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Bio-Efficacy of Broflanilide 30 SC against Fall Army Worm, *Spodoptera frugiperda* (Noctuidae: Lepidoptera) on Corn

Lakshman Chandra Patel* and Md Imraj Zaman

College of Agriculture, BCKV, Burdwan, West Bengal (713 101), India

Corresponding Author

Lakshman Chandra Patel

✉: patel123lakshman@gmail.com

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Abstract

Chemical control is a common practice by the farmers to manage fall armyworm (*Spodoptera frugiperda*) in corn since its invasion in India from 2018. Thus, the main purpose of the work was to evaluate for the first time the field efficacy of a recently introduced novel insecticide *i.e.*, broflanilide against fall army worm (FAW) during winter 2019-20 and kharif 2020. Broflanilide 30 SC @ 60 ml ha^{-1} resulted highest overall mean mortality (86.15 and 87.02%) in larval population of FAW over untreated control. It was significantly at par with its next lower dose of 50 ml ha^{-1} (83.13 and 85.06%) followed by chlorantraniliprole 18.5 SC (79.58 and 81.30%) and emamectin benzoate 5 SG (78.75 and 81.81%). Statistically at par remarkable lower damage and attack intensity with considerable higher yield occurred in broflanilide (60 and 50 ml ha^{-1}), chlorantraniliprole (200 ml ha^{-1}) and emamectin benzoate (300 g ha^{-1}). So, broflanilide @ 50-60 ml ha^{-1} could be recommended as another alternative insecticide to manage *S. frugiperda* in corn.

Keywords: Bio-efficacy, Broflanilide, Corn, Fall armyworm, *Spodoptera frugiperda*

Introduction

Corn by presence of highest genetic production potential is known as the queen of cereals worldwide. It is grown over 150 m ha in about 160 nations. India produced 31.51 million tonnes covering an area of 9.9 million hectares in 2020-21 (Anonymous, 2022). Among the major insect pests of corn, fall armyworm *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) is considered the most devastative key pest. It is a polyphagous pest that feeds on 353 plant species belonging to 76 families and causes significant loss in crop production (Montezano *et al.*, 2018). The larvae feed on several plant species *viz*., maize, rice, sorghum, sugarcane, cabbage, beet, peanut, soybean, alfalfa, onion, tomato, potato and cotton (CABI, 2019). Among these host plants, maize and sorghum are most preferred by *S. frugiperda*. The fall armyworm is native to the Americas. This pest is found in most parts of the Western Hemisphere, from southern Canada to Chile and Argentina. Of late, the fall armyworm was noticed in West Africa and East Africa during 2016 and 2017, respectively. Recently during August 2018, fall armyworm was reported for the first time in India, near Bangalore, Karnataka state on the maize crop (Ganiger *et al.*, 2018). In subsequent months this species was also reported from other maize growing states of India *viz*., Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, Gujarat and several North-eastern states (Sharanabasappa *et al.*, 2018; Swamy *et al.*, 2018; Chormule *et al.*, 2019). In Karnataka, a quick roving survey suggested the damage ranging from 9% to 62.5% on maize (Ganiger *et al.*, 2018; Shylesha *et al.*, 2018). Maize is one of the important cereal crops grown in India. This new invasive species has been occurring in serious proportions, causing significant damage to the maize crop, thus posing serious threat for maize production in the country. The fall armyworm persists on maize crop from the early crop stage till cob maturity.

Use of insecticides is a common practice to manage this pest. Conventional insecticides under organophosphates

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and synthetic pyrethroids diminishes the efficiency and resulting diverse serious problems such as pesticide residues on foods, threat to natural enemies, health hazard to human and environment, insect resistance to insecticides, insect resurgence and biotype development along with other direct and indirect negative effects (Kwizera and Susurluk, 2017; Sabry *et al*., 2016). So, newer molecule having unique mode of action is always in need to mitigate the above stated issues. In this regard, broflanilide insecticide is a recently introduced, powerful and versatile insecticide with a new mode of action. With its unique mode of action, broflanilide insecticide is among the first compounds in the market introduced under the new IRAC group 30. Plus, there's no known cross-resistance with existing products in the market, making it a superior insecticide resistance management tool.

