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Field Bioefficacy of Thiamethoxam 25WG Over *Lipaphis erysimi* (Kalt.) in Mustard Eco-System in Open Field Conditions

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ABSTRACT

Mustard aphid, *Lipaphis erysimi* Kaltenbach is a key pest of rapeseed-mustard and form the basis of crop loss from December to March. Field assessment was done to evaluate the bioefficacy of various doses of thiamethoxam over *L. erysimi* in mustard agroecosystem. Thiamethoxam 25%WG @ 25g a.i per ha was highly efficient against aphid with high grain yield, cost-effective. The results of former dose was on par with 37.5 g a.i per ha and 50 g a.i per ha after first and second spray with an interval of 10 days under open field environment with > 80% of decline in aphid populations. This was further followed by standard check dimethoate 30 % EC @ 200 g a.i per ha which was on par with thiamethoxam 25%WG@ 12.5 and 16.67 g a.i per ha. The control plot was least efficient and showed huge number of the mustard aphids. To manage the aphid population that reaches ETL, two applications with thiamethoxam 25 WG @ 25 g a.i. per ha at 10 days interval will be quite effective and provide good return.

Keywords Thiamethoxam, Bioefficacy, Mustard, Aphids.

INTRODUCTION

Oil seed crops play an imperative function in Indian agricultural-based economy. *Brassica* oilseed crops, often known as rapeseed-mustard are farmed as the *rabi* crop, comprise one of the oilseed crops farmed in India and therefore are a part of the Cruciferae group (Singh *et al*. 2018). Inspite of a diversity of agro-climatic circumstances, along with irrigated/ rainfed, timely/ late planted, saline soils and composite farming, rapeseed-mustard is grown across India, from the north-eastern/north-western hills to the down south (Pradhan *et al*. 2020). In India, it is grown on 6.7 million hectares of land, with yields of 11.75 million tonnes and 1524 kg per ha, respectively. It is farmed in Bihar on an expanse of 0.08 million hectares, generating 0.10 million tonnes and obtaining yield of 1271 kg per hectare, respectively (Anonymous 2022).

From seedling to harvests, almost 50 insect species in India pose a serious menace to mustard (Sharma and Singh 2010). In all mustard-growing countries, the predominant pest is the mustard aphid *L. erysimi*, which might diminish oil content by 5

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to 6% (Shylesha *et al*. 2006) and potentially trigger economic output losses amounting to 96% (Patel *et al*. 2019). The aphid's nymphs and adults suck cell sap from that of the plant's leaves, stems, twigs, buds, inflorescences, and immature pods, which has a highly deleterious effect on pod setting and production. Nevertheless, aphids secretes honeydew which further causes sooty mould growth, which turns the foliage and pods appearance filthy black and eventually hampers photosynthetic activity (Awasthi 2002). Infestations of aphids peaked from the end of December to the first week in March, according to Patel *et al*. (2019). The *L. erysimi* is acknowledged as a nationwide pest attributable to its economic importance (Rao *et al*. 2014, Dotasara *et al*. 2022). According to Bakhetia and Sekhon (1989), yield losses caused by aphid infestation ranged from 11.6 to 39.0%. Verma (2000) documented a yield loss of 96%, Chauhan and Chauhan (2005) found a loss of 14.0 to 27.9% and Kular and Kumar (2011) stated a loss of 6.5 to 26.4%, Mukherjee and Singh (2017) estimated the yield losses > 30%. However, Sharma *et al*. (2019) study concludes that for all *Brassica* spp. the mean oil content on late sowing was considerably lower in unprotected plots i.e. 38.1 to 38.6% than in protected plots of 40.59 to 41.48%.

