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Bio-efficacy of Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC against lepidopteran insect pests in Rice ecosystem

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Abstract
A field experiment was conducted to evaluate the bio efficacy of different doses of Spinetoram 6% + Methoxyfenozide 30% SC against lepidopteran insect pest in paddy at Agricultural Research Station, Kawadimatti during 2014-15. The results revealed that application of Spinetoram 6% w/v + Methoxyfenozide 30% SC @ 400ml/ha was found to be excellent insecticide in suppressing the leaf folder and stem borer population during kharif 2014-15 paddy crop by registering 0.52 % and 0.78 % reduction over control of leaf folder and stem borer, respectively. The next best treatment was Spinetoram 6% w/v + Methoxyfenozide 30% SC @ 375 ml/ha with 0.71 % and 1.15 % reduction over control of leaf folder and stem borer, respectively. The effect of these applications was also resulted on the yield attributes, with highest grain yield of 52.89 q/ha was observed in Spinetoram 6% w/v + Methoxyfenozide 30% SC @ 400 ml/ha treated plot followed by Spinetoram 6% w/v + Methoxyfenozide 30% SC @ 375 ml/ha (51.88 q/ha) and did not have any severe depressing effect on the natural enemies in the field when applied at recommended doses.

Keywords: Bio-efficacy, insecticides, stem borer, leaf folder, rice, natural enemies

Introduction
Rice (*Oryza sativa* L.) is an important staple food crop for more than two third of the population of India and the total area under rice in Karnataka is 1.42 m ha with an annual production of 3.5 million tones and the productivity is about 2.63 tons per ha [1]. Comparative yields in rice can be obtained by adopting various cultural practices *%*., selection of suitable cultivars, proper sowing time, optimum seed rate, proper weed and water management. Low productivity in rice is attributed by many factors. Among so many biotic and abiotic constraints of rice production insect, mite and nematode pests are the key biotic stresses limiting rice production in India. Over 100 species of insect pests attack on rice ecosystem in various stages of the crop, in which yellow stem borer *Scirpophaga incerulas* (Walker) and Leaf folder *Cnapholocrocis medinalis* (guenee) are the major Lepidopteran insect pests of paddy. Outbreak of these pests habitually leads to entire loss of the rice crop, if no effectual control measures are taken up.

Presently, chemical control is the only practical method for a farmer to respond to an increasing these pests infestation. However, the intensive and continuous cultivation of rice with excessive use of nitrogenous fertilizers has paved the congenial conditions for pest population out breaks thus compelled the farmers to use insecticides for their suppression, results in development of resistance and their negative impact on natural enemies. Hence farmers forced to apply broad spectrum insecticides in heavy doses against recommended due to which diversity of natural enemies has been reduced and further more led to resurgence of lepidoptean pests of rice. Keeping these points in view, an experiment was conducted to determine the effective dose of Spinetoram 6% + Methoxyfenozide 30% SC for the management of lepioperan pests of rice.

Materials and Methods
Evaluation of the Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC against paddy lepidoptern pests were under taken in an experimental block, at Agricultural Research Station, Kawadimatti during Kharif 2014-15.

The experiment was laid out in randomized block design (RBD) with eight treatments replicated thrice. The test chemical Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC (supplied by M/s Dow Agro Sciences India Private Limited) was tested in three different concentrations%., 350, 375 and 400 ml/ha for bio-efficacy and at 800 ml/ha for phytotoxicity (Table 1). The test chemical was compared with standard check Chlorantraniliprole 20% SC and Flubendiamide 48%SC @150 and 50ml/ha against paddy lepidoptern pests and untreated control. Treatments were imposed one time based on pest population build up (above ETL).All the agronomic packages were followed as per recommended package of practices of UAS Raichur.

Table 1: Detail of treatments imposition

Treatments	Details	Dosage ml/ha
T1	Spinetoram 6% /v(5.66%w/w)+Methoxyfenozide 30%w/v(28.3w/w)SC	350
T2	Spinetoram 6% /v(5.66%w/w)+Methoxyfenozide 30%w/v(28.3w/w)SC	375
T3	Spinetoram 6% /v(5.66%w/w)+Methoxyfenozide 30%w/v(28.3w/w)SC	400
T4	Spinetoram 12%w/v(21.8%w/w)SC	192
T5	Methoxyfenozide24%w/v(21.85%w/w)SC	471
T6	Chlorantraniliprole 20%SC	150
T7	Flubendiamide 48%SC	50
T8	UTC	-

