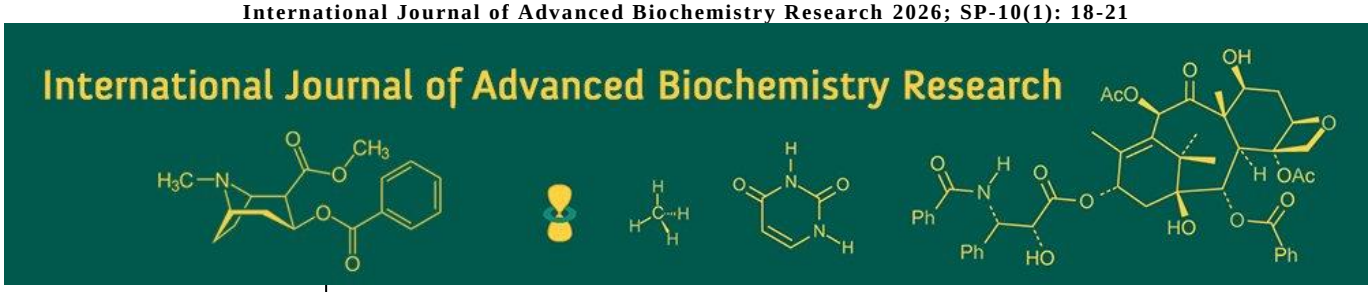

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On-farm testing of IPM module against *Spodoptera frugiperda* (f.) in maize

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Abstract
On farm trial on the assessment of IPM module against fall armyworm in maize under irrigated field conditions were conducted at ICAR-Krishi Vigyan Kendra, Kalyandurg during *kharif* season for three consecutive years *i.e.,* 2019-20, 2020-2021 and 2021-2022 in Ananthapur district, Andhra Pradesh. From each farmer 0.4 ha was selected for OFT and all integrated pest management (IPM) practices were imposed and an adjacent field of 0.4 ha was treated as Farmer Practice (FP). Fall armyworm incidence was found lower in IPM fields (18.00, 9.10 and 7.80%) with a mean of 11.63% when compared to Farmer Practice fields (37.00, 17.84 and 14.50%) with a mean of 23.11% during 2019-20, 2020-21 and 2021-22, respectively. Similarly, per cent damage due to fall armyworm was found significantly lower in IPM fields (12.00, 6.72 and 6.30%) with a mean of 8.34% as compared to farmer's practice fields (28.00, 13.56 and 13.20%) with a mean of 18.25% during 2019-20, 2020-21 and 2021-22, respectively.

Keywords: Fall armyworm, integrated pest management, on-farm testing, maize

Introduction
In India, the predominant maize growing states that contributes more than 80% of the total maize production are Andhra Pradesh (20.9%), Karnataka (16.5%), Rajasthan (9.9%), Maharashtra (9.1%), Bihar (8.9%), Uttar Pradesh (6.1%), Madhya Pradesh (5.7%), Himachal Pradesh (4.4%). India as the state like Andhra Pradesh having an area of 2.6 lakh ha has recorded the highest production (4.14 m t) and productivity (5.26 t/ha) in the country although the productivity in some of the districts of Andhra Pradesh is more or equal to the USA. Maize borers and shoot flies are common pests that attack the crop during its three growing seasons. The spotted stem borer, *Chilo partellus* (Swinhoe) is a common *kharif* maize pest while the pink stem borer, *Sesamia inferens*, (Walker) is more common in *rabi* crop, but it can also be found in spring maize. *Atherigona* spp. is a common pest of spring maize in northern India. Furthermore, there are nearly a dozen other pests that appear intermittently and inflict significant crop losses at times. Insect infestations cause losses ranging from 5% to 15% in maize crops. These are *C. partellus*, *S. inferens*, shoot fly, *Atherigona* spp, fall armyworm, *Spodoptera frugiperda* (J. E. Smith), Corn worm/Earworm: *Helicoverpa armigera* (Hub) as reported by Upadhay *et al.* (2023) [7]. The fall armyworm *S. frugiperda* is a notorious invasive pest infesting maize crop. In India, the pest has been reported in Karnataka in the month of July, 2018 and subsequently in other states (Sharanabasappa *et al.*, 2018) [5]. Farmers resort to spray various insecticides within short intervals resulted in development of resistance, secondary pest outbreak and pest resurgence along with destruction of natural enemies and leads to environmental pollution. The farmers are spending on an average of Rs. 10,000-12,000/acre on pesticides for the management of this dreaded pest. Recent incidence of fall armyworm on maize and other crops has also drawn attention of researchers and policy makers to issue a nation-wide advisory to the farming community to safeguard their produce as well as to combat against this dreaded pest (Mukhtar *et al.*, 2023) [3].

