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Evaluation of different modules for the management of fall army worm *Spodoptera frugiperda* in maize

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Abstract
Field experiment was carried out during the *rabi*, 2018-19 to evaluate different modules for the management of Fall army worm in maize, which is a invasive pest of India during 2018. Four different modules were tested and data was recorded on per cent plant damage, per cent severity and percent reduction over control. Among different modules, Module IV recorded lowest per cent plant damage (3) and per cent severity (1.57) with 95.45 and 96.08 per cent reduction over control respectively after the imposition of treatments during rabi 2018-19. Module III is the next best module with 90.91 and 91.67 percent reduction over control of plant damage and severity. Regarding the grain yield, highest was recorded in module IV with 5480 kg/ha followed by module III with 5320 kg/ha. The highest cost benefit ratio was recorded in module I (1:.90) followed module III (1:1.61) and all tested modules were superior over control in controlling fall army worm damage in maize.

Keywords: Modules, fall army worm, insecticides, maize

Introduction
Maize known as Queen of Cereals, also called corn is one of the most important cereal crops of the world. Maize distinguished botanically as *Zea mays*, belongs to the grains family Graminae. Maize ranks as the major grain crop worldwide. Maize, which is the only food cereal crop that can be grown in different seasons requires moderate climate for growth. Fall army worm *Spodoptera frigiperda* (JE Smith) (FAW) is an invasive pest of India. Invasive alien species pose a serious threat to agriculture and reduced the crop production and productivity. New insect pest species spread mainly due to increased transboundary movement of agricultural commodities, anthropogenic activities, climate change etc. (Paini *et aI.*, 2016) [7]. FAW is native insect pest confirmed to American continent but its outbreak in West and Central Africa was reported in early 2016 where it is a serious pest of corn but also known to attack more than 100 hosts. In addition, it is reported to cause major damage to economically important cultivated grasses such as rice, sorghum, and sugarcane as well as 23 horticultural crops like cabbage, beet, tomato, potato and onion besides cotton, pasture grasses, peanut, soybean, alfalfa and millets (CABI, 2016, (Goergen *et aI.*, 2016) [1, 3]. The FAW is thus a migratory and polyphagous insect pest which can destroy a wide range of crop varieties if left to multiply (Meagher *et al*., 2013) [5]. Its life cycle gets completed in about 30 days during the summer, but 60 days in the spring and autumn, and 80 to 90 days during the winter (Capinera, 2000) [2]. First observations of fall armyworm, S. *jrugiperda* were made in early May-June 20lS in maize fields at College of Agriculture, Shivamogga, Kamataka, India (Sharanabasappa *et al.*, 2018) [9]. For effective control of insect pest, application of judicious dose of insecticide is desired to save the crop. Chemicals with insecticidal activities are always first weapons to control insect pests damage. Keeping in view of the above, in the present study an attempt has been made to evaluate the efficacy of different chemical modules for the management of FAW.

Materials and Methods
Efficacy of different modules were studied to identify the effective module for the management of the Fall army worm in maize. The field experiment was carried out under field conditions at Regional Agricultural Research Station, polasa, Jagtial, PJTSAU during *rabi*, 2018-19 with Maize hybrid Karimnagar makka 1, which is a popular maize hybrid in Telangana Telangana state. Experiment was laid in Randomized Block design with 5 modules including untreated control. Crop was raised with plot size 100 m^2 with a plant spacing of 60 X 20 cm and adopted a standard package of practices.

Five different modules include, Module I - 10DAG- Azadirachtin 1500ppm (5ml/litre), 20 DAG- Emamectin benzoate (0.4 g/lire), 30 DAG – Sand +Lime 10kg/acre(9:1 ratio), 40 DAG-Chlorantraniliprole18.5SC ((0.3 ml/litre), Module II - 10DAG- Azadirachtin 1500ppm (5ml/litre), 20 DAG- Bt formulation (2 g/lire), 30 DAG – Emamectin benzoate (0.4 g/lire), 40DAG-Spinetorum ((0.5 ml/litre), Module III - 10DAG- Azadirachtin 1500ppm (5ml/litre), 20DAG- Spinetorum ((0.5 ml/litre), 30 DAG – Soil slurry (red soil with sand9:1 ratio), 40DAG-Flubendiamide ((0.2 ml/litre), Module IV - Seed treatment with imidacloprid 600FS, 20DAG-Chlorantraniliprole18.5SC ((0.3 ml/litre), 30 DAG – Spinetorum ((0.5 ml/litre), 40DAG- Poison bait with thiodicarb (100g/acre) and Module V – Untreated control.

Data was recorded on per cent plant infestation, per cent severity and the per cent reduction over control was calculated as per the formulae hereunder.

Per cent plant infestation = (Total No. of plants infested/ 20 plants) X 100

Per cent severity = (Total No. of damaged leaves/ total leaves of 10 Plants) X 100

The per cent infestation of damage was angular transformed for analysis.

Per cent reduction over control =(C-T)/C X 100

C= Per cent damage in control plots; T= Per cent damage in treated plots

The yield data was recorded from each plot separately. Grain yield from each plot was converted into kilograms per hectare. Cost benefit ratio was also assessed by dividing the net returns by the total additional cost due to treatments.

