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Estimating the Economic Threshold Levels of *Spodoptera frugiperda* through Larval Damage and Adult Moth Trap Catches in Andhra Pradesh, India

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ABSTRACT

The experiment was conducted during *kharif* (June–September, 2022) in the Rayalseema region of Kurnool, Chittoor, Kadapa and Ananthapuramu districts, Andhra Pradesh, India to determine the percentage of leaf and cob damage caused by Fall armyworm. The roving surveys were carried out throughout the crop's vegetative (7 to 45 DAS) and reproductive (50 to 70 DAS) stages in the major Maize growing areas. The findings of the roving survey on the incidence of FAW during the *kharif* (June–September, 2022) showed that, of the districts surveyed, Kurnool (82.62%) and Chittoor (71.20%) recorded the highest percentage of leaf damage, followed by Kadapa (65.14%) and Ananthapuramu (52.82%) during vegetative stage. The districts with the highest percentage of cob damage during the reproductive stage were Chittoor (67.99%) and Kurnool (58.88%), followed by Kadapa (54.21%) and Ananthapuramu (53.21%), Through these surveys the extent of damage in each stage of Maize can be assessed. Using pheromone traps to study population dynamics of FAW is a great way to keep a watch on pest populations which not only improves early detection but also helps to determine the ETL levels of adults as a forewarning signal to the Maize cultivators. The Phermone trap catches during *kharif*, 2022 showed that at 28 days after planting (V_5, V_6, and V_7 stages of Maize), Chandragiri recorded the highest trap catches for the entire season, with 70.99 moths trap^{-1} week^{-1} followed by Narayanavanam at 21 DAS with 73.11 moths trap^{-1} week^{-1} which exceeded the ETL level.

KEYWORDS: Cob damage, percent leaf, phermone trap, rayalaseema region

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Maize is known as Queen of cereals which is attacked by Numerous biotic (diseases, insects, and weeds) and abiotic (temperature, rainfall, relative humidity, etc.) factors which restrict the production potential of Maize by lowering the yields. Globally, invasive alien species pose a significant threat to agricultural crops which has been predicted to increase with a changing climate and increased international trade (Pratt et al., 2017). Studies have shown that invasive alien species can also displace native organisms, negatively impact biodiversity, and modify ecosystems causing huge economic losses (Kenis et al., 2010; Pratt et al., 2017; Kumar and Singh, 2020. Despite the fact that 250 insects have been identified in the Maize environment, the most significant ones are the major native pests, such as *Atherigona soccata, Sesamia inferens, and Chilo partellus,* as well as the recent transboundary invasive pest, *Spodoptera frugiperda* (FAW) According to estimations released by, Anonymous Statistia, (2022), in the event that, if appropriate control measures are not taken up, there is every chance of the insect to reduce Maize yields by 8.3 to 20.6 mt year^{-1}. Hence there is an initial need to assess the adult population through pheromone trap catches, extent of larval damage needs to be explored in the terms of Per cent leaf damage and Per cent Cob damage.

An efficient way to detect new infestations at very early stages, monitor the size of established populations and suppress resurgent infestations of this and other agricultural pests is to deploy traps with synthetic lures that mimic the highly species-specific female sex pheromone, Meagher et al., 2019, Rizvi et al., 2021. Pheromone lures can be used to attract more FAW males and prevent ambiguity among the noctuids which are difficult to distinguish such as African armyworm (*Spodoptera exempta*), beet armyworm (*Spodoptera exigua*), African cotton leafworm (*Spodoptera littoralis*) and various *Helicoverpa* species in the same family. Development and implementation of coordinated integrated pest management (IPM) programs is highly dependent on effective species-specific detection, monitoring and pest management at the local, state levels and effective pheromone traps are critical cornerstones of IPM programs.

To manage fall armyworm (FAW) infestations in maize, many small scale farmers have relied heavily on use of synthetic chemical insecticides that has been associated with environmental pollution, food crop contamination, development of insecticide resistances in the pests and highly costly. The sustained use of insecticides in small holder farms to manage FAW poses environmental risks and has a significant negative effect on human health and agricultural trade attributable to synthetic pesticide residues in food material (Anonymous, 2018). The indiscriminate application of toxic pesticides also has a negative effect on beneficial natural enemies, reducing the gains of biological control (Meagher et al., 2019), and this could probably lead to increase or introduction of secondary pests (Tscharntke et al., 2016) Hence, Thomas (2008) suggested that using pheromone traps to study the population dynamics of Fall armyworm is a great way to keep a watch on pest populations which not only improves early detection, baseline data collection for action thresholds and decision support but also aids in mapping pest distribution and carrying out quarantine inspection. According to Cruz et al. (2010), the most effective way to determine how many pesticide treatments are necessary is to use pheromone traps. Therefore, the present experiments were taken up to track the adult population of FAW and also assess the larval damage extent.

