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Original Research

Evaluated The Efficacy and Economic Viability of Movento® Insecticide Mustard Aphids Infesting *Brassica napus*

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ABSTRACT

This study evaluated the efficacy and economic viability of four concentrations of Movento® SC insecticide-Movento® 30 SC, Movento® 60 SC, Movento® 120 SC, and Movento® 240 SC-against mustard aphids infesting *Brassica napus* at the Agriculture Research Institute Tarnab farm during the 2021-2022 growing season. The study was conducted during the growing season of 2021-2022, with different concentrations of Movento® SC applied to control mustard aphids on *Brassica napus*. The research used a factorial randomized complete block design (RCBD) with two factors. Results indicated that diet type and population density significantly influenced the biological parameters of *S. c. ricini*. Silkworms fed castor leaves exhibited higher survival rates and heavier cocoon weights than those fed cassava leaves. Results revealed that Movento® 60 SC was the most effective in managing mustard aphids, resulting in the lowest aphid infestation level and the highest crop yield of 8526.7 kg/ha. This treatment also provided the highest net benefit of Rs.161,315.10/ha, with a cost-benefit ratio (CBR) of 18.50. While Movento® 120 SC and Movento® 240 SC were also effective in controlling aphids, they were less cost-effective than Movento® 60 SC. Movento® 30 SC showed the highest aphid infestation and the lowest economic returns. Movento® 60 SC provided the best combination of efficacy and economic benefit in managing mustard aphids in *Brassica* crops. It resulted in the maximum yield and net benefit, making it the most economically viable option. Although Movento® 120 SC and Movento® 240 SC were effective, they proved to be less cost-effective when compared to Movento® 60 SC. This suggests reassessing pest management strategies to balance optimal pest control with greater economic returns in mustard cultivation.

Keywords: *Brassica napus*, economic viability, insect-pest management, movento, mustard aphid

INTRODUCTION

Brassica crops, including rapeseed and mustard, are major rabi oilseed crops grown globally, with India ranking first in area and second in production, after China. These crops, belonging to the Brassica genus and Cruciferae family, include indigenous varieties such as *Brassica campestris* L. var. toria, *Brassica juncea*, and *Eruca sativa*, alongside non-traditional varieties yields by up to 96% under favorable conditions and decreasing oil content by 5-6% (Sahoo, 2012; Shylesha et al., 2006).

Moreover, aphid feeding not only damages the plant by sucking sap but also transmits viral diseases, futher intensifying losses, particularly in canola crops, which have seen significant damages from aphids in Pakistan (Ahmad et al.,2013). In Pakistan, canola, a non-traditional variety of *Brassica napus*, has gained importance due to its high oil content (44-46%) and protein-rich fodder (38-40%). However, the average canola yield remains low, ranging from 700-900 kg/ha, primarily due to insect pests like aphids. Aphid infestations lead to substantial losses in yield and oil content, exceeding 75% in severe cases. While chemical pesticides are the most common method for controlling aphids, concerns about their residual effects on the environment and human health have raised the need for alternative pest management strategies.

Cultural practices—such as intercropping, crop rotation, and adjusting planting methods—have been found to reduce aphid infestations by attracting biocontrol agents or concealing the target crop. However, the full potential of these practices has not been explored in Pakistan, especially in the context of canola cultivation. Previous studies have indicated that companion crops like barley, berseem, lucerne, and garlic could significantly reduce aphid populations (Tahir et al., 2003; Norris et al., 2002).

Despite these findings, organized experimentation linking these practices with aphid management in canola is lacking. This study aims to fill the gap by investigating the effect of different companion crops on aphid populations in *Brassica napus*. Specifically, the research will evaluate the efficacy and economic viability of various treatments, including the use of Movento® SC insecticide in different concentrations, to manage aphid infestations. The objectives of this study are as follows: to study the effect of various treatments, including Movento® SC, on the aphid population in *Brassica napus*. To determine the cost-benefit ratio of the different treatments and evaluate their economic viability.

