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Field evaluation of new insecticides against budworm, *Helicoverpa armigera* (Hubner) in flue cured Virginia tobacco

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Abstract
Helicoverpa armigera Hubner (Noctuidae: Lepidoptera) is one of the major pests of Virginia tobacco in India. As bud worm, it infests the crop during the grand growth stage and cause considerable yield loss. The studies were conducted with an objective to identify new molecules in place of the obsolete and ineffective insecticides for management of budworm. Chlorantraniliprole 18.5 SC @ 0.055%, cyantraniliprole 10 OD @ 0.018%, spinosad 480 SC @ 0.018%, flubendiamide 480 SC @ 0.012% and novaluron 10 EC @ 0.01% were evaluated for their field efficacy against bud worm, *H. armigera* on flue cured Virginia tobacco during 2015-17 seasons. The results indicated that among the various insecticides, spinosad, chlorantraniliprole and flubendiamide were most effective as they recorded lowest leaf damage and highest cured leaf yield. Studies on persistency of the new molecules on tobacco showed that the persistent toxicity of spinosad, chlorantraniliprole and flubendiamide was higher than that of cyantraniliprole and novaluron. Cyantraniliprole and novaluron were relatively less effective compared to others.

Keywords: budworm, tobacco, insecticides, *Helicoverpa armigera, Nicotiana tabacum*

1. Introduction

Budworm, *Helicoverpa armigera* (Hubner) is one of the major insect pests of tobacco. It infests the crop during the grand growth period, feeds voraciously on the apical bud and bud leaves adversely affecting the growth of the plant resulting in considerable yield loss. In flue cured Virginia (FCV) tobacco the loss in green leaf and cured leaf was recorded to be up to 2891 and 426 kg/ha, respectively [1]. Application of insecticides against the insect pests remains indispensable and economical to minimize the losses. Control of the pest with conventional insecticides requires repeated applications. Also the guidance residue levels (GRLs) of the recommended insecticides have been revised to a lower level by CORESTA [2]. Besides other adverse effects due to indiscriminate use of insecticides, the problem of insecticide residues in tobacco is the major cause of concern. In order to circumvent the problems, there is a need to replace the conventional insecticides with selective insecticides effective at low dose in tobacco. Search for safer alternatives for pest control, which are less aggressive for the environment, has brought a significant development in identification and deployment of new insecticides, with possibilities of use in pest management and contributing to a safer and more efficient way of pest control. Among emerging insecticides, anthranilic diamides are a new, promising class because of their high efficacy mainly in controlling lepidoptera [3]; they also have very low toxicity for mammals and favorable eco-toxicological characteristics [4]. Chlorantraniliprole is a new insecticide belonging to the anthranilic diamide class of chemistry and is intended for the control of Lepidopteran, Coleopteran, and some Dipteran pests. Chlorantraniliprole exhibits excellent differential selectivity for insect ryanodine receptors over mammalian ryanodine receptors [5]. Cyantraniliprole is another novel, cross-spectrum anthranilic diamide insecticide that control insects by activating ryanodine receptors in the muscle cells, which induce an uncontrolled liberation of calcium in the muscles of the insect muscular paralysis, and finally death [6]. Flubendiamide, a benzene dicarboxamide, is a new class of insecticide having a new biochemical mode of action, affecting ryanodine receptors in insects and is highly effective at very low dose against a broad spectrum of lepidopteran pests including resistance strains [7]. Spinosad is a novel mode-of-action insecticide derived from a family of natural products obtained by fermentation of *Saccharopolyspora spinosa*. Spinosad contains a mix of two spinosoids, spinosyn A and spinosyn D. Spinosad is highly active, by both contact and ingestion, in numerous insect species. spinosoids have a novel mode of action, primarily targeting binding sites on nicotinic acetylcholine receptors (nAChRs) of the insect nervous system that are distinct from those at which other insecticides have their activity. Spinosoid binding leads to disruption of acetylcholine neurotransmission. Spinosad also has secondary effects as a γ-amino-butyric acid (GABA) neurotransmitter agonist. It kills insects by hyper excitation of the insect nervous system. Spinosad so far has proven not to cause cross-resistance to any other known insecticide [8]. Novaluron is a benzoylphenyl urea and is an insect growth regulator, a low risk molecule to the environment, non target organisms and effective against *H. armigera* in several crops. The new molecules are expected to provide the necessary protection against budworm, *H. armigera*, if needed to supplement the actions of other control components such as cultural, mechanical and biological in tobacco. The objective of this study was to evaluate the efficacy of new insecticides for management of budworm, *H. armigera* in Virginia tobacco.