2. MATERIALS AND METHODS

In order to evaluate the damage caused by FAW, roving surveys were carried out during the vegetative and reproductive stages of the crop in *kharif* (June–September), 2022 (Figure 1) from four districts of Rayalaseema region of Andhra Pradesh, India that majorly cultivate Maize, amongst which five mandals were chosen in turn three villages from which three farmer's fields were then picked from each village to conduct roving surveys.

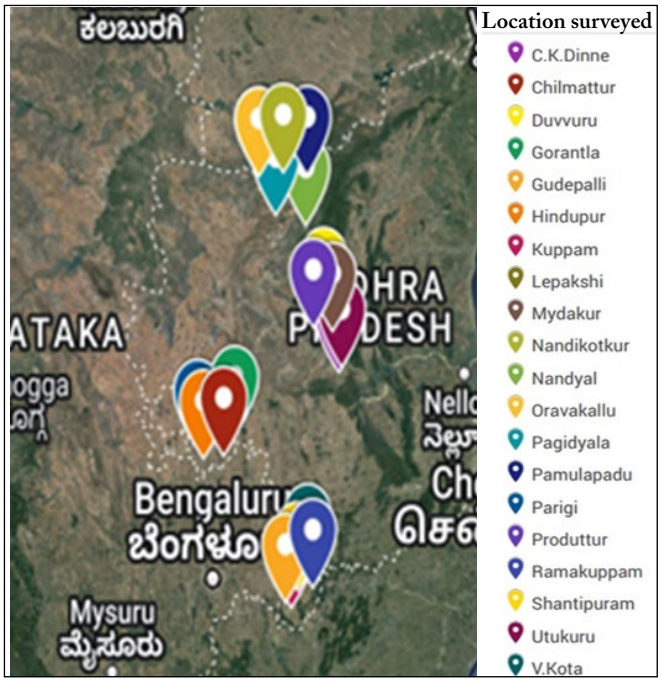

Figure 1: Map depicting locations (mandals) surveyed for Fall armyworm incidence

2.1. Survey methodology for assessing larval damage

In order to determine the percentage of leaf and cob damage caused by Fall armyworm (FAW), surveys were carried out

throughout the crop's vegetative (7 Days after sowing (DAS) to 45 DAS) and reproductive (50 DAS to 70 DAS) stages. Ten plants in each field were chosen at random to form a "W" shape during the vegetative stage in order to record the percentage of leaf damage, and a "H" pattern or ladder type sampling during the reproductive stage (Prasanna et al., 2018). The percentage of leaf and cob damage, respectively, was calculated from the average of 10 observations made from farmer fields in each village throughout the vegetative and reproductive stages. The method provided by Davis and Williams (1992) was used to calculate the percentage of leaf and cob damage.

Percent leaf damage=(No. of damaged leaves/ Total no. of leaves)×100

Percent cob damage=(No. of cobs damaged/No. of cobs present on ten plants)×100

2.2. Pheromone trap catches

At Dryland College Farm, S.V. Agricultural College, Tirupati (latitude: 13.6243° N, longitude: 79.3779°), ARS, Perumalpalli (latitude: 13.3781° N, longitude: 79.3243° E) and the farmer's field at Chandragiri (13.5891° N, 79.2821° E) phermone trap catches were installed. The phermone trap utilized was a polythene funnel type with yellow rubber septa manufactured by M/S Phermone chemicals, Nacharam, Hyderabad. Z9-14Ac, Z11-16Ac, and Z7-12Ac. was a lure designed specifically for *S. frugiperda* with combination ratio 87:12.5:0.5. In the seedling stage, the traps were positioned one meter above the ground; and were placed 20 cm above the plant canopy as when the crop progressed to further stages. The traps were positioned vertically by using a rope to tie one end to a wooden pole and a thread to fasten the other end. The lures were replaced every 45 days as per the manufacturers instruction, four traps acre^{-1} were placed to monitor the adult population (Table 3).

