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# Evaluation of Chlorantraniliprole, Spinetoram Solo & Its tank mixtures against *Spodoptera frugiperda* (JE Smith) in Maize in India

**R Janarthanan[1], S Arivudainambi[2], Mohammad Ikram[2]**
[1] Scholar, Department of Entomology, Annamalai University, Chidambaram, Tamil Nadu, India
[2] Professor and Head, Department of Entomology, Annamalai University, Chidambaram, Tamil Nadu, India

**Abstract**
The Fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith), is a Lepidoptera: Noctuidae was first detected in the Indian subcontinent, in the districts of Bangalore Rural and Chikkaballapur (Ganiger *et al*. 2018) and during the first week of July 2018, South Karnataka (ICAR-NBAIR pest alert, 2018), and is currently moving to Tamil Nadu. FAW is widely distributed in India, causing significant damage to maize. Synthetic pesticides have been the primary technique for controlling fall armyworms. As a result, in the Americas, the fall armyworm is resistant to at least 29 insecticidal active components from six different mode-of-action groups**.** Six new synthetic pesticides from various chemical groups were evaluated in open fields as solo mixtures and tank mixtures for their effectiveness against maize FAW. Spinetoram + Novaluron (76.67%), Spinetoram + Emamectin (70%) and Chlorantraniliprole + Novaluron (64.29%) outperformed all other tank mixture combinations in terms of effectiveness and knockdown impact (24 hours after application) over control. When administered alone, Spinetoram has a better efficacy and a longer duration of efficacy than other solo spray. When CTPRL and spinetoram were compared, spinetoram had a prolonged effectiveness than CTPRL. When compared to untreated plots, spinetoram + novaluron demonstrated good plant height growth (181 cm). When compared to whole plant treatment, leaf whorl application had high effectiveness and lowered pesticide requirements and consumption.

**Keywords:** *Spodoptera frugiperda*, spinetoram, Novaluron, CTPRL, Emamectin, Leaf whorl application

## Introduction
The fall armyworm (FAW), *Spodoptera frugiperda* (JE Smith), is a Lepidoptera: Noctuidae species native to the western hemisphere's tropical areas, ranging from the United States to Argentina. It was initially identified in West and Central Africa in 2016 and then during May and June 2018, the FAW was first detected in the Indian subcontinent, in the districts of Bangalore Rural and Chikkaballapur (Ganiger *et al.* 2018) [6] and during the first week of July 2018, South Karnataka (ICAR-NBAIR pest alert, 2018), and is currently moving to Tamil Nadu. FAW may be an extremely polyphagous pest that attacks quite eighty host plant species and is favoured by grasses. The most well-liked plants are maize, sweet corn, sorghum, millet, sugarcane, Bermuda grass weeds corresponding to crabgrass, *Digitaria spp*, and vegetable crops (Regupathy & Ayyasamy, 2016) [8] Nevertheless, maize is the primary crop stricken by FAW in India. Maize is a vital grain for billions of people, serving as food, animal feed, and a raw ingredient in industry. Over 170 nations are now producing roughly 1147.7 million MT of maize over an area of 193.7 million ha, with average productivity of 5.75 t/ha (FAOSTAT, 2020) India is fourth in terms of area and seventh in terms of production among maize-growing countries, accounting for around 4% of global maize production (DACNET, 2020). From 1950-1951, India produced 1.73 million metric tonnes of maize, which has climbed to 27.8 million metric tonnes in 2018-2019, an almost 16-fold increase in output (ICAR-IIMR, 2020). FAW larvae consume the maize plant's foliage, causing it to die. Young larvae feed mostly on epidermal leaf tissue, but they also causing holes in leaves, which is a common FAW damage sign. The dead heart is caused by feeding on young plants through the whorl. The bigger larvae in the whorls of older plants might feed on maize cobs or kernels, lowering production and quality**.** Synthetic pesticides have been the primary technique for controlling fall armyworms. As a result, in the Americas, the fall armyworm is resistant to at least 29 insecticidal active components from six different mode-of-action groups (Mota-Sanchez and Wise, 2017).

For fall armyworm control, the Central Insecticide Board and Registration Committee now recommend chlorantraniliprole 18.5 SC, thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC, and spinetoram 11.7 SC (DPPQS, 2019).

