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Evaluation of Ready Mix Insecticide Novaluron 5.25% + Indoxacarb 4.5% SC Against Pod Borer Complex in Pigeonpea

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ABSTRACT

A field experiment was conducted at Regional Agricultural Research Station, Warangal during *Kharif*, 2012-13 and *Kharif*, 2013-14 to evaluate the efficacy of ready mix insecticide novaluron 5.25% + indoxacarb 4.5% SC at three different doses (750, 825, 875 ml ha^{-1}) against *Helicoverpa armigera* (Hübner), *Maruca vitrata* (Geyer) and *Melanagromyza obtusa* (Malloch) in pigeonpea**.** Among the treatments *viz.*, novaluron 5.25% + indoxacarb 4.5% SC at three different doses of 750, 825, 875 ml ha^{-1}, novaluron 10% EC @ 750 ml ha^{-1}, indoxacarb 14.5% SC @ 400 ml ha^{-1} and lambda-cyhalothrin @ 500 ml ha^{-1}, novaluron 5.25 % + indoxacarb 4.5 % SC @ 875 ml ha^{-1} recorded lowest larval population of *H. armigera*, *M. vitrata*, lowest pod damage by *H. armigera*, *M. vitrata* and *M. obtusa* followed by novaluron 5.25 % + indoxacarb 4.5 % SC @ 825 ml ha^{-1}. Novaluron 5.25 % + indoxacarb 4.5 % SC @ 875 ml ha^{-1} recorded significantly higher yield closely followed by novaluron 5.25 % + indoxacarb 4.5 % SC @ 825 ml ha^{-1} with almost equal incremental benefit cost ratios.

Key words*: Helicoverpa armigera, Maruca vitrata, Melanagromyza obtusa*, Novaluron 5.25% + indoxacarb 4.5% SC, Pigeonpea.

Pigeonpea (*Cajanus cajan* L. Millsp.) is the second most important pulse crop in India after chickpea. Among the various constraints limiting pigeonpea production, insect pests are the major ones, with avoidable losses extending up to 78 per cent in India (Lateef and Reed, 1983). More than 200 species of insects have been found feeding on pigeonpea, although only a few of these cause significant and consistent damage to the crop (Lateef and Reed, 1990). Pod borers cause 60 to 90 per cent loss in grain yield under favourable conditions and damage of seed by pod fly ranged from 14.3 to 46.6 per cent (Lal *et al*., 1992). Gram pod borer (*Helicoverpa armigera*) and pod fly (*Melanagromyza obtusa)* cause adequate economic damage leading to very low yield levels of 500 to 800 kg ha^{-1} as against the potential yield of 1800 to 2000 kg ha^{-1} (Lal *et al*., 1997). A yield loss of 60 to 80 per cent was recorded due to pod fly, *M. obtusa* (Durairaj, 2006). Randhawa and Verma (2011) reported 26-28 per cent flower damage due to spotted pod borer, *Maruca vitrata* in pigeonpea crop. Management of these pests mainly relies on insecticides often excluding non-chemical methods of pest management. More often, insecticides form the only solution to sudden outbreak of pests. Several insecticides were tested for their bio-efficacy against these pests. However, indiscriminate application of insecticides is causing serious threat of insect resistance as well as residual effect. The development of resistance and resurgence has limited the application of single insecticides and resort to tank mixtures. However, tank mixtures implies several problems like lack of knowledge about the compatibility of the components, probability of overdose of diluents in the mixture (Rodriguez, *et al*., 2002), which can be overcome by promoting ready mix formulations. The present experiment was conducted to evaluate the bio-efficacy of ready mix insecticide novaluron 5.25% + indoxacarb 4.5% SC against pod borer complex in pigeonpea.

MATERIAL AND METHODS

The field experiment was conducted during *Kharif*, 2012-13 and *Kharif*, 2013-14 at Professor Jayashankar Telangana State Agricultural University (*formerly part of Acharya N.G. Ranga Agricultural University*), Regional Agricultural Research Station,Warangal. Pigeonpea crop (variety - WRG-53) was grown in black soil at a spacing of 120 x 20 cm, following all recommended

agronomic package of practices except plant protection measures. The experiment was laid out in Randomized Block Design with seven treatments (including untreated control) (Table 1) and three replications at an individual plot size of 24 sq. m. under each treatment.

