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Field Efficacy of Selected Newer Insecticide Molecules on *Spodoptera frugiperda* (J. E. Smith) in Maize

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ABSTRACT: The combinations may be physically incompatible, effect the bio efficacy, result in phytotoxic effects or aid in insecticide resistance development in pests and injudicious use of pesticides in combinations without proper knowledge may reduce the efficacy of the combinations in managing the pests and diseases. The combinations include physically incompatible, effect the bio efficacy, result in phytotoxic effects or aid in insecticide resistance development in pests. Injudicious use of pesticides in combinations without proper knowledge may reduce the efficacy of the combinations in managing the pests and diseases. A field experiment was carried out at Main Agricultural Research Station (MARS), College of Agriculture, Dharwad, UAS, Dharwad, to study the efficacy of new generation insecticides and fungicides alone and in combination against maize fall armyworm *Spodoptera frugiperda* (J.E. Smith). It is a severe polyphagous pest with a wide host range of 186 plant species including many economically important crops such as maize, sorghum, sugarcane, rice, wheat, cowpea, groundnut, potato, soybean and cotton. Adult moths can travel up to 500 km during a single season to seek out oviposition sites and can fly over 100 km for seeking the host plants. The treatments comprising of eight newer insecticide molecules and three bio pesticides were further evaluated under field conditions during late *kharif* of 2019-20 and 2020-21 at Main Agricultural Research Station, Dharwad. The trial was conducted in Randomized Block Design (RBD) with twelve treatments and three replications. The popular maize hybrid, NK-6240 was sown over plot size of 5 × 4 m at a spacing of 60 × 20 cm for each treatment. The crop was raised as per recommended packages including plant protection measures except for target pest. Application of different treatments was done two times (at 30 and 50 days of germination) using knapsack sprayer by directing the spray solution into leaf whorls. The highest efficacy was found in newer insecticide molecules, cyantraniliprole 10 OD @ 0.30 g/l and spinetoram 11.7 SC @ 0.50 ml/l treatments causing cent per cent larval mortality within 3 days of application. By 7th day, more than 80 per cent larval mortality was registered in all other chemical treatments as compared to less than 50 per cent in case of biopesticides. All chemical treatments in general recorded lower leaf damage than biopesticide treatments which were even at par with the untreated check. Spinetoram 11.7 SC spray @ 0.5 ml/l resulted in highest grain yield which was at par with cyantraniliprole 10 OD @ 0.3 ml/l. Lower yields were obtained from the plots which received biopesticides application.

Keywords: *Spodoptera frugiperda*, spinetoram, cyantraniliprole, chlorantraniliprole, nimbecidine, *Bacillus thuringiensis var.* kurstaki.

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop cultivated globally due to its versatile growth habit and higher productivity. It is gaining popularity among growers. Maize is grown on 193.7 million hectares worldwide, with a productivity of 5.75 tonnes per hectare. Currently, approximately 1147.7 million tonnes of maize kernels are being produced per year (Anonymous, 2020). Importantly, maize is an indispensable source of raw material for the synthesis of corn oil, margarine, corn syrup, sweeteners, marmalade, and instant non-dairy coffee creamer besides its dedicated usage as animal and bird feed (Kaul *et al.,* 2019). Corn is also used to make beverages, industrial chemicals, ethanol, fuel, plastics, and high-quality paper among other things (Naz *et al.*, 2019: Gamage *et al.,* 2022).

Maize is originated in Mexico and Central America, later from center of origin it spread to different parts of the world including America, Europe, Africa, and Asia. It was introduced to India from Central America in the beginning of 17th century (Hossain *et al.,* 2016; Anon., 2017). Maize (*Zea mays* L.) is the most cultivated cereal in the world followed by rice and wheat (FAO 2017) for its high nutritional value because of its carbohydrate content. (Undie *et al.* 2012; FAO 2017). It is the most important cereal in Cameroon and it is grown across the five agro-ecological zones. Fall army worm (FAW) *Spodoptera frugiperda* (J E Smith) is an invasive pest, which was first reported in India in maize fields during mid-May 2018 (Sharanabasappa *et al.*, 2018a). Since then, it has spread to different southern states of India on maize (Mahadevaswamy *et al.,* 2018; Sharanabasappa *et al.*, 2018b).

