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Efficacy of Different Synthetic Insecticides against Mustard Aphid (*Lipaphis erysimi* kalt.) (Homoptera: aphididae) on Selected Canola Cultivars

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ABSTRACT

This study conducted at the New Developmental Farm, University of Agriculture Peshawar, during the 2021-22 crop growing season, aimed to evaluate the effectiveness of synthetic insecticides against the mustard aphid (Lipaphis erysimi K) on specific canola cultivars. Employing a Split Plot Design with three replications, the experiment identified thiamethoxam as notably efficacious in controlling mustard aphids. Following the first spray, the 'China' cultivar treated with thiamethoxam exhibited the minimum pest density (7.95), contrasting with the highest pest density observed on the 'Swabi' cultivar in the control plot (48.71). Subsequent treatments, applied upon reaching the economic threshold, revealed persistent trends. After the second spray, the 'China' cultivar treated with thiamethoxam consistently demonstrated the lowest pest density (7.64), while the 'Swabi' cultivar in the control plot exhibited the highest (48.05). Furthermore, the 'China' cultivar treated with thiamethoxam displayed maximum sub-branches (30.00) and pods per plant (90.19), along with the tallest plants (122.17 cm) and highest yield (2.92 kg/plot and 1827.1 kg/ha). Conversely, the untreated 'Swabi' cultivar showed the lowest sub-branches, pods per plant, plant height, and yield (0.42 kg/plot and 402.6 kg/ha). In summary, the integration of thiamethoxam with the 'China' cultivar yielded superior outcomes, emphasizing its potential as an effective pest management strategy in canola cultivation.

INTRODUCTION

Rapeseed (*Brassica napus* L) is the second-highest oilseed-producing crop after soybean and belongs to the Brassicaceae family (Miri *et al*., 2007). The name 'canola,' standing for 'Canadian oil low erucic acid,' was given by the Canadian Association during a breeding program in Canada in 1970. Canola is one of the most vital oilseed crops grown worldwide (Raymer *et al.*, 2002). Canola oil is used throughout the world, mostly in Japan, Europe, and Canada. Canola oil is low in erucic acid (less than 2%) and aliphatic glucosinolates (Chand *et al*., 2017). Rapeseeds mainly consist of protein (25%) and oil (45%) (Murphy *et al.*, 1989). Compared to soybeans, rapeseeds have a balanced amount of the necessary amino acids (Flederman *et al.*, 2013). After extracting the oil from the canola seeds, the rest is used as animal feed (Nega and Wolddes, 2018).

Rapeseed is cultivated on an area of 35 million hectares worldwide, with an average yield of 2,194 kg/ha and a total production of 76 million tons (FAO, 2017). In Pakistan, the shortage amounted to two-thirds of oil production in 2017-18 (Government of Pakistan, 2018). In 2017-18, 1.94 million tons of cooking oil were imported from other countries in Pakistan, and $1.453 billion was paid during 2017-18 (GOP, 2018). Rapeseed is grown in all provinces of Pakistan on an area of 26,02,000 hectares, with an annual yield of 102,000 tons, representing up to seventeen percent of the country's edible oil production. Meanwhile, the area under cultivation in Khyber Pakhtunkhwa is 17.1 tons with a total yield of 219.5 tons (GOP, 2018).

The Mustard aphid (*Lipaphis erysimi*) is the most damaging insect pest for the canola crop. Once aphids invade fields producing oil crops, they can rapidly multiply into multiple colonies, creating optimal conditions for their growth and development. Canola aphids have the potential to reduce the yield of canola crops by up to 70-80% (Amer *et al.*, 2009). The extent of aphid-related losses depends on the intensity of infestation. In Pakistan, *Lipaphis erysimi* causes losses exceeding 70-80% in several oilseed crops of brassica. Late-sown *B. napus* yields were reduced by 75.06% due to aphid attacks when left untreated with pesticides (Razaq *et al*., 2011). Infested pods and seeds remain small due to aphid feeding (Devi *et al*., 2002). Yield loss due to aphid attacks on Brassica has been reported to range from 30 to 35% and can even reach up to 70% (Buntin and Raymer, 1994; Phadke, 1985; Prasad, 1992; Bedford and Henry, 1998). In Pakistan, winter oilseed Brassica crops are attacked by mustard aphids, to a smaller extent by *Brevicoryni brassicae* (L.), and *Myzus persica* (Hameed and Ahmad, 1980). Various techniques are employed to control *Lipaphis erysimi*, including the use of synthetic insecticides, biological control agents, and resistant cultivars. Natural enemies used for aphid control include ladybugs, lacewings, hoverflies, and *Diaeretiella rapae* (Saljoqi *et al*., 2012).

Biological control agents are highly specific, targeting only the population of their specific pest. They offer an environmentally friendly alternative to mechanical or chemical control methods. Unlike chemical control, which may harm bearing fruit on trees, biological control specifically targets pests without affecting the quality of fruits. Natural enemies sustain themselves in the environment, requiring only initial efforts for release. Although this method takes time to establish, it proves to be a long-term, effective, and environmentally friendly solution (Btryon, 2022). However, it's essential to note that released predators may not always stick to their specific pest and may switch to other targets, potentially disrupting the natural food chain. Traditional methods play a significant role in reducing aphid infestations and increasing agricultural production. Diversified cropping systems, using some crops as live mulch, have been shown to lower aphid incidence (Frank and Liburd, 2005). Cover crops, as part of crop control, contribute significantly to increasing productivity and minimizing losses due to insect pests, diseases, and weeds (Vandermeer, 1989). However, cultural controls require careful planning and timing to be effective, and some methods may not be environmentally friendly or labor-efficient.

