it a substantial crop especially in rainfed and dryland agriculture [1]. In India it is cultivated in 23.47 million ha area with a production 18.34 million tones with an average yield of 781 kg ha^{-1} during 2012-13. In Andhra Pradesh, it is cultivated in an area of 502.20 lakh ha contributing nearly 12.86 percent total area of India with a production of 221.6 tonnes [2]. On an average, 2.5 to 3.0 million tonnes of pulses are lost annually due to pest problems [3]. About 250 insect species belonging to 8 orders and 61 families have been found to infest redgram from seedling to harvesting stage and virtually no plant part is free from insect infestation [4]. A yield loss due to pod borers in pigeonpea was estimated to a tune of 40.6% [5]. Among the pod borer complex infesting redgram heavy yield loss is due to *Helicoverpa armigera* (Hubner) because of its destructive nature [6]. It is estimated that the infestation of *H.armigera* one larva per plant on pigeon pea can cause yield loss of 1015 kg ha^{-1} [7]. The extent of losses due to *H. armigera* on pigeon pea is often highly variable across the localities. Despite all the drawbacks that come with chemical control of pests, there are still many reasons that can persuade farmers to still choose to use them. Regardless of several control strategies that were found effective in managing this pest the chemical control plays a vital role because of quick action, readily available and very easy to use unlike alternative methods, such as biological control and other similar methods which can take a long while to plan and often don’t have an immediate effect on pests [8]. In case of controlling pests over larger areas chemical management proves to be very cost effective besides economic benefits. If the practice of suggested insecticide at recommended dose is adapted against the targeted pest, there will low risks pertaining to resistance, resurgence and residual effect and offers effective management of the insect pest. A number of insecticides have been reported to be effective for controlling *H. armigera* on pigeonpea.

In recent years, newer compounds with novel modes of action are being evolved to check infestation by this insect pest [9]. Hence, the present investigation was conducted to compare efficacy of different insecticides against gram pod borer, *H. armigera* both in terms of reduction in larval population and also percent pod damage besides yield advantage over control.

2. Material and Methods

2.1 Study area

The Field experiments were conducted at Agricultural Research station, Garikapadu for two seasons during *Kharif*, 2016 and 2017 to determine the efficacy of certain insecticides in terms of suppressing the larval population and reduction of pod damage by *H.armigera* infesting redgram. The experiment was laid out in randomized block design (RBD) with seven treatments that were replicated thrice.

2.2 Treatments imposed

Seven treatments *viz*., Emamectin benzoate 5SG, Flubendamide 20WG, Chlorantraniliprole 20 SC, Thiodicarb 75% WP, Indoxacarb 14.5 SC, Novaluron 10 EC and untreated control were imposed in all three replications randomly. Total 21 plots of 5.4 m × 5.0 m size were sown with variety ICPL-85063 and spacing of 180 cm X 30 cm between plants and rows was maintained respectively. The crop was raised under rainfed conditions and only one protective irrigation was provided during the flowering stage of the crop. All the recommended agronomic practices *i.e*., fertilizer application, thinning, inter cultivation and weeding operations were practiced.

2.3 Data collected

Three spraying were made throughout the season at 50% flowering, pod initiation and 50% pod formation stages. The data on number of larvae/plant and percent pod damage with respect to imposition of various insecticides was recorded from ten randomly selected plants from each plot.

2.4 Statistical analysis

The recorded data was transformed and analysed using SPSS package. The percent reduction of larval population, pod damage and yield advantage over control was calculated.

3. Results

The pooled mean results revealed that the larval population per plant of *H.armigera* infesting redgram ranged from 1.04 to 10.92 and the percent pod damage varied from 1.86 to 13.51. All the insecticidal treatments were found significantly superior over control both in terms of suppressing the larval population and percent pod damage.

