



Available Online at EScience Press International Journal of Agricultural Extension

ISSN: 2311-6110 (Online), 2311-8547 (Print)
https://esciencepress.net/journals/IJAE

COMPARATIVE EFFICACY OF SEED TREATMENTS AGAINST EARLY-SEASON SUCKING INSECT PESTS OF SESAME (*SESAMUM INDICUM* L.)

^aQurban Ali, ^bAsad Aslam, ^cMuhammad K. Malik, ^cMuhammad F. Akhtar*, ^cMuhammad Bilal bin Iqbal, ^cMuhammad J. Saleem, ^cTamsila Nazir, ^bMishal Khizar, ^cAsifa Hameed, ^dMuhammad A. Ayub, ^eMuhammad Arshad

^aAyub Agricultural Research Institute, Faisalabad, Pakistan.

^bEntomological Research Sub-Station, Multan, Pakistan.

^cEntomological Research Institute, AARI, Faisalabad, Pakistan.

^dRice Research Station, Bahawalnagar, Pakistan.

^eAgronomic Research Station, Khanewal, Pakistan.

ARTICLE INFO

Article History

Received: August 12, 2025

Revised: February 26, 2026

Accepted: March 11, 2026

Keywords

Population Reduction

Jassid

Mirid bug

Seed treatment

Sesame

Sucking insect pests

Whitefly

ABSTRACT

Sesame (*Sesamum indicum* L.) is a conventional oilseed crop and is known as the queen of oilseeds. The objective of the study was to evaluate different seed treatments against sucking insect pests of sesame, aiming to protect the crop during its early growth stages from pest infestation. Sesame crop (TH-6) was sown at the farm area of the Entomological Research Institute, Ayub Agricultural Research Institute, Faisalabad (31.4049, 73.0504), during 2024-25. The seeds were treated with five seed treatments viz. Imidacloprid + Tebuconazole 372.5 FS, Azoxystrobin + Clothianidin 62.5 WS, Tetraniliprole 480FS, Fipronil 5%FS, Thiamethoxam 350FS and one control (no treatment) at the time of the sowing. The results revealed that Fipronil 5% FS was the most effective (85.49%, 81.94%, 85.49%, and 76.52% at 10, 20, 30, and 40 DAG, respectively) in reducing mirid bug infestation. At the same time, in case of whitefly, excellent performance of Imidachloprid+Tebuconazole372.5 FS was observed (87.08%, 82.54%, 80.42%, and 76.33% after 10, 20, 30, and 40 DAG, respectively) during the period of the study. Similarly, Imidachloprid+Tebuconazole372.5FS showed maximum population reduction 86.89% at 10 DAG in Jassid population, while thiamethoxam 350 FS showed relatively higher effectiveness (77.97% at 40 DAG) at later stages. The least population reduction of mirid bugs was observed with Azoxystrobin + clothianidin 62.5WS, whereas Tetraniliprole 480FS was least effective against whitefly and Jassid. Overall, these findings suggest that seed treatments with Fipronil 5% FS and imidacloprid + tebuconazole 372.5 FS may be suitable components of integrated pest management for the control of early-stage sucking insect pests.

Corresponding Author: Muhammad Faheem Akhtar

Email: mfahakh@gmail.com

© The Author(s) 2026.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is a conventional oilseed crop (Sanni et al., 2024) belonging to the Pedaliaceae family, mostly grown in Asia and Africa (Noor et al., 2020). In Pakistan, the sesame crop is cultivated in Punjab for different purposes, i.e. food (dry seeds and oil) (Wacal et al., 2024), animal feed (leaves, branches,

and dry pods) (Dwarkaet al., 2024), and other elemental medicines (cancer treatments) (Sanni et al., 2024). Sesame is marketed as a high-income, high-value crop, particularly among smallholders on marginal land in Pakistan (Wacal et al., 2024; Zhou et al., 2024). It contained nutritional, industrial, and medicinal values as its seeds contain approximately 48-60% oil and 20-25%

protein, along with vitamins and minerals, is widely known as the “queen of oilseeds” (Pandey et al., 2015; Nayyar et al., 2018; Qizi, 2025). Sesame is a promising diversification and climate-resilient crop in the arid and semi-arid areas of Pakistan due to its adaptation to harsh environments and low input requirements (Wacalet al., 2024; Dwarka et al., 2024; Sanni et al., 2024).

