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Impact of Intercropping Systems on the Management of Defoliators in Groundnut (*Arachis hypogaea* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Groundnut (*Arachis hypogaea* L.), a crucial oilseed and protein crop, encounters substantial yield and quality losses due to insect pests. This study explores the efficacy of various intercrop systems in managing major insect pests, particularly defoliator populations conducted during the *kharif* 2022-23 at the Main Agricultural Research Station, University of Agricultural Sciences Dharwad. The research employed a randomized block design (RBD) to evaluate different intercrop combinations. Results indicated that, the combination of groundnut + pearl millet was found to be effective in suppressing the *Spodoptera litura* (F) by recording the lowest average larval population (0.76 larvae/meter row length), followed by groundnut + sorghum (1.17 larvae/meter row length) and the same combination was also proved to be effective in minimizing the leaf miner incidence too (1.49 larvae/plant) and had least percent of leaf damage than other intercrops. The combination of these millets in groundnut can provide sustainable groundnut cultivation.

Keywords: Groundnut; high-protein; animal feed; leafhoppers; oilseed crops.

1. INTRODUCTION

Groundnut is a major player in India's edible oil sector, ranking third in vegetable protein sources and fourth in oilseed crops. Its seeds contain 43-55% oil and 25-28% protein, along with vitamins E, K, and B [1]. The oil, rich in oleic (75-80%) and linoleic acids, has 5.6 calories per gram [2]. The oil cake is a high-protein animal feed, and the haulm provides quality fodder. In India, groundnut is grown on 4.73 million hectares, producing 6.72 million tonnes with a productivity of 1,422 kg/ha. Major producing states Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, and Maharashtra account for 80% of the area and 84% of production. Karnataka contributes 0.51 million hectares and 0.39 million tonnes with a productivity of 759 kg/ha [3].

Productivity is affected by biotic and abiotic stresses and insect pests, which cause losses of Rs. 238 crores [4]. Over 100 insect species damage groundnut, with major pests including the red hairy caterpillar (*Amsacta albistriga* Walker), tobacco caterpillar (*Spodoptera litura* Fabricius), gram caterpillar (*Helicoverpa armigera* Hübner), leaf miner (*Aproaerema modicella* Deventer), and sucking pests such as thrips (*Scirtothrips dorsalis* Hood), aphids (*Aphis craccivora* Koch), and leafhoppers (*Empoasca kerri* Pruthi) [5]. Yield declines are due to low inputs, non-adoption of high-yield varieties, rainfed cultivation, pest and disease issues, and extreme climate conditions. Chemical insecticides, while effective, are costly and ecologically harmful. This study investigates the use of intercrops to manage defoliators in groundnut, aiming to develop cost-effective, environmentally friendly, and sustainable pest management strategies.

2. MATERIALS AND METHODS

The present investigation on the impact of various intercrops on the incidence of major insect pests and natural enemies in groundnut was carried out during *kharif* 2022-23 and 2023-24 at Main Agricultural Research Station, University of Agricultural Sciences Dharwad. The experiment was laid out in a randomized block design (RBD) with three replications having a plot size of 5.0 x 3.0 m leaving a gang way of one meter around the treatment plots. The groundnut variety, Dh-256 was sown at a spacing of 30 x 10 cm by following the recommended package of practices along with various intercrops at ratios specified in treatment details. All the agronomic practices were adopted and no plant protection measures were taken throughout the season. The data obtained was subjected to one way Analysis of Variance (ANOVA) and the treatment means were compared using Duncan Multiple Range Test (DMRT). The data was analysed using the software OPSTAT.

Observations on the incidence of major defoliators like groundnut leaf miner (No. of mines per plant), *S. litura* (No. of larvae per meter row length) were recorded from five randomly selected plants from each treatment at weekly interval from 25 to 90 days after sowing and percent leaf damage were calculated by using following formula:

$$\text{Percent of leaf damage} = \frac{\text{Number of damaged leaflets per plant}}{\text{Total number of leaves per plant}} \times 100$$

List 1. Treatment details

Sl. No	Intercrop combination	Variety/hybrid of intercrops	Intercropping ratio
T1	Groundnut + Pearlmillet	Kaveri Super Boss	4:1
T2	Groundnut + Maize	CP-818	4:1
T3	Groundnut + Foxtail millet	Dhft109-3	4:1
T4	Groundnut + Sorghum	CSH-30	4:1
T5	Groundnut + Cowpea	DC-15	4:1
T6	Groundnut + Clusterbean	Pusa Navabahar	4:1
T7	Groundnut + Sunflower	RSFH1887	4:1
T8	Groundnut sole crop	-	-

3. RESULTS AND DISCUSSION

During the kharif season of 2022-23, the population of *Spodoptera litura* larvae was monitored weekly from 25 days after sowing (DAS) through eight weeks. The incidence of *S. litura* was observed from 30 to 75 DAS under various intercropping systems. Notably, no larvae were detected in the groundnut + pearl millet intercrop in the first week, whereas the groundnut + foxtail millet, groundnut + sorghum, and groundnut + cowpea intercrops each had 0.33 larvae per meter row length (mrl). These systems were significantly better compared to the groundnut + sunflower (0.97 larvae/mrl) and groundnut + cluster beans (1.00 larvae/mrl), with sole groundnut crops having the highest larval population of 1.33 larvae/mrl (Table 1).

