Bio-efficacy of chemical insecticides against major insect pests of mustard apllied through seed treatment

ABSTRACT

Seed treatment application of chemical insecticides is getting popularity in the management of insect-pest population. The present investigation was conducted to study the bio-efficacy of different chemical insecticides, widely used against major insect-pest of mustard crop. A mustard variety Bio-902 was sown in twenty-seven plots of 2× 2 m^2 at the agronomy farm of Sri Karan Narendra College of Agriculture, Jobner, during the *Rabi* season of 2020-21. A total of nine treatments including an untreated control group with three replications were investigated in a randomized block design (RBD). The data was recorded for aphid population and seed yield in each treatment. The treatments including imidacloprid 40% + fipronil 40% (10 g/kg seed) was found significantly effective followed by imidacloprid (10 g/kg seed), clothianidin (10 g/kg seed), thiamethoxam (10 g/kg seed), imidacloprid 40% + fipronil 40% (5 g/kg seed), imidacloprid (5 g/kg seed), clothianidin (5 g/kg seed) and thiamethoxam (5 g/kg seed). The ranking of treatments based on seed yield in mustard was found to be similar to the trend observed in the aphid population for different treatments. Seed treatment helps protect the seed and emerging plant from insects until they become more resilient. Method of seed treatment and doses of pesticides to be used in seed treatment are deciding factor for bio efficacy of pesticides.

Keywords: [Musatrd, Insect, Pest, Bioefficacy, Insecticides, Seed, Treatment, Yield]

1. INTRODUCTION

Mustard, *Brassica juncea* (Linn.) Czern and Coss belongs to family Brassicaceae, is an important *Rabi* season oilseed crop. After groundnut, mustard is considered second most significant oil seed crop in India, accounting for around 25 per cent of all oilseed production. Different minerals like calcium, phosporous, and magnesium are found abundantly in mustard seed. The oil content in its seed ranges from 32-40 percent. Furthermore, it has a sufficient amount of linolenic and linoleic, two necessary fatty acids. Due to its high nutritional content, mustard plays a substantial role in Indian cooking as well as the pharmaceutical and cosmetic industries. Moreover, the mustard oil is also used to lubricate, soften leather, and manufacture soap and detergent. Because of its low antinutritional factors, mustard cake appears to be a potential source of protein in place of groundnut and soybean cakes in fish and poultry rations. Since it is a high source of carbohydrates therefore it is widely used to feed cattle as well. In terms of nutrients, the mustard cake has 5.2% nitrogen, 1.8% phosphorus and 1.2% potassium. Therefore, it is considered a good source of improving soil fertility and restoring salt-damaged soils. In India, this is cultivated over 62.30 lakh hectares of land annually with a production and productivity of 93.39 million tonnes and 1500 kg ha^{-1} respectively. In India, Rajasthan ranks first with 25.00 lakh hectares area under cultivation and 41.96 million tonnes annual production followed by Uttar Pradesh and many other states (1).

Insects such as mustard aphid (*Lipaphis erysimi* (Kalt.), painted bug (*Bagrada cruciferarum* Kirk.), leaf miner (*Phytomyza horticola* Meign), mustard sawfly (*Athalia lugens proxima* Klug.), diamond back moth (*Plutella xylostella* Linn.), flea beetle (*Phyllotreta cruciferae* Geoze) and cabbage leaf webber (*Crocidolomia binotalis* Zeller) are major pest of the mustard imposing severe threat to its production. Amongest all, the mustard aphid alone can cause significant losses ranging from 66.0 to 99.0 percent in *B. campestris* and 27.0 to 28.0 per cent in *B. juncea*, with a 15.0 per cent decline in oil content (2–5). Mustard aphid is classified as a major pest based on monetary losses it causes (6). Plant sap from sensitive parts is sucked by both active stages of aphid *i.e.,* adult and nymph. Infested plant may curl, and if the infestation progresses far enough, plants may even wither and die. Plants affected by their infestation show wilting, yellowing, and stunting (7). The plants covered in honeydew secreted by this insect boost sooty mould colonisation on plant, which has a negative impact on photosynthesis and the crop's yield (8). The mustard aphid proliferates and spreads rapidly in favourable weather, forcing farmers to apply insecticides.