The captured adults in each trap were removed from the traps and counted at weekly intervals. Thus, mean number of moth catches trap^{-1} week^{-1} was determined (Figure 4) and is subjected to statistical analysis. The collected data (Number of moth trap^{-1}) was subjected to square root transformation and the data was analysed through OP STAT software and Duncan's Multiple Range Test (DMRT) ($p \leq 0.05$) by using IBM SPSS (Statistical Package for Social Sciences) statistics version 20 for drawing the conclusions.

3. RESULTS AND DISCUSSION

3.1. Per cent leaf and Cob damage

According to the Davis and Williams scale (1992), the mean percentage of leaf damage during the vegetative stage was 71.20, 65.14, 82.62, and 52.82% in the districts of Chittoor, Kadapa, Kurnool, and Ananthapuramu, respectively. These percentages fell between 3 and 8 damage ratings. According to the Davis and William scale (1992), the districts with the highest percentage of leaf damage during the vegetative stage were Kurnool (82.62%) and Chittoor (71.20%), which were statistically on par with damage ranges of 4–8 and 3–7, respectively followed by Kadapa (63.16%) and Ananthapuramu (50.26), having damage ranges of 5–8 and 4–7, respectively. According to the Davis and Williams scale (1992) (Table 1, Table 2), the districts with the highest percentage of cob damage during the reproductive stage were Chittoor (67.99%) and Kurnool (58.88%), which were statistically comparable with damage ranges of 3–8 and 3–5, respectively, followed by Kadapa (54.21%) and Ananthapuramu (53.21%) (Figure 1, Figure 2, Figure 3).

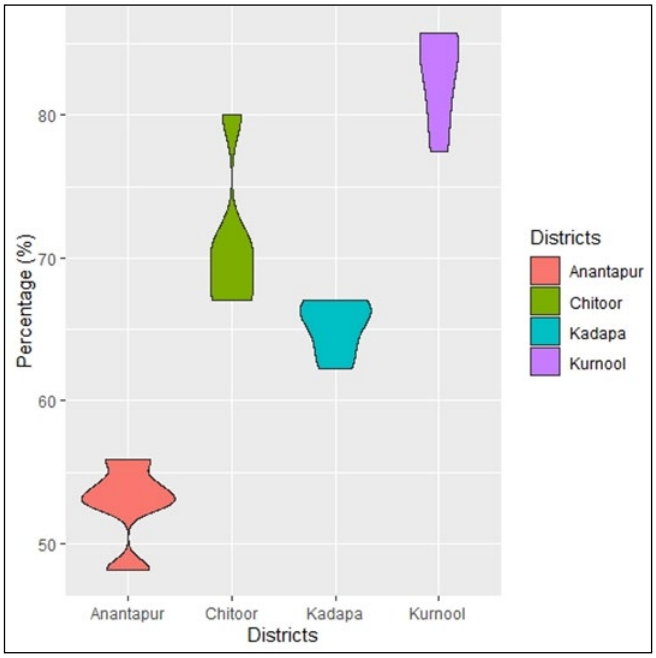

Figure 2: Per cent leaf damage by fall armyworm in Rayalseema region

The Kurnool district reported highest per cent leaf damage due to a number of factors, including the recurrent use of Emamectin benzoate, which may have increased insect incidence, and the Maize-cotton cropping pattern, which may have helped the larvae survive the off-season. Fall armyworm incidence was found to be greater in Chittoor because Maize was primarily grown there as a border crop or as animal feed. Ananthapuramu and Kadapa districts, on the other hand, suffered less damage because of the two years of intense rainfall in both districts and the humid weather that encouraged the growth of the fungus *Metarhizium riley*, which was identified after the cadavers that were affected were tested in a lab. The survey's findings are consistent with research done in Andhra Pradesh by where the percentage incidence of fall armyworm ranged from 5 to 100%, with the highest incidence occurring in the vegetative stage on Maize in the Vizianagaram region. Shylesha et al. (2018)

