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Subbireddy KB
PG Scholar, Deptt. of Entomology, B. A. College of Agriculture, AAU, Anand, Gujarat, India

HP Patel
Research Scientist, Main Pulse Research Station, AAU, Vadodara, Gujarat, India

NB Patel
Training Associate, Tribal Research-cum-Training Centre, AAU, Devgadhbaria, Gujarat, India

TM Bharpoda
Retd. Professor, Deptt. of Entomology, B. A. College of Agriculture, AAU, Anand, Gujarat, India

Correspondence
NB Patel
Training Associate, Tribal Research-cum-Training Centre, AAU, Devgadhbaria, Gujarat, India

Utilization of ready-mix insecticides for managing fruit borers in okra, [*Abelmoschus esculentus* (L.) Moench]

Subbireddy KB, HP Patel, NB Patel and TM Bharpoda

Abstract
The field experiment was conducted to evaluate the effectiveness of seven ready-mix insecticides against fruit borers *i.e. Earias vittella* (Fab.) and *Helicoverpa armigera* (Hübner) Hardwick in okra at Main Vegetable Research Station, Anand Agricultural University, Anand (Gujarat) during summer and *kharif*, 2016. Among seven different ready-mix insecticides evaluated for their relative bio-efficacy, chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC (0.007%) and indoxacarb 14.5% + acetamprid 7.7% SC (0.022%) found most effective against fruit borers by recording less larval population and fruit damage on both number as well as weight basis which followed by profenophos 40% + cypermethrin 4% EC (0.044%). The maximum fruit yield of okra fruit was harvested from the plots treated with chlorantraniliprole 9.3% + lambda-cyhalothrin 4.6% (68.44 and 151.12 q/ha) followed by indoxacarb 14.5% + acetamprid 7.7% SC (62.72 and 145.83 q/ha)during summer and *kharif*, respectively. Maximum net realization was obtained in the treatment of chlorantraniliprole 9.3% + lambda-cyhalothrin 4.6% ZC (`87895/ ha and `85103/ ha) followed by indoxacarb 14.5% + acetamprid 7.7% SC (`76868/ha and `80226/ha) during summer and *kharif*, respectively.

Keywords: Okra, bio-efficacy, ready-mix insecticides and fruit borers

1. Introduction

Okra, [*Abelmoschus esculentus* (L.) Moench] is an annual vegetable belonging to malvaceae family; it is also known by different names *viz.*, ladies finger, bhindi, bamia, okro or gumbo in different parts of the world. Okra is valued for its tender green fruits. It is cooked in a variety of ways and used as an ingredient in a wide variety of dishes. Young tender leaves are used as a leafy vegetable in some parts of the world. The ripe seeds are roasted, ground and used as substitute for coffee in Turkey [15]. It also contains 16-22 per cent edible oil. The roots and stem are used for clearing the cane juice from which gur or brown sugar is prepared [5]. Its medicinal value has also been reported in curing ulcer and relief from haemorrhoids [1].

Saudi Arabia, Mexico and Cameroon. India ranks first in area and production which followed by Nigeria. In India, it is grown in an area of 0.51 million ha with an annual production of 5.85 million tonnes. West Bengal is the leading producer followed by Bihar [2]. One of the important limiting factors in the cultivation of okra is insect pests. Many of the pests occurring on cotton are found to ravage okra crop. As high as 72 species of insects have been recorded on okra [21] of fruit borers like *Earias spp.* and *H. armigera* causes significant damage to crop to the tune of 91.60 per cent [17].The fruit borers are alone reported to cause damage to the extent of 3.5 to 90 per cent to okra in different parts of the country [23,18,11,22,4,14]. Frequent use of certain insecticides leading to the development of insecticide resistance [9,8]. To combat such situation, simultaneous administration of two or more toxic chemicals in ready-mix formulation has become popular and is available in the market. At present, the numbers of new combinations of insecticides are available but scanty information is available about their efficacy against okra fruit borers. The mixture producing greater insecticidal action than the sum of their individual component is desirable. One cannot ignore the harmful effects of synthetic pesticides reported in almost every component of biosphere. Moreover, in crops such as okra, the short interval between picking of fruits poses the residue hazards to the consumers when the chemical insecticides are used. Nevertheless, it is to be confessed by one and all that when used properly, pesticides provide an efficient, fast, reliable and cost effective means of pest management [12]. Keeping in view and above considerations, the present study was objectified to evaluate different ready-mix formulations against fruit borers.

