Ecological engineering for the management of fruit borers in okra ecosystem by encouraging natural enemies

ABSTRACT: Experiment was conducted to study the Ecological engineering for encouragement of natural enemies against fruit borers of okra under field conditions at College of Horticulture Bagalkot. The treatments were T_1-okra as main crop (untreated check), T_2-okra + barrier crop (two rows of 25 days old maize seedlings) + trap crop (one row of 25 days old marigold seedlings), T_3-okra + border crop (two rows of cowpea) + okra intercropped with coriander (5:1) and T_4-okra + barrier crop (two rows of 25 days old maize seedlings) + trap crop (one row of 25 days old marigold seedlings) + border crop (two rows of cowpea) + okra intercropped with coriander (5:1). Results revealed that the treatment T_4 recorded significantly lowest mean shoot damage (5.11%), fruit damage (7.42%) by *E. vittella* and *H. armigera* (17.68%) as compared to other treatments. Further, T_4 treatment significantly encouraged the build-up of natural enemies like coccinellids (1.95/plant) and spiders population (0.61/plant) suggesting ecological engineering as a fundamental and integral tool for inclusion in integrated pest management. Thus, T_4 treatment superiority was mainly due to excellent ecological engineering provided in the form of barrier, trap, border and intercrops which played a significant role in reducing the insect pests of okra. For the first time recorded the *E. insulana* adults attracting towards trap crop (Marigold) for mating and egg laying purpose in okra ecosystem.

Key words: Okra, ecological engineering, maize, marigold, cowpea and coriander.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is commercial vegetable crop cultivated for domestic consumption and export. Its origin is Africa and belongs to family Malvaceae having chromosome number 2n=130. Okra related to cotton family, often referred to, as "Lady Finger". India ranks second in area and production after China. In India, okra is grown in 0.528 million hectares area with 61.46 lakh tons of production and productivity of 11.64 t per ha. In India, major growing states are Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Himachal Pradesh, Jammu and Kashmir, Jharkhand and Karnataka. In Karnataka, major okra growing districts are Bagalkot, Mandya, Belagavi, Haveri, Bengaluru, Kolar and Vijayapur.

Okra production is limited by number of factors; among them insect pest attack is the major one. Okra crop is attacked with as many as 45 species of insect pests throughout its cropping period (Nair, 1984). Among them, shoot and fruit borer *Earias vittella* (Fabricius), *Earias insulana* and fruit borer *Helicoverpa armigera* (Hubner) are most serious and major limiting biotic factors in okra cultivation. In general, 48.97 per cent economic loss in fruit yield is noticed due to overall damage by insects (Kanwar and Ameta, 2007). The crop loss estimation for major pests are 3.5 to 90.0 per cent by fruit borers (Nair *et al.,* 1984).

Indiscriminate use of chemical pesticides results in pollution of natural resources like water, soil, reduced density of beneficial insects and soil microorganisms, reduction of pollinators and natural enemies like predators and parasitoids, which play a significant role in suppression of pest population. Due to spraying of spurious chemicals on fresh vegetable crops, pesticide residues remain in the produce, causing health hazards to human beings and also leading to the development of resistance and resurgence in pests. In this contest, ecological engineering practices were carried out against the fruit borers of okra, which includes the integration of barrier, trap, border and inter crops along with the main crop in which border crops act as physical barrier and prevent the movement of adults from one field to another. Further, trap crops attract the fruit borers so as to escape the egg laying or infestation by borers on main crop. Similarly, intercrops during effective flowering period encourages the conservation of natural enemies by providing food source like pollen, nectar and shelter, making them less favorable for pests and more attractive to beneficial insects (Gopi *et al*., 2019).