In direction to either prevent or avoid infestation of *L. erysimi* and to ensure qualitative crop production, it is indispensable to timely control the pest population below economic threshold level with appropriate control measures. The conventional method of insect management by insecticidal spray is a good way to avoid insect pest damage to crops. But it requires blanket application of pesticides in greater quantity which in turn increase pesticides associated problems in proportionate to dose of pesticides being used to manage pest. Major problems associated with such pesticide usage includes environmental pollution, enlarged cost of production, food poisoning and pest resurgence which does not support sustainable agricultural production. Therefore, it becomes inevitable to device new insect pest management techniques, as conventional methods of insect management are neither economical nor ecological suitable for pest management. The worldwide research supports this idea and recommend to adopt alternatives of these high dosed insecticides. Insecticidal seed treatment at sowing for insect pest management is a good alternative to minimise pesticidal usage for crop production. Seed treatment possess several advantages over full dose application of insecticides as very minute amount of insecticides is used in seed treatments and protect the crop against many harmful insect for some considerable period. Thus, pest management through seed treatment is a good way to manage pest in an economic and ecological way. Keeping these facts in consideration following experiment entitled “Bio-efficacy of chemical insecticides against major insect pests of mustard applied through seed treatment” was carried out.

2. MATERIAL AND METHODS

Experiment location and field preparation

The present investigation was conducted at the agronomy farm of Sri Karan Narendra College of Agriculture, Jobner, on mustard crop during the *Rabi* season of 2020-21. It lies approximately 78°28' east of longitude, 26°26' north of latitude, and 427 meters above mean sea level (MSL) in Jaipur, Rajasthan. The location belongs to agro-climatic zone III A, which refers to Rajasthan's semi-arid eastern plain, which is characterized by sandy loam soil.

The experimental plots were ploughed twice using tractor drawn plough followed by thoroughly ploughing, planking and levelling to bring the field to a good tilth and preserve soil moisture for crop. One third dosage of nitrogenous fertilizer (60 kg N ha^{-1}) was applied through urea whereas, complete dosage of phosphatic fertilizer (60 kg P_2O_5 ha^{-1}) and potassic fertilizer (40 kg K_2O ha^{-1}) were added during land preparation for sowing and remaining (2/3) quantity of the nitrogenous fertilizer was top-dressed in two applications at 20 and 40 days after sowing, respectively. In addition to this, a well decomposed farmyard manure with a rate of 10 tonnes/ ha was also incorporated into soil before the sowing of mustard crop.

Experimental material and layout

The experimental material comprised of a total of nine treatments (8 treatments + 1 control group) (Table 1) and a mustard variety, Bio-902 was planted in a randomized block design (RBD) on October 30, 2022 in twenty-seven plots, measuring dimensions of 2×2 square meters each, with a spacing of 30 X 10 cm. The seeds were treated with the required dosage of insecticides before sowing and further followed by a two-hour drying period, and then were sown on the same day as the treatment.

Table 1 Details of treatments used in the study

S. No.	Treatments	Formulations	Doses (per kg seed)
1.	Imidacloprid	600 FS	5 g
2.	Imidacloprid	600 FS	10 g
3.	Clothianidin	50 WDG	5 g
4.	Clothianidin	50 WDG	10 g
5.	Thiamethoxam	70 WS	5 g
6.	Thiamethoxam	70 WS	10 g
7.	Imidacloprid 40% + Fipronil 40% w/w	80 WG	5 g
8.	Imidacloprid 40% +Fipronil 40% w/w	80 WG	10 g
9.	Untreated control	-	-

Recording of observations

The data about the incidence of insect pests was started to record from ten days of sowing to the harvesting of the crop at weekly intervals. The population of mustard aphids was recorded during the early morning hours. However, the populations of other insects were not found significant and thus, were not recorded. Five plants were randomly selected and tagged from each individual plot. The aphid population on these plants was visually observed and recorded from 10 cm terminal shoot of each plant using a magnifying lens.