Observations were recorded from ten tagged plants per plot. Observations on paddy leaf folder and paddy stem borer and natural enemies were recorded on whole plant basis on ten tagged plants/plot. Observations for paddy leaf folder damaged leaves were recorded at 1day before spraying, 7 and 15 days after spraying, for paddy stem borer percent dead heart was recorded at 40,60 and 90 days after transplanting and per cent white ear recorded after last spray. Natural enemies were recorded on whole plant basis from ten tagged plants at 1DBS and 7 days after last spray for all the treatments. Yield was recorded per plot basis at harvest. The data collected from each sprays was averaged and expressed on per plant basis. The yield data collected from the each plot was extrapolated on hectare basis. The treatments were subjected to statistical analysis by single factor ANOVA and were compared by following Duncan's Multiple Range Test.

Results and Discussion

The bio-efficacy of Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC in comparison with other insecticides for the management of lepidopteran insect pests in rice has been pooled (2014 and 2015) and presented in table 1.

Leaf folder

Before application of the treatments, there was uniform distribution of the leaf folder infestation in all the treatments. However, Variation was observed after imposition of the treatments at 30 Days after transplanting. Observations were recorded on leaf damage due to leaf folder at 7 Days after spraying significantly lowest percent leaf damage was noticed in Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC @ 400ml/ha (0.52%)as against 6.19 percent in untreated control. Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC @ 400ml/ha was significantly on par with Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC @ 375ml/ha (0.71%leaf damage). Similar trend was noticed at 15DAS, The Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w)SC @ 400ml/ha recorded lowest percent of leaf damage (0.4%) and was significantly on par with Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC @ 375ml/ha (0.67%). The remaining treatments were on par with each other. Whereas untreated control recorded highest percent of leaf damage (5.41) (Table 2).

Spinetoram and Methoxyfenozid are the new chemicals, evaluation of these chemicals against leaf folder is first of its kind against rice pests, hence there are no reports of screening of these chemicals against rice pests, particularly stem borers and leaf folders. However there are other reports, [13], who evaluated various insecticides against leaf folder, among them flubendiamide 20% WG @ 25 g a.i./ha was found best effective re against leaf folder followed by Chlorantraniliprole 18.5% SC @ 30 g a.i./ha, Lamda Cyhalothrin 5% EC @ 20 g a.i./ha, Fipronil 5% SC @ 50 g a.i./ha, Dinotefuran 20% SG @ 40 g a.i./ha, and Thiamethoxam 25% WG @ 25 g a.i./ha respectively during both Kharif season of 2016-17 and 2017-18. Similarly [4], tested the efficacy of certain insecticides %., Proaxis 60CS (gammacyhalothrin) @ 75ml, Karate 2.5EC (lambda cyhalothrin) @ 200ml, Padan 4G (cartaphydrochloride) @ 9Kg, Belt480SC (flubendiamide) @ 50ml, Virtako40WG (thiamethoxam + chlorantraniliprole) @ 40gm, Coragen 20CS (chlorantraniliprole) @ 50ml per acre was checked against rice leaf folder *Cnaphalocrocis medinalis* (Guenee). Belt 480 Sc with 1.12% damaged leaves was the best amongst all treatments followed by Proaxis 60CS 1.28%, Karate 2.5 EC 1.83%, Padan 4G 2.37% Virtako 40WG 2.53%, Coragen 20CS 2.59% and in control 15.83% damage was observed. Highest paddy yield was achieved in case of Belt 480 Sc 3.33 t/h followed by Proaxis 60CS 3.18 t/h, Karate 2.5 EC 3.01 t/h, Virtako 40WG 2.87t/h, Padan 4G 2.75 t/h, Coragen 20CS 2.57t/h and control 2.21 t/h. All the new test insecticides proved very effective for the control of rice leaf folder [2]. who evaluated insecticides %., deltamethrin 2.8 EC @ 12.5 g a.i./ha, chlorpyriphos 20 EC @ 300 g a.i./ha, triazophos 40 EC @ 500 g a.i./ha, lambda cyhalothrin 5 EC @ 12.5 g a.i./ha, indoxacarb 14.5 SC @ 30 g a.i./ha and flubendiamide 39.35 SC @ 24 g a.i./ha and one bio pesticide, *Bacillus thuringiensis* var. *kurstaki* were evaluated against rice leaf folder. The infestation of rice leaf folder was effectively checked by the spray of flubendiamide followed by lambda cyhalothrin, indoxacarb, triazophos, chlorpyriphos and deltamethrin.