The larval population generally increased from the second to the fifth week, peaking in the fourth week before declining to its lowest by the eighth week. In the second week, the lowest larval population was recorded in the groundnut + pearl millet intercrop (0.33 larvae/mrl), which was statistically similar to groundnut + sorghum and groundnut + cowpea (0.67 larvae/mrl each), and significantly lower than other treatments. The sole groundnut crop had the highest larval population at 2.00 larvae/mrl. By the third week, the groundnut + pearl millet intercrop had the least larvae (1.00 larvae/mrl), comparable to groundnut + sorghum and groundnut + maize (1.33 larvae/mrl). Other treatments, including groundnut + cowpea (1.67 larvae/mrl), showed moderate effectiveness but were still significantly lower than the sole groundnut crop (3.33 larvae/mrl).

In the fourth and fifth weeks, the peak incidence of *S. litura* larvae was observed. Groundnut + pearl millet had the lowest larval counts (1.33 larvae/mrl and 1.39 larvae/mrl, respectively) and was statistically similar to groundnut + maize and groundnut + sorghum. Sole groundnut crops recorded the highest larval populations (3.67 larvae/mrl and 4.00 larvae/mrl) during these weeks. Groundnut + cluster bean, groundnut + sunflower, and groundnut + cowpea also had moderately high larval populations. By the sixth to eighth weeks, the larval population decreased, with groundnut + cowpea, groundnut + sunflower, and groundnut + cluster bean showing 1.00, 1.00, and 1.33 larvae/mrl, respectively, compared to the sole groundnut crop, which had 2.67 larvae/mrl.

Overall, the groundnut + pearl millet intercrop recorded the lowest average larval population (0.76 larvae/mrl), followed by groundnut + sorghum (1.17 larvae/mrl). Other intercropping systems managed *S. litura* populations within the range of 1.42 to 2.04 larvae/mrl, with the untreated control showing the highest larval count (2.95 larvae/mrl). These results are consistent with Girija et al. [6] and Agasimani et al. [7] who noted reduced *S. litura* incidence in intercrop systems like groundnut + jowar. Nath and Singh [8] and Rashmi et al. [9] also observed reduced pest populations in groundnut intercropped with bajra and foxtail millet (Table 1).

Leaf miner incidence was zero in all treatments at 25 DAS but increased by the second week. Groundnut + foxtail millet (1.52) and groundnut + pearl millet (1.49) had the lowest populations, statistically similar to each other. Other treatments had moderate leaf miner numbers, with groundnut + sunflower showing the highest count (2.34 larvae/plant), similar to the sole crop. The percent reduction in leaf miner population was highest in groundnut + foxtail millet and groundnut + pearl millet (44.00%), followed by groundnut + sorghum and groundnut + maize (38.00%). Groundnut as a sole crop had a mean larval load of 1.70 per plant. Phytochemicals in millets and cowpea may have influenced oviposition by leaf miner moths, leading to lower populations in these intercrops. Intercropping might also create a microclimate that benefits the natural enemies of the leaf miner (Table 2).

Table 1. Effect of intercropping on population of Spodoptera litua in groundnut during kharif 2022-23