First spray of the test insecticides was given at the time of sufficient infestation of pests with the help of hand operated knapsack sprayer and subsequently repeated at 10 days intervals. Water was sprayed in untreated control when treatments were imposed. Spray volume of 500 litres was used per hectare. The spray pump was flushed thoroughly with clean water every time before spraying next insecticide. Utmost care was taken to avoid spray drift from one treatment plot to another. Observations on larval population of gram pod borer (*H. armigera*) and spotted pod borer (*M. vitrata*) were recorded at pre-treatment as initial count before first spray and 1, 5, 7 and 10 days after each spray, on five randomly selected plants per plot and mean larval population per plant was arrived at. Mean larval population 1, 5, 7 and 10 days after the sprays was pooled and average of this across the sprays was taken for statistical analysis after affecting square root transformations. The per cent pod damage by different pod borer complex including pod fly (*M. obtusa*) was also recorded by collecting pods from five randomly selected plants/plot at harvest. Pods were segregated based on pod damage and per cent pod damage was calculated using the following formula:

$$\text{Per cent pod damage (\%)} = \frac{\text{Total number of affected pods/ 5 plants}}{\text{Total number of pods/ 5 plants}} \times 100$$

Pod yield from each plot was recorded at harvest and converted into Kg per hectare. Based on the yield, Incremental Benefit Cost Ratio (IBCR) of different treatments was also calculated.

To find the effect of the test product novaluron 5.25 % + indoxacarb 4.5 % SC at different doses against natural enemies, observations on spiders and coccinellids were recorded on five randomly selected plants per plot and mean population per plant was arrived 1, 5, 7, 10 days after spraying. Data across the three sprays was pooled and analyzed after affecting square root transformations.

RESULTS AND DISCUSSION

Efficacy against larval population of *H. armigera*

In general, incidence of gram pod borer was relatively lower during second year of testing. Initial infestation was uniformly distributed among all the treatments in the experimental plot. Observations on larval counts of gram pod borer before first spray ranged from 2.03 to 3.43 larvae per plant during *Kharif,* 2012-13 and from 0.57 to 1.17 larvae per plant during *Kharif,* 2013-14. During both the seasons, significant differences in larval population of gram pod borer were noticed among different treatments after 1, 5, 7 and 10 days after sprays with highest number of gram pod borer larvae per plant in untreated control plot. All the treatments were found to be superior over the un-treated control. Pooled data of three sprays during 2012-13 indicated significantly lowest larval population of *H. armigera* in the plots treated with novaluron 5.25% + indoxacarb 4.5% SC @ 875 ml ha^{-1} right from one day after spraying to ten days after spraying. The population was reduced to below economic injury level (0.76 per plant) on 1 day after spraying itself showing quick knock down effect. Supremacy of this chemical at 875 ml ha^{-1} persisted even till 10 days after spraying with 0.22 larvae per plant. However, novaluron 5.25% + indoxacarb 4.5% SC @ 825 ml ha^{-1} was significantly at par with novaluron 5.25% + indoxacarb 4.5% SC @ 875 ml ha^{-1} at 1, 3, 5, 7 and 10 days after sprays. Novaluron 10 % EC @ 750 ml ha^{-1} with 1.04 larvae per plant and indoxacarb 14.5% SC @ 400 ml ha^{-1} with 1.03 larvae per plant on 1 day after spraying were statistically at par with their combination product @ 825 ml ha^{-1} and 875 ml ha^{-1}. However, their efficacy decreased in the consequent days. Similar trend was noticed even during *Kharif,* 2013-14 (Table 2). *The results are in conformity with the findings of Ghosal et al., 2016 who reported that* novaluron 5.25% + indoxacarb 4.5% SC gave superlative effect over the sole insecticides novaluron, indoxacarb and standard check lambda-cyhalothrin against pigeonpea pod borer, *H. armigera* (Hubner). Novaluron 5.25% + indoxacarb 4.5% SC @ 875

Table 1. Treatment details for bio-efficacy studies.