Results and Discussion

The data on the efficacy of different modules against Fall army worm in maize during *rabi* 2018-19 season is presented in Table 1. The incidence of FAW in terms of per cent plant infestation from 21-32 and there is no Signiant difference was noticed before the treatment imposition. Per cent severity before treatment application varied from 7.09 – 15.05. Mean number of coccinellids were also recorded before the treatments imposition and it varied from 2-3 per plant.

The efficacy of insecticides in different modules against fall army worm after imposition treatment was recorded and observed that all modules were effective in controlling FAW damage in maize crop. After imposition of all insecticides in each module, the per cent plant infestation varies from 3 - 66. Module IV (Seed treatment with imidacloprid 600FS, 20DAG-Chlorantraniliprole18.5SC ((0.3 ml/litre), 30 DAG – Spinetorum ((0.5 ml/litre), 40DAG- Poison bait with thiodicarb (100g/acre)) recorded lowest per cent plant infestation (3%) followed module III (10DAG- Azadirachtin 1500ppm (5ml/litre), 20DAG- Spinetorum ((0.5 ml/litre), 30 DAG – Soil slurry (red soil with sand9:1 ratio), 40DAG-Flubendiamide ((0.2 ml/litre) with 9 per cent plant infestation. Module I (10DAG- Azadirachtin 1500ppm (5ml/litre), 20 DAG- Emamectin benzoate (0.4 g/lire), 30 DAG – Sand +Lime 10kg/acre (9:1 ratio), 40 DAG-Chlorantraniliprole18.5SC ((0.3 ml/litre)) was the next best module in controlling plant infestation (9%) in maize. All modules were significantly different from each other in controlling plant damage.

Regarding the per cent reduction over control of per cent plant infestation, highest recorded in Module IV (95.45) due to spraying of two novel insecticides *viz*., Chlorantraniliprole and Spinetorum and these results were inconformity with Jarrod et al., (2011) [4] followed by module III (90.91) and Module I (86.36). The order of module for the control of plant damage in maize after treatments imposition is Module IV> Module III> Module I> Module I > Control.

The per cent severity of FAW in maize after insecticides imposition, Module IV recorded lowest per cent severity (1.57) and this module was significantly superior over all other modules. Module III (3.34) is the next best module followed by module I (5.88) and module II (10.78). All modules were effective in controlling the per cent severity of damage by FAW compare to untreated control (40.09). Regarding the per cent reduction over control same trend was noticed and highest was recorded in Module IV (96.08) followed by module III (91.67) and Module I (85.33). The order of modules for the per cent severity in maize after treatments imposition is Module IV> Module III> Module I> Module I > Control.

The grain yield data was also revealed that, all the modules were significantly superior to control. The yield data indicated that, Module IV recorded highest grain yield 5480 kg ha $^{-1}$ and it is on par with module III (5320 kg ha^{-1} and Module I (5200 kg ha^{-1}) followed Module II (5170 kg ha^{-1}). This result was supported by Ram Kumar and Tanweer Alam. (2017) [8] who observed highest yield due to chrolrantraniliprole application in maize.

Cost benefit ratio was calculated based on the yield data obtained during the season of *rabi*, 2018-19. The highest cost benefit ratio was obtained in module I (1:1.90) followed by Module III (1:1.61), Module IV (1;1.57) and module II (1:1.46) (Table 2).

However, new insecticide molecules shows higher efficacy in controlling FAW in maize due to their new broad spectrum and high insecticidal activity with novel mode of action (Prasad *et al.*, 2014) [6].

Table 1: Evaluation of different Modules for management of fall army worm *Spodoptera frugiperada* in maize during *Rabi*, 2018-19

Module	Before Application of treatments			After application of all treatments in each module				
	Plant Infestation (%)	Severity (%)	Mean No. of Coccinellids/ plant	Plant Infestation (%	%ROC	Severity (%)	% ROC	Mean No. of Coccinellids/ plant
Module I	32 (35.64)	13.95 (22.68)	2	9 (18.06)	86.36	5.88 (14.51)	85.33	1
Module II	21 (28.21)	15.05 (23.61)	3	11 (20.03)	83.33	10.78 (19.82)	73.11	2
Module III	26 (31.71)	10.28 (19.34)	2	6 (14.66)	90.91	3.34 (10.89)	91.67	1
Module IV	33 (36.27)	7.09 (15.97)	2	3 (10.31)	95.45	1.57 (7.44)	96.08	1
Control	28 (33.05)	10.56 (19.610	3	66 (56.20)	-	40.09 (40.64)	-	4
CD (0.05)	NS	4.14		1.79		1.21		

Figures in parenthesis are angular transformed values

Table 2: Yield and Economics of different modules in maize during rabi 2018-19

Treatments	Yield (kg/ha)	Increased yield over control	Cost of spray (insecticide cost + labour cost)	Profit of additional yield @ 1750/q	cost Benefit ratio
Module I	5200	1200	11016	21000	1:1.90
Module II	5170	1280	15252	22400	1:1.46
Module III	5320	1320	14340	23100	1:1.61
Module IV	5480	1480	16452	25900	1:1.57
Control	4000	-	-	-	-
CD (0.05)	204.75	-	-	-	-

Conclusion

Based on the results of the present study, it may be concluded that, insecticides with novel mode action were effective against the control of FAW in maize. Among different modules, module IV (Seed treatment with imidacloprid 600FS, 20DAG-Chlorantraniliprole18.5SC ((0.3 ml/litre), 30 DAG – Spinetorum ((0.5 ml/litre), 40DAG- Poison bait with thiodicarb (100g/acre) was effective for the management of FAW.

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