The Pharma Innovation Journal 2023; 12(6): 5085-5090

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 5085-5090

www.thepharmajournal.com
Received: 08-03-2023
Accepted: 13-04-2023

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Influence of seed treatment of tetraniliprole 480 FS on plant germination, major insect pests and natural enemies of rice

Swoyam Singh, AK Pandey, Mayank Kumar, Rupak Jena and Pradyot Nalini

Abstract
Damage to rice crop by insect pest has been one major problems in rice cultivation. The present study focuses on the management of major rice pests like yellow stem borer and leaf folder by seed treatment of rice seeds with Tetraniliprole 480 FS by both dry seed treatment method and wet seed treatment method. The results indicated that both the seed treatment methods @ 3.6 g a.i. / kg seeds was the best treatment for the management of both the insects. Moreover, no side effects on the germination of seeds were recorded in the present study. The efficacy of Tetraniliprole 480 FS on the natural enemies was negligible where maximum parasitization (20.21 percent in 2016 and 23.47 percent in 2017 after 40 DAT) and spiders (1.98 spiders/m^2 in 2016 and 2.92 spiders/m^2 in 2017 after 40 DAT) were recorded on rice seedlings treated with Tetraniliprole 480 FS 3.6 g a.i. / kg seeds. The maximum yield (53.89 q/ha) was reported in rice treated with Tetraniliprole 480 FS 6 g a.i. / kg seeds.

Keywords: Yellow stem borer, seed treatment, leaf folder, tetraniliprole, spiders, parasitisation

1. Introduction
Rice, *Oryza sativa* (L.), one of the world's most important food crops, is attacked by a variety of insect pests and pathogens in field as well as during storage (Peng *et al*., 2009). To control these insect pest and diseases the most popular practice among the farmers is the use of chemical pesticides (Singh and Tiwari, 2020) [9]. However, the most common method of their application is restricted to foliar sprays and soil treatment by dusts or granule formulations. These methods are labour intensive and repeated usage of these traditional chemicals have led to an additional problems of insecticide resistance. Seed treatment have been developed as an effective method of control of insect pests of rice. Moreover, they are effective, safe, economical and broad spectrum in their application. Generally, systemic insecticides were used for seed treatment, since they get incorporated into the plant system.
The urge for new molecules is mandatory to avoid the problem of insecticide resistance among insect pests. In that context Bayer crop science have developed tetraniliprole 480 FS exclusively for seed treatment keeping in view the rising cases of insecticide resistance and labour scarcity in Indian agriculture. Tetraniliprole 480 FS is an anthranilic diamide insecticide with a novel and specific mode of action. There are some reports on the efficacy of tetraniliprole 480 FS against maize stem borer, however, literature concerning its efficacy against rice insect pests is scanty. Hence, the objective of the study was to evaluate the bio-efficacy of Tetraniliprole 480 FS seed treatment against insect pests and on natural enemies of rice.

2. Material and Methods
2.1 Study site
The field experiment was conducted at Crop Research Centre, GB Pant University of Agriculture and Technology (Pantnagar), during kharif 2016 and 2017 in Randomised Block Design with three replications to assess the bio efficacy of Tetraniliprole 480 FS at different doses against yellow stem borer and leaf folder of rice. The plots were 5 x 5 sq. meters in size, topographically levelled and filled with sandy loam type of soil. The rice variety used for sowing was Pusa basmati 1121.

2.2 Seed Treatment
There was a total of 9 treatments among which two were treated control and one was untreated control. The rest of treatments were equally divided to wet seed treatment and dry seed treatment of tetraniliprole 480 FS at different doses per kilograms of seed, respectively. The seed treatment was done a day prior to sowing by following the polybag method.

2.3 Observations recorded
a. Germination and Seedling vigour
Percent germination of rice seedlings recorded at 10 days after sowing. Seedling vigour was recorded by measuring shoot and root length of 100 seedlings before transplanting.

b. Stem borer
Dead Hearts: Observations were recorded on 10 randomly selected hills/ treatment/ replication at 10, 20, 30 & 40 days after transplanting in seed treated and untreated plots and worked out percent damage as per Abbott's formula.

