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Effect of chemical insecticides on the incidence of leaf folder (*Cnaphalocrocis medinalis*) in terms of leaf damage

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Abstract
The rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) (Lepidoptera: Pyralidae) was earlier considered a minor pest in many Asian countries. But after 1980 it has become a major pest of rice due to changing agro climatic conditions and new cultural practices. Therefore, present studies on to check the bio-efficacy of newer molecules of different insecticides against leaf folder of rice. Among the nine insecticides, application of Spinetoram 6SC + Methoxyfenozide 30SC @ 400 ml/ha was found to be most effective against leaf damage in case of incidence in both years 2016 and 2017. But it was at par with spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/ha and flubendiamide 48% SC @ 50 ml/ha. This new type of chemical insecticide has been very successful in reducing the population of leaf folder in a very short time and it also causes very little damage to the environment.

Keywords: Rice, newer molecules, insecticides, *Cnaphalocrocis medinalis*, bio-efficacy

Introduction
Rice is one of the leading cereal crops in the world and half of the population depends on this cereal crop for its dietary needs [1]. It is the major staple food for most of Asia [2]. Rice belongs from the family Graminae and is self-pollinated crop. More than half of the world's population depends on rice for it's main food. The rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) (Lepidoptera: Pyralidae) is considered as a serious pest of paddy and is also known as rice leaf roller. It has been found that the infestation of the world's 70% Rice is produced in India and the rest of it is produced in Pakistan. In Indian-Punjab, Haryana, U.P, Uttrakhand, Jammu and Kashmir are major states. In India the area and production under cultivation are 27 lakh hectare and 81 lakh tonne respectively. Among various constraints, rice production, losses due to insect pests are substantial and demands more attention [3]. Rice yield is decreased slightly at global level due to increased insects and pests. It has been evaluated that these pests cause damage up to 21-51% which is one of major reasons for poor crop productivity in India. Leaf folder (*Cnaphalocrocis medinalis*) has caused most of the loss to the paddy. Ramzan *et al.*, (1992) [4] accounted one of major pests of paddy. The Rice leaf folder is a leaf feeding rice pest. Out of eight species of leaf folder (*Cnaphalocrocis medinalis)* is the most important. The young larvae feed on leaves by scratching it and fold the leaves and secreted sticky substances. Khan *et al.* (1989) [5] Observed that more than 90% of leaf folders die by application of various insecticides. Our results are in partial agreement with those of Mishra *et al.* (1998) [6] who observed that Monocrotophos and Cypermethrin gave good control of rice leaf-folder and were at par statistically. Therefore, present studies to check the bio-efficacy of newer molecules of different insecticides against leaf folder of rice with the objective of effect of chemical insecticides on the incidence of leaf folder (*Cnephalocrosis medinalis*) in terms of leaf damage (LDLF %) of rice.

Methods and Materials
In order to evaluate field bio-efficacy of newer molecules of different insecticides against leaf folder of rice, a field trial was conducted at Rice research farm, RAC,B.A.U, Kanke, Ranchi, Jharkhand during *kharif season*, 2016 and 2017. Treatment application: Periodical and need based application of the respective test insecticidal treatments were applied based on the ETL of the pest species at the different stages of the crop.

Observations on leaf folder incidence were to be recorded at 4th, 7th, & 10th days after insecticidal application (DAA) in terms of leaf damage (LDLF %)

Table 1: Details of experiment conducted in *kharif* season in year 2016 and 2017

Design Insecticidal treatments :	RBD (Randomized block design) 10
Replications	3
Spacing (plant to plant)	15 cm
Spacing (row to row)	20 cm
Plot size	5 x 4 m
N:P:K	80:40:20 ka/ha (As per local recommendation)
Date of sowing	3rd July
Date of transplanting	22th July
Date of insecticide application	80 DAT
Date of harvesting	7th November
Crop variety	Naveen

Table 2: Treatment details of field bio-efficacy of some selected commercial formulations of newer molecules of chemical insecticide against leaf folder of rice