Materials and Methods
ICAR-Krishi Vigyan Kendra, Kalyandurg, has conducted 6 On-farm trials (OFT) under the natural field infestation under irrigation during *kharif* season for three consecutive years *i.e.,*

2019-20, 2020-2021 and 2021-2022 at different villages of Krishi Vigyan Kendra Operational area in Ananthapur district, Andhra Pradesh with a latitude of 14.5135^0 N and longitude of 77.0629^0 E (Figure 1). From each farmer 0.4 ha (one acre) was selected as OFT and all Integrated Pest Management (IPM) practices were imposed and an adjacent field 0.4 ha (one acre) was treated as Farmer Practice (FP).

The following recommended IPM Practices like deep summer ploughing, seed treatment with Fortenza Duo (Cyantraniliprole 19.8% + Thiamethoxam 19.8%) @ 6 ml/kg, collection and destruction of egg masses, pheromone traps (*S. frugiperda*) @ 4 nos/acre, border crop with grain sorghum and inter crop with cowpea (few rows), azadirachtin 10000 ppm @ 2 ml/l (10 to 15 days after sowing (DAS)), EPN or Bt spray @ 2 ml/l (15 to 21 DAS), first insecticide spray with emamectin benzoate 5 SG @ 0.4 g/l or Spinosad 480 SC @ 0.5 ml/l (21-28 DAS), *Metarhizium anisopliae* spray ($1x10^7$) @ 2 ml/l (30-35 DAS), second insecticide spray with flubendiamide 480 SC @ 0.3 ml/l or chlorantraniliprole 18.5 SC @ 0.3 ml/l or Spinetoram 11.7 SC @ 0.3 ml/l (36-42 DAS), poison baiting-(45-65 DAS) using thiodicarb 75 WP were followed (ICAR-Indian Institute of Maize Research (IIMR), Ludhiana, Punjab.

Observations on the incidence of fall armyworm and damage percentage was recorded on 25 plants selected randomly both in IPM and FP plots. Grain yield was recorded after the harvest, shelling and drying for all the fields in IPM and FP. For economic analysis, cost of cultivation including plant protection, yield and benefit cost ratios was also computed.

Results and Discussion

Data shows that IPM fields registered significantly low fall armyworm incidence when compared to fields of FP indicating the suitability of effective IPM components. During 2019-20, 2020-21 and 2021-22, the fall armyworm incidence was found lower in IPM fields (18.00, 9.10 and 7.80%) with a mean of 11.63% when compared to Farmer Practice (37.00, 17.84 and 14.50%) with a mean of 23.11%, respectively. Similarly, per cent damage due to fall armyworm was found significantly lower in IPM fields (12.00, 6.72 and 6.30%) with a mean of 8.34% as compared to farmer's practice (28.00, 13.56 and 13.20%) with a mean of 18.25% during 2019-20, 2020-21 and 2021-22, respectively (Figure 2).

