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Field efficacy of certain insecticides against gall fly *Asphondylia sesami* Felt. on sesame

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Abstract
A field experiment was conducted during *summer* 2019 and 2020 to study the field efficacy of certain insecticides against *A. sesami* on sesame. The pooled results revealed that, per cent flower infestation of *A. sesami* before insecticidal spray varies from 5.90 – 7.05 in different treatments. Five days after insecticidal spray, the lowest mean per cent flower infestation was recorded in spinosad 45% SC @ 0.3 ml lit^{-1} treatment (3.08%) followed by profenophos 50% EC @ 2.0 ml lit^{-1}, chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1} and acephate 75% SP @ 1.0 g lit^{-1} with 3.90, 4.08 and 4.38 per cent flower infestation, respectively. Ten days after treatment imposition, significantly lowest mean per cent flower infestation was recorded in spinosad 45% SC @ 0.3 ml lit^{-1} (1.40%) followed by profenophos 50% EC @ 2.0 ml lit^{-1}, acephate 75% SP @ 1.0 g lit^{-1} and chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1} with 2.37, 2.57 and 2.60 per cent flower infestation, respectively. Regarding pooled per cent reduction of flower infestation over control, highest was recorded in spinosad 45% SC @ 0.3 ml lit^{-1} followed by profenophos 50% EC @ 2.0 ml lit^{-1} with 81.12 and 68.04 per cent. Acephate 75% SP @ 1.0 g lit^{-1}, was the next best treatment with 65.34 per cent reduction flower infestation over control. The treatments *viz.*, Chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1}, imidacloprid 17.8% SL @ 0.4 ml lit^{-1} and ethofenprox 10% EC @ 2.0 ml lit^{-1} and azadirachtin 1500 ppm @ 5.0 ml lit^{-1} recorded the 64.93, 52.53, 51.31 and 26.77 per cent flower infestation reduction over control.

Keywords: gallfly, efficacy, insecticides, infestation, sesame

Introduction
Sesame, *Sesamum indicum* (L.), is the world's oldest oilseed crop, grown throughout India and known as the "Queen of oilseeds" owing to its unique oil quality. It is grown in India throughout the crop growing seasons, including *kharif*, late *kharif*, *rabi* and *summer*. Sesame seeds contain 38-54 percent oil, 18-25 percent protein, phosphorus, calcium, and oxalic acid, among other nutrients. It is grown in India with an area of 16.22 lakh ha, 6.57 lakh tonnes production and 405 kg ha^{-1} productivity. In Telangana sesame occupies an area of 21,000 ha with production and productivity of 0.14 lakh tonnes and 636 kg ha^{-1}, respectively (INDIASTAT, 2019-20) [2].

One of the most important reasons contributing to low sesame yields is insect pest damage. At different phases of its growth, this crop is attacked by 29 insect pests (Biswas *et al.*, 2001) [1]. Among insect pests, *A. sesami* Felt. (Diptera: Cecidomyiidae) commonly known as sesame gall fly and is widely distributed in Southern India. It causes serious damage to sesame in South India, Andhra Pradesh and Gujarat (Singh *et al*., 1990) [9]. The infestation by *A. sesami* was recorded about 99.23 per cent of the plants from the plains of West Bengal and estimated loss in the yield was 31.28 per cent (Sengupta *et al*., 2002) [10]. The female lays its eggs singly by its needle-like ovipositor in the flowers and buds of sesame. Maggots cause damage and feed inside the floral bud leading to formation of gall like structure and the damaged flower does not produce capsule. Finally, the affected buds wither and drop. Insecticides are the primary weapons to control any insect pest. Present-day need emphasizes not only the use of different groups of chemicals that are eco-friendly but also the ones which give satisfactory control of insect pest population by their novel mode of action. The insecticides which are having low toxicity against natural enemies are safer to environment. Keeping these facts in view, present study on efficacy of certain insecticides against gall fly on sesame was taken.

Material and Methods
The experiment was laid out in randomized block design (RBD) with eight treatments

including untreated control and replicated thrice. Required numbers of plots having a plot size of 12 m^2 (3 m × 4 m) were prepared to accommodate all the eight treatments. Spacing of 30 X 15 cm was adopted for raising the sesame crop. Irrigation channels of one meter width was prepared between each replication for effective irrigation to the crop. Each plot was separated by a gap of 0.75 m, so that drifting of insecticides during spraying was minimized. Selected insecticide molecules that are known to have novel mode of action *viz.*, acephate 75% SP, spinosad 45% SC, profenophos 50% EC, imidacloprid 17.8% SL, ethofenprox 10% EC, chlorantraniliprole 18.5% SC and azadirachtin 1500 ppm were tested at their respective recommended field concentrations. The insecticidal application was done at 45 days after sowing.

