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Bio-efficacy of seven insecticides against mustard aphid, *Lipaphis erysini* kalt and their effect on foraging bee, *Apis cerana* under field condition

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Abstract
Bio-efficacy of seven insecticides viz. Phosphamidon (0.03%) Dimethoate (0.03%) Carbayrl (0.03%), Cypermethrin (0.01%) Chloropyriphos (0.05%), quinalphos (0.05%), Malathion (0.05%), and untreated control (water) were evaluated against mustard, aphid, Lipaphis crysimi Kalt and their effect on foraging bee *Apis cerana* during rabi season 2017-18. Dimethoate was found to be the most effective in suppression of aphid population upto 14 days after insecticidal treatment. Evaluation of the effect of these insecticides on *A. cerana* population show that malathion cypermethrin and quinalphos were safer to bees than carbaryl, dimethoate and phosphamidon which did not reduce the bee population. Moreover, *A. cerana* spent maximum time in flowers of cypermethin treated plots and minimum in carbaryl treated plots. The highest seed yield was obtained with dimelthoate treated plots, closely followed by phosphamidon and cypermethrin.

Keywords: Insecticides, mustard, aphid, bees, infected

Introduction

Rapeseed and mustard are the major rabi oilseed crops that belong to the genus *Brassicae* and family *cruciferae*. Rape and mustard are placed third as important edible oilseed crops worldwide after soya bean and palm oil. In Manipur rape and mustard, the only major oilseeds rabi crops grown in wide scale still remained as marginal rabi crops cultivated with minimum inputs. The gap between the demand and supply is still wider as only 20 percent of the total requirement of oilseeds are produced in the state.

The insects pest problem is one of the major constraints in oilseed production, Rapeseed crop is mainly infested by mustard sawfly, *Athalia lugens* out of these two pests mustard aphid is more serious causing damage upto 87.9 percent (Pradhan 1960) [8] Pollination of agricultural crop is seriously affected by non-selective and indiscriminate use of insecticides for the control of insect pest of crops in most crops it can be possible to control the pest before the start of flowering and the next treatment can be postpone till the end of flowering period, but in some cases the flowering period is staggered and pesticidal treatment may become essential (Mishra 1995) [6]. In rape and mustard the aphid infestation is synchronized with the peak activity of insect pollinator. Application of insecticides with the selection of insecticides may be unavoidable but can be reconciled with the selection of insecticides which are relatively harmless to bees. However Mishra (1995) [6] concluded that it should be accepted that some loss is inevitable in certain circumstances and that a realistic aim should be an acceptably low level of loss rather than protection of bees.

So, keeping in view the importance of honey bee in the pollination of rapeseed it is necessary to evaluate insecticides under the agro climatic condition of Manipur to find out the most effective insecticides against mustard aphid without affecting insect pollinator.

Materials and methods

Field experiment was carried out in an area of 19 x 12 m in randomized block design on rapeseed var M-27 during the rabi season of 2017-18 at Kadamtala, Jiribam, Manipur. There were in all eight treatments including untreated control plots and each treatment were replicated thrice. The rape var-27 was sown in parallel rows at a spacing of 30 x 10 cm with a recommended package of practice. The insecticide namely phosphamidon, dimethoate, carbaryl, cypermethrin, chloroyriphos, Quinalphos, and malathion were sprayed by using a knapsack hand sprayer and plain water was sprayed on plants of control plots. Second spray was given fifteen days after first spray. The population of aphid on the five randomly selected plants from each plot were counted at 3.7 and 14 days after first and second spraying of insecticide for evaluating the effect of insecticide on foraging population of *Apis cerana* was recorded during peak foraging time on 10 randomly selected plants before 1 day and 1, 2, 3 and 7 days after first and second spraying of insecticides. For the foraging speed, the time spent by an individual *A.cerana* on a single flower was recorded at 1, 2, 3 and 7 days after each insecticidal treatment. Seed yield was recorded by selecting 10 plants randomly from each plot and calculated in terms of hectares and expressed as quintals per hectare.

