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Bio-efficacy of new combination formulation against *Helicoverpa armiger* on groundnut

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Abstract
A field experiment to study the Bio-efficacy of new combination formulation against *Helicoverpa armiger* on Groundnut (*Arachis hypogea* L.) was studied during September to December 2014, at Research farm, oilseeds research station, Latur. Groundnut crop was infested by *Helicoverpa armiger*. The experiment was laid out in randomized block design with seven treatment and three replications with view to find out the effective insecticide's combination formulation and it's most effective dose against *Helicoverpa armiger* of groundnut. Variety Phule Pragati (JL-24) was sown in September. The insecticide and combination formulation used for the treatment were Novaluron 5.25% + Indoxacarb 4.5% SC @ 825 ml/ha Novaluron 5.25% + Indoxacarb 4.5% SC @ 875 ml/ha, Novaluron 5.25% + Indoxacarb 4.5% SC @ 925 ml/ha, Novaluron 10% EC @ 750 ml/ha, Indoxacarb 14.5% SC @ 400 ml/ha, Methomyl 40% SP @ 850 g/ha, along with one untreated control. The results of present investigation clearly showed that the Novaluron 5.25 + Indoxacarb 4.5% SC @ 875 & 925 ml/ha is equally effective in lowering the infestation of *H. armiger*. Further, protection with the chemical pesticide, Novaluron 5.25 + Indoxacarb 4.5% SC (@ 875 & 925 ml/ha) produced groundnut yield with cost benefit ratio comparable to recommended chemical insecticides.

Keywords: *Helicoverpa armiger*, groundnut and novaluron 5.25% + Indoxacarb 4.5% SC

Introduction
Groundnut (*Arachis hypogea*) is an important oilseed and supplementary food crop of the world. It is also known as Indian Almond and eaten as roasted or boiled. After the oil extraction groundnut cake is a high protein animal feed and haulm provides quality fodder. A variety of value products like peanut butter, chikki, milk, burfi, bhujia and biscuits are made from groundnut. The groundnut shell used in industries as fuel, filler in fertilizers and in extraction of mustard facilitates better recovery and low energy consumption. India ranks first both in area and production, however its productivity (1257 kg/ha) is quite low as compared to many groundnut producing countries like USA, China and Myanmar. It is grown in India during the *Kharif, Rabi* and summer seasons using a variety of cropping techniques. The largest groundnut producing states are Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Rajasthan, and Maharashtra. Constituting and contributing around 80percent of area and production, respectively. Furthermore, groundnut is grown in the states of Odisha and Madhya Pradesh. In India, there are more than 6.16 million hectares of groundnut crops, producing 7.17 million tons annually. Groundnut yields are often higher in *Rabi* (1600 kg/ha) than in *Kharif* (1000 kg/ha). (NICRA team of Groundnut Pest Surveillance, 2011) [9].
The main causes of poor output in rain-fed groundnut farming are attacks by a variety of insect pests and diseases. As the crop and its pests are sensitive to extreme weather events, the crop productivity is determined by the interplay of weather and pests in a given season. Considering the importance of the groundnut grown across Indian cropping systems as an edible oilseed and its associated role in food and livelihood security, A plan to study groundnut pest dynamics through surveillance integrating geographical, field, crop, agronomical and pest management practices is essential Low productivity of groundnut in India is due to many reasons of which, rainfed cultivation, erratic or low rainfall, drought, soil salinity, continuous use of popular old cultivars coupled with attack by a variety of diseases and insect-pests are important. (NICRA team of Groundnut Pest Surveillance, 2011 & Annual groundnut report, 2015) [9].
The biggest threat to groundnut cultivation is the vulnerable widespread attack by more than 115 insects have been reported to occur on groundnut in India and few are quite destructive and reduce the yield considerably.

