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Evaluation of insecticide formulations against bud flies (*Dasyneura lini* Barnes) in linseed

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Abstract
Experiments on bio-efficacy of various insecticides *i.e.*, Acephate 75% SP @ 1.35g/ l water (T_1), Fipronil 5% SC@ 1ml/ l water (T_2), Diafenthiuron 50% WP@ 0.2g/ l water (T_3), Dimethoate 30% EC@ 2ml/ l water (T_4), Imidacloprid 17.8% SL @ 0.3ml/ l water (T_5), Monocrotophos 36% SL @ 1.5ml/ l water (T_6) including untreated control were conducted with the linseed variety Neelum against bud fly (*Dasyneura lini*) during *rabi* 2014-2015 and 2015-2016. Only one spray was given at 50 per cent flowering of the crop during both the years. Results revealed that all the insecticides offered considerable suppression of infestation by bud fly when compared with the unprotected plots. Among various treatments, spraying of Imidacloprid@0.30ml/l and Fipronil @ 1.0ml/l recorded with minimum mean incidence (7.42% and 7.54%) of bud fly by giving 12.07 and 11.10 q/ha seed yield of linseed during both the seasons, respectively. Whereas, older conventional insecticides like Monocrotophos (13.41%) and Acephate (14.30%) were significantly inferior to the novel insecticides but are better than untreated control and hence proves the superiority of newer molecules over conventional insecticides.

Keywords: Linseed, *Dasyneura lini*, budfly, insectides

1. Introduction
Linseed (*Linum usitatissimum* L.) is an important oilseed crop grown in India, after Rapeseed and Mustard, either for oil extracted from seed or for fiber from stem. The left over cortical tissues serve as source of wax and raw material for paper industries [4]. In India, linseed is cultivated in about 2.63 lakh ha with a total linseed production of 1.25 lakh MT and 477 kg/ha productivity. A total of 0.34 Lakh tones of linseed oil had been extracted during the year 2015-2016 [1]. Jharkhand is one of the important linseed growing states of India with an average productivity of 560 kg/ha [2].
Among the various factors for its low production, insect-pest also forms an important restraining factor. Linseed budfly (*Dasineura lini* Barnes), leaf minor (*Phytomyza horticola* Gour), linseed caterpillar (*Laphygma exigua* Hübn.), semilooper (*Plusia orchalcea* Fabr.) and aphid (*Myzus persicae* Sulz.) are found to attack this crop from early stage to maturity [11]. Amongst these, linseed bud fly, *Dasineura lini*, (Cecidomyiidae: Diptera) has been rated the most destructive key pest of the flower bud [9] causing 88 per cent of grain damage [7]. The adult of this gall midge is a small orange fly. But the damage is the result of feeding activity by maggots on buds and flowers resulting in the failure of pod-formation. The infested buds become hollow and can be easily distinguished from the healthy buds. Keeping in view of limited investigation regarding relative efficacy of newer insecticides against this midge, an attempt was made to find out their efficacy under field conditions. Besides, a comparative study has been made between the newer/novel insecticides like Fipronil (phenyl pyrazole group), Imidacloprid (neo-nicotinoid group), Difenthiouron (thiourea group) and conventional insecticides like Monocrotophos, Acephate and Dimethoate in order to know their efficacy.

2. Materials and Methods
The present field experiments were conducted during *rabi* season of 2014-15 and 2015-16 with linseed variety Neelum at Linseed Research Farm, Birsa Agricultural University, Kanke, Ranchi (Jharkhand) to find out the most effective insecticide formulations against linseed bud fly. The treatments comprised of Acephate 75% SP @ 1.35g/ l water (T_1), Fipronil 5% SC@ 1ml/ l water (T_2), Diafenthiuron 50% WP@ 0.2g/ l water (T_3), Dimethoate 30% EC@ 2ml/ l water (T_4), Imidacloprid 17.8% SL @ 0.3ml/ l water (T_5), Monocrotophos 36% SL @ 1.5ml/ l water (T_6) and Control (Spraying of water) (T_7), was laid out in randomized block design with

three replications. The crop was sown in plot size of 1.95 m x 3 m keeping row to row and plant to plant spacing of 30 cm and 5 cm, respectively. The sowing was done on the first week of December in both the years. The insecticides were sprayed for only one time at fifty per cent flowering of the crop stage during both years.