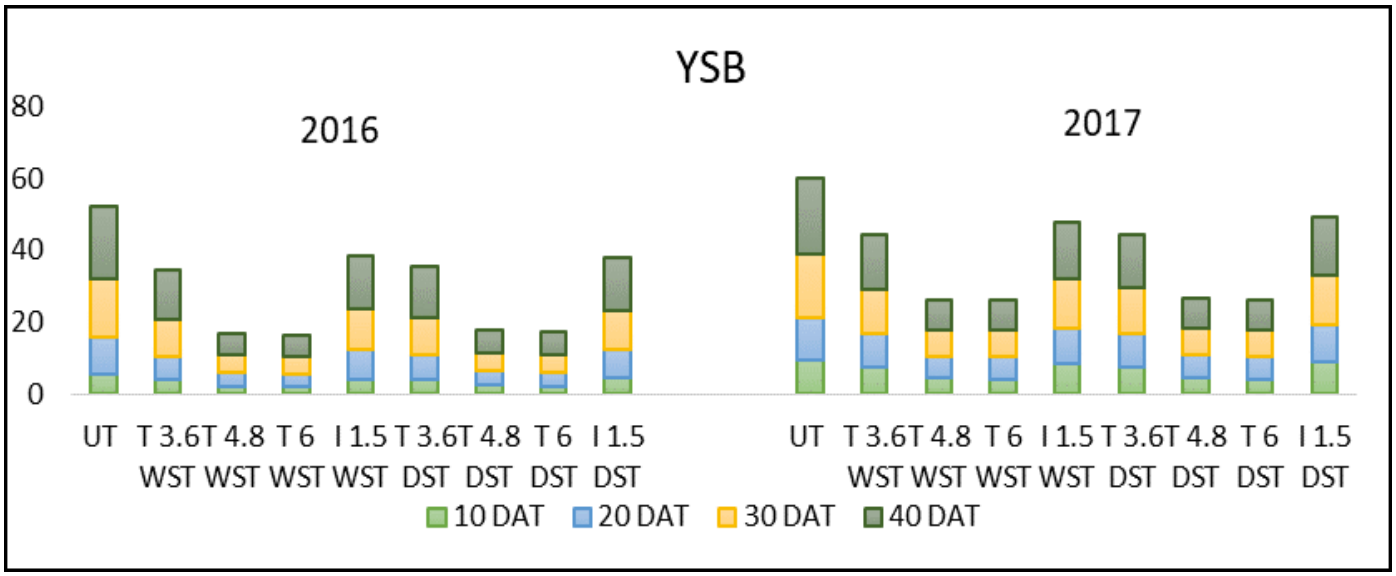
c. Leaf folder
Observations were recorded at 10, 20, 30 & 40 days after transplanting in seed treated and untreated plots on 10 randomly selected hills/replication/treatment of freshly damaged or folded leaves/hill. The percent leaf damage was calculated using Henderson & Tilton formula (1955).

d. Natural Enemy
Number of spiders was recorded in one square meter area in nursery as well as in each plot. Parasitoids of yellow stem borer were recorded in five egg mass collected from each plot. The collected egg masses were preserved in the plastic vials separately for hatching after which number of parasitoids and larvae was counted from each vial. The data was used to calculate percent egg mass parasitized and percent parasitisation.

e. Yield
All of rice plants of each plot were harvested. The grains of the rice plants were collected, dried outside and weighed to assess rice yield per plot, and was then converted to rice yield per ha.

3. Results
3.1 Effect of Tetraniliprole 480 FS on germination
The percent germination among the treatments were observed to be non-significantly different at 10 days after sowing (DAS) during 2016 and 2017 (Table 1). Moreover, the seed treatment method (wet or dry seed treatment) had no significant effect on the seed germination and vigour of the plants. However, shoot length recorded was the highest in treatment treated with Tetraniliprole 480 FS (wet seed treatment @ 6.0 g a.i./ Kg) with 28. 46 and 27.78 cm during the year 2016 and 2017, respectively. On the contrary, the lowest lengths of the plants were observed in the untreated plots.