It is a severe polyphagous pest with a wide host range of 186 plant species including many economically important crops such as maize, sorghum, sugarcane, rice, wheat, cowpea, groundnut, potato, soybean and cotton (Casmuz *et al.,* 2010). Adult moths can travel up to 500 km during a single season to seek out oviposition sites and can fly over 100 km for seeking the host plants. It is capable of causing 34 % yield losses in maize. The recent invasion of the fall armyworm, *Spodoptera frugiperda* (Noctuidae: Lepidoptera) has become a great threat for maize cultivation in northern Karnataka causing damage ranging from 0 to 100 per cent on maize crop (Mallapur *et al*., 2018). FAW is known to cause major damage to economically important cultivated crops maize, sorghum and also reported on sugarcane (Chormule *et al.,* 2019).

Wu *et al.* (2021) reported that invasive populations of *Spodoptera frugiperda* show bet-hedging strategy life history, enabling earlier reproduction and elongated reproductive lifespan, and that it promotes invasion success of the species. The damaging stage of the pest is the larvae. The larvae have various feeding patterns; most of the time, they hide in the mouths of plants or the soil until sunset, when they emerge to feed. However, the day-feeding fall armyworm is active during the day as well. If fall armyworm is not controlled, maize yield losses could range from 8.3 to 20.6 million tonnes per year (21–53 percent of total production), according to Day *et al.* (2017). Similarly, earlier studies indicated severe yield loss, with 11.6 % yield loss observed by Baudron *et al.* (2019), 32–47 % by Kumela *et al.* (2019), and 22 and 67 % by Day *et al.* (2017).

On maize, the insecticides molecule treatments comprising of eight newer insecticide molecules and three bio pesticides were further evaluated under field conditions during *kharif* of 2019 and 2020 at Main Agricultural Research Station, Dharwad.

There are four major pests of maize prevalent in India *viz*., spotted stem borer *Chilo partellus* (Schinobi), pink stem borer *Sesamia inferens* (Walker), shoot fly *Atherigona* spp. and fall armyworm *Spodoptera frugiperda* (J.E. Smith). Among all the pests fall armyworm is causing serious damage to maize at all stages of its growth. In addition to the pests some of the diseases like charcoal rot, common rust, turcicum leaf blight occur simultaneously on maize. So, in order to reduce both pest and disease incidence farmers go for combination spray of both insecticide and fungicide which eventually leads to development of phytotoxicity, reduces the efficacy of one or the other pesticide. Therefore, there is a need to study the compatibility of insecticides and fungicides on maize.

MATERIAL AND METHODS

The treatments comprising of eight newer insecticide molecules and three bio pesticides were further evaluated under field conditions during late *kharif* of 2019-20 and 2020-21 at Main Agricultural Research Station, Dharwad. The trial was conducted in Randomized Block Design (RBD) with twelve treatments and three replications. The popular maize hybrid, NK-6240 was sown over plot size of 5 × 4m at a spacing of 60 × 20 cm for each treatment. The crop was raised as per recommended packages including plant protection measures except for target pest. Application of different treatments was done two times (at 30 and 50 days of germination) using knapsack sprayer by directing the spray solution into leaf whorls.

Observations on per cent defoliation and per cent cob damage were recorded 20 randomly selected plants in each treatment at one day before spraying and 3, 7 and 10 days after each spraying. The grain yield from individual treatment was recorded separately and expressed on hectare basis.

RESULTS AND DISCUSSION

A. Field evaluation

(a) Larval population

Pooled data. The pooled data indicated non significant difference among various treatments (1.02 to 1.32 larvae/pl) before imposition of various treatments. After 3 DAS of 1st spray however, cent per cent larval reduction was noticed in cyantraniliprole 10 OD @ 0.30 ml/l and spinetoram 11.7 SC @ 0.50 ml/l treatments. Next to follow were spinosad 45 SC @ 0.50 ml/l (91.87 %) and novaluron 5.25 % + emamectin benzoate 0.9 SC @ 0.20 ml/l (89.76 %). At 7 DAS however, the larval reduction varied from 80.00 to 95.93 per cent in different chemical treatments compared to 25.45 to 50.93 per cent in case of biopesticides. Cent per cent larval mortality was also observed at 10DAS in spinosad 45 SC @ 0.50 ml/l (91.87 %), novaluron 5.25% + emamectin benzoate 0.9 SC @ 0.20 ml/l and chlorantraniliprole 18.5 SC @ 0.20 ml/l. In other chemical treatments, the larval reduction was more than 85 per cent compared to 42.73 to 67.59 per cent in case of biopesticides.

