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ECO-FRIENDLY MANAGEMENT OF LEAF WEBBER AND CAPSULE BORER, *Antigastra catalaunalis* (Duponchel) INFESTING SESAME

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Sesame (*Sesamum indicum* L.) is a highly valued oilseed crop, often referred to as the "Queen of Oilseeds." It belongs to the order Tubiflorae and the family Pedaliaceae. As one of the oldest oilseed crops, sesame is believed to have originated in Africa and is also among the earliest domesticated plants. India produces a diverse array of sesame varieties, each with distinct grades specific to different regions. Sesame is typically harvested twice a year and is categorized into various seed colours, including white, yellow, red, brown, and black. The leading sesame-producing countries are Sudan, India, China, Myanmar, Ethiopia, Nigeria, Tanzania, and Mexico (FAOSTAT, 2024). In India, sesame is grown across multiple states, including Rajasthan, Gujarat, Uttar Pradesh, Odisha, Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu, and West Bengal. India holds the largest sesame acreage globally, encompassing approximately 1.523 million hectares, with a production of 8,02,000 tons and a productivity rate of 527 kg/ha. In Gujarat, sesame is cultivated across 1,96,000 hectares, yielding 1,43,000 tons and achieving a productivity rate of 732 kg/ha (Anonymous, 2023). The primary sesame-growing regions in Gujarat include Surendranagar, Banaskantha, Bhavnagar, Kachchh, Rajkot, Amreli, and Mehsana.

Among the various production constraints, insect pests are of primary concern in sesame cultivation. Several insect species are known to damage sesame crops, including the red hairy caterpillar (*Amsacta moorei* Butler), Bihar hairy caterpillar (*Spilosoma obliqua* Walker), sesame leaf webber (*Antigastra catalaunalis* Duponchel), hawk moth (*Acherontia styx* Westwood), gall midge (*Asphondylia sesame* Felt), mirid bug (*Cyrtopeltis tennius* Reuter), pentatomid bug (*Nezara viridula* Linnaeus), thrips (*Thrips tabaci* Lindeman), blister beetle (*Mylabris pustulata* Thunberg), yellow mite (*Polyphagotarsonomus latus* Banks), leaf hopper (*Orosius albicinctus* Distant), and sesame bud fly (*Dasineura sesami* Gennadius). Among these, the sesame leaf webber (*A. catalaunalis*) and the capsule borer are particularly damaging, causing extensive harm to both the foliage and fruiting bodies of the plant (Bhadauria *et al.*, 2000). This pest is found in all regions where sesame is grown. The larvae of *A. catalaunalis* initially infest the upper leaves, rolling them in the early stages of crop growth. As the crop matures and pod formation occurs, the larvae move into the pods, causing further damage (Pandey *et al.*, 2019). The pest infestation can range from 10-70% on leaves, 34-62% on flower buds or flowers, and 10-44% on pods, leading to potential yield losses of up to 72% (Ahirwar *et al.*, 2010). In severe cases, just one to three larvae can defoliate a fully grown plant within 24 to 48 hours. Among the various pest management strategies, the use of insecticides is the primary method of control for farmers. While insecticides have contributed to increased food grain production, their indiscriminate use has led to several significant challenges, including the development of insecticide resistance, pest resurgence, and outbreaks of secondary pests on other crops. Furthermore, the presence of insecticide residues in sesame seeds and oil raises concerns regarding food safety, human health, and export quality. Consequently, there is a growing need for alternative pest management approaches. In this context, biopesticides and plant extract-based formulations such as *Brahmastra*, *Agniastra*, and *Neemastra* have been evaluated as potential alternatives to chemical insecticides for controlling *A. catalaunalis* in sesame cultivation.