Insecticides from a more recent generation have lower toxicity toward non-target species, stronger efficacy against the pests they are intended to control, and are not as tenacious as earlier insecticides. The efficacy of thiamethoxam combating mustard aphids is asserted by its broad-spectrum, systemic nature was supported by the results of Dhillon *et al*. (2022), Sharma *et al*. (2020), Lal *et al*.(2018), Maurya *et al*. (2018), Shankarganesh *et al*. (2015) and Kumar *et al*. (2013). Chemical management is the most effective strategy since the mustard aphid multiplies and spreads quickly in a short amount of time under favorable climatic circumstances. In light of this, the current interpretation was employed to analyze thiamethoxam's field bioefficacy over mustard aphid.

MATERIALS AND METHODS

Field experiment

Open field experiments were conducted at RPCAU, Pusa, Bihar, India in a Randomized Block Design (RBD) with seven treatments replicated thrice having each treatment area of 27m^2. Mustard, Rajendra Sufalam variety was raised during *rabi*, 2021 according to the recommended agronomic practices. Sowing of the crop was done in first week of December. Seven treatments including control viz., T_1) Thiamethoxam 25% WG @ 12.50 g a.i. per ha, T_2) Thiamethoxam 25% WG @ 16.67 g a.i. per ha, T_3) Thiamethoxam 25% WG @ 25 g a.i. per ha, T_4) Thiamethoxam 25% WG @ 37.50 g a.i. per ha, T_5) Thiamethoxam 25% WG @ 50 g a.i. per ha, T_6) Dimethoate 30 % EC @ 200 g a.i. per ha (Check), T_7) Control (Water spray) were used against mustard aphid in mustard ecosystem. Two sprays were given. First application was given when the pest population reached economic threshold level (ETL) and the second application will be made 10 days after the first application using manually operated knapsack sprayer.

For identifying the sightings of the mustard aphids, five plants were selected randomly and tagged. The population of nymphs and adults of aphids were counted from top 10 centimeters central twig of those plants that were preselected. The sightings were identified one day of the first spray (pre count) as well as after 1, 3, 7 and 10 days following every spray. After threshing and sorting the mustard seeds out of each plot, the yields were determined. Per plot's yield was weighted independently, converted to kilograms per hectare and only then analyzed statistically.

In order to combat mustard aphids, the incremental cost-benefit ratio (ICBR) of several treatments was computed. Based on the current market pricing, the overall prices of the chemicals used per hectare for every treatment were ascertained. The yield obtained in the untreated control was deducted out from yield generated in every insecticidal application to compute the net increase (yield) over control. Moreover, based on the improved yield (kg/ha) compared with untreated, additional profit was derived for every treatment. The expense of the insecticide treated was eliminated from the additional profit to just get the net profit (Rs/ha) on every treatment. Net profit was divided by the price of treatment to figure the ICBR, reflecting net gain in rupees for every rupee invested on insecticide treatment.

Fig. 1. Mustard aphid, L. *erysimi* infestation on mustard before spraying.

Statistical analysis: The data on mustard aphid population in different treatments were subjected to Analysis of Variance following Randomized Block Design using the statistical software OPSTAT (Sheoran *et al*. 1998). The level of significance was set at 5%.

RESULTS AND DISCUSSION

The infestation by the mustard aphid before spray is displayed in Fig. 1 and it is clearly evident that the aphid population was above the economic threshold level of 20-30 aphids/ plant. Hence, the spraying was done to protect the crop and ensure good yields with after spray aphid infestation displayed in Fig. 2. The mustard aphid incidences before and after two sprays of insecticidal treatments in 2020-21 are illustrated in Tables 1 - 2. The nymphs and adults aphid population prior to spraying was 150.30 -170.33 per top 10 cm shoot. Thiamethoxam 25WG at 50 g a.i. per ha reduced the aphid population significantly and gave lowest mean aphid population after 1st spray (26.76 aphids/ top 10 cm shoot) which also was significantly at par with the doses 37.5 and 25 g a.i. per ha (32.31 and 39.07 aphids/ top 10 cm shoot). The other insecticide, dimethoate 30 EC at 200 g a.i. per ha and thiamethoxam 25WG at 12.5 and 16.67 g a.i. per ha employed were less effective with mean aphid population of 46.41, 58.94 and 69.07 aphids/ top 10 cm shoot. The untreated control had 179.80 mean number of nymphs and adults of aphid population per top 10 centimeter of shoot. The mean per cent reduction of aphids population over control after first spray was observed to be in the range of 61.59 – 85.12%.