Tr. No.	Treatments	Dose ha^{-1}	
		g *a.i.* ha^{-1}	Formulation (g or ml ha^{-1})
T_1	Novaluron 5.25% + indoxacarb 4.5% SC	(39.38+33.75)	750
T_2	Novaluron 5.25% + indoxacarb 4.5% SC	(43.31+37.13)	825
T_3	Novaluron 5.25% + indoxacarb 4.5% SC	(45.94+39.38)	875
T_4	Novaluron 10 % EC	75	750
T_5	Indoxacarb 14.5% SC	60	400
T_6	Lambda- cyhalothrin 5% EC	25	500
T_7	Un-treated control	-	-

ml ha^{-1} was recorded as best in managing *H. armigera* population up to harvesting period. The ready mix insecticide novaluron 5.25%+ indoxacarb 4.5% SC @ 825 ml ha^{-1} was effective against fruit borer complex in tomato with higher cost benefit ratio (Ghosal *et al.*, 2016). Das *et al.*, 2015 reported that mixed formulation of novaluron 5.25% + indoxacarb 4.5% SC was most effective than that of their sole formulation against *Helicoverpa armigera* in pigeonpea.

Efficacy against larval population of *M. vitrata*

Larval incidence of *M. vitrata* was low to moderate during the study period. During *kharif*, 2012-13, infestation was higher in second to fourth week of December when the crop was in pod development stage. During *Kharif*, 2013-14, infestation was higher right from initial spray period. Highest number of spotted pod borer larvae per plant was recorded in untreated control plot throughout the crop period during both the seasons.

Incidence of spotted pod borer before first spray ranged from 0.50 to 0.87 larvae per plant during *Kharif*, 2012-13 and from 2.27 to 4.17 per plant during *Kharif*, 2013-14 and were uniformly distributed among all the treatments in the experimental plot. Pooled data of three sprays indicated that significant differences in larval population of spotted pod borer were noticed among different treatments after spraying during both the seasons. All the treatments were found to be superior over the un-treated control. During first season, consequent to sprays, lowest population of *M. vitrata* (0.49 per plant) was recorded in the treatment novaluron 5.25% + indoxacarb 4.5% SC @ 875 ml ha^{-1} which was found on par with novaluron 5.25% + indoxacarb 4.5% SC @ 825 ml ha^{-1} (0.61 per plant). The insecticide combination at 875 ml ha^{-1} maintained lowest larval population of *M. vitrata* till 10 days after spray followed by that @ 825 ml ha^{-1}(Table 3). Even during second season, lowest larval count per plant was recorded in novaluron 5.25% + indoxacarb 4.5% SC @ 825-875 ml ha^{-1} right from 1 day after spraying to 10 days after spraying and were on par with each other. Since the insecticide combination is new, little information on its efficacy on spotted pod borer is available and hence efficacy of component insecticides is presented. Srihari and Patnaik (2006) reported that indoxacarb 0.0145% on blackgram was effective against *M. vitrata*. Chaithanya *et al.* (2013) reported that the efficacy of insecticides against *M. vitrata* (Geyer) in the descending order was: thiodicarb (1g l^{-1}) > spinosad (0.3 ml l^{-1}) > emamectin benzoate (0.1 g l^{-1}) > endosulfan (2 ml l^{-1}) > lambda-cyhalothrin (1 ml l^{-1}) > flubendiamide (0.1 ml l^{-1}) > rynaxypyr (0.25 ml l^{-1}) > Neem seed kernel extract (50g l^{-1}) > *Bacillus thuringiensis* (1 g l^{-1}).

Effect on Pod damage

Per cent pod damage by different borers was significantly lower in all the treatments than untreated control (Table 4) during both the seasons. During *Kharif*, 2012-13, pod damage by *H. armigera* was lowest in the treatment novaluron 5.25 % + indoxacarb 4.5 % SC @ 875 ml ha^{-1} (3.32 %), followed by 4.51 % in the treatment novaluron 5.25 % + indoxacarb 4.5 % SC @ 825 ml ha^{-1}, 5.48 % in novaluron 5.25 % + indoxacarb 4.5 %

Table 2. Efficacy of novaluron 5.25% + indoxacarb 4.5% SC against *Helicoverpa armigera* larvae in pigeonpea during *Kharif*, 2012-13 and *Kharif*, 2013-14 at RARS, Warangal.