The crop annually incurs losses amounting to Rs. 238 Crores due to insect-pests and diseases (Dutta *et al.*, 2020). Insect pests of groundnut causes damage in both field and storage conditions. Of these, *Spodoptera litura*, *Aproaerema modicella*, white grub, thrips, aphid, jassids, gram caterpillar, red hairy caterpillar and termites are found to be economically important. Possible yield losses due to *A. modicella* are estimated 49.56 percent, Jassids 40 percent, aphid 16- 40 percent, thrips 17-40 percent, red hairy caterpillar 26-75 percent. *Helicoverpa armiger* is one of the important pests which is polyphagous and occur regularly in the field. *Armiger* and *S. litura* causes about 26 to 100% yield loss under field conditions (Dhir *et al*., 1992). *H. armiger* and *S. litura* are reported to cause damage on more than 180 crops (Islam *et al*., 2007). Therefore, present investigation was carried out with objective to study the effect on bio-efficacy of Novaluron 5.25% + Indoxacarb 4.5% SC formulation against the *H. armiger* and to study the influence of treatments on pod yield of groundnut.

Materials and Methods

A field experiment to study the bio-efficacy of new combination formulation against *Helicoverpa armiger* on Groundnut (*Arachis hypogea* L.) was studied during September to December 2014, at Research farm, oilseeds research station, Latur. The experiment was laid out in randomized block design with seven treatment and three replications with view to find out the effective insecticide's combination formulation and it's most effective dose against *Helicoverpa armiger* of groundnut. Variety Phule Pragati (JL-24) was sown in September. The insecticide and combination formulation used for the treatment were Novaluron 5.25% + Indoxacarb 4.5% SC @ 825 ml/ha, Novaluron 5.25% + Indoxacarb 4.5% SC @ 875 ml/ha, Novaluron 5.25% + Indoxacarb 4.5% SC @ 925 ml/ha, Novaluron 10% EC @ 750 ml/ha, Indoxacarb 14.5% SC @ 400 ml/ha, Methomyl 40% SP @ 850 g/ha, along with one untreated control. Groundnut crop was sown a gross plot of 4m x 5m maintaining net plot of 3.6 m x 4.8 m. The row-to-row distance of 30 cm and plant to plant distance of 15 cm was maintained. The dose of fertilizer at the rate of 20 kg N, 40 kg P_2O_5 and 40 kg K_2O per hectare was given at the time of sowing. The crop was grown under protective irrigation. Treatments were applied on appearance of *H. armiger* and subsequent spray were given at 15 days interval using manually operated knapsack sprayer. The observations on total number of *H. armiger* larvae were recorded per five plants from each on top, middle and bottom leaves of five randomly selected plants from each treatment at before spray and 1, 5, 7 and 10 days after each spray. The insect pest population was recorded on randomly selected 20 plants per treatment first and second application of insecticides. The data was analyzed for statistical significance.

Table 1: Treatment details

Treatments	a. i. (g)	Dosages /ha	
		Formulation (ml)	Water volume (Lit)
T_1- Novaluron 5.25 + Indoxacarb 4.5% SC	(43.31+37.13)	825	500
T_2-Novaluron 5.25 + Indoxacarb 4.5% SC	(45.94+39.38)	875	
T_3-Novaluron 5.25 + Indoxacarb 4.5% SC	(48.56+41.63)	925	
T_4 - Novaluron 10% EC	75	750	
T_5 -Indoxacarb 14.5% SC	60	400	
T_6 - Methomyl 40% SP	350	850	
T_7-Untreated control	-	-	-