3.2 Bio-efficacy of Tetraniliprole 480 FS against Stem borer
Bio-efficacy of Tetraniliprole 480 FS against yellow stem borer (YSB) was studied under field condition during kharif season of year 2016 and 2017. The data indicated that Tetraniliprole 480 FS @ 6 g a.i/kg seeds was highly effective against yellow stem borer. The infestation of borer was highest in untreated control as compared to other treatments. During 2016, Tetraniliprole 480 FS under wet seed treatment @ 6 g a.i/kg showed the lowest infestation of 1.97 percent at 10 DAT followed by 2.34 percent when treated under dry seed treatment method @ 6 g a.i/kg seeds at 10 DAT. Similar trends were observed in 2017 also. Higher percent infestation (4.31 and 8.74 percent at 10 DAT during 2016 and 2017, respectively) of stem borer was observed in the standard check (imidacloprid 600 FS @ 1.5 g a.i./ Kg). However, the untreated plots recorded the highest infestation *i.e.*, 5.48 and 9.45 percent, respectively during the year 2016 and 2017. The infestation data was recorded at 10 days interval and it was found that Tetraniliprole 480 FS @ 6 g a.i/kg seeds showed the least stemborer infestation during the entire crop period followed by Tetraniliprole 480 FS @ 4.8 g a.i/kg seeds (Figure 1). However, the standard check and the untreated plots showed comparatively higher infestation during the entire crop period.



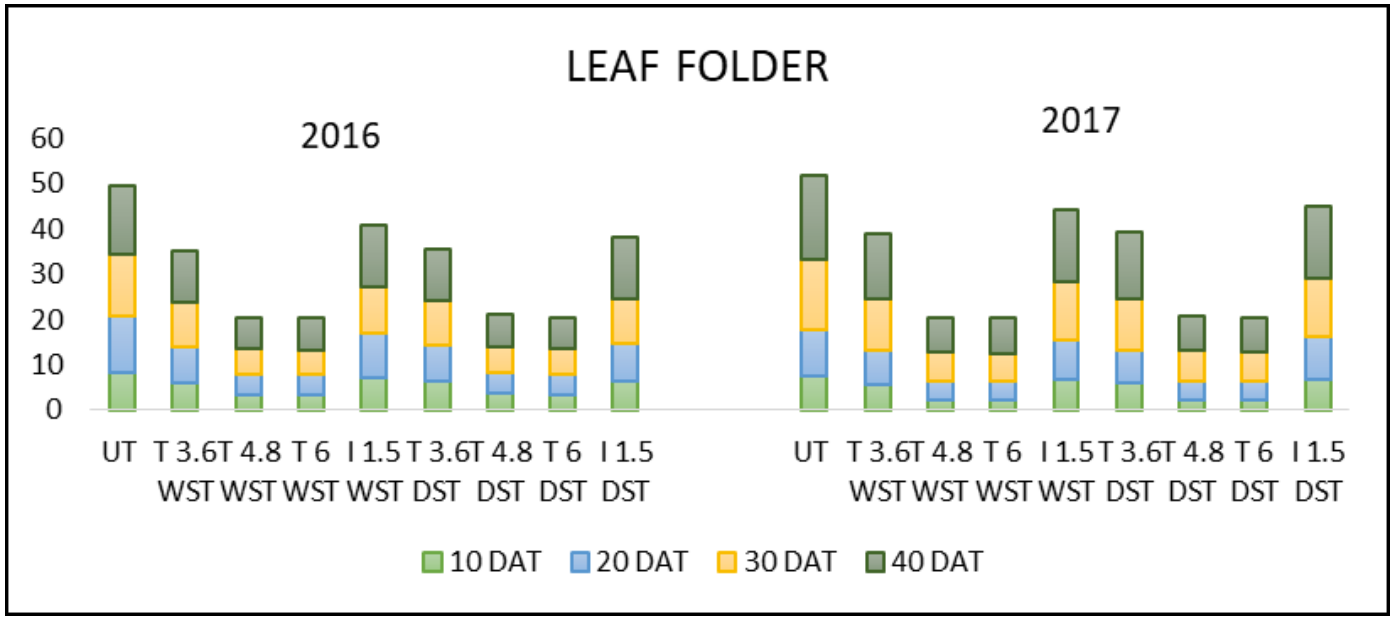
UT= untreated control; T3.6= Tetraniliprole 480 FS @ 3.6 g a.i/ha; T4.8= Tetraniliprole 480 FS @ 4.8 g a.i/ha; T4.8= Tetraniliprole 480 FS @ 3.6 g a.i/ha; WST= Wet Seed Treatment; DST= Dry seed Treatment

