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Management of the Fall Army Worm, *Spodoptera frugiperda* (J.E. Smith) in Maize

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ABSTRACT

Background: Fall army worm is an invasive insect pest in India during year 2018 which caused severe damage to the crop and economic loss to the farmers. So, the main objective of the study is to evaluate the efficacy and effectiveness of seed treatment, biological and insecticidal applications for the management of fall army worm in maize.

Methods: The study was conducted *Kharif*, 2018 and 2019 at Regional Agricultural Research Station, Chintapalle, Visakhapatnam during. It was evaluated with eleven treatments, after seed treatment with Cyantraniliprole 19.8% + Thiamethoxam 19.8 FS 5 ml per kg seed in 03 windows of application at 20, 35 and 50 DAS with battery operated sprayer. Data was collected on number of larva per plant (20 DAS), per cent plant infestation and % cob infestation, yield (q/ha) and cost benefit ratio.

Result: Among three windows of applications, third window application with different insecticides was found most significant, followed by second window application (poison bait with Thiodicarb 75WP) in comparison to control (20.96). In 3rd window treatments application, spinetoram 11.7SC @ 0.5ml (T_3 with 0.74 and T_8 with 1.14 %) and spinosad 45SC @ 0.3 ml (T_4 with 1.35 and T_9 with 1.39 %), were found most significant, followed by Chlorantraniliprole 18.5SC (T_2 with 1.76 and T_7 with 1.25 %) in the management of fall army worm. Least Cob damage per cent (T_3 with 7.23 and T_8 with 8.00 %) and maximum yield (T_3 with 72.55 and T_8 with 73.00 q/ha) was recorded in Spinetoram 11.7 SC. Thus Spinetoram 11.7SC followed by Spinosad 45SC and Chlorantraniliprole 18.5SC found effective against *S. frugiperda* in Maize.

Key words: % Infestation, Biological, Botanical, Fall army worm, Insecticides, Seed treatment, Windows application, Yield.

INTRODUCTION

The fall armyworm, *Spodoptera frugiperda* is a polyphagous pest and native of America, but in 2016 it was appeared in African countries (Goergen *et al.,* 2016) and caused severe losses in Negria, Benin and Togo. This destructive invasive insect pest had been reported from Karnataka, India on maize crop during May 2018 (Sharanabasappa *et al.,* 2018), later it was also recorded from Tamil Nadu andhra Pradesh and other states of India. It was also identified and reported from agency area of Visakhapatnam andhra Pradesh in July, 2018 (Ramesh *et al.,* 2020). Later its spread to other asian countries, like Thailand, Sri Lanka, Bangladesh, Myanmar, Vietnam, Laos and China (Guo *et al.,*2018; Wu *et al.,* 2019). It feeds on the vegetative and reproductive parts of about 80 plant species preferably gramineae family and causing severe economic losses in crops like maize, millet, soybean, cotton (Pogue, 2002), rice, other grasess and weed plants (Nabity *et al.,* 2011). Its infestation was increasing during increase in maximum temperature (Prathima *et al.,* 2023) and it is found that 35°C was found optimum for its fast multiplication and spread of fall army worm Shubhasree (2024).

The recent invasion of fall armyworm threatens the maize cultivation in India, as it is causing heavy damage to about 80 - 90% in vegetative stage. Insecticides are used widely as a tool in fall army worm management both in the America (Gutierrez-Moreno *et al.,* 2019; Hardke *et al.,* 2011; Tomquelski and Martins, 2007) and in Africa (Prasanna *et al.,* 2018; Sisay *et al.,* 2019). Therefore, the main objective of the study is to evaluate the efficacy of seed treatment, biological and insecticidal applications for the management of fall army worm in maize.

