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Efficacy of spinosad for the management of mustard & wheat aphid species

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Abstract: Aphids are major pests of mustard and wheat crops, causing significant yield losses worldwide, necessitating effective management strategies. Spinosad, a bio pesticide with a unique mode of action, offers an environmentally friendly alternative for pest control. A study was conducted in the Insect Biotechnology and Biopesticide Laboratory, Department of Entomology, Bangladesh Agricultural University, from February 2019 to February 2020, to assess the efficacy of Spinosad (Tracer 45SC) against mustard aphids (*Lipaphis erysimi*) and wheat aphids (*Diuraphis noxia*) using a leaf-dip bioassay. Different concentrations of Spinosad were tested, and mortality was recorded at intervals of 24, 48, 72, 96, and 120 hours after treatment (HAT). Results indicated that Spinosad exhibited significant insecticidal activity against both aphids, with the highest concentration (500 ppm) causing maximal mortality. For mustard aphids, mortality increased from 3.33–16.67% at 24 HAT to 36.67–66.67% at 120 HAT, with a maximal mortality of 66.67% at 500 ppm. The LC50 values decreased from 2883.88 ppm at 24 HAT to 232.31 ppm at 120 HAT, indicating increased toxicity over time. Similarly, for wheat aphids, mortality ranged from 10–30% at 48 HAT to 46.67–73.33% at 120 HAT, with a maximal mortality of 73.33% at 500 ppm. The LC50 values fell from 3049.90 ppm at 24 HAT to 140.31 ppm at 120 HAT. LC90 values for both aphids also decreased over time, demonstrating heightened efficacy with protracted exposure. These findings emphasize Spinosad's potential as an effective insecticide against mustard and wheat aphids, with its lethality increasing substantially over time. The concentration of 500 ppm consistently delivered the highest mortality for both aphids.

Keywords: Spinosad; Mustard aphid (*Lipaphis erysimi*); Wheat aphid (*Diuraphis noxia*); Bio-rational insecticide; Leaf-dip bioassay

INTRODUCTION

Bangladesh is primarily an agricultural country, with rice, wheat, maize, and mustard being key crops. Among oilseeds, mustard (*Brassica spp.* L.), including varieties like rapeseed, plays a vital role in the country's agriculture. However, the productivity of rapeseed and mustard remains low, averaging just 0.95 t/ha, far below that of other oilseed-producing countries (Hasan et al., 2024). The primary reasons for low yields are the use of poor-quality seeds and insufficient adoption of improved agricultural practices (Seiler et al., 2022). As a result, Bangladesh imports a significant quantity of edible oil, meeting less than one-third of its annual requirement through domestic production. Despite the potential to increase mustard yield through the selection of high-yielding varieties and better management practices, several challenges persist, including pest infestations (Sparks et al., 2021).

Mustard is a crucial source of edible oil, contributing 40-50% oil and 20-25% protein in its seeds, and it accounts for 80% of the country's oilseed acreage (Abdelgaleil et al., 2024; Shonga & Getu, 2021). The crop is primarily grown in the low-lying areas of the Brahmaputra-Jamuna and Meghna floodplains, with higher cultivation in districts like Chittagong, Sylhet, and Dhaka. Mustard's production, however, faces significant limitations, particularly due to pest infestations, such as the mustard aphid *Lipaphis erysimi*, which severely affects the crop's yield (Mushinamwar et al., 2024). This pest causes direct damage by sucking sap from the plant, resulting in stunted growth, yellowing, and reduced pod formation, leading to yield losses of up to 90%. Similarly, wheat, another staple crop, faces challenges from aphid infestations, such as the Russian wheat aphid (*Diuraphis noxia*), which similarly damages plants by feeding on the sap and stunting growth (Dwivedi & Singh, 2019; Karim et al., 2024).

Aphids are known for their rapid reproduction and significant impact on crop productivity. These insects can reproduce both sexually and asexually, allowing them to quickly build up large populations. Their feeding behavior damages plant tissues and reduces crop yield by impairing photosynthesis, root development, and overall plant vitality. Additionally, aphids can transmit various plant viruses, compounding the problem (Sen & Kumar, 2023; Mwanika et al., 2024). The mustard aphid is particularly destructive to mustard crops, causing extensive damage to leaves, flowers, and pods, thus severely limiting the crop's productivity.

