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Efficacy of newer insecticides against mustard aphid *Lipaphis erysimi* (Kalt.)

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Abstract
A Field study was conducted at research farm, college of agriculture, RVSKVV Gwalior (M.P.) to determine the effectiveness of eight treatments *viz*., Imidacloprid 17.8 SL, Thiamethoxam 25 WG, Acephate 75 SP, Acetamiprid 20 SP, Dimethoate 30 EC, Diafenthiuron 50 WP, Spinosad 45 SC, and Control (water spray) against mustard aphid during *rabi* season 2019-20 & 2020-21. The observations were taken at 1st day before and 3rd, 7th and 14th days after spray of insecticides. The results obtained on the basis average of two years, data indicate significant difference among insecticides Imidacloprid 17.8 SL was the most effective among the seven insecticides showing the minimum numbers of aphid population followed by Thiamethoxam, Dimethoate. Whereas, Spinosad was least effective followed by Diafenthiuron. The highest seed yield of 1038 kg/ha was recorded in Imidacloprid, which was significantly higher than the rest of the treatment followed by Thiamethoxam and Dimethoate. Whereas, the lowest seed yield of 397 kg/ha was recorded in the untreated plot, which was found significantly less than recorded in the rest of the treatments, followed by Spinosad. The highest cost-benefit ratio with highest net return was obtained from Imidacloprid (1:18.56). Whereas, lowest cost-benefit ratio was obtained from Spinosad (1:2.06). So these newer insecticides could be used in mustard ecosystem to control mustard aphid.

Keywords: Efficacy**,** newer insecticides, mustard aphid, infestation

Introduction
Rapeseed-mustard is the third most important oilseed crop in the world. It contributes about 28.6% in the total oilseed production in India, whereas it is the second most important edible oilseed after groundnut sharing 27.8% in India's oilseed economy. In India, rapeseed-mustard occupy 5.99 million ha area with production and productivity of 6.31 million tones and 1053 kg/ha respectively (Kumar *et al.*, 2018) [7]. The US and China were the leading importing countries of mustard oil in the world. India was the 7th largest importing country in 2018-19. (Anonymous, 2018) [2]. Indian mustard *Brassica juncea* (L.) is primarily cultivated in Rajasthan, Haryana, MP, UP, and West Bengal (Anonymous, 2021) [1]. Mustard aphids may cause 66% to 99% loss in *B. campestris L*. and 27-28% in *B. juncea* L with a 15% reduction in oil content (Pradhan *et al*., 2019) [11]. Imidacloprid is mostly effective against sap-sucking insects and has low natural enemy toxicity and a long residual phase (Barbera, 1989) [3]. A number of chemical insecticides have been found effective against pests in different parts of the country (Singh *et al.*, 2014) [14]. Chemical insecticides are not only toxic to natural enemies of aphids such as *Coccinellid* (Nagar *et al*., 2012) [9], but these are also responsible for environmental pollution, health hazards to human beings, toxic to pollinators, pest resurgence, development of resistance in insect pests and residues in oil and cake (Singh, 2001) [15].

Method and Materials
A field experiment was laid out in randomized block design (RBD) to study the efficacy of some insecticides against mustard aphid, *Lipaphis erysimi* (Kalt). on mustard crop during *Rabi* season, 2019-20 & 2020-21at Crop Research at College of agriculture, RVSKVV Gwalior (M.P.) with seven treatments *viz*., Imidacloprid 17.8 SL, Thiamethoxam 25 WG, Acephate 75 SP, Acetamiprid 20 SP, Dimethoate 30 EC, Diafenthiuron 50 WP, and Spinosad 45 SC, and control, and replicated three times. The crop variety Kranti was sown on 6th December with plot size of 4m x 3m and distance between row to row and plant to plant was 30cm and 10cm, respectively. The recommended agronomic practices were followed. Foliar spray of different treatments was made in 500 lit of water/ha.

The population of mustard aphid was recorded from 10 cm top portion of the terminal shoot on 5 randomly selected plants from each plot one day prior and 3, 7 and 14 days after insecticide application. The yield in each treatment was recorded and expressed in kg/ha.

Statistical analysis

The data were subjected to the analysis of variance using simple randomized block design (RBD) programme.