2. Material and Methods

The experiment was conducted in randomozied block design with four replications using flue cured Virginia tobacco (*Nicotiana tabacum* L.) *cv Siri* at Central Tobacco Research Institute, Research farm, Rajahmundry for two seasons (2015-16 and 2016 -17). The plot size was 5.6 m X 4.8 m with plant to plant and row to row spacing of 0.7 m X 0.7 m. Laboratory reared 8 days old budworm larvae were used for infesting 5 plants/plot at random @ 1 larva per plant, allowed to establish and start feeding. Foliar spray of the test insecticides chlorantraniliprole (Coragen 18.5 SC) @ 0.055%, cyantraniliprole (Benevia 10 OD) @ 0.018%, spinosad (Spintor 480 SC) @ 0.018%, flubendiamide (Fame 480 SC) @ 0.012% and novaluron (Rimon 10 EC) @ 0.01% were carried out with a high volume knap sack sprayer using 500 litres of water/ha. Observations were recorded periodically on the number of leaves damaged and per cent leaf area damaged. Yield data on cured leaf, bright leaf were collected and grade index was computed. The data were subjected to analysis of variance.

The persistent residual toxicity of the new insecticides was studied. The 40 day old plants were treated with respective insecticides and the leaves were used to study the residual persistent toxicity from 0 days till there is no mortality in that particular treatment at 24 hrs interval. Eight day old *H. armigera* larvae (10 per replication) were released for each treatment and mortality was recorded after 24 hrs. All the six treatments were replicated four times. The persistent residual toxicity was determined by slightly modifying the method suggested by Pradhan [9] and subsequently used by Sarup *et al.* [10].

3. Results and Discussion

During both the years all the treatments gave significantly better protection than control from budworm damage at 2, 4, 8 and 15 days after spray (DAS). Among the treatments the number of leaves damaged by *H. armigera* at 2 DAS was least in spinosad, chlorantraniliprole and flubendiamide during 2015-16 (1.5). At 4, 8 & 15 DAS same trend continued except that flubendiamide recorded 1.75 damaged leaves (Table 1). Though all the treatments were at par, at 2 DAS, significantly higher leaves were damaged in novaluron and cyantraniliprole at 4, 8 and 15 DAS. Similar trend was observed during 2016-17 season also (Table 2). As regards the leaf area damaged by budworm, it was significantly less in all the treatments than control at all the observations during both the seasons. During 2015-16, the damage was lowest (1.46, 1.53, 1.54 and 1.61%) in spinosad treatment followed by chlorantraniliprole (1.51, 1.58, 1.61%) at 2, 4, 8 and 15 DAS respectively. Flubendiamide treated plots recorded leaf damage that was on a par with the above two treatments at all the observations. Cyantraniliprole and novaluron treatments recorded higher leaf area damage compared to spinosad, chlorantraniliprole and flubendiamide. However, cynatraniliprole remained on a par with flubendiamide at all the observations. During 2016-17 chlorantraniliprole recorded lowest leaf area damaged (1.46, 1.52 and1.59) followed by spinosad (1.48, 1.55, 1.62) at 2, 4, 8 and 15 DAS respectively. Similar trend of leaf area damage was recorded in flubendiamide, cyantraniliprole and novaluron as that of 2015-16 season.

