Original Research Article

Assessment of Integrated Pest management modules against Fall Army Worm and its economic impact in Maize

Abstract

Aim: The present study was undertaken to assess the IPM modules and their economic impact against Fall Armyworm in maize through on farm trail (OFT).

Place and Duration of Study: The present study was carried out in the farmers' fields of Bhadradri Kothagudem district of Telangana during *Rabi* 2019-20, 2020-21 and 2021-22.

Methodology: The main objective of on farm trail is to test and evaluate the findings of the research stations at the farmer's field and to refine and modify the technologies, if required for better adoption by farmers. The KVK, Bhadradri Kothagudem conducted on farm trail for the management of fall armyworm in maize during *Rabi* 2019-20, 2020-21 and 2021-22, as part of technical programme of Krishi Vigyan Kendra, Bhadradri Kothagudem in KVK operational area of adopted villages.

Results: In technology assessment plot (On farm trail) the treatments followed were avoiding staggered sowing of maize, installation of pheromone traps @ 8-10 per acre, clean cultivation, balanced application of fertilizers, erection of bird perches @10/acre, spraying of Azadiractin (1500ppm) to repel the egg laying and need based whorl application of Emamectin benzoate @ 0.5g/l and *Metarrhizium anisopliae* @ 5g/l of water, if more than8 adult moths were trapped in the pheromone trap for three consecutive days. It was compared with the farmers practice plots *i.e* application of Carbofuran 3G granules @ 3kg/acre and indiscriminate usage of fertilizers and insecticides. The experiment was conducted in five locations. The benefit cost ratio (BC Ratio) was higher in technology assessed plots with 2.78, 2.63 and 2.75 whereas BC ratio was comparatively lower in farmers practice plots with 2.43, 2:21 and 2.25 in corresponding *Rabi* 2019-20, 2020-21 and 2021-22 respectively.

Conclusion: Technology assessed package proved its effectiveness among maize farmers with increased net returns, lower per cent of FAW incidence and high yield and BC ratio compared to the farmers practiceduring *Rabi* 2019-20, 2020-21 and 2021-22, respectively. Hence, this on farm trial proved to be feasible for demonstration in wide scale to farming community of Bhadradri Kothagudem district.

Key words: Fall Army Worm, Maize, Invasive, Polyphagous, Pheromone, Emamectin benzoate, *Metarrhizium anisopliae*

Introduction

In India, maize is the third most important cereal crop after rice and wheat, both in terms of area and production, registering maximum growth rate among food crops. Though maize is emerging as an important industrial crop in India, its productivity (3.1 tonne/ha) is much lower than the world average (5.62 t/ha) [3&4], because of major biotic stresses. Among them, FAW is the major constraint limiting the production. It emerged as the most destructive pest of maize in India since its report in May, 2018 and spread to almost all the maize growing Indian states except Jammu and Kashmir. In 2019, Karnataka State had the highest area affected with FAW (2,11,300 ha) followed by Telangana (24,288 ha), Maharashtra (5,144 ha) and low infestation in Tamil Nadu, Madhya Pradesh, West Bengal and Arunachal Pradesh (< 500 ha) [3]

Fall armyworm (*Spodoptera frugiperda* (J. E. Smith)(Lepidoptera: Noctuidae), a native pest of North and South America. It is likely to be a real threat to Indian agriculture in near future as it is currently observed to be causing damage only on maize in India and likely to spread to other crops due to its Polyphagous nature. It can spread quickly across large geographic areas as adult moths can move up to 500 km. Itdoes not undergo diapause in any stage of life cycle hence, can persist throughout the year on many crops and weeds.

The caterpillars of FAW feed mainly on leaves, munching on their edges and making holes, giving them a ragged and torn appearance. If the larvae are numerous, they can completely defoliate the plants. When they have exhausted their food source, they invade neighbouring

vegetation - which may often be another crop – in large numbers sites close to the ground. By far most of the damage, however, is caused by the last instar larva, which consumes more plant biomass than all of the other younger larval instars put together. This factor is often responsible for people thinking and assessing that the attacks by fall armyworm are sudden and occurred at once. In corn, the caterpillars feed deep in the whorl, often concealed under their own frass. While the leaves may be heavily damaged, the plant usually compensates for the loss. If the growing point is destroyed, however, "dead heart" symptoms will appear. As the crop grows tasselling stage, emerging tassel often pushes the feeding larva out of the whorl. At this stage, some larvae may start feeding on the side leaves while some larvae may shift to the developing cob. The larvae shifted to developing cob frequently feed on the immature kernels inside the ear. This generally causes greater injury than the leaf damage. Further, the extent of loss depends on the stage of cob development at the time of attack and the extent of feeding by the larva on the cob. When the larvae are very numerous they defoliate the preferred plants, acquire an "armyworm" habit and disperse in large numbers, consuming nearly all vegetation in their path. Due to cannibalistic behaviour of FAW, the larvae as they grow in size are forced to disperse to neighbouring plants from the plant where eggs are laid. Hence, only one or very few larvae can be found per plant, despite adults laying egg masses comprising hundreds of eggs [5].