The results after 2nd spray was in line with the results observed in the first spray i.e. thiamethoxam 25WG at 50 g a.i. per ha showed lowest mean aphid population after 2nd spray (0.73 aphids/ top 10 cm shoot) followed by statistically similar results in doses 37.5 and 25 g a.i. per ha (1.19 and 3.12 aphids/ top 10 cm shoot). Comparatively higher aphid populations were observed in dimethoate 30 EC at 200 g a.i. per ha (11.96), thiamethoxam 25WG at 12.5 (14.58) and 16.67 (20.76) g a.i. per ha. Amongst all the treatments, it was observed that untreated plot showed highest mean aphid populations i.e. 239.08 aphids/ top 10 cm shoot. After 2nd spray, mean per cent reduction of aphids over control ranged from 91.32 – 99.69%.

Fig. 2. After spraying.

Table 1. Efficacy of insecticides against aphids in mustard ecosystem after 1st spray, *rabi* 2020-21. DAS- Days After Spray, Figures in parenthesis are square root transformed values.

Tr. No	Chemical name	Dose (g a.i/ ha)	No. of nymphs and adults of aphids/ top 10 cm shoot 1st spray						
			Pre count	1 DAS	3 DAS	7 DAS	10 DAS	Mean	Mean percent reduction over control
T_1	Thiamethoxam 25% WG	12.50	161.73^{a} (12.76)	132.00^{e} (11.53)	67.85^{e} (8.30)	35.00^{e} (6.00)	41.41^{c} (6.36)	69.07^{d} (8.37)	61.59
T_2	Thiamethoxam 25% WG	16.67	155.67^{a} (12.52)	120.53^{de} (11.02)	52.20^{d} (7.29)	27.33^{d} (5.32)	35.67^{bc} (5.72)	58.94^{d} (7.74)	67.22
T_3	Thiamethoxam 25% WG	25.00	170.33^{a} (13.09)	98.24^{bc} (9.96)	29.38^{bc} (5.51)	12.60^{b} (3.69)	16.08^{a} (4.42)	39.07^{bc} (6.33)	78.27
T_4	Thiamethoxam 25% WG	37.50	160.40^{a} (12.70)	86.90^{ab} (9.38)	24.54^{ab} (5.05)	7.60^{ab} (2.93)	10.19^{a} (3.09)	32.31^{ab} (5.77)	82.03
T_5	Thiamethoxam 25% WG	50.00	159.67^{a} (12.68)	74.93^{a} (8.71)	18.60^{a} (4.43)	5.73^{a} (2.59)	7.79^{a} (2.91)	26.76^{a} (5.27)	85.12
T_6	Dimethoate 30 % EC	200.00	169.93^{a} (13.07)	105.20^{cd} (10.31)	35.13^{c} (6.01)	19.00^{c} (4.47)	26.30^{b} (5.22)	46.41^{c} (6.89)	74.19
T_7	Control (Water spray)	--	153.40^{a} (12.43)	158.81^{f} (12.64)	166.80^{f} (12.95)	185.33^{f} (13.65)	208.27^{d} (14.47)	179.80^{e} (13.45)	--
	SEm(±)		6.22	5.62	3.00	1.94	3.09	3.55	--
	CD (0.05)		N/A	17.50	9.35	6.05	9.62	11.05	--
	CV%		6.67	8.77	9.22	8.04	10.82	9.51	--

The findings of Kumar *et al*. (2022) were comparable to the current observation, which suggested that thiamethoxam 25 WG @ 100 g per ha gave 94.9% reduction and effective in treatment of aphids and thiamethoxam 25WG @ 50 g per ha resulted in 71.3% reduction. Din *et al*. (2022) work also supported and they too recorded lowest no. of aphids in plots treated with thiamethoxam 25 WG @ 100 g per ha in both mustard cultivars i.e. China (8.49) and Swabi (19.72). The current outcomes are supported by Kumar (2021)

Table 2. Efficacy of insecticides against aphids in mustard ecosystem after 2nd spray, *rabi* 2020-21. DAS- Days After spray, Figures in parenthesis are square root transformed values.

