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Bio efficacy of insecticides against mustard APHID

Neha Sharma, SN Upadhyaya, UC Singh, Megha Dubey and Anjum Ahmad

Abstract
The present investigations were conducted at the experimental site of entomological research farm, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh during 2011-12 and 2012-13. Bio-efficacy of nine insecticides namely, acephate, acetamiprid, oxy-demeton methyl, dimethoate, Imidacloprid, carbosulphan, flonicamid, thiamethoxam and fipronil were studied against mustard aphid, Lipaphis erysimi (Kalt.) and their effect on its natural enemies, Coccinella septempunctata under field condition. Mean aphid population (after three sprays, nine observations, average taken over two years) showed significant superiority of insecticide treatments against control. Imidacloprid was found most effective followed by Thiamethoxam and Oxy -dameton methyl. Carbosulphon was least effective followed by flonicamid and fipronil as given in table 5. All the insecticidal treatments proved significantly superior registering high grain yield. With regard to yield all the insecticides treatment proved significantly superior registering higher yield (980 to 1425 kg/ha) than control (780kg/ha). The maximum grain yield (1425 kg/ha) was obtained with Imidacloprid treated plot followed by Thiamethoxam and Oxy -demeton methyl. Whereas, Carbosulphon recorded the lower yield (980 kg/ha) and was at par with Flonicamid. In control, the yield obtained was (780 kg/ha). The cost benefit ratio ranged from1: 1.52 to 1:13.28. Highest incremental cost benefit ratio with highest return was obtained from (1:13.28) with Imidacloprid followed by Dimethoate (1:9.88) and Oxydemeton-methyl (1:9.15). Poor incremental cost benefit ratio was obtained from Flonicamid (1:1.52) followed by Fipronil (1:3.30).

Keywords: bioefficacy, natural enemies, incremental cost benefit ratio

Introduction

The oleiferous Brassica species, commonly known as rapeseed-mustard, are one of the economically important agricultural commodities. Rapeseed-Mustard comprising seven different species viz. Indian mustard, *toria*, yellow *sarson*, brown *sarson*, *gobhi sarson*, *karan rai* and *taramira*, are being cultivated in 53 countries spreading all over the globe. Asia contributed around 59% of hectarage and 49% of the world production; India holds a premier position for global oilseed production contributing 9% to the world's oilseeds with an area of 19%. India is the world's third largest producer of rapeseed-mustard having an area of 6.33 m ha, and the crop is spreading over 23 states and union territories. More than 43 species of insect pests infested mustard crop in the world, which include about dozen species as major pests (Parwar and Sachan, 2004) [2] are known to be associated with various phenological stages of rapeseed –mustard crops in India, of which mustard aphid, *Lipaphis erysimi* Kalt. is an important pest of mustard. The loss in grain weight varies greatly within Brassica; being 35.0-73.3% under different agro climatic regions with a mean loss of 54.2% on all India basis (Bakhetia and Sekhon, 1989) [1]. The heavy attack of aphid results in mustard plant to wither loss of seed yield and oil content. Various strategies were employed to manage this pest but none of them was found effective due to high parthenogenetic reproductive capacity and migratory nature of this aphid. With the demand for oilseed running ahead of supplies, the production trends have been unsatisfactory due to attack of various insect pests. Mustard aphid, *Lipaphis erysimi* is the major limiting factor in the production of mustard in North West Madhya Pradesh. It causes severe damage to the plants by sucking plant sap from the tender shoots and flowers of the plant in the beginning and later sucks the sap from tender pods The infested plants become weak and stunted. Several infested plant do not flower at all. The excessive excretion of honey dew by the aphid on the leaves results in the growth of black shooty mould which interferes in the photosynthetic activity of the leaves. The management of the pest with organophosphorus systemic insecticides is quite effective but it adversely affects the predators and parasitoids of the pest.

