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Sujay Hurali
Agriculture Research Station, Gangavathi, University of Agricultural Sciences, Raichur, Karnataka, India

Vinoda
Agriculture Research Station, Gangavathi, University of Agricultural Sciences, Raichur, Karnataka, India

Ravi Biradar
Agriculture Research Station, Gangavathi, University of Agricultural Sciences, Raichur, Karnataka, India

H Mahantashivayogayya
Agriculture Research Station, Gangavathi, University of Agricultural Sciences, Raichur, Karnataka, India

Pramesh D
Agriculture Research Station, Gangavathi, University of Agricultural Sciences, Raichur, Karnataka, India

Gowdar SB
Agriculture Research Station, Gangavathi, University of Agricultural Sciences, Raichur, Karnataka, India

Corresponding Author:
Sujay Hurali
Agriculture Research Station, Gangavathi, University of Agricultural Sciences, Raichur, Karnataka, India

Evaluation of new generation granular insecticides against major lepidopteran pests of rice *Oryza sativa* L.

Sujay Hurali, Vinoda, Ravi Biradar, H Mahantashivayogayya, Pramesh D and Gowdar SB

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Abstract
Field experiments were conducted during kharif season 2015-16 at Agriculture Research Station, Gangavathi. 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. 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 Moreover, these new insecticide molecules are comparatively safer to non-targeted organism in comparison with other conventional insecticides.

Keywords: generation granular insecticides, lepidopteran pests

Introduction
Rice (*Oryza sativa* L.) is the staple food for more than half of world population and it is chief source of dietary energy for 2.7 billion rice eating population of developing countries of Asia and South East Asia. Rice occupies the prominent place in Indian agriculture and it is regarded as an important food crop supporting food security for 5 percent of the global population (FAO, 2011). India produces 112.91 million metric tons of rice from the 43.79 million/ha area with the productivity of 3.87 metric tons/ha, (world agricultural production-USDA). Among the biotic factors limiting the rice productivity insect pests are most important. The hot and humid environment in which rice is grown is very conductive for proliferation of rice insect pests. More than 175 species of insect pest were identified as rice pests (Kalode, 2005) [5]. Of these 15 to 20 insect species are known to be the pests of paramount importance and are regularly noticed in tropical and subtropical climate Asia and South East Asia. More than 25% yield loss was estimated due to the infestation of insect pests (Dhaliwal and Koul, 2010) [2]. The major insect pests of rice include stem borers, particularly yellow stemborer, *Scirpophaga incertulas* (Walker), leaf folder, *Cnaphalocrocis medinalis* (Guenee), and plant hoppers; brown plant hopper, *Nilaparvata lugens* (Stal) and white backed planthopper, *Sogatella furcifera* (Horvath). Yield losses due to yellow stem borer are estimated 27-34 per cent every year (Prasad *et al.* 2004) [8]. Stem borer larvae after emerging from egg mass enter the tiller to feed inside it and damages the central whorl that turn brownish and dries resulting in “dead hearts”. The affected tillers do not grow further and dries up. At reproductive stage, the damage is characterized by whitish, erect and chaffy panicles called, “white ears”. Muralidharan and Pasalu (2006) [7] reported that due to 1% dead heart or white ear, or due to both phases stem borer damage would be 2.5, 4.0 and 6.4% yield loss, respectively. In general, Yellow stem borer causes 1 percent to 19 percent yield loss in early planted and 38 percent to 80 percent in late transplanted rice crops (Srivastava *et al.*, 2003) [13]. Among the

various strategies adopted to combat the pest of rice, insecticides are the first line of defense. Most of the insecticides used on agricultural crops are based on quit limited number of chemically different classes out of them the most important inorganic insecticides that are used against the pest on rice belongs to organophosphate, carbamates and synthetic pyrethroids. Therefore an effort has been made in present investigation to evaluate the new molecules of chemical insecticides such as against rice yellow stem borer.