Results and Discussion

Data on population of Gram pod borer *Helicoverpa armigera* larvae on groundnut after first spray related to effect of different insecticides formulation after first spray are presented in Table 2 and depicted in Fig. 1. no significant differences were observed among various treatments before one day of the spray. The results revealed that all the insecticides and insecticides formulation were found significantly superior over untreated control in reducing population of *H. armiger* larvae at 1,5,7, and 10 days after spray. At one day after first spray, significantly minimum population of *H. armiger* larvae (3.35 larvae/five plant) was recorded from the plots treated with treatment T_2 i.e., Novaluron 5.25 + Indoxacarb 4.5% SC @ 875 ml/ha. The next effective treatment was treatment T_3 Novaluron 5.25 + Indoxacarb 4.5% SC @ 925 (3.36 larvae/five plant) which was followed by treatment T_5 Indoxacarb 14.5% SC @ 400 ml/ha (3.48 larvae/five plant), T_4 Novaluron 10% EC @ 750 ml/ha (3.50 larvae/five plant) in reducing *H. armiger* larvae population. All these treatments were found statistically at par with each other. The subsequent order of effectiveness was treatment T_1 Novaluron 5.25 + Indoxacarb 4.5% SC @ 825 (3.66 larvae/five plant) and treatment T_6 - Methomyl 40% SP @ 0.1 percent (3.67 *H. armiger* larvae/five plant). Both these treatments were found statistically at par with each other. Significantly highest *H. armiger* population (3.88 larvae/five plant) was observed in treatment T_7 i.e., untreated control. At five days after first spray it was observed that the treatment T_3 i.e. Novaluron 5.25 + Indoxacarb 4.5% SC @ 925 (3.36 larvae/five plant) found most effective. The next effective treatment was treatment T_2 Novaluron 5.25 + Indoxacarb 4.5% SC @ 875 (2.86 larvae/five plant) in reducing *H. armiger* larvae population. Both these T_3 and T_2 treatments were found statistically at par with each other. The subsequent order of effectiveness was treatment T_5 Indoxacarb 14.5% SC @ 400 ml/ha (3.34 larvae/five plant), T_4 Novaluron 10% EC @ 750 ml/ha (3.40 larvae/five plant), T_6 - Methomyl 40% SP @ 0.1 percent (3.52 larvae/five plant) and T_1 Novaluron 5.25 + and Indoxacarb 4.5% SC @ 825 (3.62 larvae/five plant). All these treatments were statistically at par with each other. While the highest *H. armiger* population of 3.80 *H. armiger* larvae/five plant was recorded in treatment T_7 i.e., untreated control. At seven days after first spray, significantly lowest population of *H. armiger* larvae (2.24 *H. armiger* larvae/five plant) was observed in the plots treated with treatment T_3 i.e., Novaluron 5.25 + Indoxacarb 4.5% SC @ 925 which was observed significantly effective in minimizing *Helicoverpa armiger* larvae population. The next effective treatment was treatment T_2 i.e., Novaluron 5.25 + Indoxacarb 4.5% SC @ 875 ml/ha (2.30 *H. armiger* larvae/five plant) and both these

treatments were found statistically at par with each other. And next treatments in order of their effectiveness were T_5 Indoxacarb 14.5% SC @ 400 ml/ha, T_4 Novaluron 10% EC @ 750 ml/ha, T_6 - Methomyl 40% SP @ 0.1 percent and T_1 Novaluron 5.25 + and Indoxacarb 4.5% SC @ 825 in reducing *H. armigera* larvae population. The highest pest infestation was recorded in the treatment of untreated control (4.98 larvae/five plant). At 10 days after first spray T_3 i.e. Novaluron 5.25 + Indoxacarb 4.5% SC @ 925 (2.12 larvae/five plant) found most effective. The next effective treatment was treatment T_2 Novaluron 5.25 + Indoxacarb 4.5% SC @ 875 (2.22 larvae/five plant) in reducing *H. armiger* larvae population. Both these treatments were found statistically at par with each other. The next effective treatment was T_5 Indoxacarb 14.5% SC @ 400 ml/ha, T_4 Novaluron 10% EC @ 750 ml/ha, T_6 - Methomyl 40% SP @ 0.1 percent and T_1 Novaluron 5.25 + and Indoxacarb 4.5% SC @ 825 in reducing *H. armiger* larvae population. These T_5, and T_4 were at par with each other. The highest population of *H. armiger* larvae (5.52 larvae/five plant) was recorded in treatments T_7 i.e., untreated control. Thus, after first spray it can be concluded that the *H. armiger* larvae population was remained higher up to initial five days after spray and thereafter the population slowly decreased. Also, the plots treated with Novaluron 5.25 + Indoxacarb 4.5% SC @ 925 recorded significantly lowest population of *H. armiger* larvae on groundnut to at 1, 5, 7 and 10 days after spraying and found effective over rest of the treatments. More or less similar trend of effectiveness was observed after second spray and as the pest population was still there thir spray was imposed and it was observed that There was no significant difference in larval population between treatments as well as untreated control during *rabi* 2014 (Table 1). All the treated plots with chemicals were significantly superior in their performance over that of control plots after application of insecticides. During 2014, at 1 day after spraying, lowest *H. armiger* population was recorded in Novaluron 5.25%+ Indoxacarb 4.5% SC sprayed @ 925 ml/ha followed by the same chemical sprayed @ 875 ml/ha with 1.30 and 1.35 larvae per five plants respectively. These two treatments were at par with each other and followed by Indoxacarb 14.5% SC @ 400 ml/ha, Novaluron 10% EC @ 750 ml/ha, Methomyl 40% SP @ 0.1 percent and Novaluron 5.25 + and Indoxacarb 4.5% SC @ 825. At 5,7 and 10 days after spraying, Novaluron 5.25%+ Indoxacarb 4.5% SC sprayed @ 925 and 875 ml/ha showed lowest larval population of *H. armiger*. These two treatments were followed by Indoxacarb 14.5% SC @ 400 ml/ha, Novaluron 10% EC @ 750 ml/ha, Methomyl 40% SP @ 0.1 percent and Novaluron 5.25 + and Indoxacarb 4.5% SC @ 825. A steady increase in the *H. armiger* population was observed in untreated control plot throughout the experimental period.