Materials and Methods

The present investigation was carried out during the period from Rabi season of 2011-12 to 2012-13 at the field of Entomological research farm, College of Agriculture, RajMata VijyaRaje Scindia Agriculture University, Gwalior (M.P.). The research farm is situated in Grid zone at the latitude of 26^0 13'N and longitude 76^0 10'E with an altitude of 197 meters from mean sea level (MSL). The climate of experimental site is semi-arid and sub-tropical dominated with extreme weather conditions having hot and dry summer and cold winter, where maximum temperature goes up to 45^{0}C during summer and steeps down to a chilling temperature of as low as 1 – 2^{0}C during winter in December and January. Frost also expected from the last week of December to the first week of February. The monsoon sets in during last week of June. Most of which falls during last June to middle of September with mean annual rainfall of area is about 730 mm. Winter rains are occasional and uncertain. The experiment was laid out in a following randomized block design with three replications having plot size of 2 and 3m spacing between row to row and plant to plant as 40c.m. and 10c.m. respectively. The mustard cultivar used was Rohini sown on 2nd week of November in both the years and all the standard agronomic practices were followed to raise the good crop. All the operations viz. fertilizer application, weed control, irrigation etc. were done as per recommended package and practices of R.V.S.K.VV, Gwalior. Ten treatments including control i.e. Acephate 75 SP @ 350 g a.i. per ha/1 ml per liter of water, Acetamiprid 20 SP @ 10 g a.i. per ha/0.15 g per liter of water, Oxydameton Methyl 25 EC @ 250 g a. i./ha, Imidacloprid 17.8 SL @ 20 g a.i. per ha/ 0.25 ml per liter of water, Dimethoate 30 EC @ 300 g a.i. per ha/1 ml per liter of water, Carbosulphan 25 EC @ 300 g a. i./ha Flonicamid 50 WG 0.15 g a.i. per ha/1 ml per liter of water per ha, Thiamethoxam 25 WG @ 25 g a.i. per ha/ 0.25 g per liter of water, Fipronil 5SC @ 50 g a.i per ha/ 2 ml per liter of water, replicated three times as given in (table 1).The respective treatments were applied on the crop in the form of spray with the help of knapsack hand sprayer having 20 litres capacity fitted with hollow cone nozzle. Pest sampling started with the appearance of aphids in the field and continued till harvesting of the crop. Aphid population was counted on 10 randomly selected tagged plants per plot one day before and 3, 7 and 10 days after spray on 10 cm top twig per plant and population of natural enemies were also recorded. Yield was recorded from net plot area and converted into kilogram per ha. and data were statistically analyzed. When a sufficient population of pest build up, the chemical were sprayed with pneumatic sprayer at specific doses. Two consecutive spray were done at fifteen days interval. From each plot 10 plants were randomly selected and tagged and aphid were counted from per 10 cm long top portion of central twig of the plant. Observation were taken one day before spraying and at 3,7 and 10 day(s) after each spray as given in table 2, 3 and 4.