Statistical analysis

Two parameters *i.e.,* avoidable loss and the increase in grain yield as compared to the control treatment were calculated for each treatment using the following formulas-

$$\text{Avoidable loss (percent)} = \frac{\text{Highest yield in treated plot} - \text{Yield in the treated plot}}{\text{Highest yield in treated plot}} \times 100$$

$$\text{Increase in grain yield (percent)} = \frac{\text{Yield in treated plot} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

The accuracy of these formulas in determining losses or yield improvements may be compromised as some level of damage is inevitable even in the most effective treatment. Nevertheless, this formula is widely regarded as the most practical approach for calculating the percentage of yield loss attributed to insect pests in any given treatment (9).

3. RESULTS AND DISCUSSION

The bio-efficacy of chemical insecticides (Table 1) applied through seed treatment was determined against key insect of mustard crop *i.e.,* aphid during *Rabi,* 2020-21. Before sowing, seed was subjected to treatment with desired dose of insecticides. Bio-efficacy of insecticide was determined on the basis of aphid population and seed yield from respective insecticidal treatments.

The mean data indicated that population of aphid was commenced during last week of December *i.e.,* 52nd SMW which ranged from 5.60 to 17.53 aphids per 10 cm terminal shoot. All the insecticide, irrespective of their doses, evidenced significantly higher efficacy in respect to aphid population which was lesser in treated plots as compared to control. The minimum population of aphid (5.60 aphids per 10 cm terminal shoot) was found in the treatment of higher doses of imidacloprid 40% + fipronil 40% (10 g) being the most effective, followed by imidacloprid (10 g) (6.66 aphids per 10 cm terminal shoot) and both were at par in their efficacy. Afterwards, treatments including clothianidin (10 g) and thiamethoxam (10 g) were found effective and comparable in terms of their performance which resulted in aphid population of 7.53 and 7.80 aphids per10 cm terminal shoot, respectively. The treatment involving imidacloprid (10 g) was also recorded statistically comparable results to those of clothianidin (10 g) and thiamethoxam (10 g). The treatments half doses of imidacloprid 40% + fipronil 40% (5 g), imidacloprid (5 g), clothianidin (5 g) and thiamethoxam (5 g) proved moderately effective having aphid population of 10.73, 11.46, 11.93 and 12.13 aphids per 10 cm terminal shoot, respectively.

Aphid population increased regularly and attained a peak in all the treatments in the 2nd week of February *i.e.,* 6th SMW. The data clearly demonstrated that all the insecticidal treatments administered through seed treatments exhibited significant superiority compared to the untreated control. The least aphid population (128.33 aphids/ 10 cm terminal shoot) was registered in the plots treated with higher doses of imidacloprid 40% + fipronil 40% (10 g) which proved to be the most effective treatment followed by imidacloprid (10 g) and clothianidin (10 g) registering, 133.86 and 135.93 aphids/ 10 cm terminal shoot, respectively. All of these were at par with each other in their effectiveness in controlling aphid. The next effective treatment was thiamethoxam (10 g) with 141.13 aphids/ 10 cm terminal shoot and differed non-significantly with imidacloprid (10 g) and clothianidin (10 g).

The treatments half doses of imidacloprid 40% + fipronil 40% (5 g) and imidacloprid (5 g) proved moderately effective having aphid population of 151.03 and 153.00 aphids per 10 cm terminal shoot, respectively and both were at par. While, the treatments clothianidin (5 g/ kg seed) and thiamethoxam (5 g) were proved least effective having aphid population of 170.33 and 171.90 aphids per 10 cm terminal shoot, correspondingly and both remained statistically at par with each other in effectiveness.