Most farmers favour older molecules because they are less expensive, and they use synthetic pesticides without understanding the techniques of administration or mode of action. The purpose of this study is to evaluate a variety of tank and ready-to-use new synthetic insecticides in the field for fall armyworm treatment in order to determine the most effective insecticides for leaf whorl application.

## Materials and Methods

### Study area

From February to May 2021, a field experiment was done in a farmer's field in Gangavelli village, Attur, to test CTPRL, Emamectin Benzoate & Spinetoram as a single agent and in combinations against maize FAW in a flood irrigated maize hybrid (INDUS 888) with spacing of 60 × 20 cm in a plot size of 5 × 6 m² for each treatment. The treatments included Chlorantraniliprole, Emamectin Benzoate, Indoxacarb, Novaluron, Spinetoram and a non-treated control. To keep the crops healthy, all crop-raising methods were followed, including cultural practises, fertigation, irrigation and weed control. Except for the control, the first spray was applied as a foliar application 18 days after sowing, and the second spray was applied 11 days following the first. Using a High volume knapsack sprayer fitted with a hollow cone nozzle and 375 L per hectare, spraying was done in the morning while the temperature did not surpass 25° C. The spray solution was pointed specifically to the leaf whorl using a hollow cone nozzle that had been modified. Knockdown studies after 4 & 24 hours after application. Efficacy evaluation at 3,7,10 & 14 days after application, ten plants were tagged at random within each plot. Count numbers of live larvae, dead larvae, and pupae in the treated plants and untreated control plants. FAW damage severity was recorded on an individual plant basis at seven-day intervals based on a rating scale described by (Davis *et al.* 1992) 0 = no visible leaf damage, 1 = only pin-hole damage to the leaves, 2 = pin-hole and shot-hole damage to 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 eaten on 3–5 leaves, 6 = elongated lesions (>30 mm) and large portions eaten on 3–5 leaves, 7 = elongated lesions (>30 cm) and 50% of leaf eaten, 8 = elongated lesions (30 cm) and large portions eaten on 70% of leaves.

### Statistical Analysis

A generalised linear model was used to perform one-way analysis of variance (ANOVA) on mean live larvae, leaf damage, plant height, stem thickness, and leaf numbers acquired from field experiments. A randomized block design has been used to set up the field trials. To equalize the variations, the mean leaf damage from synthetic insecticide field trials was transformed using a square root transformation. The AGRES 0.74 statistical programmer was used for all statistical studies