Tr. No.	Treatments	Dose (ml ha^{-1})	Mean no. of larvae of *Helicoverpa armigera* per plant									
			2012-13					2013-14				
			Pre-count	1 DAS*	5 DAS*	7 DAS*	10 DAS*	Pre-count	1 DAS*	5 DAS*	7 DAS*	10 DAS*
T_1	Novaluron 5.25% + indoxacarb 4.5% SC	750	2.03 (1.73)	1.41 (1.55)	1.22 (1.49)	1.43 (1.56)	1.13 (1.46)	0.70 (1.30)	0.61 (1.27)	0.55 (1.25)	0.58 (1.26)	0.61 (1.27)
T_2	Novaluron 5.25% + indoxacarb 4.5% SC	825	3.43 (2.10)	0.77 (1.33)	0.17 (1.08)	0.26 (1.12)	0.26 (1.12)	0.63 (1.28)	0.48 (1.22)	0.31 (1.14)	0.29 (1.14)	0.32 (1.15)
T_3	Novaluron 5.25% + indoxacarb 4.5% SC	875	2.80 (1.94)	0.76 (1.32)	0.13 (1.06)	0.23 (1.11)	0.22 (1.11)	0.57 (1.25)	0.38 (1.18)	0.23 (1.11)	0.25 (1.12)	0.27 (1.13)
T_4	Novaluron 10 % EC	750	2.17 (1.87)	1.04 (1.43)	0.63 (1.28)	0.64 (1.28)	0.52 (1.23)	0.77 (1.33)	0.63 (1.28)	0.55 (1.25)	0.51 (1.23)	0.50 (1.23)
T_5	Indoxacarb 14.5% SC	400	2.83 (1.95)	1.03 (1.43)	0.54 (1.24)	0.60 (1.26)	0.44 (1.20)	0.70 (1.29)	0.56 (1.25)	0.51 (1.23)	0.47 (1.21)	0.48 (1.22)
T_6	Lambda-cyhalothrin 5% EC	500	2.60 (1.89)	1.51 (1.58)	1.00 (1.41)	1.14 (1.46)	0.99 (1.41)	1.10 (1.45)	1.01 (1.42)	0.92 (1.39)	0.86 (1.36)	0.89 (1.37)
T_7	Un-treated control		2.90 (1.97)	3.03 (2.01)	3.08 (2.02)	3.69 (2.15)	3.12 (2.03)	1.17 (1.47)	1.31 (1.52)	1.37 (1.54)	1.41 (1.55)	1.44 (1.56)
	S.Em ±		-	(0.04)	(0.02)	(0.05)	(0.02)	-	(0.02)	(0.01)	(0.01)	(0.01)
	CD (P=0.05)		NS	(0.13)	(0.06)	(0.17)	(0.05)	NS	(0.05)	(0.03)	(0.02)	(0.02)

DAS– Days after spray; NS – Non Significant; Figures in parentheses are SQRT transformations; *Pooled data of 3 sprays

Table 3. Efficacy of novaluron 5.25% + indoxacarb 4.5% SC against *Maruca vitrata* larvae in pigeonpea during *Kharif*, 2012-13 and *Kharif*, 2013-14 at RARS, Warangal.

