Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; Sp 9(5): 603-607
Received: 02-07-2020
Accepted: 05-08-2020

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# Bio-efficacy of different insecticides against fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on Maize

**GS Bharadwaj, DS Mutkule, BA Thakre and AS Jadhav**

**Abstract**
The present field experiment were conducted to estimate "Bio-efficacy of different insecticides against fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on Maize" under field condition during *Kharif* season of 2019 at research farm of Oilseed Research Station, Latur (Maharashtra, India). The observations were recorded on total number of live *S. frugiperda* larvae per 25 plants on one day before spray and three, seven days and fourteen days after the spray. The treatments of different insecticides *viz.*, Chlorantraniliprole 18.5 SC @ 0.005 per cent, Emamectin benzoate 5 WG @ 0.002 per cent, Spinetoram 11.7 SC @ 0.011 per cent, Lambda Cyhalothrin 5 EC @ 0.025 per cent, Chlorantraniliprole 9.3 + Lambda Cyhalothrin 4.6 ZC @ 0.008 + 0.002 per cent and Thiomethaxam 12.6 + Lambda cyhalothrin 9.5 ZC @ 0.003 + 0.002 per cent were evaluated against *S. frugiperda* and revealed that Spinetoram 11.7 SC @ 0.011 per cent was found most effective treatment in reducing the population of *S. frugiperda* followed by Emamectin benzoate 5 WG @ 0.002.

**Keywords:** Bio-efficacy, fall armyworm, *S. frugiperda*.

## Introduction
Maize (*Zea mays* L.) is one of the most important cereal grains grown worldwide in a wider range of environments because of its greater adaptability (Kogbe and Adediran, 2003) [1]. In India it was cultivated in an area of 9.47 million hectares during 2017-18 with production of 28.72 million tonnes and with average productivity of 3032 kg per hectare during 2017-18 and in Maharashtra it was cultivated in an area of 1.16 million hectares with production of 3.54 million tonnes and average yield of 3062 kg per ha (Anonymous, 2018) [2].
The *S. frugiperda* is a cosmopolitan pest of the maize crop (Wiseman, 1966) [3]. It feeds on all growth stages of maize but most frequently in the whorl of young plants up to 45 days old. *S. frugiperda* larvae usually consume large amount of foliage and eventually destroys the growing point of the plant. Ovipositional preference and larval behavior for this species within host plants greatly reduces susceptibility to many insecticides. Adults may deposit clusters of 10-500 eggs throughout the plant canopy, but often prefer to oviposit in the whorls of corn or sorghum. First instars can be observed in an aggregate near the site of the egg mass, while late instars aggressively disperse within and across adjacent plants (Ali *et al*., 1989) [4]. The adult female lays the eggs in masses, randomly distributed within the crop. During the summer, egg hatch occurs in 3 days. The newly hatched larvae immediately start feeding on the tissues, usually beginning with the tender portions. First instar larvae usually eat the green tissue from one side of the leaf, leaving the membranous epidermis on the other side intact. Older instars begin to make holes in the leaf and the fourth to sixth instars may completely destroy small plants and strip larger ones (Cruz, 1995) [5]. As larvae age, they feed inside fruiting structures or deeper in the whorls of grass crops further reducing their exposure to insecticide applications (Morrill & Greene, 1973; Young, 1979; Martin *et al*., 1980; Pitre, 1986) [6, 7, 8].
*S. frugiperda* alone is responsible for causing millions of dollar losses to farmers around the world. In India, maize, bajra and sorghum are sustenance crops grown by many marginal farmers. However, the earnings from these crops are meager. Considering the ravaging nature of *S. frugiperda* the economic damage would be too high to be ignored. Yield reductions in maize due to feeding of *S. frugiperda* have been reported as high as 34.00 per cent (Williams and Davis, 1990) [10]. In addition, larvae become more tolerant to insecticides as larval age or size increases (Yu, 1983; Mink & Luttrell, 1989) [11, 12]. Several insecticides have been used for the effective management of *S. frugiperda*. Though, according to several reports many of these insecticides could not give effective results. Hence, these insecticides along with some new insecticides need to be re-evaluated against *S. frugiperda* for effective management of the pest.