Table 1: Population of aphid under different treatments after first spray

Treatments	Dose (g a.i./ha)	Pre - Population			3 DAS			7 DAS			10 DAS		
		2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
Acephate 75 SP	350	71.67 (1.85)	72.33 (1.86)	72.00 (1.86)	15.03 (1.17)	10.27 (1.01)	12.65 (1.09)	23.67 (1.37)	12.40 (1.09)	18.03 (1.23)	29.67 (1.47)	15.20 (1.18)	22.43 (1.32)
Acetamiprid 20 SP	10	60.00 (1.76)	69.83 (1.84)	64.66 (1.80)	13.67 (1.13)	7.27 (0.89)	10.47 (1.01)	20.67 (1.31)	9.83 (0.97)	15.25 (1.14)	25.00 (1.40)	12.83 (1.10)	18.91 (1.25)
Oxydameton Methyl 25EC	250	60.00 (1.77)	79.33 (1.89)	69.66 (1.83)	10.60 (0.99)	6.17 (0.77)	8.38 (0.88)	16.67 (1.21)	9.23 (0.96)	12.95 (1.08)	21.83 (1.33)	11.67 (1.06)	16.75 (1.20)
Imidacloprid 17.8 SL	20	63.33 (1.78)	84.33 (1.93)	73.83 (1.85)	3.57 (0.55)	3.83 (0.55)	3.70 (0.55)	6.83 (0.81)	6.17 (0.78)	6.50 (0.79)	14.23 (1.13)	8.77 (0.93)	11.50 (1.03)
Dimethoate 30 EC	300	73.33 (1.85)	69.33 (1.84)	71.33 (1.84)	14.83 (1.17)	8.43 (0.92)	11.63 (1.04)	22.17 (1.34)	10.93 (1.03)	16.55 (1.19)	27.03 (1.43)	13.33 (1.12)	20.18 (1.27)
Carbosulphon 25 EC	185	75.00 (1.86)	68.33 (1.83)	71.66 (1.84)	26.67 (1.41)	28.17 (1.45)	27.42 (1.43)	31.13 (1.49)	37.50 (1.57)	34.31 (1.53)	36.50 (1.56)	44.03 (1.64)	40.26 (1.60)
Flonicamid 50 WG	0.15	72.67 (1.86)	78.83 (1.90)	75.75 (1.88)	28.33 (1.44)	32.17 (1.51)	30.25 (1.47)	35.33 (1.54)	41.50 (1.61)	39.75 (1.58)	42.00 (1.62)	47.50 (1.68)	44.50 (1.65)
Thiamethoxam 25 WG	25	74.50 (1.90)	86.67 (1.93)	80.58 (1.91)	8.40 (0.92)	4.93 (0.72)	6.66 (0.82)	14.63 (1.16)	7.23 (0.85)	10.93 (1.01)	19.33 (1.28)	10.07 (1.00)	14.70 (1.14)
Fipronil 5SC	50	66.67 (1.82)	74.33 (1.87)	70.50 (1.84)	16.00 (1.19)	11.50 (1.05)	13.75 (1.12)	27.07 (1.43)	13.67 (1.13)	20.37 (1.28)	32.00 (1.50)	16.33 (1.20)	24.16 (1.35)
Control		70.00 (1.84)	86.67 (1.93)	78.33 (1.89)	85.17 (1.93)	123.33 (2.09)	104.25 (2.01)	110.67 (2.04)	151.67 (2.18)	131.17 (2.11)	135.33 (2.13)	181.10 (2.26)	158.21 (2.19)
SEm (±)		(0.06)	(0.05)	(0.04)	(0.07)	(0.08)	(0.05)	(0.05)	(0.06)	(0.04)	(0.05)	(0.05)	(0.03)
CD (P=0.05)		NS	NS	NS	(0.19)	(0.24)	(0.15)	(0.16)	(0.17)	(0.11)	(0.15)	(0.14)	(0.10)

Note: Figures in parentheses indicated log x transformed value

Table 2: Population of aphid under different treatments after second spray

Treatments	Dose (g a.i./ha)	3 DAS			7 DAS			10 DAS		
		2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
Acephate 75 SP	350	15.00 (1.16)	17.50 (1.24)	16.25 (1.20)	15.97 (1.20)	17.67 (1.24)	16.82 (1.22)	15.10 (1.17)	19.50 (1.29)	17.3 (1.23)
Acetamiprid 20 SP	10.	9.37 (0.95)	9.50 (0.96)	9.43 (0.96)	10.83 (1.02)	11.83 (1.06)	11.33 (1.04)	12.60 (1.10)	13.83 (1.13)	26.43 (1.11)
Oxydameton Methyl 25EC	250	6.60 (0.79)	8.00 (0.90)	7.3 (0.84)	9.20 (0.96)	10.17 (1.00)	9.68 (0.98)	10.80 (1.03)	12.17 (1.08)	11.48 (1.05)
Imidacloprid 17.8 SL	20	3.67 (0.54)	5.37 (0.73)	4.52 (0.63)	5.30 (0.72)	7.33 (0.86)	6.31 (0.79)	6.57 (0.79)	8.70 (0.94)	7.63 (0.86)
Dimethoate 30 EC	300	11.70 (1.05)	12.50 (1.09)	12.1 (1.07)	12.97 (1.10)	14.83 (1.17)	13.9 (1.13)	14.83 (1.17)	16.83 (1.22)	15.83 (1.19)
Carbosulphon 25 EC	185	18.33 (1.25)	20.03 (1.30)	19.18 (1.27)	22.93 (1.36)	22.17 (1.34)	22.55 (1.35)	24.60 (1.39)	24.60 (1.39)	24.60 (1.39)
Flonicamid 50 WG	0.15	21.00 (1.31)	26.73 (1.43)	23.86 (1.37)	23.43 (1.37)	28.43 (1.45)	25.93 (1.41)	26.10 (1.42)	30.47 (1.48)	28.28 (1.45)
Thiamethoxam 25 WG	25	5.73 (0.74)	6.83 (0.83)	6.28 (0.78)	8.87 (0.94)	8.33 (0.92)	8.6 (0.93)	10.10 (1.00)	9.50 (0.98)	9.8 (0.99)
Fipronil 5SC	50	15.83 (1.19)	16.33 (1.21)	16.08 (1.20)	17.10 (1.22)	18.17 (1.25)	17.63 (1.24)	17.67 (1.24)	20.00 (1.30)	18.83 (1.27)
Control		106.33 (2.03)	147.00 (2.16)	126.66 (2.10)	98.67 (1.99)	123.33 (2.09)	111.00 (2.04)	91.00 (1.96)	95.00 (1.98)	93.00 (1.97)
SEm (±)		(0.07)	(0.05)	(0.04)	(0.06)	(0.04)	(0.03)	(0.06)	(0.04)	(0.04)
CD (P=0.05)		(0.21)	(0.14)	(0.12)	(0.16)	(0.12)	(0.10)	(0.17)	(0.12)	(0.10)