Tr. No.	Treatments	Dose (ml ha^{-1})	Mean no. of larvae of *Maruca vitrata* per plant									
			2012-13					2013-14				
			Pre-count	1 DAS*	5 DAS*	7 DAS*	10 DAS*	Pre-count	1 DAS*	5 DAS*	7 DAS*	10 DAS*
T_1	Novaluron 5.25% + indoxacarb 4.5% SC	750	0.70 (1.30)	0.79 (1.34)	0.72 (1.31)	0.72 (1.31)	0.70 (1.30)	2.27 (1.80)	0.99 (1.41)	0.93 (1.39)	0.79 (1.31)	0.77 (1.33)
T_2	Novaluron 5.25% + indoxacarb 4.5% SC	825	0.73 (1.32)	0.61 (1.27)	0.40 (1.18)	0.39 (1.18)	0.43 (1.20)	3.37 (2.07)	0.73 (1.32)	0.47 (1.21)	0.23 (1.18)	0.27 (1.13)
T_3	Novaluron 5.25% + indoxacarb 4.5% SC	875	0.50 (1.22)	0.49 (1.22)	0.32 (1.15)	0.30 (1.14)	0.36 (1.17)	2.73 (1.91)	0.71 (1.31)	0.42 (1.19)	0.20 (1.14)	0.23 (1.11)
T_4	Novaluron 10 % EC	750	0.87 (1.35)	0.82 (1.35)	0.70 (1.30)	0.69 (1.30)	0.68 (1.30)	2.47 (1.86)	0.97 (1.40)	0.77 (1.33)	0.48 (1.30)	0.49 (1.22)
T_5	Indoxacarb 14.5% SC	400	0.87 (1.35)	0.77 (1.33)	0.60 (1.27)	0.59 (1.26)	0.64 (1.28)	2.70 (1.89)	0.87 (1.37)	0.71 (1.31)	0.41 (1.26)	0.52 (1.23)
T_6	Lambda-cyhalothrin 5% EC	500	0.83 (1.35)	0.83 (1.35)	0.73 (1.32)	0.67 (1.29)	0.69 (1.30)	4.17 (2.22)	1.12 (1.46)	0.86 (1.36)	0.54 (1.29)	0.63 (1.28)
T_7	Un-treated control		0.87 (1.37)	1.50 (1.58)	1.59 (1.61)	1.62 (1.62)	1.72 (1.65)	3.00 (1.99)	2.88 (1.97)	2.61 (1.90)	2.68 (1.62)	2.49 (1.87)
	S.Em ±		-	(0.02)	(0.01)	(0.01)	(0.01)	-	(0.02)	(0.01)	(0.01)	(0.01)
	CD (P=0.05)		NS	(0.07)	((0.03)	(0.03)	(0.04)	NS	(0.08)	(0.03)	(0.03)	(0.03)

DAS– Days after spray; NS – Non Significant; Figures in parentheses are SQRT transformations; *Pooled data of 3 sprays

Table 4. Effect of novaluron 5.25% + indoxacarb 4.5% SC on per cent pod damage by different borers in pigeonpea during *Kharif*, 2012-13 and 2013-14 at RARS, Warangal.

Tr. No.	Treatments	Dose (ml ha^{-1})	*Kharif*, 2012-13			*Kharif*, 2013-14		
			Per cent pod damage			Per cent pod damage		
			H. armigera	*M. vitrata*	*M. obtusa*	*H.armigera*	*M. vitrata*	*M. obtusa*
T_1	Novaluron 5.25% + indoxacarb 4.5% SC	750	5.48 (13.26)	0.52 (4.09)	19.10 (25.90)	0.41 (3.53)	0.84 (5.20)	0.42 (3.02)
T_2	Novaluron 5.25% + indoxacarb 4.5% SC	825	4.51 (11.96)	0.17 (2.35)	19.03 (25.85)	0.19 (2.46)	0.94 (5.37)	0.56 (4.24)
T_3	Novaluron 5.25% + indoxacarb 4.5% SC	875	3.32 (10.26)	0.15 (2.22)	17.73 (24.86)	0.12 (1.61)	0.52 (4.07)	0.75 (4.81)
T_4	Novaluron 10 % EC	750	7.17 (15.30)	0.30 (3.05)	22.36 (28.08)	0.38 (3.44)	0.91 (5.45)	1.11 (5.62)
T_5	Indoxacarb 14.5% SC	400	7.97 (16.38)	0.31 (3.13)	25.39 (30.25)	0.57 (4.24)	1.04 (5.69)	0.68 (4.73)
T_6	Lambda-cyhalothrin 5% EC	500	12.14 (20.37)	0.58 (4.33)	34.35 (35.86)	1.99 (7.96)	3.39 (10.57)	0.57 (4.32)
T_7	Un-treated control		19.10 (25.87)	0.61 (4.46)	41.86 (40.30)	2.23 (8.57)	4.23 (11.79)	0.93 (5.00)
	S.Em ±		(1.65)	(0.30)	(1.57)	(0.70)	(0.81)	-
	CD (P=0.05)		(5.08)	(1.20)	(4.84)	(2.16)	(2.51)	NS

NS – Non Significant; Figures in parentheses are Arc Sin transformations

SC @ 750 ml ha^{-1}, 7.17 % in novaluron10% EC @ 750 ml ha^{-1} which were found superior over rest of the treatments. Similar result was obtained even during *Kharif*, 2013-14. Suhas *et al*. (1999) reported that application of indoxacarb 14.5 SL @ 50 g *a.i.*/ha was very effective in bringing down the pod damage (23.1 %) by *H. armigera* in pigeonpea. Yogeeswarudu and Venkata Krishna (2014) in their findings concluded that novel insecticides indoxacarb and novaluron can manage *Helicoverpa* up to 95.83 per cent and 87.12 per cent, respectively, in chickpea.

