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Studies on the evaluation of some newer insecticides against of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on rabi maize

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Abstract
The studies on "Population dynamics and management of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on rabi maize" was carried out under field conditions during Rabi 2020-21 at Agricultural Research Farm, Tirhut College of Agriculture, Dholi, Muzaffarpur District, Bihar, which is a sub-campus of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar. The research outcome revealed that the lowest mean larval population (0.40 larvae/plant), damage severity (1.67/ plant) with the maximum grain yield (7.59 t/ha) and highest benefit cost ratio (4.60:1) was recorded in plot treated with Chlorantraniliprole 18.5 SC @ 0.4 ml/l, followed by Emamectin benzoate 5SG @ 0.15 g/l, Lambda-cyhalothrin 9.5% + Thiamethoxam 12.6% ZC @ 0.25 ml/l, Lambda-cyhalothrin 5EC @ 1 ml/l were found effective insecticides than Azadirachtin 0.15% EC (1500 ppm) @ 5 ml/l, and carbofuran 3G @ 0.50 g/plant, *Beauveria bassiana* 2.5 WP @ 2 g/l were found least effective insecticides among all other treatments.

Keywords: Fall armyworm, *Spodoptera frugiperda,* insecticides, maize, newer insecticides

Introduction
Maize (*Zea mays* L.) is the third most important food grain cereal crops after wheat and rice. In India it is grown in wide area under different agro-climatic conditions. Currently fall armyworm is the most destructive, notorious, and endemic pests of maize. Which is responsible for 57.6% to 58% of yield losses in maize (Cruz *et al*., 1999) [6] and due its polyphagous nature (Goergen *et al*., 2016) [10] and cosmopolitan nature (Wiseman *et al*., 1966) [26], it is going to feed more than 42 different families of 186 plant species, *viz*., Poaceae (35.5%), Fabaceae (11.3%), Solanaceae (4.3%), Asteraceae (4.3%), Rosaceae (3.7%), Chenopodiaceae (3.7%), Brassicaceae and Cyperaceae (3.2%) are important families which are affected by fall armyworm attack (Casmuz *et al*., 2017) [5]. Keeping in view of the importance of maize crop, and to reduce the economic losses caused by the fall armyworm during rabi season, the present study aimed to study the evaluation of some newer insecticides molecules against the fall armyworm of maize, because newer insecticides effective in reducing pest damage with unique mode of action and reduces high pesticides selection pressure, minimize the development resistance and small dose of insecticides are detrimental to insect pest and they are more safer to natural enemies and environment than organochlorins, organophosphates and carbamate insecticides and less residue found on food commodity and natural enemies (predators) of fall armyworm.

Materials and Methods
The entomological field trial was carried out to know the efficacy of some newer insecticides against fall armyworm, on maize crop, the field trial was carried out in plot number-15 at Agricultural Research Farm, T.C.A, Dholi, Muzaffarpur, Bihar during *Rabi,* 2020-21 and assess the fall armyworm larval population, damage severity, grain yield and benefit cost ratio.
The field experiment was conducted by using RBD (Randomized Block Design) design with eight treatments including untreated control (Table 2) and three replications.

The size of each plot was 15 m^2 and each plot consist of eight rows and each row contains 15 plants and the gap between the replications and treatments was 1 meter and 0.5 meters respectively. Shaktiman-5 was selected as the test variety for experimentation purposes and sowing was done on 05th Jan 2021.

The spray formulations were prepared from the commercially available material except carbofuran 3G and all the treatments were applied with manually operated knap sack sprayer whereas carbofuran 3G is applied manually with hands. All the package of practices for raising of crop was followed to maintain healthy crop growth and no insecticides other than those included in the trial were applied. The treatments were applied thrice at 15 days interval starting from 30 DAS, 45 DAS, and 60 DAS.