Materials and Methods

The experiment was laid out at University of Horticultural Sciences, Bagalkot. Both farm yard manure (2.5 t ha^{-1}) and neem powder (2.5 q ha^{-1}) were incorporated to the soil before sowing. Okra variety, Arka Anamika seeds were procured from Indian Institute of Horticultural Research (IIHR), Bengaluru and sown by maintaining 60 x 45 cm spacing in Randomized Completely Block Design (RCBD) design with four treatments and five replications with a plot size of 6 x 4 m. In the present study, as a part of ecological engineering in okra, totally four crops were selected such as maize as barrier crop, marigold as trap crop, cowpea as border crop and coriander as intercrop/repellent crop.

Out of four crops, two border crops such as maize and marigold, 25 days old seedlings were kept ready in polythene bags for planting at the time of sowing of okra. At the time sowing of okra, two rows of 25 days old maize seedlings were transplanted along border of okra field as barrier crop followed by one row of 25 days old marigold seedlings as trap crop. Further, two rows of cowpea were sown as border crop and one row of coriander as intercrop after every five rows of okra, without affecting the plant population.

Observations on Shoot and fruit borers

(a) Shoot damage: Total number of shoots along with the infested ones were counted from five okra plants at ten days intervals and expressed as per cent shoot infestation using the following formula.

$$\text{Shoot infestation (\%)} = \frac{\text{Number of infested shoots}}{\text{Total number of shoots}} \times 100$$

(b) Fruit damage: Total number of fruits and number of damaged fruits per plant were recorded from selected plants and was expressed as per cent. The observations were recorded at ten days intervals starting from 50 days after sowing. The per cent fruit damage calculated using the below formula:

$$\text{Fruit infestation (\%)} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

Natural enemies

Total number of natural enemies like coccinellids and spiders per plant were recorded at ten days interval starting from 20 days after sowing till the final harvest of the crop on whole plant basis by visual observation. Infested fruits (bored holes on fruits by fruit borers) were collected during harvesting period, then the infested fruits reared in a cage and observed and recorded the emergence of different parasitoids.

Statistical analysis

The data collected from various experiments were subjected to suitable transformation. Further, the data was subjected to single factor ANOVA using statistical software (WASP-2) and different treatments were compared using Duncan's multiple range test (DMRT).

Table 1. Treatment details for evaluation of ecological engineering for encouragement of natural enemies against major fruit borers of okra

Sl No.	Treatments
T_1	Okra as main crop (untreated check)
T_2	Okra + Barrier crop (two rows of 25 days old maize seedlings) + Trap crop (one row of 25 days old marigold seedlings)
T_3	Okra + Border crop (two rows of cowpea) + okra intercropped with coriander (5:1)
T_4	Okra + Barrier crop (two rows of 25 days old maize seedlings) + Trap crop (one row of 25 days old marigold seedlings) + Border crop (two rows of cowpea) + okra intercropped with coriander (5:1)

Results

Ecological engineering against fruit borer *H. armiger* and shoot and fruit borer *E. vittella* in okra

The treatment T_4-okra + barrier crop (two rows of 25 days old maize seedlings) + trap crop (one row of 25 days old marigold seedlings) + border crop (two rows of cowpea) + okra intercropped with coriander (5:1) registered significantly reduced mean fruit per cent damage of *H. armigera* (17.68%) which was in turn on par with T_2 (22.76%), T_2 which was in turn on par with T_3 (28.22%) which was at par with T_1 untreated check (34.41%) (Table 2).

Among the treatments, T_4 emerged as significantly efficient by recording the lowest shoot damage of *E. vittella* 5.11 per cent. Second best treatment was T_2 (7.49%). On the contrary T_3 (10.90%) was ineffective which was on par with T_1 (13.52%) (Table 3).

The T_4 treatment was one of the outstanding treatments in reducing per cent fruit damage by *E. vittella* (7.40%) which was in turn on par with the T_2 (13.42%). However, treatment T_3 recorded (16.60%) which was at par with the T_1 untreated check (16.80%) registered highest damage (Table 4).

Ecological engineering for encouragement of natural enemies against major pests of okra

The treatment T_1 registered significantly lowest mean number of coccinellids 0.50 per plant. Whereas, treatment T_2 0.94 per plant was recorded. Second best treatment was T_3 (1.40/plant). The superior treatment was T_4 (1.95/plant) indicating effective in encouraging coccinellid population (Table 5).