Material and Methods

Field experiment was conducted in randomized block design (RBD) replicating thrice with a plot size of 8.4 X 4.2 m^2 and spacing of 20x20cm at Agriculture Research Station, Gangavathi during *Kharif*, 2015-16. The experimental site was located at 76º 32' E longitude and 15º 15' N latitude with an altitude of 419 m above mean sea level. Locally well-known rice variety BPT-5204 was used as test variety for the experiment. Experimental details are enlisted in table 1. There was an untreated control in each replication for the comparative evaluation of the efficacy of different treatments. The first spray was taken 20 days after transplanting and second spray was 60 days after transplanting. The treatments were applied with the help of a knapsack sprayer and care was taken to avoid spray drift on adjacent plants. All the control plots were sprayed with water.

Table: Details of the treatment

Sl. No.	Treatments	Dose /ha	
		g a.i.	Formulation (kg)
T_1	Spinetoram 0.8% Gr	50	6.25
T_2	Spinetoram 0.8% Gr	60	7.50
T_3	Flubendiamide 0.7% Gr.	70	10.00
T_4	Flubendiamide 0.7% Gr.	85	12.14
T_5	Flubendiamide 0.7% Gr.	100	14.28
T_6	Cartap hydrochloride 4% Gr.	1000	25.00
T_7	Untreated control	-	-

Assessment of number of dead hearts and healthy tillers in ten randomly selected hills in each plot before application and at 10 and 20 days after 1st application and assessment of number of white ear heads and healthy ear heads in ten randomly selected hills in each plot at 20 days after 2nd application. The data collected were converted to per cent dead heart analyzed statistically after angular transformation and presented below. The population of natural enemies, mirid bugs and spiders which are considered as important in rice ecosystem were assessed in ten randomly selected hills in each plot before application and at 10 days after 1st and 2nd applications. These data were analyzed statistically after square root transformation. Grain yield was recorded at the time of final harvest plot wise (in kilograms), later was converted to quintals per hectare.

Result and Discussions

Dead heart: Application of the granular insecticides were done at 20 days after transplanting when the dead heart symptoms started appearing and was 5.36 to 5.80% during *kharif* 2015. Further observations were recorded at 10 and 20 days after 1st application. At 10 days after application, all the granular insecticides showed its superiority in controlling the dead heart and was between 1.46% and 3.63% as against 10.19% in untreated check. Similar trend was observed at 20 days after application. Maximum reduction was recorded in the treatement, flubendiamide 0.7% Gr at 100g a.i./ha followed by its next lower dose of 85g a.i./ha which was found superior to spinetoram 0.8% Gr at 50 and 60g a.i./ha and cartap hydrochloride 4% Gr at 1000g a.i./ha (Table 1). The result of the present investigation showed that the Flubendiamide 0.7% Gr was most effective control against dead heart (DH) incidence.

Similar trend waas noticied during *kharif* 2016, the dead heart symptoms started appearing and was 3.89 to 5.46%. Further observations were recorded at 10 and 20 days after 1st application. At 10 days after application, all the granular insecticides showed its superiority in controlling the dead heart and was between 1.76 and 4.06% as against 10.41% in untreated check. Similar trend was observed at 20 days after application. Maximum reduction was recorded in the treatement, flubendiamide 0.7% Gr at 100g a.i./ha followed by its next lower dose of 85g a.i./ha which was found superior to spinetoram 0.8% Gr at 50 and 60g a.i./ha and cartap hydrochloride 4% Gr at 1000g a.i./ha (Table 2). From the two year evaluation it is confirmed that the Flubendiamide 0.7% Gr was most effective control against dead heart (DH) incidence. The present findings are in agreement with the result of Sekh *et al.,* (2007) [11] who reported that Flubendiamide 480 SC @ 24 and 30 g a.i ha^{-1} provided effective control against yellow stem borer. Similarly Bhutto and Soomro (2009) also reported the efficacy of different granular insecticide of 4G formulation against yellow stem borer under field conditions.