3.1Efficacy of insecticides against larval population of *H.armigera* infesting Redgram

The number of *H.armigera* larvae/plant ranged from 0.20 to 6.58 and 1.03 to 15.25 during *Kharif*, 2016 and 2017 respectively. All the insecticides exhibited significant superiority in suppressing the larval population. Among all the treatments, chlorantraniliprole 20 SC has recorded highest percent reduction over control with 82.81 and 74.2 percent during *Kharif*, 2016 and 2017 respectively (Table 1). During *Kharif*, 2016 chlorantraniliprole 20 SC harboured lower larval infestation (0.20 larvae/ plant) and is found on par with flubendamide 20 WG (0.25 larvae/ plant). The next better insecticide found effective in restraining the larval population was novaluron 10 EC (2.95 larvae/ plant) with only 33.20 percent reduction over control. Emamectin benzoate 5SG and indoxacarb 14.5 SC also found superior over control and on par to each other in harbouring larva population of 3.55 and 5.30 larvae/plant with 25.78 and only 10.15 percent reduction over control respectively as against untreated control with maximum larval population (6.58 larvae/plant).

Similar trend was noticed during *Kharif*, 2017 where chlorantraniliprole 20 SC has recorded lower larval infestation (1.03 larvae/plant) exhibiting 74.62 percent reduction over control and found on par in harbouring larval population with flubendamide 20 WG (1.83 larvae/ plant), indoxacarb 14.5 SC (2.68 larvae/plant), emamectin benzoate 5SG (2.95 larvae/plant) and thiodicarb 75%WP (4.52 larvae / plant) recording 66.21, 58.98, 56.95 and 46.58 percent reduction of larval population over control respectively.

3.2 Efficacy of insecticides against pod damage of *H.armigera* infesting Redgram

The mean data of *Kharif*, 2016 and 2017 revealed that the percent pod damage of *H.armigera* varied from 1.50 to 9.35 and 2.22 to 17.67 respectively. The highest percent pod damage was noticed in untreated control plots with 9.35 and 17.67 during *Kharif*, 2016 and 2017 respectively (Table 2). During *Kharif*, 2016 all the insecticides expressed significant difference among them and proved superior over control in reducing percent pod damage. Among all, chlorantraniliprole 20 SC showed lower percent pod damage (1.50) and highest percent reduction over control (60.50) of *H.armigera*. The other insecticides also exhibited superior reduction of pod damage over control and their efficacy order is flubendamide 20 WG (54.32%), emamectin benzoate 5SG (42.58%) > thiodicarb 75% WP (23.82%)> novaluron 10 EC (17.35)> indoxacarb 14.5 SC (8.90%). The percent pod damage due to *H.armigera* during *Kharif*, 2017 was recorded comparatively lower in plots treated with chlorantraniliprole 20 SC (2.22%) with 65.55 percent reduction over control and found on par with flubendamide 20 WG (2.60%) and emamectin benzoate 5SG (3.15%) with 62.67 and 58.87 percent reduction over control. The highest pod damage was noticed in untreated control plots with 17.67%.

3.3 Efficacy of insecticides against pod yield in Redgram

From Table. 3 it is evident that, the highest pod yield was observed in plots treated with chlorantraniliprole 20 SC and flubendamide 20 WG with 1592, 1538 and 1680, 1615 Kg ha^{-1} as against control with 985 & 1050 kg ha^{-1} during *Kharif*, 2016 and 2017 respectively. The pooled mean inferred that, chlorantraniliprole 20 SC (60.78%) and flubendamide 20 WG (54.93%) has recorded highest percent yield advantage over control. The other treatments in order of yield efficacy were indoxacarb 14.5 SC (46.73%) > emamectin benzoate 5SG (43.68%)> thiodicarb 75% WP (42.45%)> novaluron 10 EC (27.37%).

Table 1: Efficacy of insecticides against larval population of *Helicoverpa armigera* infesting redgram

