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Diversified cropping system for managing major insect pests in sesame

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Abstract

Two field experiments were conducted during *kharif* 2016 and *rabi/*summer 2017 with VRI-2 sesame variety to screen the best border crop for managing the major insect pest shoot cum capsule borer *Antigastra catalaunalis* by attracting and sustaining the natural enemy population in sesame ecosystem. Treatments consisted of sesame, the main crop along with border crops *viz*., T_1-Sesame+sorghum, T_2-Sesame+blackgram, T_3-Sesame+cowpea, T_4-Sesame +clusterbean, T_5-Sesame+pearlmillet, T_6-Sesame+sunflower, T_7-Sesame+castor and T_8- Sesame sole. Results showed that lowest population of *Antigastra* larva (0.4/plant) was recorded in T5 (sesame + pearl millet) followed by T_1 (sesame + sorghum) and T_7 (sesame + castor) (0.6/plant). Damage percent was more in T_8 (26.39%) (Sole sesame) followed by T_6 (sesame + sunflower) (20%). T_5 (sesame + pearl millet) registered the lowest capsule damage (4.17%) followed by T_7 (4.95%) and T_3 (5.04%). Sesame+pearl millet registered lowest leafhopper population (1.0/plant) followed by T_1=T_2 = T_4 (1.20/plant). However, phyllody incidence was less (2.02% & 6.35%) in sesame+blackgram combination as against 6.35% & 17.96 in control during vegetative and flowering stage. During *rabi*/summer 2017, lowest number of *Antigastra* (0.70/plant) was recorded in sesame + pearl millet followed by sesame + sorghum (0.73/plant) at vegetative stage. During flowering stage, pearl millet border cropping recorded lesser damage (14.04%) followed by sesame+sorghum (14.67%) whereas sole sesame recorded damage to the tune of 23.72%. However, sorghum border cropping recorded lowest capsule damage (4.67%) followed by sesame+pearl millet (4.93%). The same trend was observed during capsule formation stage also. During *kharif* 2016, predatory coccinellids population was more in black gram border cropping (1.41/plant) followed by sorghum and cowpea border cropping (1.10/plant). During *rabi*/summer 2017, also the coccinellids population was more in sesame border cropped with pulses like black gram (1.67/plant) and cow pea (1.33/plant) during flowering stage. With regard to spiders, highest population was recorded in sesame+pearl millet (0.73/plant) followed by sesame+sorghum (0.67/plant) in *kharif* 2016 and 1.03/plant and 0.93/plant respectively in *rabi*/summer 2017. Sesame+pearl millet combination recorded maximum of seed yield 547 and 636 kg/ha during *kharif* 2016 and *rabi*/summer 2017 followed by sesame+sorghum combination (528 & 612 kg/ha).

Keywords: *Antigastra***,** leaf hopper, border crop, pearl millet, phyllody, pod bug

Introduction

Sesame *Sesamum indicum* Linn. is the oldest oilseed crop cultivated in semi arid tropics and sub-tropics to temperate regions in India. It is grown in 17.14 lakh hectares area with production of 7.84 lakh tonnes and productivity of 457 kg ha^{-1}. In India, Rajasthan, Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, Karnataka, Uttar Pradesh, West Bengal, Orissa, Punjab and Tamil Nadu are the major states of sesame cultivation. It also grown in Assam, Bihar, Haryana, Jammu and Kashmir, Kerala, Himachal Pradesh, North Eastern hill states and Pondicherry. Sesame yield is relatively low in India due to low harvest index, susceptibility to insect pests and diseases, seed shattering, and indeterminate growth habit.

