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Influence of intercrops and decoy crops on incidence of fall armyworm (*Spodoptera frugiperda*), (intercrops and trap crops) in maize crop

MV Matti, CP Mallapur and DN Kambrekar

Abstract
Influence of intercrops and trap crops on incidence of fall armyworm (*Spodoptera frugiperda*), (intercrops and trap crops) in maize crop was evaluated by carrying out field experiments during *kharif* 2019 and 2020 at Main Agricultural Research Station, Dharwad. Different maize based inter crops were planted in 1:1 ratio, by following Randomized Block Design (RBD) with eleven treatments replicated thrice. The popular maize hybrid, NK-6240 was sown in plot size of 5 × 4m at a spacing of 60 × 20 cm for each treatment.

The intercrops and trap crops assessment against FAW in field that the egg masses, larval population, defoliation and pest infestation were recorded maximum in case of Napier grass (trap crop) as border crop with maize intercropped with cowpea, French bean in which maize as main crop. Whereas, in the treatments such as maize intercropped with sweet corn, maize with maize as boarder crop (15 days after sowing) and maize as boarder crop (30 days after sowing) were recorded higher of egg masses, larval population, defoliation, pest infestation and cob damage. The maximum number of natural enemies were recorded in the treatment in maize intercropped with cowpea along with Napier grass as border crop. Whereas, none of egg masses, larval population, defoliation, pest infestation, cob damage and natural enemies in the treatments such as maize intercropped with cowpea, maize intercropped with French bean, maize intercropped with soybean and maize intercropped with groundnut.

Keywords: *Spodoptera frugiperda*, maize, Napier grass, cowpea, French bean, sweet corn

Introduction
Maize is commonly called as “Queen of cereals”. In India maize is cultivated to serve various purposes like human consumption, cattle and poultry feed, food processing and in the extraction of starch, dextrose, corn syrup, corn oil *etc*. by various industries. In India, maize is cultivated in an area of 96.33 million hectares with a production of 258.99 million tonnes and productivity of 2.69 tonnes per hectare. In Karnataka, maize is cultivated over an area of 13.70 million hectares with a production and productivity of 33.14 million tonnes and 2.42 tonnes per hectare, respectively (Anon., 2017) [10].

Currently, about 1147.7 million tonnes of maize is being produced together by over 170 countries with an average productivity of 5.75 t/ha (Anon., 2020) [3]. Maize production in India increased from 5101 thousand tonnes in 1971 to 31990 thousand tonnes in 2020 growing at an average annual rate of 4.67 per cent. In India maize is cultivated in area of 9.89 m.ha with production of 31.65 MT and productivity of 3.19 t/ha. In Karnataka, maize is cultivated over an area of 1.38 m.ha with a production of 3.96 MT and productivity of 3.48 t/ha (Anon., 2020) [3]. The fall armyworm, *S. frugiperda* is a polyphagous insect pest that can feed on plants from more than 20 families but it displays a preference for plants of the family Poaceae (Luginbill, 1928) [11].

Day *et al.* (2017) [5] reported 20-50 per cent maize yield loss in Africa and stated that current trade and transportation routes particularly through Australia, China, India, Indonesia, Malaysia, Philippines and Thailand, face high threat of FAW invasions originating from Africa. They also added that South and Southeast Asia and Australia have a favourable climate that would permit FAW to invade these regions. The pest was first reported from India by Sharanabasappa *et al.* (2018) [9] wherein the pest was presumed to be migrated from African continent after its first confirmed reports from West Africa in early 2016 (Goergen *et al*., 2016 [6] and Cock *et al*., 2017) [5]. In India, the infestation of FAW ranged from 2 to 35 per cent in maize (Naganna *et al.*, 2020) [8]. Infestation of FAW on maize in northern Karnataka ranged from 6.00 to 100 per cent during *kharif*, 2018 (Mallapur *et al*., 2018) [7].

FAW poses a serious threat to crops other than maize due to its capacity to survive on wide range of hosts. In this context the present study was conducted to monitor the infestation of FAW on different crops.