Table 1: Per cent leaf and cob damage by fall armyworm in Rayalaseema region

Name of the district	Name of the mandal	Vegetative stage		Reproductive stage	
		Kharif, 2022	Davis and William 1992 scale	*Kharif*, 2022	Davis and Williams 1992 scale
Chittoor	Ramakuppam	67.52 (55.25)[b]	6	62.22 (52.07)[b]	5
	Gudepalli	70.62 (57.17)[b]	5	65.55 (54.06)[b]	6
	Shantipuram	80.05 (63.47)[a]	5	69.99 (56.78)[b]	7
	V. Kota	70.78 (57.27)[b]	6	68.88 (56.09)[b]	6
	Kuppam	67.03 (54.95)[b]	6	73.32 (58.90)[a]	8
	SEm±	1.06	-	1.71	-
	CD (p=0.05)	3.21	-	5.20	-
	CV %	8.53	-	14.16	-
Kadapa	Mydakur	66.52 (54.67)[b]	6	56.66 (48.82)[ab]	5
	Proddatur	65.88 (54.25)[b]	5	53.33 (46.90)[b]	4
	Rajampeta	62.25 (52.09)[b]	6	52.22 (46.27)[b]	4
	Duvvur	67.06 (54.97)[ab]	7	53.33 (46.90)[b]	5
	C.K.Dinne	64.03 (53.14)[b]	6	55.55 (48.18)[b]	5
	SEm±	1.54	-	1.91	-
	CD (p=0.05)	4.66	-	5.78	-
	CV %	12.97	-	17.80	-
Kurnool	Nandikotkur	80.90 (64.08)[ab]	7	58.88 (50.11)[b]	6
	Jupadu Bungla	85.72 (67.70)[a]	8	54.44 (47.54)[b]	5
	Oravakallu	85.61 (67.70)[a]	8	55.55 (48.16)[b]	6
	Pagidyala	83.33 (65.90)[a]	7	59.99 (50.76)[b]	6
	Nandyala	77.45 (61.64)[b]	6	65.55 (54.06)[ab]	6
	SEm±	0.80	-	1.32	-
	CD (p=0.05)	2.42	-	4.02	-
	CV %	5.91	-	11.80	-
Ananthapuramu	Chilmattur	54.18 (47.39)[b]	5	53.33 (46.90)[a]	-
	Lepakshi	55.91 (48.39)[ab]	4	55.55 (48.18)[a]	5
	Hindupur	53.13 (46.79)[b]	5	51.11 (45.63)[a]	4
	Parigi	48.20 (43.96)[b]	3	54.44 (47.54)[a]	5
	Gorantla	52.76 (46.58)[b]	4	56.66 (48.82)[a]	4
	SEm±	0.55	-	0.42	-
	CD (p=0.05)	1.66	-	1.27	-
	CV %	5.16	-	3.90	-

Values in parentheses are arcsine transformed values; Values followed by same letter in each column are not significantly different (DMRT)

also published similar results, demonstrating that the percentage incidence of fall armyworm in maize vegetative stage ranged from 9 to 62%. These findings are consistent with the current survey data done during the *kharif,* 2022. The current findings were also consistent that throughout the early phases of the maize crop growth period, the percentage incidence of fall armyworm on Maize varied from 6 to 100%. Similar findings were reported on the abundance

Table 2: Mean per cent damage of *S. frugiperda* in vegetative and reproductive stages of maize

Sl. No.	District	Per cent damage		Range of damage rating. Davis and William, 1992 scale (Per cent leaf damage)	Range of damage rating. Davis and William, 1992 scale (Per cent cob damage)
		Vegetative stage (Per cent leaf damage)	Reproductive stage (Per cent cob damage)		
1.	Chittoor	71.20 (57.81)ab	67.99 (58.39)a	3-7	3-8
2.	Kadapa	65.14 (53.61)c	54.21 (43.65)c	5-8	2-8
3.	Kurnool	82.62 (62.04)a	58.88 (50.37)ab	4-8	3-5
4.	Ananthapuramu	52.82 (43.14)cd	53.21 (43.65)c	4-7	2-5
	S.Em.+	0.81	0.86	-	-
	CD (p=0.05)	2.46	2.73	-	-
	CV%	6.89	8.59	-	-

Values in parentheses are arcsine transformed values; Values followed by same letter in each column are not significantly different (DMRT)