Fig 1: Percent infestation of Stem borer recorded in plots treated with Tetraniliprole 480FS during *Kharif* 2016 and 2017

3.3 Bio-efficacy of Tetraniliprole 480 FS against Leaf folder

The observation recorded to study the efficacy of Tetraniliprole 480FS against Leaf folder was studied in the main field in kharif season 2016 and 2017. The data indicated that after 10 DAT, significantly lowest folded leaves (3.39 and 2.03 percent) was recorded in nursery raised with seed treated by Tetraniliprole 480 FS (wet seed treatment 6 g a.i/kg seeds) followed by Tetraniliprole 480 FS (dry seed treatment 6 g a.i/kg seeds) with 3.41 and 2.07 percent in @ 6 g a.i. /kg seed. While, higher folded leaves (7.23 and 6.69 percent) were observed in standard check (imidacloprid 600 FS @ 1.5 g a.i./ Kg) in wet seed treatment and dry seed treatment (6.26 and 6.78 percent) whereas control recorded highest infestation with 8.34 and 7.45 percent, respectively. After 20 DAT, significantly lowest percent folded leaves was recorded in Tetraniliprole 480 FS wet seed treatment (4.48 and 4.17 percent) and dry seed treatment (4.57 and 4.25 percent) @ 6 g a.i. /kg seed while control still observed highest percent folded leaves with 12.49 and 10.45 percent, respectively (Figure 2).

Similar trend was followed after 30 and 40 DAT, where percent lowest folded leaves was recorded at dose of Tetraniliprole 480FS, wet seed treatment (5.35 and 6.39 percent) @ 6 g a.i./kg seed and Tetraniliprole 480FS dry seed treatment (5.66 and 6.41 percent) while highest as obtained in control with 13.39 and 15.51 percent, respectively.



UT= untreated control; T3.6= Tetraniliprole 480 FS @ 3.6 g a.i/ha; T4.8= Tetraniliprole 480 FS @ 4.8 g a.i/ha; T4.8= Tetraniliprole 480 FS @ 3.6 g a.i/ha; WST= Wet Seed Treatment; DST= Dry seed Treatment

Fig 2: Percent infestation of Leaf folder recorded in plots treated with Tetraniliprole 480FS during *Kharif* 2016 and 2017

3.4 Effect of Tetraniliprole 480 FS on Spider

Observations recorded revealed that after 20 DAS, population of spiders ranged from 0.67 to 0.35 spiders/ m^2 in seed treated with Tetraniliprole 480 FS and there were no-significant differences among all these treatments in year 2016, while control recorded 0.67 spiders/ m^2. After 30 DAT, number of spiders per meter square area ranged from 1.14 to 2.01 spiders/ m^2. Similarly, after 40DAT, range of spider population varied from 1.49 to 1.98 spiders/ m^2, while control recorded 1.67 spiders/ m^2 (Table 2).

Data recorded in year 2017 also indicated that there were no significant differences among the treatments. After 20 DAS, number of spiders was varied from 1.22 to 1.54 spiders/ m^2, while control recorded 1.53 spiders/ m^2. Similarly, after 30 DAT, number of spiders ranged from 1.74 to 2.41 spiders/ m^2, whereas control had 1.79 spiders/ m^2. Observations recorded after 40DAT revealed that spider population varied 2.15 to 2.62 spiders/ m^2 while control recorded 2.28 spiders/ m^2 (Table 2).