Stem borer

The testing chemical Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC was tested in different concentration, at 40 DAS Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC

@400ml/ha was recorded lowest percent of dead heart (0.78%) compared to untreated control (3.92%) and was significantly on par with Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC @ 375 ml/ha (1.15%). In remaining treatment dead heart infestation ranged between 2.09 % to 2.44%. Sixty days after transplanting and ninety days after transplanting similar trend were observed in all the treatments. Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC @ 400ml/ha and 375 ml/ha recorded lowest per cent of white ear (2.31% and 2.69% respectively) and were on par with each other. However, untreated control recorded highest percent of white ear 7.54%. Overall, it can be concluded that Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC @ 375ml/ha optimum effective dose for suppressing Leaf folder and stem borer *Scirpophaga* spp., in Kharif paddy.

The results are in agreement with report [5] who evaluated two doses of Flubendiamide 0.7% Gr @ 70 and 85 g a.i./ha, two doses of Spinetoram 0.8% Gr @ 50 and 60 g a.i. ha-1 and standard check Cartap hydrochloride 4% Gr @ 1000 g a.i. ha-1 was tested against yellow stem borer infesting transplanted paddy. Results revealed that, flubendiamide 0.7% Gr at 100 g a.i./ha was found quite effective against YSB recording mean per cent dead heart (DH) and white ear head (WEH) of 1.59 and 1.40 respectively, followed by its next lower dose of 85 g a.i./ha (1.81 DH% and 1.96 WEH %), which was found superior to spinetoram 0.8% Gr @ 60 and 50 g a.i./ha during 2015-16.

Similarly an experiment was conducted [12] to evaluate different doses Spinetoram 6% + Methoxyfenozide 30% SC against early shoot borer (ESB), *Chilo infuscatellus* and Internode borer, *Chilo sacchariphagus indicus* in sugarcane at Agricultural Research Station, Bidar, during 2017- 18 and 2018-19 Summer. Among all the treatments Spinetoram 6% + Methoxyfenozide 30% SC @ 160 ml/ac and 150 ml/ac were found to be very effective in managing the early shoot borer incidence and inter node borer incidence and recorded highest cane yield. Similarly the reports of [11] who evaluated the Rynaxypyr 20 SC @ 30 g a.i/ha treated plot recorded significantly lower per-cent of dead heart (0.42%) and white ear- head (1.24%) caused by stem borer and higher grain yield than the other treatments.

However, [9], who evaluated efficacy of some next-generation insecticides against the rice yellow stem borer (YSB), *Satcirpophaga incertulas* (Walk.), and their compatibilities with natural enemies were investigated during 2014 and 2015. Application of chlorantraniliprole 0.4% G at 10.96 kg/hm2 resulted in the greatest reduction in YSB infestation (Dead hearts and whiteheads) and greatest increase of yield compared to the untreated control plots, followed by methoxyfenozide 24% SC at 0.41 L/hm2, dinotefuran 20% SG at 0.15 kg/hm2, carbufuran 5 G at 10.96 kg/hm2, and quinalphos 25 EC at 1.50 L/hm2. The results are also agree with [10], who revealed that, chlorantraniliprole 18.5 SC was found most effective and minimum cumulative infestation of *S. incertulas* with 2.73 percent dead heart and 2.06 percent white ear recorded after first and second spray, respectively. Whereas, among the treatments the maximum dead hearts (6.18 %) and white ears (7.47 % WE) infestation were recorded from chlorpyriphos 50 + cypermethrin 5 EC (Treated check) [7]. who, showed that in terms of efficacy against stem borer, on the basis of overall performance of granular insecticides, fipronil 0.3G at 10 and 20 kg ha-1 was found to be more effective and superior among other granules in reduction of stem borer infestation to minimum of 1.84 and 2.13 per cent of dead hearts (DH) and 5.63 and 4.07 per cent of white ear heads (WEH) respectively. This was followed by Cartap hydrochloride 4G at 25 and 50 kg ha-1 with 4.61 and 4.63 per cent of DH; 7.00 and 6.40 per cent of WEH respectively. Chlorantraniliprole 0.4 G at 10 kg ha-1 found to be the least effective one with 5.46 and 9.23 per cent of DH and WEH respectively.

Yield

Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC at its higher dosage 400ml/ha was to be significantly superior by registering highest yield of 52.89 q/ha compared to standard checks flubendiamide 48%SC @ 50ml/ha (48.00 q/ha) and Chlorantraniliprole 20%SC @ 150ml/ha (48.17 q/ha) and was on par with Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC @ 375ml/ha (51.88 q/ha). Untreated control recorded lowest yield of 35.10 q/ha.