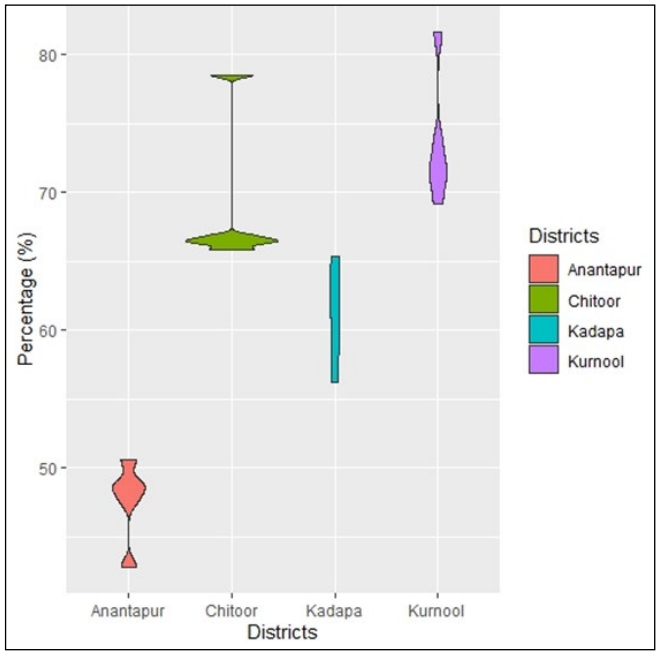

Figure 3: Per cent cob damage by fall armyworm in Rayalseema region

of FAW in Maize crops in Chhattisgarh's northern hill zone and discovered that the crop's mean infection levels varied from 30% to 80% during the vegetative phase.

The crop's 2–4 leaf stage showed the highest percentage of leaf damage as more larvae plant^{-1} directly correlated with a higher percentage of damage to leaves and cobs. Of the two stages, the vegetative stage showed the most damage in the *kharif,* 2022. It might be because of the tenderness of the leaves, which allowed more newly hatched first and second instar larvae to survive. This led to an increase in the number of larvae plant^{-1} and subsequent leaf damage, suggesting that a larger percentage of the damage was caused by more larvae plant^{-1}. These results are consistent with the survey conducted by Oscar et al. (2013) in Colonia Benítez, Argentina, which showed that 82% of FAW larval attacks occurred during the vegetative stage, when the plants had two to three fully grown leaves. After that, the larval attack tended to decline, reaching 53% of affected plants at the twelve leaf stage.

The results of this study confirm the findings eating habits of FAW larvae on Maize and found that early (vegetative stage) leaf tissue is favorable for FAW development and survival. These outcomes are also consistent with the research conducted by Trisyono et al. (2019), who reported FAW damage in two Maize fields in the African community of Sidokerto. The fields' ages were somewhat different (5 and 7 weeks). Thirty percent of the five-week-old Maize had damage, compared to ten percent of the other field's seven-week-old corn. These findings support the current research, which showed that damage was greater in the vegetative stage than in the reproductive stage.

When compared to leaves and tassels, higher damage to silk, ears, and ear sheaths was seen in the reproductive stage in the 2022 *kharif*. These results are consistent with those of Wendell et al. (2010), who counted the larvae in different plant regions and tracked the movement of larvae in plants during the tassel emergence period. They discovered that, following the appearance of tassels and ear shoots for seven days, the distribution of larvae was 0, 45, 38, and 7% on leaves, ears, ear sheaths, and tassel, respectively.

The present results are also in accordance with Hernandez et al. (2008) who recorded infestation of Fall armyworm levels in two Maize fields and carried out analysis on the spatio temporal distribution and indicated that *S. frugiperda* larvae showed a random distribution pattern in Maize.Cock et al. (2017) conducted field surveys in nine major Maize growing locations of Ghana Per cent leaf damage recorded from each location was 86.23, 79.11, 36.24, 81.94, 74.98, 69.33, 84.34, 71.11 and 68.93 per cent respectively.Shylesha *et al.* (2018) conducted survey on incidence of Fall armyworm which ranged from 9 to 62 per cent with minimum and maximum recorded in Hassan and Chitradurga districts respectively.