Bhadradri Kothagudem district falls under Central Telangana Zone of Telangana State with tropical climate typically receives about 147.76 millimeters (5.82 inches) of precipitation with 135.35 rainy days annually. The reduction in maize growing areaduring 2019-20 issolely attributed to the failure of the maize crop due to infestation of Fall Army Worm (FAW). Farmers' resort to spray various insecticides within short intervals resulted in resistance, secondary pest outbreak and pest resurgence along with destruction of natural enemies and environmental pollution.The farmers invested on an average of Rs.10,000-12,000/acre on pesticides for the managementof this dreaded pest. This resulted in severe damage to the natural resources as well as natural enemies and reduction in net income of the farmers. Considering the above situation and to overcome this menace, KVK, Bhadradri Kothagudem conducted an on farm trial (OFT)"Assessment of integrated pest management modulesagainst fall armyworm and its economic impact in Maize" in a systematic manner on farmers' fields to show the worth of a technology and its feasibility in Bhadradri Kothagudem by convincing farmers about potentialities of improved management practices of maize for further adoption.

Materials and Methods

The present study was undertaken at five farmers fields with two plots per location (0.2ha/plot) in Bhadradri Kothagudem district of Telangana state, India in medium black soils with cropping patterns of maize followed by summer pulses with two treatments *viz.*,technology assessment (treatment) and check (farmers practice). The experiment was conducted consecutively for three years i.e. during the *Rabi* season (October–February) of 2019-20, 2020-21 and 2021-22. The experimental design, site and farmer selection, the layout of demonstration, farmer's participation, etc., were followed as suggested by Choudhary (1999) [6].

In technology assessment plot (On farm trail) the treatments followed were avoiding staggered sowing of maize, installation of pheromone traps @ 8-10 per acre, clean cultivation, balanced application of fertilizers, erection of bird perches @10/acre, spraying of Azadiractin (1500ppm) to repel the egg laying and need based whorl application of Emamectin benzoate @ 0.5g/l and *Metarrhizium anisopliae* @ 5g/l of water, if more than 8 adult moths were trapped in the pheromone trap for three consecutive days. It was compared with the farmers practice plots *i.e* application of Carbofuran 3G granules @ 3kg/acre and indiscriminate usage of fertilizers and insecticides. The farmers don't have the sufficient knowledge on IPM components to manage the FAW in maize crop.

The pest incidence was calculated by randomly selecting 20 plants and observing the damage symptoms visually. The yield parameters were collected from both technology assessment plot and farmers practiced plot by random crop cutting method and analyzed by using simple statistical tools. Using the yield parameters extension gap, technology gap, yield gap, technology index was calculated as procedure suggested by Rajashekhar et al. [7] and Samui et al. [8]. To find out the economic impact of treatments effected due to FAW incidence and yield the benefit cost ratio was calculated.

Extension gap (q/ha) = Demonstrations yield –Yield under existing farmer's practice
Technology gap (q/ha) = Potential Yield – Demo Yield
Additional return = Demonstration return – farmer's practice return

$$\text{Yield gap (\%)} = \frac{\text{Extension gap}}{\text{Yield under farmers practice}} \times 100$$

$$\text{Technology gap (\%)} = \frac{\text{Technology gap}}{\text{Potential yield}} \times 100$$

$$\text{Technology index (\%)} = \frac{\text{Potential yield - Demonstration yield}}{\text{Potential yield}} \times 100$$

Results and Discussion

The results of the present study state that the incidence of fall armyworm was lower in the technology assessed plot compared to the farmers practice. The reason is attributed to the regular monitoring of the fall armyworm by erection of pheromone traps followed by prophylactic spraying of Azadiractin 1500ppm which act as a strong oviposition deterrent & repellent against FAW adults. Further, if more than 8 adult moths were trapped in the pheromone trap for three consecutive days, the technology assessed plot was sprayed with Emamectin benzoate @ 0.5g and *Metarrhizium anisopliae* @ 5g/l of water which further reduced the FAW incidence up to 18-40 per cent compared to farmer practice (Fig 1.).