Treatments	Trade name	Common Name	% a.i. in formulations	Dose of the formulated product (ml or g /ha)	Dose ml or g/l of water
T 1	Spinetoram 6 %SC+Methoxyfenozide 30% SC	Spinetoram 6 % SC+Methoxyfenozide 30 % SC	36SC	375 ml	0.75 ml
T 2	Spinetoram 6 % SC+Methoxyfenozide 30 % SC	Spinetoram 6 % SC+Methoxyfenozide 30 % SC	36SC	400 ml	0.80ml
T 3	DPX-RAB55	Triflumezopyrim	106SC	238 ml	0.475 ml
T 4	Fame	Flubendiamide 480 % SC	48SC	50 ml	0.10 ml
T 5	Coragen	Rynaxypyr	20SC	150 ml	0.30 ml
T 6	Hunk	Acephate	95SG	526 g	1.053
T 7	Osheeen	Dinotefurain	20 SG	200g	0.40 g
T 8	Hostathion	Triazophos	36SL	1500 ml	3 ml
T 9	Furadan + Hostathion (in form of alternate use)	Carbofuran + triazophos (in form of alternate use)	3G+40EC	30kg+1500ml	30kg+ 3 ml
T 10	Untreated control	-	--	-	-

Result and Discussion

The data Table -3. Depicted that the leaf damage caused by leaf folder (LDLF) were recorded in the late vegetative stage to pre-maturity stage of the crop. As such, observations on per centage of leaf damage, due to leaf folder (LDLF %) was recorded at 4, 7 and 10 DAA (Days after Application) during *Kharif* season 2016 and 2017. Peak duration of occurrence of leaf folder was observed almost from 80 DAT and onward period during both years of the experimentations.

1. Incidence of leaf damage (LDLF) recorded at 4 days after application (4 DAA)

i) Incidence of LDLF recorded at 4 DAA, during 2016

The effect of insecticides used against leaf folder in terms of leaf damage was found to be significant. The minimum leaf damage (0.44%) was found in the treatment of ready mix combination product of spinetoram 6 % SC + methoxyfenozide 30% SC @ 400 ml/ha, which was found to be superior over all the test insecticides, but it was at par with that of leaf damage due to the pest under the production cover provided with the lower combination product of spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/ha (0.52% LDLF) and flubendiamide48 % SC @ 50 ml/ha (0.65% LDLF). The highest leaf damage of 7.58 per cent LDLF was observed in case of the unprotected crop.

ii) Incidence of LDLF recorded at 4 DAA, during 2017

The effects of the test insecticides on the incidence of leaf folder in terms of leaf damage were found to be significant results (Table 4.5.4). The minimum leaf damage was found in terms of leaf damage 0.44 per cent LDLF in the treatment consisting of the readymade combination of spinetoram 6 % SC + methoxyfenozide 30% SC @ 400 ml/ha, which remained superior over all the test insecticides, but it was at par with spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/ha (0.52% LDLF) and flubendiamide48% SC @ 50 ml/ha (0.65% LDLF). The highest leaf damage of 7.58 per cent LDLF was observed in case of the untreated plot.

iii) Pooled mean incidence LDLF of recorded at 4 DAA, during2016 and 2017

A perusal of the pooled data of the test insecticides against leaf folder in terms of leaf damage was found to be significant. The minimum leaf damage (0.65%) was found in the treatments comprising of the ready-mix new combination of spinetoram 6 % SC + methoxyfenozide 30% SC @ 400 ml/ha, which was found to be superior among all the test insecticides, but it was at par with spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/ha (0.74%). The highest leaf damage of 7.79 per cent LDLF was observed in case of the untreated plot.