Treatments		No. of larvae /meter row length								Mean
		1 week	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks	8 weeks	
T_1	Groundnut + Pearl millet	0^{c} (0.71)	0.33^{c} (0.9)	1^{c} (1.22)	1.33^{c} (1.34)	1.39^{c} (1.37)	1^{c} (1.46)	0.67 d (1.07)	0.33 d (0.9)	0.76
T_2	Groundnut + Maize	1.33^{a} (1.34)	1^{b} (1.22)	1.33^{c} (1.34)	2^{bc} (1.56)	2.33^{bc} (1.68)	1.67^{bc} (1.58)	1^{cd} (1.22)	0.67^{cd} (1.07)	1.42
T_3	Groundnut + Foxtail millet	0.33^{bc} (0.9)	1^{b} (1.22)	2.33ab (1.68)	2^{bc} (1.58)	2.67ab (1.77)	2^{b} (1.34)	0.67 d (1.07)	0.67^{cd} (1.07)	1.46
T_4	Groundnut + Sorghum	0.33^{bc} (0.9)	0.67^{bc} (1.07)	1.33^{c} (1.34)	2^{bc} (1.56)	2^{bc} (1.58)	1.33^{c} (1.46)	1^{cd} (1.22)	0.67^{cd} (1.07)	1.17
T_5	Groundnut +cowpea	1^{a} (1.22)	0.67^{bc} (1.05)	1.67^{bc} (1.46)	3ab (1.87)	2.33^{bc} (1.68)	1.67^{bc} (1.66)	1.83^{bc} (1.51)	1^{bc} (1.22)	1.65
T_6	Groundnut + cluster bean	1^{a} (1.22)	1.33ab (1.34)	2.33ab (1.68)	2.67ab (1.77)	2.67ab (1.74)	2.33^{c} (1.56)	2.67ab (1.77)	1.33^{b} (1.34)	2.04
T_7	Groundnut + Sunflower	0.97^{a} (1.21)	1.33ab (1.34)	2.67ab (1.77)	2.33^{abc} (1.68)	2.5^{bc} (1.73)	2^{b} (2.04)	1.33^{cd} (1.34)	1^{bc} (1.22)	1.77
T_8	Groundnut sole crop	1.33^{a} (1.34)	2^{a} (1.58)	3.33^{a} (1.95)	3.63^{a} (2.03)	4^{a} (2.12)	3.67^{a} (4.02)	3^{a} (1.86)	2.67^{a} (1.77)	2.95
	S.Em. ±	0.08	0.1	0.1	0.12	0.13	0.14	0.1	0.07	
	C.D. (5%)	0.24	0.30	0.31	0.36	0.38	0.42	0.32	0.22	
	C. V. (%)	12.24	13.99	11.45	12.21	12.77	12.76	13.07	10.55	

Weeks (25 days after sowing)

** Figures in the parentheses are square root transformed values # Similar letters in the columns do not differ significantly by the DMRT (0.05)*

Table 2. Effect of intercropping on population of leaf miner in groundnut during *kharif* 2022-23

Treatments		No. of larvae / plant								Mean
		1 week	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks	8 weeks	
T_1	Groundnut + Pearl millet	0^{a} (0.71)	1.49^{c} (1.41)	1.38^{c} (1.37)	1.1^{c} (1.27)	0.84^{b} (1.16)	0.63^{b} (1.11)	1.05^{bc} (1.24)	1.12^{bc} (1.27)	0.95
T_2	Groundnut + Maize	0^{a} (0.71)	1.88^{bc} (1.54)	1.87^{abc} (1.54)	1.18^{c} (1.30)	0.91^{b} (1.191)	0.62^{b} (1.13)	1.01^{bc} (1.23)	1.01^{c} (1.23)	1.06
T_3	Groundnut + Foxtail millet	0^{a} (0.71)	1.52^{c} (1.4)	1.5^{c} (1.41)	1.16^{c} (1.29)	0.88^{b} (1.17)	0.65^{b} (1.1)	0.93^{c} (1.19)	0.96^{c} (1.21)	0.95
T_4	Groundnut + Sorghum	0^{a} (0.71)	1.66^{bc} (1.47)	1.61^{c} (1.42)	1.19^{c} (1.3)	0.92^{b} (1.19)	0.71^{b} (1.14)	1.06^{bc} (1.25)	1.06^{bc} (1.25)	1.03
T_5	Groundnut +cowpea	0^{a} (0.71)	1.99^{abc} (1.58)	2.22^{abc} (1.65)	2.09^{a} (1.61)	1.02^{b} (1.23)	0.8^{b} (1.06)	1.08^{bc} (1.26)	1.08^{bc} (1.26)	1.28
T_6	Groundnut + cluster bean	0^{a} (0.71)	1.92^{abc} (1.55)	1.85^{bc} (1.53)	1.22^{bc} (1.31)	0.95^{b} (1.2)	0.73^{b} (1.07)	1.16^{abc} (1.29)	1.22^{abc} (1.31)	1.13
T_7	Groundnut + Sunflower	0^{a} (0.71)	2.34ab (1.69)	2.45ab (1.72)	2.18^{a} (1.64)	1.14ab (1.28)	0.77^{b} (1.17)	1.18ab (1.3)	1.66ab (1.47)	1.47
T_8	Groundnut sole crop	0^{a} (0.71)	2.8^{a} (1.8)	2.87^{a} (1.82)	2.24^{a} (1.62)	1.46^{a} (1.39)	1^{a} (2.53)	1.37^{a} (1.37)	1.83^{a} (1.51)	1.7
	S.Em. ±	0	0.08	0.09	0.08	0.05	0.09	0.03	0.07	
	C.D. (5%)	0.00	0.25	0.28	0.26	0.14	0.28	0.10	0.22	
	C. V. (%)	0	9.2	10.24	10.37	6.51	12.5	4.32	9.37	