Insect pests and seed-borne pathogens severely limit sesame productivity in Pakistan (Noor et al., 2020; Jasmine et al., 2020; Wei et al., 2022). Major insect pests of sesame include mirid bug (*Nesidiocoris tenuis*), leafhopper (*Orosius albicinctus*), whitefly (*Bemisia tabaci*), shoot/leaf webber, and capsule borer (*Anticarsia gemmatilis*). (Nayyar et al., 2018; Myint et al., 2020; Wei et al., 2022). These sucking pests can infest leaves (10–70%), flower buds (34–62%), and capsules (10–44%), which can lead to a loss of about 90% of the crop yield (Haider et al., 2025) because they are active all year long and have about 12 overlapping generations (Chandaka et al., 2020; Qizi, 2025).

Recent studies focus on developing integrated pest management strategies for sesame that combine cultural, biological, and chemical control to reduce reliance on pesticides while enhancing crop protection and sustainability (Roy, 2021; Abbas et al., 2023; Vashisht et al., 2023). The key components of IPM modules for sesame incorporate natural enemies, botanicals (such as neem-based products), biological agents, and selective insecticides and seed treatment technologies, resulting in reduced pest infestation and improved crop yield compared with conventional production systems (Nayyar et al., 2018; Roy, 2021; Qizi, 2025). Furthermore, economic threshold levels have been established for several major sesame pests, facilitating climate-sensitive and need-based pest management interventions (Jasmine et al., 2020).

However, farmers often apply pesticides excessively, following the misconception that “if a little is good, more will be better” (Akhtar et al., 2009). This practice leads to detrimental effects on non-target organisms and beneficial fauna (Corket et al., 2003). Seed treatment with systemic insecticides is considered one of the safest and most promising approaches for managing sucking insect pests during the early growth stages of crops, particularly at the seedling stage, while minimising adverse effects on beneficial insect fauna (Kumar et al., 2020; Alemu et al., 2025). Unlike foliar insecticide

applications, seed treatments do not require repeated spraying and are less affected by weather conditions. The active ingredients are absorbed by germinating seeds and translocated throughout the developing plant, protecting against insect pests during the critical early stages of crop growth. Furthermore, seed treatments offer prolonged pest suppression, reduce overall pesticide use and labor costs, and minimize exposure of natural enemies and other non-target organisms to insecticides (Sekulic and Rempel, 2016). To promote the conservation and restoration of biological control agents, the present study was designed to evaluate different seed treatments against sucking insect pests of sesame, aiming to protect the crop during its early growth stages from pest infestation.

METHODOLOGY

Sesame crop (TH-6) was sown (at a seed rate of 02 kg/acre) at the farm area of the Entomological Research Institute, Ayub Agricultural Research Institute, Faisalabad (31.4049,73.0504), during the kharif season of 2024-25. All recommended agronomic practices were adopted to achieve better growth.

Experimental Design

The experiment was carried out under natural field conditions, using a randomised complete block design (RCBD) with three replications. This plot size was 3.6 (5.0 meters square) for each replication. A buffer space of 2m was maintained between plots to minimize treatment interference. The agronomic guidelines were used for planting, with a 40-50 cm row-to-row distance and 10 cm between plants (Lakewet et al., 2018).

