The Journal of Plant Protection Sciences, **7**(1-2) : 6-13, 2015

Management of rice insects by granular formulation of chlorantraniliprole along with foliar sprays of some new molecules

[1]Sitesh Chatterjee, [1]Chirasree Gangopadhyay and [2]Santosh Kumar Roy

[1]Rice Research Station, Government of West Bengal, Department of Agriculture, Chinsurah -712 102, Hooghly, West Bengal, India

[2] Field Crop Research Station, Office of the Entomologist, Government of West Bengal, Kanla Road, Burdwan - 723101, West Bengal, India

**Corresponding author: sitesh.chatt@gmail.com*

Received: 08 December 2015; Accepted: 25 December 2015; Availabale Online: 28 December 2015

DOI: http://dx.doi.org/10.17582/journal.jpps/2015/7.1-2.6.13

ABSTRACT

The experiment was conducted during *kharif* seasons of 2014 and 2015 to evaluate field bio-efficacy of new generation molecules against rice insect-pests. Control of pests in seedbed is relatively less expensive than transplanted main-field because of smaller area of nursery that can be managed better way as compared to transplanted field. In the present study, chlorantraniliprole granule was applied both in seedbed and transplanted field along with spraying of some new generation insecticides like indoxacarb, flubendiamide, spinosad and chlorantraniliprole to test their efficacy against different rice insect-pests. The study found that whorl maggot can be managed properly in seedbed application with chlorantraniliprole granule 0.4% WW/SR in seven days prior to seedling uprooting along with spraying of indoxacarb 14.5 SC /chlorantraniliprole 18.5% SC /flubendiamide 48% SC in the main-field. The leaf folder was also managed properly by application of chlorantraniliprole granule in seedbed along with spraying of chlorantraniliprole/spinosad in the main-field. The incidence of dead heart incidence was found lowest in chlorantraniliprole granule when applied in seedbed followed by spraying of chlorantraniliprole in the main-field or chlorantraniliprole granule application. Chlorantraniliprole granule application along with spraying of same chemical provided the best result against white heads due to stem borer followed by chlorantraniliprole granule application in seedbed or the same granular application in the main-field along with spraying of chlorantraniliprole/flubendiamide in the main-field. The highest grain yield of rice was obtained from plot receiving granule application with spraying of chlorantraniliprole in transplanted field followed by chlorantraniliprole granule application in seedbed along with spraying of chlorantraniliprole in main-field. The spider population was recorded maximum in the chlorantraniliprole granule applied plots in comparison to scheduled spray plots.

Keywords: Rice insect, granular insecticide, chlorantraniliprole, yellow stem borer, leaf folder, whorl maggot

Introduction

Rice in West Bengal is considered as the dominant food crop and is grown in all six agro-climatic zones of the state under diversified situations such as upland, rainfed shallow, semi-deep and deep-lowland and finally irrigated conditions. The state, West Bengal ranks second in area (5,386,000 ha) and first in production (14,771,0000 tons) of rice in India. The state is suffering from poor productivity due to adverse weather conditions like, flood, drought, cyclone, salinity etc. and different biotic stresses like, insect-pests, mites, nematodes, diseases etc. Losses due to chronic insect-pest infestation in rice in Asiatic region have been estimated at 18.4%. A critical analysis of the gap between the potential and actual rice yields across the nation would reveal that several factors act as yield constraints Hence, one of the major pathways of increasing rice productivity in the state is through effective insect-pest management. More than 100 species of insects have been recorded as pests of rice crop, of which about twenty are of economic significance in India (Katti 2007). In India, the yellow rice stem borer is distributed in almost all the rice ecosystems and damage the rice crop from seedling to maturity (Padhi 2009). Yellow stem borer (*Scirpophaga incertulas*) is considered to be the most important pest in rice ecosystems and is also an important pest of rice in temperate and tropical areas (Deka et al. 2010). *S. incertulas* and rice leaf folder, *Cnaphalocrocis medinalis* are the dominant and most destructive insect-pest occurring throughout the country causing yield loss ranging from 10 to 60% (Chatterjee & Mondal 2014). Chlorantraniliprole (rynaxypyr™), the first commercialized ryanodine receptor insecticide belongs to class anthranilic diamide, has exceptional insecticidal activity on a range of lepidopteran pests and on the other orders such as coleoptera, diptera, isoptera and hemiptera. The insecticidal action of Chlorantraniliprole involves activation of the unregulated release of internal calcium stores, leading to Ca^{2+} depletion, feeding cessation, lethargy, muscle paralysis and finally insect death. It is an excellent alternative for use in integrated pest management (IPM) programmes and in regions where commercial standards are no longer effective owing to resistance (Sattelle et al. 2008; Lahm et al. 2009; Panda & Mishra 2014). Hence, this experiment was conducted to evaluate the field bioefficacy of chlorantraniliprole along with other new generation molecules against rice insect-pests.

