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Bio-efficacy of conventional insecticides against fall armyworm *Spodoptera frugiperda* (J E Smith) IN/ON Maize

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Abstract
The present investigation entitled "Bio-efficacy of conventional insecticides against fall armyworm *Spodoptera frugiperda* (J E Smith)" was conducted at Instructional Farm of Post Graduate Institute, M.P.K.V., Rahuri during *Rabi* 2020-21.
The experiment consisted eight treatments *viz*., bifenthrin 10% EC @ 50 g a.i./ha, deltamethrin 2.8% EC @ 15 g a.i./ha, lambda cyhalothrin 5% EC 15 g a.i./ha, cypermethrin 10% EC @ 50 g a.i./ha, ethion 50% EC @ 500 g a.i./ha, fenvalerate 10% EC @ 75 g a.i./ha, profenofos 50% EC @ 500 g a.i./ha and untreated control. These treatments were evaluated in Randomized Block Design in three replications. Total three sprays of each insecticide were given at 10 days interval starting from the time when sufficient pest population was observed. Observations were recorded as number of larvae per 30 plants and per cent infestation of fall armyworm. Among all the tested insecticides, the treatment of profenofos 50% EC @ 500 g a.i./ha expressed its superiority over rest of the treatments disclosing itself to be the most promising treatment with mean larval population of 4.61 and per cent infestation of 9.77. The range of mean larval population for other treatments varied from 7.27 to 28.86 and that for per cent infestation varied from 12.52 to 46.04 per cent. The next treatments to follow profenofos 50%EC @ 500 g a.i./ha were lambda cyhalothrin 5% EC @ 15 g a.i./ha and cypermethrin 10% EC @ 50 g a.i./ha.

Keywords: Fall armyworm, profenofos, lambda cyhalothrin, cypermethrin, larval population and percent infestation

Introduction
Maize (*Zea mays*), also known as "Queen of Cereals" is the world's third most important cereal crop after rice and wheat. The crop is used as human and poultry feed, as well as livestock fodder. It is also an important input for corn starch industry, corn oil production, baby corns, etc. Globally, India ranks 4th in area and 7th in production of maize contributing approximately 4% and 2% of global area and production of maize, respectively (DACNET 2020). In India, area under maize crop is 9.63 million hectare with production and productivity of 25.90 million tones and 2.68 T/ha respectively during 2016-17 (Anon., 2018). Of the total production of maize, poultry feed accounts for approximately 47 per cent, whereas the remaining produce is used for livestock feed and food (13%), industrial purposes (12%), starch industry (14%), processed food (7%), export and other purposes (6%). Madhya Pradesh has the highest area under maize (14.22%) followed by Karnataka (13.3%), Maharashtra (11.91%), Rajasthan (9.54%), Telangana (8.33%) and Uttar Pradesh (7.67%). Maharashtra has the highest state productivity (3T/ha) (Anon., 2018). Maize is principally grown in India during two seasons: Kharif and Rabi. Kharif maize accounts for approximately 83 per cent of maize area in India, while Rabi maize accounts for 17 per cent of maize area.
Since 2018, maize crop production in India has been threatened by the arrival of a new pest, Spodoptera frugiperda (J E Smith). The pest is native to the Americas' tropical and subtropical regions, and it is also found in Argentina, Brazil, Mexico, and the United States (Prowell *et al*. 2004; Clark *et al*. 2007). It harms a variety of crops including maize, soybean, cotton (Pogue 2002; Nagoshi *et al*. 2007; Bueno *et al*. 2010) rice, other grasses, and feeds on a number of weeds (Nabity *et al*. 2011). The incursion of fall armyworm as an invasive pest into Asia was reported for the first time from India on maize during May 2018 (Sharanabasappa *et al*. 2018a). Later, it has spread in other states on maize (Mahadevaswamy *et al*. 2018; Sharanabasappa *et al*. 2018b).

It was first reported in Maharashtra in September 2018 in Tandulwadi village, Solapur district by the farmer Ganesh Babar (Khergamker, 2019). A female moth lays approximately 1000 hair-covered eggs in single or multiple clusters. The newborn larvae disperse from the hatching site in groups and feed on the epidermal layers of the lower surface of tender leaves. The larvae grow through six stages of development before pupation.

In severe cases, it defoliates the leaves extensively and produces a large amount of fecal matter. Tassels and corn ears are vulnerable parts to be damaged during the reproductive stage. According to Sena (2003), the loss caused by fall armyworm observed by using digital color images was found to be 94.72% of 720 images. This signifies the importance of this pest in maize crop production.