Result and discussion

Effect of insecticides on aphid population after first spray

Mean population of mustard aphid *L. erysimi* indicate that none of the insecticides proved effective in reducing the *L. erysimi* population as compared to control at 7 days after treatment. Among the treatments, phosphamidon and dimethoate at 0.03 percent were found to be the most effective with 2.60 aphid per plant and carbaryl 0.05 percent was found to be the least effective giving 258.13 aphid per plant. No significant differences was observed among the

treatments at 14 DAT. However the minimum L. erysimi population was observed in cypermethrin 0.01 percent that proved longer residual action upto 14 days after application, when means of all the time intervals of first spray was calculated, it was observed that dimethoate 0.03 percent was found to be the most effective insecticides against aphid closely followed by phosphamidon 0.03 percent and cypermethrin 0.01 percent. However the insecticide were at par with other insecticides except carbaryl 0.05 percent which proved ineffective in suppression of aphid population.

Mean population of mustard aphid following second insecticidal treatment

In the second insecticidal treatment (table1) all the treatments except carbaryl 0.05 percent were found to be significantly superior over control in reducing aphid population at 3DAT. At 7 DAT among the effective treatment, phosphamidon 0.03 percent gave least aphid population (2.73 aphid/plant) closely followed by cypermethrin 0.01 percent with 3.80 aphids per plant. After 14 days of second insecticidal treatments all the treatment except Carbaryl 0.05 percent were significantly superior over control in reducing aphid population. Cypermethrin 0.01 percent with 4.60 aphids per plants proved to be the most effective and longer residual action upto 14 DAT. When means of all the time intervals of the second spray were Calculated, all the insecticides were significantly superior over Carbaryl 0.05 per cent and control, minimum aphid population was recorded in Cypermethrin 0.01 percent (5.31) treated plots closely followed by Chloropyriphos 0.05 percent (6.40 aphids percent) and phosphamidon 0.03 percent giving (7.13 aphids/plant).

Effect of insecticides on the population of *Apis cerana* on rapeseed flower

Bee population recorded at 1,2,3 and 7 days after application of insecticides showed no significant difference among the treatments. When means of all the time intervals were Calculated though non significant difference were observed, *A cerana* population was highest in the treatments of quinalphos 0.05 percent recording 9.23 bees/10 plants and the least in Chloropyriphos 0.05 percent with 6.75 bees per 10 plants. In the second insecticidal treatment, significant differences were observed in the bee population among the treatments as compared to untreated treatment at I DAT (Table 2).

Among the treatments, malathion 0.05 percent recorded maximum bee population with 9.00 bees/10plants and it was at par with other treatments except phosphamidon 0.03 percent and Carbaryl 0.05 percent which gave 4.50 and 3.00 bees per 10 plants, respectively. At 2 DAT among the tested insecticides highest bee population was achieved with treatment of malathion 0.05 percent which gave 14.00 bees/10 plants and it was at par with chloropyriphos 0.05 percent, quinalphos 0.05 percent with bee population ranging from 10.70 to 13.70.

At 3 DAT it was noticed that the highest number of *Apis cerana* population was observed in the treatment of cypermethrin 0.01 percent having 16.00 bees/plants end it was at par with other insecticides except dimethoate 0.03 percent and Carbaryl 0.05 percent at 7 DAT, the highest *A cerana* population was found with the treatment of chloropyriphos end quinalphos at 0.05 percent having 19 bees/10 plants each which were at par with phosphamidon 0.03 percent and malathion 0.05 percent. The lowest bee population was found in the treatment of Carbaryl 0.05 percent which gave 3.33 bees/10 plants (table 2) when mean values of bee population at all time intervals of the second insecticidal treatment were calculated malathion 0.05 percent was recording the least toxic insecticides to bees recording 13.25 bees/10 plants) and Carbaryl 0.05 percent to be the most toxic chemicals which gave 3.41 bees per 10 plants.

Effect of insecticides on foraging speed of *A. cerana* after insecticidal application.

Table 3 show that at one day after application of first insecticidal treatment no significant difference was observed on the foraging speed of bees. The significant difference observed on the time spent by bees after 2 DAT and 3 DAT indicated that the application of insecticides have effect on the time spent by bees. Among the treatments the maximum time was spent by the bees in cypermethrin 0.01 percent treated plots (17.67 sec//flowers; 19.00 sec/flowers) which was significantly longer than other insecticides and the minimum time spent was observed in quinalphos (3.67 sec/flower) at 2 DAT and Malathion (11.67 sec/flower) at 3 DAT respectively. When means of all the time intervals were pooled, it was observed that there was no significant difference in the time spent by bees in the treated as well as untreated plots. However, the bees spent maximum time (14.5 sec/flower) in the cypermethrin 0.01 percent treated plots.