In this regard, the present attempt is taken to generate valuable information about the efficacy of broflanilide against *S. frugiperda* at field condition. It is noteworthy to mention that the present study is conducted for the first time to produce information with the product broflanilide against the said culprit in corn ecosystem.

Materials and Methods

The experiment was conducted at research farm of College of Agriculture, BCKV, Burdwan, West Bengal, India. The bio-efficacy evaluation was done for consecutive two seasons of crop (Winter 2019-20 and Kharif 2020). Field trial plot was laid out for randomized block design with seven treatments (Table 1) including untreated control and each of which was replicated thrice. All standard and recommended packages of practices such as tillage, spacing, nutrition and irrigation were adopted for cultivation of the crop with the high yielding variety Sindhu. The treatments were applied for two times for each season at 15 days interval on crop foliage with high volume knap sack sprayer fitted with hollow cone nozzle using five hundred litres (500 lit) of water ha^{-1}. Both leaves and whorls are wetted during first spray, whereas it was thrown directly towards whorl in the second spray.

Table 1: List of different insecticide treatments for S. *frugiperda*

Name		Formulation	Mode of action	Chemical group	Formulation dose (g or ml)
Technical	Commercial				
Broflanilide	Exponus	30 SC	Prevents GABA from transmitting inhibitory signals.	Metadiamides and isoxazolines	30
Broflanilide	Exponus	30 SC	Prevents GABA from transmitting inhibitory signals.	Metadiamides and isoxazolines	40
Broflanilide	Exponus	30 SC	Prevents GABA from transmitting inhibitory signals.	Metadiamides and isoxazolines	50
Broflanilide	Exponus	30 SC	Prevents GABA from transmitting inhibitory signals.	Meta-diamides and isoxazolines	60
Chlorantraniliprole	Coragen	18.5 SC	Opens muscular calcium channels in particular the ryanodine receptor, rapidly causing paralysis and ultimately death.	Diamide	200
Emamectin Benzoate	Proclaim	5 SG	Inhibits signal transmission at the neuromuscular junction.	Macrocyclic Lactones	300
Untreated control	-	-	-	-	-

The data were taken from 10 randomly selected plants from each plot. The population of the pest (larva of *S. frugiperda*) were recorded directly at one day before first spray & 3, 5, 7 and 10 days after each spraying. Total numbers of leaves and number of damaged leaves were also counted to find out percent leaf damage at 7 and 14 days after spray. While the intensity of attacks were scored based on the scale of the leaf damage according to Davis *et al.* (1992) (Table 2).

The recorded scores were transformed by using this following formula,

$$1= \frac{\sum (n \times v)}{ZN} \times 100\%$$

Where, I = Attack intensities, n = number of the damaged leaves, v = damage scores, Z = highest scores, N = Number of leaves observed.

Plot wise marketable green cob yield was also recorded and

Table 2: Visual rating scales for leaf damage assessment

Scale	Description
0	No visible leaf damage.
1	Only pinhole damage on leaves.
2	Pinhole and shot hole damage to the leaves.
3	Small elongated lesions (5-10 mm) on 1-3 leaves.
4	Midsized lesions (10-30 mm) on 4-7 leaves.
5	Large elongated lesions (> 30 mm) or small portions have eaten on 3-5 leaves.
6	Elongated lesions (> 30 mm) and large portions have eaten on 3-5 leaves.
7	Elongated lesions (> 30 cm) and 50% of leaf eaten.
8	Elongated lesions (30 cm) and large portions have eaten on 70% of leaves.
9	Most leaves with long lesions and complete defoliation observed.

converted into quintal hectare^{-1} (q ha^{-1}). Necessary statistical analysis was performed using OPSTAT on all collected data after suitable transformations whenever necessary.