Treatments

The seeds were treated with the following treatments (Table 1). For this purpose, 500 grams of sesame seeds were placed in a plastic Jar (2000ml capacity). The treatment dose rate mentioned below was mixed with 50 ml of water and added to the seeds. Further water was added dropwise while thoroughly mixing to obtain a uniform slurry. Then placed the treated seed into a plastic bag (2000 ml capacity), tightly sealed it, and vigorously shook it for 30 seconds to ensure even coating of the seed surface with treatments. The treated seeds were subsequently air-dried under shade overnight and sown the following day (Chaudhari et al., 2024).

Table 1. List of seed treatments used in study.

Chemical name	Formulation	Trade name	Dose/kg
Imidachloprid+Tebuconazole	372.5FS	Hombre	10ml/kg
Azoxystrobin+clothianidin	62.5WS	Argyl super	05gm/kg
Tetraniliprole	480FS	Reatis	10ml/kg
Fipronil	05%FS	Growup	10-20ml/kg
Thiamethoxam	350FS	Cruiser	10ml/kg
Control	-	-	-

Data recording

Ten plants were randomly selected from each replication and tagged for observations. Data on sucking insect pests, viz., mirid bug, Jassid, and whitefly, were recorded from the selected plants at 10, 20, 30, and 40 days after crop emergence. Data on jassid and whitefly observations were recorded from the upper, middle, and lower canopy leaves of each of the selected 10 plants. In contrast, for mirid bugs, the mean population per plant was calculated.

Data analysis

The percentage population reduction of targeted sucking insect pests due to seed treatments was calculated by using Abbott's formula:

$$\text{Percentage reduction (\%)} = [(C - T) / C] \times 100$$

Where C=mean insect pest Population in control (untreated plot)

T= Mean insect pest Population in the seed-treated plot

The recorded pest population data were subjected to analysis of variance (ANOVA) using Statistix 8.1 software.

Treatment means were separated using Tukey's (HSD) test at $P \leq 0.05$, and data are presented as mean $\pm$ standard error (SE).

RESULTS

The results regarding seed treatments against sucking insect pests, viz., mired bug, whitefly, and Jassid were significantly more effective than the control throughout the study period.

A gradual decline in efficacy was observed over time in all seed treatments. In case of mired bug, the results showed that Fipronil 05% FS was most effective (85.49%, 81.94%, 85.49%, and 76.52% population reduction at 10, 20, 30, and 40 days after germination (DAG), respectively) followed by Tetraniliprole 480 FS (82.59%, 79.09%, 82.59%, and 71.96%) at the respective observation intervals. In contrast, Azoxystrobin + Clothianidin 62.5 WS exhibited the lowest efficacy (65.97%, 62.23%, 65.97%, and 55.84%) during the same period (Table 2).

Table 2. Percentage population reduction of mirid bug after 10,20,30,40 days of germination.

Treatments	Infestation Reduction (Mirid bug)			
	10 DAG	20DAG	30DAG	40 DAG
Imidachloprid + Tebuconazole372.5FS	78.78 $\pm$ 1.92b	75.19 $\pm$ 0.24c	78.77 $\pm$ 0.50b	59.08 $\pm$ 0.46c
Azoxystrobin + clothianidin 62.5WS	65.97 $\pm$ 0.39c	62.23 $\pm$ 0.78d	65.97 $\pm$ 1.08c	55.84 $\pm$ 0.53d
Tetraniliprole 480FS	82.59 $\pm$ 0.84ab	79.09 $\pm$ 0.71ab	82.59 $\pm$ 0.85ab	71.96 $\pm$ 0.55b
Fipronil05%FS	85.49 $\pm$ 0.27a	81.94 $\pm$ 0.48a	85.49 $\pm$ 0.75a	76.52 $\pm$ 0.41a
Thiamethoxam 350FS	80.34 $\pm$ 2.77ab	77.31 $\pm$ 0.95bc	80.34 $\pm$ 0.21ab	70.85 $\pm$ 0.08b
Control	0.00	0.00	0.00	0.00
Tukey HSD	6.41	3.59	3.45	2.22

