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Evaluation of integrated pest management module against fall army worm, *Spodoptera frugiperda* in maize

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Abstract
Maize recognized as the "queen" of cereals for its great potential and capacity to generate greater biological yields in a shorter amount of time infested by new invasive pest, fall armyworm (FAW), *Spodoptera frugiperda*, a devastating polyphagous pest which feeds on more than 360 plant species causing substantial yield losses in economically important crops such as maize, soybean, beans and cotton *etc.* Adoption of integrated pest management tactics is therefore a potential solution that is crucial. A twoyear study was conducted by Krishi Vigyan Kendra, Kalyandurg, Anantapur at farmers' fields during the *kharif* season (June-September) of 2020-21 and 2021-22 following IPM strategy following clean cultivation, pheromone traps @ 8-10/ acre, bird perches @10/acre, application of Azadiractin 1500ppm, whorl application of Emamectin benzoate @ 0.5g/l and *Metarrhizium anisopliae* @ 5g/l of water. Observations were noted at weekly intervals from 15 to 50 DAS from 20 plants about no of larvae and no of plants damaged. Using data from 10 IPM and FP fields, the cost-benefit ratio, plant damage, and larval incidence were observed to assess the impact of the modules and the results shows that less larval incidence was found in IPM fields (9.10% and 6.72%) with pooled mean of 7.91% compared to fields of FP (17.84% and 13.56%) with a pooled mean of 15.7% 2020-21 and 2021-22, respectively. Damage incidence was found lower in IPM fields (18.0% and 12.0%) with a mean of 15.0% as compared to FP fields (37.0% and 28.0%) with a mean of 32.5% during 2020-21 and 2021-22, respectively. The two years pooled data reveals that implementing IPM increased yield by 9.40% when compared to FP, whereas the benefit-cost ratios for FP and IPM were 2.0 and 2.4, respectively.

Keywords: Fall army worm, Maize, IPM, Pheromone traps, Damage Incidence

Introduction
Zea mays L., or Maize, is recognized as the "queen" of cereals because of its great potential and capacity to generate greater biological yields in a shorter amount of time. Over 9.86 million hectares of land are used for maize farming in India, which produces 26.26 million tons of grain at a productivity of 2664 kg/ha. (Anonymous, 2018) [1]. It is known that maize has the ability to double farmers' profits. Country, infecting the maize crop in every region where it grows (Rakshit *et al*., 2019) [12]. In India, around 130 different insect pest species attack it, significantly reducing crop yields (Atwal 2022) [3]. Spodoptera frugiperda (Noctuidae: Lepidoptera), a new alien pest, is indigenous to the tropical western hemisphere, extending from the United States to Argentina. It was originally noted on maize in the Karnataka district of Hassan (Sharanabasappa, 2019) [15], and it then expanded to West Bengal, Tamil Nadu, Telangana, and Andhra Pradesh. More than 350 plant species are consumed by this destructive polyphagous pest, which significantly reduces agricultural yields in economically significant crops including maize, cotton, soybeans, and beans (Bueno *et al*., 2010) [5]. It is reported that the yield loss in maize caused by FAW can reach 33% (Aruna Balla *et al*., 2019) [2]. However, the productivity of maize in the is very low per unit area due to lack proper management schedules and advanced technological interventions Growing knowledge of the possible effects of these harmful substances has sparked the development of new, environmentally friendly molecules to assure the least amount of risk to humans and the environment.

Due to maize cultivation utilizing a traditional farming method, repetitive usage of various insecticides and lack of awareness regarding cutting-edge technologies, and major abiotic and biotic stresses, the potential yield of maize is decreasing. In light of the aforementioned circumstances, an on-farm trial (OFT) titled "Assessment of integrated pest management modules in contrast to fall armyworm and its economic impact in maize" was shown in a methodical manner on farmers' fields in order to combat this threat and demonstrate the value of the technology and its ability to persuade farmers to adopt improved maize management practices.

Materials and Methods

The present study was conducted by Krishi Vigyan Kendra, Kalyandurg, Anantapur at ten farmers' fields with IPM and FP fields per location (0.2ha/plot) in Kalyandurg mandal of Anantapur district of Andhra Pradesh state, India with two treatments *viz.*, technology assessment (IPM module) and Check (farmers practice). The trial was shown successively for two years *i.e.*, during the *kharif* season (June-September) of 2020-21 and 2021-22.