The average aphid populations recorded in all treatments further confirmed that all the treatments were significantly more effective as compared to the untreated control. The least aphid infestation (61.80 aphids per 10 cm terminal shoot) was recorded in the treatments showing higher doses of imidacloprid 40% + fipronil 40% (10 g) being the most effective followed by imidacloprid (10 g/ kg seed) which resulted in 65.19 aphids per 10 cm terminal shoot and were statistically comparable. The subsequent effective treatments were clothianidin (10 g) and thiamethoxam (10 g) exhibited 68.35 and 71.11 aphids per 10 cm terminal shoot, respectively however, both treatments were differed non significantly. Moreover, the treatments clothianidin (10 g) as well as thiamethoxam (10 g) were also differed non significantly with imidacloprid (10 g/kg seed). The half doses of imidacloprid 40% + fipronil 40% (5 g) and imidacloprid (5 g/ kg seed) proved moderately effective having aphid population of 80.77 and 84.35 aphids per 10 cm terminal shoot, respectively and both treatments were found statistically comparable to each other. Although, treatments of clothianidin (5 g) and thiamethoxam (5 g) proved least effective having aphid population of 88.90 and 90.06 aphids per 10 cm terminal shoot, respectively. However, both of the treatments differed non-significantly in their efficacy.

In the order of effectiveness for reducing aphid population in mustard crop, the treatments were ranked as: imidacloprid 40% + fipronil 40% (10 g) > imidacloprid (10 g) > clothianidin (10 g) > thiamethoxam (10 g) > imidacloprid 40% + fipronil 40% (5 g) > imidacloprid (5 g) > clothianidin (5 g) > thiamethoxam (5 g).

The results were in concordance with findings of Mane & Mohite, (2014) who reported imidacloprid 40 per cent + fipronil 40 per cent as the most effective insecticide when applied through soil drenching. The current findings also align with previous research of Ghidiu et al., (2012); Ghosal et al., (2013); Liu et al., (2011) who showed that the imidacloprid was one of the most effective insecticides in suppression of aphid population. Tandi, (2012) found the seeds treatment with imidacloprid @ 7 g/ kg seed as a very promising results along with only 8.83 per cent infested plants. Sushil et al., (2015) also reported the superiority of imidacloprid seed treatment in minimizing aphid infestation effectively. The results stand in corroboration with Patil et al., (2009); R.K. et al., (2001) who reported that imidacloprid effectively managed the aphid population when applied against insect either as seed dresser or as spray. Shobharani et al., (2017) reported that the higher doses of imidacloprid 60 were superior in protecting the crop from the early season sucking pests. The present finding is partially supported by the finding of Jayarao et al., (2016) who found both imidacloprid and thiamethoxam as most effective insecticides against leafhopper on okra.

The next effective treatments were clothianidin 50 WDG (135.93 & 68.35 aphids per 10 cm terminal shoot) and thiamethoxam 70 WS (141.13 & 71.11 aphids/10 cm terminal shoot). Similar results were reported by Ding et al., (2018) who found following insecticides *i.e.,* thiamethoxam (1.0 and 2.0 g a.i./kg of seeds), clothianidin (1.0 and 2.0 g a.i./kg of seeds), and imidacloprid (2.0 g a.i./kg of seeds) very effective in controlling corn thrips throughout the crop season.