The treatment T_1 registered highest spider population (0.61/plant) which was statistically on par with both treatment T_2 registered 0.52 per plant. Next best module was T_3 (0.28/plant). Whereas, T_1 registered lowest spiders (0.21/plant) (Table 6).

Discussion

Among different treatments evaluated against insect pests of okra the data presented in the tables from 2 to 6 indicated that, T_4 comprising of okra with two rows of 25 days old maize as barrier crop, one row of 25 days old marigold as trap crop, two rows of cowpea as border crop and okra intercropped with coriander (5:1) recorded significantly lowest mean of shoot damage (5.11%) and fruit damage (7.42%) by *E. vittella, H. armigera* (17.68%) as compared to other treatments. Further, T_4 treatment significantly encouraged the build-up of natural enemies like coccinellids (1.95/plant) and spiders (0.61/plant) suggesting ecological engineering as a fundamental and integral tool for inclusion in (Integrated Pest Management) IPM. Thus, T_4 treatment superiority was mainly due to excellent ecological engineering provided in the form of barrier, trap, border and intercrops which played a significant role in reducing the insect pests of okra through various means of mode of action. It is quite interesting to note that in nature, natural enemy population buildup appears to begin when pest population has attained peak status, by the time enough damage has been caused to the crop. In the present investigation, 25 days old border crops such as maize and marigold were planted along with sowing of main crop, so as to colonise and encourage the natural enemies well in advance to take care of insect pests of okra.

The suppression of pest population and encouragement of natural enemies in T_4 was mainly due to 25 days old maize crop planted at the time of sowing of okra as main crop. The maize plant acted as barrier crop that physically avoided the movement and oviposition of fruit borers. The *H. armigera* larvae attracted to maize after emergence of cobs and prefers to lay eggs and feed on cobs. Further, planting of one row of 25 days old marigold seedlings on border area acted as trap crop for *H. armigera*, *E. insulana* and *E. vittella* larvae that are migrated to marigold flowers from vegetative stage till fruit maturity stage of okra crop. Further, these larvae were easily detected by parasitoids like tachinids, braconids, *Nepiera* sp. and *Neofacydes* sp., and predators like coccinellids, spiders, crysopids, syrphids, wasps, reduviid bug and also predatory birds like yellow wagtail and cattle egret. Further, these border crops were also attracted many pollinators like honey bees and butterflies for pollination. The role played by cowpea as border crop infested with aphid population resulting in secretion of honeydew which further attracted natural enemies. Whereas, coriander as intercrop during vegetative stage repelled the fruit borers due to its odour which hindered the orientation of insect pests. The coriander plants during its peak flowering stage encouraged various natural enemies especially coccinellids by providing food like pollen, nectar and shelter which in turn suppressed the pest population. Overall, barrier, trap, border and intercrops prevented insect pests of okra not reaching to economical injury level. Further, insect pests which are supposed to be present on main crop gets diverted to border and intercrops throughout the cropping season.

Similar findings were corroborated with the authors on okra (Risch, 1981) who reported that higher level of aggregation of natural enemies in habitat manipulation mainly due to early immigration of natural enemies from the colonization source to mixed crop habitats than mono-cropping because of the greater attractiveness of mixed cropping by providing vital food, shelter and resting sites supported by Abro *et al*. (2004). Similarly, maize as border crops, marigold as trap crop, cowpea and coriander as intercrop in okra were reported to harbour higher population of coccinellids, spiders, syrphids and crysopids than the sole crop resulting in suppression of fruit borers as observed by Saxena and Basit (1982) and Nderitu *et al.* (2008). The increased parasitism might be due to the availability of host and existence of favourable microclimate in intercropped zones of the crop diversification (Risch, 1981). Similar opinion was made by Dong, (1984). The current findings were supported by Ramachandra *et al.* (2013) who stated that, intercropping may reduce pest dispersion, thus affecting the biology of the pest at different stages of its development. These results are of great significance in reducing the pest management system, as crop diversification besides giving additional economic benefit to the farmers.