One of the major constraints in sesame production is the damage caused by insect pests. Among the various insect pests of sesame, shoot webber cum capsule borer, *Antigastra catalaunalis* Duphonchel and leafhopper *Orosius albicinctus* Distant, are considered to be the most important in causing economic damage. Sesame shoot webber was observed first time in South India by Fletcher (1914) [4]. The pest attacks all parts of sesame plant except root and it feeds on the tender foliage by webbing top leaves and also bores into the shoot, flower and capsule. Singh (1983) [13] recorded 10 to 71% plant infestation and 10 to 43.5% capsule infestation, resulting in 8.9 to 71.5% yield loss; 66.31% seed loss per capsule (Kumar and Goel, 1994) [8]. Sesame leafhopper was well known for its role as vector in spreading phyllody disease in sesame. Vasudeva and Sahambi (1955) [17] reported that the vector of sesame phyllody was *Deltocephalus* sp. and Ghauri (1966) [5] identified the same vector as *O.*

albicinctus. Prasad and Sahambi (1982) [10] confirmed the nature of transmission of sesame phytoplasma by leafhopper, *O. albicinctus*. For managing these two major insect pests in sesame, insecticides are being used by farmers.
Insecticides frame the front line defense mechanism against insect pests among the various methods of pest management. Though synthetic insecticides stands first in the chain, eco-friendly method of insect pest management offers adequate level of pest control with less hazards and safe to non-target organisms. One pest management alternative is the diversification of agricultural fields by establishing "polycultures" in other words companion cropping that include one or more different crop varieties within the same field to encourage natural enemies population and their activity, enhances pest control to achieve sustainable yield and quality, brings out green environment. Keeping this in view, investigations were undertaken to manage major insect pests in sesame by raising different crops as border around the main crop sesame.

Materials and Methods
Field experiments were conducted during *kharif* 2016 and *rabi/*summer 2017 at Regional Research Station, Vriddhachalam (11° 30' 0.00" N; 79° 19' 48.00" E), Tamil Nadu, India. The popular sesame variety VRI 2 was used for this experiment. The ratio of fertilizer (N:P:K) to the experimental field was 23:13:13 kg/ha during *kharif* season and 35:23:23 kg/ha during *rabi*/summer. The recommended dose of fertilizers and $MnSO_4$ (5 kg/ha) were applied as basal. Thinning was done on 15th and 30th DAS along with weeding. The crop was irrigated six times as follows, immediately after sowing; one life irrigation on 7th DAS, two irrigations at flowering stage, one at capsule formation stage and the final one was on maturity stage.
Treatments consisted of sesame (VRI 2), the main crop along with border crops *viz*., T_1-Sesame+sorghum, T_2-Sesame+blackgram, T_3-Sesame+cowpea, T_4-Sesame +clusterbean, T_5-Sesame+pearlmillet, T_6-Sesame+sunflower, T_7-Sesame+castor and T_8-Sesame sole (Plate.1). The eight treatments were replicated three times in a Randomized Block Design with a plot size of 5.4 x 4 m. In an each block, sesame seeds were sown with a spacing of 30x30 cm between row to row and plant to plant. All the recommended package of practices was followed except plant protection measures. Each replication for all the eight treatments, 10 plants were randomly selected for observation during vegetative, flowering and capsule formation stages. Observations on the incidence of *Antigastra* population, and its damage (%), leaf hopper population, natural enemy population were recorded. During maturity stage, incidence of pod bug was also recorded. Seed yield was recorded while harvesting to calculate the cost economics.

Statistical analysis
The data were analysed by OPSTAT (Sheoran *et al*., 1998) [11]. Population data were square root transformed and the percentage infestation data were arcsine transformed. Based on the sesame seed yield, cost benefit ratio was worked out.