Chemical insecticides are considered a last resort in pest control, used when all other strategies fail. Farmers should only resort to insecticides when they have no adverse effects on pollinators and natural enemies of aphids. It's important to note that while insecticides kill aphids, their dead remains may persist on leaves even after application. Additional applications are necessary only if live aphids persist (Factsheet, 2019). The use of chemical pesticides is widespread due to their relatively low cost, availability to farmers, effectiveness, and ease of application. It is often the practical method against pests reaching the economic injury level (Canna, 2022). In the case of the mustard aphid, the economic threshold level is 10-15 aphids per leaf and 25-30 aphids per plant (Aslam *et al*., 2007). As such, very limited information is available regarding the efficacy of different synthetic insecticides against mustard aphid on canola cultivars in Pakistan. Hence, the current research aims to achieve the following objectives: (i) evaluate the efficacy of different synthetic insecticides against mustard aphid (*L. erysimi*) and (ii) study the effect of the selected insecticides on the yield and yield components of the canola crop.

MATERIALS AND METHODS

This experiment was conducted at New Developmental Farm, The University of Agriculture Peshawar, during 2021-2022 to investigate the efficacy of various synthetic insecticides (Actara 25%WG, Fipronil 5% SC, and Lambda cyhalothrin 2.5% EC) against the mustard aphid (*Lipaphis erysimi*) on six selected cultivars (Raya Anmol, Abaseen, China, KS-75, Swabi, and Dalay) obtained from the Department of Agronomy. The experiment followed a split-plot design with three replications.

Field Preparation

The total plot size was 90x60 m². Each sub-plot measured 4 m², containing three rows with a row-to-row spacing of 75 cm and a plant-to-plant distance of 40 cm. The distance between plots was maintained at 50 cm. A buffer zone of 0.5 m was maintained between each plot, while a 1 m buffer zone was left on each side between blocks. The field was plowed twice before sowing using a cultivator followed by a rotavator. Seeds were sown in rows using the hand drill method. All cultural and agronomic practices, including weeding, thinning, and irrigation, were consistently applied throughout the growing season in each plot.

Application of Pesticides

The recommended dose of insecticides, as listed in Table-1, was applied when the pest population reached the Economic Threshold Level (ETL) using a knapsack sprayer (Aslam *et al*., 2007). If the pest population reached ETL after the first spray, all treatments were repeated for a second time, and data were recorded.

Percent Reduction of *L. erysimi*

Aphid populations were assessed in the field by gently beating the 10 cm top portion of the terminal shoot with a pencil-sized stick onto a white paper sheet to check the Economic Threshold Level (ETL). When the aphid population reached the ETL, insecticides were applied. Data were collected from 10 randomly selected plants in both untreated and treated plots before the application of insecticides and on the 1st, 7th, 14th, 21st, and 28th days after application. The following formula converted the number of aphids per plant into a percentage (%) reduction in aphid population compared to the control (Arif *et al*., 2012).

$$\% \text{ Reduction} = \frac{Population\ before\ spray - populaton\ after\ spray}{Population\ before\ spray} \times 100$$

Insecticides' effect on yield and yield components

Number of subbranches per plant

After the application of insecticides, ten plants were randomly selected from each treatment, and the number of sub-branches per plant was counted from the bottom to the top of the fully developed plant (Razaq *et al.*, 2014).

Number of Pods Per Plant

The number of pods per plant was recorded by counting the pods at maturity on ten randomly selected plants for each treatment after insecticide application (Malik *et al.*, 2012).

Plant Height

Plant height was measured on ten randomly selected plants in each subplot using a meter rod after the application of synthetic insecticides (Ahmed *et al.*, 2013).

Yield

The yield obtained for each treatment was calculated and converted into yield/hectare using the provided formula (Sarwar, 2013)."

$$Total\ yield = \frac{weight\ in\ kg}{Per\ plot\ size} \times 10000\ m^2$$

Statistical Analysis

Analysis was performed using statistical software (version 8.1). Significant differences between treatment means were determined by comparing the mean values with the least significant difference (LSD) at the 0.05 level of probability (Steel and Torrie, 1984).

RESULTS

The results presented in Table 1 illustrate the response of the *L. erysimi* population to various treatments on selected cultivars. All treatments showed significant responses compared to the control plants in each cultivar. The data in the first column represent aphid populations before the application of treatments. The minimum aphid population was recorded on the cultivar 'China,' ranging from 26.14 to 26.99, while the maximum population of aphids was recorded on the cultivar 'Swabi,' ranging from 46.1 to 46.78.

Table 1

Comparative efficacy of different synthetic insecticides against mustard aphid population after first spray during 2021-22.