## Materials and Methods

The studies on "Bio-efficacy of different insecticides against fall armyworm, *Spodoptera frugiperda* (J. E. Smith) on Maize" were conducted under field condition during *Kharif* -2019 at research farm of Oilseed Research Station, Latur (Maharashtra, India). The experiment was conducted in a randomized block design (RBD) with seven treatments including untreated control with three replications. Maize crop was sown on 06 August, 2019 in a gross plot of 4.2 m x 5.0 m maintaining net plot of 3.6 m x 4.8 m. The row to row distance of 60 cm and plant to plant distance of 30 cm was maintained. The crop was grown under protective irrigation, with all recommended package of practices recommended by V.N.M.K.V., Parbhani including the dose of fertilizer at the rate of 120 kg N, 60 kg $P_2O_5$ and 60 kg $K_2O$ per hectare, except plant protection.

The treatments of different insecticides *viz.*, Chlorantraniliprole 18.5 SC @ 0.005 per cent, Emamectin benzoate 5 WG @ 0.002 per cent, Spinetoram 11.7 SC @ 0.011 per cent, Lambda Cyhalothrin 5 EC @ 0.025 per cent, Chlorantraniliprole 9.3 + Lambda Cyhalothrin 4.6 ZC @ 0.008 + 0.002 per cent and Thiomethaxam 12.6 + Lambda cyhalothrin 9.5 ZC @ 0.003 + 0.002 per cent were evaluated against *S. frugiperda* and subsequent sprays were given at 15 days interval using manually operated knapsack sprayer. The observations were recorded on number of live larvae per 25 plants on one day before spray and three days, seven days and fourteen days after the spray. These observations of live larvae were taken based on appearance of fresh excreta in leaf whorl of plant. The data was subjected to statistical analysis for interpretation.

## Results and Discussion

The data regarding bio-efficacy of different insecticides on larval population of fall army worm, *S. frugiperda* during *Kharif*-2019 on Maize is presented here under.

### First Spray

The data pertaining to effect of different insecticides on larval population of *S. frugiperda* revealed that all the treatment were found significantly superior over the untreated control in reducing larval population of *S. frugiperda* with first spray at 3, 7 and 14 days after spraying (Table no. 1 and Fig. no. 1).

The data recorded on larval population on one day before first spray revealed no significant difference among the treatments.

The data recorded for *S. frugiperda* larvae on three days after spraying exhibited significant differences among the treatments. The population ranged from 4.67 to 40.67 larvae per 25 plants. The least population was recorded on Spinetoram 11.7 SC which exhibited much effective management of *S. frugiperda* population (4.67 larvae per 25 plants) followed by Emamectin benzoate 5 WG (7.87 larvae per 25 plants), Chlorantraniliprole 18.5 SC (10.67 larvae per 25 plants) and were found statistically at par with each other. The next effective treatment was with Chlorantraniliprole 9.3 + Lambda Cyhalothrin 4.6 ZC (15.33 larvae per 25 plants). Significantly highest number of larval population was recorded in untreated plot (40.67 larvae per 25 plants).