METHODS

Experimental Design

The experiment was conducted at the Agriculture Research Institute (ARI), Tarnab Peshawar, during the 2021-2022 growing season. The objective was to assess the effect of aphids on yield reduction in *Brassica* crops and the efficacy of various concentrations of Movento® SC in controlling aphid infestations. The study followed a **Randomized Complete Block Design (RCBD)** to ensure robust and reliable results, with a total of 12 plots allocated to the different treatments

Experimental Layout

Design: Randomized Complete Block Design (RCBD)

Plot Size: Each plot measured 36 m²

Row Spacing: 1 meter between rows

Number of Plots: 12

Treatments: Four different concentrations of Movento® SC were used:

Movento® 240 SC: 240 grams/L

Movento® 120 SC: 120 grams/L

Movento® 60 SC: 60 grams/L

Movento® 30 SC: 30 grams/L

Preparation of Movento® SC Concentrations

The four concentrations of Movento® SC were prepared by mixing specific amounts of the insecticide with water:

Movento® 240 SC: 240 grams of Movento® SC dissolved in 1 liter of water.

Movento® 120 SC: 120 grams of Movento® SC dissolved in 1 liter of water.

Movento® 60 SC: 60 grams of Movento® SC dissolved in 1 liter of water.

Movento® 30 SC: 30 grams of Movento® SC dissolved in 1 liter of water.

The insecticide was thoroughly mixed to ensure complete dissolution before application, and all safety measures, such as gloves and masks, were followed during preparation and application.

Experimental Procedure

The insects were reared starting from the egg stage. The research began with the preparation of eggs based on the studied population density treatments, specifically 20, 30, 40, and 50 eggs, which determined by referring to previous research where the minimum density for *S. c. ricini* propagation was 20, and based on the availability of insects in the laboratorium.

Randomization and Replication

The experimental design was randomized to account for spatial variation within the field. Plots were randomly assigned to the different concentrations of Movento® SC, and each treatment was replicated three times to control for variability and ensure statistical reliability. Replication allowed for a consistent evaluation of the efficacy of each treatment.

Data Collection

Aphid counts were taken on ten randomly selected plants per plot, focusing on the terminal 10 cm of the main apical shoot. Aphid incidence was recorded multiple times: one day before treatment (pre-treatment) and 1, 2, 3, 7, and 14 days post-treatment. The aphids on each plant's upper, middle, and bottom portions were counted, focusing on eight to ten leaves from each selected plant to standardize the data collection process.

Statistical Analysis

The data were analyzed using **one-way ANOVA** to assess significant differences between the treatments. The means were separated using **Least Significant Difference (LSD) test** to determine which treatments showed significant efficacy. All statistical analyses were performed using **Statistix 8.1** software. Assumptions of normality and homogeneity of variance were checked before conducting the ANOVA. Post-hoc analyses were carried out to ensure that the differences between groups were statistically significant.

Eggs were incubated in a petri dish (86 x 13 mm) until hatching. Hatchlings were transferred to rearing trays (30 x 11.5 x 3.5 cm) containing the designated diet. Larvae were reared in enclosed containers until the fourth instar. Afterward, they were transferred to open trays placed in insect cages (37 x 30 x 33 cm) to prevent overcrowding, reduce disease transmission, and maintain cocoon cleanliness. Feeding schedules varied by instar stage, with more frequent feeding as larvae matured.

After pupation, cocoons were hung with their heads upward to facilitate moth emergence and minimize wing deformities. Adults were maintained in the same cage until death.

RESULTS AND DISCUSSION

Table 1 presents the mean infestation of aphids per plant at different intervals following the first spray application in 2022, showing how each concentration of Movento® SC affected aphid populations over time. The results in Table 1 show that Movento® 60 SC provided the most effective control of aphids compared to the other concentrations. Although the initial infestation levels were similar across all treatments, significant differences emerged after the first application of the insecticide. **Movento® 60 SC** demonstrated superior efficacy, reducing aphid populations from an initial count of 26.40 per plant per plant (Pre-Count) to just 2.40 per plant by day 14. This marked decrease suggests that this concentration struck an optimal balance between effectiveness and environmental impact, likely due to its moderate concentration, which is more efficient in controlling aphids without causing resistance or overstimulation of the pest population.

Table 1. Mean Aphid Infestation per Plant on Different Days After Spray (2022)

Treatments	Pre-count	1DAS	2DAS	3DAS	7DAS	14DAS	Means
Movento® 240 SC	26.26a	23.53b	20.33b	18.40b	16.40b	12.46b	19.56b
Movento® 120 SC	26.40a	22.30c	19.30c	17.56c	15.40c	11.44c	18.73c
Movento® 60 SC	26.40a	16.46d	13.60d	6.43d	4.52d	2.40d	11.64d
Movento® 30 SC	26.53a	27.03a	27.56a	28.56a	29.90a	32.13a	28.62a
LSD	0.39	0.28	0.8	0.31	0.2	0.45	0.86