2. Materials and Methods

In order to study the bio-efficacy of ready-mix formulations of insecticides (Table 1) against fruit borers, a field experiment was laid out in Randomized Block Design with three replications having gross plot size of 6.0 × 3.0 m and net plot size of 4.8 x 2.4 m, respectively. There were eight treatments including control (Table 1). Okra, GAO-5 seeds were sown at a distance of 60 cm between two rows and 30 cm within the rows in the third week of March and last week of June during summer and *kharif*, 2016, respectively at Main Vegetable Research Station, Anand Agricultural University, Anand (Gujarat). Recommended agronomical practices were followed to raise the crop. Treatment-wise application of insecticides was given at ETL of fruit damage due to *H. armigera* or *E. vittella* (*i.e.* 5% fruit damage) by using high volume knapsack sprayer with required concentration. Subsequent spray was given on need based during both the seasons of experimentation. The observations on larval population of *E. vittella* and *H. armigera* were recorded from five randomly selected plants per treatment by replication-wise before spray as well as 3, 7, 10 and 15 days after each sprays. The observations on fruit damage due to *H. armigera* and *E. vitella* was recorded at each picking by counting the healthy and damaged fruits from net plot area on number as well as weight basis and per cent fruit damage was worked out by using the following formula. The yield of marketable okra fruits from each treatment was recorded at each picking separately. The yield obtained from net plot area was converted into quintal per hectare. In order to know the economics of different treatments evaluated against fruit borers, Incremental Cost Benefit Ratio (ICBR) was worked out.

3. Results

3.1 Fruit damage

The data on pooled over periods and sprays (number basis) in summer, 2016 indicated that the higher effectiveness was found in chlorantraniliprole + lambda-cyhalothrin (2.31%) and it was at par with indoxacarb + acetamprid (2.84%). Profenophos + cypermethrin registered 4.49 per cent fruit damage and found next in order of effectiveness and remaining ready-mix insecticides were found equally effective in checking the fruit damage to the range of 5.75 to 6.77 per cent. The highest (9.28%) fruit damage was registered in untreated control (Table 1). On weight basis significantly the highest effectiveness of chlorantraniliprole + lambda-cyhalothrin (2.23%) recorded reducing weight loss in fruits due to fruit borers. Further, treatment indoxacarb + acetamprid proved equally effective and found at par by registering less weight loss of 2.72 per cent (Table 1).

During *kharif* season (Table 2), the higher effectiveness was found in chlorantraniliprole + lambda-cyhalothrin and it was at par with indoxacarb + acetamprid by registering 3.71 and 3.81 per cent fruit damage, respectively. The treatment profenophos + cypermethrin (5.70%) stood next in order. On weight basis, chlorantraniliprole + lambda-cyhalothrin (3.58%) was found superior against fruit borers and it was at par with indoxacarb + acetamiprid (3.70%) followed by profenophos + cypermethrin (5.60%). Remaining insecticides were found equally effective in reducing weight losses except acephate + imidacloprid which recorded 8.14 per cent loss in fruit weight (Table 2).

3.2 Larval population

H. armigera

Pooled over periods and sprays results of summer, 2016 (Table 3) showed that chlorantraniliprole + lambda-cyhalothrin (0.72 larva/plant)was more effective against *H. armigera* and it was at par with indoxacarb + acetamprid (0.98 larva/plant). The plots treated with profenophos + cypermethrin was found next in order for controlling the pest by registering 1.41 larvae/plant. Remaining insecticides harbored the pest population between 1.83 and 2.04 larvae/plant and proved as mediocre treatments in their effectiveness against the pest when compared to untreated control (2.93 larvae/plant).

During *kharif* season, significantly the highest effectiveness was observed in the treatment of chlorantraniliprole + lambda-cyhalothrin (1.14 larvae/plant) and it was at par with indoxacarb + acetamprid (1.28 larvae/plant) followed by profenophos + cypermethrin and deltamethrin + triazophos by registering larval population between 2.11 and 2.39 larvae per plant.

E. vittella

During summer, 2016 the less population of *E. vittella* was recorded in the treatment of chlorantraniliprole + lambda-cyhalothrin (0.80 larva/plant) followed by indoxacarb + acetamprid (1.04 larvae/plant) and profenophos + cypermethrin (1.50 larvae/plant). Whereas, deltamethrin + triazophos, thiamethoxam + lambda-cyhalothrin and imidacloprid + β-cyfluthrin exhibited population between 1.90 and 2.18 larvae per plant and emerged out as mediocre.

The data on pooled over periods and sprays during *kharif* season (Table 3) indicated higher effectiveness of chlorantraniliprole + lambda-cyhalothrin (0.34 larva/plant) followed by indoxacarb + acetamiprid (0.40 larva/plant) and profenophos + cypermethrin (0.98 larva/plant). The insecticides, deltamethrin + triazophos, thiamethoxam + lambda-cyhalothrin and imidacloprid + β-cyfluthrin exhibited the larval population (1.35 to 1.50) and remained at par with each other.