Larval Population

FAW larval incidence was calculated by selecting the 10 random plants in each of the treated and untreated control plots and presence of live larvae, dead larvae present per 10 random plants were recorded, and also plant showing pin damage, presence of frass, and excreta near whorl of plant were also considered as presence of larvae. In the present experimental field trial the pre-count larval observation will be recorded at one day before imposing of spray by destructive sampling method and the post-treatment observations will be recorded on 1st, 3rd, 5th, 7th and 10th days after each spraying of insecticidal chemicals. The recorded observation on mean larval population was subjected to the RBD (Randomized Block Design) by using 'OPSTAT' software and data was subjected to log transformation and to know the treatments variations for significance, the separation of mean larval population was done by using 'Duncan's Multiple Range Test' (DMRT) ($p<0.05$) by using 'IBM-Statistical Package for the Social Science' software (IBM-SPSS Statistics version 20).

The Mean larval population of fall armyworm was calculated as follows.

$$\text{Mean Larval Population} = \frac{\text{Number of larva}}{\text{10 randomly slelected plants}} \quad (1)$$

Damage Severity

Damage severity of fall armyworm was recorded on pre-spray, followed by 5th, 10th, and 15th day interval after 1st sprays, 2nd sprays, and 3rd sprays by non-destructive sampling method by selecting 5 random plants in each of the treated plots containing three replications. Damage severity was recorded by observing top five leaves in each of the treated plots and damage severity ratings were given to leaves based on level of damage caused by fall armyworm as per 0-9 rating scale, described by (Davis *et al.*, 1992) [8] (Table 1) and finally mean of damage severity score was workout out at one day before sprays (DBA), followed by 5th day, 10th day and 15th days intervals and mean of damage severity score was analyzed by using OPSTAT software, and mean of damage severity score was separated based on 'tukey test' by using 'IBM-Statistical Package for the Social Science' (IBM-SPSS Statistics version 20), and finally efficacy of insecticides was judged based on level of foliar damage observed on plant.

Table 1: Damage severity scale

Damage severity rating Scale	Damage severity
0	No visible leaf damage
1	Only pin hole damage to the leaves
2	Pin hole and shot hole damage to the 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 portion 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% leaf eaten
8	Elongated lesions (30 cm) and large portion eaten on 70% of leaves
9	Most leaves have long lesions and complete defoliation

Grain yield

Crop was harvested when it attains maturity, and efficacy of different insecticidal treatments were determined based on the grain yield obtained from the different insecticides treated plots by selecting 5 random plants and after harvesting and threshing, yield of grain per plot was calculated, and respective yield from different treated plots were converted to tons per ha, and percent yield increase over control was calculated. The grain yield performance in relation to various treatments was determined by using the formula.

$$\text{Percent increase in yield} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \text{x100} \quad (2)$$

Analysis of benefit cost ratio of insecticidal treatment

The cumulative efficacies of different insecticidal treatments were judge on the basis of grain yield recorded from their respective treated plots in term of (₹/ha) and B: C ratio was calculated for all treatments on the basis of minimum support price fixed by government of India - 2020-21, insecticides and spraying cost, and wages of labor were considered.

B: C ratio was worked out by using the formula

$$\text{B: C ratio} = \frac{\text{Net return of treatment}}{\text{Net return of control}} \quad (3)$$

Table: 2 Details of treatments (Anonymous 2019) [1]

Treatment	Brand Name	Group	Dosage ml or g a.i./ha)	Dose/L	Mode of Action
Azadirachtin 0.15% EC 1500 ppm	SAKTI NEEM	Botanicals	3.75	5 ml	Antifeedant, repellant
Beauveria bassiana 2.5% WP	WAH!!	Bio pesticides	25	2 g	Penetrate the insect cuticle and haemocoel and multiply and kill the insects
Lambda-cyhalothrin 5% EC	COMMANDO	Pyrethroids	25	1 ml	Voltage-gated sodium channels blocker
Emamectin benzoate 5% SG	EMBOZ	Avermectins	3.75	0.15 g	Block the GABA at the neuromuscular junction of insect.
Lambda cyhalothrin + Thiamethoxam 9.5%+ 12.6% ZC	EKKA	Synthetic pyrethroids + Neonicotinoids	27.62	0.25 ml	Voltage-gated sodium channels blocker + irreversible blockage of postsynaptic nicotinic acetylcholine receptors
Carbofuran 3% G	FURADAN	Carbamate	7.5	0.50 g	Acetyl cholinesterase inhibitor
Chlorantraniliprole 18.5% SC	CORAGEN	Anthranilic diamides	37	0.4 ml	Opens muscular calcium channels in particular the ryanodine receptor
Untreated Control	-	-	-	-	-

Results and Discussion

The observations on overall efficacy of some newer insecticides against fall armyworm, larval population, damage severity and yield of crop (t/ha), with percent larval population reduction over control, and percent yield increased over control after three successive spraying has been depicted in (Table 3 and Fig 1).