3.5 Percent parasitization of yellow stem borer eggs in transplanted plot during kharif 2016 and 2017

Observations recorded in year 2016 and presented in table 3 revealed that there were no significance differences among the treatments treated with Tetraniliprole 480FS and untreated plots. After 30 DAT, percent parasitisation of yellow stem borer egg ranged from 13.31 to 14.91% and 18.69 to 20.39% after 40 DAT. Data recorded in year 2017 and presented in table 3 revealed that there were also no significance differences among the treatments treated with Tetraniliprole 480FS and untreated plots, while after 30 DAT, percent parasitization of yellow stem borer egg ranged from 16.82 to 18.16% and 22.62 to 24.045% after 40 DAT.

3.6 Effect of Tetraniliprole 480 FS on yield of rice

Observations recorded on yield and presented in table 4 revealed that treatments T3 (Tetraniliprole 480FS wet seed treatment @ 6.00 g a.i./ kg seed) with 53.89, 50.40 q/ha followed by T2 (Tetraniliprole 480FS wet seed treatment @ 4.8 g a.i./ kg seed) with 53.51 and 49.94 q/ ha, were superior over rest of the treatments and recorded significantly highest yield in both the year, 2016 and 2017, respectively.

4. Discussions

There are numerous insecticides which are used for management of rice insect pests. However, a few insecticides are used for seed treatment. The reason for this narrow screening of insecticides used for seed treatment might be

their phytotoxic effects. However, some neonicotinoids are exclusively used for seed treatment in rice which helps in management of major insects like yellow stem borer and leaf folder (Stevens *et al*., 2008). Seed treatments has an additional benefit of environmental sustainability since the insecticide is used in very less quantity (Chandrasekharan *et al*., 2012). It is also clear that the insecticides used for the purpose of seed treatments have no phytotoxic effects, in fact, thiamethoxam and imidacloprid treatments to rice seeds have enhanced germination by 9 percent (Stevens *et al*., 2008; Annamalai *et al*., 2017). However, insecticides like Fipronil have no significant effect on germination of rice seedlings, rather they enhance the growth and development of the seedlings (Moore and Kroger, 2010). Similar observations were recorded in the present study, where Tetraniliprole 480FS at recommended doses have no significant effect on germination percentage rather it enhances the growth and development of the seedlings. There might be some stimulatory effect of the insecticide which have resulted in enhancing the growth in rice upon insecticide application (Moore and Kroger, 2010). However, higher concentration of insecticide dose affects the germination and development of seeds (Ma *et al*., 2021). For instance, the higher concentration of thiamethoxam is toxic to plants (Seraguzi *et al*., 2018). Imidacloprid and thiamethoxam when used as seed treatment inhibits the growth of cotton plant at higher doses (Zhang *et al*., 2019b). On the contrary, in the present study it was confirmed that there was no adverse effect of tetraniliprole 480 FS on the germination of the rice seeds at recommended doses which was in accordance with the studies conducted by Alam *et al*., 2019 who revealed the same in case of maize. Further, there is a need for evaluation of Tetraniliprole 480 FS is on the germination of rice at higher doses.

It was observed by Koushika and Kuttayam (2021) that tetraniliprole @ 50 and 60 g a.i/ha when applied thrice at 14 days interval managed both yellow stem borer and leaf folder efficiently. However, there was no literature citing its efficacy as a seed treatment chemical against yellow stem borer of rice. Studies conducted by Alam *et al*., 2021 confirms that seed treatment of Maize sseds with Tetraniliprole 480 FS @ 3.6 g a.i/ha was found to be effective against maize stem borer, *Chilo partellus*. Similarly, the current study suggests, Tetraniliprole 480 FS under wet seed treatment @ 6 g a.i/kg is the best suited for management of both Yellow stem borer and leaf folder.

Spiders are efficient predators of many insects. The presence of spiders in rice field have contributed to increase in yield of rice by nullifying the damage caused by insects. However, the use of harmful broad-spectrum insecticides has caused numerous abnormalities in the spiders like reduced capture of prey, increased migration and death of spiders leading to reduced predation of major insect pests of rice (Rhoades and Stoddart, 2021). The present study revealed no harmful effects on spiders at the prescribed doses which corroborates the studies of Koushika and Kuttayam (2021).

