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Management Of Canola Aphid (*Lipaphis Erysimi* (Kalt); Hemiptera: Aphididae) Through Different Control Tactics.

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Abstract
Mustard aphid, *Lipaphis erysimi* (Aphididae: Hemiptera) is one of the major constraints for mustard production in Pakistan. Sustainable management of mustard aphids is a serious issue due to their unusual life cycle and widespread habitats. Synthetic chemicals are a great threat to the environment and human health. In the present study, as an alternative different sowing dates and plant extract being ecofriendly approaches to manage insect pests. In this study two different experiments were performed to test the effect of sowing dates on the population trend of canola aphids (*Lipaphis erysimi* (Kalt) on four selected canola cultivars (Tara seed, Dalay, Abaseen and KS-75). The trials comprised three different sowing dates at a time interval of 10 days; (S_1) 26th October 2021, (S_2) 6th November 2020, (S_3) 16th November 2020. In second experiment, the efficacy of insecticide (Fipronil) and botanical extract (Neem seed extract) against canola aphids on two tested canola cultivars (Abaseen and KS-75) regarding different parameters were studied. Data regarding the population trend of aphids on four tested cultivars at three various sowing dates show that significantly minimum aphids plant^{-1} (S_1 (7.60), S_2 (6.79), S_3 (8.79) was obtained from canola cultivar KS-75, while, statistically maximum aphids plant^{-1} (S_1 (77.91), S_2 (53.28), S_3 (62.40) was obtained from Abaseen variety on all three sowing dates. During second experiment, significantly maximum mean per cent population reduction (67.183), Sub-branches plant^{-1} (29.360), Pods plant^{-1} (377.58), and Yield (105.62) was obtained from Fipronil treated plots while statistically minimum mean per cent population reduction (2.467), Sub-branches plant^{-1} (16.625), Pods plant^{-1} (210.99), and Yield (48.39) was recorded from control. Our findings show that KS-75 is the most resistant canola variety among all tested cultivars and conventional pesticide Fipronil proved highly effective against *L.erysimi*.

INTRODUCTION

Pakistan is among the world's largest consumer of edible oil and ranks as the third-largest global importer of edible oils. Oilseed crops play a vital role in Pakistan's economy. Sunflower, cotton and rapeseed-mustard constitute the major oilseed crops in the country Ijaz et al (2021). Despite its fertile fields, an efficient canal system and an economy deeply rooted in agriculture, Pakistan remains reliant on imported edible oil due to inadequate domestic oilseed production, Rehman et al (2011). Several factors are responsible for the low yield i.e., insect pests, biotic and abiotic factors, non-availability of certified seeds, in-equal fragmentation of land and improper irrigation. The deficiency of edible oil can be minimized by improving production of local oilseed and producing resistant cultivars against insect pest, weeds, and diseases which reduce the yield of canola, as this crop has been invaded by more than 20 insect pests including mustard aphid, leaf miner and cabbage caterpillar throughout the globe (Blackman and Eastop, 2000). Among these pests, mustard aphid (*L. erysimi*) is one of the most vital and economic pests all over Pakistan (Saljoqi *et al.* 2006). It is highly damaging pest staying on stem, buds, and new leaves, which results in stunted growth of plants and hence crops losses its shape, as well as development. It affects all growth stages of plants which causes losses in cop yield from 10-90%. This insect (*Lipaphis erysimi*) has multiple over-lapping generations per year as they give birth to young ones through parthenogenesis. A single females produces around 22-30 offspring and mature in 8-10 days, furthermore, resulting in 4-5 generations per year. After emergence, female give birth to young ones with an average time of 10.8 days; as it produces young ones for 15 days with a rate of 1.6 nymphs/female, depending on various factors such as host quality, favorable environmental conditions and averages life span of 22-24 days (Capinera, 2011).

