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Bio-efficacy evaluation of new molecule PII 1721 60% WG against sucking pests of rice

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Abstract
The major production constraint of rice production is attack by pests and diseases**.** Among all the pests, the sucking pests *viz*., brown plant hopper (BPH), WBPH (white backed plant hopper), GLH (green leafhopper) and rice bug (RB) can cause economic losses extending up to 95 per cent. In case of severe pest incidences the usage of insecticides is inevitable. But, regular usage of chemicals with same mode of action may led to pest resistance, resurgence residual effect. Hence, alternate chemicals are need of the hour with no phytotoxic levels. Hence, studies on efficacy pertaining to coded product PII 1721 at different concentrations along with check chemicals and untreated control were evaluate at Agricultural Research Station, Garikapadu for two seasons during *Rabi* and *Summer* (late *Rabi*) 2017-18 to assess the efficacy of various insecticides in suppressing the population buildup of sucking pests infesting rice. The experimental trial was laid out with eight treatments that were replicated thrice and two spraying were imposed during the entire crop period at tillering at panicle initiation stage, respectively. The data on number of BPH, WBPH, GLH and RB per hill were recorded at 3, 7, 10, 15 and 20 days after spray and pooled the two sprays and analyzed the observations using SPSS statistical package. The results revealed that, among the various treatments evaluated for efficacy, the treatment T_3 (PII 1721 60% WG @200 g a.i. ha^{-1}) was found effectual in suppressing the sucking pest population during both the seasons evaluated and the next better treatment in order of efficacy was T_7 (Pymetrozine 50% WG @ 150g a.i. ha^{-1}). None of the treatments exhibited phytotoxic effect on the plant.

Keywords: PII 1721 60% WG, BPH, WBPH, rice, bio efficacy

1. Introduction
In India rice cultivation constitutes about 52 per cent of the total food grain production and 55 per cent of total cereal production in world (Kakde and Patel, 2014) [1]. In India, rice is the prominent crop grown in an area of 43.86 million ha with the production level of 104.80 million tones and the productivity is about 2390 kg ha^{-1}. In Andhra Pradesh it is cultivated in an area of 38.09 lakh ha with a production of 127.24 lakh tons and 4234 kg ha^{-1} productivity (WWW. India stat.com) [2]. Insect pests and diseases attack was considered to be the major constraint in rice production. Nearly 300 species of insect pests interfere with the rice crop at various stages and among them only 23 species are considered as pests of economic importance (Pasalu and Katti, 2006) [3]. On an average 21 per cent of the global production losses of rice crop are accredited due to attack by insect pests (Yarasi *et al*., 2008) [4]. Among the sucking pests infesting rice, the brown plant hopper (BPH), *Nilaparvata lugens* (Stal) and white backed plant hopper (WBPH), *Sogatella frucifera* (Horvath) are the monophagous species and are inevitably associated with rice cultivation in Asia (Park *et al*., 2008) [5]. The brown plant hopper (BPH) is an economic important pest and causes damage to plants directly by sucking the plant sap and also by oviposition in plant tissue causing plant wilting or hopper burn (Turner *et al*., 1999) [6]. BPH damages the rice crop directly by feeding on the phloem and indirectly by transmitting grassy stunt viruses. Insecticides are the major dependable tools in managing BPH and several insecticides belonging to different classes were reported to be effective (Krishnaiah *et al*., 2008) [7]. Hence, a paid up trial was conducted at Agricultural Research Station, Garikapadu during *Rabi* and late *Rabi* (summer), 2017-18 to evaluate the efficacy of PII 1721 60% WG in suppressing the sucking pests population in rice.

2. Materials and Methods
2.1 Experimental site
Field studies were carried out a at Agricultural Research Station, Garikapadu, Krishna district, Andhra Pradesh during *Rabi* and late *Rabi* (summer) 2017-18 to evaluate the efficacy of coded

product PII 1721 60% WG at different concentrations in comparison to dinotefuron and Pymetrozine. The experiment was laid out in RBD design with a plot size of 5 x 5 m including eight treatments which were replicated thrice. To avoid migration of BPH population from control to other treated plots a buffer area of 5 m was kept as bulk crop. 30 days old seedling were transplanted (line sowing) with a spacing of 15 x 15 cm. Judicious fertilizer, inter cultivation and other agronomic practices were employed as per recommendations. Rice variety BPT-5204 which is prone to all pest and disease attack was used for experimentation.

2.2 Imposition of treatments
To evaluate efficacy of PII 1721 60% WG, a total of eight treatments including two effective insecticides (Dinotefuron and pymetrozine) as check and untreated control were imposed twice during the crop period (Table 1).