Note: Figures in parentheses indicated log x transformed value

Table 3: Population of aphid under different treatments after third spray

Treatments	Dose (g a.i./ha)	3 DAS			7 DAS			10 DAS		
		2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
Acephate 75 SP	350	13.83 (1.13)	11.50 (1.04)	12.66 (1.09)	16.00 (1.20)	13.70 (1.13)	14.85 (1.16)	17.17 (1.23)	15.03 (1.17)	16.1 (1.20)
Acetamiprid 20 SP	10.	8.83 (0.93)	8.83 (0.95)	8.83 (0.94)	9.50 (0.98)	10.33 (1.01)	9.91 (0.99)	10.17 (1.01)	11.30 (1.05)	10.73 (1.03)
Oxydameton Methyl 25EC	250	6.07 (0.77)	7.33 (0.86)	6.70 (0.82)	7.33 (0.86)	9.17 (0.96)	8.25 (0.91)	8.33 (0.92)	10.60 (1.02)	9.46 (0.97)
Imidacloprid 17.8 SL	20	2.27 (0.34)	3.53 (0.52)	4.03 (0.43)	4.53 (0.65)	5.33 (0.72)	4.93 (0.69)	5.53 (0.74)	6.67(0.82)	6.1 (0.78)
Dimethoate 30 EC	300	11.20 (1.04)	10.83 (1.03)	16.61 (1.04)	13.73 (1.13)	12.50 (1.09)	13.11 (1.11)	13.73 (1.13)	13.43 (1.13)	13.58 (1.13)
Carbosulphon 25 EC	185	19.17 (1.27)	19.00 (1.28)	19.08 (1.28)	20.50 (1.30)	22.37 (1.35)	21.43 (1.32)	22.00 (1.33)	24.60 (1.39)	23.3 (1.36)
Flonicamid 50 WG	0.15	22.00 (1.33)	22.67 (1.37)	22.33 (1.35)	23.33 (1.36)	25.90 (1.41)	24.61 (1.39)	25.17 (1.39)	28.50 (1.45)	26.83 (1.42)
Thiamethoxam 25 WG	25	4.83 (0.68)	5.33 (0.74)	7.49 (0.71)	6.50 (0.81)	6.73 (0.83)	6.61 (0.82)	7.80 (0.89)	7.90 (0.90)	7.85 (0.89)
Fipronil 5SC	50	15.33 (1.18)	14.50 (1.14)	14.91 (1.16)	17.67 (1.24)	16.53 (1.22)	17.1 (1.23)	19.17 (1.28)	18.10 (1.26)	18.63 (1.27)
Control		77.00 (1.89)	67.87 (1.83)	72.43 (1.86)	52.00 (1.71)	46.37 (1.66)	49.1 (1.69)	37.33 (1.57)	26.67 (1.43)	32.00 (1.50)
SEm (±)		(0.05)	(0.06)	(0.04)	(0.05)	(0.03)	(0.03)	(0.04)	(0.02)	(0.02)
CD (P=0.05)		(0.16)	(0.18)	(0.11)	(0.15)	(0.09)	(0.08)	(0.13)	(0.07)	(0.07)