For the management of mustard aphids, various control methods such as cultural, biological, chemical and physical control tools have been used. Proper control of mustard aphid *Lipaphis erysimi* (Kalt) is possible by the use of systemic insecticide but it could not be permanent solution as its population again attains the same level within a fortnight after spray of chemical (Singh et al., 1984). Among all these methods, integrated pest management is the most effective and durable pest control method with no imbalance in natural environmental conditions, economy, as well as human health. Through IPM, pest population can be managed below economic threshold level by the integration of more than two methods in a combined program with no harmful impact of environment which is socially acceptable and economically feasible

(Mottaghinia *et al*., 2011). Therefore, the present investigation was undertaken to evaluate the effect of different sowing dates and bio-efficacy of insecticide Fipronil and botanical (Neem seed extract) under field conditions against aphids (*Lipaphis erysimi* (Kalt) on the selected canola genotypes (Tara seed, Dalay, Abaseen and KS-75).

MATERIALS AND METHODS

The study was conducted in the University of Agriculture Peshawar Research Farm, to evaluate the effect of different sowing dates of selected canola genotypes against canola aphids (*Lipaphis erysimi* (Kalt) under a field conditions. Two different chemicals (Fipronil and bio-pesticide neem seed extract) were used during this experiment).The First experiment consists of 4 selected canola cultivars (Local variety V_1 (Tara seed), V_2 (Dalay) V_3 (Abaseen) and V_4 (KS-75).The Randomized Complete Block Design (RCBD) was used with three replications. The genotypes were obtained from The University of Agriculture Peshawar research farm. Seeds were sown in rows through hand drill method. Total plot size was kept 164 m^2 with sub plots size 54 m^2 having three rows with spacing of 70 cm row to row and 40 cm plant to plant distance. Three different sowing dates with time interval of 10 days, were planned as (S1) 26th October 2020, (S2) 6th November 2020 and (S3) 16th November 2020

Four different cultivars were sown at three different sowing dates (mentioned above) to record the population trend of canola aphids. Data collection was started as soon as the pest appeared in the field. Data were collected at weekly interval from three stages i.e., stage A (Seedling stage), stage B (Flowering stage) and stage C (Pods stage) by using a stick of size equal to pencil softly trampled with piece of white paper on randomly selected three plants (central rows) in each sub plot. During seedling stage, data was collected from whole plant, however during stage B and C, data was recorded only from top 10 cm portion of the plant and brought in polythene bags to laboratory for further identification if required and counted thee number of aphids with a magnifying glass for further analysis. Data collection: The data collection parameters were planned, as number of aphids per plant (Seedling stage) and during flowering and pods stage the sample size changed as (top 10cm) of each plant.

During the second experiment only two genotypes were chosen based on preliminary data. To evaluate the Efficacy of selected insecticide and neem seeds extract against canola aphid. For this experiment three treatments were recommended (T_1) Fipronil (T_2) botanical extract (Neem seed extract) and (T_3) control on the selected canola cultivars (V_1= Abaseen, V_2 = KS-75).

The prepared extract was used at a concentration of 3 per cent using the equation of (Shah *et al*, .2015). $C_1V_1 = C_2V_2$.

Data collection Parameters:

The data was taken from the following parameter.

1. Mean per cent population reduction
2. No. of pods/plant
3. No. of sub branches/plant
4. Yield

1. Mean Per cent population reduction:

Data regarding mean per cent population reduction of canola aphids in two different canola cultivars by synthetic insecticide and plant extract were collected after (3rd, 7th, 10th, 14th, and 21st days) by counting the number of aphids per plant, from randomly selected three plants and mean was calculated. The below formula was utilized to calculate the percent population decline.

% reduction = Population before spray minus population after spray divided by population before spray x100

2. Number of pods per plant:

After the plant reached to fully matured stage, pods number per plant were counted in the field from randomly selected ten plants from each of the two subplots (treated and untreated) following applications of botanical extracts and insecticides (Malik *et al* 2012).

3. Number of sub branches per plant:

After applying insecticides and botanical extracts to randomly selected ten plants from each sub plot, the number of sub branches per plant were counted when the plant has fully developed from the bottom to the top (Razaq *et al*., 2014).