There is no significant effect was observed among treatments with respect to larval population and damage severity of fall armyworm at one day before imposing of treatments, but the larval population and damage severity were above economic threshold levels (ETL). One day after spraying of insecticides, all the treatments were found significantly superior over untreated control plot, and significant declining of larval population and damage severity was observed in different treatments.

The cumulative efficacy of all treatments after three successive sprays the mean larval population of fall armyworm was ranges from (0.40 to 2.52 larvae/plant) and mean damage severity of (1.67 to 5.91). In the present experiment after three successive sprays the plot treated with chlorantraniliprole 18.5% SC 0.4 ml/l was found superior insecticide among all insecticides and it record the lowest mean larval population of (0.40 larvae/plant), damage severity ratings of (1.67/plant), and maximum percent larval population reduction over control of (84.13%) with highest grain yield of (7.59 t/ha) was recorded with maximum percent grain yield increased over control was (108.88%).

Followed by emamectin benzoate 5% SG 0.15 g/l, was found to be next best effective treatments, with least mean larval population of (0.51 larvae/plant), followed by mean damage severity of (2.19/plant), with the (79.87%) reduction over control and (7.28 t/ha) of grain yield was obtained, with percent yield increased over control of (102.22%).

The present research trials almost similar with the findings of Nayaka *et al.,* (2019) [16], who found Chlorantraniliprole 18.5 SC, was found most effective insecticides in reduction of *Spodoptera litura,* larval population followed by, Emamectin benzoate 5 SG was found next best treatments, and also similar with the findings of Dabhi *et al.,* (2020) [7], who recorded the lowest larval population of *Spodoptera litura* in soybean field, which was treated by Chlorantraniliprole 18.5 SC with the mean larval population of (5.90 larvae/plant) followed by Emamectin benzoate 5SG (9.86 larvae/plant). Hardke *et al.,* (2011) [13], found the lowest infestation of *Spodoptera frugiperda* on maize was significantly reduced in plot treated with Chlorantraniliprole. Extent of leaf damage depends on activity of larvae, which was minimized by spraying of effective insecticides before reaching of economic threshold level. The experimental results was may be supported by the Gontijo *et al.,* (2018) [11], who observed the lowest foliar damage and 90 to 100 percent mortality of fall armyworm, *Spodoptera frugiperda* was observed in soybean crop, which treated with Chlorantraniliprole at 24 hours after treatment.

The damage of plant was depending on phenological stage of crop, plant age, availability of water and nutrients, abiotic and biotic factors, stages of larvae etc. The infestation of maize plant was severe during initial growth periods particularly during knee high or mid whorl stage of crops than late growth or late whorl stage, because during initial growth stage larvae is going to feed tender leaf than older plant. Present investigation strongly supported by Bajracharya *et al.,* (2020) [2], who recorded the lowest damage score and plant infestation (%) with least foliar damage on maize crop, which was treated by Chlorantraniliprole 18.5% SC @ 0.4 ml/l, followed by Emamectin benzoate 5% SG @ 0.4 g/l and Azadirachtin 0.15% @ 5 ml/l. The economic yield of crop is mainly depending on photosynthetic rate of crop and it was directly correlation with the leaf area of crop. Fall armyworm attacks almost all parts of maize, and it responsible for severe foliar damage, which influence reduction of photosynthetic rate of plant and finally economic yield of crop was decreases. The present field investigations were close conformity with the Ompraksh *et al.,* (2020) [17], who recorded the lowest percent of plant damage (3%), and lowest damage severity (1.57) with maximum grain yield in plot treated with Chlorantraniliprole 18.5 SC @ 0.3 ml/l on maize.