During the second insecticidal application, significant difference were observed only at 2 days after treatments. The maximum time was spent in dimethoate 0.03 percent treated plots with 14.67 sec/flower which was at par with other insecticides except phosphamidon and Carbaryl at 0.03 percent and malathion 0.05 percent with a range of 3.67 to 7.00 sec/flower. When mean values of all the time intervals were calculated no significant difference existed among the treatments. However, time spent by an individual bee was maximum in the cypermethrin 0.01 percent treated plot recording 11.25 sec/flower and minimum in the dimethoate 0.03 percent treated plots with 4.75 sec/flower.

Effect of insecticidal treatments on yield of rapeseed

Data in table 4 show that the yield of rapeseed in different insecticidal treatment ranged from 5.34 to 11.58 q/ha indicating that all the treated plots produced higher yield than control plots. The highest yield among the treatments was obtained with the treatment of dimethoate 0.03 percent (11.58 q/ha closely flowed by cypermethrin 0.01 percent (10.86 q/ha) which were at par with each other. Carbaryl 0.05 percent recorded the lowest seed yield (5.34 q/ha).

Table 1: Relative efficacy of insecticides against *Lipaphis crysime* (Kalt) on rapeseed during Rabi.

Mean aphid population per plant									
Treatment	**Conc.%**	**3DAT**	**7DAT**	**14 DAT**	**Mean**	**3 DAT**	**7DAT**	**14DAT**	**Mean**
Phosphamidon	0.03	3.07	2.60	19.47	8.38	5.60	2.73	13.07	7.13
		(1.85)	(1.75)	(3.43)	(2.34)	(2.30)	(1.79)	(3.65)	(2.58)

Dimethoate	0.03	2.53	2.60	12.53	5.89	6.00	9.00	12.07	9.02
		(1.71)	(1.70)	(3.59)	(2.33)	(2.33)	(2.68)	(3.41)	(2.77)
Carbaryl	0.05	76.13	258.13	272.67	202.38	70.73	87.47	118.73	92.3
		(8.41)	(15.93)	(16.47)	(13.60)	(7.87)	(8.90)	(10.54)	(9.10)
Cypermethrin	0.01	8.67	9.60	8.27	8.85	7.53	3.80	4.60	5.31
		(2.71)	(2.62)	(2.66)	(2.66)	(2.68)	(1.93)	(2.22)	(2.28)
Chloropyriphos	0.05	25.20	44.40	48.13	39.24	3.20	4.20	11.80	6.40
		(4.95)	(10.04)	(6.91)	(7.30)	(1.91)	(2.13)	(3.46)	(2.50)
Quinalphos	0.05	14.93	14.47	20.53	16.04	6.47	5.67	9.93	7.36
		(3.68)	(3.84)	(4.46)	(3.99)	(2.54)	(2.42)	(2.87)	(2.61)
Malathion	0.05	15.60	64.20	78.53	52.78	6.20	10.20	19.27	11.89
		(3.70)	(7.63)	(8.76)	(6.70)	(2.55)	(3.21)	(3.85)	(3.20)
Water (Control)		159.47	475.53	417.60	250.87	98.20	146.27	165.13	136.53
		(12.63)	(21.82)	(20.44)	(18.29)	(9.89)	(11.89)	(11.55)	(11.55)
C.D at 5%		NS	(3.25)	NS	(6.30)	(2.69)	(3.19)	(3.02)	(3.88)

Figures in parenthesis are transformed values of $\sqrt{x+0.5}$; DAT Days after treatment NS : Non Significant

Table 2: Effect of insecticides on foraging *Apis cerana* population on rapeseed crop