LSD = Least Significant Difference. Values below this threshold are not statistically significant

Movento® 120 SC was also effective in controlling aphids but not as superior as Movento® 60 SC. Although it reduced aphid populations significantly, the infestation levels were still slightly higher than those of Movento® 60 SC by day 14. The results show that while Movento® 120 SC had an initial strong effect, the long-term impact was less than Movento® 60 SC, with the infestation remaining higher (11.44 aphids per plant by day 14). **Movento® 30 SC** had the highest aphid infestation across all intervals, with the population increasing to 32.13 aphids per plant by day 14. This suggests that Movento® 30 SC might be less effective at controlling aphids due to its lower concentration. The formulation may not be potent enough to effectively kill or repel the aphids. **Movento® 240 SC** showed a similar trend to Movento® 30 SC, with the infestation numbers peaking at 32.13 aphids per plant by day 14. The failure of the higher concentration to produce better results suggests that higher dosages do not necessarily lead to more effective pest control. This could indicate aphid resistance or a lack of sufficient application efficacy under the conditions tested.

Mechanisms and Resistance Issues

The superior performance of **Movento® 60 SC** can be attributed to the optimal dosage used, which likely targets the pest population effectively without over-saturating the environment. While **Movento® 120 SC** is effective, its higher concentration may have prompted resistance or ineffectiveness in aphid populations, especially considering the rising infestations observed after repeated applications. Aphids also possibly developed resistance to higher concentrations, making Movento® 240 SC less effective. Frequent use of insecticides such as Movento® SC can lead to resistance, so integrating **Integrated Pest Management (IPM)** strategies should be considered. IPM involves using biological, mechanical, cultural, and chemical control methods, reducing reliance on insecticides alone and mitigating the risk of resistance.

Practical Implications

From a practical standpoint, **Movento® 60 SC** offers the best combination of efficacy and economic viability. Given its lower cost and superior control, farmers may prefer Movento® 60 SC over higher-concentration formulations such as Movento® 120 SC. However, the price difference between these formulations should be considered. While Movento® 120 SC showed good efficacy, its higher cost may make it less attractive for cost-sensitive farmers, mainly when Movento® 60 SC provides a similarly high level of control at a lower price. Therefore, farmers may lean towards Movento® 60 SC for economic reasons while still considering Movento® 120 SC for areas with high pest pressure.

The results from this trial support the use of **Movento® 60 SC** as the most efficient and cost-effective solution for controlling aphid

infestations in *Brassica napus*, with **Movento® 120 SC** providing a good alternative for higher pest pressures but at a higher cost. Future studies should explore the long-term impacts of repeated use to assess the potential for aphid resistance and to optimize IPM strategies.

Table 2. Means infestation of Aphids/plants at different day intervals after second spray application in 2022

Treatments	Mean Aphid/plant						
	Pre-count	1DAS	2DAS	3DAS	7DAS	14DAS	Means
Movento® 240 SC	16.24b	15.20b	11.51b	10.37b	8.48b	7.33b	11.52b
Movento® 120 SC	14.13c	13.30c	10.32b	8.34c	6.44c	5.62c	9.69c
Movento® 60 SC	8.48d	5.35d	7.58b	3.34d	2.33d	0.95d	4.67d
Movento® 30 SC	31.53a	31.83a	32.03a	32.72a	34.00a	35.54a	32.94a
LSD	0.5	0.89	0.35	0.98	0.76	0.66	0.32

From the various letters, it can be seen that treatments become important with a P value of 0.05.

Data from Table 2 presents an updated detailed assessment of the temporal performance of different formulations of Movento® against mustard aphids. The mean counts for aphid infestation have been interpreted below: The highest mean counts across all post-application intervals were obtained for Movento® 30 SC. The starting number of aphids was 31.53 per plant before treatment, reaching 35.54 per plant on the 14th day. This is a high level of infestation at all observation points. This has shown that at all points of observation, Movento® 30 SC is the least effective among the treatments conducted in reducing aphids' populations. Movento® 240 SC showed moderate efficacy in managing the population of aphids. Before the treatment, the count was 16.24 per plant. This figure, while lowering with the progress of days, was fairly high compared to other treatments and reached as high as 7.33 per plant on the 14th day. This indicates that Movento® 240 SC reduced the count of aphids but was less effective than the other concentrations like Movento® 120 SC or Movento® 60 SC. Movento® 120 SC gave better results in the case of aphid control than Movento® 240 SC. The original count was lower at 14.13 per plant and progressed steadily downward to 5.62 per plant after 14 days. This was an effective control, though not quite as effective as Movento® 60 SC. Movento® 60 SC was the most effective treatment for reducing aphid populations.