With similar trend of larval reduction during 2nd spray, cyantraniliprole 10 OD @ 0.30 ml/l and spinetoram 11.7 SC @ 0.50 ml/l treatments caused cent per cent larval mortality within 3 DAS of application. At 10

DAS however, chlorantraniliprole 18.5 SC @ 0.20 ml/l also resulted cent per cent larval mortality followed by spinosad 45 SC @ 0.50 ml/l (96.55 %) and novaluron 5.25 % + emamectin benzoate 0.9 SC @ 0.20 ml/l (89.55 %). The larval mortality ranged from 31.58 per cent in *Metarhizium rileyi* 2×10^8 CFU @ 2 g/l to 69.92 per cent in case of nimbecidine 0.03% @ 3 ml/l (Table 1).

The result of field trial clearly indicated the highest efficacy of cyantraniliprole 10 OD @ 0.30 g/l and spinetoram 11.7 SC @ 0.50 ml/l treatments causing cent per cent larval mortality within 3 days of application. By 7th day, more than 80 per cent larval mortality was registered in all other chemical treatments as compared to less than 50 per cent in case of biopesticides (Fig. 1). Sisay *et al.* (2019) from laboratory studies reported that spinetoram caused the highest mortality of 96.7 per cent 48 h after treatment application and cent per cent mortality at 72 h of treatment application, while Lambda cyhalothrin caused 96.7 per cent mortality at 48 h and 72 h after treatment application. Similarly, the higher efficacy of many of the tested products in the present study have been reported on other pests/crops by many workers from time to time. Satyaanarayana *et al.* (2010) found that emamectin benzoate 0.00725 % was the most effective insecticide followed by indoxcarb 0.0145 % and indoxcarb 0.00725 % + novaluran 0.005 % in reducing the larval population of *Spodoptera litura*. The mortality among the different dosages of emamectin benzoate ranged from 94.30 to 100 and 88.10 to 100 per cent at 10 and 15 days after spray, respectively (Kambrekar *et al.*, 2012). Similarly, Karthik *et al.* (2018); Rabari *et al.* (2018) observed 100 and 87.49 per cent mortality of *Helicoverpa armigera* and *Spodoptera litura* with emamectin benzoate 5 SG and spinosad 45 SC, respectively.

Table 1: Field efficacy of newer insecticide molecules and biorationals against fall armyworm in maize (Pooled data).

