# EVALUATION ON THE EFFICACY OF SYNTHETIC INSECTICIDES FOR THE MANAGEMENT OF FALL ARMYWORM, *Spodoptera frugiperda* (J.E. SMITH) (Lepidoptera: Noctuidae) IN MAIZE

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## ABSTRACT

Fall armyworm, *Spodoptera frugiperda* is an invasive and notorious pest of maize in many countries including Nepal. Several approaches of integrated management have been adopted for its control, chemical being the most popular choice inthe farmers' fields. Efficacy of such chemical pesticides for fall armyworm is interpreted as per the location, season, time and crops. In some cases, insect pests are always increasing the pesticide resistance. Hence to minimize the confusion of insecticide efficiency in various levels of understanding in the farmers' level, field research was conducted in October 2021 to April, 2022. Seven different treatments (azadirachtin, chlorantraniliprole, emamectin benzoate, spinosad, spinetoram, imidacloprid and control) were tested in afour replicated RCBD design. Two sprays were made in twenty-days after seeding and fifteen-days after first spray in open-field condition. Minimum damage across various stages of maize plant was recorded inspinosad sprayed plots followed by spinetoram, chlorantraniliprole and emamectin benzoate, respectively. Maize yield was also recorded highest in spinosad and spinetoram sprayed plots. Highest score of damage was recorded in imidacloprid treated plots. This study further proved spinosad and spinetoram are the most popularly applied insecticides for the fall armyworm management.

**Key words :** Chlorantraniliprole, emamectin benzoate, management, spinosad, spinetoram, *Spodoptera frugiperda*

## INTRODUCTION

Fall armyworm (FAW) is an invasive pest of maize, voracious in nature and has become a major problem in almost all maize growing regions of Nepal. It was first identified in Gaindakot of Nawalpur district in May 2019 (Bajracharya *et al.,* 2019). The larval stage is the most devastating stage of the insect (FAO, 2019), feeding on 350 species of host plants (Montezano *et al.,* 2018) belonging 42 plant crop families (Early *et al.,* 2018). The larva feeds on the leaves, stem, and reproductive parts of the maize plants (Tefera *et al.,* 2019). In Argentina, food security was threatened by the highest yield loss (72%), and a range of maize yield losses of 15-73% incurred of FAW was common case (Hruska and Gould, 1997). The management of this pest by any sole method is almost impossible. So, different techniques of pest management as an IPM packages are the best way for FAW management in the field. Using of resistant varieties of maize, intercropping with

different leguminous crops, using parasitoids for controlling the population of egg and larva, adopting proper cultural practices, use of light trap, hand picking and destroying egg and larval stages in small scale are the most used management strategies in many parts of the world (Khatri *et al.*, 2020). Most preferred host crop varieties or any other preferred crops can be used as a trap crop and least preferred one can be used as repelling crops in push-pull strategy (Tiwari, 2022). Pesticide applications are the most common used methods of management in many countries including Nepal (Bhusal and Chapagain, 2020). Spinosad, chlorantraniliprole, azadirachtin, emamectin benzoate are the most frequently used pesticides for the fall armyworm management (Gahatraj *et al.,* 2020). The best performance of the insecticide spinosad, causing >90% larval mortality was reported by Cruz *et al.,* 2012. In laboratory studies, mortality of FAW was reported better with new insecticides, namely chorantraniliprole, flubendiamide, and spinetoram compared to the traditional one, namely (lambda-cyhalothrin and novaluron) (Hardke *et al.,* 2014). Insect pests, in a stress of insecticides, can regularly develop resistance against insecticides. Hence, this study was aimed to understand the current efficacy of such pesticides against FAW in open field conditions.

## MATERIALS AND METHODS

A field experiment was laid out in the National Maize Research Programme, Rampur, Chitwan Nepal to test the efficacy of six different insecticides against the fall armyworm (FAW) in maize var. Rampur Hybrid-12. The experiment was conducted from October 2021 to April 2022. Seven different insecticides including control (Table 1) were tested against the FAW in four replications in a Randomized Complete Block Design (RCBD). The maize planted area of each plot was 5 x 3 sq m, with 20 cm plant to plant spacing and 60 cm row to row spacing. Each plot consisted of six rows of maize plants.