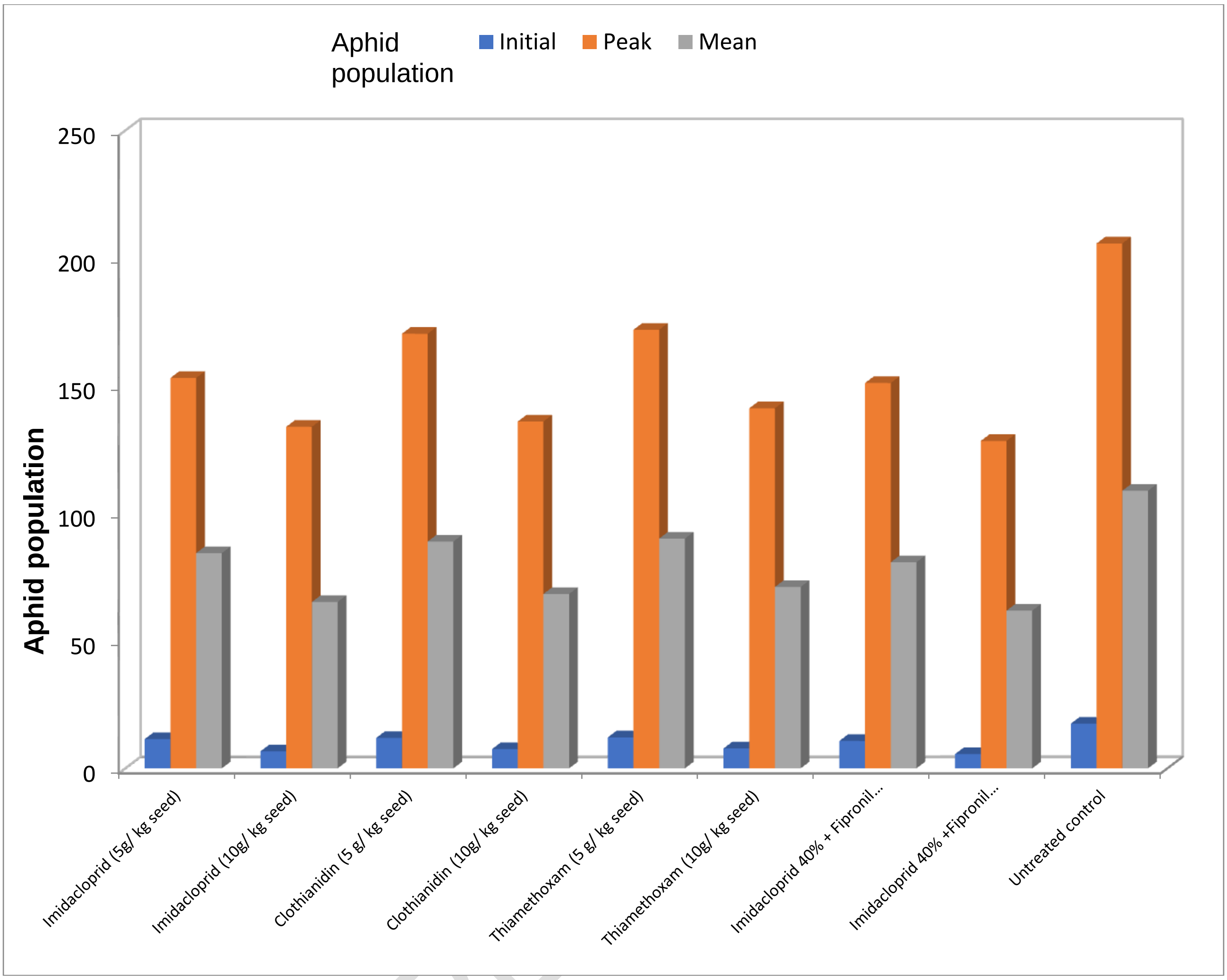

Fig. 1 Bio-efficacy of chemical insecticides against mustard aphid, *Lipaphis erysimi* Kalt. applied through seed treatments

Table 2 Bio-efficacy of chemical insecticides against mustard aphid, *Lipaphis erysimi* Kalt. applied through seed treatment

