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Evaluation of Diamide and Neonicotinoid group of insecticides against maize stem borer, *Chilo partellus* (Swinhoe) as seed treatment

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Abstract
The present investigation was carried out at research farm, Tirhut College of Agriculture, Dholi during *kharif* 2018 in evaluate the efficacy of tetraniliprole 480 FS. The results revealed that treatment T4 was found to be the best among all insecticides tested with respect to number of damaged plant, minimum leaf injury, plant height and yield. However, treatment T2, T3, T5 and T6 were found safe to natural enemies among all the insecticides tested.

Keywords: Tetraniliprole, efficacy, *Chilo partellus*

1. Introduction
Globally maize (*Zea mays* L.) is one of the most important cereal crops in the agriculture economy after wheat and rice. In India maize is grown widely under extremely divergent agro-climatic conditions. It ranks third after wheat and rice among cereals, among the 250 species of insect and mite attacking maize in field and storage conditions [1]. Spotted stem borer, *Chilo partellus* is the most serious one during *kharif* causing 26.7-80.4 per cent yield losses in different agro-climate regions of India. Maize area, production and productivity in India have shown a steady upward trend in recent years mainly due to their high demand. Adult moth laid 20-25 eggs at night in cluster which is creamy white and oval in shape. The fecundity of adult female moth is around 250-300. After hatching, grayish white larva with black head crawl over the leaf and feed on the surface of tender leaves and bore downwards through the whorl and reach the growing point of the plant. As the whorl opens, pin holes are seen on leaves in parallel fashion. The larvae cut the growing point resulting in drying up of the central shoot and leads to formation of "dead heart" which on pulling comes out easily and plant vigor lost and reduction in grain yield. Keeping in view of the importance of maize crop, and the economic losses caused by the spotted stem borer during Kharif season, the present study aimed to test the efficacy of new insecticide molecules against *C. partellus* for its management. Insecticide sprays registered for the control of stem borers in maize are all intended for whorl applications [2] and in spite of this chemical control of stem borers is often ineffective [3]. Because insecticides do not always reach the larvae inside the whorl leaves (funnel) of maize plants [4]. In recent years, various methods insect pest management viz., chemical biological, physical, agronomical and host plant resistance have been developed to manage insect pests below economic threshold level and to prevent the crop from economic losses, with special emphasis on development of new chemical. Effectiveness of many insecticides viz., earbofuran and phorrate as granular application and imidacloprid, thiomethaxam, endosulphan, and indoxaxarb as foliar application were reported [5]. For management of insect pests below ETL and to check economic losses. But due to ban of many insecticides and development of resistance in many insects for different insecticides, it is necessary to develop new chemicals. However, no information about new chemicals is available. After long time a new chemical tetraniliprole 480 FS is developed by Bayer Crop Science, is an anthranilic diamide insecticide with a novel and specific mode of action. These group of insecticides acts on novel target and potently activate ryanodine receptor and releasing stored calcium from the sarcoendoplasmic reticulum causing impaired regulation of muscle contraction leading to feeding cessation, lethargy, paralysis, and death of target organisms. Reports on efficacy of teraniliprole 480 FS against maize stem borer is not available, therefore an experiment has been carried out to evaluate the bio-efficacy of

tetraniliprole 480 FS as seed treatment, at different doses against maize stem borer besides it phytotoxicity, safety to natural enemies and finally grain yield were assessed also.

Materials and Methods

A field experiment was conducted at research farm Tirhut College of Agriculture, Dholi (Muzaffarpur), a campus of Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar during *kharif* 2018 in Randomized Block Design to assess the bio efficay of Tetraniliprole 480 FS at different doses.

Efficacy of Tetraniliprole 480 FS on Maize crop against stem borer and shoot fly as seed treatment.