2. Incidence of leaf damage (LDLF) recorded at 7 days after application (7 DAA)

i) Incidence of LDLF recorded at 7 DAA, during 2016

The effect of the test insecticides used against leaf folder in terms of leaf damage remained significant. The minimum leaf damage (1.00%) was found in the treatment comprising of the ready mix combination of spinetoram 6 % SC + methoxyfenozide 30% SC @ 400 ml/ha, which, in turn, remained superior over all the test insecticides, but it was at par spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375

ml/ha (1.15% LDLF), flubendiamide48% SC @ 50 ml/ha (1.32% LDLF) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.47% LDLF). The highest leaf damage of 8.85 per cent was observed in case of the untreated crop of rice.

ii) Incidence of LDLF recorded at 7 DAA, during 2017

The effect of insecticides on the incidence of leaf folder was found significant. The minimum leaf damage (1.46%) were found in the treatment with the new combination product of spinetoram 6 % SC + methoxyfenozide 30% SC @ 400 ml/ha, which was superior over all the test insecticides, but it was at par with spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/ha (1.62% LDLF), flubendiamide 48% SC @ 50 ml/ha (1.79% LDLF), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40EC @ 1500 ml/ha (1.94% LDLF) and acephate 95% SG @ 526g/ha (2.08% LDLF). The highest leaf damage of 9.31 per cent LDLF was observed in case of unprotected crop of rice.

iii) Pooled mean incidence of LDLF recorded at 7 DAA, during 2016 and 2017

A perusal of the pooled data of the test insecticides against leaf folder in terms of leaf damage was found to be significant. The minimum leaf damage of 1.23 per cent was found in the treatment comprising of the new combination of spinetoram 6 % SC + methoxyfenozide 30% SC @ 400 ml/ha, which was superior over all the test insecticides, but it was at par with spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/ha (1.38% LDLF) and flubendiamide 48% SC @ 50 ml/ha (1.56% LDLF). The highest leaf damage of 9.08 per cent LDLF was observed in case of the unprotected crop.

3. Incidence of leaf damage (LDLF) recorded at 10 days after application (10 DAA)

i) Incidence of LDLF recorded at 10 DAA, during 2016

The effects of insecticides used against leaf folder in terms of leaf damage remained significant results. The minimum leaf (1.59%) damage was found in the treatment comprising of the ready mix combination of spinetoram 6 % SC + methoxyfenozide 30% SC @ 400 ml/ha, which in turn, remained superior over all the test insecticides, but it was at par with to lower dose of the same combination product of spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/ha (1.82% LDLF), flubendiamide 48% SC @ 50 ml/ha (2.03% LDLF) and carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40 %EC @ 1500 ml/ha (2.16%). The highest leaf damage of 9.88 per cent was observed in case of unprotected crop.

ii) Incidence of LDLF recorded at 10 DAA, during 2017

The effect of insecticides on the incidence of leaf folder was found significant. The minimum leaf damage (2.03%) was found in the treatment having foliar spray with the combination product spinetoram 6 % SC + methoxyfenozide 30% SC @ 400 ml/ha, which was superior over all the test insecticides, but it was at par with spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/ha (2.27% LDLF), flubendiamide48 %SC @ 50 ml/ha (2.48% LDLF), carbofuran 3G @ 30 kg/ha followed by need based foliar spray with triazophos 40 %EC @ 1500 ml/ha (2.61% LDLF) and acephate 95 %SG @ 526g/ha (2.77% LDLF). The highest leaf damage of 10.33 per cent was observed in unprotected crop of rice.

iii) Pooled mean incidence of LDLF recorded at 10 DAA, during 2016 and 2017

A perusal of results of insecticides, against leaf folder was found to be significant. The minimum leaf damage (1.81%) was found in the treatment of spinetoram 6 % SC + methoxyfenozide 30% SC @ 400 ml/ha, which was superior among all the test insecticides, but it was at par with the lower dose of spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/ha (2.05% LDLF). The highest leaf damage of 10.11 per cent LDLF was observed in case of untreated crop.

