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Evaluation of Bio-rational Insecticides against *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) in Maize

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ABSTRACT: The fall armyworm, *Spodoptera frugiperda* is the potential insect pest of maize, causes a severe damage on the vegetative and reproductive stages of that plant. Insecticides are the common practices to manage the broad categories of the pest in a maize field. Further, these practices have been linked to farmers health, biodiversity loss and declining of predatory arthropods. However, pest management by adopting bio-rational insecticides for pest management is one potential option to reduce the pesticide in maize fields. Present study on evaluation of bio-rational insecticides against *S. frugiperda* in maize experiment was carried out in Regional agricultural research station, Lam, Guntur, during *kharif*, 2019-20 and 2020-21. Among different insecticides used lowest per cent of leaf damage was observed in spinosad 45% SC 0.32 ml/L treated plot by 21.50 per cent and which is statistically on par with emamectin benzoate 5% SG 0.5 g/L (23.39%) and novaluron 10% EC 1 ml/L (28.79%). Remaining treatments *i.e* azadirachtin 1500 ppm 5 ml/L, NSKE 5%, *Bacillus thuringiensis* 2 ml/L and *Nomuraea rileyi* 1 g/L were recorded highest per cent leaf damage and statistically at par with one another by recording 43.30, 45.73, 49.38 and 50.98 per cent respectively. Similar trend was observed in number of larvae per plant and per cent population reduction over control.

Keywords: *S. frugiperda,* spinosad 45% SC, emamectin benzoate 5%, novaluron 10% EC, azadiractin 1500 ppm, NSKE 5%, *B. thuringiensis* and *N. rileyi.*

INTRODUCTION

The fall armyworm, *S. frugiperda,* is a an invasive species that has caused havoc on commercial crops in large parts of the world. Being first detected in the African continent in 2016 (Goergen *et al.,* 2016), the pest has affected at least 28 sub-Saharan African countries by the end of 2017 (Day *et al.,* 2017). Within a year, *S. frugiperda* continued its spread across South Asia (Kalleshwaraswamy *et al.,* 2018). By 2019, it has been reported to attack maize in Vietnam and Indonesia (Hang *et al.*, 2020; Ginting *et al.,* 2020). The FAW was first noticed in the Indian subcontinent at Bangalore Rural and Chikkaballapur districts during May and June 2018 (Ganiger *et al.,* 2018) and South Karnataka during the first fortnight of July 2018 (ICAR-NBAIR pest alert, 2018). An investigation by agricultural officials and researchers found FAW in other districts, including Chikkamagaluru, Chitradurga, and Davangere, where 40 to 70 per cent of the crops were infested. The molecular identification of larval populations collected from different regions of South and Central Karnataka confirmed 100% match with populations from Canada and Costa Rica (ICAR-NBAIR pest alert, 2018). Within a short period (By August 2018) this pest has been reported in most of the corn growing states of India and made the farmers feel panic about the incidence. The modality of introduction, the capacity of biological and ecological adaptation of FAW across India is still speculative.

The pest has caused considerable yield loss to farmers along their invasive pathway. Losses due to *S. frugiperda* incursions on maize in Africa were estimated between US $ 2,481 million to US $ 6,187 million per annum, translating to a loss ranging from 8.3 to 20.6 million tonnes annually (Shylesha *et al.*, 2018; Day *et al*., 2017, respectively). Maize is a staple crop in India, grown in an area of 8.8 million ha with a production of 22.5 million tons per year. Among the major maize producing states, Karnataka stands first with an area of 1.22 million ha and a production of 3.31 million tons (Anonymous, 2017). The recent invasion of fall armyworm threatens the food security of India.

As *S. frugiperda* is polyphagous pest, as per the available literature, efforts are needed to manage the pest and to check its further spread and to attack other crops. For this purpose, insecticides are the main method to control *S. frugiperda* in corn in Brazil, however, it pollutes the environment when they are used indiscriminately. Another option is the biological control with several beneficial organisms acting as natural enemies, *viz.,* parasitoids, predators, fungi, virus, bacteria and nematodes (Cruz *et al.*, 2002). Judicious selection of pesticide has been realized, which were evaluated and tested in a maize field. The current market available pesticides are not equally effective for the management of *S. frugiperda*. Farmers have been troubled from the agro-vets and they are forced to use chemical pesticides. To balance both situations, the study aimed to select the suitable and eco-friendly pesticides applicable to the farmers which fully considered the broad aspects of integrated pest management. Hence, the present experiment was conducted to evaluate the effectiveness of some bio-pesticides for controlling FAW in maize.

MATERIAL AND METHODS

The experiment was carried out during 2019-20 and 2020-21 in *kharif* at RARS, Lam, Guntur. The experiment was laid out in RBD design with seven treatments and three replications. P-3396 variety was used for experiment with 60cm x 20cm spacing in 6 m x 5 m area of each plot. First spray of treatments was imposed after pest population reaching ETL level and subsequent sprays of treatments was imposed at 10 days interval after each spray. After crop reaches 60 days blank spray will be applied.