Table 1: Chemical properties of the soil

Sl. No.	Particulars	Value obtained
1.	EC (dSm^{-1} at 25 °C)	0.22
2.	pH (1: 2.5 water suspension)	8.27
3.	Organic carbon (%)	0.46
4.	Available N (kg/ha)	206.0
5.	Available P_2O_5 (kg/ha)	16.30
6.	Available K_2O (kg/ha)	106.24
7.	Soil type	Sandy loam

Weather condition of seed sowing date:

- Temperature: Maximum **:** 31.4 and Minimum : 26.6
- Relative humidity: Maximum : 82 and Minimum: 79
- Precipitation: 0.0
- Wind speed: 8.4Km/hr
- Sunshine: 9.6 hr

Table 2: Weekly mean weather parameters during experimentation (July-November 2018)

Standard Week No.	Month and Date	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
		Maximum	Minimum	Morning	Evening	
30	July 22-28	32.2	25.3	89	77	58.0
31	July 29-04	31.1	25.3	92	79	91.8
32	Aug. 05-11	32.8	26.4	88	74	60.4
33	Aug. 12-18	33.7	26.5	86	66	63.4
34	Aug. 19-25	32.6	26.3	91	82	168.2
35	Aug. 26-01	33.0	26.1	90	76	39.0
36	Sept. 02-08	32.7	25.7	90	81	40.2
37	Sept. 09-15	33.2	25.7	87	71	7.0
38	Sept. 16-22	33.6	25.1	84	71	57.0
39	Sept. 23-29	33.8	24.8	86	66	0.0
40	Oct. 30-06	33.6	22.7	81	58	12.6
41	Oct. 07-13	30.9	21.5	88	64	0.0
42	Oct. 14-20	32.2	18.4	85	52	0.0
43	Oct. 21-27	31.5	15.7	87	49	0.0
44	Oct. 28-03	31.8	16.1	84	62	0.0

Table 3: Treatment details

Treatment	Treatment details
T_1	Untreated Control
T_2	Tetraniliprole 480 FS @ 1.2 g/kg of seed
T_3	Tetraniliprole 480 FS @ 2.4 g/kg of seed
T_4	Tetraniliprole 480 FS @ 3.6 g/kg of seed
T_5	Imidacloprid 48% w/w FS (Imidacloprid 600 FS) @ 6 g/kg of seed
T_6	Thiomethoxam 30% FS @ 2.4 g/kg of seed
T_7	Tetraniliprole 480 FS @ 7.2 g/kg of seed

The crop was grown in a field with homogenous fertility and uniform textural property by following all recommended agronomic practices except other insecticidal application. The nutrient status of the field before sowing was as follows: EC (dsm-1 at 25 ^{0}C) 0.22, pH (1:2.5 water suspension) 8.27, Organic carbon (%) 0.46, Available N (kg/ha) 206.0, Available P_2O_5 (kg/ha) 16.30, Available K_2O (kg/ha) 106.24. The experiment consists of seven treatments and four replications. Seed treated with Tetraniliprole 480 FS at different doses viz., 1.2 g/kg, 2.4 g/kg, 3.6 g/kg, 7.2 g/kg, Imidacloprid 48% w/w FS (Imidacloprid 600 FS) @ 6 g/kg, Thiomethoxam 30% FS @ 2.4 g/kg, of seed and an untreated check were sown during *kharif* dated 4/08/2016 . Each plot size was 30 square meter with six rows of five meter length. The lot consists of seed treatment with Tetraniliprole 480 FS @ 7.2 g/kg, of seed was considered only for phytotoxicity assessment but not for bio-efficacy. The germination per cent and mean plant height were recorded at 20 and 30 days after sowing (DAS) whereas, mean number of damaged plant leaf injury score and natural enemies population were observed on 20, 30, 40 and 50 DAS. Phytotoxicity symptoms like leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty on maize plants were observed on 10, 15, 20 and 30 DAS. Maize grain yield was obtained after crop harvest and expressed in quintal per ha at 15 per cent moisture. Infestation of maize stem borer and leaf injury score were recorded from 20 randomly selected plants while, natural enemies' population was recorded from five randomly selected plants.

Results and Discussion

The data presented in Table 4, evinced that the germination per cent of the crop in experimental plot ranged from 88 to 95 per cent. The maximum germination per cent (95%) was observed in T_4 and minimum (88%) in untreated control, respectively. No significant variation of plant height was found among treated plot. The maximum plant height (68cm)

at 30 days after sowing was observed in T_4 treated plot followed by T_6 (63cm), T_3 (63), T_2 (58cm), T_5 (54cm), T_1 (43cm), The results discussed above showed that the infestation of *C. partellus* reduces plant height as minimum plant height was recorded in T_1 (Untreated control) and the maximum in T_4 (Kumar (1997) and (Singh *et al*. (2012) showed that stem tunneling damage had a significant influence on maize plant growth.