Data on per cent flower infestation by *A. sesami* was recorded from 10 randomly selected plants, day before spraying as pre-treatment count and at 5 and 10 days after spraying as post treatment counts. The per cent flower infestation was calculated by using following formula

Per cent flower infestation = (No. of infested flower / Total no. of flowers) X 100

The per cent reduction of flower infestation over control was calculated by using following formula.

Per cent reduction over control = ((Per cent flower infestation in control - Per cent flower infestation in treatment) / Per cent flower infestation in control) X100

The observations recorded were subjected to statistical analysis (RBD) to know the significance of difference among different treatments. The values in percentages were transformed to arc sine values before analysis. Statistical analysis was carried out using ANOVA technique given by Panse and Sukhatme (1985) [7].

Results and Discussion

Efficacy of insecticides against per cent flower infestation of *A. sesami* during *summer* 2019

During *summer* 2019, the per cent flower infestation of *A. sesami* before insecticidal spray varies from 6.41 - 8.14 in different treatments and there were no significant difference was observed among the treatments. At five days after insecticidal spray, the lowest mean per cent flower infestation was recorded in spinosad 45% SC @ 0.3 ml lit^{-1} followed by profenophos 50% EC @ 2.0 ml lit^{-1} with 3.96 and 4.49 per cent infestation and these treatments were on par with each other. Chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1} (5.10%) was the next best treatment and this treatment was significantly superior over other treatments. Acephate 75% SP @ 1.0 g lit^{-1}, imidacloprid 17.8% SL @ 0.4 ml lit^{-1} and ethofenprox 10% EC @ 2.0 ml lit^{-1} recorded with 5.43, 5.81 and 6.80 per cent flower infestation of *A. sesami*. Azadirachtin 1500 ppm @ 5.0 ml lit^{-1} (8.51%) was least effective in controlling per cent flower infestation. All insecticidal treatments were significantly superior over untreated control. The efficacy of different insecticidal treatments against per cent flower infestation of *A. sesami* at five days after spray was found to be in the following order

T2 > T3 > T6 > T1 > T4 > T5 > T7 > T8

At ten days after insecticidal spray, spinosad 45% SC @ 0.3 ml lit^{-1} was recorded significantly lowest per cent flower infestation (1.89%) followed by profenophos 50% EC @ 2.0 ml lit^{-1} and acephate 75% SP @ 1.0 g lit^{-1} with 2.88 and 3.06 per cent flower infestation and these were on par with each other. Chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1}, imidacloprid 17.8% SL @ 0.4 ml lit^{-1} and ethofenprox 10% EC @ 2.0 ml lit^{-1} were the next best treatments with 3.19, 3.92 and 4.17 per cent flower infestation of *A. sesami*. Azadirachtin 1500 ppm @ 5.0 ml lit^{-1} (9.18%) was least effective in controlling per cent flower infestation. All insecticidal treatments were significantly superior over untreated control. The efficacy of different insecticidal treatments against per cent flower infestation of *A. sesami* at ten days after insecticidal spray was found to be in the following order

T2 > T3 > T1 > T6 > T4 > T5 > T7 > T8

The highest mean per cent reduction of flower infestation of *A. sesami* over control was recorded in spinosad 45% SC @ 0.3 ml lit^{-1} followed by profenophos 50% EC @ 2.0 ml lit^{-1} with 79.41 and 68.63 per cent. Acephate 75% SP @ 1.0 g lit^{-1} was next best treatment with 66.67 per cent reduction flower infestation over control. The treatments *viz.*, chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1}, imidacloprid 17.8% SL @ 0.4 ml lit^{-1} and ethofenprox 10% EC @ 2.0 ml lit^{-1} and azadirachtin 1500 ppm @ 5.0 ml lit^{-1} recorded the 65.25, 57.30, 54.58 and 38.24 per cent reduction over control. The per cent reduction of flower infestation over control in different treatments after insecticidal spray as follows.

T2 > T3 > T1 > T6 > T4 > T5 > T7

The present findings were in agreement with Patil *et al.* (2014) and Deshmukh (2009) [4] who reported that, spinosad 45 SC (0.01%) was effective against gall fly in sesame.