Material and methods

Influence of different inter crops and trap crops in maize against fall armyworm was evaluated by carrying out field experiments during *kharif* 2019 and 2020 at Main Agricultural Research Station, Dharwad. Different maize based inter crops were planted in 1:1 ratio, by following Randomized Block Design (RBD) with eleven treatments replicated thrice. The popular maize hybrid, NK-6240 was sown in plot size of 5 × 4m at a spacing of 60 × 20 cm for each treatment. The crop was raised as per recommended package including plant protection measures except for target pest.

Observations on egg masses, per cent defoliation and per cent cob damage were recorded randomly on 20 plants in each treatment at 15 days interval after germination. Observations on number of larvae and natural enemies (predators, parasitized larvae and larval cadavers affected by diseases) were taken on 10 randomly selected plants in each treatment at 15 days interval and per cent pest infestation on whole plot basis were recorded at 15 days interval. The grain yield of maize from individual treatment was recorded separately and converted to hectare basis.

Table 1: Inter crop and trap crop treatment details

Tr. No	Treatment
T_1	Maize + Cowpea (Var. DC-15) (intercrop 1:1)
T_2	Maize + French bean (Var. Anupama) (intercrop 1:1)
T_3	Maize + Soybean (Var. JS 335) (intercrop 1:1)
T_4	Maize + Groundnut (Var. G2-52) (intercrop 1:1)
T_5	Maize + Sweet corn (Var. Misthi) (intercrop 1:1)
T_6	Maize + Napier grass (Var. CoBN-5) as border crop
T_7	Maize + French bean intercrop + Napier grass as border crop
T_8	Maize + cowpea intercrop + Napier grass as border crop
T_9	Maize + Maize sowing after 15 days as border crop
T_{10}	Maize + Maize sowing after 30 days as border crop
T_{11}	Sole Maize

Results

a) Number of egg masses

The data from table.2 indicated significant difference among different treatments up to 150 days of sowing although there was numerical variation between different treatments at 15, 30, 45 and 60 DAG. At 120 DAG, numerically no egg masses could be recorded in T_1 Maize + Cowpea, T_2 Maize + French Bean, T_3 Maize + Soybean, T_4 Maize + Groundnut, T_5 Maize + Sweet Corn, T_9 Maize + Maize 15 days after sowing, T_{10} Maize + Maize 30 days after sowing and T_{11} Sole Maize. However, in treatments such as T_6 Maize + Napier Grass, T_7 Maize + French Bean + Napier Grass and T_8 Maize + cowpea + Napier Grass the highest number of egg masses were recorded. Maize + Napier Grass treatment (T_6) recorded as high as 22.67 egg masses per 20 plants at 150 DAG in which at par with Maize + French Bean + Napier Grass (T_7) and Maize + cowpea + Napier Grass (T_8).

Influence of intercrops and trap crops in maize on fall armyworm incidence

Table 2: Effect of intercrops and trap crops in maize on fall armyworm oviposition (Intercrops and trap crops) (Pooled Data)