The results are also in agreement with the reports of [3], evaluated the efficacy of some novel insecticidal formulation for the control of yellow stem borer in rice. Application of Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex) @ 120 ml/ha resulted by 47.57% yield increase over control and only presence of 0.76% and 1.44% dead heart and white ear head respectively in field with a cost benefit ratio by (1: 4.56), proved to be the most effective treatment for reducing the stem borer infestation similarly proved to be highly safe towards the native predatory fauna. However, [5] a study evaluated two doses of Flubendiamide 0.7% Gr @ 70 and 85 g a.i./ha, two doses of Spinetoram 0.8% Gr @ 50 and 60 g a.i. ha-1 and standard check Cartap hydrochloride 4% Gr @ 1000 g a.i. ha-1 was tested against yellow stem borer infesting transplanted paddy. All the granular insecticides recorded the higher grain yield compared to the untreated check. However maximum yield was recorded in the treatment, flubendiamide 0.7% Gr @ 100g a.i./ha (66.29 qts/ha) and minimum yield was in untreated check plot (48.49qts/ha). Based on the evaluations it can be concluded that, the granular insecticide flubendiamide 0.7% Gr @ 85-100g a.i./ha found superior in reducing the dead heart and white ears and in obtaining higher grain yield. Similarly [9], who showed that chlorantraniliprole 0.4% G was proved to be the best of all the insecticides for reduction in YSB infestation, increase in grain yield, and compatibility with natural enemies. Similarly [13], who revealed the highest mean grain yield 5.10 t/ha during 2016-17 and 4.77 t/ha during 2017- 18 was recorded from the plots treated with Flubendiamide 20% WG @ 25 g a.i./ha. Similarly [10], showed the maximum yield (44.58 q/ha) was recorded from chlorantraniliprole 18.5 SC, whereas the highest cost benefit ratio (1:12.56) was calculated in fipronil 5 SC.

Table 2: Bioefficacy of Spinetoram 6% + Methoxyfenozide 30% SC against Lepidopteran insect pest in Paddy during 2014 and 2015 (Pooled data)

Treatments	Dosage ml/ha	% Leaf Damage			% Dead Heart			%White Ear	Yield q/ha
		1DAS	7DAS	15DAS	40DAS	60DAS	90DAS		
T_1:Spinetoram 6% /v(5.66%w/w)+Methoxyfenozide 30%w/v(28.3w/w)SC	350	5.23	1.30bc (6.54)	1.36c (6.61)	2.09b (8.41)	1.43bc (6.86)	0.78c (5.06)	5.07 (13.01)	48.18ab
T_2: Spinetoram 6% /v(5.66%w/w)+Methoxyfenozide 30%w/v(28.3w/w)SC	375	4.66	0.71cd (4.83)	0.67d (4.69)	1.15cd (6.15)	0.75cd (4.96)	0.26d (2.92)	2.69 (9.43)	51.88a
T_3: Spinetoram 6% /v(5.66%w/w)+Methoxyfenozide 30%w/v(28.3w/w)SC	400	4.11	0.52d (4.13)	0.40d (3.62)	0.78d (5.06)	0.31d (3.19)	0.16d (2.29)	2.31 (8.74)	52.89a
T_4:Spinetoram 12%w/v(21.8%w/w)SC	192	5.19	2.13b (8.39)	2.02bc (8.17)	2.44b (8.98)	1.77b (7.64)	1.39b (6.77)	4.97 (12.88)	46.18b
T_5:Methoxyfenozide24%w/v(21.85%w/w)SC	471	5.31	2.30b (8.72)	2.05b (8.23)	2.18b (8.49)	1.58b (7.22)	1.07bc (5.93)	4.93 (12.86)	45.86b
T_6:Chlorantraniliprole 20%SC	150	4.90	1.37bc (6.72)	1.40bc (6.79)	1.94b (8.00)	1.23bc (6.36)	0.90c (5.44)	3.91 (11.40)	48.17ab
T_7:Flubendiamide 48%SC	50	5.33	1.59b (7.24)	1.52bc (7.08)	1.71bc (7.51)	1.11bc (6.04)	0.74c (4.93)	4.19 (11.81)	48.00ab
T_8:UTC	-	6.42	6.19a (14.11)	5.41a (13.29	3.92a (11.35)	3.63a (10.68)	3.17a (10.16)	7.54 (15.84)	35.10c
SEm±									
CD@5%			2.28	1.59	1.53	1.98	1.02	1.35	5.69
CV			17.18	12.43	11.02	17.11	10.76	6.45	6.86