Table 4: Germination percentage and plant height in different treatment

Sr. No.	Treatment	Dosage a.i.(g)/kg of seed	Germination % at 20 days after sowing	Mean plant height at 30 days after sowing
1	Untreated Control	-	88	43
2	Tetraniliprole 480 FS	1.2	93	58
3	Tetraniliprole 480 FS	2.4	94	63
4	Tetraniliprole 480 FS	3.6	95	68
5	Imidacloprid 48% w/w FS(Imidacloprid 600 FS)	6	92	54
6	Thiomethoxam 30% FS	2.4	94.5	63
7	Tetraniliprole 480 FS	7.2	-	-
	C.D. @ 5%			58.16
	SE(m)			19.57

***** see table 3 for treatment detail

Germination % of the crop in experimental plot varies from 88 to 95. The maximum germination % is observed in treatment no. four i.e. Tetraniliprole 480 FS @ 3.6g a.i/kg of seed treated plot and minimum germination % is observed in Treatment-1 i.e. untreated control respectively. No significant variation of plant height is found among treated plot, the maximum plant height is observed in treatment 4th followed by 6th, 3rd, 2nd, 5th, and 1st.

The number of damaged plant/20 plants under artificial infestation condition of maize stem borer, *C. partellus* was recorded at 20, 30, 40 and 50 DAS (days after sowing) in different treatment as indicated in Table 3. Among all the treatments T_4 was performed best with minimum damaged plant/20 plant i.e., 0.0, 0.0, 1.22 and 1.40 at 20, 30, 40, and 50 DAS, respectively. The treatment T_3 recorded 0.33, 0.78, 1.56 and 1.98 damaged plants/ 20 plants at 20, 30, 40 and 50 DAS, respectively was found to be 2nd best treatment. The maximum number of damaged plant / 20 plants was reported in T_1. The minimum leaf injury 1.0, 1.0, 1.10 and 1.20 at 20, 30, 40 and 50 DAS were recorded in T_4 treated plot. This was followed by treatment T_3 with leaf injury score 1.11 (20 DAS), 1.28 (30DAS), 1.47 (40DAS) and 1.61 (50DAS). The maximum leaf injury score was recorded in T_1 i.e., 2.54 (20DAS), 4.22 (30DAS), 6.23 (40DAS), and 6.55 (50DAS). Ali *et al*. (2014) reported that the leaf injury score 3.21 (25DAS) and 3.51 (45 DAS) was observed in imidacloprid treated plot. Pal *et al*. (2009) observed that leaf injury rating 2.09 (20DAS) and 2.41(40DAS) in imidacloprid treated plot which provide support to the present investigation.

Table 5: Number of damaged plants by stem borer/plot and leaf injury score at 20, 30, 40 and 50 days after sowing.

Treatment	Dosage a.i.(g)/kg of seed	Mean number of damaged plant/ 20 plant				Leaf injury score			
		Days after sowing				Days after sowing			
		20	30	40	50	20	30	40	50
Untreated Control	-	4.2	8.36	12.61	14.41	2.54	4.22	6.23	6.55
Tetraniliprole 480 FS	1.2	0.85	1.16	1.69	2.33	1.22	1.57	1.81	2.24
Tetraniliprole 480 FS	2.4	0.33	0.78	1.56	1.98	1.11	1.28	1.47	1.61
Tetraniliprole 480 FS	3.6	0.0	0.0	1.22	1.40	1.0	1.0	1.10	1.20
Imidacloprid 48% w/w FS (Imidacloprid 600 FS)	6	1.01	1.32	1.44	2.08	1.37	1.96	2.15	2.53
Thiomethoxam 30% FS	2.4	1.15	1.29	2.04	2.51	1.47	2.05	2.38	2.54
Tetraniliprole 480 FS	7.2	-	-	-	-	-	-	-	-
C.D. @ 5%		1.84	3.51	5.30	6.13				
SE(m)		0.62	1.18	1.78	2.06				