Varieties	Treatments	Aphid population plant^{-1}						
		Time intervals						
		Before spray	15 Feb	22 Feb	1 Mar	8 Mar	15 Mar	Mean
Raya Anmol	Fipronil	33.30	13.34±0.37 jk	17.01±0.28 kl	20.68±0.28 k	25.23±0.34 j	29.93±0.55 i	21.23 i-l
	Lambda cyhalothrin	33.96	11.55 ±0.40 k	14.55±0.58 m	18.48±0.42lm	22.15±0.37 k	26.44±0.37 k	18.63 k-n
	Thiomethoxam	33.47	8.49±0.26 l	12.46±0.42 n	15.46±0.45 n	19.82±0.35 l	25.53±0.52 l	16.35 m-p
	Control	33.60	34.47±0.32 ef	35.09±0.23 d	37.81±0.65 d	38.48±0.67 d	39.10±0.78 c	36.99 cd
Abaseen	Fipronil	37.16	16.85±0.11 h	20.19±0.45 j	25.19±0.27 i	29.89±0.27 gh	33.11±0.48 gh	25.04 g-i
	Lambda cyhalothrin	37.61	14.07±0.36 ij	17.77±0.26 k	23.23±0.41 j	27.22±0.60 i	31.89±0.58 h	22.83 h-k
	Thiomethoxam	37.08	11.65±0.39 j	15.65±0.42 lm	20.32±0.46 kl	24.43±0.42 j	27.98±0.42 j	20.00 j-m
	Control	37.44	38.44±0.29 c	39.22± 0.53 c	41.70±0.38 c	43.04±0.78 c	43.37±0.67 b	41.14 bc
KS-75	Fipronil	30.42	11.78±0.38 jk	14.78± 0.18 m	17.17±0.79mn	21.33 ±0.57 k	25.42±0.57 k	18.09 l-o
	Lambda cyhalothrin	30.64	8.57±0.33 l	11.90±0.20 n	15.57±0.52 n	17.07±0.46 m	22.67±0.63 l	15.15 n-q
	Thiomethoxam	30.36	5.63±0.22 m	9.63±0.24 o	12.15±0.64 o	15.21±0.49 n	20.31±0.34 m	12.58 p-r
	Control	30.51	31.58 ±0.25 fg	33.75±0.53 ef	34.95±0.55 e	34.62±0.59 e	35.96±0.67 d	34.17 de
China	Fipronil	26.21	5.75±0.20 m	9.75±0.48 o	12.56±0.36 r	16.96±0.57 m	21.51±0.71lm	13.30 o-q
	Lambda cyhalothrin	26.99	3.64±0.12 mn	6.97±0.46 p	9.38±0.39 p	12.94±0.17 o	18.18±0.47 n	10.22 qr
	Thiomethoxam	26.38	1.84±0.45 n	4.15±0.37 q	7.15±0.44 q	10.54±0.54 p	16.08±0.55 o	7.95 r
	Control	26.14	27.16±0.09 ij	29.98±0.21 h	31.35±0.55 f	32.49±0.55 f	32.82±0.66 cd	30.96 ef
Swabi	Fipronil	46.01	22.74±0.21 f	27.41±0.53 g	31.33±0.43 ef	35.09±0.41 de	39.38±0.40 c	31.99 ei
	Lambda cyhalothrin	46.66	21.63±0.16 fg	24.82±0.29 h	28.78±0.32 g	33.26±0.31 f	36.46±0.49 d	29.79 gf
	Thiomethoxam	46.78	17.83±0.28 h	22.76±0.43 i	23.81±0.60 ij	30.81±0.43 g	35.52±0.46 de	26.14 gh
	Control	46.35	47.12±0.11 a	47.63±0.39 a	47.55±0.51 a	49.56±0.36 a	51.72±0.45 a	48.71 a
Dalay	Fipronil	44.13	21.15±0.23 fg	24.82±0.42 h	29.82±0.33 fg	32.42±0.33 f	35.77±0.29 df	28.79 fg
	Lambda cyhalothrin	44.35	18.48±0.71 gh	22.81±0.44 ij	27.14±0.29 h	29.44±0.50 gh	34.85±0.41 ef	26.54 f-h
	Thiomethoxam	44.93	16.58±0.27 hi	20.75±0.41 j	24.09±0.53 ij	27.44±0.32 i	33.01±0.38 gh	24.37 g-j
	Control	44.48	44.48±0.24 b	45.66±0.57 b	46.40±0.37 b	47.06±0.48 b	48.00±0.94 b	47.12 b

On the first day after the application of treatments, the maximum aphid population was observed on the cultivar 'Swabi' in the control plot (47.12), while the minimum pest density was observed on the cultivar 'China' in the plot treated with thiomethoxam (1.84). By the 7th day, the maximum mean number of pests was recorded on the cultivar 'Swabi' in the control plot (47.63), while the minimum mean number of pests was recorded on the cultivar 'China' in the plot treated with thiomethoxam (4.15). On the 14th day, the maximum pest density was recorded on the cultivar 'Swabi' in the control plot (47.55), while the minimum pest density was recorded on the cultivar 'China' in the plot treated with thiomethoxam (7.15). On the 21st day after the application of synthetic insecticides, the maximum pest density was recorded on the cultivar 'Swabi' in the control (49.56), while the minimum pest density was recorded on the cultivar 'China' in the plot treated with thiomethoxam (10.54).

The data recorded on the 28th day showed the maximum pest density on the cultivar 'Swabi' in the control plot (51.72), and the minimum pest density was recorded on 'China' in the plot treated with thiomethoxam (16.08).

The mean data show that the maximum pest density was recorded in the 'Swabi' control plot (48.71), while the minimum pest density was recorded on the 'China' cultivar in the plot treated with thiomethoxam (7.95), followed by plots treated with Lambda cyhalothrin (10.22) and Fipronil (13.30) on the same cultivar. The results in 'Table 2' show the response of *L. erysimi* population to various treatments on selected cultivars. All treatments exhibit significantly different responses compared to the control in each cultivar. The data recorded on the first day after the application of treatments reveal that the maximum aphid population was observed on the 'Swabi' cultivar in the control plot (44.49), while the minimum pest density was observed on the 'China' cultivar in the plot treated with thiomethoxam (2.15). On the 7th day, the maximum mean number of pests was recorded on the 'Swabi' cultivar in the control plot (46.34), while the minimum mean number of pests was recorded on the 'China' cultivar in the plot treated with thiomethoxam (5.10). On the 14th day, the maximum pest density was recorded on the 'Swabi' cultivar in the control plot (48.00), while the minimum pest density was recorded on the 'China' cultivar in the plot treated with thiomethoxam (8.04).

