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Impact of intercrops on predatory fauna in rainfed sesame

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Abstract
Intercropping influences pests by altering the micro-climate by modifying crop canopies, minimizing the build-up of the pest population through physiological factors such as shading wind cover, sheltering, color change, dispersal prevention, stand shape, etc. and biological agents like natural enemies. Uses of intercrops are vital tools that alter population status of pests and predators. Field experiments were executed to investigate the impact of intercropping on population of predatory fauna of sesame and cost economics. Statistically significant and highest coccinellid population was reported in sesame+green gram (1.08, 1.22 and 1.08 per plant) and sesame+finger millet (1.08, 1.08 and 1.02 per plant) during the years 2018, 2019 and 2020, consistently. Similarly, highest spider population was also recorded in sesame+green gram (1.08, 0.87 and 1.02 per plant) and sesame+finger millet (1.12, 0.97 and 0.98 per plant). Sesame intercropped with finger millet has achieved highest SEY of 285.7, 277.3 and 284.7 kg/ ha during three consecutive years of 2018, 2019 and 2020 respectively followed by sesame+green gram (241.9, 235.3 & 239.2 kg per ha in the respective years).

Keywords: Sesame, intercropping, predators, equivalent yield

Introduction
Sesame (*Sesamum indicum* L.) is an ancient oilseed crop cultivated throughout the world in semi-arid and sub-tropical regions for its high in oil seeds which have multiple uses. Sesame is renowned as the queen of oilseeds due to more oil (38-54 per cent), protein (18-25 per cent), calcium, oxalic acid and phosphorous content [1]. India is the largest producer of sesame with highest acerage in the world. The average sesame area in India is about 1.79 mha (nearly half of world area) with 8.02 lakh tonnes of production and 448 kg/ha productivity. Within India, Andhra Pradesh along with Rajasthan, Uttar Pradesh, Gujarat, West Bengal, Madhya Pradesh and Telangana contributes to more than 85 percent production [2]. Input starved conditions, pests and diseases are the major factor for lower yields in sesame [3].
Intercropping has been reckoned as the most significant adoptable cultural practices for pest management by increasing ecological diversity [4]. Intercropping influences pests by altering the micro-climate owing to diversified crop canopies (Wu *et al.*, 1999; Srinivas *et al.*, 2003) [5, 6], minimizing the build-up of the pest population through physiological factors such as shadingwind cover, sheltering, color change, dispersal prevention, stand shape, etc. and biological factors such as the existence of natural enemies. Mechanisms by which intercrops or border crops affect insect pest dynamics may include attraction of natural enemies, alteration of wind and vector dispersal [7]. Uses of various intercrops are vital tools that alter population status of pests, predators and parasites [8].
Intercrops may act as barrier crops, deter or attract insect pests and natural enemies. A large number of natural enemies have been reported to be associated with insect pests of sesame crop and these natural enemies population is high in variegated crops as compared to sole crop. Intercropping with certain crops can be used to boost the existence of predators and parasitoids by providing them with changed micro climate and varied food sources [9].
The predator fauna and parasitoids of insect pests can be influenced to take up residence within cropping systems by providing habitat for them [10]. Farm management to enhance the number of beneficial insects refers to the provision of food resources and habitat required by these species that increase and sustain their population [11]. Pollinators and parasitoids can be attracted to cropped fields by including nectar producing flowering plants. These natural enemies can be attracted to cropped areas and their numbers increased by including within-field habitat strips, select cover crops, and proper management of field margins, hedgerows,

fencerows, windbreaks, irrigation and drainage ditches, and roadside margins (Nentwig, 1998; Schoenig *et al.*, 1998; Wratten *et al.*, 1998) [12, 13, 14]. Sharma *et al.* (2009) [15] revealed millet and legume intercropping enhanced the activity of predators due to diverse microclimate, easy and higher availability of prey, nectar and pollen, which in turn encouraged buildup of natural enemy population, compared to monocropping with less biodiversity. Therefore, the present research was initiated to study the role of intercropping on predatory fauna in sesame.

Materials and Methods

The experiments were executed at Agricultural Research Station, Yellamanchili, Visakhapatnam, Andhra Pradesh during *kharif* (May to September) of 2018, 2019 and 2020 to assess the impact of intercropping on predatory fauna in sesame, yield and cost economics.

Cultivation of sesame with intercrops

The experiment was performed in a randomized block design, with seven treatments including control, each replicated thrice. The variety YLM-66 was sown adopting seed rate of 6 kg/ha and fertilizers applied were FYM @ 10 t/ha and NPK as 40:20:20 with N in two equal splits as basal and at 30 days after sowing (DAS). The standard set of recommended crop practices were followed, however, no chemical plant protection measures were taken up during the entire crop growth period. The experiment was raised as purely rainfed. Manual weeding was done twice in the season. Six intercropping systems have been evaluated in comparison with sole sesame crop. The intercrops were raised with main crop in replacement series. Sesame (*Sesamum indicum* L.; Variety: YLM-66) was grown as the main crop along with red gram (*Cajanus cajan* L.), black gram (*Vigna mungo* L.) green gram (*Vigna radiata* L.), groundnut (*Arachis hypogaea* L) pearl millet (*Pennisetum glaucum* L.), and finger millet(*Eleusine coracana* L.) as intercrops.