The treatments used in the technology assessment plot (On Farm trail) included avoiding staggered maize sowing, installing pheromone traps @ of 8–10/ acre, clean cultivation, a balanced fertilizer application, erecting bird @ 10/ acre, applying Azadiractin 1500 ppm to deter egg laying, and need-based whorl application of Emamectin benzoate at 0.5g/l and *Metarrhizium anisopliae* at 5g/l of water if more than eight adult moths were trapped in the pheromone trap for three days in a row. It was contrasted with farmers' practice plots, which applied 3 kg of carbofuran 3G granules per acre and used pesticides and fertilizers carelessly. In order to manage the FAW in the maize crop, the farmers lack the necessary understanding of the components of IPM. The farmers lack the necessary understanding of the components of IP M,in order to manage the FAW in the maize crop. From 15 to 50 DAS, observations on 20 plants were conducted on a weekly basis on the fall army worm. By monitoring the incidence of larvae, plant damage, yield, and cost-benefit ratio, the impact of the modules was ascertained all as reported by Davis and Williams in 1992 [7].

Results and Discussions

Fall army worm incidence shows that IPM fields registered significantly less with a mean of 9.10% and 6.72% compared to fields of FP with a mean incidence of 17.84% and 13.56%, during 2020-21 and 2021-22, respectively, with a pooled of two consecutive years showing larval incidence of 7.91% and 15.7% in IPM and FP fields (Table 1). Similarly, damage incidence was found lower in IPM fields (18.0% and 12.0%) with a mean of 15.0% as compared to FP fields (37.0% and 28.0%) with a mean of 32.5% during 2020-21 and 2021-22, respectively. Rajashekhar *et al*. provided support for the aforementioned outcomes. According to a 2022 study, the incidence of free-range eggs (FAW) was low in IPM compared to farmer practices and decreased by up to 46-73% after a whole application of Emamectin benzoate at 0.5 g/lt. The study found that Azadiractin 1500 ppm acted as the best oviposition deterrent, resulting in the majority of eggs failing to hatch.

Economics of IPM

The combined yield and economics data from the two years showed that IPM adoption increased yield over FP by 9.40% (Table 1). The benefit-cost ratio in FP was 2.0 whereas it was 2.4 in IPM. Good agricultural practices, which supported plant vigor under insect assault and enabled plants to offset pest damage, were primarily responsible for the increase in output in IPM fields. Dhaka *et al*. (2010) [8], Mistry *et al.* (2015) [9], and Bhati *et al.* (2017) [4] reported that net returns and maize yields were both increased. In Andhra Pradesh's tribal regions, a comparable study found that maize yields rose from 62.1-85.3 q/ha. Similar to the current experiment, Reddy *et al.* (2023) [13] found that the benefit cost ratio was much greater in the suggested technology (2.51) related to farmers practice (2.12).

Table 1: Comparative incidence of FAW damage (Larvae and damage) and Economic analysis of Maize IPM and FP fields over two consecutive years 2020-22).

Parameters	2020-21		2021-22		Pooled	
	FP	IPM	FP	IPM	FP	IPM
Fall Army worm incidence (%)	17.84	9.10	13.56	6.72	15.7	7.91
Damage incidence (%)	37.0	18.0	28.0	12.0	32.5	15.0
Yield (kg/ha)	6833	7542	4737.5	5246	5785.6	6394
Percent Increase in yield over control	-	9.40	-	9.69	-	9.51
Cost of cultivation (Rs./ha)	63937	58625	47475	43893	55,706	51259
Gross returns (Rs./ha)	1,26,410	1,39,527	94750	104920	1,10,580	1,22,223.5
Net returns (Rs./ha)	62,473	80,902	47275	61027	54847	70,964.5
Benefit Cost ratio (B: C)	1.97	2.38	1.99	2.39	2.0	2.4

Conclusion

One of the most destructive pests in the world, the autumn armyworm (*Spodoptera frugiperda*), can wipe out an entire crop because of its unanticipated presence from seedling to cob development stage. More robust extension services are desperately needed to help growers learn how to use newer technologies. The yield level was lower under local practices, though, and it may be raised even more by implementing integrated pest management strategies that are advised. For maize producers, the OFT intervention is very effective, increasing their net returns. It is advised to move forward with a broad demonstration based on the technology assessment plot results, as this might continue the pattern of positive outcomes in the Anantapur district.

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