## Results and Discussion

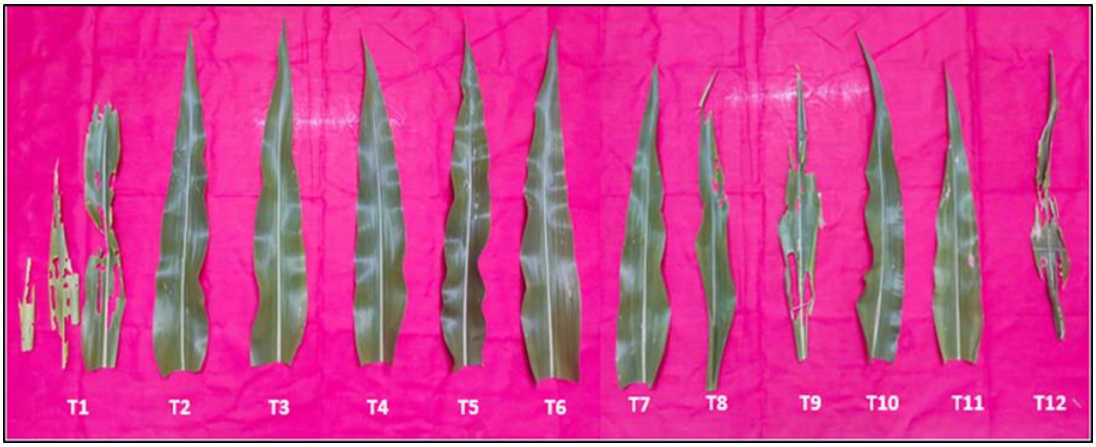


**Fig 1:** Leaf damage caused by fall armyworm in maize 11 Days after 1st spraying under various treatments of synthetic pesticides.*T1-Untreated control,T2- Spinetoram + Indoxacarb @ 45+75 g a.i/,T3- Spinetoram +Novaluron @ 45+60 g a.i/ha,T4- Spinetoram + Emamectin @ 45+10 g a.i/ha,T5- Chlorantraniliprole + Indoxacarb @ 25+75 g a.i/ha,T6- Chlorantraniliprole + Novaluron @ 25+60 g a.i/ha,T7- Chlorantraniliprole + Emamectin @ 30+10 g a.i/ha,T8- Chlorantraniliprole 20 SC @ 30 g a.i/ha,T9- Emamectin Benzoate 50 SG @ 15 g a.i/ha,T10- Spinetoram 120 SC @ 54 a.i/ha,T11- Novaluron 5.25% + Emamectin 0.9%SC @ 78.75+15 g a.i/ha,T12- Cartap 25% + Emamectin 1% SG @ 375+15 g a.i/ha.*

**Table 1:** Mean live larvae of maize FAW with various treatments

| Treatments | Dose (g or ml/Ha) | | 1st Spray | | | 2nd spray | | | % pest population reduction after15 days of 2nd spray over control |
|---|---|---|---|---|---|---|---|---|---|
| | | Pre count | 3DAT | 7DAT | 10DAT | 7DAT | 10DAT | 15 DAT | |
| Untreated Control | NA | 1.267 (1.329) | 2.133 (1.622)$^{b}$ | 2.333 (1.683)$^{d}$ | 2.533 (1.739)$^{e}$ | 2.067 (1.602)$^{c}$ | 1.800 (1.516)$^{d}$ | 2.000 (1.580)$^{e}$ | |
| Spinetoram + Indoxacrb (Tank Mix) | 45+75 | 1.133 (1.277) | 0.00 (0.707)$^{a}$ | 0.00 (0.707)$^{a}$ | 0.267 (0.874)$^{ab}$ | 0.00 (0.707)$^{a}$ | 0.333 (0.911)$^{ab}$ | 0.667 (1.079)$^{abc}$ | 66.67 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Spinetoram + Novaluron (Tank Mix) | 45+60 | 1.000 (1.225) | 0.000 (0.707)$^{a}$ | 0.000 (0.707)$^{a}$ | 0.133 (0.793)$^{a}$ | 0.000 (0.707)$^{a}$ | 0.200 (0.837)$^{a}$ | 0.467 (0.978)$^{a}$ | 76.67 |