**Table 1.** Treatments used in fall armyworm management in maize

| SN | Common name | Formulation | Safety Label | Trade name | Dose/lit water |
|---|---|---|---|---|---|
| 1 | Azadirachtin | 1500 ppm | Green | Bio-Neem | 4 ml |
| 2 | Emamectin benzoate | 5% SG | Blue | G-SUPER | 0.4 g |
| 3 | Spinosad | 45% SC | Blue | Tracer | 0.3 ml |
| 4 | Chlorantraniliprole | 18.5% SC | Green | Allcora | 0.4 ml |
| 5 | Spinetoram | 11.7% SC | Green | Delegate | 0.3 ml |
| 6 | Imidacloprid | 17.8% SL | Yellow | Rajmida | 0.3 ml |
| 7 | Control | - | - | - | - |

The experimental field was irrigated two days prior to sowing maize seeds. The field was prepared and leveled using tractor. Sowing was done with the help of manually operated maize planter. Irrigation, weeding, and intercultural operations were carried out as per the need. Insecticidal treatment was performed with the help of a 16-litre capacity knapsack sprayer. Every time the sprayer was thoroughly cleaned with the help of soap and water before the commencement of insecticide treatment in maize plants in the experimental unit.

Treatments were sprayed for two times; first spray was done twenty-days after the maize sowing, and the next one in the fifteenth day after the first spray. Different field research parameters such as total number of plants per plot, number of FAW infested plants and FAW damage scoring (0-9) as mentioned in Table 2 were taken. FAW damage scoring was taken on the basis of damage on the

upper six leaves of the maize plants. The FAW damage scoring and other field parameters were collected just before the first spray, one week after first spray, just before the second spray, and one week after the second spray. Yield of each treatment plot was recorded.

Sample plants were selected from the middle four lines of maize plants of each experimental plot. The infested plant data were converted into percent data which was transformed by arcsine transformation. The data were subjected to one way analysis of variance (ANOVA) by using GenStat (Version-GenDisc4**)** and the means were separated by using the Tukey's test.

The average temperature, relative humidity and rainfall during field experimental period were recorded as 18.3 ± 2.4º C, 55.8 ± 3.5% and 0.31 ± 0.2 mm, respectively.

**Table 2.** FAW damage scoring (0-9) on maize plant

| Score | Damage symptoms |
|---|---|
| 0 | No visible leaf-feeding damage |
| 1 | Few pinholes on whorl |
| 2 | Pinholes and small circular lesions on whorl |
| 3 | Pinholes, small circular and a few small, elongated lesions on whorl and/or furl leaves |
| 4 | Small elongated and a few mid-sized elongated lesions on whorl and/or furl leaves |
| 5 | Small elongated and a several mid-sized elongated lesions on whorl and/or furl leaves |
| 6 | Small and mid-sized elongated and a few large, elongated lesions on whorl and/ or furl leaves |
| 7 | Many small and mid-sized elongated lesions plus several large elongated lesions on whorl and furl leaves |
| 8 | Many small and mid-sized elongated lesions on whorl plus many large elongated lesions on whorl and furl leaves |
| 9 | Whorl and furl leaves almost destroyed |

Source: Modified Davis scale [adapted and modified from Prasanna *et al.* (2018), and Toepfer *et al.* (2021)]