Materials and Methods

Field experiment was conducted at Rice Research Station, Chinsurah, West Bengal during *kharif* seasons of 2014 and 2015. The trial was laid out in randomized block design with three replications. Twenty five to thirty days old rice seedlings of c.v. Swarna (MTU 7029) were transplanted in 4m x 6m plots with 15cm x 20cm spacing. Fertilizers were applied in the field as recommended doses ($N:P_2O_5:K_2O$ @ 80:40:40). The test insecticide chlorantraniliprole and other new molecules *viz*., indoxacarb, flubendiamide, spinosad were applied as in following ten treatments **:** T_1=chlorantraniliprole 0.4% WW/SR @ 10 kg/ha at seedbed on seven days prior to seedling uprooting and indoxacarb 14.5 SC @ 4.0 ml /10 litres of water at 45 days after transplanting (DAT), T_2=chlorantraniliprole 0.4% WW/SR @ 10 kg/ha at seedbed on seven days prior to seedling uprooting and flubendiamide 48% SC @ 3.0 ml /10 litres of water at 45 DAT, T_3=chlorantraniliprole 0.4% WW/SR @ 10 kg/ha at seedbed on seven days prior to seedling uprooting and spinosad 45%SC @ 2.0 ml/10 litres of water at 45 DAT, T_4= chlorantraniliprole 0.4% WW/SR @ 10 kg/ha at seedbed on seven days prior to seedling uprooting and chlorantraniliprole 18.5% SC @ 3.0 ml/10 litres of water at 45 DAT, T_5=chlorantraniliprole 0.4% WW/SR @ 10 kg/ha at 30 DAT and indoxacarb 14.5 SC @ 4.0 ml /10 litres of water at 50 DAT, T_6=chlorantraniliprole 0.4% WW/SR @ 10 kg/ha at 30 DAT and flubendiamide 48% SC @ 3.0 ml /10 litres of water at 50 DAT, T_7=chlorantraniliprole 0.4% WW/SR @ 10 kg/ha at 30 DAT and spinosad 45% SC @ 2.0 ml/10 litres of water at 50 DAT, T_8=chlorantraniliprole 0.4% WW/SR @ 10 kg/ha at 30 DAT and chlorantraniliprole 18.5% SC @ 3.0 ml/10 litres of water at 50 DAT, T_9=chlorantraniliprole 0.4% WW/SR @ 10 kg/ha at 30 DAT, T_{10}=untreated check (water spray). The spray water was used as @ 500 liters/ha. Observations were taken from ten randomly selected plants from each plot starting from 30 DAT onwards at 15 days interval for dead heart (DH), whorl maggot (WM) and leaf folder (LF) infestation. The white ear head (WE) was counted at pre-harvest stage. Infestation of whorl maggot and leaf was assessed by counting total leaves in each tiller to the infested leaves in that particular tiller at vegetative stage. Stem borer infestation was assessed by counting total tillers to the infested ones at vegetative stage and at mature stage. Final assessment was made by counting the total panicle to the infested ones in each hill. The spider population was recorded randomly from selected ten hills from the plots of each treatment at 80 DAT. The grain yield from each plot was recorded leaving two border rows from each side.

