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Evaluation of Synthetic and Bio-Pesticides against Mustard Aphid Lipaphis Erysimi (Kalt) (Homoptera: Aphididae) in Canola Cultivars

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Abstract

The evaluation and efficacy of different pesticides, Actara (Thiamethoxam) 25WG, botanical pesticides (Neem oil and Tobacco leaves extract 3%) against mustard aphid Lipaphis erysimi in selected canola cultivars (China, Sawabi, KS-75, Oscar, and Cornel-I) was performed during during2023-24. The experiment was conducted under field conditions at the University of Agriculture, Peshawar, using a split-plot design. Two sprays with an interval of 14 days of the selected chemicals were used against L. erysimi upon reaching the ETL level. Results showed that after the first spray minimum mean number of aphids per 10cm shoot (8.53 and 8.19), further SD or SE should have been calculated were recorded with maximum percent reduction (63.38 and 60.88%) of L. erysimi was caused by Thiamethoxam 25WG followed by Neem oil (10.68 and 10.66 aphids per 10cm shoot, 55.28 and 56.24%). Among the varieties after first and second spray applications, KS-75 cultivar sustained minimum mean number of aphid (11.40 and 19.34 aphids per 10cm shoot) and maximum percent reduction (34.90 and 41.86%), while the cultivar 'Swabi' was attracted maximum mean number of aphids (31.78 and 50.56 aphids per 10cm shoot) and followed by minimum percent aphid reduction (22.10 and 20.81%) respectively. Moreover, after 14 days of Thiamethoxam 25WG 1st and 2nd spray applications, the mean minimum number of L. erysimi (1.75 and 1.22 aphids per 10cm shoot) was recorded in canola cultivar 'KS-75', respectively. A significantly maximum mean number of L. erysimi was recorded 14 days after both 1st and 2nd spray applications in variety 'Swabi' in the control plots (86.20 and 166.43 aphids per 10cm shoot, respectively). Tobacco leaf extract (3%) performed on average in both the mean counts and percent reduction of L. erysimi; however, overall maximum mean number with negative percent population reduction in the control plots in all the treatments showed a drastic increase in L. erysimi infestation. All the physiological characteristics of the canola crop, number of sub-branches (28.69), pods (124.71), plant height (88.52) and yield (1159.4 kg.ha-1) were recorded significantly maximum in case of Thiamethoxam 25WG treated cultivar 'KS-75', which was followed by variety 'China' (27.86, 121.34, 87.57, 1046.4). The same characteristics were found minimum in the case of control plots in variety 'Swabi'(21.83, 82.62, 67.77, 351.91) respectively. Thus, it was concluded that Thiamethoxam 25WG proved highly effective against L. erysimi infestations in canola tested cultivars. However, among bio-pesticides, Neem oil (3%) is a better add article 'a' alternative against canola aphid. The tested canola cultivars 'KS-75' and China are recommended for the farming community based on higher yields.

Keywords: QTL, marker-assisted selection, CRISPR/Cas9, genomic breeding, stress resistance, fibre quality.

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Introduction

Canola crop (*Brassica napus* L.) belongs to the family Brassicaceae and valuable brassica oilseed crop, cultivated globally (Miri, 2007). This crop is planted for multiple uses, including feed, fodder, edible oil and vegetables. Although canola is known as an important crop due to its high oil quality (Chand et al., 2017). Mustard oil is edible, having high-energy food ingredients, and is frequently used in food preparation to enhance their flavour palatability (Cheema et al., 2018). oilseed crop is grown worldwide on a range of 35 million hectares of agricultural land. The average seed production per hectare is 2,193 kilograms, and the worldwide production is 76 million tons (FAOSTAT, 2021). The leading growers are Canada, China, Australia and European countries that provide sufficient oils for human consumption as well as biodiesel with the release of improved varieties that added to the canola oil production (Kirkegaard et al., 2020).

The main rapeseed growing area in Pakistan is Attock, Rawalpindi, Faisalabad, Jhelum, Bahawalpur, Chakwal, Multan, Rahim YarKhan, Bahawalnagar and Muzaffargarh. Pakistan produces rapeseed with an annual yield of 675 thousand tonnes on an area of 613 thousand hectares, which shares only 32% of the total consumption (Pakistan Economic Survey, 2022-23). In Khyber Pakhtunkhwa, the major rapeseed producing areas in the province are Swabi, Mardan, Malakand, Swat and D.I. Khan, where an area under cultivation is 10.55 thousand hectares with a total yield of 5.38 thousand tons (Crop Statistics, 2021-22).