Rwomushana et al. (2018) conducted a survey in 71 and 300 Maize farmer field's in Zambia and Ghana respectively by scouting to determine the damage percentage by FAW on 100 plants and recorded 97.2% damage in Ghana and 89.9% damage in Zambia. Bagariang (2019) conducted a survey and recorded the incidence of *S. frugiperda* in regions of Indonesia *viz.,* West Solor (100%), Titehena (95%). Fotso et al. (2019) recorded the presence of *S. frugiperda* on Maize in 10 regions of Cameroon, with damage per cent ranging from 5.7±22.9% in the North region to 3.4±79.2% in the West region. Baudron et al. (2019) surveyed a total of 394 and 397 fields for Fall armyworm incidence on Maize in Chipinge, Makoni districts respectively and observed that proportion of plants with leaf damage ranged from 41.5±28.7% in Chipinge and 54.9±26.3% in Makoni.

A survey was conducted to determine the distribution of Fall armyworm and damage severity in Ethiopia, Kenya and Tanzania in 2016 and 2017 by Sisay et al. (2018) and the per cent leaf damage in Maize fields ranged from 33.21 to 99.86% in Ethiopia. Kerketta et al. (2020) reported the presence of Fall armyworm in Orissa by conducting a survey on the presence and intensity of infestation in different farmer's field of Koraput district. Out of five locations surveyed, two locations *viz.,* Semiliguda (84.11%) and Boipariguda (85.15%) showed higher intensity of infestation, Sharon et al. (2020) conducted a survey regarding the per cent incidence of Fall armyworm in Bulambuli district in Uganda during 2019. (1–20%), nine fields showed moderate incidence (21–49%) and 17 fields showed relatively higher incidence (>50%) of Fall armyworm.Balakrishnan and Srinivasan (2020) conducted a random survey for assessing the incidence of Fall armyworm during *rabi*, 2019 in Tirunelvelli district of Tamil Nadu on Maize and observed Infestation ranged from 1.67 to 11.67, per cent respectively. Sidol et al. (2020) conducted a study on yield losses due to FAW in Maize in 19 districts of Benin (West Africa). The results showed that around 97.1% of fields were infested with *S. frugiperda* in 2018. Suraj et al. (2020) made a survey on incidence of FAW in Maize from the provinces of Sri Lanka during 2019, of which Eastern, Uva and North Central provinces had shown infestation levels of 81.6, 73.11 and 58.30% respectively. Yang et al. (2021) found the presence of FAW in China. at a density of around 12.0 per 100 plants in December 2019 and about 5.0 larvae per 100 maize plants in January 2020.

3.2. Adult phermone trap catches

Average weekly moth catches traps^{-1} during the 2022, *kharif* revealed that Chandragiri, recorded the largest trap catches of the season which were seen twenty-eight days after planting at the V_5, V_6, and V_7 stages of Maize, with 70.99 moths trap week^{-1} trap captures. In ARS Perumalpalli, thirty-five days after planting in the V_8 and V_9 stages of Maize, trap catches recorded 26.33 moths trap^{-1} week^{-1}, while at twenty-one days after sowing in the V_3, V_4 stages of Maize, trap catches at Narayanavanam recorded 73.11 moths trap^{-1} week^{-1}. The overall trap catches in the entire season were recorded in Chandragiri (19.54 moths trap week^{-1}) and Narayanavanam (18.13 moths trap week^{-1}) and both trap catches were statistically at par in comparison to the trap catches of Chandragiri and Narayanavanam, the least mean moth trap captures were recorded in ARS, Perumalpalli (12.40 moths trap^{-1} week^{-1}) (Figure 4).

According to Barlow and Kuhar (2009), pheromone traps are more effective and sensitive to population fluctuations, Insecticidal treatments should only be scheduled when a pheromone trap catches are 10–20 adult moths in a single night (or 70–100 adults week^{-1}). The number of moths caught during the season varied significantly across the several periods of observation (Table 3), The ETL (Economic Threshold Level) exceeded only at 21 and 28 DAS since the entire belt was only planted with Maize, it's possible that more moths from the nearby fields of Maize were drawn to the farmer's fields in Chandragiri and Narayanavanam during the *kharif*, 2022 (70.99 moths trap^{-1} week^{-1} in Chandragiri at 28 DAS and 73.11 moths trap^{-1} week^{-1} in Narayanavanam at 21 DAS). On the other hand ARS, Perumalpalli, (26.33 moths trap^{-1} week^{-1} at 35 DAS), trap catches in ARS Perumalpalli did not exceed the ETL standard. Thus, it can be deduced that the peak moth activity period was observed between 21 DAS (V_3 and V_4 stage of Maize) and 28 DAS (V_6 to V_9 stage of Maize) in