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MATERIALS AND METHODS

Study was conducted during *Kharif*, 2018 and 2019 at Regional Agricultural Research Station, Chintapalle, Visakhapatnam andhra Pradesh for two years. It was conducted in randomised block design (RBD) with 11 numbers of treatments in three replications with the hybrid variety VMH 6474 of maize, in 5 × 5 m^2 treatment plot size following all the agronomic recommended practices in its

production. At the time of sowing, seed was treated with Cyantraniliprole 19.8 + Thiamethoxam 19.8FS 5 ml per kg seed irrespective of three windows and ten treatments, except in control. The eleven (11) treatments were imposed in three windows, first window at 20 DAS, second window at 35 DAS and third window at 50 DAS respectively with battery operated sprayer. The first window application with NSKE @ 5% was taken from T_1 to T_5 treatments and Neem oil 1500 ppm @ 5 ml was taken from T_6 to T_{10} treatments at 20 DAS followed by second window application with poison bait (Rice bran 10 kg + Jaggery 1 kg + 1 l. of water + 100 g Thiodicarb 75WP @ 50 kg/ha) was taken for all the treatments from T_1 to T_{10} except control (T_{11}) at 35 DAS. The third window application includes, T_1 and T_6 with Novaluron 10EC @ 1 ml/l.; T_2 and T_7 with Chlorantraniliprole 18.5 SC @ 0.4 ml/l.; T_3 and T_8 with Spinetoram 11.7 SC @ 0.5 ml/l.; T_4 and T_9 with Spinosad 45SC @ 0.3 ml/l.; T_5 and T_{10} with Emamectin benzoate 5 SG @ 0.4 gm/l. at 50 DAS.

On the basis of large plot technique, plants were counted for healthy and infested plants for calculating per cent plant infestation in treatments, before and 10 days after the window application. But for the data on number of larvae per plant, 10 plants were randomly selected from each treatment in each replication for the first window only. During Harvest, number of damaged and healthy cobs was counted for calculating per cent cob damage and yield data was taken treatment wise and calculated it for hectare.

RESULTS AND DISCUSSION

Results revealed that all the insecticide treatments were found effective in reducing the fall army worm infestation in comparison to the control. In this experiment, data was taken on number of larvae per plant; per cent plant infestation; per cent cob damage; yield and economics of the experiment and presented in the Table 1.

Number of larvae per plant

Number of larva per plant recorded during 01st window of application was found non significant before (ranging from 0.68 to 1.21larva per plant) and after application with NSKE 5% (from T1 to T5) and Neemoil 1500 ppm @5 ml (fromT6 to T10) in both the years (*Kharif*, 2019 and 2020), as reduction in number of larvae per plant was too low ranging from 0.45 to 0.74 in 01st window of application compared to control 0.84 larva per plant.

During both the years, even though there was reduction in number of larva per plant, it was found non-significant as there is continuous egg laying and larval infestation, which lead to non significant. Similar results were reported by Deshmukh *et al.* (2020) that, due to continuous egg lying and larval infestations made difficult to extend management beyond 10 days even after spraying with novel insecticides. Viana and Prates (2003) were also reported the toxic effect of aqueous neem leaf extract against *S. frugiperda* caterpillars, which caused the mortality of *S. frugiperda* caterpillars.

Per cent plant infestation

Results reveal that, per cent plant infestation in first window application with NSKE 5% (fromT_1 to T_5) and Neemoil (fromT_6 to T_{10}) was found non significant difference between the treatments and ranged from 30.15 to 43.41%. Followed by this in the second window application, a treatment of poison bait with thiodicarb 75 WP, the per cent plant infestation at 45 DAS was found significant between the treatments and it was ranged from 4.77 to 20.96%.

A similar result of lowest per cent plant damage was recorded with thiodicarb poison bait by Omprakash *et al.,* (2020). Shahanaz (2018) also concluded that emamectin benzoate, thiodicarb and chlorpyriphos were found as superior poison baits against *S. litura* infesting tobacco. Lunagariya *et al.,* (2020) were also reported that poison bait with Thiodicarb found most effective in managing the population of fall army worm, which in turn reflected to higher yield.

Later, third window application of different treatments showed a significant difference in infestation ranged from 0.74 to 22.99% at 60 DAS. Among third window treatments, spinetoram 11.7SC 0.5 ml (T_3 with 0.74 and T_8 with 1.14%) and spinosad 45 SC 0.3 ml (T_4 with 1.35 and T_9 with 1.39%), were found effective in the management of fall army worm, followed by chlorantraniliprole 18.5 SC @ 0.4 ml (T_2 with 1.76 and T_7 with 1.25%), novaluron 10 EC @ 1 ml (T_1 with 2.23 and T_6 with 3.46%) and emamectin benzoate 5 SG 0.4 gm (T_5 with 3.22 and T_{10} with 3.05 %) which were also on par with each other except untreated control (T11) with 22.99 per cent.