**Table 1:** Effect of different insecticides on larval population of *S. frugiperda* after first spray.

| Sr. no. | Treatments | Concentration of pesticide (%) | No. of larvae per 25 plant | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | First imposition | | | | | |
| | | | 1 DBT | 3 DAT | 7 DAT | 14 DAT | Mean | ROC (%) |
| 1 | Chlorantraniliprole 18.5 SC | 0.005 | 38.33 (6.23) | 10.67 (3.34) | 9.73 (3.20) | 16.35 (4.10) | 12.25 | 71.79 |
| 2 | Emamectin benzoate 5 WG | 0.002 | 41.33 (6.47) | 7.87 (2.89) | 4.53 (2.24) | 6.13 (2.58) | 6.18 | 85.77 |
| 3 | Spinetoram 11.7 SC | 0.011 | 35.67 (6.01) | 4.67 (2.27) | 3.47 (1.99) | 5.20 (2.39) | 4.44 | 89.76 |
| 4 | Lambda cyhalothrin 5 EC | 0.025 | 34.67 (5.93) | 27.00 (5.24) | 23.67 (4.92) | 28.40 (5.38) | 26.36 | 39.30 |
| 5 | Chlorantraniliprole 9.3 + Lambda Cyhalothrin 4.6 ZC | 0.008+0.02 | 38.67 (6.26) | 15.33 (3.98) | 14.00 (3.81) | 17.19 (4.21) | 15.51 | 64.29 |
| 6 | Thiomethaxam 12.6 + Lambda Cyhalothrin 9.5 ZC | 0.003+0.002 | 39.67 (6.34) | 21.53 (4.69) | 18.33 (4.34) | 21.77 (4.72) | 20.54 | 52.68 |
| 7 | Untreated control | - | 38.67 (6.26) | 40.67 (6.42) | 42.67 (6.57) | 46.93 (6.89) | 43.42 | - |
| S.E m± | | | 0.23 | 0.28 | 0.24 | 0.25 | | |
| CD (5%) | | | 0.72 | 0.87 | 0.75 | 0.77 | | |
| CV (%) | | | 6.51 | 11.89 | 10.89 | 10.01 | | |

- Figures in parentheses are square root (x + 0.5) transformed values.

DBT- Day before treatment, DAT- Day after treatment, ROC- reduction over control

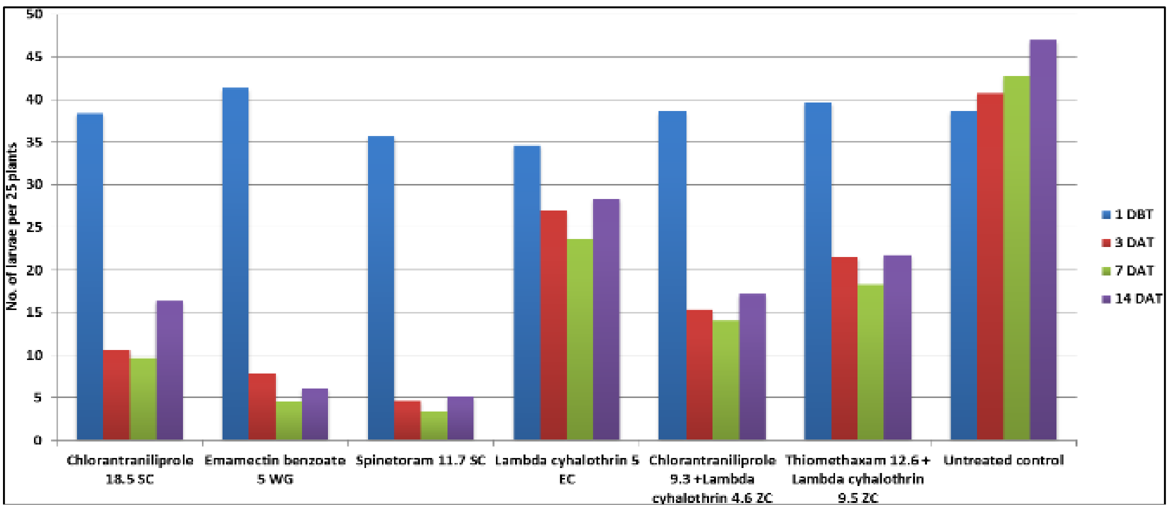


**Fig 1:** Larval population of *S. frugiperda* after first spraying

The data recorded of *S. frugiperda* on seven days after spraying revealed significant differences among the treatments with the population ranged between 3.47 to 42.67 larvae per 25 plants. The treatment with Spinetoram 11.7 SC has outperformed among rest of the treatments with 4.67 larvae per 25 plants, which was statistically at par with Emamectin benzoate 5 WG treatment with 4.53 larvae per 25 plants. The next effective treatment observed was Chlorantraniliprole 18.5 SC (9.73 larvae per 25 plants) followed by Chlorantraniliprole 9.3 + Lambda Cyhalothrin 4.6 ZC (14.00 larvae per 25 plants) and were found at par with each other. However, significantly highest number of larval population was recorded in untreated plot (42.67 larvae per 25 plants).