Apart from predators, the parasitoids have major role in pest management of rice pests. There have been numerous studies which suggests up to 44 percentage of parasitisation of eggs of yellow stem borer under natural conditions. However, use of insecticides had resulted in 25 to 75 percentage decrease in the parasitisation of eggs which might be due to unrealistic death of the parasitoids due to the use of numerous insecticides like Spinosad, Fipronil, chlorantraniliprole etc. (Venilla *et al*., 2018). On the contrary, the parasitisation of eggs in treated plots were at par with the parasitisation on the controlled plots in the current study suggesting least effect of Tetraniliprole on parasitoids at recommended doses. Since the damage caused by insect pests are reduced by efficient effect of tetraniliprole 480 FS, the yield of the crop is thereby increased.

Table 1: Percent germination, mean shoot length (cm) and mean root length (cm) in nursery of crop during *kharif* 2016 and 2017

Name of Insecticides	Dosage (g a.i /kg seed)	2016			2017		
		Germination% (10 DAS)	MSL (25DAS)	MRL (25DAS)	Germination% (10 DAS)	MSL (25DAS)	MRL (25DAS)
Untreated Control	-	90.00	24.51	6.83	90.33	24.12	5.39
Tetraniliprole 480FS (WST)	3.6	91.33	26.66	7.37	92.00	25.81	6.48
Tetraniliprole 480FS (WST)	4.8	91.00	28.38	9.24	92.33	27.72	7.85
Tetraniliprole 480FS (WST)	6.0	91.67	28.46	9.31	92.33	27.78	7.92
Imidacloprid 600 FS) (WST)	1.5	90.67	26.28	6.63	90.67	24.89	6.07
Tetraniliprole 480FS (DST)	3.6	90.33	26.51	7.29	90.67	25.65	6.36
Tetraniliprole 480FS (DST)	4.8	90.67	27.73	8.31	91.33	26.47	7.29
Tetraniliprole 480FS (DST)	6.0	90.33	28.15	8.49	91.67	26.96	7.43
(Imidacloprid 600 FS) (DST)	1.5	90.33	26.11	6.56	90.67	24.45	5.89
SEM ±		NS	0.05	0.09	NS	0.06	0.08
CD at 5%		-	0.16	0.26	-	0.17	0.24

DAS= Day after Sowing, MSL= Mean shoot length, MRL= Mean root length, WST= Wet seed treatment, DST= Dry seed treatment

Table 2: Population of spiders in nursery and transplanted plot during *kharif* 2016 and 2017

Name of Insecticides	Dosage (g a.i /kg seed)	2016			2017		
		Spiders/m² (20 DAS)	Spiders/m² (30 DAT)	Spiders/m² (40 DAT)	Spiders/m² (20 DAS)	Spiders/m² (30 DAT)	Spiders/m² (40 DAT)
Untreated Control	-	0.67 (1.06)	1.54 (1.42)	1.67 (1.47)	1.53 (1.42)	1.79 (1.51)	2.28 (1.64)
Tetraniliprole 480 FS (Wet seed treatment)	3.6	0.51 (0.97)	1.73 (1.48)	1.98 (1.56)	1.54 (1.41)	2.27 (1.66)	2.62 (1.76)
Tetraniliprole 480 FS (Wet seed treatment)	4.8	0.35 (0.91)	1.45 (1.39)	1.79 (1.51)	1.38 (1.37)	2.41 (1.70)	2.57 (1.75)
Tetraniliprole 480 FS (Wet seed treatment)	6.0	0.47 (0.96)	2.01 (1.54)	1.67 (1.47)	1.52 (1.41)	1.74 (1.48)	2.15 (1.62)
Imidacloprid 48% w/w FS (Imidacloprid 600 FS) (wet seed treatment	1.5	0.40 (0.94)	1.26 (1.30)	1.49 (1.41)	1.22 (1.31)	1.89 (1.53)	2.47 (1.72)
Tetraniliprole 480 FS (Dry seed treatment)	3.6	0.61 (1.03)	1.48 (1.40)	1.87 (1.53)	1.74 (1.48)	1.77 (1.50)	2.35 (1.68)
Tetraniliprole 480 FS (Dry seed treatment)	4.8	0.64 (1.04)	1.61 (1.45)	1.52 (1.41)	1.55 (1.42)	1.94 (1.55)	2.62 (1.76)
Tetraniliprole 480 FS (Dry seed treatment)	6.0	0.53 (1.01)	1.14 (1.28)	1.69 (1.47)	1.46 (1.40)	2.19 (1.62)	2.38 (1.69)
Imidacloprid 48% w/w FS (Imidacloprid 600 FS) (Dry seed treatment	1.5	0.45 (0.96)	1.28 (1.33)	1.85 (1.53)	1.38 (1.37)	1.87 (1.53)	2.26 (1.65)
SEM ±		(NS)	(NS)	(NS)	(NS)	(NS)	(NS)
CD at 5%		-	-	-	-	-	-