Results and Discussion

Effect of Insecticides against Fall Army Worm during Winter, 2019-20

Pre-treatment observations recorded a day before insecticidal application. The larval population ranged from 1.30 to 1.67 plant^{-1} and did not differ significantly (Table 3). The data recorded at 3rd, 5th, 7th and 10th days after each of two applications indicates that all insecticides were found effective and significantly superior over untreated control. The most effective treatment *i.e.*, broflanilide 30 SC @ 60 ml ha^{-1} resulted overall 86.15% reduction of larval population over control. It was significantly at par with its next lower dose 50 ml ha^{-1} resulting the reduction of same population by 83.13%. The next effective treatments in order of efficacy for respective reduction of fall armyworm larval population over untreated control were chlorantraniliprole 18.5 SC @ 200 ml ha^{-1} (79.58%), emamectin benzoate 5 SG @ 300 g ha^{-1} (78.75%), broflanilide 30 SC @ 40 ml ha^{-1} (76.04%) and broflanilide 30 SC @ 30 ml ha^{-1} (72.50%).

Effect of Insecticides against Fall Army Worm during Kharif, 2020

The similar trend as noticed during winter (2019-20) apropos efficacy of different schedule insecticides to reduce larval population of fall army worm (*S. Frugiperda*) in corn was also depicted in *Kharif*, 2020 (Table 4). Pre-treatment incidence of larva varied at par level between 2.37 to 2.67 plant^{-1}. After two round applications of insecticides in treated plots, the mean larval population plant^{-1} varied significantly from 0.13 to 1.00; whereas, it was highest as 3.73 plant^{-1} in untreated control plot. The maximum overall mean reduction of larval population (87.02%) over control was recorded in broflanilide 30 SC @ 60 ml ha^{-1}. This was statistically very close with it's another dose @ 50 ml ha^{-1} reducing 85.06% larval population. The next descending orders of treatments to reduce larval population over untreated control were chlorantraniliprole 18.5 SC @ 200 ml ha^{-1} (81.30%), emamectin benzoate 5 SG @ 300 g ha^{-1} (81.81%), broflanilide 30 SC @ 40 ml ha^{-1} (73.36%) and broflanilide 30 SC @ 30 ml ha^{-1} (71.82%). The percent réduction over untreated control in chlorantraniliprole was statistically at par with emamectin benzoate.

Damage (Percent Leaf, Leaf Damage Rating or Scoring in 1-9 Scale and Percent Leaf Attack Intensity) Caused by S. frugiperda in Corn at Different Treatments during Winter, 2019-20

The data on damage variations at 7 and 14 days after each of 2 round sprays with different insecticides were expressed considering percent leaf damage, its scoring into 1-9 scale and percent leaf attack intensity (Table 5). The overall lowest leaf damage (4.87%), score (0.68) and leaf attack intensity (0.35%) were observed with the insecticide broflanilide 30 SC @ 60 ml ha^{-1}. It was significantly at par with broflanilide 30 SC @ 50 ml ha^{-1} (6.26%, 0.80 and 0.71%), chlorantraniliprole 18.5 SC @ 200 ml ha^{-1} (7.55%, 0.85 and 0.71%) and emamectin benzoate 5 SG @ 300 g ha^{-1} (9.16%, 0.83, 0.82%). However, somewhat lesser effect was recorded for another two lower doses of broflanilide *i.e.*, @ 40 ml ha^{-1} (9.90%, 1.16 and 1.30%) and @ 30 ml ha^{-1} (13.53%, 1.30 and 1.95%). Whereas, the highest effect on damage (leaf damage - 33.84%, Score - 2.95 and leaf attack intensity - 6.49%) caused by larva of *S. frugiperda* in corn was seen for untreated control field.