Population of Predators

Data had been recorded in the early morning (7:00 am and 9:00 am) using standard sampling methods from ten randomly selected plants per plot. The naturally occurring predators were recorded as number per plant in various intercropping systems and sole sesame. Data was recorded from initial appearance till crop maturity at fortnightly interval and the seasonal means were computed. All the coccinellids observed, were reported together as one entity, regardless of the family to which they belonged. Similarly, all species of spiders were reported together as one entity.

Evaluation of Yield and Cost Economics

Treatment wise yield was recorded separately for each replication for sesame (main crop) and intercrops. The total yield per hectare was estimated as per the following formulav [16].

Yield, kg/ha = Factor × Seed yield (per plot)

Where,

Where, Factor = $\frac{10000}{Net\ plot\ size}, m^2$

Equivalent Yields

The yields of the various intercrops are transformed into the equivalent yield of main crop (sesame) on the basis of the price of the crop produce. The system equivalent yield (SEY) is calculated as follows (Chetty and Reddy, 1987) [17].

$$SEY_{i=1}^{n} = \sum (Y_i \times e_i)$$

Where Y_i is yield of i^{th} component and e_i is equivalent factor of i^{th} component or price of i^{th} crop.

Benefit cost ratio

Benefit cost ratio (B: C ratio) for was calculated different intercropping systems versus sole sesame, according to following formula (Bondre *et al.*, 2017).

$$B:C\ ratio = \frac{Gross\ returns}{Cost\ of\ cultivation}$$

Statistical analysis

The data from field experiments was analysed by ANOVA (analysis of variance) and the critical difference was calculated at 5% probability level and treatments mean values were compared using Duncan's Multiple Range Test (DMRT) as per Gomez and Gomez, 1984 [18].

Results and Discussion

The mean population of predatory fauna (coccinellids and spiders) was recorded and the equivalent sesame yield in various intercropping systems was computed in comparison to sole sesame for the three consecutive years. The results with related discussion are outlined hereunder.

Effect of intercropping on population of predators

The mean population of coccinellids was ranged between 0.12-1.08, 0.1-1.22 and 0.12-1.08 respectively during the year 2018, 2019 and 2020. Mean population of coccinellids was significantly varied among the different intercropping systems during the years 2018 and 2020, whereas non significant variation was observed during the year 2019. Highest and significantly on-par coccinellid population was reported in sesame+green gram (1.08, 1.22 and 1.08 per plant) and sesame+finger millet (1.08, 1.08 and 1.02 per plant) intercrops as shown in the Table 1 followed by sesame+black gram(0.58,0.47 and 0.38per plant). These predator populations are significantly superior compared to sole sesame (0.12, 0.10 and 0.12 per plant). Growing of two or more crops not only creates crop diversity, but also makes favorable ecology for the predators (Nicholls and Altieri, 2013 [19]). According to Surulivelu (2004) [20] short-term pulse crop intercropping increased coccinellid occurrence and propagation of coccinellids and other predators in the groundnut ecosystem. Coccinellids in sorghum or green gram systems were substantially abundant (Srinivasa, 2007) [21].
Similarly, the mean population of spiders varied significantly among various intercropping systems and were recorded in the range of 0.18-1.12, 0.12-0.97 and 0.12-1.02 respectively during the year 2018, 2019 and 2020. Statistically significant highest spider population has been reported in sesame+green gram (1.08, 0.87 and 1.02 per plant) and sesame+finger millet (1.12, 0.97 and 0.98 per plant) as shown in the Table 1 followed by sesame+pearl millet (0.82, 0.75 and 0.35 per plant). Sole sesame recorded very low spider population per plant (0.18, 0.11 and 0.12) during 2018, 2019 and 2020 as depicted in Table 1. Studies by Singh *et al.* (1991) [22] on the

impact of intercropping on groundnut natural enemy complex revealed that the spider population was higher in the intercropping system than the sole crop population. Wu *et al*. (1991) [23] reported that the population of spiders, coccinellids and chrysopids increased by 62.8-115.7 per cent by intercropping maize in cotton. The crop diversity approach for management of sucking pests was also asserted by Chamune *et al*. (2007) [24] and Swaminathan *et al*. (2002) [25]. Parthiban *et al.* (2016) [7] reported that intercropping in groundnut significantly reduced the incidence of sucking pests as well as gave higher yield and benefit cost ratio