Results

The populations of *Lipaphis erysimi* on mustard in various treatments were recorded one day before spray and 3rd, 7th and 14th days after insecticide application during the crop season 2019-20 & 2020-21. The results obtained on the basis of the average of replicated wise 2019-20 data (Table 3) recorded significant differences among different treatments with regards to aphid population. Minimum mean population of aphid (18.07 aphids/twig) was recorded in plots treated with Imidacloprid which was found significantly less than the population recorded in rest of the treatments, but at par with Thiamethoxam, Dimethoate, Acephate, and Acetamiprid. Whereas, the maximum mean aphid population (82.88 aphids/twig) was recorded in the untreated plot, which was found significantly higher than the population in rest of the treatments. In 2020-21 data recorded minimum mean population of aphid (15.81 aphids/twig) was recorded in plots treated with Imidacloprid which was found significantly less than population recorded in rest of the treatments, but at par with Thiamethoxam. Whereas, the maximum mean aphid population (79.13 aphids/twig) was recorded in the untreated plot, which was found significantly higher than the population in rest of the treatments. And on the basis of average two year data minimum mean aphid population (16.94 aphids/twig) was recorded in treated plots with Imidacloprid which was found significantly less than the population in rest of the treatments, but at par with Thiamethoxam. Whereas, the maximum mean aphid population (81.01 aphids/twig) was recorded in the untreated plot, which was found significantly higher than the population in rest of the treatments. Data recorded on seed yield per hectare showed a significant effect of different treatments on mustard yield during the year 2019-20 (Table 4). The highest yield was recorded in Imidacloprid 1043 kg/ha, which was significantly higher than the rest of the treatments followed by Thiamethoxam, and Dimethoate. Whereas, the lowest yield of 405 kg/ha was recorded in the untreated plot, followed by Spinosad. In 2020-21 the highest yield was recorded in Imidacloprid 1032 kg/ha, which was significantly higher than the rest of the treatments followed by Thiamethoxam, and Dimethoate. Whereas, the lowest yield of 389 kg/ha was recorded in the untreated plot, which was significantly less than recorded in the rest of the treatments, followed by Spinosad. On the basis of the average of two years, data indicate significant differences among different treatments of mustard the highest yield of 1038 kg/ha was recorded in Imidacloprid, which was significantly higher than the rest of the treatments followed by Thiamethoxam and Dimethoate. The lowest yield of 397 kg/ha was recorded in the untreated plot, followed by Spinosad. All the treatments were found economical and received 684 to 1038 kg/ha yield over control (Table 5). Treatment of Imidacloprid gave maximum net return (Rs. 42,452/ha) followed by Thiamethoxam (Rs. 37,922/ha) and Dimethoate (Rs. 34,742/ha) treated plots. Spinosad gave a minimum net return (Rs. 10,352/ha). The incremental cost-benefit ratio ranged from 1:2.06 to 1:18.56. The highest cost-benefit ratio with the highest return was obtained from Imidacloprid (1:18.56) followed by Thiamethoxam (1:15.94), Acetamipride (1:14.82). Whereas, the lowest cost-benefit ratio with low return was obtained from Spinosad (1:2.06) treated plot.

Table 1: Efficacy of newer insecticides against mustard aphid under field conditions during the *Rabi* 2019-20

Tr. No.	Treatments	Dose/ha	Number of aphids/10 cm apical twig/plant									
			1 DBS	First spray			Second spray			Third spray		
				3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Imidacloprid 17.8 SL	100 ml/ha	56.47 (7.55)*	15.47 (4.00)	27.67 (5.31)	44.67 (6.72)	14.73 (3.90)	21.67 (4.71)	29.33 (5.46)	5.53 (2.46)	2.67 (1.78)	0.93 (1.20)
T_2	Thiamethoxam 25 WG	100 gm/ha	53.73 (7.36)	17.33 (4.22)	31.33 (5.64)	46.27 (6.84)	17.40 (4.23)	23.73 (4.92)	35.53 (6.00)	7.47 (2.82)	3.93 (2.11)	1.93 (1.56)
T_3	Acephate 75 SP	350 gm/ha	49.47 (7.07)	20.07 (4.54)	34.67 (5.93)	48.67 (7.01)	19.27 (4.45)	29.47 (5.47)	37.67 (6.18)	9.67 (3.19)	5.87 (2.52)	3.27 (1.94)
T_4	Acetamiprid 20 SP	120 gm/ha	48.67 (7.01)	21.33 (4.67)	35.67 (6.01)	49.33 (7.06)	20.27 (4.56)	30.67 (5.58)	38.07 (6.21)	10.40 (3.30)	6.40 (2.63)	3.87 (2.09)
T_5	Dimethoate 30 EC	500 ml/ha	52.53 (7.28)	17.67 (4.26)	32.33 (5.73)	46.67 (6.87)	18.87 (4.40)	28.73 (5.41)	36.40 (6.07)	8.73 (3.04)	4.87 (2.32)	2.33 (1.68)
T_6	Diafenthiuron 50 WP	200 gm/ha	47.87 (6.95)	21.67 (4.71)	35.87 (6.03)	49.93 (7.10)	21.07 (4.64)	31.27 (5.64)	38.47 (6.24)	12.93 (3.67)	7.93 (2.90)	4.67 (2.27)
T_7	Spinosad 45 SC	100 ml/ha	44.13 (6.68)	22.47 (4.79)	35.73 (6.02)	50.27 (7.13)	21.33 (4.67)	32.27 (5.72)	39.73 (6.34)	14.33 (3.85)	8.73 (3.04)	5.47 (2.44)
T_8	Control (Water spray)	-	49.87 (7.10)	64.53 (8.06)	73.33 (8.59	95.73 (9.81)	108.53 (10.44)	119.33 (10.95)	125.87 (11.24)	83.33 (9.16)	52.60 (7.29)	22.67 (4.81)
S.E(m)±			0.44	0.38	0.50	0.34	0.20	0.24	0.30	0.12	0.12	0.16
C.D. at 5%			NS	1.15	1.51	1.02	0.61	0.72	0.91	0.35	0.36	0.48