		Number of egg masses per 20 plants									
Tr. No	**Treatments**	**15 DAG**	**30 DAG**	**45 DAG**	**60 DAG**	**75 DAG**	**90 DAG**	**105 DAG**	**120 DAG**	**135 DAG**	**150 DAG**
1	Maize + Cowpea	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)d	0.00 (1.00)e	0.00 (1.00)e	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
2	Maize + French Bean	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)d	0.00 (1.00)e	0.00 (1.00)e	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
3	Maize + Soybean	0.00 (1.00) b	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)d	0.00 (1.00)e	0.00 (1.00)e	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
4	Maize + Groundnut	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)d	0.00 (1.00)e	0.00 (1.00)e	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
5	Maize + Sweet Corn	0.00 (1.00)b	5.33 (2.51)a	7.17 (2.84)a	8.83 (3.19)ab	5.83 (2.59)cd	0.00 (1.00)e	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
6	Maize + Napier Grass	3.17 (2.03)a	5.33 (2.51)a	7.50 (2.91)a	9.17 (3.26)a	11.00 (3.46)ab	13.83 (3.84)a	16.50 (4.17)a	18.33 (4.38)a	20.00 (4.58)a	22.67 (4.86)a
7	Maize + French Bean + Napier Grass	2.83 (2.03)a	4.50 (2.34)a	7.00 (2.82)a	9.67 (3.11)a	11.67 (3.55)a	14.00 (3.87)a	14.67 (3.95)a	17.17 (4.26)a	18.67 (4.43)a	21.67 (4.75)a
8	Maize + cowpea + Napier Grass	2.17 (1.77)a	4.67 (2.33)a	7.00 (2.82)a	8.67 (2.40)ab	10.67 (3.40)ab	11.50 (3.53)b	15.00 (4.00)a	17.33 (4.27)a	19.33 (4.48)a	20.67 (4.62)a
9	Maize + Maize 15 days after sowing	0.00 (1.00)b	2.00 (1.73)b	3.00 (1.98)b	4.83 (2.39)b	7.83 (2.95)bc	4.33 (2.28)d	6.50 (2.72)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
10	Maize + Maize sowing after 30 days	0.00 (1.00)b	0.00 (1.00)c	2.50 (1.84)b	4.83 (2.39)c	6.67 (2.74)c	7.33 (2.88)c	6.50 (2.72)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
11	Sole Maize	3.33	4.00	5.50	7.00	3.67	0.00	0.00	0.00	0.00	0.00

		(2.08)a	(2.22)a	(2.55)a	(2.82)b	(2.15)d	(1.00)e	(1.00)c	(1.00)b	(1.00)b	(1.00)b
	SEM. ±	0.11	0.13	0.15	0.12	0.18	0.12	0.11	0.09	0.16	0.14
	CD (p=0.05)	0.33	0.41	0.46	0.37	0.54	0.38	0.33	0.28	0.49	0.42
	C.V. (%)	12.91	13.73	13.19	9.53	13.45	10.56	9.32	8.22	13.62	11.58

Note: DAS – Days After Sowing
Figures within the parenthesis indicates square root transformation

b) Larval population

The larval population was significantly zero in T_1 to T_4 treatments at 15 to 150 DAG. Almost similar trend was observed during further observation intervals but however, during the peak infestation period (at 60 DAG) significantly higher larval load (2.38 larvae/pl) was observed in T_5 Maize + Sweet Corn which was on par with sole maize (T_{11}) treatment. In other treatments, the larval number varied from 0.45 to 1.00 larvae/pl. At 105 DAG, the larval population varied from 0.23 to 1.00 larvae/pl in different treatments (Table 3) but T_6 Maize + Napier Grass found to be on par with T_7 Maize + French Bean + Napier Grass and T_8 Maize + cowpea + Napier Grass. Whereas, T_9 Maize + Maize 15 days after sowing and T_{10} Maize + Maize 30 days after sowing. At 135 DAG, larval population was significantly 1.65 to 1.68 in T_6 to T_8 treatments but at par with each other.

Table 3: Effect of intercrops and trap crops in maize on fall armyworm larvae on maize (Intercrops and trap crops) (Pooled data)