During *Kharif*, 2012-13, pod damage by *M. vitrata* was lowest in the treatment novaluron 5.25 % + indoxacarb 4.5 % SC @ 875 ml ha^{-1} (0.15 %), followed by 0.17 % in the treatment novaluron 5.25 % + indoxacarb 4.5 % SC @ 825 ml ha^{-1}, 0.30 % in novaluron10% EC@ 750 ml ha^{-1},0.31 % in indoxacarb 14.5% SC @ 400 ml ha^{-1} which were at par with each other. Similar result was obtained even during *Kharif*, 2013-14, wherein pod damage by *M. vitrata* in the treatment novaluron 5.25 % + indoxacarb 4.5 % SC @ 875 ml ha^{-1} was 0.52%. Spinosad 45 SC @ 0.4 ml l^{-1} and indoxacarb 14.5 SC @ 1.0 ml l^{-1} resulted in lowest pod damage of 8.5 and 11.8 per cent, repectively, by spotted pod borer in pigeonpea and highest grain yield of 795 and 688 kg ha^{-1}, respectively (Rao, *et al*., 2007).

Pod damage by pod fly was lowest in novaluron 5.25 % + indoxacarb 4.5 % SC @ 875 ml ha^{-1} (17.73 %) followed by the same chemical at doses of 825 ml ha^{-1} and 750 ml ha^{-1} during *Kharif*, 2012-13. However, during *Kharif*, 2013-14, incidence of pod fly was negligible and non-significant (Table 4) Das, 2001 reported that significantly reduction in pod borer and pod fly damge with ready mix formulations (cyperphos, endophos and spark) of insecticides during 1997-99.

Table 5. Incremental Benefit Cost ratio (IBCR) of different treatments used for control of pod borers in pigeonpea at RARS, Warangal.

Tr. No.	Treatments	Dose (ml ha^{-1})	Cost of Insecticidal sprays	*Kharif*, 2012-13					*Kharif*, 2013-14				
				Yield		Additional yield over control (Kg)	Incremental income over control (Rs.)	IBCR	Yield		Additional yield over control (Kg)	Incremental income over control (Rs.)	IBCR
				Kg/plot	Kg ha^{-1}				Kg/plot	Kg ha^{-1}			
T_1	Novaluron 5.25% + indoxacarb 4.5% SC	750	6705.0	3.345	1394	214	7,062	1.05	4.345	1810	378	14,364	2.14
T_2	Novaluron 5.25% + indoxacarb 4.5% SC	825	7285.5	3.918	1633	453	14,949	2.05	5.185	2160	728	27,664	3.80
T_3	Novaluron 5.25% + indoxacarb 4.5% SC	875	7672.5	3.962	1651	471	15,543	2.02	5.280	2200	768	29,184	3.80
T_4	Novaluron 10 % EC	750	8878.5	3.367	1403	223	7,359	0.83	4.821	2009	577	21,926	2.47
T_5	Indoxacarb 14.5% SC	400	4752.0	3.336	1390	210	6,930	1.46	4.467	1861	429	16,302	3.43
T_6	Lambda-cyhalothrin 5% EC	500	1687.5	2.875	1198	18	594	0.35	3.736	1557	125	4,750	2.81
T_7	Un-treated control		-	2.833	1180	-	-	-	3.436	1432	-	-	-
	S.Em ±			0.14					0.08				
	CD (P=0.05)			0.44					0.26				

Market Cost : Novaluron 5.25% + indoxacarb 4.5% SC – Rs. 2580/l
Indoxacarb 14.5% SC – Rs. 3210/l
Novaluron 10 % EC – Rs. 3546/l
Lambda - cyhalothrin 5% EC – Rs. 525/l

Market Price : Pigeonpea – Rs. 33/- per Kg (March, 2013) ; Rs. 38/- per Kg (March, 2014)

Labour cost : Insecticide application – Rs. 300/ha

Table 6. Effect of novaluron 5.25% + indoxacarb 4.5% SC against spiders in pigeonpea ecosystem during *Kharif*, 2012-13 and 2013-14 at RARS, Warangal.