In contrast, with the initial count of 8.48 per plant, the aphid numbers significantly reduced to 0.95 by the 14th day. The overall mean infestation across all days of observation was 4.67 aphids per plant; therefore, the Movento® 60 SC showed superior efficacy compared to other formulations in controlling the aphids. LSD values give the minimum amount of two treatments, which means that they must differ significantly. An example could be the LSD value at 0.5 for the Pre-Count, which indicated that the aphid count differences are of no statistical significance below that value. The LSD values from every point in time ensure that the differences between treatments are statistically valid, especially towards the later stages of observation. Movento® 60 SC was the most effective against the mustard aphids by giving the lowest infestation levels throughout the study. Movento® 120 SC was the best; it was doing well but not as well as Movento® 60 SC. Movento® 240 SC had a moderate level of control, while Movento® 30 SC was the least effective and

resulted in the highest counts of aphids. As is clear from the LSD values, these conclusions are supported by the statistical analysis.

Table 3. Cost-Benefit Ratio of Different Treatments Against Mustard Aphids Crop

Treatments	Yield (kg/ha)	Gross Income (Rs.)	Cost of Control (Rs. /ha)	Return over Control (Rs. /ha)	Estimated Net Benefit (Rs. /ha)	Cost-Benefit Ratio (C
Movento® 240 SC	5116.7	102,334	8,345.67	102,334	93,988.33	12.26
Movento® 120 SC	5036.7	100,734	8,316.90	100,734	92,417.10	12.11
Movento® 60 SC	8526.7	170,534	9,218.90	170,534	161,315.10	18.50
Movento® 30 SC	2106.7	73,734.50	Not Provided	Not Provided	Not Provided	Not Calculated

It is observed that Movento® 60 SC is the cheapest treatment presented, showing a yield of 8526.7 kg/ha and gross income of Rs. 170,534. The cost of control will be Rs. 9,218.90 per hectare, but it is estimated that the net benefit per hectare will amount to Rs. 161,315.10. Besides, the C Benefit-Cost Ratio (C) will be 18.50, the maximum value compared with all other treatments, indicating that this treatment gives the highest return on investment. Movento® 240 SC and Movento® 120 SC depict similarities in cost-benefit performance. A gross income generated from Movento® 240 SC is Rs. 102,334 with a net benefit of Rs. 93,988.33 and hence a C ratio of 12.26. In the case of Movento® 120 SC, a gross income of Rs. 100,734 with a net benefit of Rs. 92,417.10 and a C ratio of 12.11 is envisaged. In the above table, both the treatments give a good return; nevertheless, Movento® 240 SC gives a better cost-benefit ratio. In Movento® 30 SC, the yield is 2106.7 kg/ha, and the gross income is Rs 73,734.50. Cost of control and net benefit data are not presented for Movento® 30 SC, and hence its cost-effectiveness cannot be elucidated.

It is less favorable than the other treatments based solely on the yield and gross income; Movento® 60 SC presents the most favorable cost-benefit ratio, translating to the highest return on investment, and hence is economically viable in respect of the control of mustard aphid among the treatments tested. Movento® 240 SC and Movento® 120 SC present good returns but are less cost-effective than Movento® 60 SC. Movento® 30 SC is not fully assessed regarding cost and net benefit. The other product gap to be filled is comparative economic analysis.

Discussion

The experiment results indicate significant variation in the efficacy of different Movento® SC formulations in controlling aphid populations on Brassica napus. Among the four treatments tested, Movento® 60 SC emerged as the most effective formulation in terms of reducing aphid infestation and economic returns. This treatment exhibited the most significant reduction in aphid populations, with a mean infestation of only 0.95 per plant by day 14 after the second application. This highlights its superior efficacy in pest management.

In contrast, Movento® 30 SC demonstrated the lowest efficacy in reducing aphid populations, with the highest aphid counts observed across all intervals, reaching 35.54 aphids per plant by day 14. This indicates that Movento® 30 SC was ineffective at controlling aphid infestations and could lead to pest resistance over time if relied upon for continuous pest control.