2.1 Observations recorded

i. Total number of buds and number of damaged buds per square meter on random basis (for bud fly infestation) were recorded at just before and after the spray. Finally, percentage of bud fly infestation was calculated treatment wise for the respective dates of observation.

$$\text{Bud fly infestation (BFI)} = \frac{\text{No. of damaged buds}}{\text{No. of total buds}} \text{ x } 100$$

ii. Yield was recorded on per plot basis (kg/ plot)

3. Statistical analysis

Percent bud fly infestation was subjected to angular transformation before the analysis. The transformed data were analyzed using ANOVA technique and subjected to DMRT (Duncan's Multiple Range test). The yield (kg/plot) recorded was computed on quintal basis (q/ ha) after harvesting. Reduction of BFI over control was calculated by the formula:

$$\text{BFI reduction over control (\%)} = \frac{\text{BFI of control-BFI of treated plot}}{\text{BFI of control}} \text{ x } 100$$

4. Results and Discussion

Efficacy of different insecticides in both years (2014-15 and 2015-16) is presented in Table 1 and 2. Pre-treatment count indicated a uniform distribution in bud infestation among various plots. After insecticidal application, all the treatments significantly effective in reducing the bud infestation due to bud fly, at different days of observations. All the new formulations namely Imidacloprid resulted in the lowest bud infestation (7.78%) and remained at par with Fipronil (7.88%) which in turn was at par with Dimethoate and Diafenthiuron. The remaining two insecticides i.e. Monocrotophos (12.06%) and Acephate (13.39%) even though superior to untreated control could not surpass Imidacloprid and Fipronil.

The results on bud infestation during 2015-16 also seemed parallel with those of previous year and evidently established the domination of both Imidacloprid and Fipronil over rest of the insecticides in all the (days after treatment) of the observation. The overall mean per cent bud damage on linseed crop revealed that the extent of bud damage due to bud fly varied from 7.78 to 33.05 per cent (2014-15) and 7.06 to 35.85 per cent (2015-16). The relative pest suppression activity of different insecticides formulations was in order of Imidachloprid@ 0.30ml/l > Fipronil@ 1.0ml/l > Diafenthiuron@ 0.2g/l > Dimethoate@ 2.0ml/l > Monocrotophos@ 1.5ml/l > Acephate @ 1.35g/l > Control. The spraying of Imidacloprid@0.30ml/land Fipronil @ 1.0ml/l were most effective by giving 12.07 and 11.10 q/ha seed yield of linseed (Table 3) with higher increase in yield over control, respectively.

In this experiment, novel insecticides like Imidacloprid and Fipronil were proved to be significantly effective at controlling the damage by bud fly in linseed. The results seem to be in agreement with those of Daharia and Katlam [5] who reported that two sprays of Imidacloprid at 45 and 60 days after sowing had lead to maximum reduction in bud fly infestation. In the same experiment, Fipronil recorded with 61 per cent reduction in infestation over control. Prasad *et al.* [10] observed that 3 to 5 rounds of foliar spraying of Imidacloprid (0.003%) proved to be economically superior. Efficacy of Fipronil and Neonicotinoids namely Imidacloprid, Acetamiprid, and thiomethoxam in suppressing BFI was also stated by Pal [8]. Among a fewer new insecticides tested by Seni and Naik [13] Fipronil emerged effective in reducing the rice gall midge damage.

In a study conducted by Sathi *et al.* [12], Dimethoate and Monocrotophos significantly reduced the damage by this dipteran midge whereas in another trial Acephate was recorded with lowest (9.93%) incidence of *D. lini* [3]. In contrast to these revelations, all these three insecticides were statistically far behind newer insecticides in reducing the bud fly infestation. These novel insecticides play an important role in managing the insect pests with good bioefficacy, high selectivity and low mammalian toxicity, which make them attractive replacement for synthetic organic pesticides [6] and may be considered while framing an integrated pest management (IPM).

Table 1: Efficacy of various insecticides against bud fly infestation on linseed var. Neelum recorded during *rabi*, 2014-15

Treatment with dose	Bud fly (*D. lini*) infestation (%)							
	(Pre-treatment count)	2 DAT	6 DAT	10 DAT	14 DAT	18 DAT	22 DAT	Mean
T_1(Acephate @ 1.35g/l)	15.25 (22.99)*	14.70 (22.55)	13.90 (21.89)	13.40 (21.47)	12.50 (20.70)	12.10 (20.36)	11.90 (20.18)	13.39
T_2 (Fipronil @ 1.0ml/l)	10.15 (18.58)	09.58 (18.01)	08.90 (17.36)	07.15 (15.51)	06.85 (15.17)	06.44 (14.71)	06.12 (14.32)	07.88
T_3(Diafenthiuron@0.2g/l)	12.38 (20.60)	11.85 (20.13)	11.15 (19.50)	10.86 (19.24)	09.75 (18.19)	08.85 (17.31)	08.36 (16.79)	10.46
T_4(Dimethoate@2.0ml/l)	12.70 (20.88)	11.70 (20.00)	11.18 (19.53)	10.22 (18.64)	10.09 (18.50)	09.55 (18.00)	08.18 (16.62)	10.52
T_5(Imidachloprid@0.30ml/l)	09.90 (18.34)	09.15 (17.61)	08.92 (17.38)	07.90 (16.32)	07.25 (15.62)	06.11 (14.32)	05.25 (13.24)	07.78
T_6 (Monocrotophos@1.5ml/l)	13.75 (21.76)	13.10 (21.22)	12.90 (21.05)	12.35 (20.57)	11.44 (19.77)	10.70 (19.09)	10.21 (18.64)	12.06
T_7(Control)	14.90 (22.71)	31.49 (34.13)	33.21 (35.20)	36.49 (37.16)	37.19 (37.56)	38.39 (38.27)	39.69 (39.04)	33.05
SEm(±)	0.903	0.824	0.824	0.866	0.926	0.938	0.979	
CD (p=0.05)	N.S.	2.567	2.566	2.698	2.885	2.921	3.051	
CV (%)	13.288	11.550	11.680	12.554	13.764	14.264	15.281	