Tr. No.	Treatments	Dose (ml ha^{-1})	Mean no. of spiders per plant									
			Kharif 2012-13					*Kharif* 2013-14				
			Pre-count	1 DAS*	5 DAS*	7 DAS*	10 DAS*	Pre-count	1 DAS*	5 DAS*	7 DAS*	10 DAS*
T_1	Novaluron 5.25% + indoxacarb 4.5% SC	750	0.20 (1.10)	0.02 (1.10)	0.09 (1.04)	0.06 (1.03)	0.01 (1.01)	0.10 (1.05)	0.28 (1.13)	0.11 (1.06)	0.17 (1.08)	0.07 (1.03)
T_2	Novaluron 5.25% + indoxacarb 4.5% SC	825	0.10 (1.05)	0.02 (1.10)	0.07 (1.03)	0.10 (1.05)	0.08 (1.04)	0.10 (1.05)	0.21 (1.10)	0.09 (1.04)	0.11 (1.05)	0.06 (1.03)
T_3	Novaluron 5.25% + indoxacarb 4.5% SC	875	0.17 (1.08)	0.03 (1.02)	0.04 (1.02)	0.07 (1.03)	0.20 (1.01)	0.20 (1.10)	0.17 (1.08)	0.08 (1.04)	0.09 (1.04)	0.14 (1.07)
T_4	Novaluron 10 % EC	750	0.03 (1.02)	0.01 (1.01)	0.04 (1.02)	0.04 (1.02)	0.03 (1.02)	0.13 (1.06)	0.13 (1.07)	0.12 (1.06)	0.14 (1.07)	0.09 (1.04)
T_5	Indoxacarb 14.5% SC	400	0.17 (1.08)	0.04 (1.02)	0.12 (1.06)	0.07 (1.03)	0.03 (1.02)	0.00 (1.00)	0.14 (1.07)	0.14 (1.07)	0.08 (1.04)	0.06 (1.03)
T_6	Lambda-cyhalothrin 5% EC	500	0.07 (1.03)	0.04 (1.02)	0.07 (1.03)	0.04 (1.02)	0.20 (1.01)	0.03 (1.02)	0.13 (1.06)	0.06 (1.03)	0.06 (1.03)	0.07 (1.03)
T_7	Un-treated control		0.13 (1.06)	0.03 (1.02)	0.07 (1.03)	0.04 (1.02)	0.04 (1.02)	0.13 (1.06)	0.12 (1.06)	0.02 (1.01)	0.06 (1.03)	0.07 (1.03)
	S.Em ±		-	-	-	-	(0.01)	-	-	-	-	-
	CD (P=0.05)		NS	NS	NS	NS	(0.02)	NS	NS	NS	NS	NS

DAS– Days after spray; NS – Non Significant; Figures in parentheses are SQRT transformations; *Pooled data of 3 sprays

Table 7. Effect of novaluron 5.25% + indoxacarb 4.5% SC against coccinellids in pigeonpea ecosystem during *Kharif*, 2012-13 and 2013-14 at RARS, Warangal.

Tr. No.	Treatments	Dose (ml ha^{-1})	Mean no. of coccinellids per plant									
			Kharif 2012-13					*Kharif* 2013-14				
			Pre-count	1 DAS*	5 DAS*	7 DAS*	10 DAS*	Pre-count	1 DAS*	5 DAS*	7 DAS*	10 DAS*
T_1	Novaluron 5.25% + indoxacarb 4.5% SC	750	0.13 (1.06)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.07 (1.03)	0.07 (1.03)	0.08 (1.04)	0.04 (1.02)	0.04 (1.02)
T_2	Novaluron 5.25% + indoxacarb 4.5% SC	825	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.07 (1.03)	0.07 (1.03)	0.02 (1.01)	0.01 (1.01)	0.04 (1.02)
T_3	Novaluron 5.25% + indoxacarb 4.5% SC	875	0.03 (1.02)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.01 (1.01)	0.07 (1.03)	0.06 (1.03)	0.06 (1.03)	0.03 (1.02)	0.06 (1.03)
T_4	Novaluron 10 % EC	750	0.03 (1.02)	0.01 (1.01)	0.00 (1.00)	0.01 (1.01)	0.00 (1.00)	0.10 (1.05)	0.06 (1.03)	0.03 (1.02)	0.02 (1.01)	0.02 (1.01)
T_5	Indoxacarb 14.5% SC	400	0.13 (1.06)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.07 (1.03)	0.04 (1.02)	0.06 (1.03)	0.03 (1.02)
T_6	Lambda-cyhalothrin 5% EC	500	0.03 (1.02)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.03 (1.02)	0.08 (1.04)	0.07 (1.03)	0.07 (1.03)	0.06 (1.03)
T_7	Un-treated control		0.07 (1.03)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.01 (1.01)	0.07 (1.03)	0.10 (1.05)	0.06 (1.03)	0.01 (1.01)	0.06 (1.03)
	S.Em ±		-	-	-	-	-	-	-	-	-	-
	CD (P=0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