Efficacy of insecticides against per cent flower infestation of *A. sesami* during *summer* 2020

The per cent flower infestation of *A. sesami* before insecticidal spray varies from 4.40 – 5.95 in different treatments and there were no significant difference was observed among the treatments. Five days after insecticidal spray, the significantly lowest mean per cent flower infestation was recorded in spinosad 45% SC @ 0.3 ml lit^{-1} (2.20%) followed by profenophos 50% EC @ 2.0 ml lit^{-1}, chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1} and acephate 75% SP @ 1.0 g lit^{-1} with 3.06, 3.26 and 3.33 per cent flower infestation and these treatments were on par with each other. Ethofenprox 10% EC @ 2.0 ml lit^{-1} and imidacloprid 17.8% SL @ 0.4 ml lit^{-1} were the next treatments recorded with 3.81 and 4.28 per cent flower infestation of *A. sesami*. Azadirachtin 1500 ppm @ 5.0 ml lit^{-1} (6.18%) was least effective in controlling per cent flower infestation. All insecticidal treatments were significantly superior over untreated control (6.18%). The efficacy of different insecticidal treatments against per cent flower infestation of *A. sesami* at five days after insecticidal spray was found to be in the following order

T2 > T3 > T6 > T1 > T5 > T4 > T7 > T8

Data at ten days after insecticidal spray revealed that, spinosad 45% SC @ 0.3 ml lit^{-1} was recorded significantly

lowest per cent flower infestation (0.91%). Profenophos 50% EC @ 2.0 ml lit^{-1}, chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1} and acephate 75% SP @ 1.0 g lit^{-1} with 1.85, 2.00 and 2.08 per cent flower infestation and these treatments were on par with each other. The next best treatments were ethofenprox 10% EC @ 2.0 ml lit^{-1} and imidacloprid 17.8% SL @ 0.4 ml lit^{-1} recorded with 3.06 and 3.13 per cent flower infestation of *A. sesami.* Azadirachtin 1500 ppm @ 5.0 ml lit^{-1} (6.18%) was least effective in controlling per cent flower infestation. All insecticidal treatments were significantly superior over untreated control (8.20%). The efficacy of different insecticidal treatments against per cent flower infestation of *A. sesami* at ten days after spray was found to be in the following order.

T2 > T3 > T6 > T1 > T5 > T4 > T7 > T8

The highest mean per cent reduction of flower infestation over control was recorded in spinosad 45% SC @ 0.3 ml lit^{-1} followed by profenophos 50% EC @ 2.0 ml lit^{-1} with 88.90 and 77.44 per cent. Chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1} was next best treatment with 75.61 per cent reduction flower infestation over control. The treatments *viz.,* acephate 75% SP @ 1.0 g lit^{-}, imidacloprid 17.8% SL @ 0.4 ml lit^{-1} and ethofenprox 10% EC @ 2.0 ml lit^{-1} and azadirachtin 1500 ppm @ 5.0 ml lit^{-1} recorded the 74.63, 62.68, 61.68 and 36.71 per cent reduction over control. The per cent reduction of flower infestation over control in different treatments after insecticidal spray as follows.

T2 > T3 > T6 > T1 > T5 > T4 > T7

After the spinosad insecticide, profenophos 50% EC @ 2.0 ml lit^{-1} and acephate 75% SP @ 1.0 g lit^{-1}were next best treatments. These findings in agreement with Jumale *et al.*, (2016) [5] who reported that, quinalphos 25 EC @ 2 ml lit^{-1} applied at 15, 30 and 45 days after crop emergence therefore prove effective against sesame gall fly. Sudha Rani *et al.* (2018) [11] who reported that, monocrotophos and chlorpyriphos were effective against rice gall midge.

Pooled efficacy of insecticides against flower infestation of *A. sesami* during *summer* 2019 and 2020

The pooled efficacy of different selective insecticidal treatments during *summer* 2019 and 2020 against flower infestation of *A. sesami* was presented in table 3.

