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Integrated pest management of an invasive pest on maize, *Spodoptera frugiperda* (J.E.Smith) in Srikakulam district of Andhra Pradesh

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Abstract
Maize is the important crop and cultivated in an area of 15979 ha and 16626 ha during *Kharif* and *Rabi*, respectively in Srikakulam district of Andhra Pradesh. A recent invasive pest fall army worm, *Spodoptera frugiperda* (J.E.Smith) has become a major threat to the maize crop and observed 35-40 % loss in production. This foreignpest has been found during June, 2018 in the district by KVK, Amadalavalasa and has become very severe in the later seasons. IPM modules have been formulated for the pest management and evaluated during *Kharif* and *Rabi*, 2019 in the farmers field comparing with the farmers practice (Non IPM). During the on farm trials conducted by KVK, Srikakulam, it was resulted that pest incidence was 11-12% in IPM plots in Kharif and 4-5% during Rabi. Whereas, the pest incidence was 30-32% in *Kharif*and 16-17% during *Rabi*innon IPM followed fields. There was 8-10% yield increase observed and incremental cost benefit ratio was 1: 5.2. The results indicated that, following IPM against fall army worm gives efficient pest control and reduces the economic loss to the farmers.

Keywords: pest management, invasive pest, maize, *Spodoptera frugiperda*

Introduction
Maize is the important crop and cultivated in an area of 15979 ha and 16626 ha during *Kharif* and *Rabi*, respectively in Srikakulam district of Andhra Pradesh. A recent invasive pest from African countries, fall army worm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) has become major pest in corn, cultivated across the globe. FAW moths have both a migratory habit and a more localized dispersal habit where in this foreign pest was observed during Kharif 2018 in Srikakulam District. In the absence of proper control methods, FAW has the potential to cause maize yield losses of 8.3 to 20.6 M metric tons per year and this represents a range of 21-53% of the annual production of maize. The losses due to this pest were estimated at between US$2.48 billion and US$6.19 billion [1]. The conventional chemical management strategies are sometimes inconsistent and often unsatisfactory to control the pest in maize [2]. Use of insecticides as a pest management tool for small scale farmers in Srikakulam district, is more frequent and causing more damage to the ecosystem. There is a need to follow integrated pest management (IPM) packages that are suitable and cost-effective, especially for smallholder farmers in the region. An effective Integrated Pest Management (IPM) strategy for control of FAW will employ a variety of integrated approaches including biological control, cultural control, and safer pesticides, to protect the crop from economic injury while minimizing negative impacts on people, animals, and the environment. Keeping this in view, the present study was conducted by following the IPM measures against FAW at farmers' fields.

Materials and Methods
An on-farm trail on integrated pest management of fall army worm was conducted in the five selected farmers of Srikakulam district by adopting the following IPM practices (T1) compared with the non IPM fields (T2) during *kharif* and *rabi* 2019-20.

Table 1: IPM and Non IPM practices followed in the management of FAW during *Kharif* and *Rabi* 2019-20

T1: IPM Practices against FAW	T2: Non IPM Practices (Farmers practice)
• Seed treatment with Thiomethoxam 19.8 + Cyantraniliprole 19.8% @ 4ml/kg seed • Napier grass/ Jowar/ Castor as border crop • Clean cultivation and recommended dose of NPK as basal • Continuous scouting/ monitoring of pest at the early stage • Erection of pheromone traps @ 10/acre • Neem oil 10000 ppm @ 1ml/l spray at 7-10 DAS • Bt spray @ 2g/l at 15-20 DAS • Emamectin benzoate 5SG @ 0.4g/l + Neem oil 1500 ppm @ 5ml/l at 20-25 DAS • Chlorantraniliprole 18.5 SC @ 0.3ml/l at 30-35 DAS • Poison bait (Rice bran 10 kg + jaggery 2kg + Thiodicarb 100g) at 45-50 DAS	• Indiscriminative use of pesticides after observation of pest • Monocrotophos @ 1.6ml/l at 7-10 DAS • Emamectin benzoate 5SG @ 0.5g/l 20-25 DAS • Emamectin benzoate 5SG @ 0.5g/l 30-35 DAS • Chlorantraniliprole 18.5 SC @ 0.3ml/l at 40-45 DAS • Emamectin benzoate 5SG @ 0.4g/l 50-55 DAS

Data recorded on average pest incidence/ damage per cent, moth catches per trap/week and yield parameters and was analyzed.

Results and Discussion

Results indicated that the pest incidence and damage due to FAW range was 8.4- 14.0 percent in IPM followed plots during *kharif* 2019. The average pest incidence was 11.44 percent. Whereas, in the Non IPM plots it was found that the pest incidence was ranged from 28.6 to 36.4 percent. The average pest incidence was 32.6 percent. The average moth catches per week was eight only during *kharif* 2019. Following IPM against this insect has proved that integrated approaches will decrease the pest incidence.