Bee population per 10mplants per 5 minutes													
		First spray						Second spray					
Treatment	Conc.%	IDBT	IDAT	2 DAT	3 DAT	7DAT	Mean	IDBT	IDAT	2 DAT	3 DAT	7DAT	Mean
Phosphamidon	0.03	10.30	5.00	7.70	9.70	7.70	7.53	6.70	4.50	4.70	15.30	18.30	10.65
		(3.19)	(2.34)	(2.84)	(2.56)	(2.83)	(2.64)	(2.67)	(2.18)	(2.24)	(3.93)	(4.33)	(3.17)
Dimethoate	0.03	16.30	5.70	11.00	9.00	7.00	8.18	6.00	5.70	7.00	7.30	7.67	6.92
		(3.97)	(2.44)	(3.32)	(3.07)	(2.73)	(2.89)	(2.53)	(2.40)	(2.72)	(2.78)	(2.85)	(2.69)
Carbaryl	0.05	14.30	6.00	6.00	6.70	8.70	6.85	9.00	3.00	5.30	2.00	3.33	3.41
		(3.78)	(2.49)	(2.55)	(2.60)	(3.02)	(2.67)	(2.91)	(1.86)	(2.31)	(1.56)	(3.33)	(2.27)
Cypermethrin	0.01	11.30	8.70	9.60	8.30	6.70	8.33	7.00	6.70	10.70	16.00	13.33	11.68
		(3.42)	(2.88)	(3.20)	(2.81)	(2.64)	(2.91)	(2.74)	(2.57)	(3.34)	(4.03)	(3.33)	(3.84)
Chloropyriphos	0.05	5.30	8.70	8.00	4.30	6.00	6.75	8.00	6.70	13.70	11.00	19.00	12.64
		(2.40)	(2.88)	(2.76)	(2.06)	(2.50)	(2.55)	(2.84)	(2.64)	(3.76)	(3.36)	(4.41)	(3.55)
Quinalphos	0.05	11.70	10.00	9.60	12.30	5.00	9.23	9.30	7.30	11.00	11.00	19.00	11.56
		(3.47)	(3.16)	(3.16)	(3.55)	(2.32)	(3.05)	(3.13)	(2.80)	(3.35)	(3.35)	(4.15)	(3.41)
Malathion	0.05	12.00	9.30	7.60	5.30	12.30	8.63	10.00	9.00	14.00	14.30	15.70	13.25
		(3.50)	(3.12)	(2.53)	(2.40)	(3.58)	(2.91)	(3.16)	(3.08)	(3.77)	(3.84)	(3.97)	(3.67)
Water (Control)		10.30	9.30	10.10	7.00	8.30	8.68	11.30	12.30	14.30	7.30	12.20	11.30
		(2.90)	(2.64)	(3.37)	(2.43)	(2.62)	(2.77)	(3.29)	(3.54)	(3.81)	(2.76)	(3.56)	(3.42)
C.D at 5%		NS	NS	NS	NS	NS	NS	NS	(0.68)	(0.81)	(0.89)	(0.76)	(1.14)

Figures in parenthesis are transformed values of $\sqrt{x+0.5}$; DAT Days after treatment NS : Non Significant

Table 3: Effect of insecticides on forgagingspeed of ApisCerana on rapeseed

			First spray					Second spray			
Treatment	**Conc.%**	**IDAT**	**2 DAT**	**3 DAT**	**7DAT**	**Mean**	**IDAT**	**2 DAT**	**3 DAT**	**7DAT**	**Mean**
Phosphamidon	0.03	6.00	7.67	12.67	11.00	9.34	10.67	3.67	5.00	6.00	6.34
		(2.52)	(2.83)	(3.60)	(3.33)	(4.32)	(3.34)	(2.00)	(2.34)	(2.49)	(2.54)
Dimethoate	0.03	14.00	8.67	14.33	5.33	10.33	5.33	14.67	4.00	4.75	4.75
		(3.74)	(2.97)	(3.78)	(2.40)	(3.24)	(2.40)	(3.85)	(2.11)	(2.34)	(2.68)
Carbaryl	0.05	11.03	7.33	16.00	10.67	11.24	11.00	6.67	4.00	12.33	8.5
		(3.31)	(2.78)	(3.94)	(3.21)	(3.13)	(3.29)	(2.67)	(2.11)	(3.50)	(2.89)
Cypermethrin	0.01	11.00	17.67	19.00	10.67	14.5	10.33	13.67	6.00	15.00	11.25
		(3.18)	(4.26)	(4.26)	(3.21)	(3.73)	(3.24)	(3.72)	(2.53)	(3.80)	(3.32)
Chloropyriphos	0.05	5.0	9.67	18.33	4.67	9.42	4.33	10.00	4.67	7.00	6.5
		(2.34)	(3.00)	(4.17)	(2.24)	(2.94)	(2.20)	(3.24)	(2.26)	(2.68)	(2.60)
Quinalphos	0.05	11.33	3.67	14.67	3.33	8.25	3.67	9.67	4.00	5.33	5.67
		(3.30)	(2.03)	(3.89)	(1.93)	(2.79)	(2.02)	(3.17)	(2.11)	(2.39)	(2.42)
Malathion	0.05	11.00	11.00	11.67	13.33	11.75	9.67	7.00	6.00	4.00	6.67
		(3.38)	(3.09)	(3.48)	(3.40)	(3.34)	(3.00)	(2.71)	(2.55)	(2.11)	(3.25)
Water (Control)		19.33	11.33	12.67	5.67	12.25	4.67	7.67	4.67	4.33	5.33
		(4.44)	(3.37)	(3.62)	(2.45)	(3.47)	(2.26)	(2.81)	(2.26)	(2.18)	(2.38)
C.D at 5%		N.S	0.43	0.39	NS	N.S	N.S	0.88	N.S	N.S	N.S