Results and Discussion

During *kharif* 2014, at vegetative stage results revealed that a very little difference was observed in whorl maggot (WM) damage at 30 DAT ranging from 0.25% to 0.67% which resulted non significant (Table 1). At 45 and 60 DAT respectively, the lowest damage was recorded in T_6 (0.11% WM) treatment where chlorantraniliprole granule and flubendiamide were applied in main-field and T_9 (0.19% WM) treatment where chlorantraniliprole granule was applied in main-field. The overall mean data indicated that the T_1 (0.22% WM) treatment (seedbed application with chlorantraniliprole granule and spraying of indoxacarb in main-field) recorded lowest infestation of whorl maggot followed by T_4 (0.30% WM) (seedbed application with chlorantraniliprole granule and spraying of chlorantraniliprole in main field). The leaf folder damage was to the tune of 5.20% with it peak activity at 60 DAT in control plots. In vegetative stage, at 30 and 45 DAT, the low infestation of leaf folder was noticed in first four treatments ranging from 0.29-0.46% and 0.37-0.56%, respectively. At 30 DAT, minimum dead heart (DH) infestation was noticed for first four treatments (0.51-0.65% DH). Similar results were observed due to chlorantraniliprole granule application at seedbed in seven days prior to seedling uprooting. The lowest leaf folder damage at 60 DAT was recorded T_4 (1.46%) treatment. The overall mean data indicated that the lowest damage by leaf folder was observed in T_4 (0.74%) followed by T_1 (1.09%) and T_8 (1.14%) (main-field application with chlorantraniliprole granule and spraying of chlorantraniliprole). The damage of stem borer varied from 0.51 to 16.65% DH at vegetative stage, its peak activity at 60 DAT and 1.68 to 11.03% white head (WE) at mature stage. At 45 and 60 DAT, the lowest borer damage was recorded in T_8 (1.51% and 3.66% DH, respectively) receiving chlorantraniliprole granule and spraying of chlorantraniliprole in main field followed by T_4 (2.23 and 4.43% DH, respectively) receiving chlorantraniliprole granule in seedbed and spraying of chlorantraniliprole in main-field. The overall mean data showed that the lowest dead heart incidence was in T_4 (2.44%) followed by T_8 (2.76%) and T_1 (3.41%). At heading stage, the lowest white heads was discernible in T_8 (1.68%) followed by T_4 (1.71%) and T_6 (1.98%). The highest grain yield was obtained from T_8 (4819 kg/ha) followed by T_4 (4611 kg/ha) and T_6 (4569 kg/ha).

Results from *kharif* 2015, revealed that the whorl maggot damage was ranged from 0.38-3.10% (Table 2). There were very little variations of whorl maggot infestation observed amongst the treatment at 30 DAT. At 30, 45 and 60 DAT, the lowest damage was in T_8 (1.30% WM) (granular application of chlorantraniliprole and spraying of chlorantraniliprole in main-field), T_9 (0.38% WM) (chlorantraniliprole granule application in main-field) and T_7 (0.67% WM) treatments (chlorantraniliprole granule and liquid formulation of spinosad application in main-field), respectively. The overall mean data indicated the lowest whorl maggot infestation in T_2 (1.19%) where chlorantraniliprole granule was applied in seedbed and flubendiamide was sprayed in transplanted field, followed by T_7 (1.29%). At vegetative stage, the leaf folder damage varied from 0.35-2.95% damage with non-significant data at 45 DAT. At 30 and 45 DAT. However, low infestation of leaf folder was recorded in first four treatments where chlorantraniliprole was applied in seedbed seven days prior to uprooting, ranging from 0.35-0.72% LF and 1.13-1.92% LF, respectively. The lowest leaf folder damage on 60 DAT was recorded in both T_3 (seedbed application with chlorantraniliprole granule along with spraying of spinosad in transplanted field) and T_5 (0.86%) (granular formulation of chlorantraniliprole and liquid formulation of indoxacarb application in main-field). The overall mean data indicated that the lowest leaf folder damage was found in T_3 (0.92%) followed by T_2 (1.25%). The damage due to stem borer damage varied from 0.65 to 6.51% DH at the vegetative stage and 1.05 to 6.63% WE at heading stage with its peak activity at 45-60 DAT at vegetative stage. At 30 DAT, borer damage was 9 1.56% DH with little variation amongst all the treatments, the dead heart was low in first four treatments ranging from 0.65 to 0.98% DH. At 45 DAT, the lowest borer damage was noticed in T_8 (1.34% DH) treatment. Although, there were very little variation in borer damage observed at 60 DAT, the lowest damage was recorded in T_4 (1.34% DH) where chlorantraniliprole was applied in seedbed and sprayed in transplanted field. The overall mean data presented lowest dead heart incidence in T_4 (1.19%) followed by T_8 (1.48%). At mature stage, the infestation of white ear head ranged from 1.05% to 6.63%. Low incidence of stem borer at pre-harvest was also recorded in T_8 (1.47% WE) and T_2 (1.85% WE). No significant variation in grain yield was observed except control plots (3542 kg/ha), the highest grain yield was obtained in T_8 (4790 kg/ha) followed by T_4 (4657 kg/ha).