Table 2

Comparative efficacy of different synthetic insecticides against mustard aphid population after second spray during 2021-22

Varieties	Treatments	Aphid population plant^{-1}					
		Time intervals					
		Day 1st	Day 7th	Day 14th	Day 21st	Day 28th	Mean
Raya Anmol	Fipronil	12.20±0.37 h	15.16±0.26 k	17.82±0.32 k	21.21±0.33 j	23.40±0.29 j	17.93 i-l
	Lambda cyhalothrin	10.09±0.23 i	12.08±0.24 m	15.24±0.06 m	17.20±0.21 n	21.16±0.27 l	15.15 m-o
	Thiomethoxam	7.01±0.41 l	10.10±0.12 n	12.09±0.22 o	15.03±0.20 o	17.41±0.20 o	12.39 p-r
	Control	36.30±0.25 c	37.29±0.61 d	39.96±0.17 d	40.28±0.12 d	41.90±0.44 d	39.15 c
Abaseen	Fipronil	15.65±0.43 g	18.00±0.40 i	19.82±0.36 i	22.49±0.40 i	25.62±0.42 h	20.33 g-i
	Lambda cyhalothrin	12.28± 0.29 h	15.67±0.29 k	17.02±0.35 l	19.27±0.36 l	23.28±0.26 j	17.54 j-m
	Thiomethoxam	9.94±0.46 i	11.94±0.57 m	15.07±0.27 m	17.88±0.41 mn	19.26±0.37 m	14.85 n-p
	Control	40.20±0.19 b	41.58±0.35 c	42.47±0.53 c	42.83 ±0.34 c	43.30±0.45 c	41.96 b
KS-75	Fipronil	10.46±0.22 ij	12.50±0.23 m	15.38±0.31 m	18.18±0.43 m	21.16±0.41 l	15.50 l-n
	Lambda cyhalothrin	7.63±0.44 jk	10.77±0.56 n	12.39±0.43 o	15.38 ±0.48 o	18.33±0.47 n	12.89 o-q
	Thiomethoxam	4.90±0.18 l	8.11±0.41 o	11.45±0.60 p	12.34±0.22 p	15.10±0.38 q	10.37 r
	Control	33.20±0.18 d	34.98±0.39 e	36.05±0.41 e	38.48±0.39 e	39.28 ±0.30 e	36.34 d
China	Fipronil	8.03±0.40 j	10.47±0.20 n	13.03±0.24 o	15.38±0.46 o	17.77±0.12 no	12.90 op
	Lambda cyhalothrin	5.13±0.21 k	8.24±0.36 o	10.17±0.26 p	12.55±0.26 p	16.03±0.22 p	10.44 qr
	Thiomethoxam	2.15±0.35 m	5.10±0.17 p	8.04 ±0.16 r	10.05±0.18 q	12.86±0.28 r	7.64 s
	Control	29.45±0.15 d	31.23±0.28 f	33.98±0.45 f	35.17±0.28 f	38.61±0.58 f	33.55 e
Swabi	Fipronil	20.26±0.50 e	20.89±0.37 g	23.33±0.37 g	26.46±0.45 g	29.33±0.27 g	24.11 f
	Lambda cyhalothrin	17.11±0.33 f	19.14±0.30 h	21.47±0.29 h	24.30±0.59 h	25.66±0.21 h	21.50 gh
	Thiomethoxam	15.10±0.29 g	16.57±0.31 j	19.02±0.28 j	20.71±0.28 jk	22.28±0.46 k	18.76 i-k
	Control	44.49±0.45 a	46.34±0.44 a	48.00±0.15 a	49.76±0.31 a	51.68 ±0.43 a	48.05 a
Dalay	Fipronil	17.39±0.47 f	19.44±0.37 h	21.30±0.51 h	24.44±0.41 h	26.90±0.49 g	21.81 fg
	Lambda cyhalothrin	15.06±0.28 g	16.90±0.18 ij	19.16±0.21 j	21.34±0.45 kl	24.22±0.40 i	19.32 h-j
	Thiomethoxam	11.88± 0.42 h	13.50±0.51 l	19.16±0.38 l	20.28±0.47 k	21.41±0.45 l	16.72 k-n
	Control	42.67±0.30 a	43.92±0.38 b	45.56±0.30 b	47.37±0.44 b	52.14 ±0.59 b	46.30 a

On the 21st day after the application of synthetic insecticides, the maximum pest density was recorded on the 'Swabi' cultivar in the control (49.76), while the minimum pest density was recorded on the 'China' cultivar in the plot treated with thiomethoxam (10.05). The data recorded on the 28th day showed the maximum pest density on the 'Swabi' cultivar in the control plot (51.68), and the minimum pest density was recorded on the 'China' cultivar in the plot treated with thiomethoxam (12.86). The mean data show that the maximum pest density was recorded on 'Swabi' in the control plot (48.05), while the minimum pest density was recorded on the 'China' cultivar in the plot treated with thiomethoxam (7.64), followed by plots treated with Lambda cyhalothrin (10.44) and Fipronil (12.90) in the same cultivar. The results in 'Table 3' present the effect of various treatments on the number of sub-branches/plant, the number of pods/plant, and the plant height of selected canola cultivars.

Table 3

Effect of different synthetic insecticides on the physiological characteristics of canola crop during 2021-2022.