The demand for edible oil in Pakistan is gradually rising and is expected to worsen, keeping in view the increase in the population growth rate and per capita income (Hameed and Azeem, 2017), while domestic production has failed to keep pace because of several reasons, like poor quality seeds, shift in crop patterns, poor land management, etc. Currently, the country is grossly deficient in the domestic production of edible oils, where about 86% of the country's demand is met through huge imports (State Bank of Pakistan, 2022). The country imported around 0.57 million tons of oilseeds in the past year, and keeping in view the high future import costs, it is a need of the time to plan for future strategies in the oilseeds production sector.

To meet the demand of an ever-increasing population, it is vital to increase mustard production by lowering the losses brought on by biotic and abiotic stresses. Low yield is caused by a number of reasons, including biotic and abiotic pressures. Among the biotic stress, Infestation by the insect pests that attack canola crops, including cabbage caterpillar (Pieris brassicae), leaf miner and mustard aphid (*Liphapis erysimi*), is the main cause. In many countries, tests on chemical pesticides against mustard aphid have revealed their efficacy. *L. erysimi* is a destructive pest as compared to others because it significantly harms the crops (Mahmoud and Shebl, 2014). Both nymphs and adults of pale greenish insects with louse-like appearance that harm the flower buds, pods and shoots are regularly seen eating in large quantities, occasionally covering the entire surface of the affected plant (Ahmad et al., 2009).

L. erysimi first appeared on leaves in the third week of January. During mid-February, the aphid proceeded to the inflorescences and stayed there until harvest. The mustard aphid causes two different types of damage to the plant, with the peak activity occurring between February 15 and March 5th; initial extraction of cell sap from leaves, inflorescences, and pods. Secondly, it secretes honeydew and serves a suitable environment for the development of sooty mould fungus, having a negative impact on the photosynthesis of plants, which causes damage to plants and ultimately leads to stunted growth (Khan et al., 2015).

To handle mustard aphids, a variety of control techniques have been developed, including physical, cultural, biological, mechanical, chemical and by host plant resistance (Mpumi et al., 2020; Ashutosh and Kunwar, 2024). Physical control involves using physical actions to remove aphids from mustard plants, while mechanical control is the use of mechanical devices to control mustard aphids. Cultural control includes agricultural practices that make the environment less favourable for aphids; it also includes crop rotation and spacing to disturb aphids' life cycle. Biological control depends on natural predators or parasites of aphids to keep their population in check. Lacewings, ladybugs and parasitic wasps are beneficial insects in this approach.

Various researchers have worked on the management of this aphid-like insect. Chemical control includes the use of pesticides to kill aphids. Use of chemical insecticide has been found harmful to various predators and parasitoids, i.e., Chrysoperla carnea, Diaeretiella rapae, syrphid flies and Coccinellids present as natural enemies in canola fields. Apart from using chemical and associated problems (residues in food products, environmental pollution, pollinator toxicity, pest resurgence, health risk to humans and development of insect pest resistance) (Calliera et al., 2013; Verger et al., 2013; Zhang, 2018; Riaz et al., 2022). Host plant resistance (HPR) is a very effective and affordable method to control insect pests that harm crops and other biological aspects of agricultural insect pests (Divekar et al., 2019). Yet, because the insect pest populations are rapidly declining, the use of insecticides is at the forefront of control measures (Ullah et al., 2019).

Naturally occurring plant extracts, known as biopesticides, are relatively cheap, less dangerous and less poisonous. Besides, botanical extracts are safe for the environment and other beneficial organisms while being effective against harmful pests. The uses of botanicals in different combinations play an important role in the IPM programs (Marghub et al., 2010).

The proposed study is therefore designed, keeping in view the importance of the crop and extent of damage caused by *L. erysimi*, to accomplish the following goals while taking into account the effectiveness of synthetic and botanical pesticides as well as resistant varieties for use in combination.

Objectives

1. To compare synthetic insecticide, Actara (Thiamethoxam 25 WG), with plant poisons (tobacco leaves extract and neem oil) on the selected canola genotypes against mustard aphid (L. erysimi)
2. To determine the effect of these selected chemicals on the yield and yield components of the canola crop.

Materials & Methods

The efficacy of selected pesticides against mustard aphid *Lipaphis erysimi* (Kalt.) (Homoptera: Aphididae) in selected canola cultivars under field conditions was conducted at The University of Agriculture, Peshawar, during the crop growing season of October 2023-24. The experiments were performed in order to compare the effectiveness of synthetic pesticide, Actara and bio-pesticides (Neem oil and Tobacco leaves extract) against the mustard aphid in the selected mustard cultivars (China, Sawabi, KS-75, Oscar, and Cornel-I). All the replications were repeated thrice with a split-plot design.