The data was collected on per cent leaf damage of the plant on 10 randomly selected plants per treatment. The data was collected at one day before and 3rd, 7th & 10th day after each spray.

The per cent leaf damage was calculated by using the following formula:

$$\text{Per cent leaf damage} = \frac{\text{No. of damaged leaves}}{\text{Total no. of leaves}} \times 100$$

Treatments:

T1- Novaluron 10% EC @ 1 ml/L (Rimon)
T2- *Nomuraea rileyi* 1g/ L
T3- Spinosad 45% SC @ 0.32 ml/L (Tracer)
T4- *Bacillus thuringiensis* @ 2g/L (Dipel)
T5- Azadirachtin 1500 ppm @ 5ml/L
T6- NSKE 5%
T7- Emamectin benzoate 5% SG @ 0.5 g/L (Proclaim)
T8- Untreated control

RESULTS AND DISCUSSION

Larval Population: Cumulative data on larval population at one day prior to the three sprays indicate that the larval population ranged from 0.38 to 0.76 larvae/ plant.

The results obtained at 3 DAT, revealed that, spinosad 45% SC was found to be most effective treatment with the lowest number of larvae per plant (0.05 larvae/plant) and it was statistically at par with emamectin benzoate 5% SG (0.07 larvae/plant). Followed by novaluron 10% EC was effective in reducing larval population of 0.11 larvae/plant. *B. thuringiensis* and *N. rileyi* found to be reduce less number of larvae to the tune of 0.40 and 0.49 larvae/plant respectively.

At 7 DAT, spinosad 45% SC was the most effective treatment in reducing larval population by 0.02 larvae/plant and it was statistically differ with the other treatments. Followed by emamectin benzoate 5% SG and novaluron 10% EC were found to be next best insecticides in reducing larval population with the 0.04 and 0.08 larvae/plant respectively and were statistically on par with one another. Whereas, *B. thuringiensis* and *N. rileyi* were found to be reduce lowest number of larval population by 0.31 and 0.43 larvae/plant and were statistically differ with one another and differ with the untreated control.

At 10 DAT, lowest pest population was observed in spinosad 45% SC and emamectin benzoate 5% SG treated plots with 0.06 and 0.09 larvae/plant respectively, and were statistically at par with one another. Followed by novaluron 10% EC (0.11) was the next best treatment in reducing larval population by 0.11 larvae/plant. Whereas, *B. thuringiensis* (0.36) and *N. rileyi* (0.48) treated plots were recorded highest larval population per plant and are statistically differ with one another.

Percent Leaf Damage: The data from Table 1. revealed that per cent leaf damage was ranged from 28.77 to 72.11 percent at one day before spraying.

The lowest per cent of leaf damage was observed in spinosad 45% SC treated plot by 21.50 per cent at 3 DAT and which is statistically on par with emamectin benzoate 5% SG (23.39%) and novaluron 10% EC (28.79%). Remaining treatments *i.e* azadirachtin 1500 ppm, NSKE 5%, *B. thuringiensis* and *N. rileyi* were recorded highest per cent leaf damage and statistically at par with one another by recording 43.30, 45.73, 49.38 and 50.98 per cent respectively. Similar trend was observed in 7 & 10 DAT.

Per cent population reduction over control: At 10 DAT, among the treatments, significantly the highest per cent population reduction over control was observed in plots treated with spinosad 45% SC (92.41%) and emamectin benzoate 5% SG (89.86%) and novaluron 10% EC (85.46%) which were statistically on par with one another. Followed by azadirachtin 1500 ppm and NSKE 5% were found to be next best treatments with 66.39 and 62.69 per cent population reduction over control respectively. Lowest per cent population reduction over control was observed in *B. thuringiensis* (46.24%) and *N. rileyi* (35.47%) treated plots and were statistically at par with one another.

In our findings spinosad 45% SC, emamectin benzoate 5% SG and novaluron 10% EC were found effective in reducing larval population, per cent leaf damage and per cent population reduction over control. Present findings are corroborate with Jat *et al.* (2017) who reported that during 2012-13 the treatment schedule comprising three spray of spinosad 45 SC at 200g/ha at 15 days interval was found effective which caused 67.44, 74.66 and 68.85 per cent reduction in *S. frugiferda* larvae population at 3, 7, and 10 days after three spray respectively. In our findings per cent reduction was higher (92.41%) at 10 days after spraying than the results of above mentioned studies. In our findings emamectin benzoate 5% SG (19.20%) is the second best insecticide in reducing per cent leaf damage after spinosad 45% SC (17.49%) during *kharif*. Whereas, Thumar *et al.* (2020) found emamectin benzoate 5% SG (14.19%) was effective insecticide in reducing per cent plant damage than spinosad 45% SC (29.71%) in *kharif.*