A field experiment was conducted during the *kharif* season of 2023 at the Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, India, employing a randomized block design with eight treatments, including an untreated control, replicated thrice. The first spray was applied at the onset of pest appearance on the sesame crop, followed by two subsequent sprays at 10-day intervals. The sesame variety *Gujarat Til-3* was sown with a spacing of 45 cm × 10 cm between rows and

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plants, respectively. Each treatment plot had a gross size of 4.0 m × 2.25 m, with a net plot size of 3.80 m × 1.35 m. Seven biopesticides were tested in comparison with the untreated control for their effectiveness against the sesame leaf webber and capsule borer. These biopesticides included azadirachtin 10000 ppm, *Brahmastra*, *Agniastra, Neemastra, Dashaparni Ark*, tobacco decoction, and *Ipomoea* leaf extract. Observations were made on the number of larvae per plant, the number of webs per plant, and capsule damage caused by *A. catalaunalis* on the day before treatment (DBT), as well as 3, 6, and 9 days after treatment (DAT). The per cent capsule damage was calculated by the following formula

$$\text{Capsule damage (\%)} = \frac{\text{No. of damaged capsules}}{\text{Total no. of capsules}} \times 100$$

The harvesting was done at physiological maturity, and grain yields were recorded for each treatment. Based on these yields, the economic analysis was performed. The increase in yield relative to the control and the avoidable losses were calculated using the formula provided by Khosla (1977).

$$\text{Increase in yield over control (\%)} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

Effect of different treatments on larval population

The data on the larval populations of the leaf webber and capsule borer were recorded at 3, 6, and 9 days after spraying. The results, pooled across the time periods and sprays, are presented in Table 1. Prior to spraying, the larval populations were found to be homogeneous across all evaluated treatments, as the treatment differences were not statistically significant.

Pooled over sprays

The pooled data across sprays (Table 1) indicated that azadirachtin 10000 ppm at 0.003% (0.64 larvae/plant) resulted in the significantly lowest larval population, which was comparable to *agniastra* at 3% (0.71 larvae/plant). This was followed by *dashaparni ark* at 3% (0.82 larvae/plant), which also demonstrated significant effectiveness in reducing the larval population. The next most effective treatment was *neemastra* at 3%, with 1.22 larvae per plant. Among all the evaluated botanicals, tobacco decoction at 2% showed a slightly higher larval population (1.54 larvae/plant), followed by Ipomoea leaf extract at 5% (1.46 larvae/plant) and *brahmastra* at 3% (1.38 larvae/plant). The untreated control recorded the significantly highest larval population (3.11 larvae/plant). These findings are consistent with those of Viroja (2011), who reported that NSKE at 3 to 5% (0.67 larvae/plant) and azadirachtin at 0.00045% (0.75 larvae/plant) were most effective against the larval population of the leaf webber and capsule borer on sesame. Similarly, Jasmine *et al.* (2023) observed a significantly lower larval population (1.03 larvae/plant) in plots treated with azadirachtin 10000 ppm.

Effect of different treatments on web infestation

The data on web infestation, recorded at 3, 6, and 9 days after spraying, pooled across periods and sprays, are presented in Table 2. Prior to spraying, web infestation was homogeneous across all treatments, as no significant differences were observed between treatments.

Pooled over sprays

The pooled data across sprays (Table 2) revealed that the lowest web infestation (0.46 webs/plant) was recorded in the plot treated with azadirachtin 10000 ppm at 0.003%, which was comparable to *agniastra* at 3% (0.50 webs/plant). Both treatments were significantly more effective than the other evaluated treatments. This was followed by *dashaparni ark* at 3% (0.58 webs/plant). No significant difference was observed between *neemastra* at 3% (0.89 webs/plant), *Brahmastra* at 3% (0.94 webs/plant), and Ipomoea leaf extract at 5% (0.99 webs/plant), all of which were equally effective. However, tobacco decoction at 2% (1.04 webs/plant) was found to be more effective than the untreated control (1.81 webs/plant). These findings are in line with those of Araya *et al.* (2023), who reported that azadirachtin resulted in the lowest leaf damage (8.56%), and Baskaran and Rajavel (2013), who found that azadirachtin 0.15 EC was effective in reducing leaf damage (8.40%).

Effect of different treatments on capsule damage

The data on capsule damage, recorded at 3, 6, and 9 days after spraying, pooled across periods and sprays, are presented in Table 3. Prior to spraying, capsule damage was homogeneous across all evaluated treatments, as no significant differences were observed between treatments.