DAS= Day after Sowing, DAT= Day after Transplanting. Data in parentheses indicate Square root (X+0.5) transformed value

Table 3: Percent parasitization of Yellow stem borer eggs in transplanted plot during kharif 2016 and 2017

Name of Insecticides	Dosage (g a.i /kg seed)	2016		2017	
		Percent parasitization at 30 DAT	Percent parasitization at 40 DAT	Percent parasitization at 30 DAT	Percent parasitization at 40 DAT
Untreated Control	-	13.31 (3.71)	20.39 (4.57)	17.05 (4.19)	22.75 (4.82)
Tetraniliprole 480 FS (Wet seed treatment)	3.6	13.59 (3.75)	19.83 (4.50)	16.82 (4.16)	22.62 (4.81)
Tetraniliprole 480 FS (Wet seed treatment)	4.8	14.24 (3.84)	20.21 (4.55)	17.46 (4.24)	23.47 (4.89)
Tetraniliprole 480FS (Wet seed treatment)	6.0	13.57 (3.75)	19.81 (4.50)	18.16 (4.32)	23.39 (4.88)
Imidacloprid 48% w/w FS (Imidacloprid 600 FS)(wet seed treatment	1.5	13.50 (3.74)	20.05 (4.53)	17.69 (4.26)	24.04 (4.95)
Tetraniliprole 480FS (Dry seed treatment)	3.6	14.51 (3.87)	18.81 (4.39)	16.76 (4.15)	23.04 (4.85)
Tetraniliprole 480FS (Dry seed treatment)	4.8	14.91 (3.92)	18.75 (4.39)	16.94 (4.17)	22.91 (4.84)
Tetraniliprole 480FS (Dry seed treatment)	6.0	13.53 (3.74)	19.82 (4.51)	17.38 (4.23)	23.60 (4.91)
Imidacloprid 48% w/w FS (Imidacloprid 600 FS) (Dry seed treatment	1.5	14.41 (3.86)	18.69 (4.38)	17.44 (4.23)	23.25 (4.87)
SEM ±		(NS)	(NS)	(NS)	(NS)
CD at 5%		-	-	-	-

Table 4: Grain yield in plots treated with Tetraniliprole 480FS

Treatments	Dosage (g a.i /kg seed)	Yield (Qtl/ha) During *Kharif* 2016	Yield (Qtl/ha) During *Kharif* 2017	Pool Data of yield	% Increase Over Control
Untreated Control	-	36.49	35.78	36.14	22.29
Tetraniliprole 480 FS (Wet seed treatment)	3.6	47.24	45.76	51.73	30.14
Tetraniliprole 480 FS (Wet seed treatment)	4.8	53.51	49.94	52.15	30.70
Tetraniliprole 480 FS (Wet seed treatment)	6.0	53.89	50.40	44.36	18.53
Imidacloprid 48% w/w FS (Imidacloprid 600 FS) (wet seed treatment)	1.5	45.04	43.67	45.33	20.28
Tetraniliprole 480 FS (Dry seed treatment)	3.6	46.20	44.46	50.64	28.64
Tetraniliprole 480 FS (Dry seed treatment)	4.8	52.87	48.40	50.87	28.97
Tetraniliprole 480 FS (Dry seed treatment)	6.0	53.02	48.72	43.54	17.01
Imidacloprid 48% w/w FS (Imidacloprid 600 FS) (Dry seed treatment	1.5	44.25	42.83	46.50	22.29
SEM ±		0.11	0.09	-	-
C.D. at 5%		0.33	0.27	-	-