| Spinetoram + Emamectin (Tank Mix) | 45+10 | 1.200 (1.304) | 0.000 (0.707)$^{a}$ | 0.000 (0.707)$^{a}$ | 0.133 (0.793)$^{a}$ | 0.000 (0.707)$^{a}$ | 0.267 (0.874)$^{a}$ | 0.600 (1.046)$^{ab}$ | 70 |
| Chlorantraniliprole + Indoxacrb (Tank Mix) | 25+75 | 1.133 (1.277) | 0.000 (0.707)$^{a}$ | 0.000 (0.707)$^{a}$ | 0.600 (1.046)$^{c}$ | 0.000 (0.707)$^{a}$ | 0.400 (0.949)$^{ab}$ | 0.867 (1.168)$^{c}$ | 56.67 |
| Chlorantraniliprole + Novaluron (Tank Mix) | 25+60 | 1.333 (1.352) | 0.00 (0.707)$^{a}$ | 0.00 (0.707)$^{a}$ | 0.467 (0.982)$^{bc}$ | 0.00 (0.707)$^{a}$ | 0.267 (0.874)$^{a}$ | 0.714 (1.107)$^{bc}$ | 64.29 |
| Chlorantraniliprole + Emamectin (Tank Mix) | 30+10 | 1.133 (1.277) | 0.00 (0.707)$^{a}$ | 0.00 (0.707)$^{a}$ | 0.467 (0.982)$^{bc}$ | 0.00 (0.707)$^{a}$ | 0.267 (0.868)$^{b}$ | 0.733 (1.110)$^{bc}$ | 63.33 |
| Coragen (Chlorantraniliprole 200 SC) | 30 | 1.200 (1.304) | 0.00 (0.707)$^{a}$ | 0.00 (0.707)$^{a}$ | 0.600 (1.046)$^{c}$ | 0.00 (0.707)$^{a}$ | 0.533 (1.015)$^{b}$ | 0.867 (1.168)$^{c}$ | 56.67 |
| Emamectin Benzoate 50 SG | 15 | 1.133 (1.277) | 0.000 (0.707)$^{a}$ | 0.667 (1.079)$^{c}$ | 1.467 (1.402)$^{d}$ | 0.800 (1.138) $^{b}$ | 1.133 (1.277)$^{c}$ | 1.533 (1.426)$^{d}$ | 23.33 |
| Spinetoram 120 SC | 54 | 1.067 (1.251) | 0.00 (0.707)$^{a}$ | 0.00 (0.707)$^{a}$ | 0.267 (0.874)$^{ab}$ | 0.00 (0.707)$^{a}$ | 0.267 (0.874)$^{a}$ | 0.667 (1.079)$^{abc}$ | 66.67 |
| (Novaluron 5.25% + Emamectin 0.9%) SC | 78.75 + 13.5 | 1.200 (1.304) | 0.00 (0.707)$^{a}$ | 0.00 (0.707)$^{a}$ | 0.533 (1.015)$^{c}$ | 0.00 (0.707)$^{a}$ | 0.333 (1.907)$^{ab}$ | 0.733 (1.110)$^{bc}$ | 63.33 |
| (Cartap 25% + Emamectin 1%) SG | 375 + 15 | 1.267 (1.329) | 0.000 (0.707)$^{a}$ | 0.467 (0.975)$^{b}$ | 1.133 (1.277)$^{d}$ | 0.667 (1.076)$^{b}$ | 1.067 (1.251)$^{c}$ | 1.400 (1.378)$^{d}$ | 30 |
| CD= | | 0.1533 | 0.0344 | 0.0777 | 0.1271 | 0.0671 | 0.1200 | 0.1153 | |