The data recorded of *S. frugiperda* on fourteen days after spraying illustrated significant differences among the treatments with the population recorded from 5.20 larvae per 25 plants of treatment with Spinetoram 11.7 SC and found statistically at par with Emamectin benzoate 5 WG (6.13 larvae per 25 plants). The next effective insecticide was Chlorantraniliprole 18.5 SC, followed by Chlorantraniliprole 9.3+ Lambda Cyhalothrin 4.6 ZC with 16.35 larvae per 25 plants, 17.19 larvae per 25 plants, respectively and were found at par with each other. The highest number of larval population was observed in untreated plot with 46.93 larvae per 25 plants.

Mean larval population of *S. frugiperda* after first spray ranged from 4.44 to 43.42 larvae per 25 plants. The subsequent order of effectiveness was with the treatments of Spinetoram 11.7 SC revealing 4.44 larvae per 25 plants, followed by Emamectin benzoate 5 WG, Chlorantraniliprole 18.5 SC, Chlorantraniliprole 9.3 + Lambda Cyhalothrin 4.6 ZC, Thiomethaxam 12.6 + Lambda cyhalothrin 9.5 ZC, Lambda cyhalothrin 5 EC and Untreated control exhibiting 6.18, 12.25, 15.51, 20.54, 26.36 and 43.42 larvae per 25 plants, respectively.

**Second spray**

The data pertaining to effect of different insecticides on larval population of *S. frugiperda* revealed that all the treatment were found significantly superior over the untreated control in reducing larval population of *S. frugiperda* with second spray at 3, 7 and 14 days after spraying (Table no. 2 and Fig. no. 2).

The data recorded of *S. frugiperda* on three days after spraying elucidated significant differences among the treatments. The population ranged from 3.07 to 40.47 larvae per 25 plants. The least population was recorded on Spinetoram 11.7 SC which revealed much effective management of *S. frugiperda* population (3.07 larvae per 25 plants) followed by Emamectin benzoate 5 WG (5.13 larvae per 25 plant) and was found statistically at par with each other. The next effective treatment was with Chlorantraniliprole 18.5 SC (9.73 larvae per 25 plants) and Chlorantraniliprole 9.3 + Lambda Cyhalothrin 4.6 ZC (13.93 larvae per 25 plants). While, highest number of larval population was recorded in untreated plot with 40.47 larvae per 25 plants.

The data recorded of *S. frugiperda* on seven days after spraying revealed significant differences among the treatments with the population ranged between 2.40 to 38.67 larvae per 25 plants. The treatment with Spinetoram 11.7 SC has outperformed among rest of the treatments with 2.40 larvae per 25 plants and gave best protection against *S. frugiperda*, followed by treatment of Emamectin benzoate 5 WG with 4.00 larvae per 25 plants and was at par with each other. The next effective treatment observed was Chlorantraniliprole 18.5 SC followed by Chlorantraniliprole 9.3 + Lambda Cyhalothrin 4.6 ZC with 8.67 and 10.67 larvae per 25 plants, respectively. However, significantly highest number of larval population was recorded in untreated plot with 38.67 larvae per 25 plants.

The data recorded of *S. frugiperda* on fourteen days after spraying exhibited significant differences among the treatments. The least population was documented on treatment of Spinetoram 11.7 SC (2.07 larvae per 25 plants) and found statistically at par with treatment of Emamectin benzoate 5 WG (2.47 larvae per 25 plants). The next effective treatment was Chlorantraniliprole 18.5 SC (93 larvae per 25 plants) followed by Chlorantraniliprole 9.3 + Lambda Cyhalothrin 4.6 ZC (7, 8.20 larvae per 25 plants) and were found at par with each other. The highest number of larval population was observed in untreated plot with 35.33 larvae per 25 plants.