5. Conclusions

The practise of insecticides is the most popular and effective approach of pest management by the farmers. The conventional method of insecticide had infinite demerits majorly being environmental pollution and insect resistance. Its high time to adapt alternate ways which could focus on need-based use of insecticides to develop sustainability. One of the best approaches of pest management concluded by our studies is seed treatment which focuses on use of insecticides at minimal dose for maximum impact of insects and pest. The current study exhibits that seed treatment of tetraniliprole 480 FS is comparatively safe to both predators and parasitoids persisting in rice ecosystem while exhibiting maximum tolerance against pests. Hence, seed treatment of rice with tetraniliprole 480 FS can be used as a alternative approach towards sustainability.

6. References

1. Alam T, Prasad R, Kumar R, Sahoo S. Studies on efficacy of tetraniliprole 480 FS on maize crop against maize stem borer, *Chilo partellus* (Swinhoe) as seed treatment. Journal of Experimental Zoology. 2020;23(1):649-652.
2. Annamalai M, Vasantha-Srinivasan P, Thanigaivel A, Muthiah C, Karthi S, Jena M, *et al*. Effect of thiamethoxam on growth, biomass of rice varieties and its specialized herbivore, *Scirpophaga incertulas* Walker. Physiological and Molecular Plant Pathology. 2018;101:146-155. doi:10.1016/j.pmpp.2017.10.009
3. Chandrasekaran R, Revathi K, Nisha S, Kirubakaran SA, Sathish-Narayanan S, Senthil-Nathan S. Physiological effect of chitinase purified from *Bacillus subtilis* against the tobacco cutworm *Spodoptera litura* Fab, Pest. Biochem. Physiol. 2012;104(1):65-438, 71.
4. Kousika J, Kuttalam S. Efficacy of tetraniliprole 200sc against rice yellow stem borer *Scirpophaga incertulas* (wlk.) and leaf folder *Cnaphalocrocis medinalis* guen. Indian Journal of Entomology. 2021;83:85-87.
5. Ma D, Yang S, Jiang J, Zhu J, Li B, Mu W, *et al*. Toxicity, residue and risk assessment of tetraniliprole in soil-earthworm microcosms. Ecotoxicology and Environmental Safety. 2021;213:11-20.
6. Rhoades SN, Stoddard PK. Nonlethal Effects of Pesticides on Web-Building Spiders Might Account for Rapid Mosquito Population Rebound after Spray Application. Appl. Sci. 2021, 11-1360. https:// doi.org/10.3390/app11041360
7. Seraguzi EF, Rego CHQ, Cardoso FB, Cândido ACDS, Alves CZ. Physiological quality of *Brachiaria brizantha* seeds treated with fungicide and insecticide. Revista Caatinga. 2018;31:651-656.
8. Shaobing P, Qiyuan T, Yingbin Z. Current Status and Challenges of Rice Production in China, Plant Production Science. 2009;12(1):3-8. DOI: 10.1626/pps.12.3
9. Singh S, Tiwari S. Sucking Pests of Rice. In: Sucking Pests of Crops (Eds: Omkar) Springer Nature Publications, Singapore. 2020. p. 55-105 Doi: 10.1007/978-981-15-6149-8_2.
10. Stevens MM, Reinke RF, Coombes NE, Helliwell S, Mo J. Influence of imidacloprid seed treatments on rice germination and early seedling growth. Pest Management Science. 2008;64(3):215–222. doi:10.1002/ps.1499
11. Vennila P, Sridevi G, Padmakumari AP. Effect of insecticides on parasitism by egg parasitoids of the rice yellow stem borer, *Scirpophaga incertulas.* Journal of Entomology and Zoology Studies. 2018;6(5):67-70
12. Zhang SL, Wang H, Qi GY, Feng Y, Wang XP, Lei QL, *et al*. The control effects of seed treatment to *Aphis gossypii* and its effects on cotton growth. Agrochemicals. 2019;58:537-539.