Fig 1. Results on incidence of fall armyworm on Maize

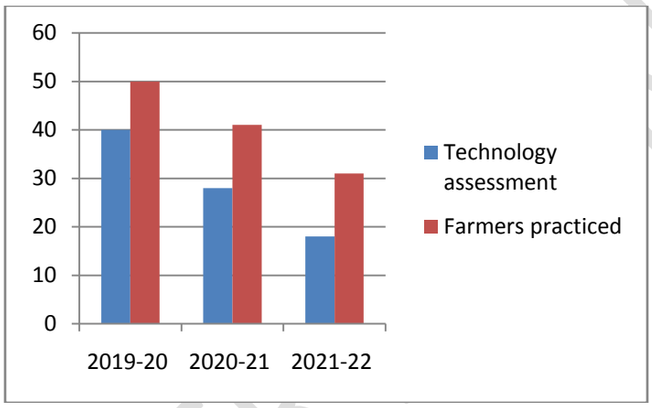

Table 1. Difference between technological intervention through OFT in maize

Technology intervention	Farmers practice	Gap
Avoiding staggered sowing of maize	Not Followed	Full Gap
Installation of pheromone traps @ 8-10 per acre	No Pheromone traps used	Full Gap
Clean cultivation, balanced application of fertilizers, erection of bird perches @10/acre,	Not Followed	Full Gap
Spraying of Azadiractin (1500ppm)	Not Followed	Full Gap
Application of Emamectin benzoate @ 0.5g and *Metarrhizium anisopliae* @ 5g/l of water	Indiscriminate use of insecticides	Partial Gap

The highest yield of 71.0, 65.0 and 68.8 (Q/ha) was recorded in the technology assessment plot, while lower yield of 63.50, 58.75 and 59.20 (Q/ha) was recorded in the farmers practice plots during *Rabi* 2019-20, 2020-21 and 2021-22, respectively. The per cent increase in yield in technology assessment plot when compared with the farmers practiced plot was 11.81, 10.64 and 16.22, respectively (Table 2).Subsequently, higher net returnswere recorded in the technology assessment plots with Rs.91,000/-, Rs.89,000 and Rs.96,320/ha and lower net returns of Rs.76,675/-, Rs.77,500 and Rs. 82,880/- , respectively were recorded in the farmers practice plots during 2019-20, 2020-21 and 2021-22, respectively.

Year	Yield (Q/ha)	% Increase in yield	Net returns Rs. /ha	B:C Ratio

	Technology assessment	Farmers practiced		Technology assessment	Farmers practiced	Technology assessment	Farmers practiced
2019-20	71.0	63.5	11.81	91,000	76,675	2.78:1	2.43:1
2020-21	65.0	58.75	10.63	89,000	77,500	2.63:1	2.21:1
2021-22	68.8	59.2	12.9	96320	82880	2.75:1	2.25:1

Table 2. Economic impact of experiment

The benefit cost ratio (BC Ratio) was higher in technology assessment plots with 2.78, 2.63 and 2.75 in *Rabi* 2019-20, 2020-21 and 2021-22, respectively whereas benefit cost ratio was lower comparatively in farmers practiced plots with 2.43, 2.21 and 2.25 (Table 3).

Table 3. Grain yield and gap analysis grain yield and gap analysis

Year	Yield gap (%)	Extension gap (Q/ha)	Technology gap (Q/ha)	Technology index (%)	Additional returns (Rs.)
2019-20	11.81	7.5	4	5.3	14,325
2020-21	10.64	6.25	10	13.3	11,500
2021-22	16.22	9.6	6.2	8.3	13,440

The results are in concurrence with the previous publication where, Rajashekhar *et al.*2022 [9] observed FAW incidence before and after application of chemicals, showed Azadiractin 1500 ppm acted as the best oviposition deterrent, due to which most of the eggs failed to hatch and after whorl application of Emamectin benzoate @ 0.5 g/lt the incidence FAW was reduced up to 47-63 % compared tofarmer practice which is similar to the present study**.**Dhaka et al. [10], Mistry et al. [11] and Bhati et al. [12] where maize yields were improved along with net returns. A similar study was reported in tribal areas of Andhra Pradesh where maize yields were increased from 62.1 q to 85.3 q/ha [13]. Reddy *et al* (2023) [14] reported that benefit cost ratio was significantly higher in the recommended technology (2.51) compared to farmers practice (2.12) which is similar tothe current experiment.

Conclusion

Based on the results obtained in the present study it can be concluded that the yield gap between farmer practice and technology assessment plot was perceptibly higher. There is urgent need to make stronger extension services for educating the cultivators in the implementation of improved technology. However, the yield level under local practice was lower which could be further improved by adopting recommended integrated pest management technologies. The OFT intervention is highly effective among maize farmers which increased their net returns. With the results obtained in technology assessment plot it is recommended to take further into wide demonstration which may record the same trend of positive results in Bhadradri Kothagudem district.

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