		Number of Larvae per 10 plants									
Tr. No	**Treatments**	**15 DAG**	**30 DAG**	**45 DAG**	**60 DAG**	**75 DAG**	**90 DAG**	**105 DAG**	**120 DAG**	**135 DAG**	**150 DAG**
1	Maize + Cowpea	0.00 (1.00)d	0.00 (1.00)d	0.00 (1.00)d	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
2	Maize + French Bean	0.00 (1.00)d	0.00 (1.00)d	0.00 (1.00)d	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
3	Maize + Soybean	0.00 (1.00)d	0.00 (1.00)d	0.00 (1.00)d	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
4	Maize + Groundnut	0.00 (1.00)d	0.00 (1.00)d	0.00 (1.00)d	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
5	Maize + Sweet Corn	0.87 (1.36)ab	1.52 (1.56)a	2.08 (1.73)a	2.38 (1.82)a	1.63 (1.61)a	0.73 (1.31)a	0.55 (1.24)b	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
6	Maize + Napier Grass	0.50 (1.22)bc	0.63 (1.27)abcd	0.85 (1.35)bc	1.00 (1.40)b	1.17 (1.45)ab	1.40 (1.53)a	1.57 (1.58)a	1.65 (1.61)a	1.82 (1.61)a	1.90 (1.66)a
7	Maize + French Bean + Napier Grass	0.50 (1.22)bcc	0.72 (1.31)abc	0.87 (1.36)bc	0.97 (1.40)b	1.12 (1.44)ab	1.23 (1.48)a	1.43 (1.55)a	1.58 (1.60)a	1.68 (1.60)a	1.83 (1.62)a
8	Maize + cowpea + Napier Grass	0.47 (1.20)c	0.58 (1.25)bcd	0.73 (1.31)c	0.83 (1.34)b	1.00 (1.40)ab	1.18 (1.46)a	1.38 (1.53)a	1.48 (1.57)a	1.65 (1.57)a	1.77 (1.61)a
9	Maize + Maize 15 days after sowing	0.00 (1.00)d	0.23 (1.11)cd	0.37 (1.17)cd	0.60 (1.26)bc	0.75 (1.32)ab	0.88 (1.37)a	0.23 (1.05)bc	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
10	Maize + Maize sowing after 30 days	0.00 (1.00)d	0.00 (1.00)d	0.28 (1.13)cd	0.45 (1.20)bc	0.65 (1.28)b	0.80 (1.33)a	0.30 (1.14)bc	0.18 (1.09)b	0.00 (1.00)b	0.00 (1.00)b
11	Sole Maize	0.95 (1.42)a	1.27 (1.49)ab	1.60 (1.61)ab	2.43 (1.85)a	1.48 (1.54)ab	0.80 (1.33)a	0.58 (1.25)b	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
	SEm. ±	0.05	0.10	0.09	0.10	0.10	0.10	0.09	0.08	0.08	0.09
	CD (p=0.05)	0.17	0.32	0.29	0.32	0.32	0.31	0.27	0.23	0.23	0.28
	C.V. (%)	8.25	15.37	13.15	14.02	13.88	13.75	12.49	11.15	11.15	13.33

Note: DAS – Days After Sowing
Figures within the parenthesis indicates square root transformation values

c) Defoliation (%)

At 15 DAG, no defoliation was observed in T_1, T_2, T_3, T_4, T_9 and T_{10} which stood on par with each other except T_6, T_7, T_8 and T_{11} treatments. The extent of defoliation increased gradually with the same trend in different treatments and the peak defoliation was observed during 75 DAG. The treatment T_8 with 39.96 per cent defoliation stood on par with T_5 treatment. A maximum of 49.17 per cent defoliation was recorded in T_6 which was found on par with T_7 treatment. After 90 DAG onwards, there was declining rate of defoliation in T_5, T_9, T_{10} and T_{11} treatments. At 105 DAG, T_6 treatment recorded significantly higher defoliation (59.00 %) while, in the remaining treatments, defoliation varied from 16.89 to 56.00 per cent (Table 4). After 120 DAG, there was increasing rate of defoliation in T_6, T_7 and T_8 treatments. Whereas, in other remaining treatments no defoliation was recorded.

Table 4: Effect of intercrops and trap crops in maize on fall armyworm defoliation (%) on maize (Intercrops and trap crops), (Pooled data)