4. Overall mean of leaf damage (LDLF) recorded at 4, 7 and 10 days after application

i) Mean of LDLF recorded at 4, 7 and 10 DAA, during 2016

A perusal of results of overall mean of three dates observations (4, 7 & 10 DAA), the effect was found significant. The minimum leaf damage (1.01%) was found in the treatment consisting of the readymade combination of spinetoram 6 % SC + methoxyfenozide 30% SC @ 400 ml/ha, which in turn, was superior over all the test insecticides, but it was at par with spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/ha (1.17% LDLF) and flubendiamide 48 % SC @ 50 ml/ha (1.33% LDLF). The highest leaf damage of 8.77 per cent LDLF was observed in case of the untreated crop of rice.

ii) Mean of LDLF recorded at 4, 7 and 10 DAA, during 2017

A perusal of results of overall mean of three dates observations (4, 7 & 10 DAA), indicated that the effect of insecticides against leaf folder was found to be significant. The minimum leaf damage (1.45%) was found in the treatment comprising of the new combination If spinetoram 6 % SC + methoxyfenozide 30% SC @ 400 ml/ha, which in turn, remained superior over all the test insecticides, but it was at par with spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/ha (1.61% LDLF) and flubendiamide 48% SC @ 50 ml/ha (1.78% LDLF). The highest leaf damage of 9.22 per cent was observed in case of the untreated crop.

iii) Pooled mean of LDLF recorded at 4, 7 and 10 DAA, during 2016 and 2017

A perusal of results pertaining to the overall mean of three dates of observations (4, 7 & 10 DAA), indicated that the impact of the insecticides used againstleaf folder in terms of leaf damage was found to be significant. The minimum leaf damage of 1.23 per cent was found in the treatment of spinetoram 6 % SC + methoxyfenozide 30% SC @ 400 ml/ha which was superior to all the test insecticides, but it was at par with spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/ha (1.39% LDLF). The highest leaf damage of 8.99 per cent was observed in case of the unprotected crop.

Earlier, various scientists evaluated the bio-efficacy of different chemical insecticide against leaf folder in rice at different locations of India. Similar studies were observed by Khan *et al.* (1989) [5] who observed that more than 90% of insects die by the application of various insecticides. Our results are in partial agreement with those of Mishra *et al.* (1998) [6] who observed that Monocrotophos and Cypermethrin gave good control of rice leaf-folder and were at par statistically findings of earlier workers (Dash and Mukherjee, 2003; Rao, 2003) [7 & 8] are more or less in the agreement with the results of the present field investigation.

Prasad (2010) [9] found that combination product (imidacloprid 40WG @+ ethiprole 40%) 80 WG @ 125 g a.i/ha as well as efficacy the combination of cypermethrin 5% EC + chlorpyriphos 50% EC i.e. Super –D @ 1500 ml/ha which could be the most efficacious against leaf folder. These findings of earlier workers also endorsed the results of the present studies. The highest incidence of leaf folder to the tune of 28.55 and 17.84 per cent LDLF were recorded, when the crop was left unprotected in the present field studies in 2016 and 2017, respectively.

Conclusion

It can be concluded that the minimum infestation of leaf folder insect in case of application of spinetoram 6 % SC + methoxyfenozide 30 % SC @ 400 ml/ha which was found to be most superior showed highest minimize the infestation of insect pests with lowest pest incidence in terms of leaf damage. But it was at par with spinetoram 6 % SC + methoxyfenozide 30 % SC @ 375 ml/h. New molecules help in the terms of minimizing the residual effect, pest resistant and pest management.

Table 3: Effect of chemical insecticides on the incidence of leaf folder (*Cnaphalocrocis medinalis*) in terms of leaf damage (LDLF %)