**Table 2:** Mean leaf damage score caused by FAW with various treatments

| **Treatments** | **Dose ( g a.i/ha)** | ***1st Spray*** | | | ***2nd spray*** | | | | **% Efficacy based on leaf damage scale** |
|---|---|---|---|---|---|---|---|---|---|
| | | ***3DAT*** | ***7DAT*** | ***10DAT*** | ***3DAT*** | ***7DAT*** | ***10DAT*** | ***15 DAT*** | |
| Untreated Control | NA | 2.200 (1.640)$^{b}$ | 3.533 (2.005)$^{c}$ | 5.667 (2.483)$^{g}$ | 6.400 (2.627)$^{c}$ | 7.200 (2.774)$^{d}$ | 7.800 (2.881)$^{e}$ | 8.400 (2.983)$^{h}$ | - |
| Spinetoram + Indoxacrb (Tank Mix) | 45+75 | 1.067 (0.816)$^{a}$ | 0.067 (0.750)$^{a}$ | 0.533 (1.015)$^{bc}$ | 0.133 (0.793)$^{ab}$ | 0.133 (0.793)$^{a}$ | 0.533 (1.015)$^{a}$ | 2.000 (1.581)$^{abc}$ | 76.19 |
| Spinetoram + Novaluron (Tank Mix) | 45+60 | 0.200 (0.837)$^{a}$ | 0.067 (0.750)$^{a}$ | 0.467 (0.982)$^{ab}$ | 0.067 (0.750)$^{a}$ | 0.067 (0.750)$^{a}$ | 0.467 (0.982)$^{a}$ | 1.733 (1.492)$^{a}$ | 79.37 |
| Spinetoram + Emamectin (Tank Mix) | 45+10 | 0.200 (0.837)$^{a}$ | 0.033 (0.73)$^{a}$ | 0.400 (0.949)$^{ab}$ | 0.067 (0.750)$^{a}$ | 0.067 (0.750)$^{a}$ | 0.467 (0.982)$^{a}$ | 1.933 (1.560)$^{abc}$ | 76.98 |
| Chlorantraniliprole + Indoxacrb (Tank Mix) | 25+75 | 0.133 (0.788)$^{a}$ | 0.133 (0.793)$^{a}$ | 0.467 (0.982)$^{ab}$ | 0.133 (0.793)$^{ab}$ | 0.133 (0.793)$^{a}$ | 0.733 (1.110)$^{a}$ | 2.400 (1.698)$^{cd}$ | 71.43 |
| Chlorantraniliprole + Novaluron (Tank Mix) | 25+60 | 0.133 (0.793)$^{a}$ | 0.167 (0.816)$^{a}$ | 0.467 (0.982)$^{ab}$ | 0.067 (0.750)$^{a}$ | 0.067 (0.750)$^{a}$ | 0.533 (1.009)$^{a}$ | 2.267 (1.660)$^{bcd}$ | 73.02 |
| Chlorantraniliprole + Emamectin (Tank Mix) | 30+10 | 0.133 (0.793)$^{a}$ | 0.067 (0.750)$^{a}$ | 0.333 (0.911)$^{a}$ | 0.067 (0.750)$^{a}$ | 0.067 (0.750)$^{a}$ | 0.467 (0.982)$^{a}$ | 2.333 (1.682)$^{bc}$ | 72.22 |
| Coragen (Chlorantraniliprole 200 SC) | 30 | 0.133 (0.793)$^{a}$ | 0.067 (0.750)$^{a}$ | 1.000 (1.223)$^{d}$ | 0.133 (0.793)$^{ab}$ | 0.067 (0.750)$^{a}$ | 1.133 (1.274)$^{b}$ | 2.733 (1.793)$^{de}$ | 67.46 |
| Emamectin Benzoate 50 SG | 15 | 0.067 (0.750)$^{a}$ | 0.733 (1.110)$^{b}$ | 2.533 (1.741)$^{f}$ | 0.267 (0.874)$^{b}$ | 0.533 (1.015)$^{b}$ | 3.133 (1.904)$^{d}$ | 6.267 (2.601)$^{g}$ | 25.40 |
| Spinetoram 120 SC | 54 | 0.133 (0.788)$^{a}$ | 0.067 (0.750)$^{a}$ | 0.400 (0.949)$^{ab}$ | 0.067 (0.750)$^{a}$ | 0.067 (0.750)$^{a}$ | 0.467 (0.982)$^{a}$ | 1.867 (1.536)$^{ab}$ | 77.78 |
| (Novaluron 5.25% + Emamectin 0.9%) SC | 78.75 + 13.5 | 0.133 (0.793)$^{a}$ | 0.067 (0.750)$^{a}$ | 0.733 (1.107)$^{c}$ | 0.133 (0.793)$^{ab}$ | 0.133 (0.793)$^{a}$ | 1.133 (1.277)$^{b}$ | 3.200 (1.924)$^{e}$ | 61.90 |
| (Cartap 25% + Emamectin 1%) SG | 375 + 15 | 0.200 (0.831)$^{a}$ | 0.667 (1.079)$^{a}$ | 2.067 (1.602)$^{e}$ | 0.267 (0.874)$^{b}$ | 0.867 (1.166)$^{c}$ | 2.067 (1.602)$^{c}$ | 5.000 (2.345)$^{f}$ | 40.48 |
| CD= | | 0.1533 | 0.2603 | 0.1018 | 0.1060 | 0.1013 | 0.1303 | 0.1527 | |

**Table 3:** Mean growth parameters of maize with various treatments

| **Treatments** | **Dose ( g a.i/ha)** | ***Mean Plant Growth Parameters*** | | |
|---|---|---|---|---|
| | | ***Plant height*** | ***Leaf number*** | ***Stem thickness*** |
| Untreated Control | NA | 115.47 (10.745)$^{h}$ | 8.40 (2.954)$^{f}$ | 6.13 (2.475)$^{e}$ |
| Spinetoram + Indoxacarb (Tank Mix) | 45+75 | 169.93 (13.036)$^{de}$ | 13.87 (3.723)$^{abc}$ | 8.67 (2.944)$^{a}$ |
| Spinetoram + Novaluron (Tank Mix) | 45+60 | 181.00 (13.453)$^{a}$ | 15.67 (3.786)$^{a}$ | 8.53 (2.921)$^{a}$ |
| Spinetoram + Emamectin (Tank Mix) | 45+10 | 173.60 (13.176)$^{bc}$ | 14.87 (3.724)$^{a}$ | 8.53 (2.921)$^{a}$ |