Pooled over sprays

The pooled data across sprays (Table 3) revealed that the treatment with azadirachtin 10000 ppm at 0.003% resulted in the least capsule damage (4.68%), which was significantly lower than that of the other treatments. *Agniastra* at 3% (6.31%) and *dashaparni ark* at 3% (6.66%) also significantly reduced capsule damage and were comparable to each other. The next most effective treatment was *neemastra* at 3%, with 9.28% capsule damage. *Brahmastra* at 3% (10.40%) and Ipomoea leaf extract at 5% (10.99%) showed

Table 1. Effect of different treatments on number of larvae per plant of *Antigastra catalaunalis* in sesame during *kharif* 2023

Tr. No.	Treatments	Conc. (%)	Before spray	No. of larvae / plant												Pooled over spray
				1st spray				2nd spray				3rd spray				
				3 DAS*	6 DAS	9 DAS	Pooled over period	3 DAS	6 DAS	9 DAS	Pooled over period	3 DAS	6 DAS	9 DAS	Pooled over period	
T_1	Azadirachtin 10000 ppm	0.003	1.64^{a} (2.19)	1.25^{d} (1.07)	1.12^{d} (0.76)	1.28^{c} (1.13)	1.22^{d} (0.99)	1.09^{c} (0.69)	0.96^{c} (0.42)	1.06^{c} (0.62)	1.04^{c} (0.58)	0.98^{d} (0.46)	0.91^{d} (0.32)	0.97^{d} (0.43)	0.95^{e} (0.40)	1.07^{e} (0.64)
T_2	Brahmastra	3.0	1.61^{a} (2.09)	1.49^{bc} (1.73)	1.38^{bc} (1.41)	1.53^{b} (1.83)	1.47^{b} (1.66)	1.38^{b} (1.39)	1.27^{b} (1.12)	1.37^{b} (1.36)	1.34^{b} (1.30)	1.32^{b} (1.25)	1.25^{bc} (1.07)	1.30^{bc} (1.20)	1.29^{bc} (1.16)	1.37^{b} (1.38)
T_3	Agniastra	3.0	1.57^{a} (1.96)	1.26^{d} (1.10)	1.14^{d} (0.80)	1.30^{c} (1.20)	1.24^{d} (1.04)	1.12^{c} (0.76)	1.00^{c} (0.50)	1.10^{c} (0.72)	1.08^{c} (0.67)	1.03^{d} (0.56)	0.94^{d} (0.39)	1.01^{d} (0.51)	0.99^{de} (0.48)	1.10^{de} (0.71)
T_4	Neemastra	3.0	1.59^{a} (2.03)	1.35^{bcd} (1.33)	1.29^{bcd} (1.15)	1.42^{bc} (1.52)	1.35^{c} (1.32)	1.36^{b} (1.34)	1.24^{b} (1.03)	1.35^{b} (1.31)	1.31^{b} (1.22)	1.30^{bc} (1.18)	1.23^{bc} (1.00)	1.28^{bc} (1.13)	1.27^{c} (1.11)	1.31^{c} (1.22)
T_5	Dashaparni ark	3.0	1.56^{a} (1.93)	1.28^{cd} (1.15)	1.17^{cd} (0.87)	1.33^{bc} (1.27)	1.26^{cd} (1.09)	1.14^{c} (0.80)	1.03^{c} (0.56)	1.13^{c} (0.78)	1.10^{c} (0.71)	1.09^{cd} (0.70)	1.03^{cd} (0.56)	1.10^{cd} (0.71)	1.07^{d} (0.64)	1.15^{d} (0.82)
T_6	Tobacco decoction	2.0	1.59^{a} (2.03)	1.52^{b} (1.82)	1.44^{b} (1.56)	1.56^{b} (1.93)	1.51^{b} (1.78)	1.45^{b} (1.60)	1.32^{b} (1.24)	1.46^{b} (1.63)	1.41^{b} (1.49)	1.43^{b} (1.54)	1.34^{b} (1.30)	1.38^{b} (1.41)	1.38^{b} (1.40)	1.43^{b} (1.54)
T_7	*Ipomoaea* leaf extract	5.0	1.63^{a} (2.16)	1.50^{bc} (1.75)	1.41^{b} (1.50)	1.54^{b} (1.86)	1.48^{b} (1.69)	1.41^{b} (1.50)	1.30^{b} (1.19)	1.41^{b} (1.48)	1.37^{b} (1.38)	1.38^{b} (1.42)	1.31^{b} (1.20)	1.35^{b} (1.32)	1.35^{bc} (1.32)	1.40^{b} (1.46)
T_8	Untreated control	-	1.56^{a} (1.94)	1.74^{a} (2.51)	1.78^{a} (2.67)	1.83^{a} (2.83)	1.78^{a} (2.67)	1.87^{a} (3.01)	1.93^{a} (3.24)	1.95^{a} (3.29)	1.92^{a} (3.19)	1.98^{a} (3.42)	2.00^{a} (3.51)	2.03^{a} (3.63)	2.01^{a} (3.54)	1.90^{a} (3.11)
		T	0.09	0.07	0.07	0.06	0.035	0.07	0.06	0.07	0.033	0.07	0.07	0.07	0.035	0.021
		P	-	-	-	-	0.024	-	-	-	0.023	-	-	-	0.025	0.013
		S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.013
S. Em. ±		T×P	-	-	-	-	0.067	-	-	-	0.064	-	-	-	0.069	0.037
		T×S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.037
		P×S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.023
		T×P×S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.064
CD ($p \le 0.05$)			NS	0.20	0.20	0.19	0.10	0.20	0.18	0.20	0.09	0.21	0.21	0.21	0.10	0.06
CV (%)			10.26	8.14	8.44	7.55	8.21	8.33	8.09	8.60	8.36	9.02	9.67	9.33	9.34	8.30