Main plot (Varieties) China, Swabi, KS-75, Oscar and Cornel-I was used as factor-A, while biopesticides Neem Oil, 3%, Tobacco Leaves Extract, 3% and Control and synthetic, pesticide, Actara (Thiamethoxam 25WG) was used as factor-B.

Field Preparation

The field was prepared, where each block was divided into five main plots measuring 30 x 25 meters, to which the varieties were randomly assigned. Each plot was further divided into four sub-plots measuring 3 by 4 meters, and the mentioned treatments were assigned randomly. Each sub-plot contained five rows with a gap of 50 and 30 centimetres between plants and rows, respectively. Between each subplot, a buffer zone of 0.5m was maintained, and on each side, a buffer zone of 1m was left between two blocks. Seeds of canola varieties were manually drilled into rows of respective plots during the middle of October 2023. To develop a successful crop, all agronomic and cultural practices, weeding, watering, and thinning were continuously carried out during the crop growing season.

Preparation of Tobacco Leaves Extract

The dried leaves of the tobacco plant were obtained from the local market in Peshawar. These leaves were finely ground with the help of a blender and then stored in an airtight container. In order to prepare a tobacco leaf extract with a 3% concentration, first, 30 grams of the prepared fine powder of tobacco leaves were taken, and 1.5 grams of detergent was added. This mixture was enclosed in a muslin cloth and then immersed in a container with one litre of boiled water and kept for 24 hours. The resultant mixture is a 3% concentration solution of tobacco leaf extract.

Parameters

Mean number of *L erysimi*

The mean number of the *L. erysimi* population was determined by selecting ten randomly chosen plants in each plot in each replication and counting the number of aphids per plant initially at the seedling stage. During the flowering/inflorescence and pod stages, the sampling parameter was changed to 10 cm of the terminal flower, and aphids were counted. The number of aphids per 10cm plant portion was counted and noted against each treatment. After pesticide application for 1, 3, 7 and 14 days, data were calculated both before and after insecticide spray applications.

Application of Pesticides

The appearance and incidence of aphids on the tested canola cultivars were strictly monitored during the seedling stage of the crop. The number of aphids was counted as the number of aphid reaches (20-25 aphids per 10cm shoot) was observed as per the procedure (Singh and Lal, 2011). As soon as the pest population reached the ETL stage. The intervention of the selected pesticides against *L. erysimi* was initiated on or before reaching the ETL level. The intervention using pesticides is necessary to control it before it exceeds the ETL stage.

A detailed list of the different insecticides used in the experiment was provided with the necessary information.

Treatments	Trade name	Common name	Chemical group	Dose	Mode of Action
T1	Thiamethoxam 25WG	Actara	Neonicotinoid	0.16 gm/L	Systemic

T2	Neem oil @3%	Neem oil	Natural	2 ml/L	Repellent
T3	Tobacco leaf Extract @3%	Tobacco	Natural	2 ml/L	Nerve toxicant
T4	Control	---	Distilled water	---	---

Percent reduction of *L erysimi*

Percent reduction of *L. erysimi* was determined by converting the number of aphids per plant to a percentage (%) reduction in aphid population over control using the given equation of Henderson and Tilton (1955). Percent (%) Reduction = (Population before spray-population after spray)/ (Population before spray) x 100

Number of sub-branches per plant

Following the application of insecticides, 10 randomly chosen plants from each treatment plot were counted from the bottom of the plant and then averaged, to determine the number of sub-branches in each plant at the time, plant is completely developed. The same procedure was repeated for each of the experimental blocks.

Number of pods per plant

At maturity, the pods of (03) randomly chosen treated and untreated plants after treatment application were counted, and data were collected to determine the number of pods per plant in each assigned treatment. The number of pods per plant was recorded for all the experimental blocks using the same procedure.

Plant height

Following the application of pesticides, the height of 10 randomly chosen plants from each sub-plot in each treatment was measured using a meter rod in the field from top to bottom and then averaged. This procedure was repeated in all the experimental blocks.

Calculating the Yield of the canola crop

The seed yield was recorded at the time of crop harvesting by weighing the canola seeds in each plot in each treatment and recording it as kg per plot. The obtained yield was then converted into kg/hectare with the help of the given formula (Sarwar, 2013).

Total yield=(weight in kg)/(plot size) x 10000 ha

Statistical Analysis

All the collected data were carefully arranged and then analyzed using Statistix 8.1 software. Means were further separated by using the LSD test at 5% probability level (Steel and Torrie, 1984).