Tr. No.	Chemical name	Dose (g a.i/ ha)	No. of nymphs and adults of aphids/ top 10 cm shoot 1st spray					
			1 DAS	3 DAS	7 DAS	10 DAS	Mean	Mean percent reduction over control
T_1	Thiamethoxam 25% WG	12.50	28.37^{d} (5.42)	24.18^{c} (4.49)	19.53^{c} (3.30)	10.96^{c} (2.80)	20.76^{c} (4.66)	91.32
T_2	Thiamethoxam 25% WG	16.67	24.59^{d} (5.06)	17.26^{b} (4.03)	10.08^{b} (2.94)	6.41^{bc} (2.36)	14.58^{c} (3.95)	93.90
T_3	Thiamethoxam 25% WG	25.00	9.65^{b} (3.26)	2.25^{a} (1.80)	0.59^{a} (1.28)	0.00^{a} (1.00)	3.12^{ab} (2.03)	98.69
T_4	Thiamethoxam 25% WG	37.50	3.74^{a} (2.18)	0.91^{a} (1.38)	0.10^{a} (1.05)	0.00^{a} (1.00)	1.19^{a} (1.48)	99.50
T_5	Thiamethoxam 25% WG	50.00	2.71^{a} (1.93)	0.20^{a} (1.10)	0.00^{a} (1.00)	0.00^{a} (1.00)	0.73^{a} (1.32)	99.69
T_6	Dimethoate 30 % EC	200.00	19.54^{c} (4.53)	13.49^{b} (3.44)	9.78^{b} (2.42)	5.05^{ab} (1.75)	11.96^{bc} (3.60)	95.00
T_7	Control (Water spray)	--	212.00^{e} (14.59)	235.60^{d} (15.38)	249.90^{d} (15.84)	258.83^{d} (16.04)	239.08^{d} (15.49)	--
	SEm(±)		1.55	2.03	2.47	1.71	3.10	--
	CD (0.05)		4.84	6.31	7.71	5.33	9.66	--
	CV%		6.23	8.35	10.34	7.38	12.90	--

Table 3. Economics of insecticides used in mustard ecosystem against aphids, *rabi* 2020-21.

Tr. No.	Insecticides (%)	Doses (g a.i./ ha)	Wt in Kg/ ha	Net gain over control (kg/ha)	% increase over control	Additional profit (Rs/ha)	Total cost of protection (Rs/ha)	Net profit (Rs/ha)	ICBR
T_1	Thiamethoxam 25 WG	12.50	1125.93	150.22	15.40	9613.78	2497.50	7116.28	1:2.849
T_2	Thiamethoxam 25 WG	16.67	1184.57	208.86	21.41	13366.87	2530.03	10836.84	1:4.283
T_3	Thiamethoxam 25 WG	25.00	1348.77	373.05	38.23	23875.51	2595.00	21280.51	1:8.201
T_4	Thiamethoxam 25 WG	37.50	1396.85	421.14	43.16	26953.04	2692.50	24260.54	1:9.010
T_5	Thiamethoxam 25 WG	50.00	1413.27	437.56	44.85	28003.90	2790.00	25213.90	1:9.037
T_6	Dimethoate 30 EC	200.00	1244.38	268.67	27.54	17195.02	3013.00	14182.02	1:4.707
T_7	Control (Water spray)	--	975.71	--	--	--	--	--	--

Market price of mustard seeds: Rs 64 / kg,
Labor charges: For spraying Rs 400/ labor/ day,
Three labors per hectare required for each spray, Two sprays were given (500 liter spray solution required for one spray for one hectare).