* see table 1 for treatment details

As the data presented in Table 6, indicates that coccinellids population among various treatments varied significantly during entire crop season and ranged from 1.87 to 17.57. The maximum coccinellids population 9.58, 12.21, 15.18 and 17.57 was recorded at 20, 30, 40 and 50 DAS after sowing, respectively in untreated control. However, the minimum coccinellids population was observed in T_4 *i.e.*, 1.87 (20 DAS), 2.66 (30 DAS), 3.23 (40 DAs), and 4.99 (50 DAS). Among all the treatments maximum spider population 4.58 (20 DAS), 6.55 (30 DAS), 7.74 (40 DAS), and 9.12 (50 DAS), were recorded in untreated control, whereas the least spider population 1.51, 2.28, 1.18 and 3.01 were found at 20, 30, 40 and 50 DAS, respectively. On the basis of above results mentioned it is obvious that, application of T_2, T_3, T_5 and T_6 were found safest to natural enemies as compare to other treatments tested. Yadav (2007) reported 50.43 per cent reduction in population of coccinellids with endosulfan. Barwal and Rao (1988) reported that endosulfan was most toxic to *Mylobrids phalerata* and *Epicautes* upto 16 hr after application of treatment.

Table 6: Occurrence natural enemies of maize stem borer during *Kharif* 2018 in experimental plot

Treatment	Dosage a.i.(g)/kg of seed	Population of coccinellids/5 plant at different intervals				Population of spiders/5 plant at different intervals			
		Days after sowing				Days after sowing			
		20	30	40	50	20	30	40	50
Untreated Control	-	9.58 (3.09)	12.21 (3.49)	15.18 (3.89)	17.57 (4.19)	4.58 (2.14)	6.55 (2.55)	7.74 (2.78)	9.12 (3.01)
Tetraniliprole 480 FS	1.2	3.27 (1.80)	4.33 (2.08)	7.27 (2.69)	7.21 (2.68)	1.91 (1.38)	2.36 (1.62)	3.12 (1.76)	3.81 (1.95)
Tetraniliprole 480 FS	2.4	2.48 (1.57)	3.67 (1.91)	4.40 (2.09)	5.90 (2.42)	1.88 (1.37)	2.04 (1.42)	2.50 (1.58)	3.35 (1.83)
Tetraniliprole 480 FS	3.6	1.87 (1.36)	2.66 (1.63)	3.23 (1.79)	4.99 (2.23)	1.51 (1.23)	2.28 (1.50)	1.88 (1.37)	3.01 (1.73)
Imidacloprid 48% w/w FS(Imidacloprid 600 FS)	6	2.64 (1.62)	3.62 (1.90)	5.34 (2.31)	6.28 (2.50)	2.11 (1.45)	2.18 (1.47)	2.47 (1.57)	3.17 (1.78)
Thiomethoxam 30% FS	2.4	2.81 (1.67)	3.71 (1.92)	5.91 (2.43)	7.31 (2.70)	1.99 (1.41)	2.20 (1.48)	2.37 (1.53)	3.09 (1.75)
Tetraniliprole 480 FS	7.2	-	-	-	-				
C.D @ 5%		0.713	1.032	1.396	1.422	0.531	0.816	0.873	0.762
SE(m)		0.237	0.345	0.458	0.467	0.694	0.287	0.296	0.251

*Figures in parentheses are square root transformed values.
*see table 1 for treatment details.

The data given in Table 7 clearly indicated that, none of the phytotoxicity symptom viz., yellowing, Stunting, necrosis, epinasty, hyponasty, wilting and rosetting was observed in T_4 and T_7 treated plot of maize.

Table 7: Phyto-toxicity of treatment no.1, 4 and 5

Tr. No.	Treatment	Dosage a.i.(g)/kg of seed	Phyto-toxicity days after sowing				
		a.i. (g)	Formulation (ml)	10	15	20	30
1	Untreated control	-	-	0	0	0	0
4	Tetraniliprole 480 FS	3.6	7.5	0	0	0	0
7	Tetraniliprole 480 FS	7.2	15	0	0	0	0

Result

Phyto-toxicity (i.e. yellowing, stunting, necrosis, epinasty, hyponasty, wilting and rosetting) were not observed on maize plants in any treatment.