Table 1.
Bio efficacy of different insecticidal treatments against insect-pests of rice during *kharif* season of 2014

Treatment	WM%			Mean WM%	LF%			Mean LF%	DH%			Mea DH%	WE%	Yield (kg/ha)
	30 DAT	45 DAT	60 DAT		30 DAT	45 DAT	60 DAT		30 DAT	45 DAT	60 DAT			
T_1	0.26 (2.92)	0.12 (1.98)	0.29 (3.09)	0.22	0.29 (3.09)	0.56 (4.29)	2.43 (8.96)	1.09	0.51 (4.09)	3.88 (11.36)	5.84 (13.98)	3.41	2.48 (9.06)	4292
T_2	0.34 (3.34)	0.34 (3.34)	0.25 (2.86)	0.31	0.46 (3.89)	0.46 (3.89)	2.74 (9.52)	1.22	0.59 (4.40)	4.25 (11.89)	6.91 (15.23)	3.92	2.20 (8.53)	4306
T_3	0.25 (2.86)	0.53 (4.17)	0.76 (5.00)	0.51	0.35 (3.39)	0.40 (3.62)	3.74 (11.15)	1.50	0.57 (4.33)	5.23 (13.21)	6.52 (14.79)	4.11	3.02 (10.00)	4431
T_4	0.26 (2.92)	0.30 (3.14)	0.34 (3.34)	0.30	0.38 (3.53)	0.37 (3.49)	1.46 (6.94)	0.74	0.65 (4.62)	2.23 (8.58)	4.43 (12.15)	2.44	1.71 (7.51)	4611
T_5	0.51 (4.09)	0.12 (1.98)	0.44 (3.80)	0.36	0.96 (5.62)	0.78 (5.06)	2.69 (9.44)	1.48	3.01 (9.99)	3.60 (10.93)	5.22 (13.20)	3.94	2.17 (8.47)	4486
T_6	0.64 (4.59)	0.11 (1.90)	0.20 (2.56)	0.32	1.08 (5.96)	0.98 (5.68)	2.09 (8.31)	1.38	3.22 (10.33)	3.15 (10.22)	5.50 (13.56)	3.96	1.98 (8.09)	4569
T_7	0.47 (3.93)	0.49 (4.01)	0.41 (3.67)	0.46	1.14 (6.13)	0.89 (5.41)	3.10 (10.14)	1.71	3.06 (10.07)	5.63 (13.72)	8.70 (17.15)	5.80	2.79 (9.61)	4417
T_8	0.53 (4.17)	0.74 (4.93)	0.24 (2.81)	0.50	1.32 (6.59)	0.83 (5.23)	1.27 (6.47)	1.14	3.10 (10.14)	1.51 (7.06)	3.66 (11.02)	2.76	1.68 (7.44)	4819
T_9	0.67 (4.69)	0.73 (4.90)	0.18 (2.43)	0.53	1.05 (5.88)	1.08 (5.96)	4.64 (12.43)	2.26	2.96 (9.90)	7.54 (15.93)	10.53 (18.93)	7.01	5.82 (13.95)	4194
T_{10}	0.45 (3.84)	1.62 (7.31)	1.29 (6.52)	1.12	1.18 (6.23)	2.75 (9.54)	5.20 (13.18)	3.04	2.64 (9.35)	15.09 (22.85)	16.65 (24.07)	11.46	11.03 (19.39)	3542
CD (0.05)	N.S.	1.59	0.93	-	1.72	1.63	2.03	-	2.03	2.91	2.24	-	2.29	219.34
SEM (±)	0.44	0.53	0.31	-	0.58	0.55	0.68	-	0.68	0.97	0.75	-	0.77	73.26
CV	20.90	25.21	15.01	-	20.05	18.30	12.21	-	15.33	13.48	8.43	-	13.06	2.91

Figures in the parenthesis are angular transformed values; DAT- Days after Transplanting; WM- Whorl maggot; LF- Leaf folder; DH- Dead heart; WE- White earhead

Table 2.
Bioefficacy of different insecticidal treatments against insect-pests of rice during *kharif* season.