Yield and Economics of IPM

Highest yield of 7542 kg/ha was recorded in IPM practice during the year 2020-21 whereas, least yield of 4738 kg/ha was recorded in FP during the year 2019-20. The pooled data of three years on yield and economics revealed that IPM implementation resulted in 9.10% increase in yield compared to FP (Table 2). Pooled data of three years revealed that, the benefit-cost ratio in IPM was 2.26, whereas in FP it was 1.91. Similarly, the net returns were also increased to a tune of 27.06% in IPM fields when compared to FP. The results are in concurrence with the previous authors where, Rajashekhar *et al.* (2022) observed FAW incidence before and after application of chemicals, showed Azadirachtin 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/l the incidence FAW was reduced up to 47-63% compared to farmer practice which is similar to the present study. Dhaka *et al.* (2010) [2] concluded that the adoption of improved production technologies significantly increased maize yield and profitability through frontline demonstrations in South-Eastern Rajasthan compared to traditional farmer practices. Bhati *et al.* (2017) [1] demonstrated the impact of front line demonstration on maize yield improvement in tribal belt of Rajasthan and found that demonstration plots yielded an average of 17.55% higher than traditional local practices, indicating that FLDs are effective in reducing the yield gap. Reddy *et al.* (2023) [4] reported that benefit cost ratio was significantly higher in the recommended technology (2.51) compared to farmers practice (2.12) which is similar to the results of present on farm trial. Gurpreet Singh *et al.* (2025) [6] has reported that feeding deterrence in the second instar larvae of *S. frugiperda* with sub-lethal concentrations of the neem based formulations i.e. commercial neem formulation (0.15%), neem oil and neem seed kernal extract (NSKE).

Table 1: Assessment of IPM modules over farmer practice against Fall army worm of Anantapur district.

Parameters	2019-2020		2020-2021		2021-2022		Pooled		% increase/decrease in IPM over FP
	FP	IPM	FP	IPM	FP	IPM	FP	IPM	
Yield (kg/ha)	4738	5246	6833	7542	6175	6570	5915	6453	+ 9.10
t-test	3.93		2.68		3.36				
Net returns (Rs./ha)	47275	61027	62473	80902	50143	61234	53297	67721	+ 27.06
Benefit Cost ratio (B: C)	1.99	2.39	1.97	2.38	1.77	2.01	1.91	2.26	-