who stated that thiamethoxam 25WG @ 0.2g/ liter water (4.8 aphids/ 10cm central twig) and dimethoate 30 EC @ 1ml/ liter of water (23.6 aphids/ 10 cm central twig) were effective in controlling *L. erysimi*. Additionally, the outcomes of this investigation are in line with Raju and Tayde (2022) who on spraying thiamethoxam 25% WG @ 0.25 g/ liter recorded 33.63 aphids over control (171.96). The conclusions drawn by Sharma *et al*. (2020), Patel *et al*. (2020), Vishal and kumar (2019), Dwivedi and Singh (2019), Maurya *et al*. (2018), Lal *et al*. (2018), Vishvendra *et al*. (2018), Kumar *et al*. (2018), Patel *et al*. (2017), Kumar *et al*. (2017), Singh *et al*. (2017), Sen *et al*. (2017) aligned with current outcomes which says that thiamethoxam 25 WG was most effective in controlling of mustard aphids as well as they have reported the efficacy of dimethoate over aphids.

The maximum yield was there from plots treated with thiamethoxam (50 g a.i per ha), it was statistical significance equivalent to doses of 37.5 g a.i per ha (1413.27 kg per ha) and 25 g a.i per ha (1348.77 kg per ha). The untreated control recorded lowest yield of 975.71 kg per ha (Table 3). Despite the fact that has proven that the greatest dose of thiamethoxam 25 WG at 50 g a.i per ha, was the best treatment for enhancing commercial output, the statistically equivalent dose of 25 g a.i per ha would represent the optimal dose while considering economic as well as prudent usage. Consequently, it may be ascertained, thiamethoxam 25 WG at 25 g a.i. per ha for limiting the mustard aphid.

Kumar (2021) reported highest seed yield of mustard with thiamethoxam 25 WG @ 0.2 g per liter (1925 kg per ha). This is in line with Kumar *et al*. (2022) who obtained good yields on treatment with thiamethoxam 25 WG @100 g per ha and 50 g per ha. The present results were supported by Sharma *et al*. (2020) who applied thiamethoxam 25 WG (25 g a.i per ha) obtained seed yield of 1370 kg per ha.

The economics computed on different treatments evidenced in Table. 3 revealed that the net profit (Rs 25213.90) was obtained in thiamethoxam 25 WG @ 50 g a.i. per ha, followed by thiamethoxam 25 WG @ 37.5 g a.i. per ha and then thiamethoxam 25 WG @ 25 g a.i. per ha. The next in order of economics was dimethoate 30 EC @ 200 g a.i. per ha, followed by thiamethoxam 25 WG @ 16.67 g a.i. per ha and 12.5 g a.i. per ha. This was supported by the findings of Patel *et al*. (2020).

CONCLUSION

Following a brief detailed evaluation of the current outcomes, it is certain that various insecticidal treatments vastly reduced the aphid population particularly compared with the non-treated control plots. The lowest aphid population was encountered in plots treated by thiamethoxam 25 WG @ 50 g a.i. per ha, however it was statistically equivalent to 37.5 g a.i. per ha and 25 g a.i. per ha, with maximum seed yields. But, keeping in view of the economic and judicious usage of the insecticides thiamethoxam 25 WG @ 25 g a.i. per ha could be employed in obtaining good seed yields as well as reducing of aphid populations. As an alternative farmers can also use dimethoate 30 EC for controlling aphids.

REFERENCES

Anonymous (2022) https:/www.indiastat.com. Ministry of Agriculture and Farmers Welfare, Govt. of India.

Awasthi VB (2002) Introduction to General and Applied Entomology, Scientific Publisher, Jodhpur (India), pp 266-271.

Bakhetia DRC, Sekhon BS (1989) Insect-pests and their management in rapeseed-mustard. *J Oilseeds Res* 6: 269-299.