The present investigation consistent with the Thrash *et al.,* (2013) [23], who observed the significant reduction of survival of fall armyworm in plant treated with Chlorantraniliprole (50 a.i) at V_3, $V_{7,}$ 2nd, 3rd and 4th days after infestation on soybean crop. The experimental result may be supported by Sharanabasappa *et al*., (2020) [21], who recorded the lowest larval population of fall armyworm at 3 days after application of insecticide and higher grain yield in crop treated with emamectin benzoate and chlorantraniliprole. Present investigation may be supported by Mallapur *et al.*, (2019) [15], who recorded the 96.26% reduction of fall armyworm larval population at 60 hours after treatment of emamectin benzoate 5SG and also supported by Korrat *et al.*, (2012) [14], who studied the 3 DAS of emamectin benzoate at 0.017 ppm was found most effective treatment against 2nd instar larvae of *S. littoralis*.

Mortality of larvae of fall armyworm depends on dose of insecticides, concentration of insecticides, time and method of application, larval stage, etc. The present field trials was supported by Song *et al.*, (2020) [22], who observed the mixture of Chlorantraniliprole, chlorfenapyr, and lufenuron were responsible for 94.86 percent reduction of fall armyworm with 94.94 percent control efficiency on sugarcane crop. Chlorantraniliprole 18.4% SC was anthranilic diamides group of insecticides and acts as ryanodine receptor activators, which is responsible for release and depletion of calcium ions by making this channel in open condition. The first and second instar larvae are most susceptible to abiotic and biotic factor and also chemical treatments. The experimental results were line with the Belay *et al.*, (2012) [3], who observed 30% and 80% mortality of fall armyworm after 16 hours and 96 hours after treatment of Chlorantraniliprole 18.4% SC on maize crop.

The present field experiments was strongly supported by Deshmukh *et al.*, (2020) [9], who observed the highest toxicity of Chlorantraniliprole 18.5 SC and Emamectin benzoate 5SG on fall armyworm of maize under field condition. In the present investigation observed that, the larval population of fall armyworm was decreases after 1, 3, 5, 7 and 10 days after spraying of insecticides. The present findings strongly accordance with the findings of Guerreiro *et al.*, (2013) [12], who recorded the lowest larval population of fall armyworm at 1st, 3rd, 5th, 10th, 15th and 21 days after spraying of Chlorantraniliprole 25 g a.i/ha on maize, and also supported by Mahesh *et al.*, (2020), who observed the more toxic effect of Chlorantraniliprole 18.5 SC @ LC_{50} value (0.0055 percent) on *Spodoptera litura* was observed at 72 hours after treatment of insecticide.

The susceptibility of larvae of *S. frugiperda* may depend on group and mode of action of insecticides. The present investigations were agreement with Ribeiro *et al.*, (2014) [20], who observed the population of fall armyworm, was found more susceptible to Chlorantraniliprole 18.5 SC on maize crop. The present results were close proximity with the findings of Triboni *et al.*, (2019) [24], who reported lowest consumption leaves of soybean and greater control efficiency of fall armyworm was observed in plant treated with Chlorantraniliprole at (62.5 a.i). The present findings were almost similar with the findings of Wang *et al.*, (2019) [25], who reported the 60.0 g a.i /ha of chlorantraniliprole 0.4% granules on first, second and third instar larvae of fall armyworm gave better control effect by causing 90.3%, 100% and 100% mortality at 1 day, 3 days and 7th DAS. 100% mortality of 2nd and 4th instar larvae of *Spodoptera exigua* was found under laboratory condition at 24 hours and 72 hours after feeding of Emamectin benzoate 0.95% SG @ 0.5 mg/l a.i through sweet pepper leaves was reported by Bengochea *et al.*, (2014) [4]. Similar results of present studies were observed by Karuppaiah and Srivastava (2013), who evaluated the toxicity and effectiveness of newer and conventional insecticides against *S. litura* and observed that chlorantraniliprole 18.5% SC, followed by emamectin benzoate 5% SG were found most toxic and effective insecticides against field populations of *S. litura* whereas the conventional insecticides treatments were found less effective.