Further, Altieri and Liebman (1986) confirmed that strong odour from the intercrops hinder the mechanism of orientation to the host plants by insect pests. The present results are in agreement with Abid and Magbool (1990) indicated that, coriander was the best intercrop in reducing pest populations on eggplant, due to presence of alkaloids like linalool and pinene in coriander plants likely through repelling property. Further, fruit borers attracted and trapped in marigold was mainly due to the presence of alkaloids like saponin, triterpenes, sesquiterpenes, scopoletin, flavonoids, quercetin and kaemferol in marigold favoured the attraction of more number of *H. armigera* on marigold plants as reported by Prasanna Lakshmi and Manjula (2014). Lower infestation of fruit borer on okra due to more activity of spiders and crop diversification diverting tomato fruit borer egg laying away from okra. Similarly, Prasad and Prasad (2002) reported highest per cent reduction of shoot and fruit damage in okra intercropped with maize and marigold by hindering its adult movement and then oviposition. Further, maize terminal bud infested by aphids, *Rophalosiphum maydis* secreted honeydew and herbivore induced plant volatiles (Powell *et al.*, 1998) which might have attracted coccinellids and other aphidophagous predators and parasitoids, as also reported by (Ninkovic *et al.*, 2001).

Conclusions

Among different treatments evaluated against insect pests of okra the treatment T_4 comprising of two rows of 25 days old maize as barrier crop, one row of 25 days old marigold as trap crop, two rows of cowpea as border crop and okra intercropped with coriander (5:1) recorded significantly lowest mean of shoot damage (5.11%) and fruit damage (7.42%) by *E.*

vittella and fruit borer *H. armigera* incidence (17.68%) as compared to other treatments. Further, T_4 treatment significantly encouraged the build-up of natural enemies like coccinellids (1.95/plant) and spiders (0.61/plant) suggesting ecological engineering as a fundamental and integral tool for inclusion in IPM. Thus, T_4 treatment superiority was mainly due to excellent crop diversification provided in the form of barrier, border, trap and intercrops which played a significant role in reducing the insect pests of okra through various means of mode of action. Thus, it can be concluded that integration of main crop with different barrier, trap, border and intercrops is most effective eco-friendly, economically feasible, sustainable and can be considered as an integral component of IPM.

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COMPETING INTERESTS DISCLAIMER:
Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

Table 2: Effect of ecological engineering on per cent fruit damage caused by *Helicoverpa armigera* in okra

Treatments	Fruit damage (%)						Mean
	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS	100 DAS	
T_1 - Okra as main crop (untreated check)	18.66 [c] (25.52)	34.87 [c] (36.12)	46.26 [b] (42.83)	46.63 [b] (43.05)	33.23 [c] (35.13)	26.79 [c] (31.09)	**34.41 [c] (35.85)**
T_2 - Okra + two rows maize + one row marigold	11.10 [b] (19.35)	24.13[ab] (29.28)	30.10 [a] (33.14)	32.10 [a] (34.38)	20.15 [b] (26.54)	18.96 [b] (25.68)	**22.76 [ab] (28.35)**
T_3 - Okra + two rows cowpea + okra intercropped with coriander (5:1)	14.66[bc] (22.42)	25.66 [b] (30.33)	30.92 [a] (33.68)	40.06[bc] (39.19)	29.03 [c] (32.50)	28.96 [c] (32.45)	**28.22 [bc] (31.98)**
T_4 - Okra + two rows maize + one row marigold + two rows cowpea + okra intercropped with coriander (5:1)	7.25 [a] (15.54)	18.06 [a] (25.03)	24.99 [a] (29.87)	32.39 [a] (34.58)	12.06 [a] (20.22)	11.36 [a] (19.6)	**17.68 [a] (24.75)**
S. Em ±	**1.07**	**1.61**	**1.96**	**2.21**	**1.58**	**1.41**	**1.62**
C.D. at 5%	**3.23**	**4.93**	**5.96**	**6.65**	**4.76**	**4.55**	**4.83**