Tr No	Treatments	I Spray (Larval number per plant)								II Spray (Larval number per plant)							
		Dosage	1 DBS	3 DAS	% reduction	7 DAS	% reduction	10 DAS	% reduction	1 DBS	3 DAS	% reduction	7 DAS	% reduction	10 DAS	% reduction
1	Nimbecidine 0.03%	3 ml/l	1.08 (1.24)^{b}	0.92 (1.38)^{a}	14.81	0.53 (1.24)^{a}	50.93	0.35 (1.16)^{b}	67.59	1.23 (1.49)^{a}	0.95 (1.39)^{a}	22.76	0.60 (1.27)^{a}	51.22	0.37 (1.18)^{a}	69.92
2	*Bacillus thuringiensis var. kurstaki* 17,600 IU/mg	2 g/l	1.00 (1.41)^{ab}	1.13 (1.46)^{b}c	-13.00	0.67 (1.31)^{bc}	33.00	0.47 (1.23)^{b}	53.00	1.07 (1.43)^{a}	1.22 (1.49)^{bc}	-14.02	0.77 (1.32)^{bc}	28.04	0.52 (1.25)^{b}	51.40
3	*Metarhizium rileyi* 2 x 10^8 CFU	2 g/l	1.10 (1.44)^{b}	1.25 (1.49)^{c}	-13.64	0.82 (1.34)^{c}	25.45	0.63 (1.28)^{a}	42.73	0.95 (1.38)^{a}	1.23 (1.48)^{c}	-29.47	0.92 (1.37)^{c}	3.16	0.65 (1.29)^{b}	31.58
4	Novaluron 10 % EC	1 ml/l	1.25 (1.49)^{a}	0.40 (1.18)^{b}	68.00	0.25 (1.12)^{b}	80.00	0.18 (1.09)a	85.60	0.67 (1.29)^{a}	0.43 (1.19)^{ab}	35.82	0.27 (1.12)^{ab}	59.70	0.20 (1.09)^{a}	70.15
5	Spinosad 45 SC	0.50 ml/l	1.23 (1.49)^{d}	0.10 (1.05)^{d}	91.87	0.05 (1.02)^{d}	95.93	0.00 (1.00)^{c}	100	0.58 (1.25)b	0.20 (1.09)^{d}	65.52	0.08 (1.04)^{d}	86.21	0.02 (1.01)^{c}	96.55
6	Emamectin benzoate 5 SG	0.3 g/l	1.02 (1.42)^{d}	0.20 (1.10)^{d}	80.39	0.13 (1.06)^{d}	87.25	0.08 (1.04)^{c}	92.16	0.50 (1.22)^{b}	0.28 (1.13)^{d}	44.00	0.15 (1.07)^{d}	70.00	0.13 (1.06)^{c}	74.00
7	Novaluron 5.25 % + Emamectin benzoate 0.9 SC	0.2 ml/l	1.27 (1.50)^{d}	0.13 (1.06)^{d}	89.76	0.05 (1.02)^{d}	96.06	0.00 (1.00)^{c}	100	0.67 (1.28)^{b}	0.13 (1.06)^{d}	80.60	0.03 (1.02)^{d}	95.52	0.07 (1.03)^{c}	89.55
8	Chlorantraniliprole 18.5 SC	0.20 ml/l	1.25 (1.50)^{d}	0.15 (1.07$^{)d}$	88.00	0.07 (1.03)^{d}	94.40	0.00 (1.00)^{c}	100	0.62 (1.27)^{b}	0.13 (1.06)^{d}	79.03	0.02 (1.01)^{d}	96.77	0.00 (1.00)^{c}	100
9	Cyantraniliprole 10 OD	0.30 ml/l	1.00 (1.40)^{d}	0.00 (1.00)^{d}	100	0.00 (1.00)^{d}	100	0.00 (1.00)^{c}	100	0.50 (1.22)^{b}	0.00 (1.00)^{d}	100	0.00 (1.00)^{d}	100	0.00 (1.00)^{c}	100
10	Spinetoram 11.7 SC	0.5 ml/l	1.15 (1.46)^{d}	0.00 (1.00)^{d}	100	0.00 (1.00)^{d}	100	0.00 (1.00)^{c}	100	0.42 (1.19)^{b}	0.00 (1.00)^{d}	100	0.00 (1.00)^{d}	100	0.00 (1.00)^{c}	100
11	Flubendiamide 480 SC	0.10 ml/l	1.32 (1.51)^{d}	0.18 (1.11)^{d}	86.36	0.15 (1.07)^{d}	88.64	0.07 (1.03)^{c}	94.70	0.82 (1.34)^{b}	0.27 (1.12)^{d}	67.07	0.17 (1.08)^{d}	79.27	0.10 (1.05)^{c}	87.80
12	Untreated Check	-	1.28 (1.51)^{d}	1.47 (1.55)^{d}	-14.84	1.65 (1.60)^{d}	-28.91	1.82 (1.63)^{c}	-42.19	2.18 (1.77)^{b}	2.37 (2.53)^{d}	-8.72	2.53 (1.85)^{d}	-16.06	2.63 (1.88)^{c}	-20.64
SEm. ±			0.08	0.07	-	0.08	-	0.08	-	0.08	0.09	-	0.07	-	0.08	-
CD (p=0.05)			NS	0.20	-	0.23	-	0.24	-	0.25	0.29	-	0.23	-	0.24	-
C.V. (%)			10.06	9.52	-	11.08	-	12.02	-	10.60	13.01	-	10.73	-	11.84	-

Note: DBS- Days Before Spray, DAS- Days After Spray

(b) Defoliation

Pooled data. A day before spray, the defoliation of maize due to fall armyworm ranged from 19.71 to 24.54 per cent in different treatments without statistical significance. At 7 DAS however, the lowest defoliation (19.71 %) was registered in spinosad 45 SC @ 0.50 ml/l which failed to differ statistically from all other treatments except nimbecidine 0.03 % @ 3 ml/l and untreated check. Similar trend was noticed at 10 DAS wherein, higher defoliation was observed the untreated check (39.21 %) and nimbecidine 0.03 % @ 3 ml/l (35.33 %) followed by other biopesticide treatments.