White ear: White ear incidence was recorded at 20 days after 2nd granular application. The data recorded revealed that, all the granular insecticides performed better in controlling white ear. Lowest per cent white ear was recorded in the treatment of flubendiamide 0.7% Gr @ 100g a.i./ha followed by its next lower dose of 85g a.i./ha (1.95% and 2.38% respectively) which was significantly superior to to spinetoram 0.8% Gr @ 50 and 60g a.i./ha and cartap hydrochloride 4% Gr @ 1000g a.i./ha and maximum white ear was in untreated check plot (14.13%) (Table 1).

Similarly during second year (*kharif* 2016) white ear incidence was recorded at 20 days after 2nd granular application. The data recorded revealed that, all the granular insecticides performed better in controlling white ear. Lowest per cent white ear was recorded in the treatment of flubendiamide 0.7% Gr @ 100g a.i./ha followed by its next lower dose of 85g a.i./ha (1.86% and 2.33% respectively) which was significantly superior to to spinetoram 0.8% Gr @ 50 and 60g a.i./ha and cartap hydrochloride 4% Gr @ 1000g a.i./ha and maximum white ear was in untreated check plot (14.07%) (Table 2). The bioefficacy of new generation insecticide flubendiamide was also reported against stem borer by Rao *et al.* (2008). Takumi 20 WG proved to be the most effective treatment in reducing the stem borer population at 35 g a.i./ha and was found to be most effective treatment recording 89.67 per cent control over untreated check. Similarly, Rath *et al.* (2010) [10] also conceded the efficacy of different insecticides in controlling the incidence of stem borer.

Natural enemies' population: The natural enemies observed in the experimental plots were mirid bugs and spiders which are considered as very important in the rice ecosystem. The observations were recorded and presented in the Table 3 and 4 indicates that, there were no any adverse effect on the mirid bug and spiders population due to the application of the granular insecticides. The result of the present study for effect

of insecticides on natural enemies are in consonance with Sekh *et al.* (2007) [11] who reported that flubendiamide 480 SC @ 24 and 30 gma.i./ha was soft to egg parasitoids of yellow stem borer and the per cent parasitisation in the treated plots was close to those of the untreated plots Similar results were also reported by Tohnishi *et al.* (2005) [15], Kubendran *et al.* (2006) [6] and Thilagam *et al.* (2006) [14] as they found that flubendiamide was proved to be least toxic against beneficial arthropods.

Grain yield: The data on the grain yield presented in the Table 1 and 2 from two year results indicate that, 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 followed by its next lower dose of 85g a.i./ha which were followed by spinetoram 0.8% Gr @ 60g a.i./ha and cartap hydrochloride 4% Gr @ 1000g a.i./ha. Minimum yield was in untreated check plot during both *kharif* 2015 and 2016. These results are in accordance with Dhawan (2010) [3] who reported that newer molecules like flubendiamide treated plot produced more yield than other newer group of insecticide like Cartap hydrochloride.

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 followed by spinetoram 0.8% Gr @ 60g a.i./ha and cartap hydrochloride 4% Gr @ 1000g a.i./ha. Moreover, these new insecticide molecules are comparatively safer to non-targeted organism in comparison with other conventional insecticides. However, further investigations on these aspects are necessary.

Table 1: Effect of granular insecticides against rice stem borer and the grain yield (*Kharif* 2015)