Defoliation (%) per 20 plants											
Tr. No	**Treatments**	**15 DAG**	**30 DAG**	**45 DAG**	**60 DAG**	**75 DAG**	**90 DAG**	**105 DAG**	**120 DAG**	**135 DAG**	**150 DAG**
1	Maize + Cowpea	0.00 (0.00)c	0.00 (0.00)e	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)e	0.00 (0.00)f	0.00 (0.00)e	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)c
2	Maize + French Bean	0.00 (0.00)c	0.00 (0.00)e	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)e	0.00 (0.00)f	0.00 (0.00)e	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)c
3	Maize + Soybean	0.00 (0.00)c	0.00 (0.00)e	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)e	0.00 (0.00)f	0.00 (0.00)e	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)c
4	Maize + Groundnut	0.00 (0.00)c	0.00 (0.00)e	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)e	0.00 (0.00)f	0.00 (0.00)e	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)c
5	Maize + Sweet Corn	19.92 (26.48)a	28.25 (32.08)ab	32.38 (34.65)bc	37.83 (37.93)ab	41.17 (39.88)b	38.33 (38.21)c	25.08 (29.94)c	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)c
6	Maize + Napier Grass	14.71 (22.53)b	23.96 (29.25)bc	34.13 (35.72)ab	39.83 (39.12)ab	49.17 (44.50)a	54.38 (47.50)a	59.00 (50.21)a	62.63 (52.34)a	67.04 (54.96)a	70.88 (57.33)c
7	Maize + French Bean + Napier Grass	13.71 (21.71)b	25.00 (29.95)bc	32.17 (34.50)ab	37.21 (37.56)ab	45.29 (42.28)ab	51.08 (45.61)a	56.00 (48.45)ab	61.25 (51.49)ab	66.25 (54.55)ab	70.63 (57.19)a
8	Maize + cowpea + Napier Grass	13.50 (21.53)b	20.79 (27.07)c	29.71 (32.99)b	34.46 (35.88)b	39.96 (39.18)b	44.63 (41.89)b	49.75 (44.84)b	55.25 (48.00)b	60.46 (51.02)b	67.00 (55.15)a
9	Maize + Maize 15 days after sowing	0.00 (0.00)c	15.29 (22.93)d	20.88 (27.11)c	27.50 (31.42)c	33.88 (35.57)c	28.50 (32.25)d	20.75 (26.97)cd	12.25 (20.36)d	0.00 (0.00)d	0.00 (0.00)c
10	Maize + Maize sowing after 30 days	0.00 (0.00)c	0.00 (0.00)e	15.21 (22.72)d	23.92 (29.21)c	31.88 (34.43)cd	36.75 (37.28)c	25.50 (30.21)c	19.25 (25.88)c	13.88 (21.55)c	0.00 (0.00)c
11	Sole Maize	20.08 (26.55)a	33.38 (35.20)a	38.25 (38.12)a	43.46 (41.20)c	27.33 (31.43)d	21.67 (27.52)e	16.83 (23.88)d	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)c
	SEM. ±	0.62	1.16	1.45	1.47	1.15	1.21	1.40	1.23	1.27	1.40
	CD (p=0.05)	1.92	3.58	4.46	4.52	3.54	3.74	4.33	3.80	3.93	4.30
	C.V. (%)	9.98	12.54	12.22	11.07	8.20	8.56	10.51	11.86	13.34	15.67

Note: DAS – Days After Sowing
Figures within the parenthesis are arc transformed values

d) Pest infestation

Significantly higher FAW infestation (32.11 %) was observed in T_6 which was on par with other treatments except T_{11}. In contrast, the lowest infestation was noticed in T_5 which stood at par with T_8 treatment. The rate of pest infestation increased with the time but trend of infestation intensity remained almost similar. During peak infestation (at 60 DAG), as high as 87.74 per cent infestation was observed in T_{11}. All other treatments remained significantly on par among themselves with the pest infestation ranging from 76.46 per cent in T_6 to 57.34 per cent in T_8 (Table 5). After 90 DAG, the infestation level in different treatments started declining and finally at 105 DAG, a maximum of 41.95 per cent infestation was recorded in T_{11} treatment except T_5, T_9, T_{10}, T_8, T_7 and T_6 treatments (27.30, 41.17, 63.26, 67.60, 75.05 and 79.52 %). At 150 DAG, no pest infestation was recorded in the treatments such as T_1, T_2, T_3, T_4, T_5, T_9 and T_{10} except in the treatments such as T_8, T_7 and T_6 infestation was increasing trend.