DAS– Days after spray; NS – Non Significant; Figures in parentheses are SQRT transformations; *Pooled data of 3 sprays

Effect on Yield

In general, yields were higher during second year of testing, *Kharif*, 2013-14 because of lower pest load especially that of *H. armigera*, pod fly and congenial weather conditions for crop growth and yield. During both the seasons, all the insecticide treatments recorded significantly higher yield than un-treated control (Table 5). During *Kharif* 2012-13, highest yield of 1651 kg/ha was recorded from the treatment novaluron 5.25 % + indoxacarb 4.5 % SC @ 875 ml ha^{-1} followed by novaluron 5.25 % + indoxacarb 4.5 % SC @ 825 ml ha^{-1} (1633 Kg/ha) which was on par with it. During *Kharif* 2013-14, highest yield of 2200 kg/ha was recorded from the treatment novaluron 5.25 % + indoxacarb 4.5 % SC @ 875 ml ha^{-1} followed by novaluron 5.25 % + indoxacarb 4.5 % SC @ 825 ml ha^{-1} (2160 Kg/ha) which was on par with it. Highest incremental benefit cost ratio of 2.05-3.80 was recorded in novaluron 5.25 % + indoxacarb 4.5 % SC @ 825 ml ha^{-1} followed by the treatment novaluron 5.25 % + indoxacarb 4.5 % SC @ 875 ml ha^{-1} (2.02-3.80). The present results are in agreement with *Ghosal et al.(2016) who reported that* novaluron 5.25% + indoxacarb 4.5% SC @ 875 ml ha^{-1} gave maximum yield of 23.40 q ha^{-1} followed by novaluron 5.25% + indoxacarb 4.5% SC @ 825 ml ha^{-1} (22.98 q ha^{-1}) with remarkable effect on *H. armigera* .

Effect on natural enemies

Observations on spiders and coccinellids before and after sprays indicated that there was no statistically significant variation among various treatments and untreated control and the population was uniformly distributed throughout the experimental plot during both the seasons. Thus, the test product was found safe to spiders and coccinellids as their population was similar to that of market standards and un-treated control (Tables 6 and 7). Kambrekar *et al.*, 2012 reported that novel insecticides like indoxacarb being target specific to lepidopteran pests could not affect the natural enemies. Olszak *et al.*, 2004 reported that novaluron neither reduced the longevity nor the fecundity of females of both of *Coccinella septempunctata* fed on aphids contaminated with novaluron. Both novaluron and indoxacarb are safe to non target organisms and quickly degraded to non toxic products. So, it can be assumed that their pre mix formulated product novaluron 5.25% + indoxacarb 4.5% SC also would be safe towards the non targets.

The present ready mix insecticide is a combination of novaluron and indoxacarb wherein novaluron acts by inhibiting chitin biosynthesis resulting in abortive moulting, indoxacarb causes rapid cessation of feeding and paralysis by blockage of axonal sodium channel and their pre mix may pronounce synergistic effect over their individual effect, which is reflected in the present study also. Thus, it can be concluded that spraying of ready mix insecticide novaluron 5.25 % + indoxacarb 4.5 % SC @ 875 ml ha^{-1} at 10 days interval thrice, very effectively reduced the infestation of pod borer complex after every spraying and recorded significantly highest yield closely followed by the ready mix insecticide @ 825 ml ha^{-1} with almost equal IBCRs. The test product was also found safe to spiders and coccinellids.

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