Lambda cyhalothrin + Thiamethoxam 9.5% + 12.6% ZC 0.25 ml/l, was found next effective treatment with mean larval population and damage severity ratings of (0.80 larvae/plant) and (3.22/plant) respectively, and 68.41% reduction over control was observed, with the grain yield of (6.78 t/ha), and (88.33%) of percent yield increased over control was recorded.

Followed by Lambda-cyhalothrin 5% EC 1 ml/l recorded the mean larval population and damage severity ratings of (0.97 larvae/ plant) and (3.65/plant) respectively, with (61.50%) reduction over control, and (6.61 t/ha) of grain yield, with percent yield increased over control of (83.61%). The present experimental findings supported by Zhao *et al.*, (2020) [27], who found lambda-cyhalothrin was shows lower toxicity against fall armyworm after emamectin benzoate, followed by chlorantraniliprole and lufenuron.

Followed by Azadirachtin 0.15% EC (1500 ppm) @ 5 ml/l, was found least effective treatment, with the mean larval population and damage severity ratings of (1.32 larvae/ plant) and (4.15/plant) respectively, with (47.47%), (5.25 t/ha), and (45.83%) of mean larval population reduction over control, grain yield and percent yield increased over control respectively. In the present field trail azadirachtin 0.15% EC (1500 ppm) @ 5 ml/l, does not show that much effective in reduction of larval population as well as foliar damage, it may be due less toxic against this pest and fail to deter this pest. The present study supported by Raffa K. F(1987) [18], who found azadirachtin was fail to deter the fall armyworm from feeding site of lima bean.

Followed by Carbofuran 3% G 0.50 g/plant was found least effective insecticides and it record (1.68 larvae per plant) and (4.42/plant) of mean larval population and damage severity respectively and (33.21%) mean larval population reduction over control, and (4.49 t/ha) of grain yield and with percent yield increased over control of (24.72%) was observed.

Among different treatments tested against larval population and damage severity of fall armyworm, the lowest efficacy was observed in *Beauveria bassiana* 2.5% WP 2 g/l, and it records the mean larval population of (1.75 larvae/plant) and damage severity of (5.27/plant) and percent mean larval population reduction over control of (30.57 percent), with the grain yield of (3.99 t/ha), and percent yield increased over control of (10.83%) over untreated control plot. It may be due to late colonization and sporulation of fungus, abiotic factors, and stage of larvae etc. The present findings was supported by Ramos *et al.*, 2020) [19], who found only 19 percent colonization of *B. bassiana* on non treated young leaves and 61 percent colonization in inoculated older leaves and mortality of fall armyworm was observed 4 days after treatments and it reach mortality up to 11 percent only and sporulation of this microbial insecticides was less.

And finally, 2.52 mean larval population per plant and 5.91 ratings of damage severity, with the grain yield of (3.60 t/ha) was recorded in untreated control plot.

Table 3: Cumulative efficacy of some newer insecticides against fall armyworm larval population, damage severity, and grain yield of maize (t/ha) during *Rabi*, 2020-21

Treatments	Dose/L	Mean damage severity/plant	Mean larval population/plant	Mean larval population reduction over control (%)	Yield (t/ha)	Percent yield increased over control
Azadirachtin 0.15% EC (1500 ppm)	5 ml	4.15[cd]	1.32[d] (0.37)	47.47	5.25	45.83
Beauveria bassiana 2.5% WP	2 g	5.27[de]	1.75[e] (0.44)	30.57	3.99	10.83
Lambda-cyhalothrin 5% EC	1 ml	3.65[bc]	0.97[c] (0.29)	61.50	6.61	83.61
Emamectin benzoate 5% SG	0.15 g	2.19[ab]	0.51[a] (0.18)	79.87	7.28	102.22
Lambda cyhalothrin 9.5% + Thiamethoxam + 12.6% ZC	0.25 ml	3.22[bc]	0.80[b] (0.25)	68.41	6.78	88.33
Carbofuran 3% G	0.50 g	4.42[cde]	1.68[e] (0.43)	33.21	4.49	24.72
Chlorantraniliprole 18.5% SC	0.4 ml	1.67[a]	0.40[a] (0.15)	84.13	7.59	108.88
Untreated Control	-	5.91[e]	2.52[f] (0.55)	0.00	3.60	-
C.D. (p<0.05)		0.946	0.137	-	0.756	-
Sem (±)		0.309	0.045	-	0.247	-
C.V. (%)		14.049	6.250	-	7.501	-