Table 5: Effect of intercrops and trap crops in maize on fall armyworm Infestation (%) on maize (Intercrops and trap crops), (Pooled Data)

Pest Infestation (%) per Plot											
Tr. No	**Treatments**	**15 DAG**	**30 DAG**	**45 DAG**	**60 DAG**	**75 DAG**	**90 DAG**	**105 DAG**	**120 DAG**	**135 DAG**	**150 DAG**
1	Maize + Cowpea	0.00 (0.00)c	0.00 (0.00)d	0.00 (0.00)e	0.00 (0.00)f	0.00 (0.00)d	0.00 (0.00)d	0.00 (0.00)f	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)d
2	Maize + French Bean	0.00 (0.00)c	0.00 (0.00)d	0.00 (0.00)e	0.00 (0.00)f	0.00 (0.00)d	0.00 (0.00)d	0.00 (0.00)f	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)d
3	Maize + Soybean	0.00 (0.00)c	0.00 (0.00)d	0.00 (0.00)e	0.00 (0.00)f	0.00 (0.00)d	0.00 (0.00)d	0.00 (0.00)f	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)d
4	Maize + Groundnut	0.00 (0.00)c	0.00 (0.00)d	0.00 (0.00)e	0.00 (0.00)f	0.00 (0.00)d	0.00 (0.00)d	0.00 (0.00)f	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)d
5	Maize + Sweet Corn	18.56 (25.40)b	37.67 (37.73)b	54.61 (47.62)b	64.72 (53.69)cd	64.57 (53.52)c	46.72 (43.09)c	27.30 (31.32)e	0.00 (0.00)e	0.00 (0.00)d	0.00 (0.00)d
6	Maize + Napier Grass	32.11 (34.50)a	50.74 (45.41)a	63.73 (52.97)b	76.46 (60.96)b	84.77 (67.08)a	84.79 (67.29)a	79.52 (63.12)a	60.87 (51.26)a	43.64 (41.32)a	30.60 (33.56)a
7	Maize + French Bean + Napier Grass	28.80 (32.42)a	41.22 (39.92)b	54.27 (47.44)bc	63.45 (52.85)cd	77.79 (61.95)ab	81.19 (64.34)ab	75.05 (60.02)ab	52.14 (46.22)b	39.00 (38.62)a	24.76 (29.82)b
8	Maize + cowpea + Napier Grass	20.31 (26.76)b	35.76 (36.70)b	44.55 (41.85)c	57.34 (49.20)de	70.17 (57.01)bc	74.07 (59.41)b	67.60 (55.31)bc	52.74 (46.56)b	32.80 (34.84)b	14.77 (22.47)c
9	Maize + Maize 15 days after sowing	0.00 (0.00)c	26.57 (30.99)b	55.48 (48.13)b	68.39 (55.78)bc	73.23 (58.85)b	56.76 (49.07)c	41.17 (39.78)d	24.50 (29.63)d	11.24 (19.55)c	0.00 (0.00)d
10	Maize + Maize sowing after 30 days	0.00 (0.00)c	0.00 (0.00)d	32.24 (34.54)d	47.40 (43.49)e	72.36 (58.27)bc	78.79 (62.74)ab	63.26 (52.69)c	45.40 (42.34)c	12.42 (32.42)b	0.00 (0.00)d
11	Sole Maize	31.07	52.63	74.81	87.74	73.13	53.33	41.95	0.00	0.00	0.00

		(33.86)a	(46.52)a	(60.52)a	(70.34)a	(58.91)b	(46.89)c	(40.34)d	(0.00)e	(0.00)d	(0.00)d
	SEM. ±	0.79	1.53	1.91	2.18	1.78	2.35	1.82	0.97	1.10	0.68
	CD (p=0.05)	2.44	4.71	5.88	6.72	5.48	7.25	5.61	2.98	3.40	2.10
	C.V. (%)	9.85	1.53	10.92	10.75	8.16	11.42	10.13	8.53	12.59	15.16

Note: DAS – Days After Sowing
Figures within the parenthesis are arc transformed value

e) Natural enemies

Significantly higher natural enemies were recorded in T_8 at all observation intervals. During peak natural enemy activity (60 DAG), the maximum natural enemy population (2.00 insects/ pl) was noticed in T_8. In the remaining treatments, the natural enemy population varied from 0.67 to 0.90 insects/pl with no statistically difference among themselves. No natural enemy activity was observed at 120 DAG onwards in any of the treatments (Table 6). In the treatments such as T_1, T_2, T_3 and T_4 no natural enemies were recorded at 15 DAG to 150 DAG.