Numerous pest management techniques, such as chemical, biological, and cultural approaches, have been investigated in order to address these issues. However, resistance problems and environmental concerns have been brought on by the careless use of synthetic pesticides. The use of bio-rational pesticides, which are less damaging to non-target organisms but efficient against pests, has increased as a result of this. Among these, the bio-rational pesticide Spinosad has drawn interest because of its target-specific activity and environmental friendliness (Laboni et al., 2024). Studies assessing Spinosad's efficacy against aphids in crops such as wheat, maize, and mustard may provide farmers a more sustainable and safer alternative to pest control, lowering their need on dangerous pesticides while increasing agricultural yields (Mwanika et al., 2024).

The current study aims to develop an eco-friendly and effective pest management strategy by evaluating the use of Spinosad against aphid infestations, ultimately benefiting farmers and contributing to better agricultural productivity in Bangladesh.

MATERIALS AND METHODS

Experimental Site and Design

The experiments were carried out at the "Insect Biotechnology and Biopesticide Laborato-

Table 1. List of mustard & wheat varieties used in the experiment

SL No	Varieties	Salient Features	Collected form
1	BINA Sarihsa- 4	➢ Plant height: 75-90 cm ➢ Life cycle: 85-88 days ➢ Average yield: 1.8 ton/ha	Bangladesh Institute of Nuclear Agriculture (BINA)
2	BINA Sarihsa-9	➢ Plant height: 80-90 cm ➢ Life cycle: 80-84 days ➢ Average yield: 1.7 ton/ha	
3	BINA Gom-1	➢ Plant height: 85-105 cm ➢ Life cycle: 105-110 days ➢ Average yield: 3.8 ton/ha	

ry" within the Department of Entomology, Bangladesh Agricultural University, Mymensingh, spanning the period from February 2019 to February 2020. The research utilized two mustard varieties and one wheat variety. A brief description along with the sources of these varieties is provided in the table.

Mustard aphids (*Lipaphis erysimi*) and wheat aphids (*Diuraphis noxia*) were collected from the Entomology field at Bangladesh Agricultural University, Mymensingh. Severely infested twigs were carefully cut, placed in a large Petri dish, and covered to prevent escape. Fresh aphids were collected daily for insecticidal testing under laboratory conditions. Spinosad was utilized in the experiment. The insecticide used in the experiment was Tracer 45 SC, which contains the active ingredient Spinosad. It was sourced from Auto Crop Care Ltd.

Statistical analysis

Some basic statistical analyses were completed. The number of insects died at each of the dose concentrations at the end of the stipulated exposure period was recorded and the percentage mortality was calculated after necessary correction as per Abbott's formula (Abbott, 1925) for each probity analysis. The concentration-mortality curve was then determined. The LC_{50} & LC_{90} values of the selected bio rational insecticides were calculated by probity analysis using LdP line software.

RESULTS

Efficacy of Spinosad against *Lipaphis erysimi*

The percentage mortality of mustard aphids (*Lipaphis erysimi*) varied substantially amongst the six Spinosad treatments. At 100 ppm concentration, aphid mortality varied from 3.333 to 36.667%. Aphid mortality was assessed as a percentage of 3.333 at 24 HAT, 6.667 at 48 HAT, 16.667 at 72 HAT, 26.667 at 96 HAT, and 36.667% at 120 HAT (Figure 3).