S.No.	Treatments	Dose	Population of aphid / 10 cm terminal shoot at weekly interval										Mean
			29.12.20	05.01.21	12.01.21	19.01.21	26.01.21	02.02.21	09.02.21*	16.02.21	23.02.21	02.03.21	
1.	Imidacloprid 600 FS	5 g/kg	11.46 (3.46)	50.60 (7.15)	99.93 (10.02)	133.60 (11.58)	137.53 (11.75)	160.03 (12.67)	153.00 (12.39)	72.46 (8.54)	23.93 (4.94)	0.93 (1.20)	84.35 (8.21)
2.	Imidacloprid 600 FS	10 g/kg	6.66 (2.68)	32.20 (5.72)	77.46 (8.83)	109.73 (10.50)	108.50 (10.44)	115.73 (10.78)	133.86 (11.59)	53.93 (7.38)	13.20 (3.70)	0.60 (1.05)	65.19 (8.10)
3.	Clothianidin 50 WDG	5 g/kg	11.93 (3.53)	52.06 (7.25)	101.53 (10.10)	135.46 (11.66)	150.53 (12.29)	158.73 (12.62)	170.33 (13.07)	80.33 (8.99)	26.93 (5.24)	1.13 (1.28)	88.90 (9.45)
4.	Clothianidin 50 WDG	10 g/kg	7.53 (2.83)	42.26 (6.54)	81.06 (9.03)	112.26 (10.62)	111.86 (10.60)	121.60 (11.05)	135.93 (11.68)	55.13 (7.46)	15.10 (15.10)	0.73 (1.11)	68.35 (8.30)
5.	Thiamethoxam 70 WS	5 g/kg	12.13 (3.55)	54.13 (7.39)	103.53 (10.20)	136.40 (11.70)	152.03 (12.35)	160.30 (12.68)	171.90 (13.13)	81.60 (9.06)	27.30 (5.27)	1.26 (1.33)	90.06 (9.52)
6.	Thiamethoxam 70 WS	10 g/kg	7.80 (2.88)	44.13 (6.68)	84.53 (9.22)	114.20 (10.71)	113.53 (10.68)	127.20 (11.30)	141.13 (11.90)	60.33 (7.80)	17.40 (4.23)	0.86 (1.17)	71.11 (8.46)
7.	Imidacloprid 40% + Fipronil 40% w/w	5 g/kg	10.73 (3.35)	48.80 (7.02)	96.73 (9.86)	131.30 (11.48)	135.46 (11.66)	140.40 (11.87)	151.03 (12.31)	70.20 (8.41)	22.13 (4.76)	0.93 (1.20)	80.77 (9.02)
8.	Imidacloprid 40% +Fipronil 40% w/w	10 g/kg	5.60 (2.47)	29.53 (5.48)	74.00 (8.63)	105.20 (10.28)	103.53 (10.20)	110.60 (10.54)	128.33 (11.35)	50.06 (7.11)	10.66 (3.34)	0.53 (1.01)	61.80 (7.89)
9.	Untreated control	-	17.53 (4.25)	66.13 (8.16)	122.26 (11.08)	160.30 (12.68)	180.66 (13.46)	189.93 (13.80)	205.73 (14.36)	102.33 (10.14)	41.60 (6.49)	1.46 (1.40)	108.79 (10.45)
	SEm±		0.07	0.08	0.07	0.08	0.08	0.10	0.11	0.12	0.10	0.02	0.08
	CD (p=0.05)		0.22	0.25	0.21	0.23	0.25	0.30	0.34	0.37	0.29	0.06	0.23
	CV (%)		6.12	5.87	6.69	5.99	6.92	8.12	7.88	6.89	8.10	7.35	8.47

Effect of insecticidal seed treatments on the seed yield of mustard

Mustard seed yield in different insecticidal treatments applied through seed treatment was found significantly higher over the control (untreated). The highest seed yield (13.65 q ha^{-1}) was registered in the plot treated by higher doses of imidacloprid 40% + fipronil 40% (10 g) followed by imidacloprid (10 g), clothianidin (10 g) and thiamethoxam (10 g) which resulted in seed yield of 12.80, 11.46 and 11.23 q ha^{-1}, respectively. However, the minimum seed yield (7.20 q ha^{-1}) was recorded in untreated control (Table 3).

The treatments of imidacloprid 40% + fipronil 40% (5 g), imidacloprid (5 g), clothianidin (5 g) and thiamethoxam (5 g) gave seed yield of 10.20, 9.87, 9.10 and 8.82 q ha^{-1}, respectively. On the basis of seed yield of mustard, the effectiveness trend of treatments was recorded as: imidacloprid 40% + fipronil 40% (10 g) > imidacloprid (10 g) > clothianidin (10 g) > thiamethoxam (10 g) > imidacloprid 40% + fipronil 40% (5 g) > imidacloprid (5 g) > clothianidin (5 g) > thiamethoxam (5 g).