Table 6: Influence of Intercrops and trap crops on population of natural enemies in different crop ecosystems (pooled data) (Intercrops and trap crops)

Number of Natural Enemies per 10 plants											
Tr. No	**Treatments**	**15 DAG**	**30 DAG**	**45 DAG**	**60 DAG**	**75 DAG**	**90 DAG**	**105 DAG**	**120 DAG**	**135 DAG**	**150 DAG**
1	Maize + Cowpea	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
2	Maize + French Bean	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
3	Maize + Soybean	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
4	Maize + Groundnut	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
5	Maize + Sweet Corn	0.32 (1.15)c	0.45 (1.20)c	0.63 (1.27)ab	0.77 (1.33)ab	0.42 (1.19)a	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b	0.00 (1.00)b
6	Maize + Napier Grass	0.38 (1.17)c	0.55 (1.24)c	0.65 (1.28)ab	0.72 (1.30)ab	0.42 (1.19)a	0.72 (1.31)a	0.87 (1.37)a	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)c
7	Maize + French Bean + Napier Grass	0.45 (1.20)c	0.67 (1.29)c	0.62 (1.27)ab	0.77 (1.33)ab	0.63 (1.28)a	0.77 (1.32)a	0.88 (1.35)a	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)c
8	Maize + cowpea + Napier Grass	1.20 (1.47)c	1.57 (1.59)c	1.80 (1.66)ab	2.00 (1.72)ab	1.38 (1.54)a	0.87 (1.37)bc	1.02 (1.42)a	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)c
9	Maize + Maize 15 days after sowing	0.32 (1.14)c	0.48 (1.21)c	0.65 (1.28)bc	0.67 (1.29)bc	0.40 (1.18)a	0.25 (1.12)ab	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)c
10	Maize + Maize sowing after 30 days	0.27 (1.12)c	0.47 (1.21)c	0.58 (1.26)bc	0.75 (1.32)bc	0.38 (1.18)a	0.63 (1.27)c	0.27 (1.12)b	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)c
11	Sole Maize	0.22 (1.10)c	0.50 (1.22)c	0.70 (1.30)a	0.90 (1.38)a	0.58 (1.25)a	0.00 (1.00)c	0.00 (1.00)b	0.00 (1.00)c	0.00 (1.00)c	0.00 (1.00)c
	SEM. ±	0.07	,0.09	0.09	0.07	0.06	0.06	0.05	0.00	0.08	0.09
	CD (p=0.05)	0.22	0.27	0.29	0.22	0.20	0.17	0.16	NS	NS	NS
	C.V. (%)	10.05	11.77	12.13	8.90	8.59	8.59	8.29	0.00	11.15	13.33

Note: DAS – Days After Sowing
Figures within the parenthesis indicates square root transformation values

f) Cob damage

Maximum cob damage (39.17 %) was recorded in T_5 at 75 DAG. With a minimum cob damage of 25.00 per cent, T_9 treatment. Further observations made at 90 and 105 DAG revealed similar trend of cob damage in different treatments. During peak infestation (105 DAG), as high as 50.00 per cent cob damage was recorded in T_5 which was at par with T_{11} treatment. On the contrary, T_9 treatment with 38.33 per cent cob damage stood on par with T_{10} (40.00 %) treatments (Table 7).