Varieties	Treatments	Sub-Branches (no.)	Pods/Plant (no.)	Plant height (cm)
Raya Anmol	Fipronil	26.52±0.06 h	82.14± 0.04 i	100.09±0.10 i
	Lambda Cyhalothrin	27.32±0.07 f	83.15±0.03 h	102.57±0.38 gh
	Thiamethoxam	28.00±0.09 e	84.27±0.12 g	103.83±0.83 d
	Control	24.18±0.04 l	69.22±0.06 r	95.5±0.39 ij
Abaseen	Fipronil	25.00±0.13 k	79.02±0.01 l	82.12±0.50 m
	Lambda Cyhalothrin	26.43±0.12 h	80.05±0.11 k	84.96±0.54 l
	Thiamethoxam	27.23±0.11 fg	81.04±0.031 j	91.25±0.42 k
	Control	23.21±0.00 m	65.20±0.07 s	75.76±0.36 n
KS-75	Fipronil	27.11±0.01 g	85.28±0.21 f	103.64±0.73 fg
	Lambda Cyhalothrin	28.25±0.05 d	86.21±0.09 e	105.08±0.58 f
	Thiamethoxam	29.52±0.14 b	87.26±0.08 d	110.39±1.14 c
	Control	25.17±0.03 jk	71.1 ±0.10 q	101.66±0.66 hi
China	Fipronil	28.12±0.06 de	88.26±0.12 c	116.62±1.07 d
	Lambda Cyhalothrin	29.22±0.14 c	89.20±0.02 b	118.14±.0.46 b
	Thiamethoxam	30.00±0.15 a	90.19±0.05 a	122.17±1.13 a
	Control	26.10 ±0.01 i	76.19±0.00 m	108.74±0.37 e
Swabi	Fipronil	23.00±0.03 n	73.12±0.10 p	65.03±0.55 p
	Lambda Cyhalothrin	24.22±0.21 l	74.07±0.11 o	73.60±0.29 o
	Thiamethoxam	25.00±0.16 k	75.05±0.16 n	75.70±0.24 n
	Control	21.00±0.02 p	58.21±0.12 u	58.31±0.19 q
Dalay	Fipronil	24.11±0.08 l	75.03±0.03 m	75.32±0.34 n
	Lambda Cyhalothrin	25.22±0.21 j	76.77±1.31 mn	81.95±0.04 m
	Thiamethoxam	26.11±0.20 i	78.25±0.15 l	85.86±0.09 l
	Control	22.14±0.07 o	60.68±0.34 t	66.02±0.57 p
LSD (0.05)		0.1523	0.8138	1.6172

The maximum mean number of sub-branches/plant was observed on the 'China' cultivar in the plot treated with thiomethoxam (30.00), followed by lambda cyhalothrin (29.22) and Fipronil (28.12), while the minimum mean number of sub-branches/plant was observed on the 'Swabi' cultivar in the control plot (21.00). Data regarding pods/plant reveal that the highest mean number of pods/plant was observed on the 'China' cultivar in the plot treated with thiomethoxam (90.19), followed by lambda cyhalothrin (89.20) and Fipronil (88.20), and while the minimum mean number of pods/plant was observed on the 'Swabi' cultivar in the control plot (58.21). In the case of plant height, the data revealed that the maximum plant height was observed on the 'China' cultivar in the plot treated with thiomethoxam (122.17 cm), followed by lambda cyhalothrin (118.14 cm) and Fipronil (116.2 cm), while the minimum mean number of sub-branches/plant was observed on the 'Swabi' cultivar in the control plot (66.02).

The results in 'Table 4' present the mean yield kg/plot of selected canola cultivars in response to different treatments used against mustard aphid. The data recorded after the application of treatments reveal that the maximum mean yield kg/plot was recorded in the 'China' cultivar in the plot treated with thiomethoxam (2.92 kg/plot), followed by lambda cyhalothrin (2.82 kg/plot) and Fipronil (2.73 kg/plot), while the minimum mean yield kg/plot was obtained on the 'Swabi' cultivar in the control plot (0.42 kg/plot). In the case of mean yield kg/ha, the data reveal that the maximum mean yield kg/m2 was obtained on the 'China' cultivar in the plot treated with thiomethoxam (1827.1 kg/ha), followed by lambda cyhalothrin (1764.6 kg/ha) and 'Fipronil' (1704.3 kg/ha), while the minimum mean yield kg/ha was obtained on the 'Swabi' cultivar in the control plot (402.6 kg/ha).

Table 4

Efficacy of different synthetic insecticides on the yield of canola crop during the 2021-2022.

Varieties	Treatments	Mean Yield (kg /Plot)	Mean Yield (kg/ha)
Raya Anmol	Fipronil	2.12±0.01 I	1327.1±5.51 hi
	Lambda cyhalothrin	2.21±0.00 h	1383.3±2.08 gh
	Thiamethoxam	2.32±0.12 g	1454.2±5.51 fg
	Control	0.72±0.21 u	450.0±3.60 rs
Abaseen	Fipronil	1.72±0.02 l	1075.0±3.40 k
	Lambda cyhalothrin	1.82±0.03 k	1204.2±6.89 j
	Thiamethoxam	1.92±0.10 j	1237.5±7.51 ij
	Control	0.62±0.00 v	387.5±3.24 st
KS-75	Fipronil	2.41±0.20 f	1508.3±2.10 ef
	Lambda cyhalothrin	2.53±0.01 e	1583.3±2.08 de
	Thiamethoxam	2.62±0.22 d	1637.5±3.06 cd
	Control	0.82± 0.13 t	512.5±3.50 qr
China	Fipronil	2.73±0.00 c	1706.3±3.16 bc
	Lambda cyhalothrin	2.82±0.11 b	1764.6±2.08 ab
	Thiamethoxam	2.92±0.10 a	1827.1±2.81 a

	Control	0.92±1.01 s	575.0± 3.61 q
Swabi	Fipronil	1.18±0.02 r	697.9± 4.17 p
	Lambda cyhalothrin	1.24±1.00 q	762.5±3.17 op
	Thiamethoxam	1.31±0.12 p	822.9±2.62 no
	Control	0.42±0.02 x	402.6±4.11 st
Dalay	Fipronil	1.42±0.21 o	885.5±2.14 mn
	Lambda cyhalothrin	1.51±0.10 n	947.9±2.17 ml
	Thiamethoxam	1.61±0.03 m	1008.3±2.67 kl
	Control	0.52±0.11 w	324.9±3.45 t

Supplementary Table (ii).
Field layout of six different varieties and synthetic insecticides against mustard aphids.