Results and Discussion
The results of the experiments conducted during *kharif* 2016 and *rabi*/summer 2017 showed that the combination of sesame with different border crops revealed significant differences with each other. Results were given in table 1-4. During *kharif* 2016, the population level of *Antigastra* larvae on sesame under different border crops ranged from 0.4 to 1.52/plant at vegetative stage. Larval populations of *A. catalaunalis* were significantly reduced in border cropped condition compared to sesame sole crop (Table 1). Lowest number of *Antigastra* (0.4/plant) was recorded in T_5 (sesame+pearl millet) followed by T_1 (sesame+sorghum) and T_7 (sesame+castor) (0.6/plant). During vegetative stage, pearl millet border cropping recorded less *Antigastra* damage (15.54%) whereas sole sesame recorded 26.39% damage. Likewise, pearl millet border cropping recorded lowest flower damage (13.71%) followed by T_1 (sesame+sorghum) (14.77%). The same trend was observed during capsule formation stage also. During *rabi*/summer 2017, lowest number of *Antigastra* (0.70/plant) was recorded in sesame + pearl millet followed by sesame + sorghum (0.73/plant) at vegetative stage. During flowering stage, pearl millet border cropping recorded lesser damage (14.04%) followed by sesame+sorghum (14.67%) whereas sole sesame recorded damage to the tune of 23.72%. However, sorghum border cropping recorded lowest capsule damage (4.67%) followed by sesame+pearl millet (4.93%). The same trend was observed during capsule formation stage also. In both *kharif* and *rabi*/summer condition the incidence of *Antigastra* population and damage (%) was less in sesame border cropped with pearl millet.
It has been reported that the groundnut chewing insect pests like *Spodoptera litura*, *Aproaerema modicella* population and damage (%) was less in groundnut border cropped with taller cereals like pearl millet, sorghum and maize (Indiragandhi *et al*., 2018) [6]. Sujayanand *et al*. (2015) [15] reported that the reduction of fruit borer and leafhopper incidences in main crop brinjal, when raised with maize as border crop. Simons (1957) [12], Alegbejo and Uvah (1986) [3] suggested that high, tall, barrier crops may act as mechanical barriers that impede insect colonization on the protected crop. In blackgram+sorghum combination, incidence of the major pod borer *Maruca vitrata* was very less (Soundarajan and Chitra, 2012). It showed that altering the cropping system either by intercrops or border crops; may significantly influences the insect rather larval feeding or ovipisition by the adult insects. The damage in harvested blackgram pods was low in sorghum+blackgram followed by pearl millet+blackgram. It indicates that all non-host cereals were good physical barriers.
With regard to leaf hopper population, during *kharif* 2016, sesame+sorghum and sesame+cluster bean registered lowest number of leafhopper (0.40/plant) during vegetative stage. Whereas in flowering stage, when compared to these combination, sesame+pearl millet recorded minimum leafhopper population (1.00/plant) as against 1.62/plant in sole sesame (Table 1). During *rabi*/summer season also, pearl millet border cropping registered lower population of leafhopper (1.27/plant) followed by sorghum (1.47/plant) during flowering stage. The leafhopper population was less in *kharif* season than that of *rabi*/summer. However, sesame combined with pearl millet or sorghum showed reduced leafhopper population. Results of our present study were concurrent with the findings of Suman Devi (2018) [16], who reported that minimum population of leafhopper nymphs in cotton with pearl millet as border crop. Patel *et al*. (2012) [9] found that intercropping of cotton with maize, cowpea, and sesame reduces the population of sucking pest *viz*., aphid, leafhopper and whitefly. In groundnut ecosystem, population of sucking pests like thrips and leafhopper population were reduced when groundnut was border cropped with pearl millet or sorghum (Indiragandhi *et al*., 2018) [6]. Pearl millet and

sorghum may likely be acted as a barrier crop for the movement of thrips and leafhoppers as those were taller than main crop groundnut. In sesame also, it might be the reason for the reduced population of leafhopper in main crop bordered with pearl millet and sorghum.

During *kharif* 2016, predatory coccinellids population was more in black gram border cropping (1.41/plant) followed by sorghum and cowpea border cropping (1.10/plant). Whereas, the sole sesame crop recorded 0.43 beetles/plant during flowering stage. During *rabi*/summer 2017, also the coccinellids population was more in sesame border cropped with pulses like black gram (1.67/plant) and cow pea (1.33/plant) during flowering stage (Table 4). With regard to spiders, highest population was recorded in sesame+pearl millet (0.73/plant) followed by sesame+sorghum (0.67/plant) in *kharif* 2016 and 1.03/plant and 0.93/plant respectively in *rabi*/summer 2017 (Table 4). Results elsewhere revealed that intercropping with pearl millet significantly increased the natural enemies like coccinellid members. A large number of natural enemies are associated with insect pests of sesame crop and these natural enemies are more in diverse crops as compared to sole crop. Sharma *et al*., (2009) revealed interplant maize/cowpea acted as source of predator due to diverse microhabitats, greater availability of food sources such as prey, nectar and pollen, all of which encouraged colonization and buildup of natural enemies, compared with mono culturing with less biodiversity. Mechanisms by which intercrops/border crops affect insect pest dynamics may include attraction of natural enemies, alteration of wind and vector dispersal; modification of microclimate, especially temperature and moisture; and direct barrier for arresting insect movement (Soundarajan and Chitra, 2012).