During 2nd spray also all the chemical treatments recorded lower defoliation in comparison to biopesticide treatments as well as the untreated check. At 10 DAS, significantly higher defolation (49.29 %) was noticed in untreated check which was on par with nimbecidine 0.03% @ 3 ml/l (44.46 %) and *Metarhizium rileyi* 2×10^8 CFU @ 2 g/l (40.46 %). In other treatments, the defoliation ranged from 25.54 to 36.04 per cent which were found to be on par with each other (Table 2).

All chemical treatments in general recorded lower leaf damage than biopesticide treatments which were even at par with the untreated check. Spinetoram 11.7 SC spray @ 0.5 ml/l resulted in highest grain yield which was at par with cyantraniliprole 10 OD @ 0.3 ml/l. Lower yields were obtained from the plots which received biopesticides application (Fig. 2). Spinetoram 11.7 SC was also reported as effective molecule against *Spodoptera frugiperda* under laboratory and field by Mallapur *et al*. (2019). Spinetoram 11.7 SC, emamectin benzoate 5 SG, chlorantraniliprole 18.5 EC, and thiodicarb 75 WP 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). Sandhya *et al.* (2022) reported the mean percent incidence of fall armyworm was less in Chlorantraniliprole 18.5 % SC (8.04) followed by combination product Lambda Cyhalothrin 4.6 % + Chlorantraniliprole 9.3 % ZC (9.19) which indicates their efficacy.

(c) Cob damage

Pooled. The cob damage at 75 DAG was as high as 38.33 per cent in case of untreated check which was on par with T_1 nimbecidine 0.03 % @ 3 ml/l and T_3 *Metarhizium rileyi* 2×10^8 CFU @ 2 g/l treatments. The cob damage continued to increase gradually in all the treatments with the time. At 105 DAG, significantly lower cob damage (7.50 %) was observed in T_{10} spinetoram 11.7 SC @ 0.5 ml/l treatment which was found at par with T_9 cyantraniliprole 10 OD @ 0.30 ml/l treatment. However, the highest (50.00 %) cob damage was recorded in the T_{12} untreated check (Table 3).

(d) Grain yield

Pooled data. The pooled data revealed significantly higher grain yield (73.25 q/ha) in T_{10} spinetoram 11.7 SC @ 0.5 ml/l treatment which was at par with T_9 cyantraniliprole 10 OD @ 0.30 ml/l. In turn, T_9 cyantraniliprole 10 OD @ 0.30 ml/l treatment stood at par with T_5 spinosad 45 SC @ 0.50 ml/l and T_{11} flubendiamide 480 SC @ 0.10 m/l treatments. Significantly lower yields (33.58 to 40.88 q/ha) were registered in T_1 nimbecidine 0.03 % @ 3 ml/l, T_2 *Bacillus thuringiensis* var. *kurstaki* 17,600 IU/mg @ 2 g/l and T_3 *Metarhizium rileyi* 2×10^8 CFU @ 2 g/l treatments and even the T_3 *Metarhizium rileyi* 2×10^8 CFU @ 2 g/l treatment was at par with T_{12} untreated check treatment (Table 3).

Spinetoram 11.7 SC spray @ 0.5 ml/l resulted in highest grain yield which was at par with cyantraniliprole 10 OD @ 0.3 ml/l. Lower yields were obtained from the plots which received biopesticides application (Fig. 2).

(e) Benefit Cost Ratio

Pooled data. With highest benefit cost ratio of 2.59, T_{11} flubendiamide 480 SC @ 0.10 m/l treatment was found on par with T_{10} spinetoram 11.7 SC @ 0.5 ml/l (2.56) (Table 3).

Table 2: Effect of newer insecticide molecules and biorationals on defoliation by fall armyworm in maize (Pooled data).