Table 7: Influence of Intercrops and trap crops on Cob Damage (%) in different crop ecosystems (pooled data) (Intercrops and trap crops)

Cob Damage (%) per 20 plants							
Tr. No	**Treatments**	**15 DAG**	**30 DAG**	**45 DAG**	**60 DAG**	**75 DAG**	**90 DAG**
1	Maize + Cowpea	0.00 (0.00)c	0.00 (0.00)e	0.00 (0.00)c	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
2	Maize + French Bean	0.00 (0.00)c	0.00 (0.00)e	0.00 (0.00)c	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
3	Maize + Soybean	0.00 (0.00)c	0.00 (0.00)e	0.00 (0.00)c	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
4	Maize + Groundnut	0.00 (0.00)c	0.00 (0.00)e	0.00 (0.00)c	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
5	Maize + Sweet Corn	39.17 (38.69)a	45.83 (42.59)a	50.00 (44.98)a	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
6	Maize + Napier Grass	0.00 (0.00)c	0.00 (0.00)e	0.00 (0.00)c	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
7	Maize + French Bean + Napier Grass	0.00	0.00	0.00	0.00	0.00	0.00

		(0.00)c	(0.00)e	(0.00)c	(0.00)	(0.00)	(0.00)
8	Maize + cowpea + Napier Grass	0.00 (0.00)c	0.00 (0.00)e	0.00 (0.00)c	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
9	Maize + Maize 15 days after sowing	25.00 (29.93)b	31.67 (34.23)d	38.33 (38.24)b	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
10	Maize + Maize sowing after 30 days	28.33 (32.13)b	35.83 (36.75)c	40.00 (39.12)b	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
11	Sole Maize	35.83 (36.72)a	40.83 (39.67)b	48.33 (44.02)a	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	SEM. ±	0.93	0.71	0.73	0.00	0.00	0.00
	CD (p=0.05)	2.87	2.20	2.26	NS	NS	NS
	C.V. (%)	12.90	8.87	8.41	0.00	0.00	0.00

Note: DAS – Days After Sowing
Figures within the parenthesis are arc transformed values

Discussion

Same results were observed in the studies Analysis of the volatile chemicals from trap plants (Napier grass) using gas chromatography coupled electro stenography (GC–EAG) on the antennae of stem borers led to the identification of the key physiologically active compounds responsible for attractiveness of the Napier grass to the gravid moths (Khan *et al.*, 2000) [12]. These comprised hexanal, (*E*)-2-hexenal, (*Z*)-3-hexen-1-ol, and (*Z*)-3-hexen-1-yl acetate. Morphological characteristics influence the climbing success of newly hatched larvae that move from the oviposition site to the feeding site in the plant whorl (Bernays *et al.*, 1983) [13].

Through the pull effect of trap plants which emit semi-chemicals that are attractive to the gravid female moths while the intercrops emit Semi chemicals that deter oviposition on the maize (Chamberlain *et al.*, 2006) [14] but attract the natural enemies (Khan *et al.*, 1997; Midega *et al.*, 2009) [15, 16]. The trap plants, however, are not suitable for survival of the larval stages of the pests, resulting in high mortality rates and delayed development of the larvae (Khan *et al.*, 2006; Midega *et al.*, 2011) [17, 18]. There is also increased abundance, diversity and activity of predatory arthropods in this system, further contributing to reducing pest populations (Midega *et al.*, 2006) [19]. In cowpea plant the neonate FAW are attracted to volatiles released from herbivore-damaged leaves. In cowpea leaves, inception induces both volatile and non-volatile anti-herbivore defenses against FAW larvae, as implicated by phenyl propanoic markers and protease inhibitor transcripts (Schmelz *et al.*, 2006) [20].

Conclusions

The intercrops and trap crops assessment against FAW in a field that the egg masses, larval population, defoliation and pest infestation were recorded high in case of Napier grass (trap crop) intercropped with cowpea, French bean in which maize as main crop. Whereas, in the treatments such as maize intercropped with sweet corn, maize with maize as boarder crop (15 days after sowing) and maize as boarder crop (30 days after sowing) were recorded higher of egg masses, larval population, defoliation, pest infestation, and cob damage. The maximum number of natural enemies were recorded in the treatment of maize intercropped with cowpea along with Napier grass as a border crop. However, none of the egg masses, larval population, defoliation, pest infestation, cob damage and natural enemies in the treatments such as maize intercropped with cowpea, maize intercropped with French bean, maize intercropped with soybean and maize intercropped with groundnut.

Maize intercropped with cowpea along with Napier grass as a border crop proved to be the best treatment in combating FAW menace in maize.

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