Damage (Percent Leaf, Leaf Damage Rating or Scoring in 1-9 Scale and Percent Leaf Attack Intensity) Caused by S. Frugiperda in Corn at Different Treatments during Kharif, 2020

Table 6 shows the data on damage variations at 7 and 14 days after each of 2 round sprays with different insecticides during *kharif* 2020. The trend was almost same like 1st season of trial. The overall lowest leaf damage (28.94%), score (1.72) and leaf attack intensity (5.22%) were observed with the insecticide broflanilide 30 SC @ 60 ml ha^{-1}. It was significantly at par with broflanilide 30 SC @ 50 ml ha^{-1} (31.73%, 1.99 and 6.74%), chlorantraniliprole 18.5 SC @ 200 ml ha^{-1} (32.33%, 2.03 and 7.09%) and emamectin benzoate 5 SG @ 300 g ha^{-1} (33.61%, 2.18, 7.58%). However, somewhat lesser effect was recorded for another two lower doses of broflanilide *i.e.*, @ 40 ml ha^{-1} (37.79%, 2.73 and 11.07%) and @ 30 ml ha^{-1} (41.64%, 3.12 and 14.68%). Whereas, the highest effect on damage (leaf damage - 77.58%, Score - 5.04 and leaf attack intensity - 42.79%) caused by larva of *S. frugiperda* in corn was seen for untreated control field.

Effect on Yield

The detailed data on yield of corn has been presented in Table 7. Yield was significantly improved and statistically varied by

Table 3: Bio-efficacy of broflanilide 30 SC against fall army worm population in Maize during winter, 2019-20

Treatments	Dose (ml ha-1 or g ha-1)	Number of larvae plant-1									
		1st spray					2nd spray				
		DBS	3 DAS	5 DAS	7 DAS	10 DAS	3 DAS	5 DAS	7 DAS	10 DAS	% reduction over control
Broflanilide 30 SC	30	1.47 (1.40)	0.8 (1.14)	0.60 (1.05)	0.47 (0.98)	0.40 (0.95)	0.77 (1.12)	0.60 (1.05)	0.43 (0.97)	0.33 (0.91)	72.50
Broflanilide 30 SC	40	1.67 (1.47)	0.6 (1.05)	0.47 (0.98)	0.43 (0.96)	0.33 (0.91)	0.77 (1.12)	0.53 (1.02)	0.40 (0.95)	0.30 (0.89)	76.04
Broflanilide 30 SC	50	1.30 (1.34)	0.4 (0.93)	0.33 (0.91)	0.27 (0.87)	0.23 (0.86)	0.70 (1.09)	0.33 (0.91)	0.25 (0.87)	0.18 (0.83)	83.13
Broflanilide 30 SC	60	1.30 (1.34)	0.3 (0.88)	0.27 (0.88)	0.23 (0.86)	0.17 (0.82)	0.67 (1.08)	0.28 (0.88)	0.18 (0.83)	0.12 (0.79)	86.15
Chlorantraniliprole 18.5% SC	200	1.40 (1.37)	0.6 (1.04)	0.33 (0.91)	0.40 (0.95)	0.27 (0.88)	0.73 (1.11)	0.37 (0.93)	0.28 (0.88)	0.28 (0.88)	79.58
Emamectin Benzoate 5% SG	300	1.40 (1.37)	0.6 (1.04)	0.43 (0.96)	0.43 (0.97)	0.28 (0.88)	0.77 (1.13)	0.35 (0.92)	0.27 (0.87)	0.27 (0.87)	78.75
Untreated Check	-	1.50 (1.41)	1.4 (1.37)	1.37 (1.36)	1.53 (1.43)	1.47 (1.40)	2.60 (1.76)	2.40 (1.70)	3.00 (1.87)	2.20 (1.64)	-
SEm±		0.05	0.09	0.03	0.03	0.02	0.04	0.03	0.04	0.02	-
CD %		0.16	0.25	0.09	0.08	0.06	0.12	0.08	0.12	0.06	-

*Figures in the parentheses are √X+0.5 transformed value; DBS: Day before Spray; DAS: Days after Spray

Table 4: Bio-efficacy of broflanilide 30 SC against fall army worm population in Maize during kharif, 2020