Thus, overall it was observed that the insecticidal treatments suppress the *H. armiger* population and the population of pest increased slowly in all three sprays in the treatment of untreated control. Among the insecticides tested Novaluron 5.25%+ Indoxacarb 4.5% SC sprayed @ 925 ml/ha followed by the same chemical sprayed @ 875 ml/ha were found most effective as it recorded significantly lowest population of *H. armiger* larvae on groundnut at1,5,7 and 10 days after all spraying, respectively over rest of the insecticides (Table 1).

Table 3, shows that the highest pod damage in groundnut was observed in the treatment of untreated control i.e. 6.70 percent whereas lowest pod damage of 1.96 percent was observed in the treatment of Novaluron 5.25%+ Indoxacarb 4.5% SC sprayed @ 925 ml/ha followed by the same chemical sprayed @ 875 ml/ha (2.00%).

Yield Data presented in Table no. 4 and Cost benefit ratio presented in table no. 5 reveals that, Novaluron 5.25% + Indoxacarb 4.5% SC @ 925 ml /ha and 875 ml /ha recorded highest grain yield of 21.88 q/ha and 21.80 q/ha and cost benefit ratio of 1:1.90 and 1: 1.96 respectively. These two treatments were followed by Novaluron 10% EC @ 750 ml/ha(20.35 q/ha), Indoxacarb 14.5% SC @ 400 ml/ha(20.00 q/ha), Novaluron 5.25 + and Indoxacarb 4.5% SC @ 825(19.20 q/ha), and Methomyl 40% SP @ 0.1 percent(18.74 q/ha) with cost: benefit ratio of 1:1.10, 1:1.79,1:1.077 and 1:1.54 respectively. Untreated control recorded lowest pod yield of 17.65 q /ha. From the present study, the result revealed that, Novaluron 5.25% + Indoxacarb 4.5% SC @ 925 ml/ha and 875 ml/ha can be used on groundnut crop for the management of the *Helicoverpa armiger*, as these two treatments recorded lowest pest population highest pod yield of groundnut and highest benefit cost ratio. The present results are in accordance with the results of Ghosal et. al., (2016) [1, 2] who reported that, technical formulation of Novaluron 5.25%+ Indoxacarb 4.5% SC (Plethora) @ 825 ml/ha and 875 ml/ha were excellently effective against *Helicoverpa armiger* of pigeon pea and were safe to the three important predator (*Menochilus sp.*, *Syrphids sp.* and *Chrysoberyl sp.* recorded in the pigeon pea field and he also reported that technical formulation of Novaluron 5.25%+ Indoxacarb 4.5% SC (Plethora) @ 875 ml/ha and 825 ml/ha can protect the tomato crop infesting with fruit borer complex (*Helicoverpa* and *Spodoptera*) more efficiently than that of their sole use by recording highest fruit yield and cost benefit ratio. Further, these results were almost similar to the findings of Das *et al*. (2015) [4], who reported that mixed formulation of Novaluron 5.25+Indoxacarb 4.5 SC proved to be the most effective insecticides than that of their sole formulation against *Helicoverpa armiger*. The Novaluron 5.25% + Indoxacarb 4.5% SC is highly vulnerable to lepidopteran insect pest with two novel modes of action viz. chitin biosynthesis inhibition creates abortive mounting by novaluron and blockage of axonal sodium channel causing rapid cessation of feeding and paralysis by indoxacarb. Yogeshwar and Venkata Krishna (2014) in their findings concluded that novel insecticides indoxacarb and novaluron can manage *Helicoverpa* up to 95.83 percent and 87.12 percent respectively. Waykule et. al. (2020) [10], Mishra (1986) [7] Singh and Singh (1990) [12]; Bhatt and Patel (2002) [12] also reported similar result about the effect of these novel insecticides on *H. armiger* and *S. litura*. Looking into the literature and results of the present study, we can conclude that the technical formulation of novaluron 5.25%+ indoxacarb 4.5% SC @ 925 ml/ha and 875 ml/ha can protect the groundnut crop more efficiently than that of their sole use.