In general, incidence of pod bug was more in all the treatment combinations and sole sesame during *kharif* than in *rabi*/summer season. The pod bug population ranged from 12.64/plant to 15.42/plant in *kharif* and 3.03/plant to 6.08/plant in *rabi*/summer season. Mimimum pod bug population was recorded in sesame+cluster bean (12.64/plant) followed by sesame+cowpea (12.77/plant) as against 15.42/plant in sole sesame. During *kharif* 2016, sesame with pearl millet border cropping recorded maximum yield of 547 kg/ha and CB ratio of 1:1.91 followed by sesame with sorghum border cropping (528 kg/ha & 1:1.85). During *rabi*/summer 2017 also, the same combination recorded maximum yield of 636 kg/ha (Fig 1) and CB ratio of 1:2.23 followed by sesame with sorghum border cropping (612 kg/ha & 1:2.14). These two combinations also recorded minimum of pod bug population during *kharif* (12.64/plant and 12.77/plant) and 3.03/plant and 3.43/plant during *rabi*/summer season. Ahirwar *et al*., (2009) [1] recorded maximum sesame seed yield with pearl millet as intercrop than other crops like cluster bean, black gram and pigeon pea.

It could be inferred that the results of the present study showed that tall plants like pearl millet and sorghum as border crop in sesame ecosystem can act as physical barrier and it would impede pest movement within a cropping system. Thus companion crops could reduce the pest attack and enhance natural enemy population. Ultimately cultural control strategies like companion planting can conserve species diversity, reduce pesticide use and enhance pest control.

Table 1: Effect of border crops on major insect pest of sesame during *kharif* 2016

T.No.	Treatments	Shoot webber , *Antigastra catalaunalis*						Leaf Hopper	
		Population/plant			Damage (%)			Population/plant	
		Plant	Flower	Capsule	Plant	Flower	Capsule	Plant	Flower
T_1	Sesame+sorghum	0.60 (1.26)	0.60 (1.26)	0.41 (1.18)	16.17 (23.44)	14.77 (22.14)	4.95 (12.75)	0.40 (1.18)	1.20 (1.48)
T_2	Sesame+blackgram	0.71 (1.30)	0.71 (1.30)	0.40 (1.18)	19.05 (25.82)	16.97 (24.29)	5.66 (13.68)	0.50 (1.22)	1.20 (1.48)
T_3	Sesame+cowpea	0.71 (1.30)	0.82 (1.34)	0.61 (1.27)	19.09 (25.85)	17.17 (24.44)	6.19 (14.33)	0.71 (1.30)	1.40 (1.54)
T_4	Sesame+ cluster bean	0.82 (1.34)	0.61 (1.26)	0.41 (1.19)	19.61 (26.23)	17.56 (24.73)	7.07 (15.36)	0.40 (1.19)	1.20 (1.48)
T_5	Sesame+pearl millet	0.40 (1.18)	0.50 (1.22)	0.40 (1.18)	15.54 (22.93)	13.71 (21.68)	4.17 (11.65)	0.50 (1.22)	1.00 (1.40)
T_6	Sesame+sunflower	0.82 (1.34)	0.82 (1.35)	0.40 (1.18)	20.00 (26.51)	16.26 (23.74)	7.14 (15.44)	0.82 (1.34)	2.00 (1.73)
T_7	Sesame+castor	0.60 (1.27)	0.60 (1.26)	0.50 (1.22)	18.65 (25.54)	16.21 (23.70)	5.04 (12.87)	0.82 (1.34)	1.62 (1.61)
T_8	Sesame	1.52 (1.60)	1.20 (1.48)	0.71 (1.30)	26.39 (34.79)	17.55 (24.73)	10.77 (21.13)	1.82 (1.64)	2.84 (2.67)
	SED	0.005	0.004	0.003	0.047	0.048	0.162	0.002	0.009
	CD 5%	0.01	0.008	0.006	0.101	0.104	0.351	0.005	0.02
	Cv	0.436	0.34	0.263	0.221	0.246	1.415	0.212	0.711

Values are mean of three replications. Values in the paranthesis are arc sine transformed for damage (%) and square root transformed for population.