Table 1: Treatment details

Treatment No	Treatment	Technical (g a.i./ha)	Formulation (g or ml/ha)	Dilution (l/ha)
T_1	PII 1721 60% WG	120	200	500
T_2	PII 1721 60% WG	160	267	500
T_3	PII 1721 60% WG	200	333	500
T_4	PII 1721 60% WG	400	667	500
T_5	Dinotefuron 20%	50	250	500
T_6	Dinotefuron 20%	40	200	500
T_7	Pymetrozine 50%	150	300	500
T_8	Untreated control	-	-	-

2.3 Meteorological data
The data on weather parameters *viz*., maximum temperature (Tmax), minimum temperature (Tmin), average relative humidity and rainfall data was recorded from Meteorological unit installed at Agricultural Research Station, Garikapadu.

2.3.1 Data recording on pest incidence
Data on number of plant hoppers (adults & nymphs) per hill pertaining to BPH, WBPH, GLH and Rice bug were recorded from 20 pre- tagged hills per replication. After imposition of treatments (spray) data at 3, 7, 10, 15 and 20 days after spray was recorded. The mean number of sucking pests per hill was calculated and suitable transformations were made before analysis. The relative highest abundance of sucking pests infesting rice was for BPH and hence per cent reduction of BPH over control upon imposition of various treatments was calculated. Per cent reduction over control = $\frac{C-T}{C} \times 100$

Where C= pest incidence in control; T=pest incidence in treatment

The damage due to rice Gandhi bug was quantified based on the grains damaged as per IRRI SES scale (Table 2).

Table 2: SES to quantify the grain damage by Earhead bugs

Scale	Damage (%)
0	No damage
1	Less than 3% damaged grains/panicle
3	4-7% damaged grains/panicle
5	8-15% damaged grains/panicle
7	12-25% damaged grains/panicle
9	26-100% damaged grains/panicle

2.4 Phytotoxicity
The crop response or injury for yellowing, stunting, necrosis, epinasty, hyponasty were recorded in all the treatments and Phytotoxicity rating was recorded (Table 3).

Table 3: Phytotoxicity scale based on crop injury

Scale	Crop injury (%)
0	0
1	1-10
2	11-20
3	21-30
4	31-40
5	41-50
6	51-60
7	61-70
8	71-80
9	81-90
10	91-100

2.5 Yield data
Plot-wise yields were also recorded after removing the two border rows and marked hills from each plot and expressed in kg ha^{-1}.

2.8 Data analysis
The recorded data was transformed with suitable transformation method before analysis and subjected to analysis of variance. Significant differences in means were separated using Duncan's multiple range test (P= 0.05).

3. Results and Discussions
3.1. Meteorological data
During the entire crop seasons the average maximum (42.5 ^{O}C) and minimum temperature (18.1 ^{O}C) was recorded during May and January, 2018 respectively. The annual rainfall was 770 mm with 47 rainy days (Table 4).

Table 4: Meteorological Data-Agricultural Research Station, Garikapadu – 2017-18

Month and year	Temperature (°c)		Humidity (%)	Rainfall (mm)	Rainy days
	Max	Min			
June 2017	36.0	22.9	80.7	159.8	7
July 2017	33.9	22.0	79.0	214.6	12
August 2017	32.8	23.0	85.2	185.7	10
September 2017	33.2	24.7	84.9	58.8	9
October 2017	33.2	23.4	87.2	105.0	5

November 2017	32.3	21.2	85.9	-	-
December 2017	31.1	17.6	85.5	-	-
January 2018	31.0	18.1	79.0	-	-
February 2018	32.0	18.0	76.5	-	-
March 2018	35.0	21.5	98.2	10.0	1
April 2018	38.2	26.0	92.0	12.0	1
May 2018	40.5	27.3	75.1	24.0	2
Total				769.9	47

3.2 Efficacy of various treatments on incidence of sucking pests infesting rice

Among all the sucking pests infesting rice, relatively the abundance of BPH was more and is followed by WBPH, GLH and Rice ear head bug. The first spray was initiated when the population crossed ETL (10-15/hill during tillering stage) and second spray 20 days after application. The data on mean number/hill for sucking pests at 3, 7, 10, 15 and 20 DAS was recorded for all treatments and evaluated their efficacy.

3.2.1 Efficacy of treatments on incidence of sucking pests infesting rice during *Rabi*, 2017-18

During *Rabi*, 2017-18 (early *Rabi*) the population of BPH attained highest which ranged from 1.0 to 300 and above no/hill. The WBPH ranged from 1.0 to 18.5 no./hill. The incidence of GLH and RB was comparatively lower.