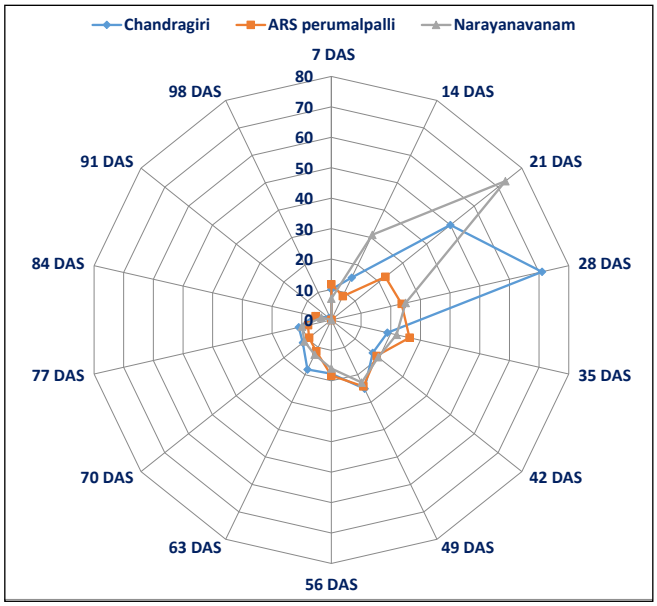

Figure 4: Phermone trap catches by Fall armyworm in Rayalseema region

all three regions (Chandragiri, Narayanavanam, and ARS, Perumalpalli) from the observations of *kharif*, 2022.

The current study's range of moth trap catches, was as follows: in Chandragiri, it was between 0.00 and 70.99 moths trap^{-1} week^{-1}; in ARS, Perumalpalli, it was between 0.00 and 26.33 moths trap^{-1} week^{-1}; and in Narayanavanam, it was between 0.00 and 73.11 moths trap^{-1} week^{-1}. In Chandragiri, ARS Perumalpalli, and Narayanavanam, the average weekly moth count was 19.54, 12.40, and 18.13 moths trap^{-1}, respectively. Rather than in the latter phases of tasseling and cob production, the greatest number of adult FAW were found to be captured in the early stages of Maize growth (whorls). The current results align with the research conducted by Mohamed and Shairra (2023), who similarly observed increased moth trap captures during the early phases of Maize growth. One month after the traps were installed, there was an increasing trend in the number of moths caught using the pheromone blend. This might be because crop phenology and the coincidence of adult moth activity. The findings of Fleischer et al. (2005), who likewise

Table 3: Mean number of adult moth catches in pheromone traps

	Mean number of moth catches trap^{-1} week^{-1*}							
Place of pheromone trap installation	7 DAS	14 DAS	21 DAS	28 DAS	35 DAS	42 DAS	49 DAS	56 DAS
Chandragiri	10.02 (3.32)^{ab}	15.39 (4.04)^{b}	49.99 (7.14)^{b}	70.99 (8.48)^{a}	18.99 (4.47)^{bc}	17.39 (4.28)^{bc}	25.11 (5.11)^{a}	17.69 (4.32)^{ab}
ARS Perumalpalli	11.69 (3.56)^{a}	8.65 (3.10)^{c}	22.67 (3.98)^{b}	23.67 (4.96)^{bc}	26.33 (5.22)^{a}	18.98 (4.47)^{b}	24.27 (5.02)^{ab}	18.29 (4.39)^{a}
Narayanavanam	6.99 (2.82)^{c}	30.99 (5.65)^{a}	73.11 (8.60)^{a}	24.99 (5.09)^{b}	21.99 (4.79)^{b}	19.67 (4.54)^{ab}	22.87 (4.88)^{bc}	15.99 (4.12)^{bc}
SEm±	0.11	0.13	0.27	0.17	0.29	0.19	0.18	0.29
CD (p=0.05)	0.28	0.49	0.69	0.49	0.69	0.99	0.99	0.99
CV%	14.99	17.81	18.99	11.89	19.99	19.99	17.09	14.99

Table 3: Continue...