Table 2: Influence of border crops on sesame natural enemies, pod bug, phyllody and CBR during *kharif* 2016

T.No	Coccinellid Population/plant		Spider Population/plant		Pod bug Population/ plant	Phyllody (%)		
	Plant	Flower	Plant	Flower		Plant	Flower	CBR
T_1	0.80 (1.34)	1.10 (1.44)	0.50 (1.22)	0.67 (1.28)	12.77 (3.69)	2.23 (8.56)	7.03 (15.29)	1.85
T_2	1.22 (1.48)	1.41 (1.55)	0.20 (1.10)	0.50 (1.23)	13.77 (3.82)	2.02 (8.14)	6.35 (14.58)	1.71
T_3	1.03 1.42)	1.10 (1.44)	0.40 (1.19)	0.40 (1.18)	13.88 (3.84)	2.45 (8.98)	8.29 (16.67)	1.55
T_4	0.90 (1.38)	1.00 (1.41)	0.50 (1.23)	0.50 (1.22)	13.21 (3.75)	2.58 (9.22)	8.54 (16.93)	1.53
T_5	0.40 (1.18)	0.80 (1.34)	0.61 (1.26)	0.73 (1.31)	12.64 (3.67)	2.77 (9.56)	8.00 (16.36)	1.91
T_6	0.60 (1.26)	0.60 (1.26)	0.43 (1.20)	0.41 (1.19)	12.93 (3.71)	2.45 (8.98)	9.11 (17.51)	1.46
T_7	0.90 (1.38)	1.00 (1.41)	0.40 (1.18)	0.40 (1.18)	13.54 (3.79)	2.58 (9.22)	8.00 (16.36)	1.76
T_8	0.30 (1.13)	0.43 (1.20)	0.20 (1.10)	0.30 (1.14)	15.42 (4.04)	6.35 (14.58)	17.96 (25.05)	1.06
SED	0.005	0.005	0.002	0.001	0.009	0.063	0.109	
CD 5%	0.011	0.012	0.004	0.003	0.024	0.192	0.332	
Cv	0.472	0.492	0.172	0.145	0.304	1.286	1.214	

Values are mean of three replications. Values in the paranthesis are square root for population and arc sin transformed for damage per cent.

Table 3: Effect of border crops on sesame insect pests during *rabi*/summer 2017

T. No	Treatments	Shoot webber , *Antigastra catalaunalis*						Leaf Hopper	
		Population/plant			Damage (%)			Population/plant	
		Plant	Flower	Capsule	Plant	Flower	Capsule	Plant	Flower
T_1	Sesame + sorghum	0.73 (1.30)	0.93 (1.38)	0.53 (1.22)	17.67 (24.80)	14.67 (22.49)	4.67 (12.23)	0.9 (1.37)	1.47 (1.56)
T_2	Sesame + blackgram	0.93 (1.38)	0.93 (1.38)	0.73 (1.30)	20.30 (26.70)	16.59 (23.97)	6.16 (14.21)	1.3 (1.51)	2.27 (1.80)
T_3	Sesame + cowpea	1.03 (1.42)	1.13 (1.45)	0.60 (1.26)	20.50 (26.85)	17.30 (24.52)	5.54 (13.42)	1.3 (1.51)	1.80 (1.67)
T_4	Sesame + cluster bean	1.03 (1.42)	0.93 (1.38)	0.67 (1.26)	20.11 (26.57)	17.89 (24.97)	6.21 (14.41)	0.9 (1.37)	1.67 (1.62)
T_5	Sesame + pearl millet	0.70 (1.29)	0.83 (1.34)	0.60 (1.26)	17.04 (24.28)	14.04 (21.93)	4.93 (12.45)	0.9 (1.37)	1.27 (1.49)
T_6	Sesame + sunflower	0.93 (1.38)	1.13 (1.45)	0.83 (1.340	19.59 (26.190	17.50 (24.67)	6.69 (14.84)	1.3 (1.51)	1.67 (1.49)
T_7	Sesame + castor	0.83 (1.35)	1.03 (1.42)	0.63 (1.26)	18.74 (25.62)	15.74 (23.35)	5.45 (13.30)	1.3 (1.51)	1.87 (1.68)
T_8	Sesame	1.63 (1.62)	2.13 (1.76)	1.10 (1.45)	28.46 (36.72)	23.72 (29.54)	11.89 (19.98)	1.67 (1.49)	4.07 (2.74)
	SED	0.005	0.009	0.039	0.818	0.556	1.957	0.008	0.04
	CD %	0.011	0.019	0.013	1.772	1.203	4.238	0.016	0.087
	Cv	0.423	0.752	3.683	3.826	2.818	16.551	0.64	2.976