DAS; Days After Sowing, S. Em ±; Standard Error Mean, CD; Critical Difference

Figures in parenthesis indicate arc sine transformed values; In a column, means followed by same alphabet do not differ significantly (P=0.05) by DMRT

Note: 25 days old maize as barrier crop, 25 days old marigold as trap crop, cowpea as border crop and okra intercropped with coriander (5:1)

Table 3: Effect of ecological engineering on the per cent shoot damage caused by *Earias vittella* in okra.

Treatments	Shoot damage (%)				Mean
	40 DAS	50 DAS	60 DAS	70 DAS	
T_1 - Okra as main crop (untreated check)	10.94 [b] (19.25)	13.96 [c] (21.87)	17.09 [c] (24.36)	12.09 [c] (20.30)	**13.52 [c] (21.50)**
T_2 - Okra + two rows maize + one row marigold	5.10 [a] (12.97)	6.25 [a] (14.39)	10.37 [b] (18.74)	8.23 [b] (16.63)	**7.49 [b] (15.79)**
T_3 - Okra + two rows cowpea + okra intercropped with coriander (5:1)	9.05 [b] (17.43)	10.17 [b] (18.52)	13.25 [b] (21.26)	11.15 [c] (19.43)	**10.90 [c] (19.19)**
T_4 - Okra + two rows maize + one row marigold + two rows cowpea + okra intercropped with coriander (5:1)	4.11 [a] (11.63)	5.10 [a] (12.98)	6.12 [a] (14.24)	5.12 [a] (13.00)	**5.11 [a] (12.99)**
S. Em±	**0.76**	**0.86**	**0.9**	**0.78**	**0.87**
C.D. at 5%	**2.30**	**2.60**	**2.67**	**2.37**	**2.68**

DAS; Days After Sowing, S. Em ±; Standard Error Mean, CD; Critical Difference

Figures in parenthesis indicate arc sine transformed values; In a column, means followed by same alphabet do not differ significantly (P=0.05) by DMRT

Note: 25 days old maize as barrier crop, 25 days old marigold as trap crop, cowpea as border crop and okra intercropped with coriander (5:1)

Table 4: Effect of ecological engineering on per cent fruit damage caused by *Earias vittella* in okra

Treatments	Fruit damage (%)						Mean
	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS	100 DAS	
T_1 - Okra as main crop (untreated check)	9.33 [c] (17.72)	14.03 [b] (21.92)	23.03 [b] (28.62)	25.06 [b] (29.96)	19.25 [c] (25.97)	10.09 [c] (18.46)	**16.80 [b] (24.12)**
T_2 - Okra + two rows maize + one row marigold	5.06 [a] (12.92)	12.01 [b] (20.16)	19.10 [b] (25.86)	24.09 [b] (29.25)	13.03 [b] (21.12)	7.25 [b] (15.52)	**13.42[ab] (21.37)**
T_3 - Okra + two rows cowpea + okra intercropped with coriander (5:1)	7.13 [b] (15.42)	13.13 [b] (21.16)	20.42 [b] (26.77)	24.13 [b] (29.32)	14.06 [b] (21.92)	7.06 [b] (15.34)	**14.32[bc] (22.14)**
T_4 - Okra + two rows maize + one row marigold + two rows cowpea + okra intercropped with coriander (5:1)	4.03 [a] (11.52)	8.03 [a] (16.38)	11.19 [a] (19.44)	13.16 [a] (21.17)	6.03 [a] (14.14)	2.05 [a] (8.18)	**7.40 [a] (18.5)**
S. Em±	**0.70**	**1.03**	**1.13**	**1.46**	**0.90**	**0.73**	**0.98**
C.D. at 5%	**2.11**	**3.10**	**3.40**	**4.40**	**2.80**	**2.21**	**2.96**