Movento® 240 SC and Movento® 120 SC showed moderate efficacy, with aphid infestations of 7.33 and 5.62 aphids per plant on day 14. Although these formulations were somewhat effective in reducing aphid

populations, their performance was not as impressive as Movento® 60 SC, which suggests that a balance between concentration and formulation plays a critical role in insecticide efficacy.

The economic analysis provided valuable insights into the cost-effectiveness of each treatment. Movento® 60 SC demonstrated the highest cost-benefit ratio (18.50), indicating the best economic return for farmers. It achieved the highest yield (8526.7 kg/ha) and gross income (Rs. 170,534) while maintaining a moderate cost of control (Rs. 9,218.90 per hectare). This highlights Movento® 60 SC as the most economically viable option for pest control, as it offers the best balance between efficacy and cost.

In comparison, Movento® 240 SC and Movento® 120 SC provided similar returns, with a cost-benefit ratio of 12.26 and 12.11, respectively. While these formulations still provided decent economic returns, their cost-effectiveness was lower than that of Movento® 60 SC. On the other hand, Movento® 30 SC was not fully assessed in terms of cost and net benefit, but based on its poor performance in aphid control, it can be concluded that it is not economically viable compared to the other formulations.

The experiment also raises important considerations regarding pesticide resistance. Higher concentrations of Movento® SC, such as Movento® 240 SC, failed to show improved results despite higher doses, suggesting that aphids have developed some resistance to these higher concentrations. This is a common issue with insecticide use; frequent exposure to high concentrations may increase the likelihood of resistance. Movento® 60 SC, with its moderate concentration, may help mitigate this risk by providing effective control without overstimulating the pest population.

CONCLUSIONS

This experiment was conducted at the Agriculture Research Institute Tarnab farm during the 2021-2022 crop season to investigate the efficacy and economic viability of different concentrations (Movento® 30 SC, Movento® 60 SC, Movento 120 SC, and Movento 240 SC) of Movento® SC insecticide against the mustard aphid, Brevicoryne brassicae, on Brassica napus. The experiment was laid out in accordance with a Randomized Complete Block Design (RCBD) with 12 plots, each measuring 36 m² and 1 m apart. Movento® 60 SC significantly reduced the aphid population to as low as an average of 0.95 aphids per plant 14 days after the second application, thus showing the highest overall efficacy. Movento® 120 SC, during which the aphid count decreased to 5.62 per plant by the 14th day post-second application. On the other hand, Movento® 240 SC and Movento® 30 SC were less effective, with Movento® 30 SC always showing the highest levels of infestation throughout the experiment. Movento® 60 SC gave the highest economic return through 8526.7 kg/ha with gross income amounting to Rs. 170,534, a net benefit of Rs. 161,315.10/ha, hence giving the highest Cost-Benefit Ratio (C) that was 18.50. Movento® 240 SC and Movento® 120 SC gave equally good returns and were thus less cost-effective than the Movento® 60 SC. • Movento® 30 SC yielded the lowest and was not fully economically compared, reflecting its poor efficacy and cost-effectiveness performance.

The ideal treatment for higher pest control efficiency and better economic return was Movento® 60 SC. The treatments of Movento® 120 SC and Movento® 240 SC were effective but not so cost-efficient. Treatment with Movento® 30 SC was the least efficient and economically viable. This result highlights the importance of an appropriate concentration to achieve better efficiency regarding pest management and monetary returns from *Brassica cultivation*.

Movento® 60 SC should be prioritized for use in controlling mustard aphids, as it provides the best combination of efficacy, economic viability, and environmental sustainability. Movento® 120 SC can be considered in areas with higher aphid pressure, but its higher cost must be factored into economic decisions.

Farmers should avoid using Movento® 30 SC due to its poor performance and lack of cost-effectiveness. To prevent the development of resistance, it is recommended to incorporate Integrated Pest Management (IPM) strategies, including rotation of insecticides, biological controls, and other non-chemical methods. This approach will help ensure long-term sustainability in pest management.

Future research should further explore the long-term effects of repeated Movento® SC applications to assess the potential for aphid resistance and to develop optimized pest management strategies that balance pest control with environmental and economic considerations.

Author Contributions

The design and execution of this study were led by a team of researchers at the Agriculture Research Institute Tarnab, with specific contributions from different team members in areas such as fieldwork, data analysis, and economic evaluation. The statistical analysis was performed using standard protocols to ensure robust and accurate results. The interpretation of results and formulation of recommendations were carried out collaboratively, with a focus on real-world applicability for farmers.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this research. All results were derived from objective analysis, and no commercial interests influenced the study's outcomes.

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