Note: Figures in parentheses indicated log x transformed value

Table 4: Seed yield and economics of different treatment of insecticides

Treatments	Seed yield (kg/ha)	Yield increase over control (kg/ha)	Additional profit (Rs./ha)*	Cost of plant protection for two sprayers (Rs./ha)			Net profit (Rs./ha)	ICBR#
				Cost of insecticide	Labour charge	Total cost		
	a	b	c= b*35/-	d	e	f=(d+e)	g = c-f	h= c/f
Acephate	1050	270	9450	1200	800	2000	7450	4.73
Acetamiprid	1205	425	14875	825	800	1625	13250-IV	9.15-III
Oxydameton Methyl	1275	495	17325	2700	800	3500	13825-III	4.95
Imidacloprid	1425	645	22575	900	800	1700	20875-I	13.28-I
Dimethoate	1175	395	13825	600	800	1400	12425	9.88-II
Carbosulphan	980	200	7000	1050	800	1850	5150	3.78
Flonicamid	1050	270	9450	5400	800	6200	3250	1.52
Thiamethoxam	1370	590	20650	1790	800	2590	18060-II	7.97
Fipronil	1025	245	8575	1800	800	2600	5975	3.30
Control	780	-	-	-	-	-	-	-

*Rate of mustard = 35/ kg
incremental cost benefit ratio

Results and Discussion

A large number of insecticides are available in the market and several new products are added every year with good aphicidal action. But still there is a need to search for effective, safer, economically and less hazardous aphicide. In the present studies, nine insecticides of different groups were evaluated for their relative efficacy and cost benefit ratio against mustard aphid. The observations recorded at different intervals after treatment indicated that all the insecticides gave effective control at each observational period over untreated control. The aphid population was suppressed up to 72 hrs. By all the insecticides but thereafter the aphid population started building up in all the treatments except Imidacloprid.

One week after spray, the aphid population was significantly lower in Imidacloprid, Thiamethoxam and Oxydemeton methyl. After two weeks of spraying the aphid population increase on different treatments necessitated a second spray. However, in case of Imidacloprid and Thiamethoxam, low level of infestation was recorded after two weeks of sprays. In control, aphid population was although significantly higher than that of all the insecticidal treatments. Imidacloprid, Thiamethoxam, Oxydameton methyl, Acetamiprid and Dimethoate showed their effectiveness against aphid. These results are in close agreement with those of effectively of Imidacloprid 17.8SL reported by Rajendra (2001), Gour and Pareek (2003), Meena and Lal (2004), Rohilla *et al.* (2004), Biswas and Chatterjee (2006), Kumar *et al.* (2007), Ghadge and Bharodia (2012), Khan *et al.* (2012) and Khedkar *et al.* (2012) [3, 4, 5, 6, 7, 8, 9, 10, 11].

The findings of earlier workers regarding the affectivity of Thiamethoxam by Lal *et al.* (2002), Kular and Agrawal (2008) and Sohail *et al.* (2011) [12, 13, 14]. Oxydameton methyl proved most effective as reported by Upadhyaya and Agrawal (1993), Bhalla *et al*. (1994), Singh and Lal (2011), Nayak (2012) and Gore lal *et al.* (2013) [15, 16, 17, 18, 19]. Acetamiprid proved most effective as reported by Chinnabai *et al*. (1999) [20]. Findings regarding Acephate, Fipronil and Flonicamid have received conformity by Choudhary and Pal (2005), Singh and Singh (2009) and Morita *et al.* (2007) [21, 22, 23]. Dimethoate proved most effective as reported by Gour and Pareek (2003) and Sahoo 2012) [24, 25].