| | | | | |
|---|---|---|---|---|
| Chlorantraniliprole + Indoxacarb (Tank Mix) | 25+75 | 175.87 (13.261)$^{ab}$ | 13.07 (3.568)$^{d}$ | 8.07 (2.840)$^{abc}$ |
| Chlorantraniliprole + Novaluron (Tank Mix) | 25+60 | 173.27 (13.163)$^{bc}$ | 14.80 (3.520)$^{d}$ | 8.20 (2.863)$^{ab}$ |
| Chlorantraniliprole + Emamectin (Tank Mix) | 30+10 | 176.00 (13.266)$^{abc}$ | 12.53 (3.535)$^{d}$ | 8.27 (2.875)$^{ab}$ |
| Coragen (Chlorantraniliprole 200 SC) | 30 | 166.47 (12.902)$^{e}$ | 12.40 (3.521)$^{d}$ | 7.87 (2.804)$^{bc}$ |
| Emamectin Benzoate 50 SG | 15 | 122.33 (11.060)$^{g}$ | 8.60 (3.088)$^{ef}$ | 7.53 (2.744)$^{cd}$ |
| Spinetoram 120 SC | 54 | 171.60 (13.099)$^{cde}$ | 13.00 (3.605)$^{cd}$ | 8.27 (2.875)$^{ab}$ |
| (Novaluron 5.25% + Emamectin 0.9%) SC | 78.75 + 13.5 | 179.13 (13.384)$^{ab}$ | 13.20 (3.633)$^{bcd}$ | 7.73 (2.780)$^{bcd}$ |
| (Cartap 25% + Emamectin 1% SG) | 375 + 15 | 128.07 (11.315)$^{f}$ | 8.93 (3.141)$^{e}$ | 7.20 (2.683)$^{d}$ |
| CD= | | 0.2212 | 0.1508 | 0.1408 |

**Larval mortality**

At 3, 7, and 10 days after treatment in the first and second spraying, all insecticides significantly reduced the fall armyworm larvae in all replications compared to the control (Table 1).The first application was made 11 days after planting, and 1 day prior to treatment the mean number of larvae per plant in the treatments ranged from 1.0 to 1.26, with no statistical differences between them. At 10 days after the first considerably least number of larvae was recorded with Spinetoram + Novaluron @ 45+60 g a.i/ha (0.13 larvae per plant), Spinetoram + Emamectin @ 45+10 g a.i/ha (0.13 larvae per plant). Spinetoram + Indoxacarb @ 45+75 g a.i/ha recorded (0.26 larvae per plant), but on par with Spinetoram 120 SC @ 54 a.i/ha (0.26 larvae per plant). The next best treatments were Chlorantraniliprole + Novaluron @ 25+60 g a.i/ha (0. 46 larvae per plant), however on par with Chlorantraniliprole + Emamectin @ 30+10 g a.i/ha (0. 46 larvae per plant), Novaluron 5.25% + Emamectin 0.9%SC @ 78.75+15 g a.i/ha (0.53 Larvae per plant) statistically on par with Chlorantraniliprole 20 SC @ 30 g a.i/ha (0.60 larvae per plant). When compared to untreated control, Emamectin Benzoate 50 SG (1.46 larvae per plant) was statistically on par with Cartap 25% + Emamectin 1% SG @ 375+15 g a.i/ha (1.13 larvae per plant) (2.5 larvae per plant ).In comparison to Chlorantiniliprole tank mixed application, Spinetoram tank mixed combination exhibited good efficacy (Table 1). Spinetoram, Chlorantiniliprole, and Novaluron solo and tank mixes exhibited 99 % efficacy compared to Cartap 25 %+ Emamectin 1 % SG (80 %) and Emamectin Benzoate 50 SG @ 15 g a.i/ha up to 7 days after the first spray treatments (71.43 %) Similar results found by Deshmukh *et al*. (2020) discovered that Chlorantraniliprole 18.5 SC, Emamectin benzoate 5 SG, spinetoram 11.7 SC, flubendiamide 480 SC, indoxacarb 14.5 SC, lambda cyhalothrin 5 EC, and novaluron 10 EC were the most effective.