*DAS: Days after spray, Figures in parentheses are retransformed values; those outside are square root transformed values.
Within a column treatment means followed by same alphabet did not differ significantly after DNMRT at $p \le 0.05$.

Table 2. Effect of different treatments on number of webs of *Antigastra catalaunalis* in sesame during *kharif* 2023

Tr. No.	Treatments	Conc. (%)	Before spray	Number of webs / plant												Pooled over spray
				1st spray				2nd spray				3rd spray				
				3 DAS*	6 DAS	9 DAS	Pooled over period	3 DAS	6 DAS	9 DAS	Pooled over period	3 DAS	6 DAS	9 DAS	Pooled over period	
T_1	Azadirachtin 10000 ppm	0.003	0.86[a] (0.25)	0.90[d] (0.32)	0.92[d] (0.35)	0.94[d] (0.39)	0.92[c] (0.35)	0.95[d] (0.40)	0.97[d] (0.43)	1.00[d] (0.49)	0.97[c] (0.44)	1.01[d] (0.53)	1.04[d] (0.57)	1.05[d] (0.60)	1.03[c] (0.56)	0.98[e] (0.46)
T_2	Brahmastra	3.0	0.87[a] (0.26)	1.08[bc] (0.66)	1.11[bc] (0.73)	1.13[bc] (0.78)	1.11[b] (0.73)	1.17[bc] (0.86)	1.19[bc] (0.91)	1.24[b] (1.03)	1.20[b] (0.94)	1.26[bc] (1.10)	1.29[bc] (1.18)	1.32[bc] (1.23)	1.29[b] (1.16)	1.20[bc] (0.94)
T_3	Agniastra	3.0	0.83[a] (0.20)	0.92[cd] (0.35)	0.94[d] (0.39)	0.97[cd] (0.44)	0.94[c] (0.38)	0.98[cd] (0.46)	1.00[cd] (0.50)	1.03[d] (0.56)	1.00[c] (0.50)	1.04[cd] (0.58)	1.08[cd] (0.67)	1.10[cd] (0.70)	1.07[c] (0.64)	1.00[de] (0.50)
T_4	Neemastra	3.0	0.87[a] (0.26)	1.07[bc] (0.64)	1.10[bc] (0.70)	1.12[bc] (0.74)	1.09[b] (0.69)	1.15[bc] (0.81)	1.17[bc] (0.86)	1.22[bc] (0.98)	1.18[b] (0.89)	1.24[bc] (1.03)	1.27[bc] (1.12)	1.30[bc] (1.18)	1.27[b] (1.11)	1.18[c] (0.89)
T_5	Dashaparni ark	3.0	0.86[a] (0.23)	0.95[bcd] (0.40)	0.98[cd] (0.46)	0.99[cd] (0.49)	0.98[c] (0.46)	1.01[bcd] (0.52)	1.04[bcd] (0.58)	1.05[cd] (0.61)	1.03[c] (0.56)	1.07[cd] (0.64)	1.11[bcd] (0.73)	1.13[bcd] (0.77)	1.10[c] (0.71)	1.04[d] (0.58)
T_6	Tobacco decoction	2.0	0.87[a] (0.26)	1.11[b] (0.74)	1.15[b] (0.82)	1.19[b] (0.91)	1.15[b] (0.82)	1.20[b] (0.94)	1.22[b] (0.98)	1.29[b] (1.16)	1.23[b] (1.01)	1.33[b] (1.26)	1.34[b] (1.30)	1.36[b] (1.36)	1.35[b] (1.32)	1.24[b] (1.04)
T_7	*Ipomoaea*leaf extract	5.0	0.90[a] (0.31)	1.09[b] (0.70)	1.13[bc] (0.77)	1.16[b] (0.84)	1.13[b] (0.78)	1.18[b] (0.88)	1.20[b] (0.95)	1.26[b] (1.09)	1.21[b] (0.96)	1.30[b] (1.18)	1.32[b] (1.24)	1.34[b] (1.30)	1.32[b] (1.24)	1.22[bc] (0.99)
T_8	Untreated control	-	0.91[a] (0.34)	1.28[a] (1.13)	1.36[a] (1.34)	1.42[a] (1.52)	1.35[a] (1.32)	1.45[a] (1.62)	1.52[a] (1.81)	1.59[a] (2.04)	1.52[a] (1.81)	1.65[a] (2.21)	1.70[a] (2.39)	1.72[a] (2.46)	1.69[a] (2.36)	1.52[a] (1.81)
SEm.±		T	0.05	0.05	0.05	0.05	0.026	0.06	0.06	0.06	0.031	0.07	0.07	0.07	0.034	0.019
		P	-	-	-	-	0.018	-	-	-	0.021	-	-	-	0.024	0.012
		S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.012
		T×P	-	-	-	-	0.051	-	-	-	0.061	-	-	-	0.068	0.033
		T×S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.033
		P×S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.020
		T×P×S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.057
CD ($p \leq 0.05$)			NS	0.15	0.16	0.16	0.07	0.17	0.19	0.19	0.09	0.20	0.21	0.21	0.10	0.053
CV (%)			10.22	8.06	8.17	8.26	8.17	8.65	9.11	9.14	8.98	9.46	9.23	9.39	9.36	8.47