Results

Data regarding the effect of 1st spray of different chemical insecticides on the mean number of canola aphid, *Lipaphis erysimi,* in selected canola cultivars is shown in Table 4.1. The number of aphids/plant was taken before treatment application. The results showed a significant difference in the efficacy of different pesticides as compared to the control plants. The mean number of aphids recorded after 1st spray application showed that all the tested pesticides performed better as compared to the control plants. Among the treatment significantly minimum population of *L. erysimi* was recorded in Thiamethoxam 25WG treated plants with average number of (8.53) aphids per 10cm shoot, followed by Neem oil (10.68 aphids), Tobacco leaves extract (3%) (16.16) aphids per 10cm shoot in comparison to the control treatments (39.94) mean number of aphids per 10cm shoot were recorded.

In varietal response, mean lowest population (11.40 aphids per 10cm shoot) was sustained by the cultivar 'KS-75' followed by China (13.78 aphids) and maximum highest population of aphid (31.78) aphids per 10cm shoot was observed in canola cultivar Swabi while

Oscar (18.92) and Cornel-1(18.35) number of aphid per 10 cm shoot were recorded.

Interaction data (treatments x varieties) showed that the minimum mean *L. erysimi* population (4.18 aphids per 10cm shoot) was recorded on cultivar KS-75 treated with Thiamethoxam 25WG. This trend was closely followed by cultivars 'China (5.52 aphid per 10cm shoot) and neem oil (3%) 5.92 mean aphid population compared to control plots of the tested cultivars. L. In control plots, the *L. erysimi* population was significantly higher in canola cultivar Swabi, followed by Oscar and Cornel-1 canola cultivars (67.37 aphids per 10cm shoot, 38.75 and 38.45 aphids per 10cm shoot, respectively.

Taking the response of *L. erysimi* mean population to different chemicals in selected canola cultivars at different time intervals (Varieties x Treatments x Time) showed that mean minimum (1.75 aphids per 10 cm shoot) population density of *L. erysimi* was observed after 14 days post-treatments application when Thiamethoxam 25WG was applied to plots with KS-75 variety, followed by mean population of *L. erysimi* after 14 days of the application of Thiamethoxam 25WG in China canola variety and then Neem oil in KS-75 variety when noted after 14 days post spray application with mean 2.12 and 2.16 aphids per 10 cm shoot respectively. Similarly, a significantly maximum population of *L. erysimi* was observed after 14 days when no insecticide treatment (control) option was used in the Swabi variety (86.20 aphids per 10 cm shoot).

Percent reduction of *L. erysimi* infestation after the first spray

Data regarding the percent reduction effect of 1st spray of different chemical insecticides on canola aphid, *Lipaphis erysimi,* in selected canola cultivars is shown in Table 4.2. Data revealed a significant difference among the different means for varieties, treatment insecticides and their interaction (varieties x treatments).

Chemical insecticides 1st spray application data revealed that all the chemicals performed better in comparison to the control treatments. Among the treatment (synthetic and botanical) insecticides, maximum percent population reduction in *L. erysimi* was caused by Thiamethoxam 25WG with a mean of 63.38%, followed by Neem oil (55.28%), Tobacco leaves extract (3%), and 36.94% population reduction in comparison to the control (40.31%) treatments.

As the varietal response, data shows that a significant and maximum percent reduction in population was observed in Canola cultivar 'KS-75' with a mean of 34.90%, followed by Cornel-I (30.11%) and China (29.65%) with a non-significant difference, while a minimum population reduction of 22.10% was observed in canola cultivar Swabi.

Interaction (treatments x varieties) data showed that maximum population reduction was observed when Thiamethoxam 25WG was applied in the KS-75 canola cultivar, with 77.01% *L. erysimi* population reduction. This was followed by Neem oil application in KS-75 canola cultivar with 69.63% *L. erysimi* population reduction, which was in turn closely followed by Thiamethoxam 25WG application in China canola cultivar with 67.97% L. erysimi population reduction. A significantly minimum aphid population increase was observed using tobacco leaf extract (3%) in canola cultivar Oscar and Cornel-I with 31.01 and 32.57% aphid population reduction, respectively. Besides, a significant increase in the percentage population of L. erysimi occurred in the control plots in all the treatments.