Tr. No.	Treatments	Dosage	I Spray (Percent Defoliation)			II Spray (Percent Defoliation)		
			1 DBS	7 DAS	10 DAS	1 DBS	7 DAS	10 DAS
1	Nimbecidine 0.03%	3 ml/l	23.29 (28.08)	32.50 $(34.71)^{ab}$	35.33 $(36.43)^{ab}$	39.08 $(38.67)^{a}$	42.25 $(40.52)^{ab}$	44.46 $(41.80)^{ab}$
2	*Bacillus thuringiensis var. kurstaki* 17,600 IU/mg	2 g/l	21.25 (27.43)	27.58 $(31.53)^{abcd}$	27.58 $(31.53)^{bcd}$	32.96 $(34.99)^{abc}$	36.04 $(36.83)^{bc}$	36.04 $(36.83)^{bcd}$
3	*Metarhizium rileyi* 2 x 10^8 CFU	2 g/l	21.54 (27.56)	28.92 $(32.45)^{abcd}$	29.96 $(33.09)^{bc}$	34.75 $(36.10)^{ab}$	39.46 $(38.88)^{ab}$	40.46 $(39.46)^{abc}$
4	Novaluron 10 % EC	1 ml/l	19.79 (26.32)	20.38 $(26.72)^{acd}$	21.75 $(27.65)^{cd}$	29.17 $(32.66)^{bc}$	29.17 $(32.67)^{cd}$	30.67 $(33.60)^{cd}$
5	Spinosad 45 SC	0.50 ml/l	19.71 (26.31)	19.71 $(26.31)^{d}$	19.71 $(26.31)^{d}$	25.75 $(30.39)^{bc}$	25.75 $(30.39)^{cd}$	26.00 $(30.54)^{d}$
6	Emamectin benzoate 5 SG	0.3 g/l	21.25 (27.33)	21.25 $(27.33)^{cd}$	22.33 $(28.10)^{cd}$	24.58 $(29.57)^{c}$	24.58 $(29.57)^{d}$	25.83 $(30.34)^{d}$
7	Novaluron 5.25 % + Emamectin benzoate 0.9 SC	0.2 ml/l	23.83 (29.15)	23.83 $(29.16)^{bcd}$	23.83 $(29.16)^{cd}$	26.75 $(31.04)^{bc}$	26.75 $(31.04)^{cd}$	26.75 $(31.04)^{d}$
8	Chlorantraniliprole 18.5 SC	0.20 ml/l	23.17 (28.73)	23.67 $(29.06)^{bcd}$	23.88 $(29.19)^{cd}$	27.54 $(31.52)^{bc}$	27.54 $(31.52)^{cd}$	27.88 $(31.73)^{d}$
9	Cyantraniliprole 10 OD	0.30 ml/l	23.71 (29.00)	23.71 $(29.00)^{bcd}$	23.71 $(29.00)^{cd}$	26.58 $(30.83)^{bc}$	26.58 $(30.83)^{cd}$	26.58 $(30.83)^{d}$
10	Spinetoram 11.7 SC	0.5 ml/l	24.54 (29.63)	24.54 $(29.63)^{bcd}$	24.54 $(29.63)^{cd}$	25.54 $(30.30)^{bc}$	25.54 $(30.30)^{d}$	25.54 $(30.33)^{d}$
11	Flubendiamide 480 SC	0.10 ml/l	22.67 (28.43)	22.67 $(28.34)^{cd}$	22.67 $(28.34)^{cd}$	26.92 $(31.07)^{bc}$	26.92 $(31.08)^{cd}$	26.92 $(31.08)^{d}$
12	Untreated Check	-	24.13 (29.32)	36.33 $(37.03)^{a}$	39.21 $(38.73)^{a}$	42.83 $(40.86)^{a}$	47.08 $(43.31)^{ab}$	49.29 $(44.58)^{a}$
SEm. ±			1.77	1.74	1.77	1.88	1.94	2.02
CD (p=0.05)			NS	5.36	5.47	5.80	5.98	6.21
C.V. (%)			10.88	10.0 1	10.04	9.83	9.91	10.17

Note: DBS- Days Before Spray, DAS- Days After Spray; Figures within the parenthesis are arc transformed values

Table 3: Impact of different treatments on cob damage due to fall armyworm and grain yield in maize (Pooled data).