**Table 2:** Effect of different insecticides on larval population of *S. frugiperda* after second spray.

| Sr. no. | Treatments | Concentration of pesticide (%) | No. of larvae per 25 plant | | | | |
|---|---|---|---|---|---|---|---|
| | | | Second imposition | | | | |
| | | | 3 DAT | 7 DAT | 14 DAT | Mean | ROC (%) |
| 1 | Chlorantraniliprole 18.5 SC | 0.005 | 9.73 (3.08) | 8.67 (3.03) | 7.93 (2.90) | 8.78 | 77.00 |
| 2 | Emamectin benzoate 5 WG | 0.002 | 5.13 (2.37) | 4.00 (2.12) | 2.47 (1.72) | 3.87 | 89.87 |
| 3 | Spinetoram 11.7 SC | 0.011 | 3.07 (1.89) | 2.40 (1.70) | 2.07 (1.60) | 2.51 | 93.42 |
| 4 | Lambda cyhalothrin 5 EC | 0.025 | 24.53 (5.00) | 20.33 (4.56) | 19.20 (4.44) | 21.36 | 44.04 |
| 5 | Chlorantraniliprole 9.3 + Lambda Cyhalothrin 4.6 ZC | 0.008+0.02 | 13.93 (3.80) | 10.67 (3.34) | 8.20 (2.95) | 10.93 | 71.35 |
| 6 | Thiomethaxam 12.6 + Lambda cyhalothrin 9.5 ZC | 0.003+0.002 | 19.00 (4.42) | 17.20 (4.21) | 15.33 (3.98) | 17.18 | 54.98 |
| 7 | Untreated control | | 40.47 (6.40) | 38.67 (6.26) | 35.33 (5.99) | 38.16 | - |
| S.E m± | | | 0.20 | 0.22 | 0.19 | | |
| CD (5%) | | | 0.62 | 0.68 | 0.59 | | |
| CV (%) | | | 9.04 | 10.72 | 9.85 | | |

- Figures in parenthesis are square root X +0.5 transformed values.