Mean number of L. erysimi population after the second spray

The effect of 2nd spray application of different chemical insecticides on the mean number of canola aphids in selected canola cultivars is shown in Table 4.3. The mean number of aphids recorded after 2nd spray application showed that all the chemicals performed better in comparison to the control. Among the treatment (synthetic and botanicals) insecticides, a significantly minimum population of aphid was noted on Thiamethoxam 25WG with mean 8.19 aphids per 10cm shoot, followed by Neem oil with 10.66 aphids per 10 cm shoot, while Tobacco leaves extract (3%) also performed but minimum among the treatment insecticides and with 17.91 aphids per 10cm shoot in comparison to the control with mean 84.68 aphids per 10cm shoot.

Varietal effect indicated that the mean minimum population 19.34 aphids per 10cm shoot was observed on Canola cultivar KS-75, followed by China (25.11 aphids per 10 cm shoot), while the maximum population was observed in Swabi canola cultivar with a mean of 50.56 aphids per 10cm shoot.

Interaction (treatments x varieties) data showed that the minimum mean L. erysimi population (3.71 aphids per 10cm shoot) was observed when Thiamethoxam 25WG was applied in the KS-75 cultivar, followed by Thiamethoxam 25WG in China canola cultivars and Neem oil in the KS-75 cultivar, with mean 5.17 and 5.36 aphids per 10cm shoot, respectively. A significantly maximum mean L. erysimi population among the treatment insecticides was observed in canola cultivar Swabi when tobacco leaves extract (3%) was used as a treatment; however, overall population in the control plots in all the canola cultivars was significantly maximum in comparison to insecticide-treated plants.

Further, the effect of treatment insecticides over a time interval showed that Thiamethoxam overall performed best in reducing the pest population and the minimum aphid population (3.78 aphids per 10cm shoot) was noted after 14 days post-treatment application, followed by the effect of Neem oil after 14 14-day interval (5.31 aphids per 10cm shoot)

For the response of aphid mean population density to different insecticides in selected canola cultivars at different time intervals (Varieties x Treatments x Time), the data showed that mean minimum (1.22 aphids per 10cm shoot) population was observed after 14 days post-treatments application when Thiamethoxam 25WG was applied to plots with KS-75 variety, followed by mean population of L. erysimi after 14 days post application of Thiamethoxam 25WG in China variety and neem oil (3%) in KS-75 canola variety noted after 14 days post spray application with mean 1.75 and 2.00 aphids per 10cm shoot respectively.

The time intervals data showed that a significantly minimum aphid population was observed after 7 days post-spray application with a mean of 28.56 aphids per 10cm shoot, while the maximum population was observed after 1day post-treatment application with a mean of 32.49 aphids per 10cm shoot.

Percent reduction of L. erysimi infestation after the second spray

Data regarding the percent reduction effect of 2nd spray of different chemical insecticides on canola aphid, aphid in selected canola cultivars, is given in Table 4.4. Data showed that there was a significant difference among the mean values of varieties, treatment insecticides and their interaction (varieties x treatments). Results revealed that all the chemicals performed better in comparison to the control. Among the treatment (synthetic and botanical) insecticides, the maximum percent population reduction in aphids was suppressed by Thiamethoxam 25WG with a mean of 60.88%, followed by Neem oil (3%) 56.24%, while Tobacco leaves extract, 43.47% population reduction in compared to no percent reduction was observed in the control (35.09%).

Among the varieties, data showed maximum population percent reduction in Canola cultivar KS-75 with a mean of 41.86%, while minimum percent reduction was recorded in cultivar Swabi (20.81%). Interaction (treatments x varieties) showed that maximum (71.17%) population reduction was observed in Thiamethoxam-treated plants in cultivar KS-75, followed by Neem oil with 69.83% aphid population reduction. A significantly minimum (35.64%) aphid population reduction was observed in canola cultivar Swabi when tobacco leaf extract was applied.

Physiological Characteristics of Canola Crop

The data given in Table 4.5 represent physiological characteristics such as the number of sub-branches per plant, number of pods per plant, plant height and yield in response to the different chemical insecticide applications against canola aphid. For the number of sub-branches, data showed that the maximum numbers of sub-branches per plant were recorded in the Thiamethoxam 25WG-treated cultivar KS-75' with a mean of 28.69 per plant, closely followed by the China cultivar (27.86 sub-branches per plant). Mean minimum values were observed in the control plots in cultivar Swabi, with a mean of 21.83 sub-branches per plant, followed by Tobacco leaves extract in cultivar Swabi (23.17 sub-branches per plant). Neem oil, 3% overall, performed best after synthetic chemical insecticides.

In case of number of pods per plant, the mean maximum pods were observed in Canola cultivar KS-75 in Thiamethoxam treated plants, followed by 124.71 pods per plant, China cultivar (121.34 pods per plant) and Neem oil. Significantly, the minimum number of pods per plant was recorded in the control plant of the variety Swabi, followed by 82.62 pods per plant, the Swabi variety and tobacco leaves extract as a treatment (88.58 pods per plant).