Treatments	Dose/ha		Mean per cent dead heart			Per cent reduction over control (dead heart)	Mean per cent white ears	Per cent reduction over control (white ears)	Grain yield (qts/ha)
	g a.i.	Formulation (kg)	Before application (PTC)	10 days after 1st application	20 days after 1st application		20 days after 2nd application		
Spinetoram 0.8% Gr (RIL-144/F1)	50	6.25	5.74 (13.84)	3.63^{ef} (10.98)	4.94^{f} (12.83)	61.52	5.47^{f} (13.52)	61.72	58.29^{d}
Spinetoram 0.8% Gr (RIL-144/F1)	60	7.50	5.80 (13.91)	2.72^{c} (9.49)	2.85^{c} (9.71)	74.99	2.75^{c} (9.54)	80.76	61.76^{c}
Flubendiamide 0.7% Gr.	70	10.00	5.60 (13.68)	2.89^{cd} (9.79)	3.44^{cd} (10.69)	71.58	3.12^{cd} (10.09)	74.95	58.05^{de}
Flubendiamide 0.7% Gr.	85	12.14	5.37 (13.39)	1.81^{ab} (7.73)	1.81^{ab} (7.73)	83.74	1.96^{b} (8.03)	86.28	63.71^{b}
Flubendiamide 0.7% Gr.	100	14.28	5.36 (13.38)	1.46^{a} (6.91)	1.59^{a} (7.23)	85.68	1.40^{a} (6.78)	90.20	66.29^{a}
Cartap hydrochloride 4% Gr.	1000	25.00	5.70 (13.79)	3.35^{de} (10.53)	3.53^{de} (10.83)	68.21	3.68^{e} (11.06)	74.25	57.86^{def}
Untreated Control	---	---	5.67 (13.77)	10.19^{g} (18.55)	12.08^{g} (20.17)	0.00	14.13^{g} (22.05)	0.00	48.49^{g}
SEm ±	---	---	0.31	0.48	0.79	--	0.49	--	1.89
CD at 5%	---	---	1.13	1.49	2.44	--	1.52	--	5.83

** Figures in parenthesis are angular transformed values.
PTC= Pre Treatment Count

Table 2: Effect of granular insecticides against rice stem borer and the grain yield (*Kharif* 2016)

Treatments	Dose/ha		Mean per cent dead heart			Per cent reduction over control (dead heart)	Mean per cent white ears	Per cent reduction over control (white ears)	Grain yield (qts/ha)
	g a.i.	Formulation (kg)	Before application (PTC)	10 days after 1st application	20 days after 1st application		20 days after 2nd application		
Spinetoram 0.8% Gr (RIL-144/F1)	50	6.25	3.89 (11.36)	4.06^{f} (11.62)	4.28^{de} (11.93)	63.85	4.30^{ef} (11.96)	69.44	55.52
Spinetoram 0.8% Gr (RIL-144/F1)	60	7.50	4.03 (11.56)	2.74^{b} (9.48)	3.27^{c} (10.41)	73.95	2.76^{c} (9.51)	80.38	64.14
Flubendiamide 0.7% Gr.	70	10.00	5.04 (12.97)	3.21^{cd} (10.31)	4.00^{d} (11.53)	69.74	3.58^{d} (10.90)	74.56	56.86
Flubendiamide 0.7% Gr.	85	12.14	5.46 (13.51)	2.84^{bc} (9.69)	2.38^{b} (8.86)	77.37	2.33^{b} (8.77)	83.44	64.43
Flubendiamide 0.7% Gr.	100	14.28	4.43 (12.15)	1.76^{a} (7.62)	1.59^{a} (7.21)	85.48	1.86^{a} (7.83)	86.78	69.14
Cartap hydrochloride 4% Gr.	1000	25.00	5.12 (13.06)	3.52^{de} (10.79)	4.00^{d} (11.53)	67.40	4.13^{e} (11.73)	70.65	61.38
Untreated Control	---	---	4.96 (12.80)	10.41^{g} (18.81)	12.99^{f} (21.11)	0.00	14.07^{g} (22.01)	0.00	52.57
SEm ±	---	---	0.54	0.36	0.31	--	0.36	--	1.75
CD at 5%	---	---	1.66	1.11	0.96	--	1.10	--	5.38

** Figures in parenthesis are angular transformed values.
PTC= Pre Treatment Count

Table 3: Effect of granular insecticides against natural enemies in rice ecosystem (*Kharif* 2015)