Tr. No.	Treatments	Dosage	Cob damage (%)				Grain yield (q/ ha)	Benefit Cost Ratio
			75 DAG	90 DAG	105 DAG	Mean		
1	Nimbecidine 0.03%	3 ml/l	27.50 (31.52)^{b}	32.50 (34.71)^{b}	35.83 (36.74)^{a}	31.94	40.88^{c}	1.49
2	*Bacillus thuringiensis var. kurstaki* 17,600 IU/mg	2 g/l	21.67 (27.67)^{bc}	25.83 (30.50)^{cd}	28.33 (32.12)^{b}	25.28	37.41^{bc}	1.33
3	*Metarhizium rileyi* 2 × 10^{8} CFU	2 g/l	25.00 (29.93)^{b}	29.17 (32.64)^{bc}	31.67 (34.22)^{b}	28.61	33.58^{ab}	1.34
4	Novaluron 10 % EC	1 ml/l	18.33 (25.33)^{cd}	20.83 (27.09)^{de}	23.33 (28.82)^{ab}	20.83	52.77^{d}	1.75
5	Spinosad 45 SC	0.50 ml/l	8.33 (16.73)^{bc}	10.00 (18.34)^{hi}	11.67 (19.94)^{c}	10.00	65.91^{g}	1.93
6	Emamectin benzoate 5 SG	0.3 g/l	15.83 (23.42)^{de}	17.50 (24.72)^{ef}	19.17 (25.91)^{c}	17.50	57.98^{de}	2.19
7	Novaluron 5.25 % + Emamectin benzoate 0.9 SC	0.2 ml/l	11.67 (19.79)^{def}	13.33 (21.28)^{fgh}	15.00 (22.73)^{c}	13.33	60.42^{ef}	2.41
8	Chlorantraniliprole 18.5 SC	0.20 ml/l	13.33 (21.39)^{efg}	15.00 (22.73)^{fg}	16.67 (23.99)^{c}	15.00	65.97^{g}	2.46
9	Cyantraniliprole 10 OD	0.30 ml/l	6.67 (14.90)^{fgh}	8.33 (16.73)^{ij}	10.00 (18.34)^{c}	8.33	68.78^{gh}	2.37
10	Spinetoram 11.7 SC	0.50 ml/l	4.17 (11.64)^{gh}	5.83 (13.91)^{j}	7.50 (15.89)^{c}	5.83	73.25^{h}	2.56
11	Flubendiamide 480 SC	0.10 ml/ l	10.00 (18.34)^{hi}	11.67 (19.94)^{ghi}	13.33 (21.39)^{c}	11.67	65.54^{fg}	2.59
12	Untreated Check	-	38.33 (38.24)^{i}	45.00 (42.11)^{a}	50.00 (44.98)^{c}	44.44	29.32^{a}	1.25
SEm. ±			1.35	1.27	1.28	-	1.79	-
CD (p=0.05)			4.17	3.92	3.96	-	5.28	-
C.V. (%)			10.09	8.67	8.22	-	15.81	-

DAG: Days after germination; Figures within the parenthesis are arc sine transformed values