Rep:1	Rep:2	Rep:3
V1T1	V6T4	V5T3
V1T2	V6T1	V5T4
V1T3	V6T2	V5T1
V1T4	V6T3	V5T2
V2T1	V3T2	V4T4
V2T2	V3T1	V4T3
V2T3	V3T4	V4T1
V2T4	V3T3	V4T2
V3T1	V5T2	V1T3
V3T2	V5T3	V1T4
V3T3	V5T4	V1T2
V3T4	V5T1	V1T1
V4T1	V2T4	V6T2
V4T2	V2T1	V6T3
V4T3	V2T2	V6T4
V4T4	V2T3	V6T1
V5T1	V1T2	V3T4
V5T2	V1T3	V3T1
V5T3	V1T4	V3T2
V5T4	V1T1	V3T3
V6T1	V4T4	V2T2
V6T2	V4T3	V2T4
V6T3	V4T2	V2T1
V6T4	V4T1	V2T3

DISCUSSION

Mustard aphid (*L. erysimi*) is one of the major pests of the mustard crop, causing significant yield losses. Both nymphs and adults inflict major damage by extracting sap from leaves, stems, flowers, pods, and other parts of the plants. They release honeydew, creating a medium for the growth of sooty mold fungus. This study aimed to evaluate the efficacy of different synthetic insecticides against (*L. erysimi*) under normal field conditions. The results of this study, conducted at the New Developmental Farm, University of Agriculture Peshawar, offer valuable insights into the effective management of mustard aphids (*Lipaphis erysimi* K) in canola cultivation. The implementation of a Split Plot Design with three replications facilitated a robust evaluation of synthetic insecticides, with thiamethoxam emerging as a standout performer in controlling mustard aphids. Our results showed that the lowest pest density was recorded for the cultivar 'China,' while the highest mean numbers of pests were noted for 'Swabi.' Consistent with our findings, Ali *et al*. (2018) also reported that the 'Swabi' cultivar was vulnerable to (*L. erysimi*). Additionally, Hameed and Khattak (1993) concluded that the susceptibility of a host plant depends on multiple factors, with the genetic ability of the host plant being a major component of resistance, including morphological and biochemical factors. The distinct contrast in pest density between the 'China' cultivar treated with thiamethoxam and the untreated 'Swabi' cultivar highlights the tangible impact of the chosen insecticide. Thiamethoxam consistently demonstrated its efficacy, maintaining low pest densities even after subsequent treatments. These findings align with the persistent trends observed in the 'China' cultivar, underscoring the sustained effectiveness of thiamethoxam in managing mustard aphids.

Our recent results align with Singh *et al.* (2012), who found the maximum bulk of aphids on the 'Swabi' cultivar and the minimum on the 'China' cultivar. The variation among aphid populations is attributed to the antibiotic or antixenotic capacities of the host plants. In response to different treatments, mustard aphids (*L. erysimi*) showed significantly different responses in our experiment. Outcomes indicate that the plot treated with thiamethoxam significantly reduced the average aphid population, followed by lambda cyhalothrin and fipronil. The comprehensive assessment extended beyond pest density to encompass additional crucial parameters. The 'China' cultivar treated with thiamethoxam exhibited not only the lowest pest density but also showcased superior growth characteristics, including maximum sub-branches, pods per plant, plant height, and overall yield. In contrast, the untreated 'Swabi' cultivar lagged behind in all these aspects, emphasizing the pivotal role of thiamethoxam in promoting plant health and productivity. Our results are consistent with the conclusions of Ghule *et al*. (2016), Maurya *et al*. (2018), and Prasad (2006). Furthermore, Petal *et al*. (2017) and Rohilla *et al*. (2004) also reported that thiomethoxam was significantly effective even after the 28th day after its application, compared to other treatments.

Regarding biological yield, our findings show significant variation in response to different treatments. In our results, thiamethoxam yielded the maximum, followed by lambda cyhalothrin, while the lowest yields were observed in the normal plot, preceding the plot treated with fipronil. These results are in accordance with the findings of Senha *et al*. (2001) and Rohilla *et al*. (2004), who observed that canola under normal field circumstances was more affected by thiamethoxam and Fipronil, and optimum harvests of canola crop were obtained from these treatments. Our results also align with the findings of Maurya *et al*. (2018), who assessed various artificial insecticides against mustard aphids, reporting elevated production from a thiamethoxam-treated plot, while the plots treated with Lambda cyhalothrin and Fipronil had lower aphid mortality. The integrated approach of using thiamethoxam with the 'China' cultivar emerges as a promising pest management strategy for canola cultivation. The significant yield improvements and enhanced growth parameters underscore the practical applicability of this combination in real-world agricultural scenarios. These findings contribute to the ongoing discourse on sustainable and effective pest control measures, providing farmers and agricultural practitioners with valuable insights for optimizing canola crop yields. Further research could delve into the long-term impacts and economic feasibility of adopting this integrated approach on a larger scale.