The data pertaining to grain yield shown in fig. 1 indicated that yield in different treatments varied widely from 17.53 to 33.79 q/ha. The maximum grain yield of 33.79 q/ha was recorded in T_4 and minimum in untreated control. The yield in treatment T_2 was 32.70 q/ha and was at par with T_5 and T_6. The maximum additional yield over control (16.26 q/ha), was recorded in T_4 treated plot whereas, the minimum additional yield over control (9.33 q/ha) was found in T_2 treated plot.

Table 8: Yield based on different treatment

Sr. No.	Treatment	Dosage a.i.(g)/kg of seed	Yield (q/ha)	Additional yield over control
1	Untreated Control	-	17.53 (4.18)	-
2	Tetraniliprole 480 FS	1.2	26.86 (5.18)	9.33
3	Tetraniliprole 480 FS	2.4	31.57 (5.61)	14.04
4	Tetraniliprole 480 FS	3.6	33.79 (5.81)	16.26
5	Imidacloprid 48% w/w FS(Imidacloprid 600 FS)	6	28.78 (5.36)	11.25
6	Thiomethoxam 30% FS	2.4	28.92 (5.37)	11.39
7	Tetraniliprole 480 FS	7.2	-	-
	C.D. @ 5%		3.623	
	SE(m)		1.148	

*Figures in parentheses are square root transformed values.

Result: The data pertaining to grain yield reported that yield varied from 17.53 to 33.79 q/ha in different treatments. The maximum grain yield of 33.79 q/ha was recorded with Tetraniliprole 480 FS @ 3.6 a.i.(g)/kg of seed and minimum grain yield of 17.53 q/ha was recorded with untreated control.

- Shoot fly infestation on maize is not reported in experimental plot.

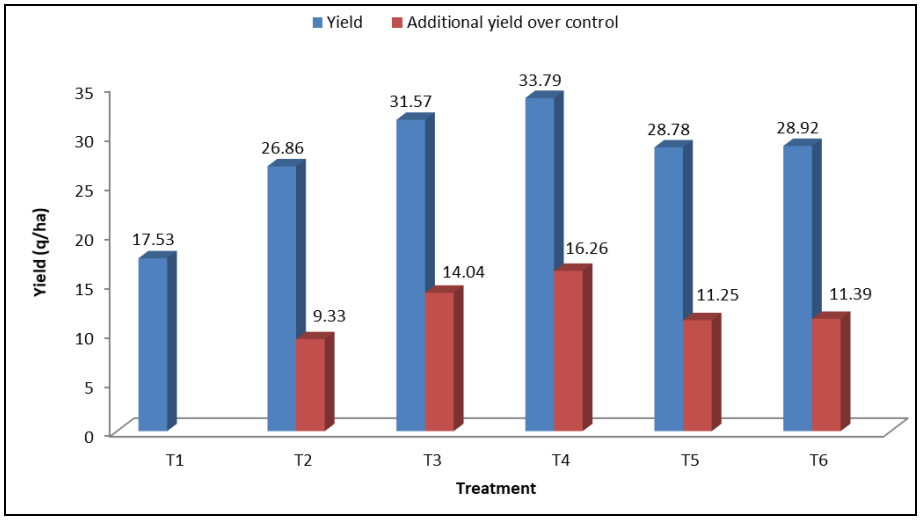

Fig 1: Yield based on different treatment

Conclusion

Tetraniliprole is a new group of insecticide which is belongs to anthranilic diamide group which has novel mode of action. It involves ryanodine receptors so that play an important role in insect muscle function. Insecticide belongs to diamide group bind to the ryanodine receptors which cause to open the calcium channel so that an uncontrolled release of calcium occurs. Ultimately lead to cessation of feeding and eventually death (Cordova *et al.*, 2006). The present study has clearly indicated the performance of tetraniliprole 480 FS @ 3.6 g/kg of seed against maize stem borer (*Chilo partellus*) as seed treatment which can effectively used for the management of the pest which gave higher grain yield of 33.79 q/ha which was additional yield over untreated control i.e. (16.26 q/ha).

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