There was an increase in infestation in all treatments (P 0.05) at 7 and 10 days after the first spray, but it was much smaller than the control. At 10 days after the second spray, Chlorantraniliprole + Novaluron @ 25+60 g a.i/ha (0.26 larvae per plant) had the lowest number of larvae per plant, but it was on par with Spinetoram + Emamectin @ 45+10 g a.i/ha (0.13 larvae per plant) (0.26 larvae per plant), Spinetoram + Novaluron @ 45+60 g a.i/ha (0.20 larvae per plant), and spinetoram 120 SC @ 54 a.i/ha (0.26 larvae per plant).Chlorantraniliprole + Indoxacarb @ 25+75 g a.i/ha (0.44 larvae per plant), Spinetoram + Indoxacarb @ 45+75 g a.i/ha (0.33 larvae per plant), and Novaluron 5.25 %+ Emamectin 0.9%) SC (0.33 larvae per plant) had statistically equivalent results (P 0.05). The best percentage of pest population reduction over control 14 days after the second spray was recorded with Spinetoram + Novaluron @ 45+60 g a.i/ha (76.67 %), followed by Spinetoram + Emamectin (70 %) and Spinetoram + Indoxacarb (66.6% ).The lowest pest population reduction was achieved with Emamectin Benzoate 50 SG as a single application (23.3%), followed by ready-to-use treatment Cartap 25% + Emamectin 1% SG @ 375+15 g a.i/ha (30%) (Table 1). Hardke *et al.* (2011) found that chlorantraniliprole (0.101 kg a.i per ha), flubendiamide (0.098 kg a.i per ha), and novaluron (0.088 kg a.i per ha) provided an effective reduction in infestation (2.5, 5.0, and 2.5%, respectively) in sorghum 7 day after treatment.

**Leaf damage score**

In both the first and second rounds of spraying, the amount of leaf damage caused by FAW larvae differed significantly between treatments. In comparison to the plants treated with synthetic pesticides, the non-treated control plants (8.40) suffered severe leaf lesions from FAW larvae (Figure 1). Plants treated with Spinetoram + Novaluron @ 45+60 g a.i/ha (1.73), Spinetoram + Emamectin @ 45+10 g a.i/ha (1.93), and Spinetoram + Indoxacarb @ 45+75 g a.i/ha (2.0) experienced the least leaf damage (15 days after the second spraying) when compared to Chlorantraniliprole tank mixture applied treatments (Table 2). Emamectin Benzoate 50 SG @ 15 g a.i/ha showed the most leaf damage of all the treatments (7.53). After 15 days of second spraying, Spinetoram 120 SC @ 54 a.i/ha solo treated plants had the lowest damage results in comparison to solo Chlorantraniliprole 20 SC @ 30 g a.i/ha treated plants and when Compared within tank mixtures of Chlorantraniliprole, they were statistically on par with each other (Table 2).

**Plant growth parameters**

Among all the treatments Spinetoram + Novaluron @ 45+60 g a.i/ha followed by Chlorantraniliprole + Novaluron @ 25+60 g a.i/ha and Novaluron 5.25% + Emamectin 0.9%SC @ 78.75+15 g a.i/ha exhibited more plant height, leaf numbers and stem thickness than other treatments (Figure 2) & Figure 3) and similar results discovered by Birhanu *et al*. (2018).