*DAS: Days after spray, Figures in parentheses are retransformed values; those outside are square root transformed values.
Within a column treatment means followed by same alphabet did not differ significantly after DNMRT at $p \leq 0.05$.

Table 3. Effect of different treatments on capsule damage by *Antigastra catalaunalis* in sesame during *kharif* 2023

Tr. No.	Treatments	Conc. (%)	Before spray	Capsule damage (%)												Pooled over spray
				1st spray				2nd spray				3rd spray				
				3 DAS*	6 DAS	9 DAS	Pooled over period	3 DAS	6 DAS	9 DAS	Pooled over period	3 DAS	6 DAS	9 DAS	Pooled over period	
T_1	Azadirachtin 10000 ppm	0.003	8.51^{a} (2.19)	10.70^{e} (3.44)	11.07^{e} (3.69)	12.06^{e} (4.36)	11.28^{f} (3.83)	12.38^{d} (4.60)	12.64^{c} (4.79)	12.96^{c} (5.03)	12.66^{f} (4.80)	13.29^{c} (5.29)	13.56^{c} (5.50)	13.76^{c} (5.66)	13.54^{e} (5.48)	12.49^{f} (4.68)
T_2	Brahmastra	3.0	7.85^{a} (1.86)	16.58^{bc} (8.14)	16.96^{bc} (8.51)	17.86^{bc} (9.40)	17.13^{c} (8.68)	18.39^{bc} (9.96)	18.97^{b} (10.57)	19.51^{b} (11.15)	18.96^{cd} (10.56)	19.88^{b} (11.56)	20.29^{b} (12.02)	20.85^{b} (12.67)	20.34^{c} (12.08)	18.81^{c} (10.40)
T_3	Agniastra	3.0	8.22^{a} (2.04)	12.08^{e} (4.38)	12.46^{e} (4.66)	13.84^{de} (5.72)	12.79^{e} (4.90)	14.27^{d} (6.07)	14.70^{c} (6.44)	15.30^{c} (6.96)	14.76^{e} (6.49)	15.74^{c} (7.36)	16.11^{c} (7.70)	16.43^{c} (8.00)	16.09^{d} (7.68)	14.55^{e} (6.31)
T_4	Neemastra	3.0	7.98^{a} (1.93)	14.66^{cd} (6.40)	15.19^{cd} (6.87)	16.01^{cd} (7.60)	15.29^{d} (6.95)	17.23^{c} (8.77)	18.23^{b} (9.79)	18.91^{b} (10.50)	18.12^{d} (9.67)	19.33^{b} (10.95)	19.91^{b} (11.59)	20.21^{b} (11.93)	19.82^{c} (11.50)	17.74^{d} (9.28)
T_5	Dashaparni ark	3.0	8.28^{a} (2.08)	12.92^{de} (5.00)	13.28^{de} (5.28)	13.92^{de} (5.79)	13.37^{e} (5.35)	14.38^{d} (6.16)	15.02^{c} (9.72)	15.72^{c} (7.34)	15.04^{e} (6.73)	16.12^{c} (7.71)	16.51^{c} (8.07)	16.77^{c} (8.33)	16.47^{d} (8.04)	14.96^{e} (6.66)
T_6	Tobacco decoction	2.0	7.88^{a} (1.88)	17.68^{b} (9.23)	19.09^{b} (10.70)	19.51^{b} (11.16)	18.76^{b} (10.34)	20.34^{b} (12.08)	20.73^{b} (12.53)	21.30^{b} (13.19)	20.79^{b} (12.60)	21.65^{b} (13.61)	22.05^{b} (14.10)	22.35^{b} (14.46)	22.02^{b} (14.06)	20.52^{b} (12.29)