Impact of intercropping on yield economics of sesame

The system equivalent yield (SEY) of the intercropping systems showed statistically significant differences during all the three consecutive years under study (2018, 2019 and 2020). The sesame intercropped with finger millet has achieved highest SEY of 285.7, 277.3 and 284.7 kgha^{-1} during three consecutive years followed by sesame+green gram (241.9, 235.3 & 239.2 kg ha^{-1}) as presented in Table 1. The lowest system equivalent yield was released in sesame sole crop (185.6, 186.8 and 184.6 kgha^{-1}) during all three years under study. The gross returns of the systems also reinforced the yield results and are presented in Table 2. Highest returns were generated from sesame + finger millet (Rs. 28962.00, Rs. 24960.00 and Rs. 25623.00 per ha in three successive years) followed by sesame+green gram (Rs. 21777.00, Rs. 21180.00 and Rs. 21534 per ha), where as lowest gross returns were reported in sesame sole crop (Rs.16707.00, Rs. 16818.00 and Rs. 16617.00 per ha). Upon comparison of the benefit cost ratio (BC ratio), the sesame+finger millet proved to be the most profitable with BC ratio of 2.48,2.14 and 2.2 during 2018,2019 and 2020, followed by sesame+green gram (2.18, 2.12 and 2.15 in respective years) as presented in Table 2.

Table 1: Effect of intercropping on predatory fauna and yield in sesame

Treatment details	Population of Coccinnelids* (Number per plant)			Population of Spiders* (Number per plant)			System Equivalent yield (Kg/ha)		
	2018	2019	2020	2018	2019	2020	2018	2019	2020
Sesame + Red gram	0.22 (1.10)^{b}	0.28 (1.13)	0.22 (1.10)^{b}	0.18 (1.09)^{b}	0.07 (1.06)^{c}	0.15 (1.07)^{c}	221.2^{bc}	202.7^{bcd}	208.9^{bcd}
Sesame + Black gram	0.58 (1.32)^{a}	0.47 (1.11)	0.38 (1.18)^{b}	0.83 (1.32)^{a}	0.37 (1.16)^{c}	0.33 (1.15)^{b}	196.1^{b}	189.6^{cde}	190.9^{cde}
Sesame + Green gram	1.08(1.44)^{a}	1.22 (1.45)	1.08 (1.44)^{a}	1.08 (1.44)^{a}	0.87 (1.39)^{a}	1.02 (1.42)^{a}	241.9^{ab}	235.3^{b}	239.2^{ab}
Sesame + Groundnut	0.23 (1.12)^{b}	0.25 (1.16)	0.18 (1.09)^{b}	0.23 (1.11)^{b}	0.13 (1.04)^{c}	0.10 (1.05)^{c}	225.7^{b}	231.8^{bc}	217.2^{bc}
Sesame + Pearl millet	0.42 (1.19)^{b}	0.50 (1.23)	0.37 (1.17)^{b}	0.82 (1.34)^{a}	0.75 (1.28)^{a}	0.35 (1.16)^{b}	170.0^{c}	162.7^{e}	162.4^{e}
Sesame + Finger millet	1.08 (1.44)^{a}	1.08 (1.29)	1.02 (1.42)^{a}	1.12 (1.45)^{a}	0.97 (1.41)^{a}	0.98 (1.41)^{a}	285.7^{a}	277.3^{a}	284.7^{a}
Sole sesame	0.12 (1.05)^{c}	0.10(1.03)	0.12 (1.03)^{c}	0.18 (1.08)^{b}	0.12 (1.08)^{c}	0.12 (1.06)^{c}	185.6^{c}	186.8^{cde}	184.6^{cde}
SE(d)	0.06	0.15	0.06	0.06	0.05	0.03	24.2	15.5	19.4
C.D.	0.12	N/A	0.14	0.13	0.11	0.06	53.4	34.2	45.8

* Mean of the entire season for the respective year

Figures in parenthesis are square root transformed values

In a column, means followed by common letter(s) are not significantly different (P= 0.05)

Table 2: Effect of intercropping on yield economics of sesame

Treatment details	2018			2019			2020		
	SEY (Kg/ha)	Gross Returns (Rs.)	BC ratio	SEY (Kg/ha)	Gross Returns (Rs.)	BC ratio	SEY (Kg/ha)	Gross Returns (Rs.)	BC ratio
Sesame + Red gram	221.2	22992	1.72	202.7	18249	1.37	208.9	18807	1.41
Sesame + Black gram	196.1	17652	1.77	189.6	17070	1.71	190.9	17184	1.72
Sesame + Green gram	241.9	21777	2.18	235.3	21180	2.12	239.2	21534	2.15
Sesaem + Groundnut	225.7	20316	1.52	231.8	20865	1.56	217.2	19554	1.47
Sesame + Pearl millet	170.0	15303	1.77	162.7	14643	1.69	162.4	14622	1.69
Sesame + Finger millet	285.7	28962	2.48	277.3	24960	2.14	284.7	25623	2.20
Sole sesame	185.6	16707	1.39	186.8	16818	1.40	184.6	16617	1.38

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