3.3 Yield and economics

During summer, 2016 (Table 1) treatment chlorantraniliprole + lambda-cyhalothrin recorded significantly the highest yield of okra (68.44 q/ha) compared to rest of the treatments except indoxacarb + acetamiprid (62.72 q/ha) with which it remained at par followed by profenophos + cypermethrin. The economics of various ready-mix insecticides revealed that the highest (` 87895/ha) net realization over control was obtained in the treatment of chlorantraniliprole + lambda-cyhalothrin followed by indoxacarb + acetamiprid (`76868/ha), profenophos + cypermethrin (` 52316/ha), deltamethrin + triazophos (` 38158/ha). The highest (23.91) ICBR was obtained from the plots treated with profenophos + cypermethrin followed by deltamethrin + triazophos (17.02).

During *kharif,* 2016, the maximum (151.12 q/ha) fruit yield was harvested from the plots sprayed with chlorantraniliprole + lambda-cyhalothrin which was significantly superior to rest of the treatments except indoxacarb + acetamiprid (145.83 q/ha) and profenophos + cypermethrin (121.64 q/ha). The economics insecticides (Table 2) showed that the highest (` 85103/ha) net realization was obtained in the treatment of chlorantraniliprole + lambda-cyhalothrin followed by indoxacarb + acetamiprid (` 80226/ha). The highest (1:26.34) ICBR was obtained from the plots treated with profenophos + cypermethrin. Though, chlorantraniliprole + lambda-cyhalothrin and indoxacarb + acetamiprid were most effective against fruit borers as well as registered higher okra fruit yield with the highest net realization over control, the ICBR was low. It might be due to very high market price of the insecticides.

4. Discussion

Excellent performance of chlorantraniliprole + lambda cyhalothrin against okra fruit borers noticed in the present study is in conformity with the earlier report of [19]. Further, the effectiveness of chlorantraniliprole + lambda-cyhalothrin in managing shoot and fruit borer in brinjal and gave maximum fruit yield [20]. Chlorantraniliprole 9.3% + lambda-cyhalothrin 4.6% ZC was highly effective in checking the larval population, lowest per cent square and boll damage as well as no significant difference in population [3]. Similarly, [6] observed the lower fruit damage and higher fruit yield in the plots sprayed with chlorantraniliprole 20 SC. All these reports are in accordance with the present findings. Indoxacarb 14.5% + acetamiprid and profenophos + cypermethrin also proved effective insecticides in controlling fruit borers population in present investigation which is in conformity with the findings of [13] who reported effectiveness of ready mixture of indoxacarb 14.5 SC + acetamiprid 7.7 SC @ 300 and 400 ml/ha when applied twice were found more effective against the pests of okra. The results drawn by [10] in okra showed that indoxacarb 14.5 SC + acetamiprid 7.7 SC @ 400 ml/ha, profenophos 40 EC + cypermethrin 4 EC @ 1000 ml/ha and chlorpyriphos 50 EC + cypermethrin 5 EC @ 1000 ml/ha were found more effective in reducing the fruit infestation on number as well as weight basis. A field experiment was conducted by [16] against *E. vittella* infesting okra at Junagadh Agricultural University, Junagadh (Gujarat) revealed that profenophos + cypermethrin (0.044%) emerged as a best treatment for controlling *E. vittella* infesting okra. Similarly, the results obtained by [7] follows the results of present study that, profenophos + cypermethrin @ 0.044% proved effectiveness against *E. vittella* in okra. This finding is in conformity with the earlier report of [10], who reported highest yield (124.44 q/ha) of healthy fruits was recorded from the plots treated with indoxacarb 14.5% + acetamiprid 7.7% SC followed by profenophos 40% + cypermethrin 4% EC (114.52 q/ha). The superior results were noticed might be due to different modes of action at different sites.

Table 1: Bio-efficacy of ready-mix insecticides against fruit borers in okra during summer, 2016

Treatments	Conc. (%)	*Fruit damage (%)		Yield (q/ha)	Net Realization (□/ ha)	ICBR
		Number basis	Weight basis			
Indoxacarb 14.5% + Acetamiprid 7.7% SC	0.0222	9.70a (2.84)	9.49a (2.72)	62.72a	76868	1:12.91
Profenophos 40% + Cypermethrin 4% EC	0.044	12.23b (4.49)	12.08b (4.38)	48.36b	52316	1:23.91
Thiamethoxam 12.6% + λ-Cyhalothrin 9.5% ZC	0.0221	14.10cd (5.93)	13.93c (5.79)	38.15bc	29416	1:07.17
Chlorantraniliprole 9.3%+ λ-Cyhalothrin 4.6% ZC	0.0067	8.75a (2.31)	8.59a (2.23)	68.44a	87895	1:13.80
Deltamethrin 1% + Triazophos 35% EC	0.036	13.87c (5.75)	13.75c (5.65)	41.33bc	38158	1:17.02
Imidaclorprid 19.81% + β- cyfluthrin 8.49% EC	0.0283	14.52cd (6.29)	14.34cd (6.13)	36.69bc	28288	1:10.52
Acephate 50% + Imidacloprid 1.8% SP	0.0259	15.08d (6.77)	14.97d (6.67)	32.88c	21538	1:11.25
Untreated control	-	17.74e (9.28)	17.63e (9.18)	21.06d	--	--
S.Em. ±		0.33	0.32	3.81	--	
C. V. (%)		10.69	10.52	15.11		