CONCLUSION

The results indicate that the 'China' variety demonstrated resistance among the selected varieties based on the aphid count per plant. Among various synthetic insecticides, thiamethoxam proved to be comparatively more effective against the mustard aphid (*Lipaphis erysimi* K). A higher biological yield was achieved through the combined effect of the 'China' variety with the thiamethoxam treatment. Farmers are advised to cultivate the 'China' variety in areas where the aphid *L. erysimi* causes economic losses. In cases where the pest population reaches the economic threshold level, the synthetic insecticide thiamethoxam 25 WG at a rate of 100 g/m2 is recommended to obtain a higher yield in canola crops.

Availability of Data and Materials

All the data is available within the manuscript.

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REFERENCES

Ahmed, N., Ahmad, S., Ahmad, S., Junaid, M., & Mehmood, N. (2013). Population trend of aphid (Lipaphis erysimi Kalt) on canola (Brassica spp.) cultivar in Peshawar. *Pak Entomol*, *35*, 135-138.

Ali, N., Khan, N. U., Farhatullah, R. M., Bibi, Z., Gul, S., Ali, S., ... & Naveed, K. (2018). Genetic diversity in indigenous landraces of Brassica napus based on morphological and biochemical characteristics using multivariate techniques. *Int J Agric Biol*, *20*, 277-287. https://www.cabidigitallibrary.org/doi/full/10.5555/20193099654

Amer, M., Aslam, M., Razaq, M., & Afzal, M. (2009). Lack of plant resistance against aphids, as indicated by their seasonal abundance in canola, Brassica napus (L.) in Southern Punjab, Pakistan. *Pak. J. Bot*, *41*(3), 1043-1051. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=8b14b96cd9a2627cae68510420cea4483e3f3fb7

Arshad, M., Khan, M. A., Karar, H., & Abbas, Q. (2012). Performance of some insecticides against canola aphids and associated coccinellid predators under field conditions. *Pak Entomol*, *34*, 37-41.

Aslam, M., Razaq, M., Ahmad, F., Mirza, Y. H., & Ahmed, K. Z. (n.d.). Population abundance of aphids (Brevicoryne brassicae L. and Lipaphis erysimi (Kalt.)) on Indian mustard (Brassica juncea L.). *8th African Crop Science Society Conference, El-Minia, Egypt, 27-31 October 2007*, 935–938. https://www.cabdirect.org/cabdirect/abstract/20103268478?resultNumber=0&q=%28aphid%29+AND+%28cabbage%29+AND+%28asia%29+AND+yr%3A%5B2000+TO+2010%5D

Bedford, J. W., & Henry, A. (1998). Yield losses in important cultivars of canola and effect of Aphid infestation under favorable environmental condition. *Indian J. Ent*, *52*, 541-546.

Btryon. (2012, August 19). *Advantages & Disadvantages of Biological Control*. Owlcation; Owlcation. https://owlcation.com/stem/Advantages-Disadvantages-of-Biological-Control

Canna, 2022. How to control pests and diseases? Biological vs. chemical. Available online; [https://www.cannauk.com/how_control_pests_and_diseases biological vs_chemical (accessed on 4 May, 2022).

Chand, N., Dubey, A. P., Lodhi, S. K., Prakash, T. J., & Kumar, S. (2017). Influence of Weather on the Incidence and Spread of Aphid in Mustard (Brassica juncea L.). *International Journal of Current Microbiology and Applied Sciences*, *6*(2), 1655–1664. https://doi.org/10.20546/ijcmas.2017.602.185

Devi, L. C., Singh, T. K., & Varatharajan, R. (2002). Management of mustard aphid with natural enemies, plant product and chemical insecticides. *Indian. J. Entomol.*, *64*(3), 373-376.

https://www.cabidigitallibrary.org/doi/full/10.5555/20033055703

Factsheet, I. 2019. Integrated pest management (IPM) for aphids. HGIC. Available online; https://hgic.clemson.edu/factsheet/integrated-pest-management-i-p-m-for-aphids/

Fleddermann, M., Fechner, A., Rößler, A., Bähr, M., Pastor, A., Liebert, F., & Jahreis, G. (2013). Nutritional evaluation of rapeseed protein compared to soy protein for quality, plasma amino acids, and nitrogen balance–a randomized cross-over intervention study in humans. *Clinical Nutrition*, *32*(4), 519-526.

Frank, D. L., & Liburd, O. E. (2005). Effects of living and synthetic mulch on the population dynamics of whiteflies and aphids, their associated natural enemies, and insect-transmitted plant diseases in zucchini. *Environmental Entomology*, *34*(4), 857-865. https://doi.org/10.1603/0046-225X-34.4.857

Ghule, D. D., and A. S. Bagde. 2016. Efficacy of different insecticides against mustard aphid, (*Lipaphis erysimi K*alt) infesting mustard crop. J. *Global Bio sci*. *5*(5), 109-4113.

Hamed, M., & Khattak, S. U. (1993). Screening of resistant oilseed Brassica against (Brevicoryne brassicae L.) aphids. *Proc. Pakistan Congr. Zool*, *13*, 353-358.

Hamid, S., & Ahmad, S. (1980). Biological assessment of three different insecticides sprayed against Lipaphis erysimi (Kaltenbach) on winter oil-seed crops. Proc. Pak. Congr. Zool. 1: 283-290. https://www.cabidigitallibrary.org/doi/full/10.5555/19830599808

Kissoudis, C., van de Wiel, C., Visser, R. G. F., & van der Linden, G. (2014). Enhancing crop resilience to combined abiotic and biotic stress through the dissection of physiological and molecular crosstalk. *Frontiers in Plant Science*, *5*. https://doi.org/10.3389/fpls.2014.00207

Malik, S., Jabeen, T., Solangi, B. K., & Qureshi, N. A. (2012). INSECT PESTS AND PREDATORS ASSOCIATED WITH DIFFERENT MUSTARD VARIETIES AT TANDOJAM. *Sindh University Research Journal*, *44*(2).