## RESULTS AND DISCUSSION

### Damage Percentage in Maize Plants after Pesticide Spray

The highest FAW damage percentage in maize plant was observed in the control plot (64%) followed by imidacloprid and azadirachtin treated maize plots, with damage percentage of 63% and 55%, respectively (Table 3). Zhao *et al.* (2020) also reported that neem-based pesticides were less effective against the FAW and imidacloprid was found non-effective as given by Gichere *et al.* (2022). Spinosad and spinetoram were found highly effective against FAW among the treatments with damage percentage of 27.07% and 26.34%, respectively which follows the similar pattern of the findings of Hardke *et al.* (2011). Following spinosad and spinetoram, chlorantraniliprole was also found effective in management of FAW in maize with damage percentage of 29.64%. Similar results were also proposed by Bajracharya *et al.* (2020). Spinosad is developed from the soil bacterium, *Saccharopolyspora spinosa* and its active component spinosyn acts on the nicotinic acetyl choline receptor of the insect (Thomson *et al.*, 2000). Also, spinetoram is a fermentation product of *S. spinosa* and is an analogue of the insecticide spinosad. Spinetoram affects nicotinic acetylecholine receptors and γ-aminobutyric acid (GABA) receptors existing on postsynaptic membranes in insect nervous systems, thereby causing abnormal neural transmission (Gao *et al.*, 2021).

**Table 3.** Effect of different treatments on the percentage damage of maize plants by fall armyworm

| Treatment | Damage percentage in maize plant | | |
|---|---|---|---|
| | One week after 1st spray | One day before second spray | One week after 2nd spray |
| Azadirachtin | 37.2 ± 6.12ab | 47.90 ± 1.37bc | 55.46 ± 3.95d |
| Emamectin benzoate | 19.00 ± 2.54a | 42.00 ± 3.19ab | 32.90 ± 2.79c |
| Spinosad | 16.60 ± 0.78a | 32.20 ± 1.53a | 27.07 ± 2.08ab |
| Spinetoram | 16.40 ± 1.68a | 31.30 ± 1.24a | 26.34 ± 1.63a |
| Imidacloprid | 66.70 ± 11.63b | 62.60 ± 1.01d | 63.12 ± 6.68e |
| Chlorantraniliprole | 19.60 ± 2.34a | 35.70 ± 1.16ab | 29.64 ± 3.89b |
| Control | 88.20 ± 1.82c | 64.00 ± 1.07d | 64.37 ± 1.30e |
| Grand mean | 37.70 ± 5.28 | 45.10 ± 3.07 | 42.70 ± 1.39 |
| CV % | 9.1 | 9.9 | 5 |
| LSD | 15.67 | 9.12 | 4.119 |
| p-value* | < 0.001 | < 0.001 | < 0.001 |

Percentage damage value in the table is the arcsine-transformed value. Same letters in the treatments are not significantly different, value after ± indicates standard error, CV is coefficient of variation and LSD denotes least significant difference. First spray was done on 20-days after maize sowing and second spray was done on 15$^{th}$ days of first spray.

**Fall Armyworm Damage Rating in Maize Plants**

The lowest damage scoring was obtained in spinetoram, spinosad and chlorantraniliprole treated maize plots in 0-9 scored scale, with average scoring value of 2.50, 3.00 and 2.75, respectively after the second spray (Table 4). Belay *et al.* (2012) also found spinosad and spinetoram were effective against the FAW damage in the maize plants. Chlorantraniliprole was also found as aneffective treatment for FAW to reduce the foliar damage in maize plants.

Spinosad and chlorantraniliprole was found highly effective in reducing the foliar damage of maize leaves (Sisay *et al.,* 2019). Bajracharya *et al.* (2020) also found the similar result of lower foliar damage in spinosad and chlorantraniliprole treated maize plants. Emamectin benzoate sprayed maize plants also has lower scoring, i.e. 4.25 after chlorantraniliprole. Argentine *et al.* (2002) found that emamectin benzoate was highly effective against all the lepidopteran pests. Chlorantraniliprole affects nervous system of insects through ryanodine receptor of insect muscles (Xu *et al.*, 2022). Similarly, emamectin benzoate is developed from the soil bacterium, *Streptomyces avermitilis* which causes a continuous flow of chlorine ions in GABA and H-Glutamate receptor site of insects (Liu *et al.*, 2022).