Treatments	Dose (ml ha-1 or g ha-1)	Number of larvae Plant-1									
		1st spray					2nd spray				
		DBS	3 DAS	5 DAS	7 DAS	10 DAS	3 DAS	5 DAS	7 DAS	10 DAS	% reduction over control
Broflanilide 30 SC	30	2.37 (1.69)	1.00 (1.22)	0.93 (1.19)	0.67 (1.08)	0.73 (1.10)	0.63 (1.06)	0.53 (1.02)	0.47 (0.98)	0.53 (1.02)	71.82
Broflanilide 30 SC	40	2.50 (1.73)	0.97 (1.21)	0.90 (1.18)	0.60 (1.05)	0.70 (1.09)	0.57 (1.03)	0.53 (1.02)	0.43 (0.96)	0.50 (1.00)	73.36
Broflanilide 30 SC	50	2.37 (1.69)	0.73 (1.11)	0.50 (0.99)	0.27 (0.88)	0.33 (0.91)	0.37 (0.93)	0.30 (0.89)	0.20 (0.83)	0.22 (0.85)	85.06
Broflanilide 30 SC	60	2.60 (1.76)	0.67 (1.07)	0.43 (0.96)	0.23 (0.86)	0.30 (0.89)	0.33 (0.91)	0.30 (0.89)	0.13 (0.79)	0.13 (0.79)	87.02
Chlorantraniliprole 18.5% SC	200	2.33 (1.68)	0.90 (1.18)	0.60 (1.05)	0.32 (0.90)	0.47 (0.98)	0.43 (0.96)	0.33 (0.91)	0.30 (0.88)	0.30 (0.89)	81.30
Emamectin Benzoate 5% SG	300	2.67 (1.77)	0.83 (1.15)	0.57 (1.03)	0.30 (0.89)	0.47 (0.98)	0.43 (0.96)	0.33 (0.91)	0.30 (0.89)	0.32 (90)	81.81
Untreated Check	-	2.60 (1.76)	2.97 (1.86)	3.73 (2.05)	2.60 (1.75)	2.40 (1.69)	2.53 (1.74)	2.30 (1.67)	1.60 (1.43)	1.40 (1.37)	-
SEm±		0.07	0.05	0.06	0.05	0.08	0.05	0.05	0.07	0.04	-
CD %		0.22	0.15	0.19	0.15	0.23	0.15	0.15	0.20	0.12	-

*Figures in the parentheses are√X+0.5 transformed value; DBS: Day before Spray; DAS: Days after Spray

Table 5: Damage (Percent leaf, leaf damage rating or scoring in 1-9 scale and percent leaf attack intensity) caused by *S. frugiperda* in corn at different treatments during winter, 2019-20

Treatments	Dose (ml ha^{-1} or g ha^{-1})	1st					
		Leaf damage (%)		Score on leaf damage (1-9 scale)		Leaf attack intensity (%)	
		7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS
Broflanilide 30 SC	30	15.03 (22.54)	16.88 (24.24)	1.30	1.23	2.25 (8.42)	2.33 (8.73)
Broflanilide 30 SC	40	10.62 (18.86)	14.21 (20.98)	1.17	1.23	1.34 (6.63)	2.41 (7.89)
Broflanilide 30 SC	50	6.61 (14.20)	9.74 (17.99)	0.83	0.73	0.75 (4.48)	0.85 (5.09)
Broflanilide 30 SC	60	5.51 (13.33)	8.90 (17.25)	0.67	0.60	0.43 (3.60)	0.58 (4.35)
Chlorantraniliprole 18.5% SC	200	6.43 (13.65)	9.90 (18.23)	0.93	0.70	0.62 (4.27)	0.84 (4.99)
Emamectin Benzoate 5% SG	300	8.69 (16.94)	9.75 (17.95)	0.80	0.73	0.76 (4.96)	0.78 (5.02)
Untreated Check	-	33.49 (35.32)	40.15 (39.28)	1.77	2.43	6.44 (14.69)	10.95 (19.22)
SEm±	-	2.38	2.63	0.15	0.23	0.79	1.45
CD %	-	7.41	8.19	0.48	0.73	2.47	4.52

Table 5: Continue...