Treatment	WM%			Mean WM%	LF%			Mean LF%	DH%			Mean DH%	WE%	Yield (kg/ha)
	30 DAT	45 DAT	60 DAT		30 DAT	45 DAT	60 DAT		30 DAT	45 DAT	60 DAT			
T_1	2.90 (9.80)	0.81 (5.16)	1.78 (7.66)	1.83	0.35 (3.39)	1.92 (7.96)	2.09 (8.31)	1.45	0.95 (5.59)	4.20 (11.82)	2.13 (8.39)	2.43	3.44 (10.68)	4257
T_2	1.62 (7.31)	1.00 (5.74)	0.95 (5.59)	1.19	0.72 (4.87)	1.25 (6.42)	1.51 (7.06)	1.16	0.98 (5.68)	3.71 (11.10)	3.37 (10.57)	2.69	1.85 (7.81)	4523
T_3	2.23 (8.58)	1.22 (6.34)	0.77 (5.03)	1.41	0.36 (3.44)	1.13 (6.10)	0.86 (5.32)	0.78	0.77 (5.03)	3.61 (10.95)	3.48 (10.75)	2.62	3.21 (10.32)	4470
T_4	3.48 (10.75)	1.27 (6.47)	1.70 (7.49)	2.15	0.48 (3.97)	1.77 (7.64)	1.39 (6.77)	1.21	0.65 (4.62)	1.60 (7.26)	1.32 (6.59)	1.19	1.05 (5.88)	4657
T_5	1.86 (7.84)	1.70 (7.49)	1.39 (6.77)	1.65	0.71 (4.83)	1.85 (7.81)	0.86 (5.32)	1.14	1.56 (7.17)	3.05 (10.05)	2.79 (9.61)	2.47	2.54 (9.17)	4460
T_6	2.01 (8.15)	1.60 (7.26)	1.35 (6.67)	1.65	1.10 (6.02)	2.06 (8.25)	1.72 (7.53)	1.63	0.77 (5.03)	2.19 (8.51)	2.22 (8.57)	1.73	2.53 (9.15)	4553
T_7	2.07 (8.27)	1.13 (6.10)	0.67 (4.69)	1.29	0.55 (4.25)	1.75 (7.60)	0.96 (5.62)	1.09	1.09 (5.99)	4.50 (12.24)	4.51 (12.26)	3.37	2.64 (9.35)	4440
T_8	1.30 (6.54)	2.14 (8.41)	0.80 (5.13)	1.41	1.03 (5.82)	2.18 (8.49)	1.70 (7.49)	1.64	1.09 (5.99)	1.34 (6.64)	2.01 8.15)	1.48	1.47 (6.96)	4790
T_9	3.13 (10.19)	0.38 (3.53)	2.11 (8.35)	1.87	0.85 (5.29)	1.81 (7.73)	1.51 (7.06)	1.39	0.79 (5.10)	4.80 (12.65)	4.22 (11.85)	3.27	3.84 (11.30)	4277
T_{10}	2.25 (8.62)	1.27 (6.47)	3.10 (10.14)	2.21	1.26 (6.44)	2.85 (9.72)	2.95 (9.89)	2.35	0.97 (5.65)	6.51 (14.78)	5.01 (12.93)	4.16	6.63 (14.92)	3347
CD (0.05)	1.87	2.18	2.39	-	1.37	NS	2.31	-	NS	1.95	NS	-	2.53	110.20
SEM (±)	0.62	0.73	0.8	-	0.46	0.72	0.77	-	0.79	0.65	1.81	-	0.84	36.81
CV	12.63	20.32	20.82	-	16.55	16.1	19.28	-	25.18	10.7	32.94	-	15.44	1.46

Figures in the parenthesis are angular transformed values; DAT- Days after Transplanting; WM- Whorl maggot; LF- Leaf folder; DH- Dead heart; WE- White earhead

Table 3.
Spider population in different insecticidal treatments in rice during *kharif* seasons of 2014 and 2015

Treatment	Spider population (No./hill)		Mean spider population (No./hill)
	Kharif 2014	*Kharif* 2015	
T_1	0.8	0.6	0.72
T_2	1.1	1.0	1.05
T_3	1.6	1.4	1.48
T_4	1.1	1.0	1.05
T_5	1.0	0.7	0.87
T_6	1.0	0.8	0.90
T_7	1.4	1.2	1.32
T_8	1.1	1.2	1.17
T_9	1.6	1.5	1.55
T_{10}	1.8	1.8	1.82
CD (0.05)	0.33	0.34	-
SEM (±)	0.11	0.12	-
CV	14.97	17.66	-