Table 2: Effect of Novaluron 5.25% + Indoxacarb 4.5% SC on population of *Helicoverpa armiger* during *Rabi*, 2014

Treatments	Average larval population of *H. armigera* per 20 plants												
	DBS	First Spray				Second Spray				Third spray			
		Days after spray				Days after spray				Days after spray			
		1	5	7	10	1	5	7	10	1	5	7	10
Novaluron 5.25% + Indoxacarb 4.5% SC @ 825 ml/ha	3.68	3.66	3.62	3.60	3.52	3.52	3.34	3.20	2.99	2.97	2.64	2.46	2.27
	(2.16)	(2.16)	(2.15)	(2.14)	(2.13)	(2.13)	(2.08)	(2.05)	(2.00)	(1.99)	(1.91)	(1.86)	(1.81)
Novaluron 5.25% + Indoxacarb 4.5% SC @ 875 ml/ha	3.40	3.35	2.86	2.30	2.22	2.20	1.81	1.53	1.42	1.35	0.96	0.55	0.00
	(2.10)	(2.09)	(1.96)	(1.82)	(1.79)	(1.79)	(1.68)	(1.59)	(1.56)	(1.53)	(1.40)	(1.24)	(1.00)
Novaluron 5.25% + Indoxacarb 4.5% SC @ 925 ml/ha	3.38	3.36	2.82	2.24	2.12	2.10	1.72	1.48	1.32	1.30	0.88	0.46	0.00
	(2.09)	(2.09)	(1.95)	(1.80)	(1.77)	(1.76)	(1.65)	(1.57)	(1.52)	(1.52)	(1.37)	(1.21)	(1.00)
Novaluron 10% EC @ 750 ml/ha	3.52	3.50	3.40	3.00	2.96	2.92	2.62	2.48	2.37	2.32	2.10	1.98	1.76
	(2.13)	(2.12)	(2.10)	(2.00)	(1.99)	(1.98)	(1.90)	(1.87)	(1.84)	(1.82)	(1.76)	(1.73)	(1.66)
Indoxacarb 14.5% SC @ 400 ml/ha	3.50	3.48	3.34	2.92	2.80	2.78	2.56	2.42	2.23	2.23	2.00	1.88	1.65
	(2.12)	(2.12)	(2.08)	(1.98)	(1.95)	(1.94)	(1.89)	(1.85)	(1.80)	(1.80)	(1.73)	(1.70)	(1.63)
Methomyl 40% SP @ 850 g/ha	3.64	3.60	3.52	3.50	3.20	3.20	2.93	2.82	2.64	2.55	2.28	2.23	2.00
	(2.15)	(2.14)	(2.13)	(2.12)	(2.05)	(2.05)	(1.98)	(1.95)	(1.91)	(1.88)	(1.81)	(1.80)	(1.73)
Control	3.66	3.80	4.26	4.98	5.52	5.64	6.32	6.40	6.50	6.58	6.75	6.78	6.84
	(2.16)	(2.19)	(2.29)	(2.45)	(2.55)	(2.58)	(2.71)	(2.72)	(2.74)	(2.75)	(2.78)	(2.79)	(2.80)
S. Em.	0.08	0.03	0.07	0.04	0.05	0.05	0.05	0.08	0.07	0.06	0.10	0.12	0.15
CD at 5%	NS	0.10	0.22	0.12	0.15	0.14	0.16	0.24	0.20	0.18	0.30	0.38	0.45

DBS: Day Before Spray, NS: Nonsignificant, note: Figures in the parenthesis are square root transformed values.