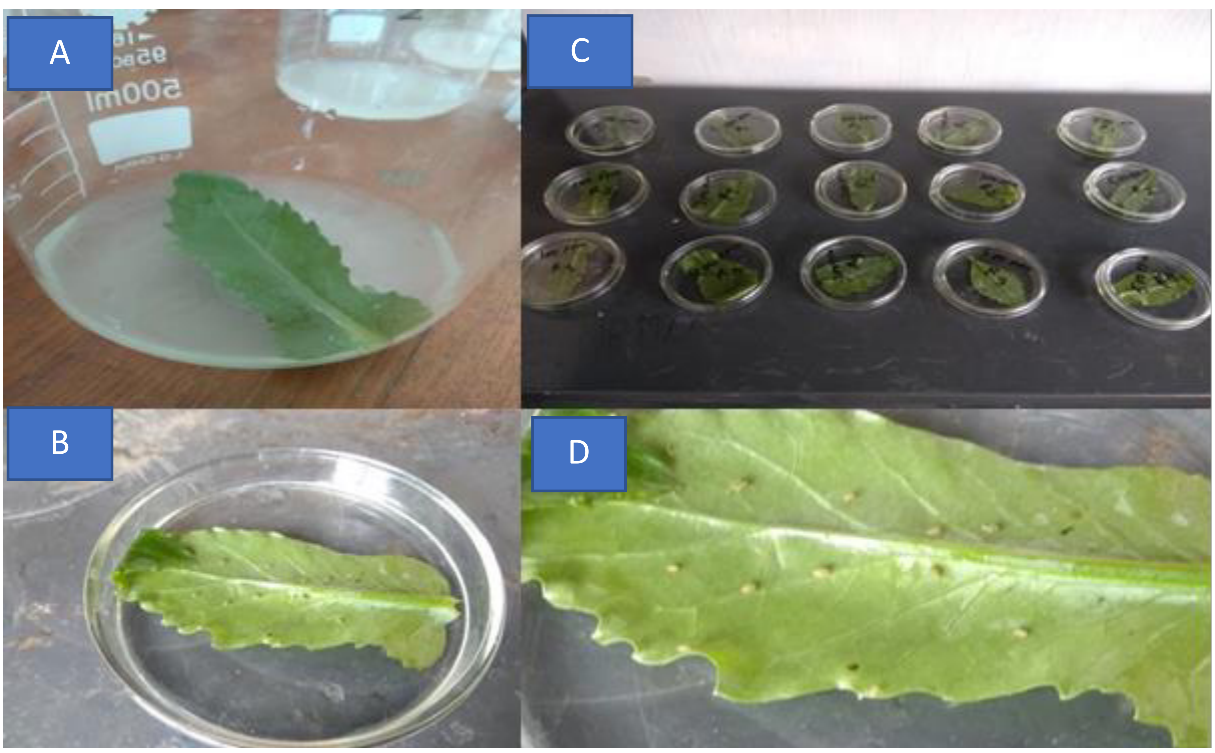

Figure 1. Steps of bioassay procedure, (A) mustard leaves dipped in the prepared diluted solution (B) Immediately after addition of aphids to mustard leaves (C) After 48 hours post application and (D) Close-up view of a single mustard leaf with the added aphid on it

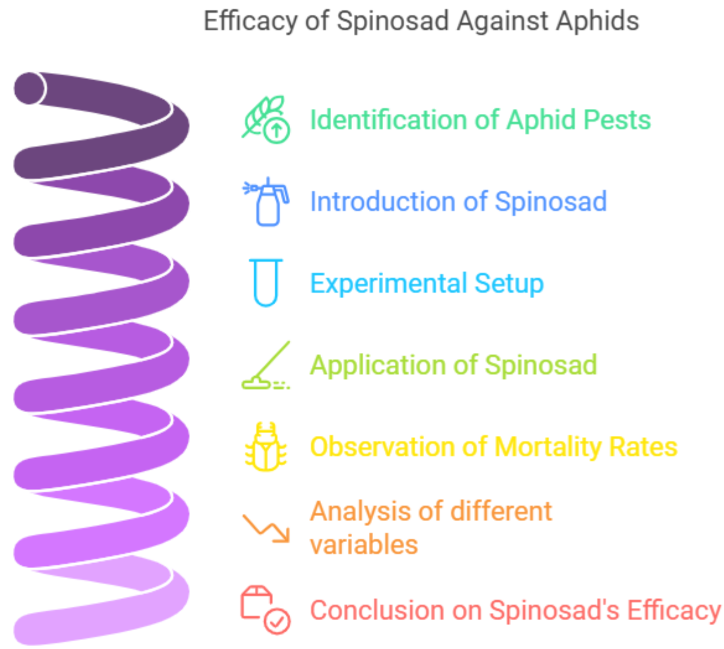

Figure 2. Overview of this investigation

The data reveal that the mortality of mustard aphids increased continuously over time at a concentration of 200 ppm Spinosad. Aphid mortality was reported to be 6.667 percent after 24 hours after treatment with 200 ppm Spinosad. The % mortality of aphids was 10, 23, 23, 36.667, and 46.667 at 200 ppm concentration at 48, 72, 96, and 120 HAT, respectively (Figure 3).