*Figures in parentheses indicated $\sqrt{x + 0.5}$ transformed value, DBS- Day before spray, DAS- Days after spray

Table 2: Efficacy of newer insecticides against mustard aphid under field conditions during the *Rabi* 2020-21

Tr. No.	Treatments		Number of aphids/10 cm apical twig/plant									
			1 DBS	First spray			Second spray			Third spray		
		Dose/ha.		3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T_1	Imidacloprid 17.8 SL.	100 ml/ha	54.27 (7.40)*	14.53 (3.88)	24.53 (5.00)	35.53 (6.00)	12.87 (3.66)	17.87 (4.29)	28.27 (5.36)	5.47 (2.44)	2.53 (1.74)	0.73 (1.11)
T_2	Thiamethoxam 25 WG	100 gm/ha	51.93 (7.24)	16.27 (4.10)	27.27 (5.27)	37.80 (6.19)	14.53 (3.88)	21.80 (4.72)	32.13 (5.71)	7.07 (2.75)	3.47 (1.99)	1.73 (1.49)
T_3	Acephate 75 SP	350 gm/ha	47.47 (6.93)	20.93 (4.63)	31.27 (5.64)	42.73 (6.57)	17.33 (4.22)	26.07 (5.15)	34.47 (5.91)	8.93 (3.07)	5.67 (2.48)	2.87 (1.84)
T_4	Acetamiprid 20 SP	120 gm/ha	46.67 (6.87)	20.73 (4.61)	31.93 (5.69)	45.80 (6.80)	18.40 (4.35)	27.47 (5.29)	36.07 (6.05)	9.73 (3.20)	6.33 (2.61)	3.73 (2.06)
T_5	Dimethoate 30 EC	500 ml/ha	48.13 (6.97)	17.07 (4.19)	29.53 (5.48)	38.87 (6.27)	16.67 (4.14)	25.27 (5.08)	33.13 (5.80)	7.53 (2.83)	4.47 (2.23)	2.07 (1.60)
T_6	Diafenthiuron 50 WP.	200 gm/ha	47.73 (6.94)	21.53 (4.69)	32.40 (5.74)	44.67 (6.72)	18.60 (4.37)	28.33 (5.37)	35.47 (6.00)	12.73 (3.64)	7.33 (2.80)	4.33 (2.20)
T_7	Spinosad 45 SC	100 ml/ha	40.40 (6.40)	22.47 (4.79)	33.73 (5.85)	45.80 (6.80)	19.47 (4.47)	29.80 (5.50)	36.93 (6.12)	13.47 (3.74)	8.67 (3.03)	5.27 (2.40)
T_8	Control (Water spray)	-	47.13 (6.90)	60.07 (7.78)	70.53 (8.43)	91.13 (9.57)	101.73 (10.11)	110.47 (10.53)	123.20 (11.12)	82.27 (9.10)	52.07 (7.25)	20.73 (4.61)
S.E(m)±			0.45	0.30	0.43	0.25	0.20	0.16	0.33	0.16	0.13	0.15
C.D at 5%			NS	0.90	1.30	0.74	0.60	0.47	0.99	0.49	0.40	0.44

*Figures in parentheses indicated $\sqrt{x + 0.5}$ transformed value, DBS- Day before spray, DAS- Days after spray

Table 3: Mean aphid population in different newer insecticides under field conditions during 2019-20 and 2020-21