The economic importance of the crop compelled farmers to use insecticidal sprays to protect the crop from the pest. At present, the Central Insecticide Board and Registration Committee recommends the use of chlorantraniliprole 18.5% SC, thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC, and spinetoram 11.7% SC for fall armyworm management (DPPQS 2019). In India, maize is primarily grown by the farmers who do not have access to reliable irrigation. As a result, these rainfed farmers prefer conventional and less expensive insecticides, which they also use on other crops. This necessitates an evaluation of the various commonly used insecticides against fall armyworm.

Materials and Methods

Bio-efficacy study was carried out to evaluate the effectiveness of some commonly used synthetic pyrethroids and organophosphate insecticides against fall armyworm in/on maize. The field experiment was conducted during Rabi 2020 at Instructional Farm of Post Graduate Institution, M.P.K.V., Rahuri.

The experiment was conducted using a locally available variety of maize – ECO-97 Parmeshwar in randomized block design (RBD) with three replications and eight treatments. The crop was grown using all the agronomical practices recommended by the university. Conventional insecticides from synthetic pyrethroid and organophosphate group were chosen, and the treatments were applied as foliar spray against the fall armyworm on maize using a knapsack sprayer with a hallow cone nozzle. Three sprays of each treatment were performed at 10-days intervals, with the first spray initiated upon the appearance of fall armyworm incidence. The amount of spray fluid required per plot was determined by spraying the untreated control plot with water at the recommended rate of 500 lit/ha.

The effectiveness of the treatment was ascertained on the basis of reduction in larval population and reduced per cent infestation due to each treatment. Hence, total number of larvae from randomly selected 30 plants from each treatment plot was counted a day before spray (Pre count) and 3, 5, 7 and 10 days after each spray. Total infested plants per plot were also counted at the time of larval count. Yield from each plot was recorded separately and expanded in T/ha.

Results and Discussion

Larval Population

The Table-1 represents the cumulative data on larval population after three sprays. All the treatments were notably superior over the untreated control in reducing the population of fall armyworm in maize. The range of larval population was between 4.61 and 14.61 larvae as observed in treatment plots against 28.86 larvae in untreated control. The treatment of profenofos @ 500 g a.i./ha excelled over other treatments with the least larval population (4.61 larvae). Lambda cyhalothrin 5% EC was witnessed as the next effective treatment recording 7.27 larvae and was at par with cypermethrin @ 50 g a.i/ha with the larval population of 7.61. The larval population for at par treatments of deltamethrin @ 15 g a.i./ha and bifenthrin @ 50 ga.i./ha was 11.22 and 11.25 while that for ethion @ 500 g a.i./ha and fenvalerate @ 75 g a.i./ha was 14.28 and 14.61 respectively following the sequence of order of effectiveness after cypermethrin @ 50 g a.i./ha.

According to the data, significant variations in the per cent reduction in larval population was observed among various treatments in comparison with control. The variation was ranged from 49.38 to 84.03 per cent over control. The maximum reduction of 84.03 per cent was recorded by Profenofos 50% EC while the lowest reduction of 49.38 per cent was registered by fenvalerate @ 75 g a.i./ha.

Per cent Infestation

The data on the per cent infestation after three sprays is presented in Table 2. The data clearly showed that all the treatments were significantly superior over untreated control in minimizing the fall armyworm infestation. The least per cent infestation (9.77) was recorded by profenofos @ 500 g a.i./ha. The overall data on the effect of various treatments on reduction of percent infestation in maize indicated that treatments with profenofos @ 500 g a.i./ha was the most effective among all the treatments followed by lambda cyhalothrin @ 15 g a.i./ha, cypermethrin @ 50 g a.i/ha and deltamethrin @ 15 g a.i/ha. Fenvalerate @ 75 g a.i./ha was least effective treatment amongst all the insecticide treatments.

The current investigation is in accordance with the findings of Worku and Ebabuye (2019) [4] who declared the supremacy of profenofos + cypermethrin in the field experiment. Hole *et al* (2009) [3] researched on bio-efficacy of profenofos and other insecticides against *Spodoptera litura* in soybean publicized that profenofos 0.1% EC gave highest degree of protection as compared to other insecticides.

Marketable Yield of Maize

The quantity of yield displays the fruitfulness of the treatments in/on maize. In accordance with the yield received from each treatment, the sequence in descending order is as given below: Profenofos 50% EC > Lambda cyhalothrin 5% EC > Cypermethrin 10% EC > Deltamethrin 2.8% EC > Bifenthrin 10% EC > Ethion 50% EC > Fenvalerate 10% EC > untreated control.