Chauhan S, Chauhan SVS (2005) Quantity and quality of oil in Indian mustard (*Brassica juncea* L.) (Czern and Coss) grown under various kinds of stress. *Brassica* 7(1): 59-62.

Dhillon MK, Singh N, Yadav DK (2022) Preventable yield losses and management of mustard aphid, *Lipaphis erysimi* (Kaltenbach) in different cultivars of (*Brassica juncea* (L.) Czern and Coss. *Crop Prot* 161: 106070. https://doi.org/10.1016/j.cropro.2022.106070.

Din M, Khan SA, Shah SH, Ullah N (2022) Efficacy of different pesticides against mustard aphid, *Lipaphis erysimi* in mustard cultivars. *Pak J Agric Res* 35(2): 371-379. https://dx.doi.org/10.17582/journal.pjar/2022/35.2.371.379.

Dotasara SK, Kumawat KC, Dinesh Swami (2022) Assessment of crop loss due to insect pests in Indian mustard in Semi-arid region of Rajasthan. *Pharma Innov J* SP-11(4): 1581-1583.

Dwivedi SA, Singh RS (2019) Evaluation of new molecular insecticides and biopesticides against mustard aphid, *Lipaphis erysimi* (Kalt.) on yield parameter in mustard. *J Biopesticides* 12(2): 203-214.

Kular JS, Kumar S (2011) Quantification of avoidable yield losses in oilseed *Brassica* caused by insect pests. *J Pl Prot Res* 51(1): 38-43.

Kumar A, Srivastava A, Rawal R, Roy N (2018) Chemical evaluation against mustard in Bundelkhand region. *J Entomol Zool Stud* 6(2): 3195-3197.

Kumar H, Singh S, Yadav A (2022) Bio-efficacy of insecticides against mustard aphid (*Lipaphis erysimi*) in Indian mustard (*Brassica juncea* L.) *J Oilseeds Brassica* 13(2): 158-162.

Kumar K, Sachan SK, Singh DV (2013) Bio-efficacy of some new insecticides against mustard aphid, *Lipaphis erysimi* (Kalt.) and their effect on coccinellid population in rapeseed mustard. *Vegetos-Int J Pl Res* 26(2): 159. https://doi.org/10.5958/j.2229-4473.26.2.069

Kumar S (2021) Evaluation of insecticides for their field efficacy against turnip aphid, *Lipaphis erysimi* (Kaltenbach) on Indian mustard. *J Oilseeds Brassica* 12(2): 113-116.

Kumar SR, Singh V, Yadav SK, Yadav AK (2017) Efficacy of insecticides and botanicals against *Lipaphis erysimi* (Kalt.) on mustard. *Ind J Entomol* 79(4): 503-506.

Lal B, Nayak MK, Tomar DS, Thakur SR (2018) Efficacy of newer insecticides against mustard aphid, *Lipaphis erysimi* (Kalt.) in Indian mustard under Bundelkhand agro climatic zone of Madhya Pradesh. *J Entomol Zool Stud* 6(6): 400-403.

Maurya NK, Singh R, Singh J, Nigam R, Hasan W, Kumar A (2018) Efficacy of novel insecticides against mustard aphid *Lipaphis erysimi* (Kaltenbach). *Int J Agric Invention* 3(1): 62 – 70.

Mukherjee U, Singh PP (2017) Assessment of yield losses in rapeseed mustard due to mustard aphid (*Lipaphis erysimi* Kalt.) in Bihar. *Trends in Biosci* 10(41): 8655-8659.

Patel S, Singh CP, Hasan W (2020) Relative efficacy of certain insecticides against mustard aphid in mustard ecosystem. *Int J Agric Appl Sci* 1(1): 46-48.

Patel S, Singh CP, Yadav SK (2019) Monitoring of insect-pest complex on rapeseed-mustard at Pantnagar. *J Entomol Res* 43(1): 73-76. 10.5958/0974-4576.2019.00014.8.