3.2.1.1 Efficacy of treatments during first spray

The first spray was initiated during tillering stage and RB damage was not noticed. At 3 DAS among all the treatments the lowest population of BPH (15.5), WBPH (2.5) and GLH (0) were noticed in T_3 (PII 1721 60% WG @200 g a.i. ha^{-1}) as against highest in T_8 control with 48.5.18.5 and 3.8 no./hill of BPH, WBPH and GLH respectively. Similar trend was noticed at 7, 10, 15 and 20 days after first spray where in the T_3 has harboured less pest population in comparison to other treatments. However the treatment T_7 (Pymetrozine 50% WG @ 150g a.i. ha^{-1}) was also found to be the next better treatment and on par to T_3 (PII 1721 60% WG @ 200 g a.i. ha^{-1}) at 15 DAS. With respect to WBPH the treatment T_3 and T_7 were found on par. All the treatments were found effective against GLH and on par to each other at 20DAS (Table 5).

Table 5: Efficacy of various treatments on population of sucking pests (no/hill) infesting rice during *Rabi*, 2017-18 after 1st spray (mean no. of pest population/hill)

	j3DAS				7DAS				10 DAS				15 DAS				20 DAS			
Treatments	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB
T_1	39.5 (6.28)	11.8 (3.43)	2.1 (1.44)	0 (1.0)	22.5 (4.74)	8.5 (2.91)	0 (1.0)	0 (1.0)	10.5 (3.24)	5.2 (2.28)	0 (1.0)	0 (1.0)	28.5 (5.33)	11.5 (3.39)	1.5 (1.22)	0 (1.0)	38.5 (6.20)	13.5 (3.67)[a]	2.0 (1.41)[a]	0
T_2	35.5 (5.95)	5.8 (2.40)	0 (1.0)	0 (1.0)	20.5 (4.52)	7.0 (2.64)	0 (1.0)	0 (1.0)	9.0 (3.0)	5.8 (4.52)	0 (1.0)	0 (1.0)	20.5 (4.52)	9.8 (3.13)	0 (1.0)	0 (1.0)	40.0 (6.32)	15.5 (3.93)	2.2 (1.48)[a]	0
T_3	15.5 (3.93)	2.5 (1.58)	0 (1.0)	0 (1.0)	6.8 (2.60)	1.5 (1.22)	0 (1.0)	0 (1.0)	8.0 (2.82)	1.5 (1.22)	0 (1.0)	0 (1.0)	15.0 (3.87)[a]	5.5 (2.34)	0 (1.0)	0 (1.0)	25.5 (5.04)	10.5 (3.24)[a]	1.5 (1.22)[a]	**0**
T_5	17.5 (4.18)	3.5 (1.87)	0 (1.0)	0 (1.0)	7.2 (2.68)	1.8 (1.34)	0 (1.0)	0 (1.0)	9.5 (3.08)	2.0 (1.41)	0 (1.0)	0 (1.0)	17.5 (4.18)	6.5 (2.54)	0 (1.0)	0 (1.0)	29.5 (5.43)	15.5 (3.93)	1.0 (1.0)[a]	0
T_6	16.8 (4.09)	3.5 (1.87)	0 (1.0)	0 (1.0)	7.0 (2.64)	1.8 (1.34)	0 (1.0)	0 (1.0)	8.9 (2.98)	2.0 (1.41)	0 (1.0)	0 (1.0)	16.8 (4.09)	7.2 (2.68)	0 (1.0)	0 (1.0)	29.0 (5.38)	14.0 (3.74)	1.0 (1.0)[a]	0
T_7	18.0 (4.24)	3.0 (1.73)	0 (1.0)	0 (1.0)	7.5 (2.73)	1. (1.22)[a]	0 (1.0)	0 (1.0)	9.0 (3.0)	2.0 (1.41)	0 (1.0)	0 (1.0)	16.5 (4.06)[a]	6.5 (2.54)	0 (1.0)	0 (1.0)	30.0 (5.47)	13.0 (3.60)[a]	1.0 (1.0)[a]	0
T_8	48.5 (6.96)	18.5 (4.30)	3.8 (1.94)	0 (1.0)	58.0 (7.61)	15.8 (3.97)	0 (1.0)	0 (1.0)	65.5 (8.09)	8.8 (2.96)	0 (1.0)	0 (1.0)	-	85.5 (9.24)	3.5 (1.87)	0 (1.0)	119.8 (10.94)	25.5 (5.04)	3.5 (1.87)	0
CD	0.19	0.15	0.45	-	0.07	0.06	-	-	0.06	0.13	-	-	0.18	0.21	0.35	-	0.29	0.48	0.55	-
CV	15.6	11.11	12.56	-	10.56	15.5	-	-	16.5	12.14	-	-	11.65	10.95	9.85	-	13.44	12.58	11.54	-