Table 2: FAW incidence, moth catches in pheromone traps and yield in Maize crop during *Kharif*, 2019 at Srikakulam district.

Location	Date of Sowing	Avg. Moth catches/trap/ week	FAW damage (%)		Yield (Kg/ha)	
			IPM	Non IPM	IPM	Non IPM
Location 1	23.07.2019	4	11.0	32.0	6960	6600
Location 2	04.07.2019	12	8.4	28.6	6820	6540
Location 3	28.07.2019	14	13.2	36.4	7130	6450
Location 4	25.07.2019	8	10.6	34.8	7080	6650
Location 5	13.07.2019	10	14.0	31.2	7040	6720
	Mean	8	11.44	32.6	7006	6590
	SD		4.94	9.4		

During rabi 2019-20, damage due to FAW was very less compared to kharif and the damage range was 3.3 – 10.0 percent in IPM followed plots. The average pest incidence was 6.98 percent. Whereas, in the Non IPM plots it was found that the pest incidence was ranged from 13.3 to 23 percent. The average pest incidence was 16.6 percent. The average moth catches per week was 10 only during *rabi* 2019-20 (Table 3).

Table 3: FAW incidence, moth catches in pheromone traps and estimated yield in Maize crop during *Rabi*, 2019-20 at Srikakulam district.

Location	Date of Sowing	Avg. Moth catches/trap/ week	FAW damage (%)		Yield (Kg/ha)	
			IPM	Non IPM	IPM	Non IPM
Location 1	03.12.2019	12	3.3	13.3	7830	7650
Location 2	14.12.2019	10	7.5	16.6	7650	7580
Location 3	14.12.2019	8	3.5	23.3	7760	7600
Location 4	18.12.2019	16	6.6	16.6	7930	7860
Location 5	22.12.2019	14	4.5	13.3	7850	7650
	Mean	10	5.08	16.62	7804	7668
	SD		3.54	16.6		

Table 4: Pest incidence levels and yield in Maize during Kharif and Rabi 2019-20 at Srikakulam district

Season	Average No of moth catches /trap/week	Mean FAW incidence/ damage (%)		Yield (Kg/ha)	
		IPM	Non IPM	IPM	Non IPM
Kharif 2019	8	11.44	32.6	7006	6590
SD		4.94	9.4		
Rabi 2019-20	10	5.08	16.62	7804	7668
SD		3.54	16.6		

Particularly, seed treatment resulted in less incidence of pest till 15-20 days compared to the non-treated plots. Neem oil spray at the early stage prevented the egg laying to certain extent, and also effective in controlling the first instar larva of FAW in the IPM followed plots. Setting pheromone traps one week after sowing was also helpful to indicate to the farmer that the pest is present. The continued capture of moths in the trap suggests that the farmer should continue to observe the plants for the presence of larvae. Early detection of the pest allows quick and timely response which will help in minimize the damage to maize crop and reduce economic loss in production. Larvae up to 12 mm (usually 10 days after the

first catch of moths in the traps) can be efficiently controlled either by beneficial insects or through biopesticides such as Metarhizium, Beauveria, Baculovirus, *Bacillus thuringiensis*, fungi, or plant extracts such as Neem products [1]. The results of the present study is also in conformity with research earlier, IPM strategy comprising installation of pheromone traps, four releases of *Trichogramma pretiosum* Riley, two sprays of neem oil, one spray of each *Bacillus thuringiensis* (NBAIR-BT25)and *Metarizium anisopliae* (NBAIR Ma-35) resulted in 76 and 71.64% egg mass; 80 and 74.44% larval population reduction at 60 days after treatment during rabi and kharif season, respectively [3].

The conventional chemical management strategies are sometimes inconsistent and often unsatisfactory to control the pest in maize [2]. This is complicated by resistance in insects, chronic poisoning of farmers in some localities due to incorrect use [2]. Use of insecticides as a pest management tool for small scale farmersin Srikakulam district, is more frequent and causing more damage to the ecosystem. There is thus a need to follow integrated pest management (IPM) packages that are suitable and cost-effective, especially for smallholder farmers in the region.

Particulars	FP	IPM
Seed Treatment	0	750
Pheromone traps	0	200
Neem oil 1500 PPM at 15-20 DAS	0	380
Monocrotophos 36SL @7-10 DAS	220	0
Emamectin benzoate 5 SC @ 20-25 DAS	570	0
Emamectin benzoate 5 SC+ Neem oil 1500PPM @ 25-30 DAS	0	950
Emamectin benzoate 5 SC @ 30-35 DAS	570	0
Chlorantraniliprole 18.5 SC @ 40-45 DAS	650	0
Poison baits @ 50 DAS	0	250
Total Cost (A)	2010	2530
Total additional Cost (B)	-	620
Yield (kg/acre)	26.36	28.02
Total income	51811.5	54639
Total additional income	-	3229
ICBR	1	5.20

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