Similarly, significant differences among treatments were observed in whitefly populations. The results depicted that highest reduction of whitefly population was consistently achieved with Imidacloprid + Tebuconazole 372.5 FS (87.08%, 82.54%, 80.42%, and 76.33% after 10, 20, 30, and 40 DAG, respectively), followed by

Azoxystrobin + Clothianidin 62.5 WS, providing pest population reductions of 83.77%, 79.69%, 78.47%, and 73.23% over the same period. On the other hand, Tetraniliprole 480 FS was the least effective treatment against whitefly (67.28%, 64.60%, 58.23%, and 55.54%) at the respective observation dates. The results

indicated that Imidacloprid + Tebuconazole 372.5 FS provided the most effective and sustained control of

whitefly as compared to the mired bug population (Table 3).

Table 3. Percentage population reduction of whitefly after 10,20,30,40 days of germination.

Treatments	Infestation Reduction (Whitefly)			
	10 DAG	20DAG	30DAG	40 DAG
Imidachloprid + Tebuconazole 372.5FS	87.08±0.94a	82.54±0.16a	80.42±0.31a	76.33±0.30a
Azoxystrobin + clothianidin 62.5WS	83.77±0.06b	79.69±0.48b	78.47±0.32ab	73.23±0.25b
Tetraniliprole 480FS	67.28±0.32e	64.60±0.53e	58.23±0.27d	55.54±0.19e
Fipronil 05%FS	72.66±0.54d	72.31±0.26d	68.12±0.40c	64.84±0.50d
Thiamethoxam 350FS	75.75±0.30c	76.55±0.41c	70.79±0.53b	67.77±0.22c
Control	0.00	0.00	0.00	0.00
Tukey HSD	2.69	1.98	1.96	1.64

The response of jassid populations to the seed treatments also differed significantly. At 10 DAG, the highest population reduction was recorded with Imidacloprid + Tebuconazole 372.5 FS (86.89%), followed by Thiamethoxam 350 FS (83.02%). A similar trend was observed at 20 DAG, where Imidacloprid + Tebuconazole 372.5 FS and Thiamethoxam 350 FS achieved 80.24% and 81.89% population reduction, respectively. At 30 DAG, both treatments maintained

their effectiveness, recording reductions of 79.03% and 79.25%, respectively. However, at 40 DAG, Thiamethoxam 350 FS provided the highest level of population reduction (77.97%), followed by Imidacloprid + Tebuconazole 372.5 FS (73.37%). In comparison, Tetraniliprole 480 FS consistently recorded the lowest efficacy in reducing jassid population (59.41%, 57.37%, 52.90%, and 50.47%) at 10, 20, 30, and 40 DAG, respectively (Table 4).

Table 4. Percentage population reduction of Jassid after 10,20,30,40 days of germination.

Treatments	Infestation Reduction (Jassid)			
	10 DAG	20DAG	30DAG	40 DAG
Imidachloprid + Tebuconazole 372.5FS	86.89±0.76a	80.24±1.46a	79.036±0.41a	73.37±0.32b
Azoxystrobin + clothianidin 62.5WS	79.41±0.55c	74.31±0.22b	70.40±2.40b	65.61±0.11c
Tetraniliprole 480FS	59.41±0.98e	57.37±0.38c	52.90±0.65c	50.47±0.19
Fipronil 05%FS	74.96±0.40d	73.36±0.87b	67.39±0.96b	67.46±0.27c
Thiamethoxam 350FS	83.02±0.16b	81.98±0.56a	79.25±0.70a	77.97±0.87a
Control	0.00	0.00	0.00	0.00
Tukey HSD	3.33	3.00	5.67	1.91

Overall, all seed treatments significantly affect the percentage infestation of targeted insect pests, such as mirid bug, whitefly, and Jassid, compared to the control. However, the persistence and magnitude of control varied among seed treatments and pest species. Fipronil 05% FS consistently gave the maximum protection against mirid bug throughout the study period, maintaining more than 76% control even at 40 DAG. In the case of whitefly and Jassid, Imidacloprid + Tebuconazole 372.5 FS and Thiamethoxam 350 FS exhibited the highest efficacy. A gradual decline in the effectiveness of all seed treatments was observed from 10 to 40 DAG, suggesting a reduction in insecticidal residues as plant growth progressed and time after germination increased. These findings demonstrate

that treatment performance was pest-specific and influenced by the mode of action and residual activity of the respective insecticides.