T_7	*Ipomoaea* leaf extract	5.0	8.17^{a} (2.02)	16.87^{bc} (8.42)	17.71^{b} (9.25)	18.33^{bc} (9.89)	17.64^{bc} (9.18)	18.72^{bc} (10.31)	19.46^{b} (11.10)	20.21^{b} (11.94)	19.46^{c} (11.10)	20.61^{b} (12.39)	21.01^{b} (12.85)	21.34^{b} (13.24)	20.99^{bc} (12.83)	19.36^{c} (10.99)
T_8	Untreated control	-	8.62^{a} (2.24)	20.31^{a} (12.05)	23.11^{a} (15.40)	24.65^{a} (17.39)	22.69^{a} (14.88)	25.68^{a} (18.78)	26.12^{a} (19.38)	27.05^{a} (20.68)	26.28^{a} (19.60)	27.92^{a} (21.92)	28.60^{a} (22.92)	30.13^{a} (25.20)	28.88^{a} (23.33)	25.95^{a} (19.15)
SEm±		T	0.48	0.76	0.77	0.88	0.426	0.89	0.84	0.94	0.441	1.02	1.03	1.04	0.515	0.283
		P	-	-	-	-	0.277	-	-	-	0.309	-	-	-	0.359	0.173
		S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.173
		T×P	-	-	-	-	0.785	-	-	-	0.875	-	-	-	1.016	0.490
		T×S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.490
		P×S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.300
		T×P×S	-	-	-	-	-	-	-	-	-	-	-	-	-	0.849
CD ($p \leq 0.05$)			NS	2.31	2.32	2.68	1.21	2.70	2.56	2.85	1.25	3.10	3.13	3.16	1.46	0.791
CV (%)			10.13	8.66	8.23	8.99	8.15	8.72	8.02	8.63	8.08	9.15	9.05	8.91	8.70	7.93

*DAS: Days after spray, Figures in parentheses are retransformed values; those outside are arcsine transformed values.
Within a column treatment means followed by same alphabet did not differ significantly after DNMRT at $p \leq 0.05$.

similar effectiveness. However, tobacco decoction at 2% resulted in higher capsule damage (12.29%), while the untreated control recorded the highest capsule damage (19.15%). These findings are consistent with those of Araya *et al.* (2023), who reported that azadirachtin was the most effective treatment, resulting in the lowest capsule damage (3.34%). Similarly, Viroja (2011) found that azadirachtin at 0.001% and NSKE at 5% also resulted in low capsule damage (3.61% and 4.84%, respectively). Additionally, Jasmine *et al.* (2023) observed that azadirachtin 10000 ppm caused the lowest capsule damage (7.56%), which aligns with the present study's findings.