Weeks (25 days after sowing)

** Figures in the parentheses are square root transformed values #Similar letters in the columns do not differ significantly by the DMRT (0.05)*

Table 3. Influence of intercropping on leaf damage in groundnut by defoliators during *kharif* 2022-23

Treatments		Per cent leaf damage at								Mean
		1 week	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks	8 weeks	
T_1	Groundnut + Pearl millet	12.29^{c} (20.52)	16.89^{b} (24.26)	18^{c} (25.1)	22.67^{c} (28.36)	25.14^{c} (30.06)	26.94^{b} (31.24)	26.94^{de} (31.24)	22.95^{bc} (28.62)	21.48
T_2	Groundnut + Maize	13.93^{abc} (21.9)	16.71^{b} (24.12)	21^{bc} (27.26)	27.63^{abc} (31.7)	34^{a} (35.67)	35.63^{a} (36.65)	34.88^{a} (36.19)	33.67^{a} (35.46)	27.18
T_3	Groundnut + Foxtail millet	12.5^{c} (20.7)	12.67^{c} (20.85)	20.2^{bc} (26.7)	24.67^{bc} (29.7)	34.78^{a} (36.12)	34.5^{a} (35.97)	35.62^{a} (36.64)	33.99^{a} (35.62)	26.12
T_4	Groundnut + Sorghum	16ab (23.56)	18.33ab (25.35)	24.04ab (29.28)	30.05ab (33.22)	32.78ab (34.92)	31.49ab (34.13)	30.14^{cd} (33.29)	28.67ab (32.33)	26.43
T_5	Groundnut +cowpea	14.58^{abc} (22.45)	17.6ab (24.8)	25ab (30)	27.4^{abc} (31.55)	26.11^{bc} (30.72)	26.11^{b} (30.72)	24.96 e (29.97)	20.33^{c} (26.8)	22.76
T_6	Groundnut + cluster bean	13.6^{bc} (21.64)	16.96^{b} (24.32)	23.27ab (28.83)	27.94^{abc} (31.9)	36.75^{a} (37.31)	35.85^{a} (36.78)	35.58^{a} (36.62)	33^{a} (35.06)	27.87
T_7	Groundnut + Sunflower	15.53ab (23.2)	17.97^{a} (25.06)	21.97^{abc} (27.92)	29.16ab (32.68)	31.49^{abc} (34.13)	30.82ab (33.7)	30.56^{bc} (33.55)	27^{abc} (31.28)	25.56
T_8	Groundnut sole crop	16.86^{a} (24.14)	19.89^{a} (26.31)	27^{a} (31.22)	33.97^{a} (35.62)	36.88^{a} (37.26)	36.78^{a} (37.21)	37.66^{a} (37.85)	35.33^{a} (36.32)	30.55
	S.Em. (±)	0.78	1	1.22	1.35	1.48	1.42	0.73	1.76	
	C. V. (%)	6.07	7.1	7.45	7.35	7.45	7.14	3.66	9.33	

*Weeks (25 days after sowing) * Figures in the parentheses are arc sine transformed values*

 # Similar letters in the columns do not differ significantly by the DMRT (0.05)

Leaf damage due to defoliators was significantly lower in groundnut intercropped with pearl millet and foxtail millet (12.29% and 12.50%, respectively) compared to the sole groundnut crop, which had the highest damage (16.86%). Groundnut + maize and groundnut + sorghum also showed lower damage (13.93% and 16.00%, respectively). Other intercropping systems, including groundnut + cowpea and groundnut + sunflower, had moderate levels of damage, with groundnut + cluster bean showing the highest damage (27.87%), comparable to the sole crop (30.55%). The reduced leaf damage in certain intercropping systems supports findings from Girija et al. [6] and Rashmi et al. [9] regarding lower damage in groundnut + foxtail millet systems. Ranga Rao and Wightman J A. [10], Maheshala et al. [11] and Patil [12] similarly reported reduced damage in groundnut + sunflower and groundnut + sorghum intercrops. Nath and Singh [8] also observed lower damage in groundnut + pearl millet systems, aligning with this study's results (Table 3) [13].

4. SUMMARY AND CONCLUSION

Crop diversification studies with growing of intercrops revealed that, the lowest mean population of *Spodoptera litura*(Fab.) was noticed in groundnut + pearl millet intercropping system which found superior over other intercrops used.

This investigation underscores the critical role of integrated pest management (IPM) strategies in optimizing groundnut cultivation. The findings reveal that, growing of intercrops such as pearl millet, foxtail millet, and sorghum effectively manages insect pests and supports beneficial fauna, demonstrating a clear advantage over sole groundnut cultivation.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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