T_1	PII 1721 60% WG @ 120g a.i. ha^{-1};	T_5	Dinotefuron 20% SG @ 50g a.i. ha^{-1}
T_2	PII 1721 60% WG @ 160g a.i. ha^{-1};	T_6	Dinotefuron 20% SG @ 40g a.i. ha^{-1}
T_3	PII 1721 60% WG @ 200g a.i. ha^{-1};	T_7	Pymetrozine 50% WG @ 150g a.i. ha^{-1}
T_8	Untreated control		

Rice ear head bug damage was not seen during first spray as the crop is at tillering stage.

Values in parenthesis are square root transformations; if the value is 0 then √0+1 transformation was made.

Table 6: Efficacy of various treatments on population of sucking pests (no/hill) infesting rice during *Rabi*, 2017-18 after 2nd spray (mean no. of pest population/hill

	3 DAS				7 DAS				10 DAS				15 DAS				20 DAS			
Treatments	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB
T_1	15.5 (3.93)	8.5 (2.91)	1.5 (1.22)	1.8 (1.34[a])	10.5 (3.24)	8.5 (2.91)	5.8 (2.40)	0 (1.0)	25.5 (5.04)	8.5 (2.19)	0 (1.0)	0 (1.0)	28.5 (5.33)	1.5 (1.22)	0 (1.0)	2.8 (1.67)	10.5 (3.24)	0 (1.0)	2.5 (1.58)	1.5 (1.22)
T_2	10.0 (3.16)	5.5 (2.34)	0 (1.0)	1.2 (1.09)	8.3 (2.88)	0 (1.0)	2.5 (1.58)	0 (1.0)	28.5 (5.33)	5.5 (2.34)	0 (1.0)	0 (1.0)	21.5 (4.63)	1.0 (1.0)	0 (1.0)	1.5 (1.22)	8.3 (2.88)	0 (1.0)	1.5 (1.22)	1.0 (1)
T_3	8.8 (2.96)[a]	2.5 (1.58)	0 (1.0)	0 (1.0)	5.5 (2.34)	0 (1.0)	0 (1.0)	0 (1.0)	15.5 (3.93)	3.5 (1.87)[a]	0 (1.0)	0 (1.0)	2.8 (1.67)	0 (1.0)	0 (1.0)	1.0 (1.0)	5.5 (2.34)	0 (1.0)	0 (1.0)	0 (1.0)

																	a			
T_5	9.3 (3.04) a	3.5 (1.87)	0 (1.0)	0 (1.0)	8.0 (2.82)	0 (1.0)	0 (1.0)	0 (1.0)	16.8 (4.09)	3.8 (1.94) a	0 (1.0)	0 (1.0)	3.8 (1.94)	0 (1.0)	0 (1.0)	1.0 (1.0)	8.0 (2.82)	0 (1.0)	0 (1.0)	0 (1.0)
T_6	9.0 (3.0)a	3.0 (1.73)	0 (1.0)	0 (1.0)	7.8 (2.79)	0 (1.0)	0 (1.0)	0 (1.0)	17.3 (4.15)	4.0 (2.0) a	0 (1.0)	0 (1.0)	4.5 (2.12)	0 (1.0)	0 (1.0)	1.0 (1.0)	7.8 (2.79)	0 (1.0)	0 (1.0)	0 (1.0)
T_7	8.6 (2.93) a	2.8 (1.67)	0 (1.0)	0 (1.0)	6.5 (2.54)	0 (1.0)	0 (1.0)	0 (1.0)	17.0 (4.12)	4.5 (2.12)	0 (1.0)	0 (1.0)	4.0 (2.0)	0 (1.0)	0 (1.0)	1.0 (1.0)	6.5 (2.54) a	0 (1.0)	1.0 (1)	1.5 (1.22)
T_8	128.5 (11.38)	15.8 (3.97)	2.0 (1.41)	2.8 (1.67) a	155.9 (12.4)	11.5 (3.39)	13.6 (3.68)	2.5 (1.58)	≠	≠	≠	≠	≠	≠	≠	≠	≠	≠	≠	≠
CD	0.12	0.07	0.18	0.24	0.05	0.18	0.12	0.15	0.14	0.18			0.22	0.12		0.15	0.41		0.13	0.11
CV	18.55	12.15	10.56	10.55	9.56	10.05	12.85	14.55	18.56	10.56			15.55	14.56		16.5	18.56		9.56	11.25