Impact of treatments on yield of sesame

The primary objective of pest management is to suppress target pests through various methods, thereby enhancing crop yield. To assess the effect of different botanical treatments on yield, data on seed yield, yield increase over control, and avoidable losses were recorded. These results are presented in Table 4.

All botanical treatments resulted in significantly higher yields compared to the control. The highest seed yield (612 kg/ha) was recorded in the plot treated with azadirachtin 10000 ppm at 0.003%, which was comparable to *agniastra* at 3% (585 kg/ha), *dashaparni ark* at 3% (568 kg/ha), and *neemastra* at 3% (532 kg/ha). The plot treated with *brahmastra* at 3% recorded an average seed yield of 507 kg/ha. Among the evaluated botanicals, the lowest seed yield was observed in tobacco decoction at 2% (435 kg/ha) and Ipomoea leaf extract at 5% (473 kg/ha). The untreated control plot recorded the lowest seed yield (338 kg/ha), which was significantly lower than all the treated plots.

Increase in yield over control

The increase in yield over control (Table 4) was calculated for the different botanical treatments. The highest yield increase (81.26%) was observed in the plot treated with azadirachtin 10000 ppm at 0.003%. This was followed by *agniastra* at 3% (73.08%) and *dashaparni ark* at 3% (68.24%). The next highest increases were recorded in *neemastra* at 3% (57.40%) and *brahmastra* at 3% (50.10%). Among the tested botanicals, the lowest yield increases were observed in tobacco decoction at 2% (28.70%) and Ipomoea leaf extract at 5% (39.94%).

Avoidable loss

The avoidable loss (%) in sesame yield due to leaf webber and capsule borer was calculated according to Khosla (1977) and is presented in Table 4. The data clearly shows that the highest seed yield (612 kg/ha) was obtained from the azadirachtin 10000 ppm at 0.003%, making it the most effective treatment. The avoidable losses in sesame yield due to leaf webber and capsule borer ranged from 4.52% to 44.83% across various treatments. The lowest avoidable losses were observed in the plots treated with *agniastra* at 3% (4.52%), followed by *dashaparni ark* at 3% (7.18%). On the other hand, the highest avoidable loss in sesame yield was recorded in the untreated control (44.83%).

These findings are consistent with those of Araya *et al.* (2023), who reported the highest seed yield (0.71 t/ha) and the greatest percent increase in sesame yield over the control (222.73%) with azadirachtin. Similarly, azadirachtin was found to result in the highest yield in groundnut (1630 kg pods/ha) (Baskaran and Rajavel, 2013). Viroja (2011) also found that NSKE at 3% and 5%, along with azadirachtin at 0.001%, resulted in the

Table 4. Seed yield, increase in yield over control and avoidable loss in different treatments

Tr. No.	Treatments	Conc. (%)	Seed yield (kg/ha)	Increase in yield over control (%)	Avoidable loss (%)
T_1	Azadirachtin 10000 ppm	0.003	612^{a}	81.26	-
T_2	Brahmastra	3.0	507^{bcd}	50.10	17.19
T_3	Agniastra	3.0	585^{ab}	73.08	4.52
T_4	Neemastra	3.0	532^{abc}	57.40	13.17
T_5	Dashaparni ark	3.0	568^{ab}	68.24	7.18
T_6	Tobacco decoction	2.0	435^{de}	28.70	29.00
T_7	*Ipomoaea* leaf extract	5.0	473^{cd}	39.94	22.80
T_8	Untreated control	-	338^{e}	-	44.83
SEm±			28.14	-	-
CD ($p \leq 0.05$)			85.36	-	-
CV (%)			9.62	-	-

Within a column treatment means followed by same alphabet did not differ significantly after DNMRT at $p \leq 0.05$.