The pooled per cent flower infestation of *A. sesami* before insecticidal spray varies from 5.90 – 7.05 in different treatments and there were no significant difference was observed among the treatments. At five days after spray, the lowest mean per cent flower infestation was recorded in spinosad 45% SC @ 0.3 ml lit^{-1} (3.08%) and this treatment was significantly superior over other treatments. Profenophos 50% EC @ 2.0 ml lit^{-1}, chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1} and acephate 75% SP @ 1.0 g lit^{-1} with 3.90, 4.08 and 4.38 per cent flower infestation and these treatments were on par with each other. Imidacloprid 17.8% SL @ 0.4 ml lit^{-1} and ethofenprox 10% EC @ 2.0 ml lit^{-1} were the next best treatments recorded with 5.05 and 5.08 per cent flower infestation of *A. sesami* and on par each other. Azadirachtin 1500 ppm @ 5.0 ml lit^{-1} (5.75%) was least effective in controlling per cent flower infestation. All insecticidal treatments were significantly superior over untreated control (7.34%). The efficacy of different insecticidal treatments against per cent flower infestation of *A. sesami* at five days after insecticidal spray was found to be in the following order

T2 > T3 > T6 > T1 > T4 > T5 > T7 > T8

Ten days after insecticidal spray, significantly lowest mean per cent flower infestation was recorded in spinosad 45% SC @ 0.3 ml lit^{-1} (1.40) followed by profenophos 50% EC @ 2.0 ml lit^{-1}, acephate 75% SP @ 1.0 g lit^{-1} and chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1} with 2.37, 2.57 and 2.60 per cent flower infestation and these treatments were on par with each other. Imidacloprid 17.8% SL @ 0.4 ml lit^{-1} and ethofenprox 10% EC @ 2.0 ml lit^{-1} were the next best treatments recorded with 3.52 and 3.61 per cent flower infestation of *A. sesami* and on par each other. Azadirachtin 1500 ppm @ 5.0 ml lit^{-1} (5.43%) was least effective in controlling per cent flower infestation. All insecticidal treatments were significantly superior over untreated control (8.69%). The efficacy of different insecticidal treatments against per cent flower infestation of *A. sesami* at ten days after insecticidal spray was found to be in the following order

T2 > T3 > T1 > T6 > T5 > T4 > T7 > T8

The pooled data revealed that, highest mean per cent reduction of flower infestation over control was recorded in spinosad 45% SC @ 0.3 ml lit^{-1} followed by profenophos 50% EC @ 2.0 ml lit^{-1} with 81.12 and 68.04 per cent. Acephate 75% SP @ 1.0 g lit^{-1}, was next best treatment with 65.34 per cent reduction flower infestation over control. The treatments *viz.,* Chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1}, imidacloprid 17.8% SL @ 0.4 ml lit^{-1} and ethofenprox 10% EC @ 2.0 ml lit^{-1} and azadirachtin 1500 ppm @ 5.0 ml lit^{-1} recorded the 64.93, 52.53, 51.31 and 26.77 per cent reduction over control. The per cent reduction of flower infestation over control in different treatments after insecticidal spray as follows.

T2 > T3 > T1 > T6 > T4 > T5 > T7

chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1} was next best treatment and these results were in accordance with Choade *et al.,* (2018) [3] who revealed that, on the basis of average percent infestation of gall fly. Another insecticide azadadirachtin was least effective in controlling *A. sesami* (Kaushal Kishore *et al.*, 2020) [6].

Table 1: Efficacy of certain insecticides against per cent flower infestation of *A. sesami* on sesame after insecticidal spray during s*ummer* 2019

Treatments	Per cent flower infestation of *A. sesami*			% Reduction over control
	DBS	5 DAS	10 DAS	
T_1: Acephate 75% SP	7.32 (15.70)	5.43^{bcd} (13.48)	3.06^{bc} (10.07)	66.67
T_2: Spinosad 45% SC	7.64 (16.05)	3.96^{a} (11.47)	1.89^{a} (7.90)	79.41
T_3: Profenophos 50% EC	6.41 (14.67)	4.49^{ab} (12.23)	2.88^{b} (9.77)	68.63
T_4: Imidacloprid 17.8% SL	7.50 (15.89)	5.81^{e} (13.95)	3.92^{de} (11.42)	57.30
T_5: Ethofenprox 10% EC	8.14 (16.58)	6.52^{ef} (14.79)	4.17^{ef} (11.78)	54.58
T_6: Chlorantraniliprole 18.5% SC	7.14 (15.50)	5.10^{bc} (13.05)	3.19^{d} (10.29)	65.25
T_7:Azadirachtin 1500 ppm	7.06 (15.41)	6.80^{g} (15.12)	5.67^{g} (13.77)	38.24
T_8: Untreated control	7.08 (15.43)	8.51^{h} (16.96)	9.18^{h} (17.64)	-
CD (p=0.05)	NS	1.44	1.28	-
SEm ±	0.74	0.47	0.41	-