DAS; Days After Sowing, S. Em ±; Standard Error Mean, CD; Critical Difference

Figures in parenthesis indicate arc sine transformed values; In a column, means followed by same alphabet do not differ significantly (P=0.05) by DMRT

Note: 25 days old maize as barrier crop, 25 days old marigold as trap crop, cowpea as border crop and okra intercropped with coriander (5:1)

Table 5: Impact of ecological engineering on coccinellids in okra

Treatments	Number of coccinellids/plant								Mean
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS	100 DAS	
T_1 - Okra as main crop (untreated check)	0.10 [b] (0.77)	0.15 [d] (0.80)	0.23 [c] (0.85)	0.52 [c] (1.01)	0.63 [d] (1.06)	0.95 [c] (1.20)	0.80 [c] (1.13)	0.60 [c] (1.04)	**0.50 [d] (1.00)**
T_2 - Okra + two rows maize + one row marigold	0.10 [b] (0.77)	0.32 [c] (0.90)	0.43 [b] (0.96)	1.04 [b] (1.23)	1.40 [c] (1.37)	1.88 [b] (1.53)	1.21[c] (1.30)	1.10 [b] (1.26)	**0.94 [c] (1.19)**
T_3 - Okra + two rows cowpea + okra intercropped with coriander (5:1)	0.40 [a] (0.97)	0.50 [b] (1.00)	0.85 [a] (1.16)	1.68 [a] (1.47)	2.16 [b] (1.62)	2.52 [b] (1.73)	1.88 [b] (1.53)	1.24[ab] (1.31)	**1.40 [b] (1.37)**
T_4 - Okra + two rows maize + one row marigold + two rows cowpea + okra intercropped with coriander (5:1)	0.50 [a] (1.00)	0.70 [a] (1.09)	0.90 [a] (1.18)	2.08 [a] (1.60)	3.25 [a] (1.93)	3.80 [a] (2.06)	2.84 [a] (1.82)	1.50 [a] (1.41)	**1.95 [a] (1.56)**
S. Em±	**0.03**	**0.04**	**0.04**	**0.05**	**0.06**	**0.07**	**0.06**	**0.05**	**0.05**
C.D. at 5%	**0.06**	**0.12**	**0.13**	**0.15**	**0.19**	**0.21**	**0.19**	**0.16**	**0.14**

DAS; Days After Sowing, S. Em ±; Standard Error Mean, CD; Critical Difference

Figures in parenthesis indicate arc sine transformed values; In a column, means followed by same alphabet do not differ significantly (P=0.05) by DMRT

Note: 25 days old maize as barrier crop, 25 days old marigold as trap crop, cowpea as border crop and okra intercropped with coriander (5:1)

Table 6: Impact of ecological engineering on spiders in okra

Treatments	Number of spiders/plant								Mean
	30 DAS	**40 DAS**	**50 DAS**	**60 DAS**	**70 DAS**	**80 DAS**	**90 DAS**	**100 DAS**	
T_1 - Okra as main crop (untreated check)	0.10 [d] (0.77)	0.16 [b] (0.81)	0.25 [c] (0.86)	0.30 [b] (0.89)	0.33 [b] (0.91)	0.21 [b] (0.84)	0.26 [b] (0.87)	0.10 [c] (0.77)	**0.21 [b] (0.84)**
T_2 - Okra + two rows maize + one row marigold	0.30 [b] (0.89)	0.40 [a] (0.94)	0.50 [a] (1.00)	0.57 [a] (1.03)	0.70 [a] (1.09)	0.80 [a] (1.13)	0.50 [a] (1.00)	0.40 [a] (0.94)	**0.52 [a] (1.00)**
T_3 - Okra + two rows cowpea + okra intercropped with coriander (5:1)	0.18 [c] (0.82)	0.25 [b] (0.86)	0.37 [b] (0.93)	0.35 [b] (0.99)	0.38 [b] (0.93)	0.25 [b] (0.86)	0.28 [b] (0.88)	0.20 [b] (0.83)	**0.28 [b] (0.88)**
T_4 - Okra + two rows maize + one row marigold + two rows cowpea + okra intercropped with coriander (5:1)	0.40 [a] (0.95)	0.49 [a] (0.99)	0.60 [a] (1.04)	0.65 [a] (1.06)	0.80 [a] (1.13)	0.87 [a] (1.16)	0.58 [a] (1.03)	0.50 [a] (1.00)	**0.61 [a] (1.05)**
S. Em±	**0.01**	**0.03**	**0.03**	**0.04**	**0.03**	**0.04**	**0.02**	**0.03**	**0.02**
C.D. at 5%	**0.03**	**0.09**	**0.10**	**0.13**	**0.10**	**0.13**	**0.06**	**0.06**	**0.06**