Treatments	2nd spray						Average		
	Leaf damage (%)		Score on leaf damage (1-9 scale)		Leaf attack intensity (%)				
	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	Leaf Damage (%)	Score (1-9 scale)	Damage intensity (%) q
Broflanilide 30 SC	16.58 (23.98)	17.40 (24.63)	1.40	1.27	2.57 (9.21)	2.48 (9.00)	13.53	1.30	1.95
Broflanilide 30 SC	13.57 (21.57)	14.23 (22.07)	1.23	1.00	1.87 (7.83)	1.54 (7.09)	9.90	1.16	1.30
Broflanilide 30 SC	9.23 (17.63)	10.52 (18.80)	0.93	0.70	0.95 (8.60)	0.77 (5.03)	6.26	0.80	0.71
Broflanilide 30 SC	9.10 (15.87)	10.24 (18.62)	0.80	0.63	0.88 (4.73)	0.72 (4.81)	4.87	0.68	0.35
Chlorantraniliprole 18.5% SC	9.94 (18.35)	11.37 (19.68)	1.03	0.73	1.15 (6.13)	0.92 (5.50)	7.55	0.85	0.71
Emamectin Benzoate 5% SG	10.08 (18.41)	11.53 (19.84)	1.07	0.70	1.17 (6.19)	0.89 (5.17)	9.16	0.83	0.82
Untreated Check	43.92 (41.41)	50.53 (45.28)	3.50	4.10	17.06 (24.37)	22.76 (28.47)	33.84	2.95	6.49
SEm±	2.44	1.21	0.10	0.21	0.81	0.67	-	-	-
CD %	7.60	3.78	0.31	0.65	2.53	2.08	-	-	-

*Figure in parenthesis is angular transformed values

Table 6: Damage (Percent leaf, leaf damage rating or scoring in 1-9 scale and percent leaf attack intensity) caused by *S. frugiperda* in corn at different treatments during kharif, 2020

Treatments	Dose (ml ha^{-1} or g ha^{-1})	1st					
		Leaf damage %		Score		Damage intensity	
		7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS
Broflanilide 30 SC	30	38.95 (38.59)	42.27 (40.53)	2.70	3.77	11.75 (19.98)	17.66 (24.82)
Broflanilide 30 SC	40	36.17 (36.93)	40.07 (39.23)	2.63	3.23	10.53 (18.92)	14.37 (22.24)
Broflanilide 30 SC	50	29.13 (32.58)	35.88 (36.77)	2.00	2.60	6.43 (14.66)	10.31 (18.70)
Broflanilide 30 SC	60	28.82 (32.40)	32.56 (34.72)	1.90	2.03	6.07 (14.22)	7.33 (15.68)
Chlorantraniliprole 18.5% SC	200	31.18 (33.67)	35.83 (36.76)	2.20	2.43	7.62 (15.82)	9.69 (18.13)
Emamectin Benzoate 5% SG	300	32.23 (34.56)	36.74 (37.24)	2.40	2.63	8.63 (17.04)	10.43 (18.79)
Untreated Check	-	72.66 (58.60)	81.73 (65.13)	5.23	6.37	42.91 (40.77)	57.57 (49.34)
SEm±		2.10	1.99	0.27	0.24	1.90	0.96
CD %		6.54	6.21	0.85	0.75	5.92	2.98

Table 6: Continue...