Values are mean of three replications for each treatment. Values in the paranthesis are arc sine transformed for damage (%) and square root transformed for population.

Table 4: Influence of border crops on sesame natural enemies, pod bug, phyllody and CBR during *rabi*/summer 2017

T.No	Treatments	Coccinellid Population/plant		Spider Population/plant		Pod bug Population/ plant	CBR
		Plant	Flower	Plant	Flower		
T_1	Sesame+sorghum	1.13 (1.44)	1.27 (1.50)	0.70 (1.30)	0.93 (1.38)	3.43 (2.09)	2.14
T_2	Sesame+blackgram	1.53 (1.59)	1.67 (1.63)	0.30 (1.13)	0.83 (1.35)	3.87 (2.19)	2.04
T_3	Sesame+cowpea	1.27 (1.50)	1.33 (1.52)	0.50 (1.22)	0.73 (1.31)	4.20 (2.27)	2.01
T_4	Sesame+ cluster bean	1.13 (1.46)	1.17 (1.47)	0.43 (1.20)	0.83 (1.35)	3.65 (2.13)	2.00
T_5	Sesame+cumbu	1.07 (1.43)	1.27 (1.49)	0.70 (1.30)	1.03 (1.42)	3.03 (1.99)	2.23
T_6	Sesame+sunflower	0.53 (1.23)	0.87 (1.36)	0.50 (1.22)	0.73 (1.31)	4.54 (2.34)	1.96
T_7	Sesame+castor	0.73 (1.31)	0.93 (1.39)	0.50 (1.22)	0.73 (1.31)	3.59 (2.13)	2.07
T_8	Sesame	0.30 (1.13)	0.53 (1.23)	0.30 (1.13)	0.63 (1.27)	6.08 (2.65)	1.35
	SED	0.078	0.053	0.004	0.003	0.119	
	CD 5%	0.124	0.115	0.008	0.007	0.257	
	Cv	6.491	4.588	0.377	0.303	6.53	

Values are mean of three replications. Values in the paranthesis are square root for population and arc sin transformed for damage per cent