**Effect of Various Treatments on Maize Yield**

The yield of the maize was found significantly higher in spinosad and spinetoram treated maize plots, 9700 kg/ha and 9654 kg/ha, respectively followed by chlorantraniliprole and emamectin benzoate treated plots, 9135 kg/ha and 8905 kg/ha, respectively (Table 5). Srujana *et al.* (2021) also found the similar result of higher yields in spinosad and spinetoram treated maize field. Similarly, higher yields of maize in spinosad and spinetoram treated fields were obtained followed by chlorantraniliprole and

emamectin benzoate treated fields as given by Nonci *et al.* (2021). The lowest yield was obtained in control field (7349 kg/ha) followed by imidacloprid and azadirachtin treated fields with yields of 7466 kg/ha and 7970 kg/ha, respectively. Bajracharya *et al. (*2020) also reported that neem-based pesticides and imidacloprid were less effective against FAW causing more damage to the maize plants thus reducing the yield.

**Table 4.** Effect of treatments on the damage scoring by fall armyworm damage

| Treatments | FAW damage scoring (0-9) | | |
|---|---|---|---|
| | **One week after 1st spray** | **One day before second spray** | **One week after 2nd spray** |
| Azadirachtin | 4.50 ± 0.65ab | 3.75 ± 0.25c | 5.75 ± 0.25bc |
| Emamectin benzoate | 3.25 ± 0.25a | 3.50 ± 0.50bc | 4.25 ± 0.48ab |
| Spinosad | 3.25 ± 0.25a | 3.00 ± 0.41ab | 3.00 ± 0.58a |
| Spinetoram | 3.50 ± 0.50a | 2.00 ± 0.71ab | 2.50 ± 0.50a |
| Imidacloprid | 5.75 ± 0.25bc | 6.50 ± 0.29d | 6.50 ± 0.29c |
| Chlorantraniliprole | 3.25 ± 0.25a | 1.75 ± 0.25a | 2.75 ± 0.48a |
| Control | 7.00 ± 0.00c | 7.00 ± 0.00d | 7.00 ± 0.00d |
| Grand mean | 4.36 ± 0.31 | 3.93 ± 0.37 | 4.54 ± 0.42 |
| CV% | 10.2 | 10.5 | 6 |
| LSD | 0.917 | 1.103 | 1.249 |
| p-value * | < 0.001 | < 0.001 | < 0.001 |

Percentage damage value in the table is the arcsine-transformed value. Same letters in the treatments are not significantly different, value after ± indicates standard error, CV is coefficient of variation and LSD denotes least significant difference.

**Table 5.** Effect of treatments on the maize yield

| **Treatment** | **Yield (kg/ha)** |
|---|---|
| Azadirachtin | 7970 ± 347.92ab |
| Emamectin benzoate | 8905 ± 394.56b |
| Spinosad | 9700 ± 397.20c |
| Spinetoram | 9654 ± 319.43c |
| Imidacloprid | 7466 ± 564.16a |
| Chlorantraniliprole | 9135 ± 392.84b |
| Control | 7349 ± 166.65a |
| Grand mean | 8611 ± 292.50 |
| CV% | 6.4 |
| LSD | 869.2 |
| p-value* | < 0.001 |

Same letters in the treatments are not significantly different, value after ± indicates standard error, CV is coefficient of variation and LSD denotes least significant difference.

## CONCLUSIONS

Fall armyworm is a highly destructive pest of maize crop in all the maize growing areas of Nepal. It is a pest of concern for all the maize growers and the researchers as well. Many research activities are going on to bring a package of IPM practices for the management of FAW. Until then, few safer chemical pesticides have also been tested for its immediate suppression in the field. Management of this pest has been found highly effective with two sprays of spinosador spinetoram with proper cultural practices of nutrient application, irrigation and other intercultural operations. Following spinosad and spinetoram, chlorantraniliprole and emamectin benzoate also has been found to work well against the fall armyworm in maize. Neem-based natural pesticides can be integrated to other pest management strategies to keep the FAW population below the economic threshold level. All these pesticides have a novel mode of action on the pests. So, scientific application of these pesticides may become an effective way for the management of the fall armyworm and a component of integrated pest management in the future.

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