Effectiveness of insecticides *i.e.* spinetoram 11.7SC, chlorantraniliprole 18.5SC, emamectin benzoate 5SG and novaluron 10EC was reported by Deshmukh *et al.*, (2020), which is similar to currentfindings. Hardke *et al.,* (2011) also reported that chlorantraniliprole, flubendamide and novaluron were effective in reduction of infestation of larvae inn sorghum 7 days after treatment, which was 10 days after treatment in our findings. During both the years, three windows of treatments resulted in the reduction of population of fall army worm.

Per cent cob damage

During harvest, % Cob damage was ranging from 7.23 to 27.62. Lowest % cob damage was recorded in spinetoram 11.7SC @ 0.5 ml (T3 with 7.23 and T8 with 8.00 %) followed by chlorantraniliprole 18.5 SC @ 0.4 ml (T2 with 9.36and T7 with 9.73%), novaluron 10 EC @ 1 ml (T1 with 10.17and T6 with 9.58%), spinosad 45 SC @ 0.3 ml (T4 with 10.17 and T9 with 10.17%) and emamectin benzoate 5 SG @ 0.4 gm (T5 with 10.96and T10 with 11.25%), which were also at par with each other except untreated control with 27.62 per cent cob damage. Tandon and Srivastava (2018) also reported that diamide group insecticides were found effective against lepidopteron in rice, where our findings were also found that diamide group insecticide chlorantraniliprole was found effective in management of FAW in maize.

Table 1: Management of fallarmy worm in maize during Khrif-2019 and 2020.

Treatment	I window 20 DAS		II window 35 DAS		III window 50 DAS		No. of larvae per plant (20 DAS)		Cob damage %	Yield (Q/ha.)
	Before spray of 1st window	10 days after spray 1st window	Before spray of 2nd window	10 days after spray of 2nd window	Before spray of 3rd window	10 days after spray of 3rd window	Before spray of 1st window	10 days after spray 1st window		
							Mean	Mean	Mean	Mean
T_1	32.00	30.71	26.19	5.51	19.46	2.23	0.68	0.45	10.17	68.21
	(45.57)	(44.90)	(39.70)	(16.00)	(24.78)	(11.88)	(1.16)	(1.13)	(18.37)	
T_2	31.68	31.00	28.99	5.67	18.21	1.76	0.68	0.45	9.36	68.59
	(47.96)	(45.96)	(43.67)	(15.14)	(24.72)	(7.01)	(1.21)	(1.15)	(17.09)	
T_3	38.49	30.20	29.56	4.78	21.24	0.74	1.21	0.74	7.23	72.55
	(51.71)	(46.71)	(45.98)	(15.65)	(24.46)	(6.99)	(1.49)	(1.32)	(16.36)	
T_4	40.04	30.26	32.32	5.87	22.97	1.35	0.74	0.66	10.17	69.66
	(51.08)	(45.25)	(47.61)	(16.25)	(24.70)	(7.71)	(1.22)	(1.29)	(17.19)	
T_5	44.81	31.23	32.20	7.23	25.12	3.22	0.91	0.60	10.96	67.05
	(54.27)	(47.20)	(48.33)	(19.24)	(26.74)	(12.66)	(1.41)	(1.28)	(18.03)	
T_6	37.48	36.00	37.93	8.43	23.06	3.46	0.97	0.45	9.58	68.34
	(54.93)	(44.87)	(50.31)	(18.41)	(26.17)	(12.86)	(1.37)	(1.12)	(19.09)	
T_7	36.49	34.22	36.17	5.21	23.00	1.25	0.91	0.68	9.73	70.82
	(52.93)	(48.31)	(50.56)	(17.76)	(24.97)	(9.08)	(1.39)	(1.34)	(18.47)	
T_8	36.81	30.15	28.82	4.77	17.66	1.14	0.73	0.47	8.00	73.00
	(53.84)	(44.78)	(43.25)	(17.31)	(25.06)	(8.67)	(1.23)	(1.13)	(17.26)	
T_9	37.52	38.67	39.48	5.45	19.57	1.39	0.81	0.51	10.17	68.00
	(53.59)	(48.42)	(49.36)	(17.92)	(25.81)	(8.68)	(1.19)	(1.19)	(18.66)	
T_{10}	39.93	33.02	35.26	5.35	25.10	3.05	0.84	0.60	11.25	66.00
	(54.93)	(44.87)	(47.44)	(18.41)	(26.05)	(12.86)	(1.28)	(1.27)	(19.09)	
T_{11}	41.10	43.41	39.55	20.96	30.07	22.99	0.83	0.84	27.62	58.00
	(56.09)	(56.30)	(51.64)	(34.80)	(34.86)	(32.79)	(1.35)	(1.36)	(32.66)	
F test	NS	NS	S	S	NS	S	NS	NS	S	S
SD e	2.12	2.02	2.53	1.37	1.77	1.28	0.29	0.28	1.62	1.73
CD	6.26	5.97	7.47	4.05	5.21	3.76	0.85	0.84	4.78	5.09