Table 1: Cumulative effect of different treatments on larval population of FAW, *S. frugiperda*on maize

Tr. No.	Name of Treatment	Larval count of FAW, *S. frugiperda* per 30 plants				
		I spray	II spray	III spray	Mean	Percent reduction over untreated control
1	Bifenthrin 10% EC	13.67 (3.82)	10.42 (3.37)	09.75 (3.28)	11.25 (3.49)	61.02
2	Deltamethrin 2.8% EC	14.17 (3.78)	10.08 (3.32)	09.42 (3.22)	11.22 (3.44)	61.11
3	Lambda cyhalothrin 50% EC	09.67 (3.25)	06.42 (2.71)	05.75 (2.59)	07.27 (2.85)	74.81
4	Cypermethrin 10% EC	10.00 (3.31)	06.75 (2.77)	06.08 (2.65)	07.61 (2.91)	73.63

5	Ethion 50% EC	16.67 (4.20)	13.42 (3.79)	12.75 (3.71)	14.28 (3.90)	50.52
6	Fenvalerate 10% EC	17.00 (4.24)	13.75 (3.84)	13.08 (3.75)	14.61 (3.94)	49.38
7	Profenofos 50% EC	7.00 (2.81)	3.75 (2.15)	03.08 (2.00)	04.61 (2.32)	84.03
8	Untreated control	22.42 (4.84)	28.25 (5.41)	35.92 (6.07)	28.86 (5.44)	-
SE (m) ±		0.07	0.05	0.05	0.05	-
CD @ 5%		0.20	0.15	0.16	0.16	-

Figures in the parenthesis are √X+0.5 transformed values, DAS- Days after Spraying

Table 2: Cumulative effects of different treatments on per cent infestation of FAW, *S. frugiperda* on maize

Tr. No.	Name of Treatment	Per cent infestation of FAW, *S. frugiperda*				
		I spray	II spray	III spray	Mean	Percent reduction over untreated control
1	Bifenthrin 10% EC	23.36 (30.08)	18.12 (30.87)	14.30 (28.77)	18.60 (25.41)	60.46
2	Deltamethrin 2.8% EC	22.78 (29.84)	16.89 (30.42)	13.63 (28.41)	17.77 (24.76)	60.22
3	Lambda cyhalothrin 5% EC	17.81 (27.74)	11.82 (27.83)	7.92 (24.95)	12.52 (20.39)	73.38
4	Cypermethrin 10% EC	18.83 (27.86)	12.97 (28.22)	8.37 (25.29)	13.33 (21.07)	71.66
5	Ethion 50% EC	26.52 (31.90)	21.74 (32.33)	19.81 (31.34)	22.70 (28.37)	51.74
6	Fenvalerate 10% EC	26.77 (32.16)	22.40 (32.60)	20.51 (31.69)	25.98 (30.39)	44.77
7	Profenofos 50% EC	14.23 (25.68)	9.36 (25.86)	5.70 (22.89)	9.77 (17.82)	79.23
8	Untreated control	41.11 (38.23)	47.60 (40.98)	52.40 (42.60)	47.04 (43.20)	-
SE(m) ±		0.43	0.40	0.45	0.708	-
CD@5%		1.28	1.03	1.28	2.097	-

Figures in the parenthesis are arc sin transformed values, DAS- Days After Spraying

It is observed that there is considerable yield advantage of 3.16 T/ha over control due to effective control of *Spodoptera frugiperda* in maize particularly through the use of profenofos 50% EC @ 500 g a.i./ha. These findings are in agreement with those reported earlier by Hole *et al.* (2009) [3] who obtained highest yield of soybean (27.46 q/ha) from the profenofos 0.1% EC treated plot.

Conclusions

According to the per cent infestation data recorded during the research work, the best treatment was profenofos 50% EC @ 500 g a.i./ha with 79.23% reduction over control in per cent infestation and 84.03% reduction over control of larval population per 30 plants as well as highest ICBR. It was followed by lambda cyhalothrin 5% EC @ 15 g a.i./ha and cypermethrin 10% EC @ 50 g a.i/ha with per cent infestation reduction over control of 73.38 and 71.66 and percent reduction in larval population over control of 74.81 and 73.63 per 30 plants respectively., and ICBR ratios just next to profenofos @ 500 g a.i./ha.

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