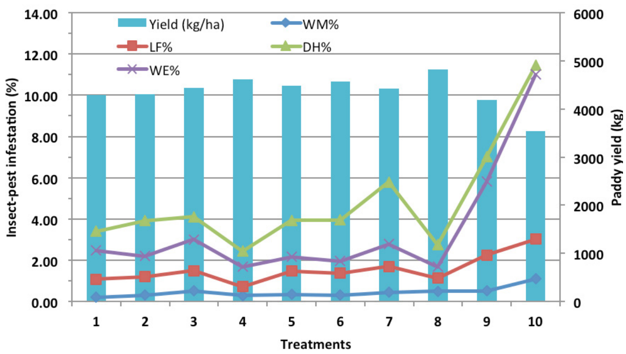

Fig 1. Efficacy of different insecticides against insect-pests of rice during *kharif* 2014

The variations of spider population during *kharif* season of 2014 were recorded; the insecticidal treatments showed 0.8 to 1.6 spiders/hill as against maximum of 1.8/hill in untreated check (Table 3), T_9 (chlorantraniliprole granule application at 30 DAT) and T_3 (1.6/hill) (seedbed application with chlorantraniliprole granule and spraying of spinosad in transplanted field) exhibited maximum spider population. In the following year, population of spiders per hill ranged from 0.6 in T_1 (chlorantraniliprole treatment in seedbed and indoxacarb spraying in main- field) to 1.8 (control plots). Relatively higher spider population was recorded from T_9 (1.5/hill) and T_3 (1.4/hill). A trend has been noted that granular insecticide applied plots exhibited more spider population as compared to the foliar sprayed plots receiving indoxacarb, flubendiamide and chlorantraniliprole; these are toxic to this beneficial arthropod. There were no or little effect of chlorantraniliprole granule and spinosad on spider was noticed.

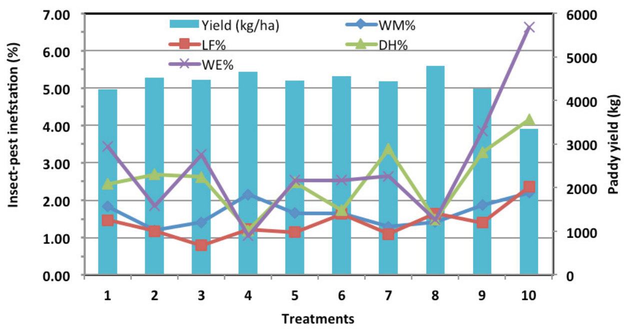

Fig 2. Efficacy of different insecticides against insect-pests of rice during *kharif* 2015

Based on the results of the present investigation it may be concluded that whorl maggot in rice can be managed properly with seedbed application of chlorantraniliprole granule seven days prior to seedling uprooting along with spraying of indoxacarb/chlorantraniliprole/ flubendiamide in the main-field. In this present studies, the effective control of leaf folder was achieved by application of chlorantraniliprole granule in seedbed along with spraying of chlorantraniliprole or spinosad in the main field. The similar results were obtained with better performance of chlorantraniliprole against leaf folder by Xuesong et al. (2011) who observed that this particular chemical exhibited great efficacy against *C. medinalis* in rice. Several others (Suri 2011; Suri & Brar 2013) also found chlorantraniliprole as effective against leaf folder with increased paddy yield, although spinosad has been reported to be better against leaf folder (Karthikeyan et al. 2008; Kulagod 2011).