Table 5. Economics of different botanicals evaluated against *Antigastra catalaunalis* on sesame

Tr. No.	Treatments	Conc. (%)	Qty. of material required for 3 sprays (L or kg/ha)	Cost of material (₹/ha)	Labour cost (₹)	Total cost of treatment	Seed yield (kg/ha)	Gross realization (₹/ha)	Net realization over control (₹/ha)	Net gain (₹/ha)	ICBR
T_1	Azadirachtin 10000 ppm	0.003	4.50	4275	2625	6900	612	52846	23660	16760	1:2.43
T_2	Brahmastra	3.0	45.0	900	2625	3525	507	43779	14593	11068	1:3.14
T_3	Agniastra	3.0	45.0	1575	2625	4200	585	50515	21328	17128	1:4.08
T_4	Neemastra	3.0	45.0	945	2625	3570	532	45938	16752	13182	1:3.69
T_5	Dashaparni ark	3.0	45.0	1845	2625	4470	568	49047	19861	15391	1:3.44
T_6	Tobacco decoction	2.0	30.0	300	2625	2925	435	37562	8376	5451	1:1.86
T_7	*Ipomoea* leaf extract	5.0	75.0	300	2625	2925	473	40844	11657	8732	1:2.99
T_8	Untreated control	-	-	-	-	-	338	29186	-	-	-

Price of sesame: ₹86.35/kg. Labours required: 2 labour/ha for one spray + 1 for extract preparation. Cost of labour: ₹375/day for spraying. Price of botanicals in ₹/kg or litre, azadirachtin 10000 ppm: ₹950/litre, *brahmastra*: ₹20/litre, *agniastra*: ₹35/litre, *neemastra*: ₹21/kg, *dashaparni ark*: ₹41/litre, tobacco decoction: ₹10/kg, *Ipomoea* leaf extract: ₹4/litre.

highest seed yields (727 and 655 kg/ha, respectively) and the greatest percent increase in yield over control (45% to 39%) among all treatments. The slight variations in yields observed in different studies could be attributed to differences in varieties and environmental conditions at each study location. Overall, the present findings are in line with these previous results.

Economics

The economics of various botanical treatments evaluated against sesame leaf webber and capsule borer (Table 5) indicated that the maximum net realization (₹23,660/ha) was obtained with azadirachtin 10000 ppm at 0.003%, followed by *agniastra* at 3% (₹21,328/ha), *dashaparni ark* at 3% (₹19,861/ha), *neemastra* at 3% (₹16,752/ha), and *brahmastra* at 3% (₹14,593/ha). The lowest net realization was recorded with Ipomoea leaf extract at 5% (₹11,657/ha) and tobacco decoction at 2% (₹8,376/ha).

The highest incremental cost-benefit ratio (ICBR) of 1:4.08 was observed with *agniastra* at 3%, followed by *neemastra* at 3% (1:3.69), *dashaparni ark* at 3% (1:3.44), and *brahmastra* at 3% (1:3.14). The ICBRs for Ipomoea leaf extract at 5% and azadirachtin 10000 ppm at 0.003% were 1:2.99 and 1:2.43, respectively. The lowest ICBR (1:1.86) was recorded for tobacco decoction at 2%. These results are consistent with those of Viroja (2011), who reported the highest seed yield and net monetary return from NSKE at 5% (727 kg/ha and ₹14,715/ha), followed by azadirachtin at 0.00045% (667 kg/ha and ₹12,015/ha).

Among the seven botanicals and plant-based extracts evaluated, azadirachtin 10000 ppm at 0.003% and *agniastra* at 3% emerged as the most effective treatments for reducing the larval population (0.64 and 0.71 larvae/plant), web infestation (0.46 and 0.50 webs/plant), and capsule damage (4.68% and 6.31%), respectively. The highest sesame seed yield was obtained from the plot treated with azadirachtin 10000 ppm at 0.003% (612 kg/ha), followed by *agniastra* at 3% (585 kg/ha) and *dashaparni ark* at 3% (568 kg/ha). The highest incremental cost-benefit ratio (ICBR) of 1:4.08 was recorded for *agniastra* at 3%, followed by *neemastra* at 3% (1:3.69) and *dashaparni ark* at 3% (1:3.44). These results highlight the effectiveness of azadirachtin and *agniastra* in pest management while maximizing economic returns in sesame cultivation.

Authors contribution

Conceptualization and designing of the research work (MKC, BKP and MSS); Execution of field/lab experiments and data collection (SBK); Analysis of data and interpretation (SBK); Preparation of manuscript (SBK and MKC).

Conflicts of interest

Authors declare that they have no conflicts of interest.

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