Increase in seed yield

The highest increase in yield over control was found in plots having treatments of higher doses of imidacloprid 40% + fipronil 40% (10 g/kg seed) and imidacloprid (10 g/kg seed) *i.e.,* 6.45 and 5.60 q ha^{-1} over control, respectively. Treatment, imidacloprid 40% + fipronil 40% (10 g/kg seed) remained statistically comparable to the treatments of imidacloprid (10 g/kg seed) which registered increase in yield *i.e.,* 6.45 and 5.60 q ha^{-1} over control. While, the treatment of clothianidin (10 g/kg seed) remained statistically comparable to thiamethoxam (10 g/kg seed) which registered increase in yield of 4.26 and 4.03 q ha^{-1} over control. This trend was followed by the treatments of half doses of imidacloprid 40% + fipronil 40% (5 g/kg seed) and imidacloprid (5 g/kg seed) which registered increase in yield of 3.00 and 2.67 q ha^{-1} over control and imidacloprid 40% + fipronil 40% (5 g/kg seed) was at par with the treatments of imidacloprid (5 g/kg seed). The minimum increase in yield over control was recorded in the plots treated with half doses of clothianidin (5 g/kg seed) and thiamethoxam (5 g/kg seed) *i.e.,* 1.90 and 1.62 q ha^{-1} over control and were at par with each other and were significant over control. The treatment of imidacloprid (5 g/kg seed) remained statistically comparable to the treatments of clothianidin (5 g/kg seed). All the insecticidal treatments applied through seed treatment were statistically superior over control.

The plots treated with imidacloprid 40% + fipronil 40% (10 g/kg seed) and imidacloprid (10 g/kg seed) exhibited the highest percentage increase in the seed yield compared to the untreated control, with values of 89.58% and 77.78%, respectively. This trend was followed by clothianidin (10 g/kg seed) and thiamethoxam (10 g/kg seed) *i.e.,* 59.17 and 55.97% respectively. The least increased yield over control was registered in the plots that were treated with clothianidin (5 g/ kg seed) and thiamethoxam (5 g/ kg seed) *i.e.,* 26.39 and 22.50% respectively.

Table 3 Effect of insecticidal seed treatments on seed yield of mustard

S. No.	Treatments	Dosage (g/kg seed)	Yield (q/ha)	Increased yield over control (q/ha)	Per cent increase in yield over control
1.	Imidacloprid 600 FS	5.0 g/ kg	9.87	2.67	37.08
2.	Imidacloprid 600 FS	10.0 g/ kg	12.80	5.60	77.78
3.	Clothianidin 50 WDG	5.0 g/ kg	9.10	1.90	26.39
4.	Clothianidin 50 WDG	10.0 g/ kg	11.46	4.26	59.17
5.	Thiamethoxam 25 WS	5.0 g/ kg	8.82	1.62	22.50
6.	Thiamethoxam 25 WS	10.0 g/ kg	11.23	4.03	55.97
7.	Imidacloprid 40% + fipronil 40% w/w	5.0 g/ kg	10.20	3.00	41.67
8.	Imidacloprid 40% + fipronil 40% w/w	10.0 g/ kg	13.65	6.45	89.58
9.	Untreated control	-	7.20	-	-
	SE(m)±		0.35	-	-
	CD (P=0.05)		1.04	-	-

CV (%)	8.52

4. CONCLUSION

Seed treatment application of chemical insecticides is effective in managing pest population as well as reducing the pesticides associated hazards as it requires very little amount of pesticides and its application is very easy. The insecticide then coats the seed surface and is taken up by the seed, providing protection against insects once the seed germinates and the plant begins to grow. Seed treatment helps protect the seed and emerging plant from insects until they become more resilient. Method of seed treatment and doses of pesticides to be used in seed treatment are deciding factor for bio efficacy of pesticides.

CONSENT (WHERE EVER APPLICABLE)

"All authors declare that consent was obtained from the institution for publication of this research paper and accompanying images.

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