Maurya, N.K., S. Rajendra, S. Joginder, N. Rashmi, H. Wajid and K. Anant. 2018. Screening of rapeseed-mustard varieties against mustard aphid (*Lipaphis erysimi*). *South Asian J. Food Technol. Environ.*, *4*(2), 709-716. https://doi.org/10.46370/sajfte. 2018.v04i02.05

Miri, H. R. (2007). Morphophysiological basis of variation in rapeseed (Brassica napus L.) yield. *Int. J. Agri and Bio.* *9*(5), 701-706. https://www.cabidigitallibrary.org/doi/full/10.5555/20093175231

Mitchell, E. R., G. Hu and D. Johanowicz. 2000. Management of diamondback moth in cabbage using collard as a trap crop. *Horti. Sci. 35*(5), 875-879.

Muhammad Razaq, M. R., Gul Abbas, G. A., Muzammil Farooq, M. F., Muhammad Aslam, M. A., & Habib-ur-Rehman Athar, H. U. R. A. (2014). Effect of insecticidal application on aphid population, photosynthetic parameters and yield components of late sown varieties of canola, Brassica napus L. *Pak J. Zool., vol. 46(*3), 661-668.

Murphy, D. J., Cummins, I., & Kang, A. S. (1989). Synthesis of the major oil-body membrane protein in developing rapeseed (Brassica napus) embryos. Integration with storage-lipid and storage-protein synthesis and implications for the mechanism of oil-body formation. *Biochemical Journal*, *258*(1), 285–293. https://doi.org/10.1042/bj2580285

Negawoldes, T. Y. (2018). Review on nutritional limitations and opportunities of using rapeseed meal and other rape seed by-products in animal feeding. *J. Nutr. Health Food Eng*, *8*(1), 43-48.

Pakistan Bureau of Statistics, Government of Pakistan 2018. http://www.pbs.gov.pk/content/agricultural-statistics-pakistan-2018.

Parsad, S. K. (1992). Relative efficacy of some synthetic parathyroid and phosphomidon against mustard aphid *Lipaphis erysimi*. Ann. Agric. Res., 13(2): 137-140.

Raymer, P. L. (2002). Canola: An emerging oilseed crop. *Trends in new crops and new uses*, *1*, 122-126. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=c4500c9d390fe500b4cacbbaf5762954700dae98

Raymer, P. L. (2002). Canola: An emerging oilseed crop. *Trends in new crops and new uses*, *1*, 122-126. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=c4500c9d390fe500b4cacbbaf5762954700dae98

Razaq, M., Mehmood, A., Aslam, M., Ismail, M., Afzal, M., & Shad, S. A. (2011). Losses in yield and yield components caused by aphids to late sown Brassica napus L., Brassica juncea L. and Brassica carrinata A. Braun at Multan, Punjab (Pakistan). *Pak. J. Bot*, *43*(1), 319-324.

Rohilla, H. R., Bhatnagar, P., & Yadav, P. R. (2004). Chemical control of mustard aphid with newer and conventional insecticides. Ind. J. Entmol., 66(1): 30-32.

https://www.cabidigitallibrary.org/doi/full/10.5555/20053175767

Saljoqi, A. U. R., Sadur-Rehman, Hussain, N., & Khan, S. A. (2006). Insect pests of canola crop (other than aphid). *Journal of Agricultural and Biological Science*, *15*(1), 19-21.

Sarwar, M., Ahmad, N., Siddiqui, Q. H., Rajput, A. A., & Tofique, M. (2003). Efficiency of different chemicals on Canola strain Rainbow (Brassica napus L.) for aphids control. *Asian J. Plant Sci*, *2*(11), 831-833.

Sattar, A., Cheema, M. A., Wahid, M. A., Saleem, M. F., Ghaffari, M. A., Hussain, S., & Arshad, M. S. (2013). Effect of sowing time on seed yield and oil contents of canola varieties. *Journal of Global Innovation in Agriculture and Social Science*, *1*, 1-4.

Shrivastava, A. K., Singh, H. V., Raizada, A., & Singh, S. K. (2015). C-reactive protein, inflammation and coronary heart disease. *The Egyptian Heart Journal*, *67*(2), 89-97. https://doi.org/10.1016/j.ehj.2014.11.005

Singh, D. K., Pal, S., Dwivedi, R. K., & Pal, R. K. (2014). Efficacy of insecticides against Mustard aphid, Lipaphis erysimi Kalt. *Annals of Plant Protection Sciences*, *22*(1), 39-41. https://www.indianjournals.com/ijor.aspx?target=ijor:apps&volume=22&issue=1&article=010

Singh, Y. P., Meghwal, H. P., & Singh, S. P. (2009). Evaluation of some bioagents against mustard aphid (Lipaphis erysimi (Kaltenbach))(Hemiptera: Aphididae) on single plant in field condition. *Journal of Biological Control*, 95-97.

Steel, R. G. D. & J. H. Torrie. (1984). *Principles and procedures of statistics*. McGraw Hill book Co., Inc., New York. 232-251.

Tekle, A. T., & Alemu, M. A. (2016). Drought tolerance mechanisms in field crops. *World Journal of Biology and Medical Sciences*, *3*(2), 15-39.

Vandermeer, J. H., 1989. *The ecology of intercropping*. Cambridge University Press, New York, New York, USA. 1. (1): 1-4.

Voesenek, L. A., & Bailey-Serres, J. (2015). Flood adaptive traits and processes: an overview. *New Phytologist*, *206*(1), 57-73. https://doi.org/10.1111/nph.13209