DAS; Days After Sowing, S. Em ±; Standard Error Mean, CD; Critical Difference

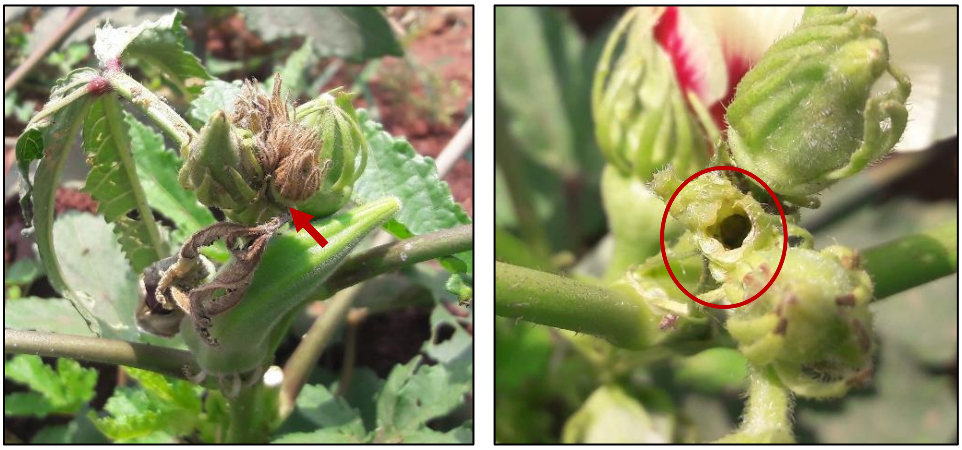
Figures in parenthesis indicate arc sine transformed values; In a column, means followed by same alphabet do not differ significantly (P=0.05) by DMRT

Note: 25 days old maize as barrier crop, 25 days old marigold as trap crop, cowpea as border crop and okra intercropped with coriander (5:1)

a. ***H. armigera*** **damage on young fruit**

A. ***H. armigera*** **damage on matured okra fruit**

Fig. 1. Infestation of *H. armigera* on okra in untreated check



A. Shoot damage by *Earias vittella*

B. Shoot and bud damage by *Earias vittella*

C. Adult *Earias vittella*

D. Adult *Earias insulana*

Fig. 2. Severity of shoot and fruit borer on okra in untreated check

A. ***Nepiera*** **sp.**

B. ***Neofacydes*** **sp.**

C. ***Bracon*** **sp.**

D. Magnified view ***Bracon*** **sp.**

E. Tachinid fly

F. ***Glyptapanteles*** **sp.**

Fig.3. Parasitoids recorded in crop diversification in okra ecosystem

A. *Helicoverpa armigera* larvae on trap crop

B. 1st time recorded the *E. insulana* adults attracted towards trap crop (Marigold) for egg laying

C. **Cattle Egret**

D. Yellow wagtail

E. **Reduviid bug**

F. **Wasp, *Delta conodeum***

G. Honey bees

H. Helicoverpa armigera damage on cobs

Fig.4. Trapped insects, predatory birds, predators and pollinators in okra ecosystem

a. Marigold as trap crop and maize as barrier crop

b. Coriander as repellent crop

c. Cowpeas as inter crop

Fig. 5. Field view