DISCUSSION

The results of the current study imply that seed treatment with Fipronil 05% FS was most effective in protecting young sesame plants during their most susceptible growth stages against mirid bugs. The superior efficacy of Fipronil may be attributed to its persistence in emerging seedlings and its strong activity against piercing-sucking insects feeding on tender plant tissues, because Fipronil belongs to a new chemistry insecticide that affects the nervous system of the insect pest (Khan et al., 2023). It is effective against

both rasping sucking insect i.e bugs (Ali et al., 1998) as well as chewing insect pests (Asaro and Creighton, 2011). So, it gave better results against the mirid bug than against Jassid and whitefly. The findings of Egonyu et al. (2005) and Ahirwar et al. (2010) were also in line with the current studies and indicated that Fipronil was most effective in protecting young sesame plants at their most susceptible stages against the mired bug of sesame. The insecticide belonging to the diamide group viz. Tetraniliprole also performed reasonably effectively against the mirid bug, but slightly lower than Fipronil. Tetraniliprole is mostly effective against insect pests belonging to the Lepidoptera and Diptera, but shows lower efficacy against sucking insect pests. These findings follow previous studies that have indicated the possibility of neonicotinoid and diamide seed treatments for suppressing infestations of sucking pests at the initial stage in oilseed and other field crops (Nayyar et al., 2018; Abbas et al., 2023). Conversely, Imidacloprid + Tebuconazole proved most effective against whitefly and Jassid, with more than 80% suppression at 10–20 days after germination and retaining a relatively high level of control till 40 days. Similarly, Thiamethoxam 350 FS also exhibited excellent control of these pests due to its systemic nature. This indicates that imidacloprid and thiamethoxam, belonging to the neonicotinoid group, have high systemic activity, provide better coverage across plant leaf tissues, and provide continuous protection until 40 DAG against sap-feeding insects such as whitefly and Jassid. In contrast, the comparatively lower efficacy of Tetraniliprole 480 FS against whitefly and Jassid may be due to its greater biological activity against chewing insects than against phloem-feeding pests. These findings are supported by earlier studies showing that imidacloprid seed treatment significantly reduced populations of whitefly and Jassid in several crops (Roy, 2021; Vashisht et al., 2023). Alemu et al. (2025) also observed similar results against whitefly and Jassid and reported that Thiamethoxam 25% WG was the most effective insecticide against both insects on the cotton crop. Similarly, the recent study by Kumar et al. (2020) demonstrated that seed treatment with thiamethoxam provided sustainable population reduction of whitefly and Jassid for up to 7 weeks after germination. Additionally, Hong et al. (2018) observe early-season population reductions of sucking insect pests, such as whitefly and Jassid, on the tomato crop. Whereas the findings of Chaudhari et al. (2024) and Anusha et al. (2016) were slightly different from those of the studies and indicated that imidacloprid 48 FS alone was

most effective against whitefly and Jassid compared to others.

A gradual decline in the efficacy of all seed treatments was observed from 10 to 40 days after germination. This trend is likely associated with the progressive degradation, metabolism, and dilution of systemic insecticide residues as plant biomass increases. Similar declines in insecticidal activity over time have been reported by Nayyar et al. (2018) and Jasmine et al. (2020). Nevertheless, some studies have documented persistence of insecticidal activity for up to seven weeks (Hong et al., 2018) or even longer (Subbiah et al., 2009), depending on environmental conditions, insecticide chemistry, and crop growth rate (Wacal et al., 2024; Dwarka et al., 2024; Sanni et al., 2024). To ensure sustainable long-term management, this trend emphasizes that seed treatment alone is primarily a tool for initial season management and should be combined depending on economic threshold levels and cultural control measures (Myint et al., 2020; Wei et al., 2022) with other IPM strategies, such as preservation of natural enemies, and timely foliar applications.