In the case of plant height, significantly, the maximum plant height (88.52 cm) was attained by KS-75 treated with Thiamethoxam 25WG. This was followed by cultivar China and cultivar Cornel-1. A significantly minimum plant height was recorded in tobacco leaf extract among the tested chemicals across all canola varieties.

Mean maximum yield (1159.4 kg ha-1) was obtained from the KS-75 canola cultivar treated with Thiamethoxam 25WG, followed by the China variety (1046.4 kg ha-1). A mean minimum yield was observed in different selected varieties in control plants, followed by Swabi variety (351.9 kg ha-1), Oscar (439.8 kg ha-1) and Colonel-1 (451.6 kg ha-1).

Discussion

During the present study, different canola varieties and chemical (both synthetic and botanical) insecticides were tested against the infestation of canola aphid, *Lipaphis erysimi* in a field trial. The maximum percent reduction of *aphid* was recorded on synthetic pesticide 'Thiamethoxam 25WG', followed by Neem oil (3%) and Tobacco leaves extract (3%) compared to the control plants. Among the tested varieties, canola cultivar KS-75 produced the maximum yield compared to the control and other tested varieties. This finding confirmed the present investigation that Canola variety 'KS-75' and 'China', when treated with 'Thiamethoxam' 25WG, performed significantly higher canola crop yields. Similar results have been reported by Rohilla et al (2004); Din et al (2022), where maximum aphid mortality was caused in 'Thiamethoxam' treated samples, followed by Neem oil and Tobacco 5% respectively. Thus, 'Thiamethoxam' performed better in reducing the aphid population, while Tobacco 5% caused the least mortality. The application and impact of 'Thiamethoxam' was also highlighted by Maurya et al (2018), which significantly decreased the aphid population in the canola crop.

The tested canola variety 'KS-75' proved comparatively resistant, thus allowing minimum aphid population densities to breed. Our results are in line with Din et al. (2022), suggesting the resistant feature of the China variety in deterring canola aphids, with mean minimum infestations recorded, while the canola variety 'Swabi' sustained the maximum aphid population, and hence, with a susceptible nature, having minimum deterrence attributes and proved susceptible to canola aphid.

Bio-pesticides of plant origin, Neem oil, and Tobacco leaves extracts are alternative candidates to synthetic chemicals. The tested bio-pesticides, neem oil, were followed by Tobacco leaves extract against mustard aphid, *L. erysimi* populations, which is in line with Bhatta et al. (2019); Neem oil, compared to tobacco leaves extract, has a promising result in controlling aphid population densities in rapeseed. Furthermore, Neem oil 5% concentration is also recommended by researchers (Din et al, 2022; Singh and Lal, 2009). The use of Tobacco leaf extract and Neem oil in the present study is an alternative option for farmers in case of low aphid populations and growers for the field, which are quite safe and cheap for use against canola aphids in the canola crop. In our study, Neem oil 3% was reasonably effective, being after chemical insecticide, with moderate and comparative efficacy against *L. erysimi*.

Thus, it is concluded that synthetic pesticide is the only option available when the pest population reaches its alarming stage. In case of below ETL, aphid infestation, alternatively, utilize the option of botanical insecticides, specifically Neem oil and tobacco leaves extract against canola aphid, during mid-February to mid-March of the growing season. The study may pave the way for farmers and researchers in finding and opting for better, safer and cost-effective control measures against insect pests.

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Table 4.1. Comparative efficacy of different pesticides against aphid population under field conditions after the first spray during 2023-24