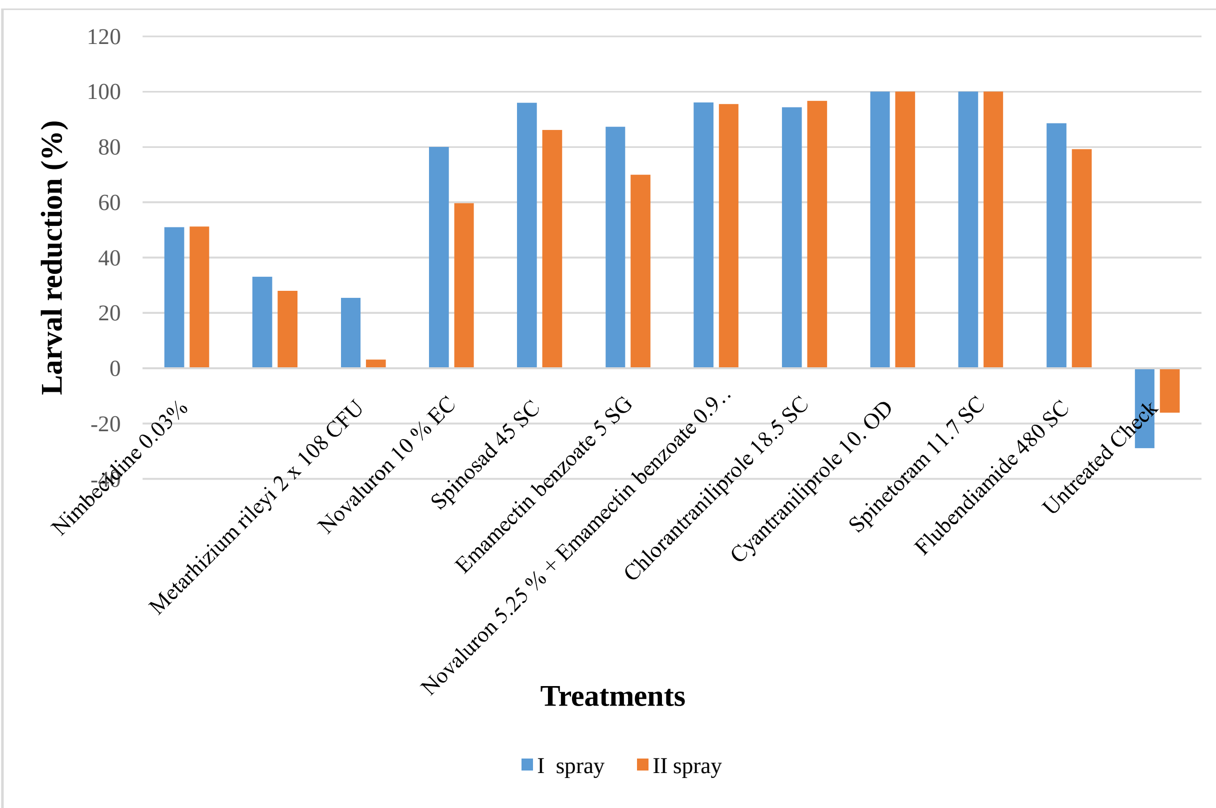

Fig. 1. Larval reduction due to application of newer insecticide molecules and biorationals at 7 DAS.

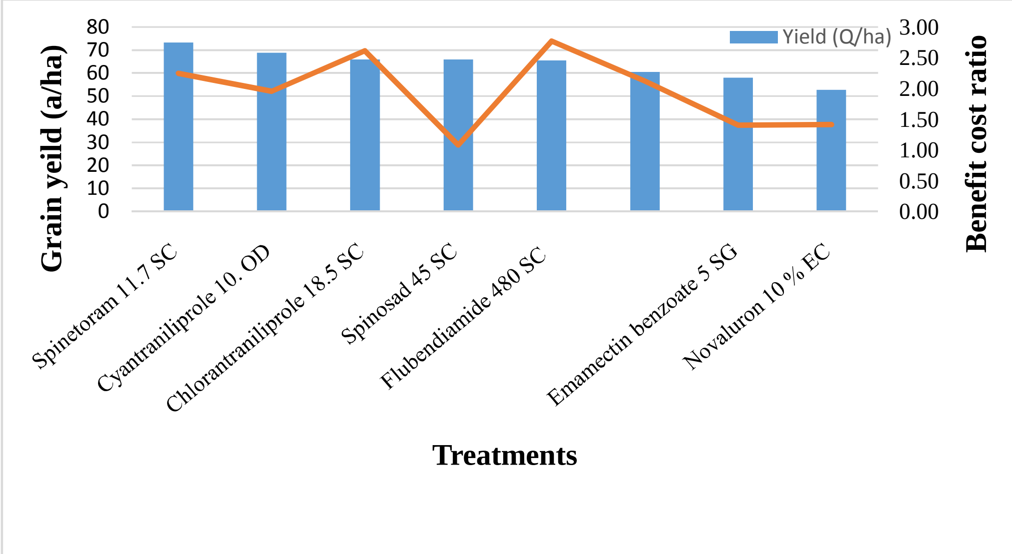

Fig. 2. Impact of different treatments on grain yield and benefit cost ratio in maize.

CONCLUSION

Application of cyantraniliprole 10 OD @ 0.30 g/l and spinetoram 11.7 SC @ 0.50 ml/l resulted treatments resulted in cent per cent larval mortality while, the biopesticides caused less than 50 per cent mortality of FAW in field conditions.

FUTURE SCOPE

Fall armyworm is a new destructive insect pest is one of the major problems for agricultural crop production, especially maize in India. This is due to its ability to breed rapidly, migrate and feed on wide host plants, all of which makes it very difficult to control. Nonetheless, there are several ways of managing the pest as reported in other parts of the world that can potentially be adapted and validated and used in India. Hence, to manage this pest the chemical management is best optional to decrease resistance build up and suppress pest population.

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