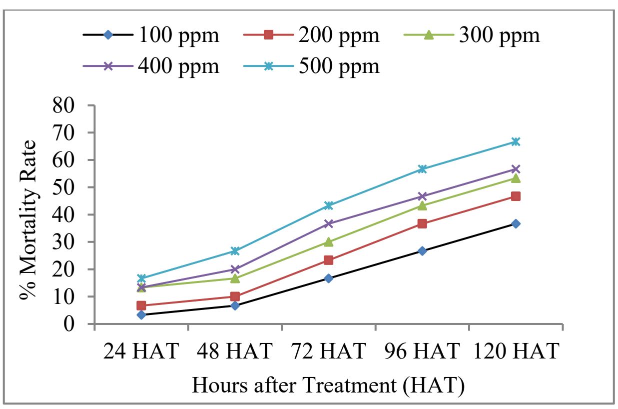

Figure 3. The concentration-mortality at different treatments of spinosad against *Lipaphis erysimi* 24, 48, 72, 96, and 120 hours after treatment (HAT). Five treatments (100, 200, 300, 400, & 500 ppm of spinosad) were used for bioassay

The mortality of mustard aphids increased significantly with an increase of time at the concentration of 300 ppm Spinosad. It was reported that the maximum mortality (13.333) was detected at 24 HAT at the concentration of 300 ppm Spinosad. At 48, 72, 96, and 120 HAT, the % mortality of aphids was 16.667, 30, 43.333, and 53.333, respectively, at 300 ppm concentration (Figure 3). The mortality mustard of aphids increased steadily with the increase of time at the concentration of 400 ppm Spinosad. At the concentration of 400 ppm Spinosad, the percent mortality of aphids was 13.333, 20, 36.667, 46.667, and 56.667, respectively, at 24, 48, 72, 96, and 120 HAT, respectively (Figure 3). The mortality of mustard aphids jumped progressively with an increase of time at the concentration of 500 ppm Spinosad. The percent mortality of mustard aphids was 16.667, observed at 24 HAT at the concentration of 500 ppm Spinosad. At 48, 72, 96, and 120 HAT, the percent mortality of aphids was 26.667, 43.333, 56.667, and 66.667, respectively, at 500 ppm concentration. The percentage of mortality was highest (66.667%) at 120 HAT at 500 ppm concentration of Spinosad (Figure 3).

Lethal Concentration (LC50 & LC90) of spinosad against *Lipaphis erysimi*

The results showed that Spinosad is lethal & efficacious against *Lipaphis erysimi*. The LC50 value of Spinosad against *Lipaphis erysimi* was 2883.8751, 1676.2769, 781.8802, 412.2964, and 232.3072 at 24, 48, 72, 96, and 120 HAT, respectively, and the LC90 value of Spinosad against *Lipaphis erysimi* was 30882.0546, 16492.9482, 10314.4364, 6806.9495, and 4284.0702 at 24, 48, 72, 96, and 120, respectively (Table 2). The lethality of the Spinosad drastically increased after 24 HAT. The data suggested that with the advancement of time, the toxicity of Spinosad increased.

Efficacy of Spinosad against *Diuraphis noxia*

The percent mortality of mustard aphids substantially increased with the increase of time and diverse treatments of Spinosad (100, 200, 300, 400, 500 ppm). The percent mortality of wheat aphids was 3.333, observed at 24 HAT at the concentration of 100 ppm Spinosad. At 48, 72, 96, and 120 HAT, the percent mortality of aphids was 10, 26.667, 36.667, and 46.667, respectively, at 100 ppm concentration (Figure 4).

The percent mortality of wheat aphids was 6.667, observed at 24 HAT, and at 48, 72, 96, and 120 HAT, the percent mortality of aphids was 20, 33.333, 43.333, and 53.333, respectively, at 200 ppm concentration (Figure 4).