* 1st window (20 DAS) - 20 days after sowing; 2nd window (35 DAS) - 35 days after sowing; 3rd window (50 DAS) - 50 days after sowing.

Yield

Among the treatments, maximum yield was recorded in spinetoram 11.7SC (T_3 with 72.55 and T_8 with 73.00q/ha), followed by chlorantraniliprole 18.5SC (T_7 with 70.82 and T_2 with 68.59 q/ha), spinosad 45SC (T_4 with 69.66 and T_9 with 68.0 q/ha), novaluron 10EC (T_1 with 68.21and T_6 with 68.34 q/ha) and emamectin benzoate 5SG (T_5 with 67.05 and T_{10} with 66.0q/ha) which were at par with each other except control with 58.0 q/ha. Deshmukh *et al.*, (2020) reported that chlorantraniliprole, spinetoram and emamectin benzoate were recorded least cob damage percent and higher yield, which is in line with our findings. Ramesh *et al.,* (2020) also reported that Emamectin benzoate 5SG found effective in reduction of cob damage per cent and with maximum yield.

CONCLUSION

Fall armyworm is polyphagous and invasive insect pest which caused severe damage and loss to the farmers during the year 2018. Therefore, the main objective of the study is to evaluate the efficacy of seed treatment, biological and insecticidal applications for the management of fall army worm. So, treatments were imposed in three windows at 20, 35 and 50 DAS after seed treatment with Cyantraniliprole 19.8% + Thiamethoxam 19.8 FS @ 5 ml/ kg seed. Results reveal that, seed treatment with Cyantraniliprole 19.8% + Thiamethoxam 19.8 FS was found effective up to 15 days after emergence of seed without infestation of fall army worm in comparison with control. Among three windows of applications, third window application with different insecticides was also found most significant followed by second window application (poison bait with Thiodicarb 75WP) in comparison to control (20.96) and 1st window was found non significant. Among 3rd window application treatments, spinetoram 11.7 SC @ 0.5ml (T_3 with 0.74 and T_8 with 1.14 %) and spinosad 45 SC @ 0.3 ml (T_4 with 1.35 and T_9 with 1.39 %), were found significant, followed by chlorantraniliprole 18.5 SC (T_2 with 1.76 and T_7 with 1.25 %) in the management of fall army worm. Similarly, Least Cob damage per cent (T_3 with 7.23 and T_8 with 8.00 %) and maximum yield (T_3 with 72.55 and T_8 with 73.00 q/ha) was recorded in spinetoram 11.7 SC followed by spinosad 45SC and chlorantraniliprole 18.5 SC. So, from present study spinetoram 11.7SC followed by spinosad 45SC and chlorantraniliprole 18.5 SC were found effective against *S. frugiperda* in Maize and seed treatment was also found most significant.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the committee of experimental animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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