Treatments	2nd spray						Average		
	Leaf damage (%)		Score		Damage intensity				
	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	Leaf Damage %	Score	Damage intensity
Broflanilide 30 SC	43.15 (41.01)	44.72 (42.35)	3.27	2.73	15.39 (23.07)	13.90 (21.80)	41.64	3.12	14.68
Broflanilide 30 SC	32.29 (34.62)	36.79 (37.30)	2.93	2.13	10.53 (18.92)	8.86 (17.17)	37.79	2.73	11.07
Broflanilide 30 SC	26.18 (30.73)	29.41 (32.83)	1.87	1.47	5.44 (13.42)	4.78 (12.58)	31.73	1.99	6.74
Broflanilide 30 SC	21.60 (27.68)	23.72 (29.07)	1.63	1.33	3.91 (11.37)	3.57 (10.78)	28.94	1.72	5.22
Chlorantraniliprole 18.5% SC	28.03 (31.92)	28.81 (32.43)	1.97	1.50	6.21 (14.32)	4.84 (12.64)	32.33	2.03	7.09
Emamectin Benzoate 5% SG	25.12 (30.02)	30.98 (33.75)	2.17	1.53	6.00 (14.15)	5.28 (13.24)	33.61	2.18	7.58
Untreated Check	69.37 (56.53)	78.74 (65.97)	4.17	4.40	31.43 (34.02)	39.26 (38.73)	77.58	5.04	42.79
SEm±	1.63	3.33	0.32	0.15	1.10	1.38	-	-	-
CD %	5.08	10.37	1.00	0.46	3.43	4.30	-	-	-

*Figure in parenthesis is angular transformed values

used insecticides over untreated control during both season (winter 2019-20 and *kharif* 2020) of experiment. In this regard, broflanilide @ 60 ml ha^{-1} (151.53 and 142.33 q ha^{-1}) was more or less statistically at par with broflanilide 60 SC @ 50 ml ha^{-1} (149.20 and 140.00 q ha^{-1}), chlorantraniliprole 18.5 SC @ 200 ml ha^{-1} (148.33 and 140.67 q ha^{-1}) and emamectin benzoate 5 SG @ 300 g ha^{-1} (147.53 and 137.33 q ha^{-1}). The respective next at par yield was obtained from the plots

Table 7: Effect of Broflanilide 30 SC on cob yield of Corn during 2019-20 (Winter) & 2020-21 (Kharif)

Treatments	Dosage (ml ha^{-1} or g ha^{-1})	2019-20	2020-21
		Yield (q ha^{-1})	Yield (q ha^{-1})
Broflanilide 30 SC	30	138.33	126.00
Broflanilide 30 SC	40	141.63	125.00
Broflanilide 30 SC	50	149.20	140.00
Broflanilide 30 SC	60	151.53	142.33
Chlorantraniliprole 18.5% SC	200	148.33	140.67
Emamectin Benzoate 5% SG	300	147.53	137.33
Untreated Check	-	125.00	113.33
SEm±		2.53	3.29
CD at 5%		7.59	9.88

treated with two other lower doses of broflanilide *i.e.*, @ 40 ml ha^{-1} (141.63 and 125.00 q ha^{-1}) and 30 ml ha^{-1} (138.33 and 126 q ha^{-1}). Whereas, the lowest yield 125.00 (winter 2019-20) and 113.33 q ha^{-1} (*kharif* 2020) were recorded in untreated control plots.

In present experiment, effect of broflanilide is evaluated first time against *S. frugiperda* of corn. So, literature on this chemical in corn is totally scanty in India. It significantly reduced the survival rate of neonate larva of *Spodoptera litura* (Shen *et al.*, 2021). Emamectin benzoate and chlorantraniliprole were found more effective in checking the larval population, plant and cob damage in maize which also reflected on grain and fodder yield as well (Thumar *et al.*, 2020). All these findings are in agreement with the present findings. No earlier report is available regarding leaf damage assessment by *S. frugiperda* in corn using different parameters (percent leaf damage, scoring of damage and attack intensity) after treated with different chemicals.

Conclusion

It can be deduced from the present investigation, that application of broflanilide 30 SC @ 50-60 ml ha^{-1} was more effective in managing the larval population, reducing subsequent leaf damage and improving yield in maize. The response obtained from chlorantraniliprole 18.5 SC and emamectin benzoate 5 SG was also more or less close to this newly introduced insecticide broflanilide 30 SC. So, intelligent alternate selection of insecticides under different chemical groups having separate specific novel mode of action can be helpful to the maize growers to manage destructive *S. frugiperda* in better way with higher yield and economic return. Accordingly, necessary need based recommendation is strongly suggested here for coping the said pest in corn.

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