Varieties	Treatments	Pre-spray	Mean No. of *L. erysimi* after 1st spray intervals				Mean
			1day	3days	7days	14days	
China	Thiamethoxam 25WG	21.23	10.21Z-f	6.97g-l	2.78n-q	2.12pq	5.52LM
	Neem oil	21.27	13.23U-Y	8.72c-h	5.23k-n	3.53m-q	7.68K
	Tobacco leaf extract	20.92	16.43RST	14.07T-X	10.50Y-e	8.86c-h	12.47H
	Control	20.37	22.82NO	25.47K-N	27.89JK	40.15F	29.08C
Swabi	Thiamethoxam 25WG	40.22	24.63LMN	18.56PQR	12.45V-a	8.04e-k	15.92G
	Neem oil	43.22	26.67KLM	23.11NO	17.16QRS	11.07Y-d	19.51F
	Tobacco leaf extract	47.96	33.67GHI	28.04JK	20.96OP	14.60S-W	24.32E
	Control	51.00	56.42D	60.40C	66.47B	86.20A	67.37A
KS-75	Thiamethoxam 25WG	14.51	6.60h-l	5.25k-n	3.11m-q	1.75q	4.18M
	Neem oil	15.86	9.30b-h	8.61c-i	3.62m-q	2.16opq	5.92L
	Tobacco leaf extract	16.16	15.38S-V	10.49Y-e	6.67h-l	5.19k-n	9.43IJ
	Control	15.03	18.90PQR	23.35NO	27.16KL	34.82G	26.06D
Oscar	Thiamethoxam 25WG	27.04	14.02T-X	9.38b-h	6.67h-l	5.07l-o	8.78JK
	Neem oil	28.90	17.12QRS	11.93W-b	8.21d-j	5.73i-m	10.75I
	Tobacco leaf extract	27.88	23.76MNO	19.41PQ	15.07S-V	11.32X-c	17.39G
	Control	28.42	30.73IJ	34.38GH	40.53F	49.36E	38.75B
Cornel-I	Thiamethoxam 25WG	24.80	13.10U-Z	9.68a-g	5.51j-n	4.65l-q	8.24JK
	Neem oil	27.88	15.58STU	10.42Y-e	7.33f-l	4.84l-p	9.54IJ
	Tobacco leaf extract	27.15	23.63NO	19.17PQR	14.71S-W	11.22X-c	17.18G
	Control	29.34	31.45HI	34.35GH	41.27F	46.74E	38.45B
China			15.67H	13.81I	11.60JKL	13.67I	13.69C
Swabi			35.35A	32.53B	29.26C	29.98C	31.78A
KS-75			12.55IJ	11.93JK	10.14L	10.98KL	11.40D
Oscar			21.41D	18.77E	17.62EFG	17.87EFG	18.92B
Cornel-I			20.94D	18.41EF	17.20FG	16.86GH	18.35B
	Thiamethoxam 25WG		13.71H	9.97I	6.10K	4.32L	8.53D
	Neem oil 3%		16.38G	12.56H	8.31J	5.47KL	10.68C
	Tobacco leaf extract 3%		22.58E	18.24F	13.58H	10.24I	16.16B
	Control		32.07D	35.59C	40.66B	51.45A	39.94A
Mean			21.18A	19.09B	17.17D	17.87C	

Means followed by different letters in rows and columns have significant difference at P≤0.05.

Table 4.2. Percent population reduction Number of Canola aphid after 1st spray of chemical insecticides in selected cultivars during the cropping season, 2023-24

Treatments	Canola varieties	Mean

	China	Swabi	KS-75	Oscar	Cornel-I	
Thiamethoxam 25WG	67.97BC	46.76G	77.01A	61.84D	63.31CD	63.38A
Neem oil (3%)	59.37DE	38.81H	69.63B	52.97F	55.63EF	55.28B
Tobacco leaf extract (3%)	34.13HI	34.82HI	52.18F	31.01I	32.57I	36.94C
Control	-42.86L	-31.99JK	-59.24M	-36.38K	-31.07J	-40.31D
Mean	29.65BC	22.10D	34.90A	27.36C	30.11B	

Means followed by different letters in rows and columns have a significant difference at P≤0.05

Table 4.3. Comparative efficacy of different pesticides against mustard aphid population under field conditions after the second spray during 2023-24