4. Yield (kg ha^{-1}):

The yield was recorded in each of the two subplots (treated and untreated sub plot) after that changed into hectare .where 1ha is equal to 1000m^2 the total yield was calculated using formula (Sarwer *et al* 2013).

$$\text{kg ha} - 1 = \frac{\text{weight (kg)}}{\text{per plot size (m)}} \times 10000$$

Statistical analysis

All of the data was statistically examined using the STATISTIX (8.1) programme. The least significant difference (LSD (0.05) approach is then used to separate the means of all genotypes.

RESULTS

The result of (S1) 1st sowing date (26-October 2020) for population trend of *L erysimi* in selected canola genotypes under field conditions is presented in table-1, where the ANOVA for population trend of *L. erysimi* revealed significant effect ($P<0.05$) as a result of sowing dates and time interval in four different canola genotypes. Population trend of *L. erysimi* shows that it appeared initially during (02-January) and gradually increases with the passage of time; as significantly maximum number of *L. erysimi* was recorded on 8th week (19-Feb) on the tested genotypes. Significantly maximum number of aphids were sustained by genotype Abaseen (224.64 $plant^{-1}$), Dalay (172.2 $plant^{-1}$), Tara (166.37 $plant^{-1}$) and 'KS-45' (27.3 $plant^{-1}$) respectively. The aphid population of *L. erysimi* started declining steadily. Data regarding the collective mean of 12 weeks for the population trend of *L. erysimi* illustrated that significantly lowest mean population density of *L. erysimi* (7.60 $plant^{-1}$) was recorded from KS-75 genotype of canola, while significantly highest mean population density of *L. erysimi* (77.91 $plant^{-1}$) was recorded from Abaseen followed by Dalay (53.63 $plant^{-1}$) and Tara (52.57 $plant^{-1}$); although there was no significant difference observed between canola varieties, Dalay and Tara.

Table.1: Effect of 1st sowing date (26-October 2020) on population trend of *L. erysimi* in designated canola genotypes during 2020-21.

Cultivars	02-Jan	09-Jan	16-Jan	23-Jan	30-Jan	06-Feb	13-Feb	19-Feb	26-Feb	03-Mar	09-Mar	16-Mar	Mean
KS-75	0.00no	0.39n	2.56lm	3.00lm	6.24l	11.7kl	18.66k	27.3 jk	16.36k	5.27 l	0.22n	0.00n	7.60c
Tara	0.62 mn	5.23l	9.88kl	29.5jk	52.37 i	78.49h	114.5f	166.37c	109.3 f	50.67 i	14.0k	2.08lm	52.57b
Abaseen	2.57lm	8.0jkl	16.0k	38.3 j	71.3hi	105.6g	142.6 e	224.64a	156.3d	74.3hi	20.6 k	3.68l	77.91a
Dalay	1.00mn	4.98	10.5kl	30.3jk	51.61 i	80.4 h	112.8 f	172.24b	115.6 f	53.33 i	11.0kl	2.14lm	53.63b
Mean	1.04h	3.53gh	9.67f	25.23e	44.90d	68.69c	97.14b	147.63a	99.39b	45.65d	11.70f	1.97g	

Different letters with Mean indicates significant difference at $P \leq 0.05$

The effect of 2nd (S2) sowing date (06-Nov 2020) on population trend of *L. erysimi* in selected canola genotypes under field conditions shows that *L. erysimi* appeared initially in the mid-week of January and gradually increases with the passage of time; as significantly maximum number of *L. erysimi* was recorded on (25-Feb). Almost similar trend was followed where greater number of aphids were recorded on cultivar Abaseen (187.35 $plant^{-1}$) followed by Dalay (143.59 $plant^{-1}$), Tara (141.36 $plant^{-1}$) and KS-45 (23.5 $plant^{-1}$) respectively, although there was no significant difference observed between the genotypes, Dalay and Tara.