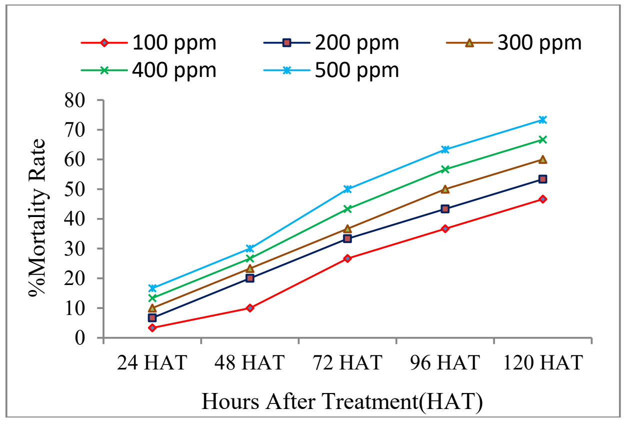

Figure 4. The concentration-mortality at different treatments of spinosad against *Diuraphis noxia* 24, 48, 72, 96, and 120 hours after treatment (HAT). Five treatments (100, 200, 300, 400, & 500 ppm of spinosad) were used for bioassay

Table 2. Lethal Concentration (LC50 & LC90) of Spinosad against *Lipaphis erysimi*

Duration	LC50	LC90	Slope±SE	χ 2
	2883.875	30882.05	1.2446 ± 0.3589	0.7134
24 HAT	Lower Limit: 1256.9267	Lower limit: 5760.8148		
	Upper Limit: 54506.0426	Upper Limit: 12528378.0189		
	1676.277	6492.948	1.2907± 0.3141	0.6918
48 HAT	Lower Limit: 928.7585	Lower limit: 4453.676		
	Upper Limit: 8336.5792	Upper limit: 647138.1676		
	781.8802	10314.44	1.1440±0.2560	0.5929
72 HAT	Lower limit: 538.8237	Lower Limit: 3373.1715		
	Upper Limit: 1852.2451	Upper Limit: 176054.8672		
	412.2964	6806.95	1.0524±0.2376	0.7828
96 HAT	Lower Limit: 318.932	Lower Limit: 2472.9035		
	Upper limit: 656.7921	Upper Limit: 90405.7994		
	232.3072	4284.07	1.0125±0.2319	0.9659
120 HAT	Lower Limit: 168.6812	Lower Limit: 1755.6069		
	Upper Limit: 301.5949	Upper Limit: 42922.1373		

At 24 HAT, wheat aphid mortality was 10% at a concentration of 300 ppm Spinosad. At 300 ppm concentration, the % mortality of aphids at 48, 72, 96, and 120 HAT was 23.333, 36.667, 50, and 60, respectively (Figure 4). At 24, 48, 72, 96, and 120 HAT, the percent mortality of wheat aphids was 13.333, 26.667, 43.333, 56.667, and 66.667, respectively, observed at the concentration of 400 ppm Spinosad (Figure 4). The percent mortality of wheat aphids was 16.667, observed at 24 HAT at the concentration of 500 ppm Spinosad. At 48, 72, 96, and 120 HAT, the percent mortality of aphids was 30, 50, 63.333, and 73.333, respectively, at 500 ppm concentration (Figure 4). The highest percentage of mortality (73.333%) was recorded in 120 HAT at 500 ppm concentration of Spinosad.

Lethal Concentration (LC50 & LC90) of spinosad against *Diuraphis noxia*

The results showed that Spinosad is lethal & effective against *Diuraphis noxia*. The LC50 values of spinosad against *Diuraphis noxia* were 3049.8993, 1562.9155, 608.2221, 261.1365, and 140.3105 at 24, 48, 72, 96, and 120 HAT, respectively, and the LC90 values of Spinosad against Diuraphis noxia were 32122.9789, 27873.3016, 19688.6515, 5875.8527, and 2983.22 at 24, 48, 72, 96, and 120, respectively (Table 3). The lethality of the Spinosad drastically increased after 24 HAT. The data suggested that with the advancement of time, the toxicity of Spinosad increased.