*Values in column followed by common letters were non-significant at (p=0.05) as per Tukey's HSD (Tukey, 1965), *Figures in parentheses are the values of log transformation, within a row means followed by same letters were not significantly different by DMRT (p=0.05)

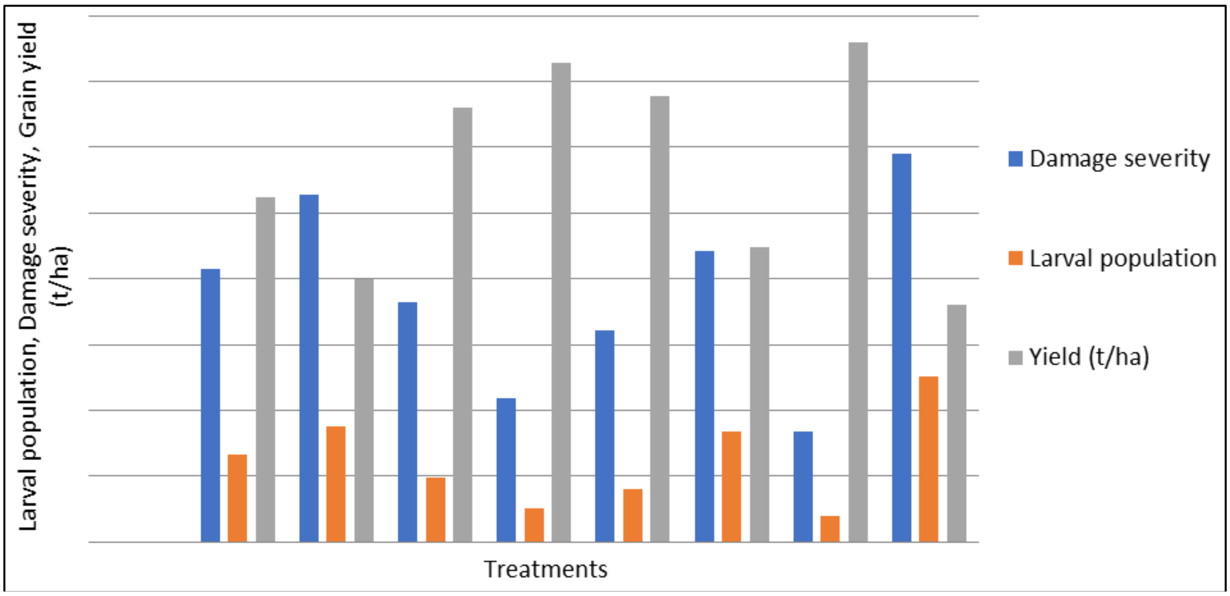

Fig 1: Cumulative efficacy of some newer insecticides molecules against fall armyworm larval population, damage severity, and grain yield of maize (t/ha) during *Rabi*, 2020-21

Economics of insecticidal treatments used for management of fall armyworm, *S. frugiperda* on maize cv. Shaktiman-5 during *Rabi* 2020-21

Impact and performance of various foliar and granular insecticides under the field condition was determined the efficacy of different insecticides on the basis of benefit obtained in terms of monitory value and the data shows the economics and benefits are presented in Table 4.

Among all the treatments, Chlorantraniliprole 18.5% SC @ 0.4 ml/l gave highest net return of (₹. 80,791/ha) with the maximum benefit-cost ratio of (4.60:1), and lowest net return was found in *Beauveria bassiana* 2.5% WP @ 2 g/l (₹. 17,730/ha) with the least benefit-cost ratio of (1.01:1). The maximum and minimum treatment cost were recorded in Chlorantraniliprole 18.5% SC @ 0.4 ml/l (₹. 59,624/ha) and Lambda cyhalothrin + Thiamethoxam 9.5% + 12.6% ZC @ 0.25 ml/l (₹. 52,117/ha) respectively.