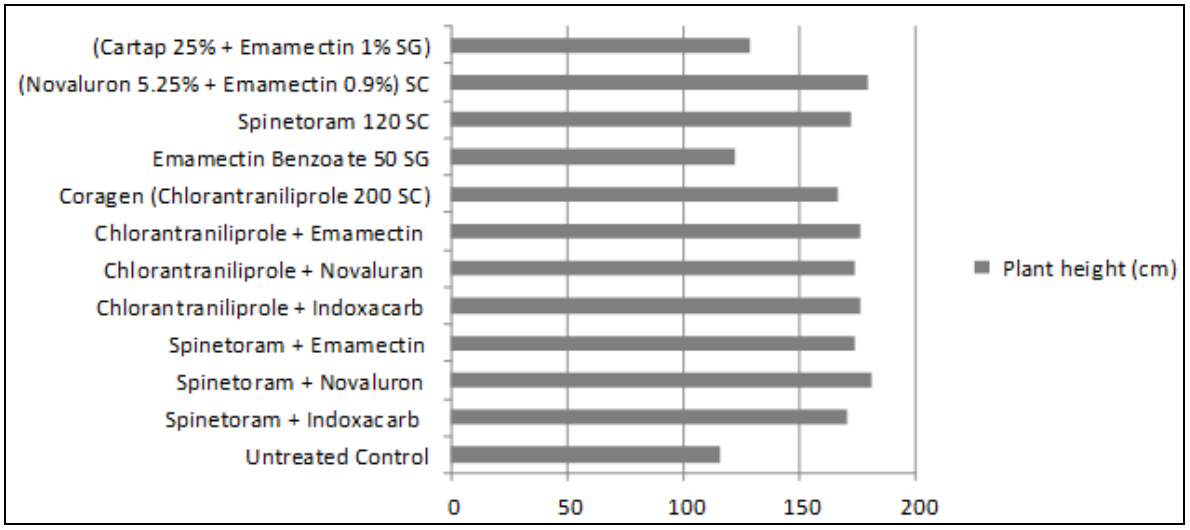


**Fig 2:** Mean plant height of various treatments

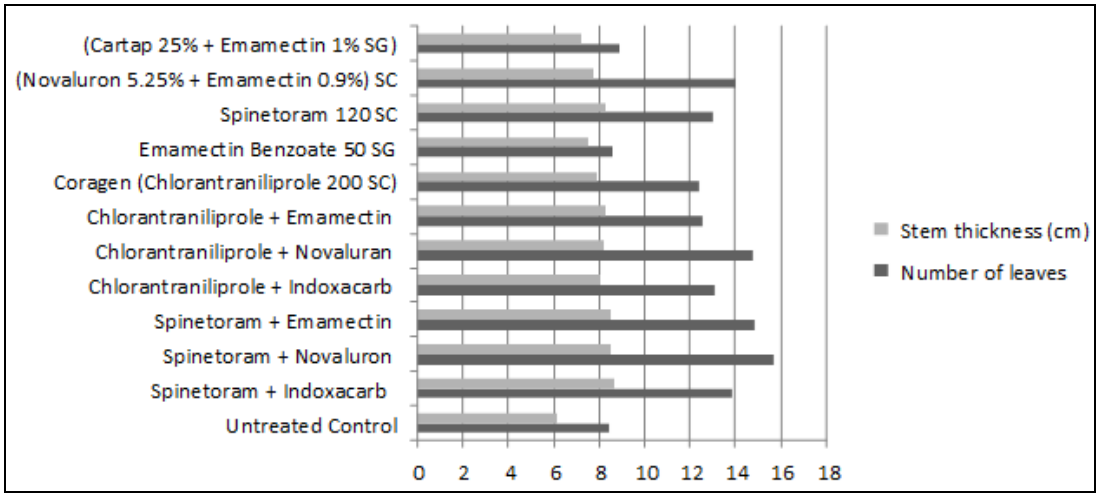


**Fig 3:** Mean number of leaves and stem thickness of various treatments

## Conclusion

It was discovered in this study, Evaluation of Efficacy of Chlorantraniliprole & Spinetoram Solo & Its Mixtures against *Spodoptera frugiperda* (JE Smith) in Maize, that applying spinetoram and Chlorantraniliprole in a Leaf whorl as a tank mixture gave longer-term efficacy than applying them separately. Spinetoram or Chlorantraniliprole in a tank with novaluron exhibited long-term efficacy, good plant growth, Phytotonic action, and decreased leaf damage. Spinetoram has a higher efficacy and a longer duration of action when used alone than other solo sprays. When CTPRL and Spinetoram were compared, spinetoram was found to be more effective over a longer period of time than CTPRL. When compared to full plant treatment, leaf whorl application was more effective and required less insecticide.

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