Figures in parenthesis are transformed values of $\sqrt{x+0.5}$; DAT Days after treatment NS : Non Significant

Table 4: Effect of insecticides on seed yield (q/ha) of rapeseed Var.- M 27

Treatment	**Conc.%**	**q/ha**
Phosphamidon	0.03	10.69
Dimethoate	0.03	11.58
Carbaryl	0.05	5.34

Cypermethrin	0.01	10.86
Chloropyriphos	0.05	8.19
Quinalphos	0.05	8.79
Malathion	0.05	8.37
Water (Control)		4.54
C.D at 5%		0.94

Discussion

The present experiment revealed that the insecticides dimethoate phosphamidon and cypermethrin were almost equally effective in controlling the mustard aphid, Lipaphis erysimi population. It was also observed that these insecticides have quick knockdown effect in reducing aphid population. Dimethoate was found effective in checking aphid population

even at once spray. (Table1) Singh et.al. 1987 [11], supported that dimethoate was the most effective against *L. erysimi.* Gupta (1971) [1] reported that phosphamidon has a very quick knock down effect but its residual toxicity is very low. In the present study also, the population of *L. erysimi* started to increase from 7th day of application ` and Gupta (1986) [4] reported that two sprays of phosphamidon or any of the other two systemic insecticides were effective in controlling aphid population which is in agreement with the findings of Singh and Sincar (1980) [10]. The result suggest that two sprays at an interval of a fortnight can effectively control aphid population.

Regarding the toxic effect of insecticides to foraging bees, the honey bees were less effected within the treatments of malathion cypermethrin and quinalphos as compared to other treatments. Among these insecticides Carbaryl, dimethoats and phosphamidon showed high toxicity to *A. cerana* because only few bees were observed and spend minimum time or flower after application Singh et. al. (1987) [11] showed that dimethoate was effective against *L. erysimi* but highly toxic to pollinating agents. Kapil and Lamba (1974) [5], Rathore et al (1987) [9] and panda et. al. (1989) [7] reported that a significant reduction in the number of bees was obtained by the application of Phosphamidon. In the present experiment the plots receiving malathion treatment show a significant number of bees population, each bee spending a considerable time on each flower. Thakur and Kashyap (1989) [13] Johansen (1977) [3] also found malathion as safer insecticides to bees Cypermethrin was also found safer to bees in the present investigation and it was observed that a large number of bees used to visit even after application of cypermethrin and each bee spending more time on each flower. Svendsen (1983) [12] reported that Cypermethrin was moderately toxic to bees and further recommended the use of Synthetic pyrethroids on flowering oilseed rape between 1200 and 5.00 hours in Denmark when bees were not visiting the crop Hassan (1986) [2] also supported our findings that pyrethroids were highly toxic to silkworm larvae but much less toxic to honey bees.

Conclusion

From the above result, it can be concluded that among the tested insecticides, the best result in controlling the aphid population were obtained with the treatment of dimethoate, phosphamidon and cypermethrin. But dimethoate and phosphamidon were found highly toxic to foraging *Apis cerana.* These insecticides can be effectively used before the initiation and after the completion of flowering when the pollinators are absent. Similar conclusion was also drawn by Singh it al (1987) [11] Cyperamethrin 0.01 percent effectively reduced the aphid population for a longer period and does not effect the bee population and their foraging activity. Regarding the seed yield, the highest seed yield was found in the plots treated with dimenthoate followed by Phosphamidon and Cypermethrin. Therefore Cypermethrin can be recommended in order to combat with mustard aphid where the pollinator population is considerably high.

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