Patel S, Yadav SK, Singh CP (2017) Bio-efficacy of insecticides against *Lipaphis erysimi* (Kalt.) in mustard ecosystem. *J Entomol Zool Stud* 5(2): 1247-1250.

Pradhan PP, Borkakati RN, Saikia DK (2020) Insect pests of mustard and their natural enemies in Assam. *Int J Curr Microbiol Appl Sci* 9(7): 2785-2790.

Raju CEP, Tayde AR (2022) Field evaluation of selected insecticides and botanical against mustard aphid, *Lipaphis erysimi* (Kalt.) on mustard, *Brassica juncea* L. *Int J Pl Soil Sci* 34 (22): 1188-1193.

Rao BB, Rao VUM, Nair L, Prasad YG, Ramraj AP, Chattopadhyay C (2014) Mustard aphid infestation in India development of fore warning models. *J Environ Biol* 35: 683-688.

Sen K, Samanta A, Hansda A, Dhar PP, Samanta A(2017) Bio-efficacy and economics of some insecticides against mustard aphid, *Lipaphis erysimi* (Kalt.) infesting mustard. *J Crop Weed* 13(2): 235-237.

Shankarganesh K, Suroshe SS, Paul B (2015) Relative susceptibility of the Bikaner and Delhi populations of mustard aphid, *Lipaphis erysimi* (Kalt.) (Homoptera: Aphididae) and its predator, *Coccinella septempunctata* L. (Coleoptera: Coccinellidae), to different insecticides. *Phytoprotection* 95(1): 1-47.

Sharma D, Yadav SP, Yadav S (2019) Assessment of avoidable yield losses due to *Lipaphis erysimi* Kalt. in various *Brassica* spp. *Int J Curr Microbiol Appl Sci* 8(6): 2020-2025.

Sharma N, Upadhyaya SN, Singh UC, Dubey M, Ahmad A (2020) Bio efficacy of insecticides against mustard aphid. *J Pharmacognosy Phytochemistry* SP6: 187-192

Sharma P, Singh YP (2010) Directorate of Rapeseed-mustard, Indian Council of Agriculture Research, Sewar, 321303, Bharatpur (Rajasthan). *Annual National Language J* 1: 47-51.

Sheoran OP, Tonk DS. Kaushik LS, Hasija RC, Pannu RS (1998)

Statistical software package for agricultural research workers. In: Hooda DS and Hasija RC (eds). Recent advances in information theory, statistics and computer applications, Department of Mathematics and Statistics, CCS HAU, Hisar, pp 139-143.

Shylesha AN, Azad Thakur NS, Pathak KA, Rao KR, Saikia K, Surose S, Kodandaram NH, Kalaishekar A (2006) Integrated management of insect pest of crops in north eastern hill region. Technical Bulletin No. 19. ICAR RC for NEH Region, Umiam, pp 50.

Singh H, Deshwal HL, Haldhar SM, Singh V (2017) Bio-efficacy of some insecticides and botanicals against mustard aphid, *Lipaphis erysimi* Kalt. (Hemiptera: Aphididae) on Indian mustard. *J Experim Zool Ind* 20(1): 249-253.

Singh VV, Agarwal N, Satish BN, Kumar S, Sachin K, Pal K (2018) Studies on insect diversity in mustard (*Brassica campestris* L.) ecosystem. *J Entomol Zool Stud* 6(5): 698-702.

Verma KD (2000) Economically important aphids and their management. In: IPM System in Agriculture (eds: Upadhyay RK, Mukherji KG, Dubey OP). Aditya Books Pvt Ltd New Delhi 7: 144–162.

Vishal SH, Kumar A (2019) Efficacy and economics of some newer insecticides against mustard aphid, *Lipaphis erysimi* (Kalt). *J Pharmacog Phytochem* 8(3): 785-788.

Vishvendra, Kumar S, Sachan SK, Singh G, Singh R (2018) Bio-efficacy of insecticides and biorational against *Lipaphis erysimi* (Kalt.) in mustard crop. *J Pharmacog Phytochem* SP5: 58-61.