Treatments	Dose/ ha	No. of Larvae/plant #					
		Kharif, 2016	% ROC	Kharif, 2017	% ROC	Mean	% ROC
T_1:Emamectin benzoate 5SG	250g	3.55 (1.9)[b]	25.78	2.95 (1.72) [a]	56.95	3.25 (1.80)	45.45
T_2: Flubendamide 20WG	150ml	0.25 (0.5) [a]	80.46	1.83 (1.35) [ab]	66.21	1.04 (1.02)	69.09
T_3:Chlorantraniliprole20 SC	150ml	0.20 (0.44) [a]	82.81	1.03 (1.02) [a]	74.62	0.62 (0.78)	76.36
T_4: Thiodicarb 75% WP	500g	4.20 (2.04) [b]	20.31	4.52 (2.13) [a]	46.58	4.36 (2.09)	36.66
T_5: Indoxacarb 14.5 SC	500ml	5.30 (2.30)	10.15	2.68 (1.64) [bc]	58.98	3.99 (2.00)	39.39
T_6: Novaluron 10 EC	500ml	2.95 (1.71)	33.20	6.73 [c] (2.59)	34.57	4.84 (2.22)	32.72
T_7: Control	-	6.58 (2.56)		15.25 (3.91)		10.915 (3.30)	-
Ftest		Sig		Sig			
CD(0.05)		0.17		1.51			
CV%		14.4		11.89			

Table 2: Efficacy of insecticides against percent pod damage of *Helicoverpa armigera* infesting redgram

Treatments	Dose/ ha	Percent pod damage*					
		Kharif, 2016	% ROC	Kharif, 2017	% ROC	Mean	% ROC
T_1:Emamectin benzoate 5SG	250g	3.15 (10.22)	42.58	3.15 (10.22) [ac]	58.87	3.15 (10.22)	52.61
T_2: Flubendamide 20WG	150ml	2.00 (8.13)	54.32	2.60 (9.28) [ab]	62.67	2.30 (8.72)	59.57
T_3:Chlorantraniliprole20 SC	150ml	1.50 (7.03)	60.50	2.22 (8.56) [a]	65.55	1.86 (7.84)	63.65
T_4: Thiodicarb 75% WP	500g	5.50 (13.56)	23.82	4.88 (12.76) [c]	48.66	5.19 (13.17)	38.94
T_5: Indoxacarb 14.5 SC	500ml	7.80 (16.21)	8.9	4.18 (11.79) [b]	52.56	5.99 (14.17)	34.30
T_6: Novaluron 10 EC	500ml	6.45 (14.71)	17.35	4.90 (12.79) [c]	48.55	5.675 (13.78)	36.11
T_7: Control	-	9.35 (17.80)		17.67 (24.86)		13.51 (21.57)	-
Ftest		Sig		Sig			
CD(0.05)		1.07		2.64			
CV%		15.85		1.75			

*Arc-sine transformation #: square root transformation.

Table 3: Efficacy of insecticides against pod yield (Kg/ha) redgram

Treatments	Dose/ ha	Pod yield (Kg/ha)			
		Kharif, 2016	Kharif, 2017	Mean	% Increase in yield over control
T_1:Emamectin benzoate 5SG	250g	1292	1632	1462.0	43.68
T_2: Flubendamide 20WG	150ml	1538	1615	1576.5	54.93
T_3:Chlorantraniliprole20 SC	150ml	1592	1680	1636.0	60.78
T_4: Thiodicarb 75% WP	500g	1354	1545	1449.5	42.45
T_5: Indoxacarb 14.5 SC	500ml	1386	1600	1493.0	46.73
T_6: Novaluron 10 EC	500ml	1272	1320	1296.0	27.37
T_7: Control	-	985	1050	1017.5	
Ftest		Sig	Sig	Sig	
CD(0.05)		200.6	93.5	147.05	
CV%		11.2	13.5	12.35	

4. Discussions

The overall mean of both the years *i.e*., *Kharif*, 2016 and 2017 revealed that among all insecticides, the larval population of *H.armigera* infesting redgram was proven to be significantly lower in plots treated with chlorantraniliprole 20 SC @ 150ml ha^{-1} (0.62 larvae/plant) and flubendamide 20 WG @ 150ml ha^{-1} (1.04 larvae/plant) exhibiting 76.36 and 69.09 percent reduction of larval population over control respectively. The other insecticides in order of efficacy with respect to percent larval population reduction over control were emamectin benzoate 5SG (45.45%) > indoxacarb 14.5 SC (39.39%) > thiodicarb 75% WP (36.66%)> novaluron 10 EC (32.72). The results are in accordance with the findings of Sambath Kumar and his coworkers [10]. who stated the minimum larval population of *H. armigera* was recorded in chlorantraniliprole 18.5 SC @ 30 g a.i./ha (9.5 nos./ 10 plants) and indoxacarb