Figures in parentheses are angular transformed values

Table 3: Bio-efficacy of Spinetoram 6% w/v (5.66%w/w) + Methoxyfenozide 30% w/v (28.3%w/w) SC against natural enemies in paddy ecosystem during 2014-15

Treatments	Dosage ml/ha	Spiders/hill		Mirid bugs/hill	
		1DBS	7DBS	1DBS	7DAS
T_1:Spinetoram 6% /v(5.66%w/w)+Methoxyfenozide 30%w/v(28.3w/w)SC	350	5.98	4.31bcd (2.07)	8.40	5.28bc (2.29)
T_2: Spinetoram 6% /v(5.66%w/w)+Methoxyfenozide 30%w/v(28.3w/w)SC	375	6.33	3.49cd (1.86)	7.92	4.60bc (2.14)
T_3: Spinetoram 6% /v(5.66%w/w)+Methoxyfenozide 30%w/v(28.3w/w)SC	400	5.62	3.12d (1.76)	7.88	4.14c (2.03)
T_4:Spinetoram 12%w/v(21.8%w/w)SC	192	5.92	4.48bc (2.11)	8.34	5.31bc (2.30)
T_5:Methoxyfenozide24%w/v(21.85%w/w)SC	471	5.98	4.78bc (2.18)	8.03	5.30bc (2.30)
T_6:Chlorantraniliprole 20%SC	150	5.98	4.85bc (2.20)	7.60	6.45ab (2.53)
T_7:Flubendiamide 48%SC	50	6.05	5.15b (2.26)	8.13	6.28ab (2.50)
T_8:UTC	-	5.98	7.67a (2.73)	7.92	8.68a (2.89
SEm±	-				
CD@5%			0.34		0.43
CV			9.09		10.41

Figures in parentheses are square root transformed values

Impact on natural enemies:

In the field trial carried out to evaluate bio-efficacy Spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC at 350,375and 400ml/ha in comparison to Spinetoram 12% @192 ml/ha, Methoxyfenozide 24% @ 471ml/ha, the population of natural enemies like predatory spiders and mirid bugs was comparatively Chlorantraniliprole 20% SC @ 150 ml/ha and Flubendiamide 48% SC @ 50ml/ha against insect pests in *kharif* paddy, low in all the insecticidal treatment when compared with untreated check. There was no clear cut difference between the insecticidal treatments so far the population of predatory spiders and mirid bugs is concerned. Spinetoram 6% + Methoxyfenozide 30% SC @ 400 ml/ha and 375 ml/ha were found be very effective in controlling the Leaf folder incidence and stem borer incidence and recorded highest garin yield. Application of Spinetoram 6% + Methoxyfenozide 30% SC at different doses did not have any severe depressing effect on the natural enemies in the paddy crop.

The results are in line with the reports of [5], who evaluated two doses of Flubendiamide 0.7% Gr @ 70 and 85 g a.i./ha, two doses of Spinetoram 0.8% Gr @ 50 and 60 g a.i. ha-1 and standard check Cartap hydrochloride 4% Gr @ 1000 g a.i. ha-1 was tested against yellow stem borer infesting transplanted paddy. The study revealed that, these new insecticide molecules are comparatively safer to non-targeted organism in comparison with other conventional insecticides. Similarly [5], revealed that the Rynaxypyr 20 SC @ 30 g a.i/ha treated plot recorded significantly lower per-cent of dead heart (0.42%) and white ear- head (1.24%) caused by stem borer and higher grain yield than the other treatments. Among the different treatments the maximum numbers of spiders were found in Rynaxypyr 20 SC @ 30 g a.i/ha treated plot followed by other treatments

Contrarily [9], showed insecticides reduced the numbers of predators *%.*, lady bird beetles, wolf spiders, carabid beetles, earwigs, green mirid bugs, and damselflies. Numbers of adults of the egg parasitoids *Trichogramma* sp., *Telenomus* sp. and *Tetrastichus* sp. were significantly reduced in insecticide-treated plots compared to untreated control plots. In all field trials, the harmful effects of the five insecticides were in the following rank order (least harmful to most harmful): chlorantraniliprole 0.4% G, carbufuran 5 G, dinotefuran 20% SG, methoxyfenozide 24 % SC, and quinalphos 25 EC.

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