The net profit and benefit cost ratio obtained under various treatments were in the following order: Chlorantraniliprole 18.5% SC @ 0.4 ml/l (₹. 80,791 /ha) and (4.60:1) > Emamectin benzoate 5% SG @ @ 0.15 g/l (₹. 80,455/ha) and (4.58:1) > Lambda cyhalothrin + Thiamethoxam 9.5% + 12.6% ZC @ 0.25 ml/l (₹. 73,313/ha) and (4.17:1) > Lambda-cyhalothrin 5% EC @ 1 ml/l (₹.69,050/ha) and (3.93:1) > Azadirachtin 0.15% EC (1500 ppm) @ 5 ml/l (₹. 41,175) and (2.34:1) > Carbofuran 3% G @ 0.50 g/plant (₹. 29,130 /ha) and (1.60:1), *Beauveria bassiana* 2.5% WP @ 2 g/l (₹. 17,730/ha) and (1.01:1) respectively, and Untreated control recorded least net return among treatments (₹.17,541/ha).

Details of Cost of insecticidal treatments, labour wage and price of maize

Selling price of maize: ₹.1, 850/q, Cost of insecticidal treatments *viz.*, Azadirachtin 0.15% EC (1500 ppm) = ₹. 650/lit, *Beauveria bassiana* 2.5% WP = ₹. 1,670/Kg, Lambda-cyhalothrin 5% EC = ₹. 1,440/l, Emamectin benzoate 5% SG = ₹. 7,660/lit, Lambda cyhalothrin + Thiamethoxam 9.5% + 12.6% ZC = ₹. 1,125/lit, Carbofuran 3%G = ₹. 260/Kg, Chlorantraniliprole 18.5% SC = ₹. 14,266/lit. Spraying labourers required/ha = 6, Labour wages = ₹. 336/day, Total wages = ₹. 2016/ha, Total Number of sprays = 3.

Table 4: Economics of insecticidal treatments used for management of fall armyworm, *S. frugiperda* on maize cv. Shaktiman-5 during *Rabi* 2020-21

Treatments	Common cost	Variable cost		Total cost (₹/ha)	Yield (t/ha)	Gross Return (₹/ha)	Net Return (₹/ha)	B:C Ratio
		Insecticides Cost (₹)	Labour Cost (₹)					
Azadirachtin 0.15% EC (1500 ppm) @ 5 ml/l	49,059	4,875	2,016	55,950	5.25	97,125	41,175	2.34:1
Beauveria bassiana 2.5% WP @ 2 g/l	49,059	5,010	2,016	56,085	3.99	73,815	17,730	1.01:1
Lambda-cyhalothrin 5% EC @ 1 ml/l	49,059	2,160	2,016	53,235	6.61	1,22,285	69,050	3.93:1
Emamectin benzoate 5% SG @ 0.15 g/l	49,059	1,125	2,016	54,225	7.28	1,34,680	80,455	4.58:1
Lambda cyhalothrin 9.5% + Thiamethoxam + 12.6% ZC @ 0.25 ml/l	49,059	1,042	2,016	52,117	6.78	1,25,430	73,313	4.17:1
Carbofuran 3% G @ 0.50 g/l	49,059	2,860	2,016	53,935	4.49	83,065	29,130	1.60:1
Chlorantraniliprole 18.5% SC @ 0.4 ml/l	49,059	8,559	2,016	59,624	7.59	1,40,415	80,791	4.60:1
Untreated Control	49,059	-	-	49,059	3.60	66,600	17,541	-

Conclusion

Among all the insecticides tested against fall armyworm, *S. frugiperda*; Chlorantraniliprole 18.5 SC @ 0.4 ml/l was found most effective insecticides in reduction of larval population, foliar damage and highest grain yield with maximum benefit cost ratio was recorded from this treatment, followed by Emamectin benzoate 5SG @ 0.15 g/l, Lambda cyhalothrin 9.5% + Thiamethoxam 12.6% ZC @ 0.25 ml/l and Lambda cyhalothrin 5EC @ 1 ml/l were found to be more effective insecticidal treatments for management of fall armyworm of maize. In addition to the above facts, the present studies have different insecticides with different mode of action, effective at very low dose, low residual effect on predators and environment. The use of insecticides in sequence with different mode of action reduces the chance of resistance development in insect and proves better in controlling the insect pest.

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