Table 3: Effect of Novaluron 5.25% + Indoxacarb 4.5% SC on percent pod damage of groundnut during *Kharif*, 2014

No.	Treatments	Percent pod damage
1	Novaluron 5.25% + Indoxacarb 4.5% SC @ 825 ml/ha	4.80 (2.41)
2	Novaluron 5.25% + Indoxacarb 4.5% SC @ 875 ml/ha	2.00 (1.73)
3	Novaluron 5.25% + Indoxacarb 4.5% SC@ 925 ml/ha	1.96 (1.72)
4	Novaluron 10% EC @ 750 ml/ha	2.52 (1.88)
5	Indoxacarb 14.5% SC @ 400 ml/ha	2.64 (1.91)
6	Methomyl 40% SP @ 850 g/ha	2.88 (1.97)
7	Control	6.70 (2.77)
	S. Em	0.24
	CD at 5%	0.74

Note: Figures in parentheses are arc sin transformed values

Table 4: Effect of Novaluron 5.25% + Indoxacarb 4.5% SC on pod yield of groundnut during *Kharif*, 2014

No.	Treatments	Pod Yield, Q/ha
1	Novaluron 5.25% + Indoxacarb 4.5% SC @ 825 ml/ha	19.20
2	Novaluron 5.25% + Indoxacarb 4.5% SC @ 875 ml/ha	21.80
3	Novaluron 5.25% + Indoxacarb 4.5% SC@ 925 ml/ha	21.88
4	Novaluron 10% EC @ 750 ml/ha	20.35
5	Indoxacarb 14.5% SC @ 400 ml/ha	20.00
6	Methomyl 40% SP @ 850 g/ha	18.74
7	Control	17.65
	S.Em	0.13
	CD at 5%	0.40

Table 5: Cost benefit ratio of different treatments used in groundnut during *Kharif*, 2014

Treatments	Input cost (Insecticide cost/ha + Labor cost/ spray/ha)	G. nut yield, Q/ha	Extra yield over untreated control	Value of additional yield (Rs)	B:C Ratio
Novaluron 5.25% + Indoxacarb 4.5% SC @ 825 ml/ha	7285.50	19.20	1.55	5611.00	1:0.77
Novaluron 5.25% + Indoxacarb 4.5% SC @ 875 ml/ha	7672.50	21.80	4.15	15023.00	1:1.96
Novaluron 5.25% + Indoxacarb 4.5% SC @ 925 ml/ha	8059.50	21.88	4.23	15312.60	1:1.90
Novaluron 10% EC @ 750 ml/ha	8878.50	20.35	2.70	9774.00	1:1.10
Indoxacarb 14.5% SC @ 400 ml/ha	4752.00	20.00	2.35	8507.00	1:1.79
Methomyl 40% SP @ 850 g/ha	2557.50	18.74	1.09	3945.80	1:1.54
Control	-	17.65	-	-	-

Market Rates:

Novaluron 5.25% + Indoxacarb 4.5% SC –Rs. 2580/- per lit.
Novaluron 10% EC –Rs. 3546/- per lit.
Market price of Groundnut – Rs. 3620/- per Quintal
Methomyl 40% SP – Rs. 650/- per Kg.
Indoxacarb 14.5% SC –Rs. 3210/- per lit.
Application cost of Labor– Rs. 300/- per ha.

Conclusion

Based on the above results, it can be concluded that the chemical insecticide Novaluron 5.25 + Indoxacarb 4.5% SC at a dose in the range of 925 and 875 ml/ha can be recommended for the effective management of *Helicoverpa armiger* Hub. of groundnut to obtain better yields.

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