Tr. No.	Treatments		Number of aphids/10 cm apical twig/plant		
		Dose/ha	2019-20	2020-21	Pooled mean
T_1	Imidacloprid 17.8 SL.	100 ml/ha	18.07 (4.31)*	15.81 (4.04)	16.94 (4.18)
T_2	Thiamethoxam 25 WG	100 gm/ha	20.55 (4.59)	18.01 (4.30)	19.28 (4.45)
T_3	Acephate 75 SP	350 gm/ha	23.18 (4.87)	21.13 (4.65)	22.16 (4.76)
T_4	Acetamiprid 20 SP	120 gm/ha	24.00 (4.95)	22.24 (4.77)	23.12 (4.86)
T_5	Dimethoate 30 EC	500 ml/ha	21.84 (4.73)	19.68 (4.49)	20.65 (4.60)
T_6	Diafenthiuron 50 WP	200 gm/ha	24.87 (5.04)	22.82 (4.83)	23.84 (4.93)
T_7	Spinosad 45 SC	100 ml/ha	25.59 (5.11)	23.96 (4.95)	24.77 (5.03)
T_8	Control (Water spray)	-	82.88 (9.13)	79.13 (8.92)	81.01 (9.03)
S.E(m)±:			0.24	0.13	0.13
C.D at 5%			0.71	0.39	0.39

*Figures in parentheses indicated $\sqrt{x + 0.5}$ transformed value

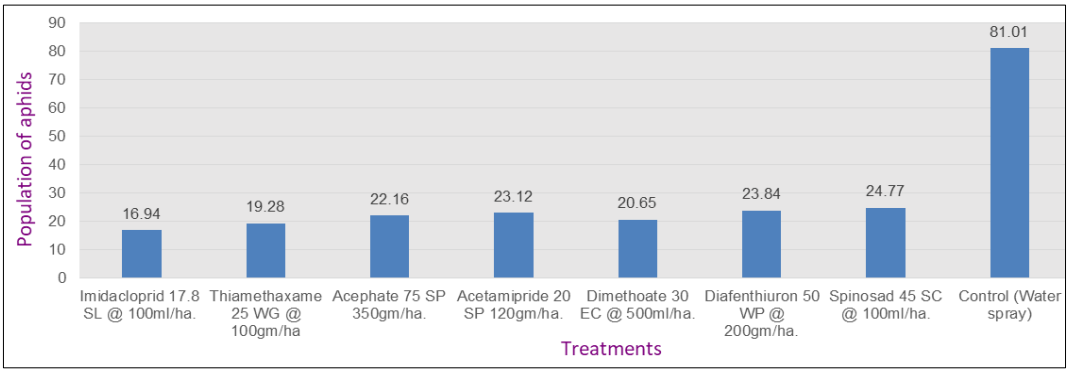

Fig 1: Population of mustard aphids in different treatments

Table 4: Seed yield (kg/ha.) in different newer insecticides

Tr. No.	Treatments	Dose/ha	2019-20	2020-21	Pooled Mean
T_1	Imidacloprid 17.8 SL.	100 ml/ha	1043	1032	1038
T_2	Thiamethoxam 25 WG	100 gm/ha	978	972	975
T_3	Acephate 75 SP	350 gm/ha	927	923	925
T_4	Acetamiprid 20 SP	120 gm/ha	907	902	904
T_5	Dimethoate 30 EC	500 ml/ha	938	934	936
T_6	Diafenthiuron 50 WP	200 gm/ha	806	781	794
T_7	Spinosad 45 SC	100 ml/ha	685	682	684
T_8	Control (Water spray)	-	405	389	397
S.E(m)±			2.69	3.51	2.21
C.D at 5%			8.15	10.68	6.41