Data on yield parameters revealed that all the treatments recorded significantly higher cured leaf and bright leaf yield and better grade index than that of un-treated control. The highest mean cured leaf yield (2725kg/ha) was recorded in spinosad followed by chlorantraniliprole (2700 kg/ha) and flubendiamide (2665 kg/ha) which was significantly higher than all other treatments except that flubendiamide remained on a par with cyantraniliprole (Table 3). Novaluron recorded lowest cured leaf yield (2350 kg/ha) among the treatments which remained on a par with that of cyantraniliprole (2455 kg/ha). As regards bright leaf yield, highest bright leaf yield (1619 kg) was recorded in spinosad followed by chlorantraniliprole (1592 kg), and flubendiamide (1573 kg/ha) which was significantly higher than the other two treatments. The overall grade index was also the highest (1983) in spinosad and was on a par with chlorantraniliprole (1965) and flubendiamide (1940). Novaluron recorded lowest grade index (1668) followed by cynatraniliprole (1735) which were significantly superior to untreated control. Effectiveness of spinosad, chlorantraniliprole and flubendiamide against *H. armigera* was reported in various crops viz., cotton, tobacco, tomato, chick pea, soybean and pigeonpea, [11-18]. The present studies are in conformity with the previous studies. The ineffectiveness of cyantraniliprole against a lepidopteran pest *Leucinodes orbanalis* was reported earlier [19].

Studies on persistent toxicity of new insecticides to *H. armigera* on FCV tobacco showed that the treatments of spinosad 480 SC @ 0.018%, chlorantraniliprole 18.5 SC @ 0.055 and flubendiamide 480 SC @ 0.012% resulted in cent per cent mortality up to 8 days after treatment (DAT) and the mortality of the larvae was above 90% up to 10 DAT (Table 4). Cynatraniliprole 10 OD @ 0.018% and novaluron 10 EC @ 0.01% recorded cent per cent mortality only up to 4 DAT. The period of persistence was highest (18 days) for spinosad, chlorantraniliprole and flubendiamide where as it was 16 days for cynatraniliprole and novaluron. The mean persistent toxicity as well as persistent toxicity index was highest for chlorantraniliprole @ 0.055 (76.89 & 1384.02) followed by flubendiamide 0.012% (76.54 & 1377.72). The lowest PT (73.52) and PTI (882.24) were recorded for novaluron 0.01%. The order of relative persistent toxicity was chlorantraniliprole 0.055% > flubendiamide 0.012% > spinosad @ 0.018% > cynatraniliprole 0.018% > novaluron 0.01%. Based on the two seasons experimental results on the leaf damage due to *H. armigera*, yield data and persistent toxicity studies, it can be inferred that spinosad 480 SC @

0.018%, chlorantraniliprole 18.5 SC @ 0.055% and flubendiamide 480 SC @ 0.012% were quite effective in checking the leaf damage due to budworm, *H. armigera* in FCV tobacco. The present studies are in conformity with the previous studies and indicated that spinosad, chlorantraniliprole and flubendiamide are highly promising for checking the damage due to budworm, *H. armigera* in tobacco.

Table 1: Budworm damage in different treatments 2015-16

Treatments	Mean number of leaves damaged/plant				Mean Per cent leaf area damaged			
	2 DAS	4 DAS	8 DAS	15 DAS	2 DAS	4 DAS	8 DAS	15 DAS
Chlorantraniliprole 18.5 SC @ 0.055%	1.50	1.50	1.50	1.50	1.51 (2.30)	1.58 (2.50)	1.61 (2.60)	1.61 (2.60)
Cyantraniliprole 10 OD @ 0.018%	1.75	2.75	2.575	2.75	1.81 (3.30)	1.90 (3.65)	1.97 (3.90)	1.97 (3.90)
Spinosad 480 SC @ 0.018%	1.50	1.50	1.50	1.50	1.46 (2.15)	1.53 (2.35)	1.54 (2.40)	1.61 (2.60)
Flubendiamide 480 SC @ 0.012	1.50	1.75	1.75	1.75	1.61 (2.60)	1.81 (3.30)	1.84 (3.40)	1.84 (3.40)
Novaluron10 EC @ 0.01	2.00	3.00	3.00	3.50	2.36 (5.58)	2.46 (6.10)	2.48 (6.20)	2.55 (6.50)
Control (Untreated)	3.00	6.75	7.50	10.75	2.73 (7.50)	3.42 (11.75)	4.22 (17.90)	4.63 (21.60)
CD (p=0.05)	0.92	0.94	0.95	0.80	0.25	0.31	0.29	0.31