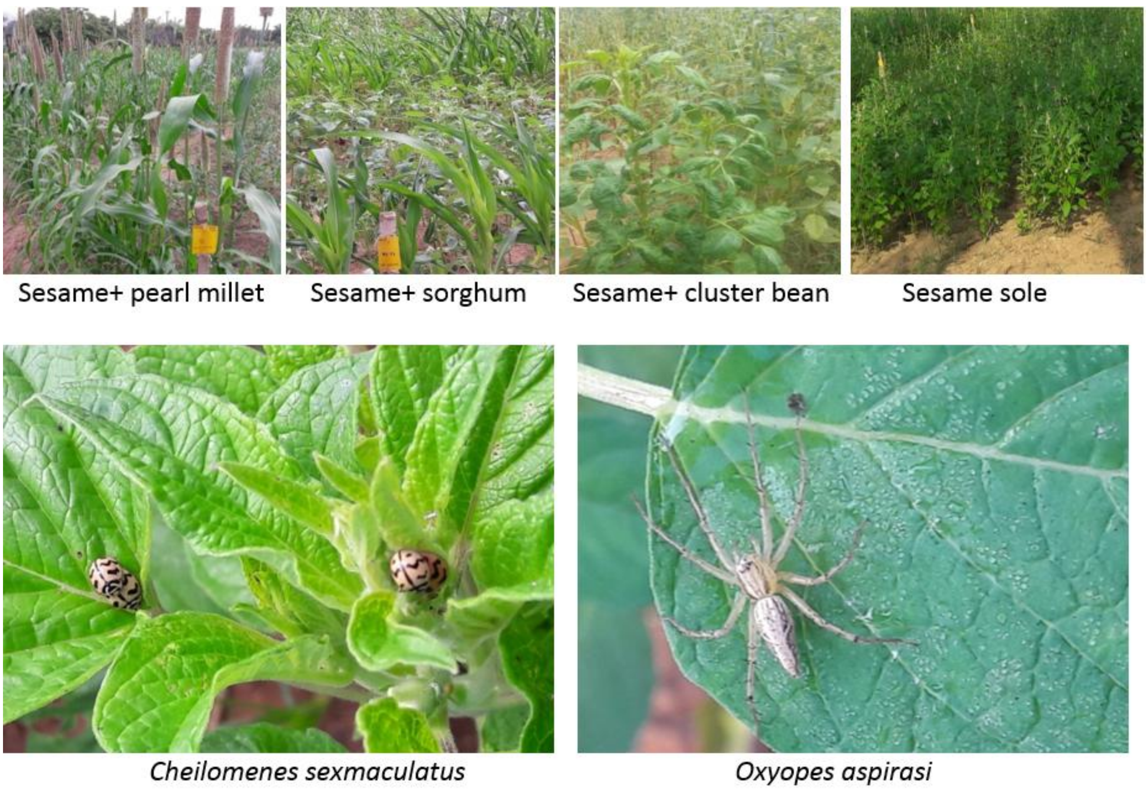

Plate 1: Field view of sesame with border crops and natural enemies

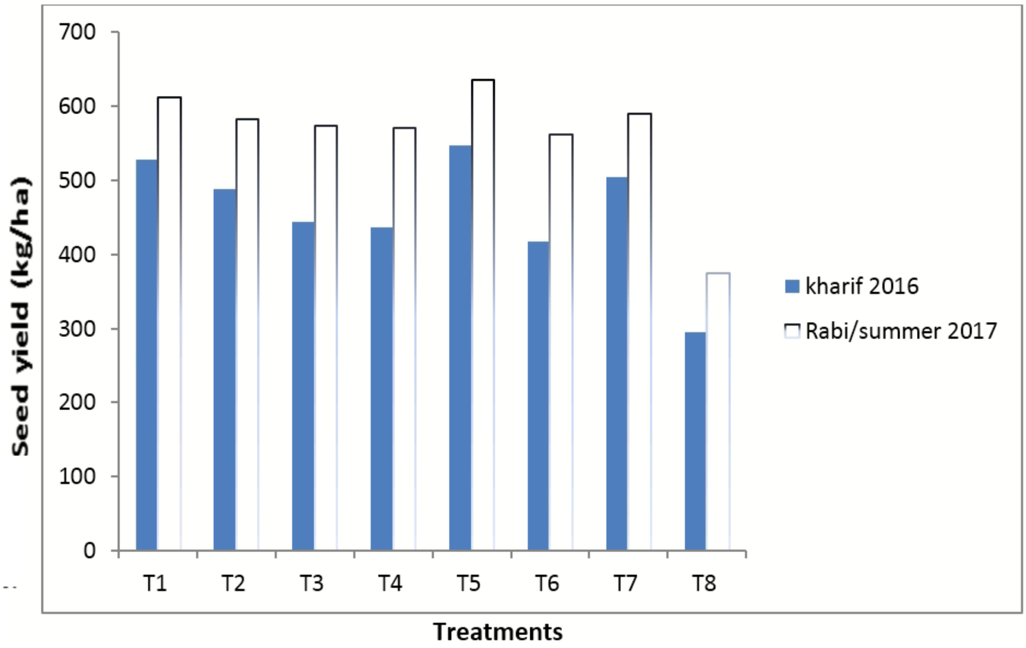

Fig 1: Effect of border cropping in sesame yield (kg/ha) during *kharif* and *rabi*/summer season

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