Data regarding overall means of 11 weeks for the population trend of *L. erysimi* illustrate that significantly lowest mean population density of *L. erysimi* (6.79 $plant^{-1}$) was recorded from KS-75 genotype of canola, while significantly highest mean population density of *L. erysimi* (53.28 $plant^{-1}$) was recorded from Abaseen followed by Dalay (42.97 $plant^{-1}$) and Tara (42.54 $plant^{-1}$);

Table. 2: Effect of 2nd sowing date (06-Nov 2020) on population trend of *L. erysimi* in selected canola genotypes during 2020-21.

Cultivars	14-Jan	21-Jan	28-Jan	04-Feb	11-Feb	18-Feb	25-Feb	2-Mar	9-Mar	16-Mar	23-Mar	Mean
KS-75	0.00 pqr	0.13p qr	2.14p	4.24p	7.88o	13.2 n	23.5 m	12.56 n	7.38o	3.28p	0.43pq	6.79c
Tara	0.34 pq	4.15p	8.36o	26.79l	49.68i	81.3 6f	141. 36b	92.9e	47.1j	13.59n	2.16p	42.54 b
Abaseen	2.08 p	8.25o	14.35n	37.91k	64.37h	113. 52d	187. 35a	136.3c	75.36 g	26.39l	3.26p	53.28a
Dalay	0.38 pq	4.65p	9.02o	28.14l	51.0i	80.2 9f	143. 59b	95.00e	50.9i	15.08n	2.58p	42.97 b
Mean	0.70 i	4.295 h	8.46g	24.27e	43.23d	72.0 9b	123. 95a	66.82c	43.34 d	14.58f	2.10h	

Different letters with Mean indicates significant difference at $P \leq 0.05$

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The ANOVA for population trend of *L. erysimi* revealed significant effect ($P<0.05$) as a result of sowing dates and time interval in four different canola genotypes. The effect of (S3)3rd sowing date (16-Nov 2020) on population trend of *L. erysimi* in selected canola genotypes under field conditions showed that *L. erysimi* population significantly varies among four different genotypes and time interval (Weeks) as well as their interaction. The population trend of *L. erysimi* adopted similar pattern and appeared first during the last week of January and gradually increases while reached to its maximum peak during 6th week (27-Feb) and decline onward on the tested canola genotypes. The maximum number of aphid were sustained by variety Abaseen (179.6 $plant^{-1}$) followed by variety Tara (148.7 $plant^{-1}$), Dalay (150.1 $plant^{-1}$) and KS-45 (26.8 $plant^{-1}$).

Furthermore, data regarding the collective mean throughout the infestation period the population trend of *L. erysimi* indicated significantly lowest mean population density of *L. erysimi* (8.79 $plant^{-1}$) was recorded from KS-75 genotype of canola, while significantly highest mean population density of *L. erysimi* (62.40 $plant^{-1}$) was recorded from Abaseen followed by Dalay (44.19 $plant^{-1}$) and Tara (45.97 $plant^{-1}$).

Table 3. Effect of 3rd sowing date (16-Nov 2020) on population trend of *L. erysimi* in selected canola genotypes during 2020-21.

Cultivars	23-Jan	30-Jan	06-Feb	13-Feb	20-Feb	27-Feb	04-Mar	11-Mar	18-Mar	25-Mar	01-Apr	Mean
KS-75	0.78q	3.21 p	8.57l	12.95n	16.58l	26.8k	15.68 mn	8.36 no	3.56p	0.25q	0.00q	8.79c
Tara	2.96p	15.7 mn	27.58j	52.58h	83.1f	148.7b	89.3e	42.25i	11.67n	3.14p	0.61q	45.97 b
Abaseen	4.59p	19.0l	41.67i	85.41f	114.5d	179.6a	133.58c	73.28g	27.65j	5.27p	2.0pq	62.40a
Dalay	3.01p	16.71 m	29.67j	53.27h	84.25f	150.1b	90.25 e	41.8i	12.91n	3.29	0.67q	44.19 b
Mean	2.83h	12.96g	32.97f	51.05d	74.57c	126.3a	82.20 b	41.42e	13.94g	2.98h	0.82i	

Different letters with Mean indicates significant difference at $P \leq 0.05$

Percent population reduction of canola aphids in different canola cultivars by synthetic insecticide and plant extract.