In our study novoluron 10% EC recorded similar per cent population reduction over control in *kharif* (85.46%) and *rabi* (84.72%). However, there are variations in per cent incidence on the efficacy of novoluron 10 EC on *S. litura* which is related to genus of *S. frugiperda* with 20.99% in *kharif* and 43.13% in *rabi* as reported by Murali Krishna *et al.* (2008); Venkataiah *et al.* (2015). Whereas, *B. thuringensis* and *N. rileyi* were not that much promising against FAW, reducing per cent leaf damage recording 49.32 and 51.27% and less per cent population reduction over control of 55.19 and 43.98% respectively was recorded at 10 DAT, this might be due to unfavorable weather conditions with high temperature and reduction of spore count because of rainfall. Similar findings were observed with the results of Mallapur *et al.* (2018) who observed 62.50 to 66.46 per cent leaf damage and 58.91 to 62.87 per cent population reduction of fall armyworm population at 15 days of *N. rileyi* spraying at vijaypur and uttar kannada district of Karnataka.

According to All *et al.* (1996) although *B. thuringiensis*, is feasible to reduce the abundance of fall armyworm larvae in corn, natural strains of *B. thuringiensis* tend not to be very potent, and genetically modified strains may improve performance and the efficacy found in this study may be due to natural stains with low potency. After 7 days of spraying increasing trend of FAW larval population was observed in all the treatments. Similar findings were observed by Dhobi *et al*. (2020) at 10 days after spraying where larval population was increased in *B. thuringiensis* 1 % WG, azadirachtin 1500 ppm and neem seed kernel extract 5% treatments by 1.63, 1.88 and 1.94 larvae/10 plants respectively when compared to 5 days after spraying (1.62, 1.73 and 1.77 larvae/10 plants).

Table 1: Cumulative efficacy of bio-rational insecticides on *S. frugiperda* during *kharif* 2019-20 and 2020-21.

	Average Number of Larvae/Plant*				**Per cent Leaf Damage****				**Per cent population reduction over control**
Treatment	**Before Spray**	**3 DAT**	**7 DAT**	**10 DAT**	**Before Spray**	**3 DAT**	**7 DAT**	**10 DAT**	**10 DAT**
Novoluron 10% EC	0.46	0.11 (0.33)b	0.08 (0.27)c	0.11 (0.34)b	35.64 (36.53)	28.79 (32.42)a	24.11 (29.39)a	25.54 (30.33)a	85.46 (67.72)a
Nomuraea rileyi	0.60	0.49 (0.70)f	0.43 (0.65)f	0.48 (0.69)e	53.09 (46.75)	50.98 (45.55)b	48.79 (44.28)b	51.27 (45.71)b	43.98 (41.50)c
Spinosad 45% SC	0.38	0.05 (0.22)a	0.02 (0.14)a	0.06 (0.24)a	28.77 (32.07)	21.50 (27.52)a	15.62 (23.22)a	17.49 (24.66)a	92.41 (75.91)a
Bacillus thuringiensis	0.56	0.40 (0.63)e	0.31 (0.56)e	0.36 (0.60)d	51.56 (45.87)	49.38 (44.62)b	46.97 (43.24)b	49.32 (44.59)b	55.19 (47.96)bc
Azadirachtin 1500 ppm	0.51	0.24 (0.49)c	0.19 (0.44)d	0.25 (0.50)c	46.88 (43.19)	43.30 (41.12)b	40.59 (39.55)b	42.81 (40.85)b	66.39 (54.56)b
NSKE 5%	0.52	0.31 (0.56)d	0.26 (0.51)e	0.30 (0.54)cd	49.10 (44.46)	45.73 (42.53)b	43.06 (40.99)b	45.33 (42.30)b	62.69 (52.38)b
Emamectin benzoate 5% SG	0.44	0.07 (0.26)a	0.04 (0.20)b	0.09 (0.29)ab	30.69 (33.32)	23.39 (28.81)a	17.96 (25.02)a	19.20 (25.94)a	89.86 (71.54)a
Untreated control	0.76	0.81 (0.90)g	0.84 (0.91)g	0.87 (0.93)f	72.11 (59.53)	80.66 (64.90)c	84.62 (68.09)c	86.39 (69.44)c	
SEM	0.01	0.01	0.01	0.02	4.52	2.58	2.31	2.17	2.81
CD	0.03	0.04	0.05	0.07	13.84	7.92	7.08	6.66	8.76
CV%	2.53	5.10	7.10	8.48	18.32	10.94	10.20	9.31	8.36

*Figures in the parenthesis are subjected to square root transformation.
** Figures in the parenthesis are subjected to arc sine transformation.

CONCLUSION

It can be deduced from the present investigation, that application of spinosad 45% SC, emamectin benzoate 5% SG and novaluron 10% EC were found more effective in managing the population and damage in maize which also reflected on yield.

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Conflict of Interest. None.

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