Place of pheromone trap installation	63 DAS	70 DAS	77 DAS	84 DAS	91 DAS	98 DAS	Average moth count
Chandragiri	18.11 (4.37)a	12.01 (3.60)a	10.99 (3.46)a	5.78 (2.60)a	1.11 (1.45)a	0.00 (1.00)a	19.54 (4.53)a
ARS Perumalpalli	11.49 (3.53)bc	9.39 (3.12)b	7.87 (2.97)c	5.35 (2.52)a	0.00 (1.00b	0.00 (1.00)a	12.40 (3.66)c
Narayanavanam	12.67 (3.69)b	11.33 (3.51)ab	9.89 (3.30)ab	3.39 (2.09)b	0.00 (1.00)b	0.00 (1.00)a	18.13 (4.37)ab
SEm±	0.19	0.23	0.14	0.22	0.16	0.16	0.29
CD (p=0.05)	0.39	0.59	0.56	0.67	0.52	0.48	0.89
CV%	12.99	14.99	13.49	17.29	13.79	12.45	14.59

noted the rising tendency of moth captures from July 27, one month after the crop was sown on June 25, which were found to be consistent with these observations.

Luciane et al. (2006) reported that Fall armyworm pheromones traps consisting of lures with either Z7-12:Ac +Z9-14:Ac (0.01:1.00 mg) or Z7- 12:Ac +Z9-14:Ac+Z11-16:Ac (0.01:1.00:0.10 mg), captured similar numbers of males and in both cases catches were significantly higher than the controls. All concentrations of Z7-12:Ac + Z9-14:Ac + Z11-16:Ac (1:100:15 ratio) captured lower males. Using pheromone traps to monitor Fall armyworm adult activity provided an effective means of determining the number of insecticides applications necessary to control the larval infestations in Maize (Cruz et al., 2010). Melanie et al. (2014) tested the pheromone lures *viz.,* Z11-16:OAc for assessing the attraction of males towards lures, and results revealed that corn-strain males from Peru were equally attracted to blends with and without different doses of Z11-16:OAc, similar to the response of corn- and rice-strain males in Florida. In general, addition of Z11-16:OAc to Z9-14:OAc and Z7-12:OAc also did not decrease the male attraction in Florida, Peru, Costa Rica and Pennsylvania. This data suggested that Z11- 16:OAc is not an essential component for *S. frugiperda* male attraction, which is supported by the observation in the laboratory experiment where *S. frugiperda* males from Mexico did not respond electro physiologically to Z11- 16:OAc.

Groot et al. (2016) tested pheromone lures mimicking the pheromone gland composition of Floridian corn-strain *S. frugiperda* females, 74% of all trapped corn strain males in a Corn field were attracted to corn-strain lure, (*i.e.,* 100% Z9-14Ac, 13% Z11-16Ac, 2% Z7-12Ac, 1% Z9-12Ac) and only 26% attracted to the rice-strain lure (*i.e.,* 100 % Z9-14Ac, 8% Z11-16Ac, 4% Z7-12Ac, 2% Z9-12Ac). Samuel et al. (2018) conducted an experiment to investigate differences between pheromone blend (Z7-12 OAc: Z9-14 OAc: Z11-16 OAc) with different ratios in three different locations *i.e.* Ejido Joaquin Miguel Gutierrez, San Nicolas Lagartero and Tapachula. Highest FAW male moth catches were observed with pheromone ratio of 1:79:20 with 15, 20 and 20 moths / trap in three locations respectively. Whereas, lowest number of male moth catches observed with ratio of 0.5:85.5:14 with 12, 10 and 8 moths / trap respectively.

In 2019, sex pheromones of *S. frugiperda* were used to examine moth trapping in Corn fields in Gochang, Korea. Four types of traps were prepared, two funnel-types and two delta-types, baited with 300 and 1000 μg, of which two-component (2C) blend of synthetic sex pheromones [100% (Z)-9-tetradecenyl acetate (Z9-14Ac) and 2% (Z)-7-dodecenyl acetate (Z7-12Ac)]. The greatest number of *S. frugiperda* (14 moths/trap) were captured in the 300 μg funnel-type trap (first catch: August 6) (Bo Yoon et al., 2020).

4. CONCLUSION

Survey results indicate larval damage had surpassed ETL levels (5% leaf damage, 15% whorl infestation) across Rayalaseema. Pheromone trap data also showed catches exceeding 70 moths $trap^{-1}$ day^{-1} in farmer fields, aiding in population dynamics monitoring of Fall armyworm. These methods enabled early detection and determination of ETLs for larvae and adults, providing forewarning awareness to maize cultivators to implement effective management strategies.

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