The ANOVA for percent population reduction of canola aphid showed significant effect ($P<0.05$) due to the application of Fipronil, Neem Seed Extract in comparison with control. Table 4.4 shows the data regarding the mean percent reduction in canola aphids and revealed that highest aphid population reduction (67.18%) was recorded from the Fipronil treated plant followed by Neem Seed Extract with 53.05% reduction while significantly lowest aphid population reduction (02.46%) was recorded from control plot.

The interaction effect of treatments with cultivars also show significant effect on percent reduction in population of aphids; as significantly maximum percent reduction in aphid population (74.50%) was recorded from Fipronil treated plants in KS-75 variety followed by the interaction of Neem Seed Extract with KS-75 (60.76%) and Fipronil x Abaseen (59.86%). However, significantly lowest mean percent population reduction was recorded from the interaction of Control with Abaseen (2.41%) and KS-75 (2.46%), respectively.

Table. .4: Mean Percent population reduction of canola aphids on two different canola cultivars by synthetic insecticide and plant extract, during 2020-21.

S. No.	Treatments	Cultivars		Mean % population reduction
		Abaseen	KS-75	
1	Fipronil	59.867 b	74.500 a	67.183 a
2	Neem Seed Extract	45.333 c	60.767 b	53.050 b
3	Control (Water)	2.413 d	2.467 d	2.467 c
Mean		35.889 b	45.911 a	

Different letters with Mean indicates significant difference at $P \leq 0.05$

Agronomic characteristics of canola cultivars relevant to synthetic insecticide and plant extract.

The ANOVA for agronomic characteristics of canola aphid showed significant effect ($P<0.05$) due to the application of Fipronil, Neem Seed Extract in comparison with control and time interval. Table-4 shows the data regarding the sub-branches/plant, pods/plant and yield/plot in canola aphids on two different canola cultivars and revealed that highest sub-branches plant^{-1} (29.36), Pods plant^{-1} (377.58) and yield (105.62 gm) was recorded from the Fipronil treated plant followed by Neem Seed Extract with 26.98 sub-branches plant^{-1}, 316.52 pods plant^{-1}, and 83.69 gm while significantly lowest sub-branches plant^{-1} (16.62), pods plant^{-1} (210.99) and yield plot^{-1} (48.39 gm) was recorded from control.

The interaction effect of treatments with cultivars also show significant effect on sub-branches plant^{-1}, pods plant^{-1} and yield plot^{-1}; as significantly maximum sub-branches plant^{-1} (30.70), pods plant^{-1} (416.00) and yield plot^{-1} (109.85) was recorded from Fipronil treated plants in KS-75 variety followed by the interaction of Neem Seed Extract with KS-75 (28.50 sub-branches plant^{-1}), (338.23 pods plant^{-1}) and (101.77 gm), respectively. However, significantly lowest mean sub-branches plant^{-1} (16.02), pods plant^{-1} (209.20) and yield plot^{-1} (47.56) was recorded from the interaction of Control with canola cultivar 'Abaseen'.

Table. 5: Efficacy of Fipronil and Neem seed karnal on agronomic characteristics of two different canola cultivars, during 2020-21.

S. No.	Treatments	Cultivars		Branches	Cultivars		Pods Plant^{-1}	Cultivars		Yield Plot (gm)
		Abaseen	KS-75		Abaseen	KS-75		Abaseen	KS-75	
1	Fipronil	28.013b	30.707a	29.360a	339.17b	416.00a	377.58 a	101.39 b	109.85a	105.62 a
2	Neem Seed Extract	25.460c	28.500b	26.980b	294.82c	338.23b	316.52 b	65.60 c	101.77b	83.69 b
3	Control	16.223d	17.027d	16.625c	209.20d	212.79d	210.99 c	47.56 e	49.22 d	48.39 c
Mean		23.232b	25.411a		281.06b	322.34a		71.519b	86.950a	