S.N	Treatment	Formulations (a.i.) or	Dose (ml or g/ha)	Percentage of leaf damage caused by the leaf folder (LDLF), recorded after spray at											
				4 DAA			7 DAA			10 DAA			Overall Mean		
				2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean	2016	2017	Pooled Mean
T1	Spinetoram 6SC+methoxyfenozide 30SC	36 SC	375 ml	0.52 (4.04)	0.95 (5.52)	0.74 (4.78)	1.15 (5.94)	1.62 (7.14)	1.38 (6.54)	1.82 (7.45)	2.27 (8.40)	2.05 (7.93)	1.17 (5.97)	1.61 (7.12)	1.39 (6.55)
T2	Spinetoram 6SC+methoxyfenozide 30SC	36 SC	400 ml	0.44 (3.70)	0.87 (5.27)	0.65 (4.48)	1.00 (5.50)	1.46 (6.78)	1.23 (6.14)	1.59 (6.95)	2.03 (7.96)	1.81 (7.45)	1.01 (5.54)	1.45 (6.76)	1.23 (6.15)
T3	Triflumezopyrim	106 SC	238 ml	1.23 (6.08)	1.66 (7.18)	1.44 (6.63)	1.90 (7.79)	2.37 (8.73)	2.14 (8.26)	2.60 (9.09)	3.04 (9.87)	2.82 (9.48)	1.91 (7.76)	2.36 (8.67)	2.13 (8.21)
T4	Flubendiamide	48SC	50 ml	0.65 (4.59)	1.07 (5.91)	0.86 (5.25)	1.32 (6.39)	1.79 (7.52)	1.56 (6.96)	2.03 (8.06)	2.48 (8.93)	2.26 (8.49)	1.33 (6.51)	1.78 (7.56)	1.56 (7.03)
T5	Rynaxypyr	20SC	150 ml	1.39 (6.55)	1.81 (7.56)	1.60 (7.06)	2.05 (8.00)	2.52 (8.93)	2.28 (8.46)	2.73 (9.47)	3.18 (10.22)	2.96 (9.85)	2.06 (8.12)	2.50 (8.98)	2.28 (8.55)
T6	Acephate	95SG	526 g	1.03 (5.59)	1.45 (6.75)	1.24 (6.17)	1.61 (7.11)	2.08 (8.13)	1.85 (7.62)	2.32 (8.66)	2.77 (9.47)	2.55 (9.07)	1.65 (7.24)	2.10 (8.20)	1.88 (7.72)
T7	Dinotefurain	20 SG	200 g	1.51 (6.84)	1.94 (7.82)	1.73 (7.33)	2.19 (8.30)	2.66 (9.19)	2.42 (8.75)	2.86 (9.64)	3.30 (10.38)	3.08 (10.01)	2.19 (8.35)	2.63 (9.19)	2.41 (8.77)
T8	Triazophos	40 EC	1500 ml	1.14 (5.81)	1.57 (6.95)	1.35 (6.38)	1.74 (7.38)	2.21 (8.37)	1.98 (7.87)	2.45 (8.93)	2.90 (9.72)	2.68 (9.32)	1.78 (7.50)	2.22 (8.43)	2.00 (7.97)
T9	Carbofuran followed bytriazophos	3G & 40 EC	30 kg & 1500 ml	0.90 (5.35)	1.33 (6.53)	1.11 (5.94)	1.47 (6.87)	1.94 (7.91)	1.71 (7.39)	2.16 (8.34)	2.61 (9.18)	2.39 (8.76)	1.51 (6.96)	1.96 (7.95)	1.74 (7.45)
T10	Untreated control	Water spray	500 lit.	7.58 (15.88)	8.01 (16.33)	7.79 (16.11)	8.85 (17.14)	9.31 (17.61)	9.08 (17.38)	9.88 (18.01)	10.33 (18.44)	10.11 (18.23)	8.77 (17.06)	9.22 (17.51)	8.99 (17.28)
SEm±				(0.40)	(0.36)	(0.25)	(0.50)	(0.48)	(0.31)	(0.57)	(0.55)	(0.36)	(0.33)	(0.33)	(0.21)
CD 5%				(1.19)	(1.07)	(0.71)	(1.48)	(1.41)	(0.89)	(1.69)	(1.63)	(1.01)	(0.99)	(0.97)	(0.61)
CV %				(10.79)	(8.24)	(9.43)	(10.72)	(9.11)	(9.87)	(10.43)	(9.28)	(9.84)	(7.15)	(6.24)	(6.67)

Figures under the parenthesis are angular transformed values. LDLF-Leaf damage due to leaf folder

DAT-Days after transplanting; DAA-Days after application of insecticidal treatment, foliar spray of the insecticidal treatments was applied at 80 DAT.

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