*Figures in parentheses are arc sin $\sqrt{\text{percentage}}$ transformed values

DAT – Days after treatment

Table 2: Efficacy of various insecticides against bud fly infestation on linseed var. Neelum recorded during *rabi*, 2015-16

Treatment	Dose	Bud fly (*D. lini*) infestation (%)							
		(Pre-treatment count)	2 DAT	6 DAT	10 DAT	14 DAT	18 DAT	22 DAT	Mean
T_1Acephate	1.35g/l	17.08 (23.37)*	16.53 (23.89)	15.73 (23.37)	15.23 (22.97)	14.33 (22.24)	13.93 (21.91)	13.73 (21.75)	15.22
T_2Fipronil	1.0ml/l	16.98 (10.21)	08.92 (17.36)	06.58 (14.85)	05.90 (14.06)	04.89 (12.78)	04.62 (12.40)	04.21 (11.83)	07.20
T_3 Diafenthiuron	0.2g/l	11.10 (20.60)	10.57 (18.97)	09.87 (18.30)	09.58 (18.01)	08.47 (16.92)	07.57 (15.97)	07.08 (15.40)	09.17
T_4Diamethoate	2.0ml/l	13.30 (20.88)	12.30 (20.53)	11.78 (20.05)	10.82 (19.19)	10.69 (19.08)	10.15 (18.58)	08.78 (17.24)	11.12
T_5Imidachloprid	0.30ml/l	15.30 (18.34)	08.37 (16.82)	07.39 (15.78)	05.37 (13.38)	04.72 (12.53)	04.58 (12.37)	03.72 (11.10)	07.06
T_6Monocrotophos	1.5ml/l	16.24 (21.76)	15.85 (23.46)	15.65 (23.30)	15.10 (22.87)	14.19 (22.12)	13.45 (21.50)	12.96 (21.10)	14.77
T_7 (Control)	-	15.65 (22.71)	30.47 (33.50)	35.19 (36.37)	38.47 (38.32)	41.17 (39.91)	43.37 (41.19)	46.67 (43.09)	35.85
SEm ±		0.835	0.999	1.856	1.222	1.056	1.398	1.269	
CD (P=0.05)		N.S.	3.112	5.781	3.807	3.290	4.356	3.953	
CV %		11.170	13.855	27.359	18.419	15.934	20.375	19.718	

*Figures in parentheses are arc sin √percentage transformed values
DAT – Days after treatment

Table 3: Evaluation of insecticide formulations against linseed bud fly

Treatment	Dose	BFI* (%)		Mean BFI (%)	Reduction over control (%)	Seed yield (q/ha)		Mean seed yield (q/ha)
		2014-15	2015-16			2014-15	2015-16	
T_1Acephate	1.35g/l	13.39	15.22	14.30	58.49	7.30	6.12	6.71
T_2Fipronil	1.0ml/l	7.88	7.20	7.54	78.11	10.90	11.30	11.10
T_3 Diafenthiuron	0.2g/l	10.46	9.17	9.81	71.52	9.60	10.12	9.86
T_4Dimethoate	2.0ml/l	10.52	11.12	10.82	68.59	8.95	7.85	8.40
T_5Imidachloprid	0.30ml/l	7.78	7.06	7.42	78.46	11.60	12.55	12.07
T_6Monocrotophos	1.5ml/l	12.06	14.77	13.41	61.07	7.90	6.76	7.33
T_7 (Control)	-	33.05	35.85	34.45	-	4.80	4.15	4.75
SEm ±						0.338	0.330	
CD (P=0.05)						1.052	1.029	
CV %						20.120	20.417	

*BFI – Bud fly infestation

5. Conclusion

To sum up, insecticides with novel modes of action like Imidacloprid and Fipronil are significantly more effective than conventional nerve poisons namely Monocrotophos and Acephate in reducing the damage caused by the dipteran midge, *Dasyneura lini* Barnes, during both the years of experiments. Still a very wide range of novel insecticides are to be evaluated, as a very less number of these insecticides were tested against linseed bud fly. Future research should be projected towards developing these newer molecules of insecticides which are bio-degradable, target-specific, less vertebrate-toxic, less persistent and eco-friendly making to make them more compatible in any of the IPM practices.

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