DISCUSSION

Eco-friendly management practices have significantly contributed to the reduction of insect nuisance populations. Lower-risk bio insecticide compounds like Spinosad can be more hazardous as biological control agents compared to certain traditional chemical insecticides (D'Ávila et al., 2018). The mortality of mustard aphids and wheat aphids increases over time when exposed to 500 ppm concentration of Spinosad, according to the results of the study. The results clearly indicate that the highest mortality of mustard aphids (66.667%) and wheat aphids (73.333%) was observed in 120 HAT at 500 ppm concentration of Spinosad. Spinosad had the greatest mor-

Table 3. Lethal Concentration (LC50 & LC90) of Spinosad against *Diuraphis noxia*

Duration	LC50	LC90	Slope±SE	χ 2
24 HAT	3049.899 Lower Limit: 1283.1418 Upper Limit: 69984.7761	32122.98 Lower Limit: 5804.9929 Upper Limit:17691845.9716	1.2534±0.3681	0.0474
48 HAT	1562.916 Lower Limit: 832.9974 Upper Limit:10715.713	27873.3 Lower Limit:5659.4872 Upper Limit:4490782.5558	1.0243±0.2743	0.4173
72 HAT	608.2221 Lower Limit:413.2221 Upper Limit:1821.3013	19688.65 Lower Limit:4202.8268 Upper Limit:3867656.0721	0.8487±0.2384	0.8609
96 HAT	261.1365 Lower Limit:191.831 Upper Limit :354.6082	5875.853 Lower Limit:2094.3417 Upper Limit:105266.1467	0.9478±0.2317	0.9304
120 HAT	140.3105 Lower Limit: 73.7002 Upper Limit:189.864	2983.22 Lower Limit:1317.9704 Upper Limit:27316.2575	0.9654±0.2318	1.2004

tality rate of at 48 hours post-treatment (HPT) of 66.67%, increasing to 93.33% at 72 hours (Morshed et al., 2023). Khatun et al. (2023) observed that Spinosad 45SC was the most efficient bacterium-derived insecticide for controlling sucking insects such as chili, resulting in insect counts of 3.68% and mortality rates of 68.89%. Sultan et al. (2020) observed that Spinosad reduced the number of bean aphids on twigs by 64.14%. At three days following the application, Spinosad 45% SC recorded a reduction in the aphid population in cabbage that was less than 54.07% (Lal et al., 2021). The first, second, and third applications of Spinosad resulted in the greatest reduction of aphids in bananas, with a 73%, 69%, and 67% reduction, respectively, after seven days of spray (Baloch et al., 2023). Refaat et al. (2021) analyzed the patterns of time-mortality and found that Spinosad caused the most mortality, either with time or with concentrations, followed by lufenuron, which required around 16 hours to kill 50% of the tested second instars. According to the findings of this study, the toxicity of Spinosad increased over time, and the LC50 value of Spinosad against *Diuraphis noxia* was 140.3105 at 120 HAT, while the LC90 value of Spinosad against *Diuraphis noxia* was 2983.22 at 120 HAT. Spinosad's LC50 value against *Lipaphis erysimi* was 232.3072 at 120 HAT, and its LC90 value was 4284.0702 at 120 HAT, according to the results of the study. Spinosad was the most effective insecticide for controlling aphids in cotton, with an LC50 of 0.501 ppm (Awasthi et al., 2013). According to George et al. (2019), aphid adults were comparatively susceptible to cotton, as evidenced by their close LC50 values of 0.10–0.11 ppm. The data indicated that the toxicity of Spinosad increased as time progressed, and the most favorable results were observed for the two species of aphids at a concentration of 500 ppm.

CONCLUSION

The mustard aphid (*Lipaphis erysimierysimi*) aphid (*Diuraphis noxia*) infestation was effectively controlled by the administration of Spinosad, as demonstrated by the results. Spinosad demonstrated the most effective performance in the case of both aphids at a concentration of 500 ppm, and its efficacy has continued to increase over time. The maximal mortality against the wheat aphid (*Diuraphis noxia*) was observed at 120 HAT when the highest concentration of Spinosad (500 ppm) was exposed.

Conflicts of interest

All writers claimed there was no conflict of interest.

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