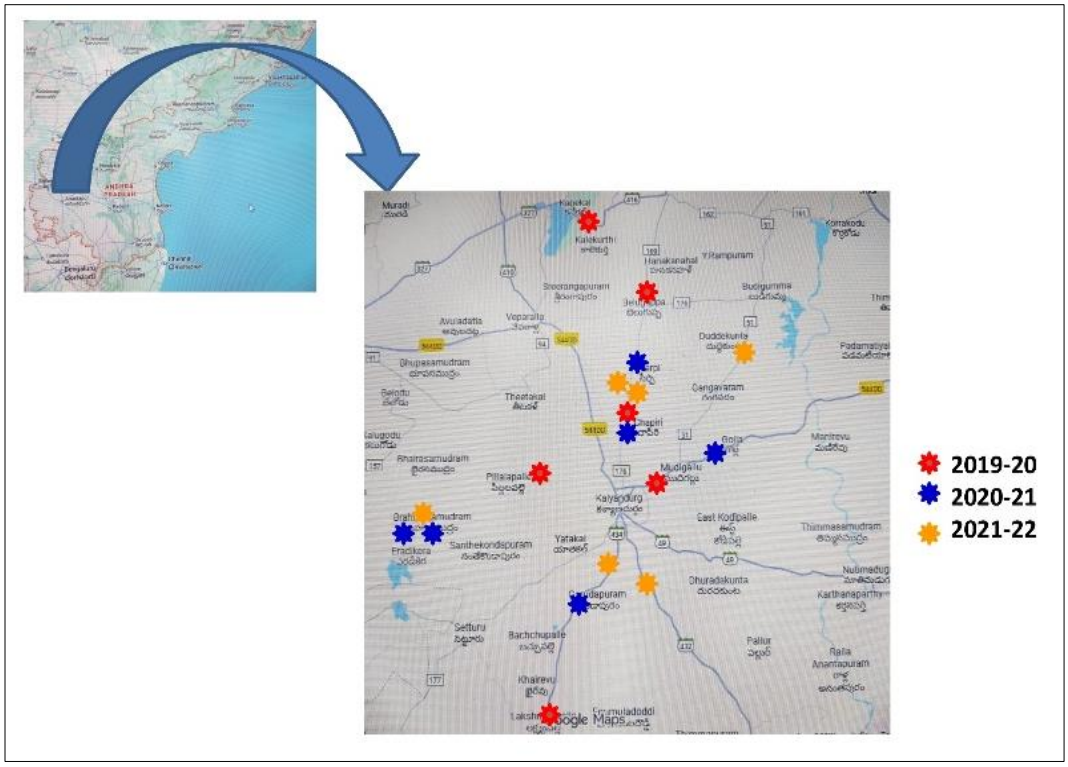

Fig 1: Map showing the locations of on farm trials conducted from 2019-20 to 2021-22

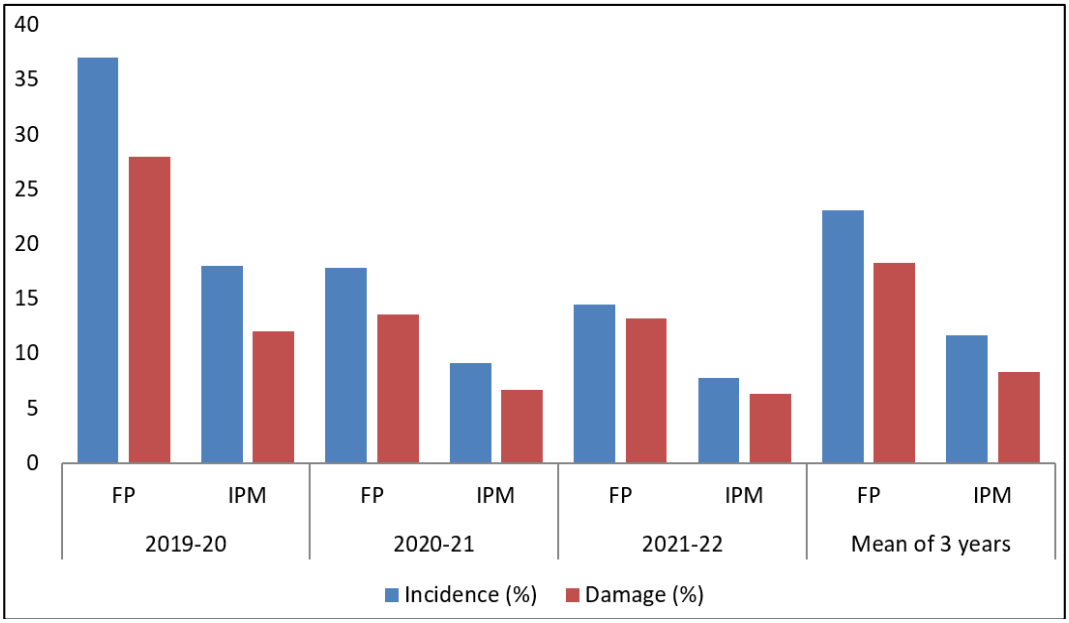

Fig 2: Fall armyworm incidence (%) and damage (%) in maize

Conclusion

Wide scale validation of Maize IPM for three years in farmer's fields provided better yield with high net returns. The overall conclusion of the study is that by adopting IPM strategies, the incidence of fall armyworm can be efficiently checked. Relying on chemical insecticides alone for the management of fall armyworm is not sustainable and increases cost of cultivation and reduces net returns. The validated IPM strategy is ecologically safe, economically viable and adoptable under farmer's field conditions and is highly effective in managing fall armyworm and other pests of maize.

Declaration

The authors declare that they have no conflict of interests.

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