Note: 1. Figures in parentheses are retransformed values; those outside are arcsine transformed values
2. Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance
3. * Mean values of two sprays

Table 2: Bio-efficacy of ready-mix insecticides against fruit borers in okra during *kharif*,2016

Treatments	Conc. (%)	*Fruit damage (%)		Yield (q/ha)	Net Realization (□/ ha)	ICBR
		Number basis	Weight basis			
Indoxacarb 14.5% + Acetamiprid 7.7% SC	0.0222	11.26a (3.81)	11.09a (3.70)	145.83ab	80226	1:13.26
Profenophos 40% + Cypermethrin 4% EC	0.044	13.82b (5.70)	13.68b (5.60)	121.64abc	60204	1:26.34
Thiamethoxam 12.6% + λ-Cyhalothrin 9.5% ZC	0.0221	15.32c (6.98)	15.21c (6.88)	108.82cd	44904	1:10.25
Chlorantraniliprole 9.3%+ λ-Cyhalothrin 4.6% ZC	0.0067	11.10a (3.71)	10.91a (3.58)	151.12a	85103	1:13.23
Deltamethrin 1% + Triazophos 35% EC	0.036	15.13c (6.81)	15.02c (6.71)	116.50bcd	54966	1:23.21
Imidaclorprid 19.81% + β- cyfluthrin 8.49% EC	0.0283	15.68c (7.30)	15.58c (7.21)	97.46cd	35336	1:12.53
Acephate 50% + Imidacloprid 1.8% SP	0.0259	16.67d (8.23)	16.58d (8.14)	89.38d	27576	1:11.05
Untreated control	-	19.25e (10.87)	19.17e (10.78)	59.06e	--	--
S.Em. ±		0.24	0.24	9.08	--	
C. V. (%)		9.81	10.00	14.15		

Note: 1. Figures in parentheses are retransformed values; those outside are arcsine transformed values
2. Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance
3. * Mean values of two sprays

Table 3: Bio-efficacy of ready-mix insecticides against fruit borers in okra during summer and *kharif*, 2016

Treatments	Conc. (%)	*Number of larva/ plant			
		Summer		*Kharif*	
		H. armigera	*E. vittella*	*H. armigera*	*E. vittella*
Indoxacarb 14.5% + Acetamiprid 7.7% SC	0.0222	1.22a (0.98)	1.24b (1.04)	1.33a (1.28)	0.95a (0.40)
Profenophos 40% + Cypermethrin 4% EC	0.044	1.38b (1.41)	1.42c (1.50)	1.62b (2.11)	1.22b (0.98)
Thiamethoxam 12.6% + λ-Cyhalothrin 9.5% ZC	0.0221	1.56cd (1.93)	1.59de (2.04)	1.77cd (2.63)	1.39c (1.42)
Chlorantraniliprole 9.3%+ λ-Cyhalothrin 4.6% ZC	0.0067	1.11a (0.72)	1.14a (0.80)	1.28a (1.14)	0.92a (0.34)
Deltamethrin 1% + Triazophos 35% EC	0.036	1.53c (1.83)	1.55d (1.90)	1.70bc (2.39)	1.36c (1.35)

Imidaclorprid 19.81% + β- cyfluthrin 8.49% EC	0.0283	1.59cd (2.04)	1.64ef (2.18)	1.82d (2.83)	1.42cd (1.50)
Acephate 50% + Imidacloprid 1.8% SP	0.0259	1.65d (2.23)	1.69f (2.37)	1.96e (3.32)	1.47d (1.66)
Untreated control	-	1.85e (2.93)	1.98g (3.43)	2.26f (4.63)	1.71e (2.43)
S.Em. ±		0.03	0.02	0.03	0.02
C. V. (%)		10.03	9.43	9.75	9.97

Note: 1. Figures in parentheses are retransformed values; those outside are $\sqrt{x + 0.5}$ transformed values
2. Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance
3. * Mean values of two sprays

4. Conclusion

From the present investigation, it can be concluded that treatments of chlorantraniliprole 9.3% + lambda-cyhalothrin 4.6% ZC and indoxacarb 14.5% + acetamprid 7.7% SC found most effective insecticides for borer pests of okra by recording least fruit damage and highest fruit yield and net realization. The present finding suggests the spraying when the pest is at peak situation and also should be able to incorporate in IPM program.

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