Treatments	Dose/ha		Mean mirid bug population per hill			Mean spider population per hill		
	g a.i.	Formulation (kg)	Before application (PTC)	10 days after 1st application	10 days after 2nd application	Before application (PTC)	10 days after 1st application	10 days after 2nd application
Spinetoram 0.8% Gr (RIL-144/F1)	50	6.25	3.67 (2.15)	5.33 (2.51)	8.67 (3.11)	2.67 (1.88)	5.67 (2.56)	5.33 (2.50)
Spinetoram 0.8% Gr (RIL-144/F1)	60	7.50	4.33 (2.31)	5.00 (2.44)	9.33 (3.21)	2.33 (1.79)	5.33 (2.48)	4.67 (2.37)
Flubendiamide 0.7% Gr.	70	10.00	4.00 (2.24)	5.33 (2.51)	8.33 (3.03)	4.00 (2.24)	5.00 (2.44)	4.67 (2.37)
Flubendiamide 0.7% Gr.	85	12.14	3.67 (2.16)	5.33 (2.51)	9.00 (3.16)	2.67 (1.91)	5.67 (2.57)	4.67 (2.37)
Flubendiamide 0.7% Gr.	100	14.28	4.00 (2.23)	5.00 (2.45)	10.33 (3.36)	2.67 (1.91)	4.67 (2.37)	4.33 (2.28)
Cartap hydrochloride 4% Gr.	1000	25.00	4.33 (2.31)	4.33 (2.31)	8.67 (3.10)	3.00 (2.00)	4.33 (2.31)	4.33 (2.30)
Untreated control	---	---	3.67 (2.16)	5.33 (2.51)	9.33 (3.15)	2.67 (1.91)	5.33 (2.51)	6.00 (2.64)
SEm ±	---	---	0.09	0.09	0.23	0.13	0.15	0.17
CD at 5%	---	---	0.28	0.27	0.70	0.41	0.46	0.53

* Figures in parenthesis are square root of x+1 transformed values.
PTC= Pre Treatment Count

Table 4: Effect of granular insecticides against natural enemies in rice ecosystem (*Kharif* 2016)

Treatments	Dose/ha		Mean mirid bug population per hill			Mean spider population per hill		
	g a.i.	Formulation (kg)	Before application (PTC)	10 days after 1st application	10 days after 2nd application	Before application (PTC)	10 days after 1st application	10 days after 2nd application
Spinetoram 0.8% Gr (RIL-144/F1)	50	6.25	4.67 (2.38)	6.33 (2.71)	10.00 (3.31)	3.67 (2.14)	5.67 (2.58)	6.33 (2.7)
Spinetoram 0.8% Gr (RIL-144/F1)	60	7.50	5.33 (2.51)	6.00 (2.64)	10.33 (3.36)	3.33 (2.06)	5.67 (2.57)	5.67 (2.58)
Flubendiamide 0.7% Gr.	70	10.00	5.00 (2.45)	6.33 (2.70)	11.33 (3.51)	5.00 (2.45)	6.00 (2.64)	5.67 (2.57)
Flubendiamide 0.7% Gr.	85	12.14	4.67 (2.38)	6.67 (2.77)	11.00 (3.46)	3.67 (2.16)	6.00 (2.64)	5.67 (2.58)
Flubendiamide 0.7% Gr.	100	14.28	5.00 (2.44)	6.00 (2.65)	10.33 (3.36)	3.67 (2.16)	5.67 (2.58)	5.67 (2.55)
Cartap hydrochloride 4% Gr.	1000	25.00	5.33 (2.51)	5.33 (2.51)	10.67 (3.41)	4.00 (2.24)	5.67 (2.58)	5.33 (2.51)
Untreated control	---	---	4.67 (2.38)	6.33 (2.68)	11.33 (3.48)	3.67 (2.16)	6.33 (2.71)	6.67 (2.68)
SEm ±	---	---	0.07	0.11	0.16	0.12	0.09	0.17
CD at 5%	---	---	0.23	0.35	0.50	0.36	0.28	0.53

* Figures in parenthesis are square root of x+1 transformed values.
PTC= Pre Treatment Count

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