DBS- Day Before Spray, DAS- Days After Spray, NS – Non-Significant
Values in parenthesis are Angular transformed values

Table 2: Efficacy of certain insecticides against per cent flower infestation of *A. sesami* on sesame after insecticidal spray during s*ummer* 2020

Treatments	Per cent flower infestation of *A. sesami*			% Reduction over control
	DBS	5 DAS	10 DAS	
T_1: Acephate 75% SP	5.62 (13.71)	3.33^{bcd} (10.51)	2.08^{bcd} (8.29)	74.63
T_2: Spinosad 45% SC	4.85 (12.72)	2.20^{a} (8.53)	0.91^{a} (5.47)	88.90
T_3: Profenophos 50% EC	5.88 (14.03)	3.06^{b} (10.07)	1.85^{b} (7.82)	77.44
T_4: Imidacloprid 17.8% SL	4.40 (12.11)	4.28^{f} (11.93)	3.13^{f} (10.19)	61.83
T_5: Ethofenprox 10% EC	5.95 (14.12)	3.81^{de} (11.25)	3.06^{e} (10.07)	62.68
T_6: Chlorantraniliprole 18.5% SC	4.65 (12.45)	3.26^{bc} (10.40)	2.00^{bc} (8.13)	75.61
T_7:Azadirachtin 1500 ppm	5.59 (13.67)	4.90^{fg} (12.79)	5.19^{fg} (13.16)	36.71
T_8: Untreated control	4.17 (11.78)	6.18^{h} (14.39)	8.20^{h} (16.64)	-
CD (p=0.05)	NS	1.35	1.53	-
SEm ±	0.74	0.47	0.41	-

DBS- Day Before Spray,DAS- Days After Spray, NS – Non-Significant
Values in parenthesis are Angular transformed values

Table 3: Pooled fficacy of certain insecticides against per cent flower infestation of *A. sesami* on sesame after insecticidal spray during s*ummer* 2019 and 2020

Treatments	Per cent flower infestation of *A. sesami*			% Reduction over control
	DBS	5 DAS	10 DAS	
T_1: Acephate 75% SP	6.47 (14.74)	4.38^{bcd} (12.08)	2.57^{bc} (9.23)	65.34
T_2: Spinosad 45% SC	6.25 (14.48)	3.08^{a} (10.10)	1.40^{a} (6.80)	81.12
T_3: Profenophos 50% EC	5.95 (14.12)	3.90^{b} (11.38)	2.37^{b} (8.86)	68.04
T_4: Imidacloprid 17.8% SL	6.15 (14.36)	5.05^{cde} (12.98)	3.52^{f} (10.81)	52.53
T_5: Ethofenprox 10% EC	7.05 (15.40)	5.08^{cdef} (13.02)	3.61^{e} (10.95)	51.31
T_6: Chlorantraniliprole 18.5% SC	5.90 (14.06)	4.08^{bc} (11.65)	2.60^{bcd} (9.28)	64.93
T_7:Azadirachtin 1500 ppm	6.32 (14.56)	5.75^{fg} (13.87)	5.43^{fg} (13.47)	26.77
T_8: Untreated control	5.62 (13.71)	7.34^{h} (15.71)	8.69^{h} (17.14)	-
CD (p=0.05)	NS	1.24	1.10	-
SEm ±	0.52	0.46	0.36	-

DBS- Day Before Spray, DAS- Days After Spray, NS – Non-Significant
Values in parenthesis are Angular transformed values

Conclusions

Looking to the overall effectiveness of various insecticidal spray tested against *A. sesami*, it can be concluded that, spinosad 45% SC @ 0.3 ml lit^{-1} was effective in reducing percent flower infestation followed by profenophos 50% EC @ 2.0 ml lit^{-1}, acephate 75% SP @ 1.0 g lit^{-1} and chlorantraniliprole 18.5% SC @ 0.3 ml lit^{-1}. Imidacloprid 17.8% SL @ 0.4 ml lit^{-1} and ethofenprox 10% EC @ 2.0 ml lit^{-1} were the next best treatments. Azadirachtin 1500 ppm @ 5.0 ml lit^{-1} was least effective in controlling per cent flower infestation. All insecticidal treatments were significantly superior over untreated control.

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