Safer insecticides to natural enemies

The findings of earlier workers regarding the effectivity of safer insecticides to natural enemies reported by Akhtar *et al*. (2006) found that the mustard aphid (*L. erysimi*) preyed upon or parasitized by a large number of predators/parasites like coccinellids, syrphids, chrysopids and parasitoids. Singh *et al*. (2007) noticed that the population of *Coccinella septempunctata* was higher in the plots treated with Achook, Nivaar and Nimbecidine. Similarly, these insecticides were found to be safer to *Diaretiella rapae* with the record of higher mummified aphid population. Sohial *et al.* (2011) [14] concluded that farmers should use Actara for the control of aphids in the field as it is the least toxic to lady bird beetle population. Singh *et al*. (2011) reported effective control of mustard aphid by neem formulations and found neem formulations safer to the natural enemies of mustard aphid and honey bees pollinators. Meena *et al.* (2013) [28] evaluated microbial agents (*Verticillium lecanii*, *Beauvera basssiana* and *Mettarhizium anisopliae* @ 5g per litre of water), plant products (Tobacco, onion and neem seed kernel extract @ 5%), cow urine @ 50 litre/ha and dimethoate 30EC @ 300 g,a.i./ha against mustard aphid, *Lipaphis erysimi* (kalt.) without any phytotoxic effect and found safe to natural enemies of mustard aphid and honeybee.

Effect of insecticides on crop yield and economics

Crop Yield

The insecticides besides suppressing the aphid population have also influenced the yield of the crop. Imidacloprid, Thiamethoxam, Oxydemetonmethyl, Acetamiprid and Dimethoate treatments recorded significantly higher yields. With regard to yield all the insecticides treatment proved significantly superior registering higher yield (980 to 1425 kg/ha) than control (780 kg/ha) as given in table 4. Maximum grain yield (1425 kg/ha) was recorded in Imidacloprid treated plots followed by Thiamethoxam and Oxydameton methyl. Whereas minimum grain yield (980 kg/ha) recorded in Carbosulphon treated plots followed by Flonicamid. The present findings regarding yield under different insecticide treatments find ample support from the findings of Gour and Pareek (2003), Kumar *et al.* (2007), Khedkar *et al.* (2012), Mandal *et al.* (2012), Patel *et al.* (2012), Gore lal *et al.* (2013) and Mishra and Yadav (2013) [4, 8, 11, 29, 30, 19, 31] who also reported highest yield under Imidacloprid treatment.

Economics

All the insecticide treatments were found economical and received 200 to 645 kg/ha, yield over control. Treatment of Imidacloprid gave maximum net return (Rs. 20875/ha) followed by Thiamethoxam (Rs.18060/ha) and Oxydameton methyl (Rs.13825/ha) and Acetamiprid (Rs13250/ha). Flonicamid gave minimum net return (Rs. 5150/ha) followed by Carbosulphon (Rs.3250/ha).

The cost benefit ratio ranged from 1:1.52 to 1:13.28. Highest incremental cost benefit ratio with highest return was obtained from (1:13.28) with Imidacloprid followed by Dimethoate (1:9.88) and Oxydemeton-methyl (1:9.15).Poor incremental cost benefit ratio was obtained from Flonicamid (1:1.52) followed by Fipronil(1:3.30). Patel *et al.* (2012) [30] reported the highest cost benefit ratio with imidacloprid than other treatments. Mandal *et al*. (2012) [29] received incremental cost benefit ratio with highest return was obtained from (1:16.12) with Imidacloprid and Gore lal *et al*. (2013) [19] received best cost benefit ratio of (1:38.27) was achieved in Imidacloprid 17.8SL @20g treatment followed by Oxydametonmethyl. Sahoo (2012) [24] was obtained most favourable return incremental cost benefit ratio (1:20.8 and1:13.3) in Dimethoate 30EC followed by Oxydementon –methyl 25 EC (1:16.8 and 1:9.1). Mishra and Yadav (2013) [31] also reported highest cost benefit ratio1:1.92 and 1:1.87 was also incurred with application of imidacloprid during first and second year, respectively as given in table 5.

Bio - efficacy of newer insecticides against mustard aphid

Mean aphid population (after three sprays, nine observations, average taken over two years) showed significant superiority of insecticide treatments against control. Imidacloprid was found most effective followed by Thiamethoxam and Oxy -dameton methyl. Carbosulphon was least effective followed by flonicamid and fipronil. All the insecticidal treatments proved significantly superior registering high grain yield. With regard to yield all the insecticides treatment proved significantly superior registering higher yield (980 to 1425 kg ha^{-1}) than control (780 kg ha^{-1}). The maximum grain yield (1425 kg ha^{-1}) was obtained with Imidacloprid treated plot followed by Thiamethoxam and Oxy -demeton methyl. Whereas, Carbosulphon recorded the lower yield (980 kg ha^{-1}) and was at par with Flonicamid. In control, the yield obtained was (780 kg ha^{-1}).