Different letters with Mean indicates significant difference at $P \leq 0.05$

DISCUSSION

This research was undertaken to evaluate the effect of different sowing dates and bio-efficacy of insecticide, Fipronil SC and botanical (Neem seed extract) under field conditions against aphids (*Lipaphis erysimi* (Kalt) on the selected canola genotypes (Tara seed, Dalay, Abaseen and KS-75). The mean number of aphids sustained by the tested canola varieties during different sowing dates showed significant difference within the tested cultivars. Maximum, number of *L. erysimi* were recorded on cultivar Abaseen while minimum, number of *L. erysimi* were sustained by cultivar KS-75. Similar, results were obtained by the application of pesticides (Fipronil and neem seed extract) against *L. erysimi*. The percent population reduction of aphid and agronomic characteristics (no. of branches plant^{-1}, pods plant^{-1} and yield) also showed significant difference among all the tested pesticides (botanicals and chemicals). Maximum number of branches, pods and yield was recorded from genotype, KS-75 treated with Fipronil and significantly minimum number of aphids was recorded from cultivar, KS-75.In contrast, similar results were obtained from tested cultivars Abaseen treated with bio-pesticide (neem seed extract) with maximum number of aphid recorded. The agronomic characteristics, no of branches plant-1, pods plant-1 and yield component. Thus, these finding reveals that canola cultivar, KS-75 showed strong resistant respond against *L. erysimi* among all the tested canola cultivars. Furthermore, the application of conventional pesticide, Fipronil against canola aphid proved significantly better compared to bio-pesticide neem seed extract. Similar view is presented by different researchers, Ali et al., (2019), Verma et al., (2003) Chattopadhyay et al., (2005) and Razaq et al., (2011) are of the view that that late sown cultivars remains tender and fresh for extended period and that's why it supports the aphid population over a longer period as compared to early sown cultivars. Furthermore, Kishor et al., (2019) investigated that some cultivars of canola plants produce certain odors (repellents) which maybe the reason for their resistant against aphids, furthermore, susceptible plants also releases certain odors but it is restricted to close proximity. These plants metabolites can be perceived as insect repellent or host recognizer through olfactory signals; similar results were also obtained by Baldwin, (2010). Results regarding the application of chemical and botanical as well as percent population reduction shows that chemical were far more effective as compared to botanical, alike findings were obtained by Sana et al., (2020) shows that highest population reduction was recorded from bifenthrin (67.26%) and acetameprid (63.21%) while lowest population reduction was recorded from *Moringa oliefera* (32.3%) and *Allium cepa* (44.6%) against aphids in canola crop, respectively. Our observations are in conformity with Arif et al., (2012) stated that aphid population reduction was recorded in 2010 (82-94%) and 2011 (83-93%) post application of pesticides. Similar results were also obtained by Arshad et al., (2016) determined the effectiveness of different pesticides against aphids in various cultivars and recorded 98.7% and 98.26% population reduction. Kafle (2015) also reported that chemicals are persistent for longer periods of times as compared to botanicals, as the effectiveness of botanicals decreases after five days.

Conclusion: The major concern in chemical control is facing multiples issues like environmental issue, the development of insecticidal resistance, resurgence, pest outbreak and suppression of natural enemies. Therefore, uses of alternative eco-friendly bio-pesticides are needed to cope these situations. As plants are rich sources of natural substances and have great potential to be formulated as botanical pesticides that can be utilized in the development of environmentally safe alternative methods for insect control in the place of synthetic insecticides Kumar and Patel (2017). Plants contain secondary metabolites that are deleterious to insect and other herbivores in diverse ways.

Future strategy: Based on practical experience during the aphid peak population period in case of mustard aphid maximum population present in first week of March to middle march, then it is highly recommended to apply control measures on insect most susceptible stage where control of insect pest is easy. Thus strong industry stewardship to ensure residue compliance, drift legislation, improved application technology required to reduce spray drift and increase spray efficacy and the dynamics of mustered aphid movement is vital for pest managers.

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