In this study, incidence of dead heart was lowest in the treatment where chlorantraniliprole granule was applied in seedbed along with spraying of chlorantraniliprole in the main-field or granular application of chlorantraniliprole. At heading stage, chlorantraniliprole granular application at 30 DAT and spraying of chlorantraniliprole at 50 DAT provided best result to reduce the white heads in *kharif* rice. Next best performance was obtained from chlorantraniliprole granule application in seedbed on seven days prior to uprooting or the same granular application at 30 DAT along with spraying of chlorantraniliprole/flubendiamide in the main-field. Our findings are in close conformity with the observations of Suri & Brar (2013), Panda & Mishra (2014) who also reported that chlorantraniliprole could effectively control white heads in rice. Chakraborty (2012) also stated that new generation pesticide flubendiamide and chlorantraniliprole granule could effectively control rice yellow stem borer with increasing grain yield. The superiority of flubendiamide against stem borer has been established (Hugar et al. 2009; Sekh et al. 2007; Bhanu & Reddy 2008; Karthikeyan et al. 2008). There were significant variations in grain yields in both the years. The highest grain yield was obtained from where the granular and liquid formulation of chlorantraniliprole was applied in transplanted field followed by chlorantraniliprole granule application in seedbed along with spraying of chlorantraniliprole in the main-field. Similar findings were also recorded by Suri (2011) and Chakraborty (2012). Among the beneficial organisms, the spider population was recorded more in chlorantraniliprole granule applied plots as compared to the liquid formulation plots. Similarly, spinosad spray plots also showed more population of spiders.

Acknowledgement

Authors are grateful to the Directorate of Agriculture, Government of West Bengal, Jessop Building, Kolkata for sanctioning RKVY project, India.

Literature Cited

Bhanu KV Reddy PS. 2008 Field evaluation of certain newer insecticides against rice insect pests. *Journal of Applied Zoological Research* **19**:11-14.

Chakraborty K. 2012 Effective management of *Scirpophaga incertulas* walker on rice crop during *kharif* season in West Bengal, India. *American Eurasian Journal of Agriculture & Environmental Sci*ences **12**:1176-84.

Chatterjee S Mondal P. 2014 Management of rice yellow stem borer, *Scirpophaga incertulas* Walker using some biorational insecticides. *Journal of Biopesticides* **7**: 143-47.

Deka S Barthakur S. 2010 Overview on current status of biotechnological interventions on yellow stem borer *Scirpophaga incertulas* (Lepidoptera: Crambidae) resistance in rice. *Biotechnological Advancement* **28**:70-81.

Hugar SV Hosamani V Pradeep S Hanumanthaswamy BC. 2009 Evaluation of New Chemical Molecules for the Managaement of *Scirpophaga incertulas* Walker, in Aerobic rice. *International Journal of Plant Protection* **2**:205-08.

Karthikeyan K Jacob S Purushothman SM Smitha R. 2008 Effect of spinosad against major insect pests and natural enemies in rice ecosystem. *Journal of Biological Control* **22**:315-20.

Katti G. 2007 Biological control of Insect-pest of rice. *Training Manual-Integrated Pest Management in Rice*, Directorate of Rice Research, Hyderabad, India, 148-153 pp.

Kulagod SD Hedge M Nayak GV Vastrad AS Hungar PS Basavanagoud K. 2011 Evaluation of insecticides and bio-rationals against yellow stem borer and leaf folder on rice crop. *Karnataka Journal of Agricultural Science* **24**:244-46.

Lahm GP Cordova D Barry JD. 2009 New and selective rynodine receptor activators for insect control. *Bioorganic Medical Chemistry Literature* **17**:4127-133.

Padhi G. 2009 Evaluation of selected low land and medium land rice cultivars against *Scirpophaga incer-*

tulas (Wlk.). *Oryza* **46**:174-176.

Panda SK Mishra IOP. 2014 Field efficacy of granular chlorantraniliprole (E 2Y 4S) against rice stem borers in Odisha. *Journal of Plant Protection & Environment* **11**(2): 107-110.

Sattelle DB Cordova D Cheek TR. 2008 Insect rynodine receptors: molecular targets for novel pest control chemicals. *Invertebrate Neurosci*ences **8**:107-19.

Sekh K Nair N Ghosh SK Somachoudhury AK. 2007 Evaluation of flulubendiamide 480 SC against stem borer and leaf folder of rice and effect on their natural enemies. *Pestology* **31**:32-34.

Suri KS. 2011 Bioefficacy of some insecticides against rice stemborers and leaffolder infesting rice in Punjab. *Pesticide Research Journal* **23**:190-93.

Suri KS Bhar DS. 2013 Bioefficacy of chlorantraniliprole against stemborers and leaffolder infesting *Basmati* rice. *Indian Journal of Plant Prot*ection **41**:215-18.

Xuesong Z Xiubei R Jianya Su. 2011 Insecticide Susceptibility of *Cnaphalocrocis medinalis* (Lepidoptera: Pyralidae) in China. *Journal of Economic Entomology* **104**:653-58.