All the insecticide treatments were found economical and received 200 to 645 kg ha^{-1} yield over control. Treatment of Imidacloprid gave maximum net return (Rs 20875 ha^{-1}) followed by Thiamethoxam (Rs.18060 ha^{-1}) and Oxydameton methyl (Rs.13825 ha^{-1}) and Acetamiprid (Rs13250 ha^{-1}).

Flonicamid gave minimum net return (Rs 5150 ha^{-1}) followed by Carbosulphon (Rs 3250/ ha^{-1}).

The cost benefit ratio ranged from 1.52 to 13.28. Highest incremental cost benefit ratio with highest return was obtained from (13.28) with Imidacloprid followed by Dimethoate (9.88) and Oxydemeton-methyl (9.15). Poor incremental cost benefit ratio was obtained from Flonicamid (1.52) followed by Fipronil (3.30) as given in table 5.

Table 4: Mean aphids population after spray of different insecticides

S. No.	Treatments	Mean aphid population after			
		Ist spray	IInd spray	IIIrd spray	Mean
1	Acephate	17.70 (1.25)	16.79 (1.23)	14.54 (1.16)	16.34 (1.21)
2	Acetamiprid	14.88 (1.17)	15.73 (1.20)	9.82 (0.99)	13.48 (1.13)
3	Oxydameton Methyl	12.69 (1.10)	9.49 (0.98)	8.14 (0.91)	10.11 (1.00)
4	Imidacloprid	7.23 (0.86)	6.15 (0.79)	5.02 (0.70)	6.14 (0.79)
5	Dimethoate	16.12 (1.21)	13.94 (1.14)	14.43 (1.16)	14.83 (1.17)
6	Carbosulphan	34.00 (1.53)	22.11 (1.34)	21.27 (1.33)	25.79 (1.41)
7	Flonicamid	38.17 (1.58)	26.02 (1.42)	24.59 (1.39)	29.59 (1.47)
8	Thiamethoxam	10.76 (1.03)	8.23 (0.92)	7.32 (0.86)	8.77 (0.94)
9	Fipronil	19.43 (1.29)	17.51 (1.24)	16.88 (1.23)	17.94 (1.25)
10	Control	131.21 (2.12)	110.22 (2.04)	51.18 (1.71)	97.54 (1.99)
SEm (±)		(0.03)	(0.05)	(0.05)	(0.04)
CD (P=0.05)		(0.09)	(0.15)	(0.14)	(0.12)

Note: Figures in parentheses indicated log x transformed value

Table 5: Seed yield and economics of different treatment of insecticides

Treatments	Seed yield (kg/ha)	Yield increase over control (kg/ha)	Additional profit (Rs./ha)*	Cost of plant protection for two sprayers (Rs./ha)			Net profit (Rs./ha)	ICBR#
				Cost of insecticide	Labour charge	Total cost		
	a	b	c= b*35/-	d	E	f=(d+e)	g = c-f	h= c/f
Acephate	1050	270	9450	1200	800	2000	7450	4.73
Acetamiprid	1205	425	14875	825	800	1625	13250-IV	9.15-III
Oxydameton Methyl	1275	495	17325	2700	800	3500	13825-III	4.95
Imidacloprid	1425	645	22575	900	800	1700	20875-I	13.28-I
Dimethoate	1175	395	13825	600	800	1400	12425	9.88-II
Carbosulphan	980	200	7000	1050	800	1850	5150	3.78
Flonicamid	1050	270	9450	5400	800	6200	3250	1.52
Thiamethoxam	1370	590	20650	1790	800	2590	18060-II	7.97
Fipronil	1025	245	8575	1800	800	2600	5975	3.30
Control	780	-	-	-	-	-	-	-

*Rate of mustard = 35/ kg

incremental cost benefit ratio

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