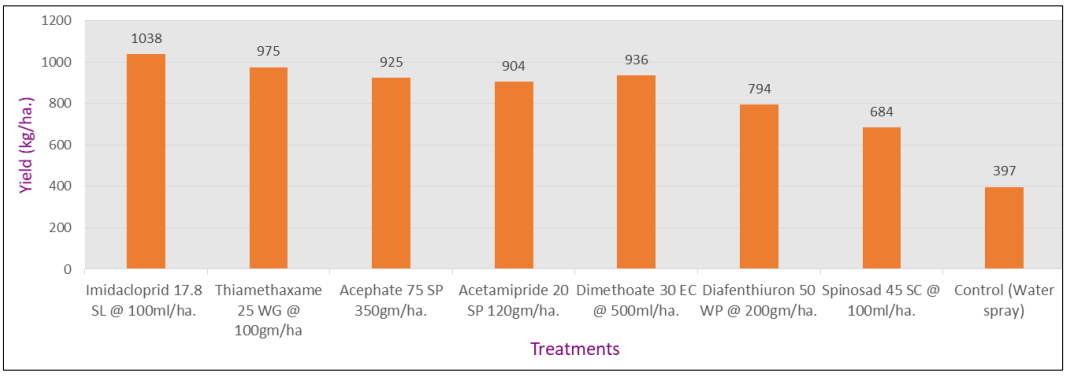

Fig 2: Seed yield of mustard

Table 5: Seed yield and economics of different newer insecticides

Treatments	Dose/ha	Seed yield (Kg/ha.)	Yield increase over control (Kg/ha.)	Additional profit (Rs/ha.)*	Cost of plant protection for three sprays (Rs/ha.)			Net profit Rs/ha.	*ICBR
					Cost of insecticides	Labour charge	Total cost		
		a	b	C=b*70/-	(d)	(e)	F= d+e	g= c-f	h=c/f
Imidacloprid 17.8 SL	100 ml/ha	1038	641	44870	480	1938	2418	42452	18.56
Thiamethoxam 25 WG	100 gm/ha	975	578	40460	600	1938	2538	37922	15.94
Acephate 75 SP.	350 gm/ha	925	528	36960	2400	1938	4338	32622	8.52
Acetamiprid 20 SP	120 gm/ha	904	507	35490	456	1938	2394	33096	14.82
Dimethoate 30 EC	500 ml/ha	936	539	37730	1050	1938	2988	34742	12.63
Diafenthiuron 50 WP	200 gm/ha	794	397	27790	1920	1938	3858	23932	7.20
Spinosad 45 SC	100 ml/ha	684	287	20090	7800	1938	9738	10352	2.06
Control (water spray)	-	397	-	-	-	-	-	-	-

* Rate of mustard =70/Kg, *Imidacloprid cost Rs. 160 per 100 ml.
* Labour cost for spraying (2 Labour per ha @ Rs. 323/-) = Rs. 646/-
* ICBR (Incremental cost benefit ratio)

Discussion

Observations recorded on aphid population showed that all the treatments are effective significantly over control in reducing the aphid population during both the years. The aphid population on treated plots during 2019-20 ranged from 18.07 to 25.59 as against 82.88 aphids/10 cm twig in untreated plots and during 2020-21 it ranged from 15.81 to 23.96 as against 79.13 aphids/10 cm twig in untreated plot. On the basis of average of two years, all the treatments were effective significantly over control with regards to aphid population. Minimum aphid population (16.94 aphids/10 cm twig) recorded in imidacloprid showed their higher efficacy against aphid, which was found significantly less than the population in rest of the treatments. These results are in close agreement with findings reported by khan *et al.*, (2012) [5], Khedkar *et al.*, (2012) [6] Chandra *et al.*, (2014) [4], Sen *et al.*, (2017) [12], and Sharma *et al.*, (2020) [13]. According to them, Imidacloprid proved the most effective treatment against mustard aphids. Imidacloprid gave higher grain yield (1038 kg/ha) and higher net return (42,452 Rs/ha.), Spinosad proved least effective against aphid and registered minimum seed yield (684kg/ha) and net return (10,352 Rs/ha). Similar findings also reported by Mandal *et al.*, (2012) [8], Patel *et al.* (2017) [10], Sen *et al* (2017) [12], and Sharma *et al.*, (2020) [13]. Who also reported highest yield under Imidacloprid treatment. Highest cost benefit ratio with highest return was obtained from (1:18.56) with Imidacloprid followed by Thiamethoxam (1:15.94) and Acetamiprid (1:14.82). Poor incremental cost benefit ratio was obtained from Spinosad (1:2.06) followed by Diafenthiuron (1:7.20). Similarly, findings reported by Mandal *et al.*, (2012) [8], Sen *et al.*, (2017) [12] and Sharma *et al.* (2020) [13]. Who also reported highest cost benefit ratio under Imidacloprid treatment.

Conclusion

Imidacloprid (17.8SL) proved most effective against aphid followed by Thiamethoxam (25WG), and Acephate 75SP. Whereas, Spinosad proved least effective against aphid. Imidacloprid gave higher seed yield (1038kg/ha) and higher net return (42,452 Rs/ha.). Whereas Spinosad was registered poor seed yield (684kg/ha) and net return (10,352 Rs/ha). Highest cost benefit ratio with was obtained from (1:18.56) with Imidacloprid followed by Thiamethoxam (1:15.94) and Acetamiprid (1:14.82). Whereas, Poor incremental cost benefit ratio was obtained from Spinosad (1:2.06) followed by Diafenthiuron (1:7.20). Newer insecticides were found most effective reducing the population of mustard aphids, *Lipaphis erysimi* (Kalt.).

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