Varieties	Treatments	Time intervals after the 2nd spray				Mean
		1day	**3days**	**7days**	**14days**	
China	Thiamethoxam 25WG	9.50d-j	6.56i-r	2.85s-w	1.75vw	5.17M
	Neem oil	12.60Z-d	8.68e-m	5.08n-v	3.28r-w	7.41L
	Tobacco leaf extract	19.39S-V	15.93W-Z	11.10a-f	9.49d-j	13.98HI
	Control	66.86JK	68.80J	73.59I	86.28G	73.88C
Swabi	Thiamethoxam 25WG	25.23PQR	17.08VWX	10.82b-g	7.84f-n	15.24H
	Neem oil	27.41OP	22.80QRS	17.42VWX	10.92a-g	19.64F
	Tobacco leaf extract	37.49N	29.79O	22.05RST	16.23V-Y	26.39E
	Control	124.12D	132.47C	140.78B	166.43A	140.95A
KS-75	Thiamethoxam 25WG	6.41j-r	4.77n-v	2.45t-w	1.22w	3.71M
	Neem oil	8.97e-l	6.75i-q	3.71q-w	2.00uvw	5.36M
	Tobacco leaf extract	18.98T-W	14.30X-a	9.52d-j	7.60g-o	12.60IJ
	Control	49.07M	52.25M	57.91L	63.55K	55.69D
Oscar	Thiamethoxam 25WG	15.68W-Z	9.94c-i	5.82l-t	4.19o-w	8.91KL
	Neem oil	18.61UVW	12.72Z-d	8.80e-l	6.03k-s	11.54J
	Tobacco leaf extract	26.70OP	21.22STU	16.15V-Y	11.78a-e	18.96FG
	Control	64.57K	73.86I	80.12H	93.99E	78.13B
Cornel-I	Thiamethoxam 25WG	12.97Y-c	9.43d-k	5.30m-u	3.91p-w	7.90KL
	Neem oil	15.56W-Z	10.29c-h	7.22h-p	4.30o-w	9.34K
	Tobacco leaf extract	25.51PQ	19.37S-V	14.21X-b	11.37a-e	17.61G
	Control	64.17K	68.14J	76.18I	90.35F	74.71C
China		27.09	24.99	23.16	25.20	25.11D
Swabi		53.56	50.53	47.77	50.36	50.56A
KS-75		20.86	19.52	18.40	18.59	19.34E
Oscar		31.39	29.43	27.72	29.00	29.39B
Cornel-I		29.55	26.81	25.73	27.48	27.39C
	Thiamethoxam 25WG	13.96H	9.56J	5.45K	3.78L	8.19D
	Neem oil	16.63G	12.25I	8.45J	5.31KL	10.66C
	Tobacco leaf extract	25.61E	20.12F	14.61H	11.29I	17.91B
	Control	73.76D	79.11C	85.72B	100.12A	84.68A
Mean		32.49A	30.26B	28.56C	30.13B	

Means followed by different letters in rows and columns have significant difference at P≤0.05.

Table 4.4. Percent population reduction of Canola aphid, after the 2nd spray of chemical insecticides during the cropping season, 2023-24

Treatments	Canola varieties					Mean
	China	Swabi	KS-75	Oscar	Cornel-I	
Thiamethoxam 25WG	61.11BC	46.11E	71.17A	61.48BC	64.53AB	60.88A
Neem oil (3%)	53.00D	37.75FG	69.83A	57.78CD	62.82BC	56.24B
Tobacco leaf extract (3%)	43.23EF	35.64G	56.47CD	40.99EFG	41.00EFG	43.47C
Control	-36.44HI	-36.25HI	-30.04H	-35.81HI	-36.88I	-35.09D
Mean	30.23B	20.81C	41.86A	31.11B	32.87B	

Means followed by different letters in rows and columns have a significant difference at P≤0.05.

Table 4.5. Effect of different chemicals on the physiological characteristics of the Canola crop during the cropping season, 2023.

Varieties	Treatments	No. of sub-branches	No. of pods	Plant height (cm)	Yield (kg.ha-1)
China	Thiamethoxam 25WG	27.86ab	121.34b	87.57b	1046.4b
	Neem oil	27.16bcd	116.29c	82.50d	956.3e
	Tobacco leaf extract	26.56b-e	109.76f	77.67g	891.4f
	Control	25.95de	103.42h	71.33j	565.7j
Swabi	Thiamethoxam 25WG	24.30fgh	97.90i	81.01e	833.6g
	Neem oil	24.14fgh	92.45k	77.52g	766.4h
	Tobacco leaf extract	23.17hi	88.58l	70.43kl	705.2i
	Control	21.83i	82.62m	67.77m	351.9l
KS-75	Thiamethoxam 25WG	28.69a	124.71a	88.52a	1159.4a
	Neem oil	27.59abc	120.41b	84.41c	1008.8c
	Tobacco leaf extract	27.12bcd	114.21d	79.60f	900.8f
	Control	26.71b-e	107.27g	73.34i	582.6j
Oscar	Thiamethoxam 25WG	26.67b-e	111.93e	84.58c	981.8d
	Neem oil	25.97de	109.56f	80.47ef	894.8f
	Tobacco leaf extract	25.34efg	102.37h	73.90hi	835.9g
	Control	24.04gh	95.07j	69.56l	439.8k
Colonel-1	Thiamethoxam 25WG	26.39cde	110.66ef	84.67c	979.6de
	Neem oil	26.18de	107.99g	80.69e	891.3f
	Tobacco leaf extract	25.49ef	103.21h	74.24h	832.8g
	Control	23.96gh	96.00j	70.86jk	451.6k

Means followed by different letters in rows and columns have a significant difference at P≤0.05