CONCLUSION

The findings depicted that seed treatments may provide effective early-season control against sucking insect pests in sesame. Based on the results, Fipronil 05% FS was found to be most effective for the management of mirid bugs. At the same time, Imidacloprid + Tebuconazole 372.5 FS and Thiamethoxam 350 FS were effective against whitefly and Jassid. Their adoption has the potential to improve crop health, increase yields, and enhance the profitability of sesame cultivation.

Fipronil 05% FS may be recommended as an important seed treatment option for the management of mirid bug. In contrast, Imidacloprid + Tebuconazole 372.5 FS and Thiamethoxam 350 FS can be effectively incorporated into IPM programs for the management of whitefly and Jassid. The results suggested that seed treatments may be suitable components of integrated pest management and increase the profitability of sesame.

This is further suggested that this recommendation should be disseminated among the farmers for seed treatment. Agricultural Extension Advisory Services department can share this recommendation among farmers.

REFERENCES

Abbas, G., Hussain, J., Nasir, I.R., Abbas, Z., Mehmood, T., et al. 2023. Management of macro-nutrients for

- sesame (*Sesamum indicum*) under changing climate scenarios of Thai region. Archives of Agriculture Research and Technology, 4: 1060.
- Ahirwar, R., Gupta, M. and Banerjee, S. 2010. Field efficacy of natural and indigenous products on sucking pests of sesame. Indian Journal of Natural Products and Resources, 1: 221–226.
- Alemu, Z., Getahun, S. and Seid, N. 2025. Efficacy of seed treatment insecticides against major early-season sucking pests on cotton in the Middle Awash, Afar Region, Ethiopia. Journal of Tropical Crop Science, 12(1): 124–131.
- Ali, A., Nayar, J.K. and Gu, W.D. 1998. Toxicity of a phenyl pyrazole insecticide, Fipronil, to mosquito and chironomid midge larvae in the laboratory. Journal of the American Mosquito Control Association, 14(2): 216–218.
- Anusha, C., Natikar, P.K. and Balikai, R.A. 2016. Insect pests of cowpea and their management: A review. Journal of Experimental Zoology India, 19(2): 631–642.
- Asaro, C. and Creighton, J. 2011. Use of systemic Fipronil and imidacloprid to control regeneration pests of loblolly pine. Journal of Economic Entomology, 104(4): 1272–1279.
- Chandaka, D., Roja, M. and Reddy, M. 2020. A review on nutrient management studies on sesame (*Sesamum indicum*). Crop Research, 55: 172–181.
- Chaudhari, V.K., Patel, V.B., Patel, M.P. and Bhanvadiya, A.S. 2024. Field efficacy of a combination of seed treatment and foliar spray against pest complex in greengram. Legume Research, 47(2): 268–276.
- Dwarka, S.T., Katara, V.K., Chadar, N. and Parmar, S. 2024. Introduction to insect pests of sesame (*Sesamum indicum* L.) and their management: A review. Journal of Advances in Biology and Biotechnology, 27(12): 378–384.
- Egonyu, J.P., Kyamanywa, S., Anyanga, W. and sekabembe, C.K. 2005. Review of pests and diseases of sesame in Uganda. African Crop Science Conference Proceedings, 7(3): 1411–1416.
- Haider, I., Younas, M., Ali, S., Ahmad, H., Mustafa, H., Hassan, E., Bashir, M., et al. 2025. Evaluation of comparative resistance in elite sesame germplasm against its insect pest complex. Journal of Agricultural Research 63(3): 239–244.
- Hong, L., Zhengqun, Z., Jin, L., Feng, L. and Wei, M. 2018. Thiamethoxam, clothianidin and imidacloprid seed treatments effectively control thrips on corn under field conditions. Journal of Insect Science, 18: 1–8.
- Jasmine, R., Indiragandhi, P. and Motilal, A. 2020. Diversified cropping system for managing major insect pests in sesame. Journal of Pharmacognosy and Phytochemistry, 9: 227–231.
- Khan, M.A., Riaz, M., Kamran, M. and Shad, S.A. 2023. Unstable fipronil resistance associated with fitness costs in fipronil-selected *Aedes aegypti* L. Experimental Parasitology, 250: 108543.
- Kumar, K.J., Kumar, L., Sanathkumar, V.B. and Raveendra, H.R. 2020. Bio-efficacy of different seed treatment chemicals against shoot fly (*Atherigonaapproximata*) infesting foxtail millet. International Journal of Chemical Studies, 8(6): 476–480.
- Myint, D., Gilani, S., Kawase, M. and Watanabe, K. 2020. Sustainable sesame (*Sesamum indicum* L.) production through improved technology: An overview of production, challenges and opportunities in Myanmar. Sustainability, 12: 3515.
- Nayyar, B., Woodward, S., Mur, L., Akram, A., Naqvi, S. and Akhund, S. 2018. Identification and pathogenicity of Fusarium species associated with sesame (*Sesamum indicum* L.) seeds from Punjab, Pakistan. Physiological and Molecular Plant Pathology, 102: 128–135.
- Noor, S. R., Hussain, F., Abbas, I. and Sun, Y. 2020. Effect of compost and chemical fertilizer application on soil physical properties and productivity of sesame (*Sesamum indicum* L.). Biomass Conversion and Biorefinery, 13 (4): 905–915.
- Pandey, R., Anokhe, A., Panday, A. and Duraimurugan, P. 2024. Biology and management strategies of sesame pests: A comprehensive review. Journal of Oilseeds Research, 41(2): 117–122.
- Qizi, S. 2025. Experiments on pest control of sesame (*Sesamum indicum* L.) crops under the conditions of Karakalpakstan. American Journal of Agriculture and Horticulture Innovations, 5(9): 16–18.
- Roy, N. 2021. Population dynamics and economic thresholds-based time series for smart pest management of sesame. International Journal of Tropical Insect Science, 1(1): 1–12.
- Sanni, G., Ezin, V., Chabi, I., Missihoun, A., Florent, Q., Hamissou, Z., Niang, M. and Ahanchede, A. 2024.