DBT- Day before treatment, DAT- Day after treatment, ROC- reduction over control

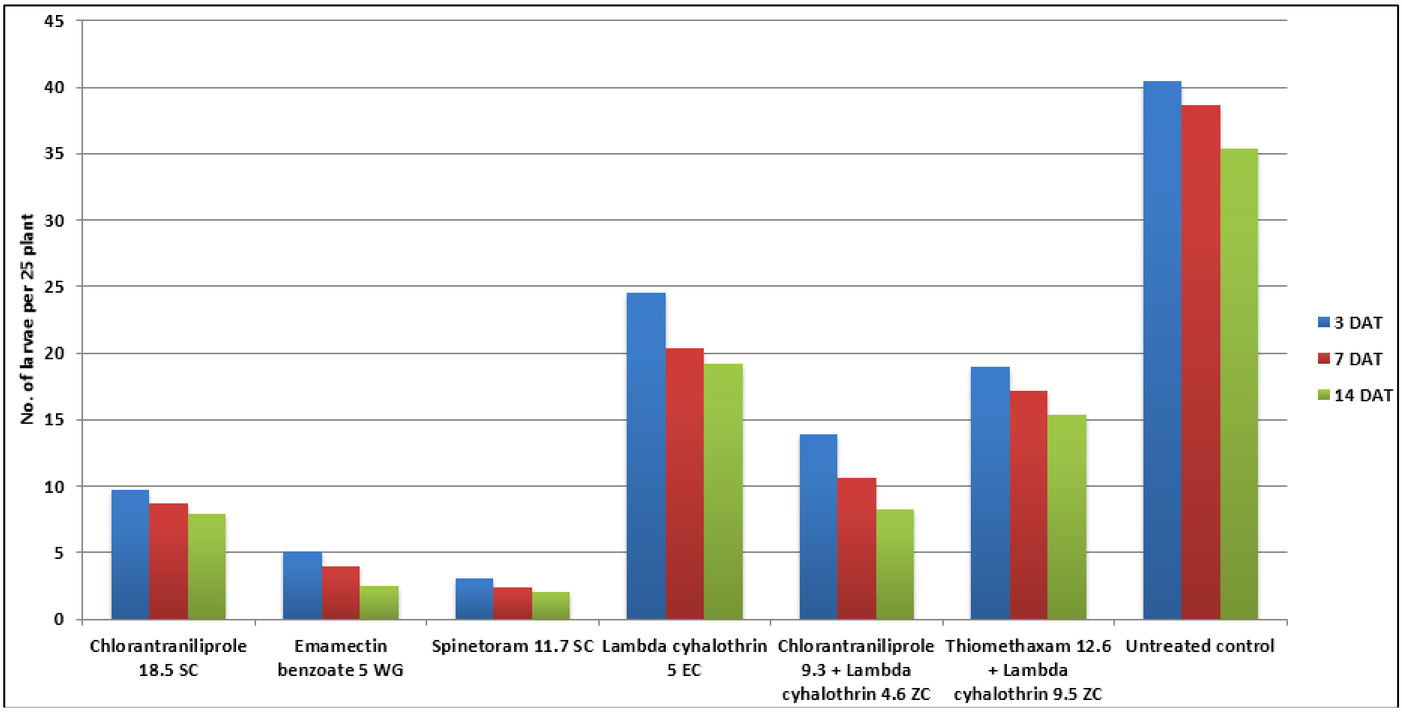


**Fig 2:** Larval population of *S. frugiperda* after second spraying

Mean larval population of S. frugiperda after first spray ranged from 2.51 to 38.16 larvae per 25 plants. The subsequent order of effectiveness was with the treatments of Spinetoram 11.7 SC revealing 2.51 larvae per 25 plants followed by Emamectin benzoate 5 WG, Chlorantraniliprole 18.5 SC, Chlorantraniliprole 9.3 + Lambda Cyhalothrin 4.6 ZC, Thiomethaxam 12.6 + Lambda cyhalothrin 9.5 ZC, Lambda cyhalothrin 5 EC and Untreated control with 3.87, 8.78, 10.93, 17.18, 21.36 and 38.16 larvae per 25 plants, respectively.

The present results are in accordance with the findings of Kumar and Mohan (2020) [13] who observed 91.21 per cent to 97.32 per cent reduction of S. frugiperda using Spinetoram 11.7 SC at varying doses in Maize. Similarly, Sisay *et al.* (2019) [14] studied the efficacy of selected synthetic insecticides and botanicals against S. frugiperda and revealed that lowest leaf damage was recorded in plants treated with Karate 5 EC and Radiant 120 SC. In second and third round sprayings Karate 5 EC, Radiant 120 SC and A. indica showed the lowest number of live larvae, while no live larvae were recorded from plants sprayed with Radiant 120 SC, Karate 5 EC and A. indica in the second and third round sprayings. Further studies revealed that spinoteram, emamectin benzoate and spinosad reported significantly higher mortality ranging from 90.40 to 96.22 and 98.28 to 100 per cent under in-vitro and in-vivo condition, respectively. Analogously, Mallapur *et al.*, (2019) [15] examined different insecticides against S. frugiperda and ascertained that Spinetoram was significantly superior with 0.67 larvae per 25 plants at seven days after treatment. Spinosad, Emamectin benzoate, Imidacloprid + Fipronil and Cyantrniliprole were on par with each other with the larval population of 1.33, 1.33, 2.33 and 2.33 larvae per 25 plants, respectively and with the larval reduction of 98.13, 96.26 and 96.26 per cent, respectively at 7 days after treatment imposition. Among other tested molecules, Thiamethoaxam 0.25 WG and Fipronil 0.5 SC were least effective. Therefore, these studies validate the results of the present findings.

## Conclusion

The present study concluded that among the seven treatments, all the insecticide treatments were more effective than control in reducing the fall armyworm, S. frugiperda. Where, Spinetoram 11.7 SC @ 0.011 per cent was found extremely effective for control of larval population on Maize.

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