15.8 EC @ 73g a.i/ha (10.3 nos./ 10 plants) in comparison to untreated control (51.8. nos./ 10 plants). The findings of [11] inferred that indoxacarb 0.007 percent, spinosad 0.005 percent and emamectin benzoate 0.005 percent were found to be the most effective in reducing the gram pod borer population with 87.26 & 84.85, 84.16 & 82.47, 83.32 & 79.81 percent mortality at 3 and 7 days after spray application. Sreekanth and his co workers [9] also inferred that the number of *Helicoverpa* larvae per plant were lowest in plots treated with chlorantraniliprole 20 SC (0.43), flubendiamide 480 SC (0.59) and spinosad 45 SC (0.85) as against untreated control plot (4.17) with 89.7, 85.9 and 79.6 percent larval reduction over control, respectively. Similar findings of [12] indicated that the treatment of indoxacarb 0.0075% caused highest mortality (89 to 96%) of the *Helicoverpa* infesting redgram followed by spinosad 0.009% (86 to 95% mortality).

The overall mean of percent pod damage inferred that among six insecticides evaluated only three were found to be effective in controlling more than 50% percent pod damage of the pest *viz*., chlorantraniliprole 20 SC, flubendamide 20 WG and emamectin benzoate 5SG exhibiting 63.65, 59.57 and 52.61 percent reduction of pod damage over control respectively. The efficacy of thiodicarb 75% WP (38.94%) > novaluron 10 EC (36.11)> indoxacarb 14.5 SC (34.30%) were below 40% in reducing pod damage of *H.armigera* infesting redgram. The findings are in concurrence with results of [13] who inferred from their research trials that among various insecticides against pod borers infesting redgram rynaxypyr 18.5 SP @ 30 g a.i. ha^{-1} was most effective insecticide with least pod borer damage (5.59%) followed by indoxacarb 14.5 SC (7.58%) as against untreated control (10.40%). Similar findings by [11] support the present findings who reported that pod borer, *Helicoverpa* was lowest in plots treated with flubendiamide (1.16%), chlorantraniliprole (1.26%) and spinosad (1.92%) with 88.7, 87.7 and 81.2 percent reduction over control respectively wherein the maximum pod damage of 10.22% was recorded in control plots.

The increased yield over control was also found to be higher in plots treated with chlorantraniliprole 20 SC (60.78%), and flubendamide 20 WG (54.93%). The results are in close agreement with the inferred yield data by [14] who indicated that, rynaxypyr 18.5 SP was more effective against pigeonpea pod borers and reducing the pod damage with its novel properties that ultimately leads to increase in yield (7.60 q ha^{-1}) as against control (3.97 q ha^{-1}) and highest cost benefit ratio(1:1.72). The findings of [11] also support the results that highest grain yield was recorded in chlorantraniliprole treated plots (686.1 kg ha^{-1}) with 127.5 percent increase over control, followed by flubendiamide (595.8 kg ha^{-1}) and spinosad (589.0 kg/ha) with 97.6 and 95.3 percent increase over control respectively as against the minimum yield of 301.6 kg/ha in the untreated check. Similar studies by [12] indicated that Indoxacarb 0.0075% recorded significantly highest grain yield (1486 kg ha^{-1}) in comparison to control (778 kg ha^{-1}).

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6. Conclusion

From present study, it may be concluded that the application of insecticides chlorantraniliprole 20 SC and flubendamide 20 WG @ 150ml ha^{-1} was found effective for suppression of larval population to extenuate the pod damage and also recorded highest pod yield. Further, the increased yield over control was found to be higher in plots treated with chlorantraniliprole 20 SC and flubendamide 20 WG. Despite of some disadvantages in convention of insecticides there are some valid reasons that can persuade farmers to still choose the insecticides to combat the pest problems hence, the above two chemicals may be suggested for alternate application towards mitigating the losses of *H.armigera* in redgram.

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