Figures in parentheses are original treatment Means

Table 2: Budworm damage in different treatments 2016-17

Treatments	Mean number of leaves damaged/plant				Mean Per cent leaf area damaged			
	2 DAS	4 DAS	8 DAS	15 DAS	2 DAS	4 DAS	8 DAS	15 DAS
Chlorantraniliprole 18.5 SC @ 0.055%	1.75	1.75	1.75	1.75	1.46 (2.15)	1.52 (2.35)	1.59 (2.55)	1.59 (2.55)
Cyantraniliprole 10 OD @ 0.018%	1.75	2.60	2.60	2.60	1.82 (3.35)	1.86 (3.50)	2.00 (4.05)	2.02 (4.10)
Spinosad 480 SC @ 0.018%	1.50	1.75	1.75	1.75	1.48 (2.20)	1.55 (2.40)	1.62 (2.65)	1.62 (2.65)
Flubendiamide 480 SC @ 0.012%	1.75	1.75	1.75	1.75	1.67 (2.80)	1.77 (3.15)	1.80 (3.25)	1.80 (3.25)
Novaluron10 EC @ 0.01%	2.25	3.00	3.00	3.25	2.32 (5.40)	2.41 (5.85)	2.45 (6.00)	2.50 (6.25)
Control (Untreated)	3.25	6.50	10.50	11.25	2.76 (7.65)	3.45 (12.00)	4.25 (18.10)	4.50 (20.40)
CD (p=0.05)	0.84	0.79	0.81	0.84	0.24	0.30	0.26	0.29

Figures in parentheses are original treatment Means

Table 3: Field efficacy of new insecticides – FCV tobacco mean yield kg/ha (2015-2017)

Treatments	Cured leaf	Bright leaf	Grade index
Chlorantraniliprole 18.5 SC @ 0.055%	2700	1592	1965
Cyantraniliprole 10 OD @ 0.018%	2455	1440	1735
Spinosad 480 SC @ 0.018%	2725	1619	1983
Flubendiamide 480 SC @ 0.012%	2665	1573	1940
Novaluron10 EC @ 0.01%	2350	1316	1668
Control	1930	830	1330
CD (p=0.05)	229	109	149

Table 4: Persistent residual toxicity of new insecticides on FCV tobacco against *H. armigera*

Treatments	Per cent mortality (Days after treatment)												P	PT	PTI
	0	1	2	4	6	8	10	12	14	16	18	20			
Chlorantraniliprole 18.5 SC @ 0.055%	100	100	100	100	100	100	94.0	78.6	46.8	19.2	7.2	0.0	18	76.89	1384.02
Cyantraniliprole 10 OD @ 0.018%	100	100	100	100	92.4	52.2	34.0	16.2	6.8	0.0	-	-	14	66.84	935.76
Spinosad 480 SC @ 0.018%	100	100	100	100	100	100	90.6	76.4	42.8	16.0	4.8	0.0	18	75.50	1359.00
Flubendiamide 480 SC @ 0.012%	100	100	100	100	100	100	92.8	78.0	46.2	18.4	6.6	0.0	18	76.54	1377.72
Novaluron 10 EC @ 0.01%	100	100	100	100	94.4	50.6	30.4	12.8	0.0	-	-	-	12	73.52	882.24

4. Conclusion

Spinosad 480 SC @ 0.018%, chlorantraniliprole 18.5 SC @ 0.055% and flubendiamide 480 SC @ 0.012% were superior and highly effective in terms of reduction in leaf damage due to *H. armigera*, higher yields and better persistence on tobacco. Whereas cynatraniliprole 18.5 SC @ 0.055% and novaluron 10 EC @ 0.01% were relatively ineffective compared to the treatments. Based on the studies, it can be inferred that spinosad 480 SC @ 0.018%, chlorantraniliprole 18.5 SC @ 0.055% and flubendiamide 480 SC @ 0.012% can be used for management of budworm, *H. armigera* in flue cured Virginia tobacco.

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