Production and achievements in *Sesamum indicum* industry in the world: Past and current state. Oil Crop Science, 9 (19): 187-197.

Sekulic, G., and Rempel, C. 2016. Evaluating the Role of Seed Treatments in Canola/Oilseed Rape Production: Integrated Pest Management, Pollinator Health, and Biodiversity. Plants 5(3): 32.

Vashisht, P., Yadav, N., Kumar, R., Jangra, P. and Indora, J. 2023. Management strategies for charcoal rot of sesame: A review. International Journal of Plant and Soil Science, 35 (19): 2255-64.

Wacal, C., Musinguzi, S., Ewaju, E., Atibo, C., Alowo, D., Alipa, J. and Basalirwa, D. 2024. Unravelling the potential benefits of sesame (*Sesamum indicum* L.) in

cropping systems, nutritional, health and industrial uses of its seeds: A review. Cogent Food and Agriculture 10(1): 2360766

Wei, P., Zhao, F., Wang, Z., Wang, Q., Chai, X., Hou, G. and Meng, Q. 2022. Sesame (*Sesamum indicum* L.): A comprehensive review of nutritional value, phytochemical composition, health benefits, food development and industrial applications. Nutrients 30;14(19): 4079.

Zhou, W., Arcot, Y., Medina, R., Bernal, J., Cisneros-Zevallos, L. and Akbulut, M. 2024. Integrated pest management: An update on the sustainability approach to crop protection. ACS Omega, 9(40): 41130–41147.

Publisher's note: EScience Press remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.