3.2.1.2 Efficacy of treatments during second spray

After twenty five days of first spray second spray was made at panicle initiation stage. At 3 DAS all the treatments exhibited significant superiority over control, the lowest population of BPH (8.8), and WBPH (1.58) were noticed in T_3 (PII 1721 60% WG @200 g a.i. ha^{-1}) as against highest in T_8 control with 128.5 and 15.8 no. of BPH and WBPH respectively. From 100 DAT the BPH incidence was increased coinciding with high temperature and relative humidity. In control where plant protection measures were not adopted the peak incidence of BPH was observed with complete hopper burn symptoms (300 and above). As the abundance of BPH was more the other sucking pest population was observed comparatively less. The peak incidence of BPH indicated apparent superiority of chemical treated plots over control. All the treatments revealed superiority in harbouring less pest population and among all the order of efficacy for BPH at 3 and 7 DAS was T_3 (1.58 & 5.5) > T_7 (1.67 & 6.5)> T_6 (1.73 & 7.8)> T_5 (3.4 & 8.0)>T_2 (5.5 & 8.3)> T_1 (8.5 & 10.5)> T_8 (128.5 &155.9). At 10 and 15 DAS among all the treatments T_3 (PII 1721 60% WG @200 g a.i. ha^{-1}) was found superior with 15.5 and 2.8 number of BPH/hill as against control with more than 300 number respectively. Similar trend was observed at 20 DAS (Table 6). The grain damage by ear head bug was quantified using SES scale and results revealed that T_3, T_6 and T_7 has rated with scale 0 (no damage), T_1, T_2 and T_5 were rated with scale 1(2.5-3.0 per cent grain damage) and T_8 was rated with scale 3 exhibiting a damage percent ranging from 4.8 to 6.5.

3.2.1.3 Efficacy of treatments (Pooled mean) in terms of per cent reduction over control

As the incidence of BPH was found to be predominant among sucking pests of rice, the efficacy of various treatments in terms of per cent reduction over control was calculated. The mean of first and second spray during *Rabi*, 2016-17 were pooled and the data revealed that among all the treatments T_3 (PII 1721 60% WG @200 g a.i. ha^{-1}) has exhibited highest per cent reduction of BPH (no/hill) with 86.3, 94.3, 93.6, 96.5 and 92.6 per cent at 3,7,10,15 and 20 days after spray. The next better treatment in order of efficacy was T_7 (Pymetrozine 50% WG @ 150g a.i. ha^{-1}) with 85.0, 93.0, 92.8, 95.8 and 91.2 per cent at 3, 7, 10, 15 and 20 days after spray (Table 7).

Table 7: Efficacy of various treatments on population BPH (no/hill) infesting rice during *Rabi*, 2017-18 (Pooled mean)

Treatments	**3DAS**	**%ROC**	**7DAS**	**%ROC**	**10DAS**	**%ROC**	**15DAS**	**%ROC**	**20DAS**	**%ROC**
T_1	27.5(5.24)	68.93	16.5(4.06)	84.56	18.0(4.24)	90.19	28.5(5.34)	88.93	24.5(5.0)	88.33
T_2	22.75(4.77)	74.29	14.4(3.80)	86.5	18.75(4.33)	89.78	21.0(4.59)	91.84	24.15(4.91)	88.50
T_3	12.15(3.50)	86.27	6.1(2.48)	94.3	11.75(3.43)	93.60	8.9(3.0)	96.54	15.5(3.94)	92.61
T_5	13.4(3.66)	84.90	7.6(2.76)	92.8	13.15(3.63)	92.83	10.65(3.26)	95.86	18.75(4.33)	91.06
T_6	12.9(3.60)	85.42	7.4(2.72)	93.0	13.10(3.62)	92.86	10.65(3.26)	95.86	18.4(4.29)	91.23
T_7	13.3(3.65)	85.0	7.2(2.65)	93.3	13.0(3.61)	92.91	10.50(3.20)	96.00	18.25(4.27)	91.30
T_8	88.5(9.41)	-	106.9(10.34)		183.5(13.55)	-	257.5(16.04)	95.92	209.9(14.49)	-
CD (P=0.05)	0.12		0.18		0.16		0.18		0.98	
CV	12.88		13.55		9.56		11.55		18.32	

T_1	:	PII 1721 60% WG @ 120g a.i. ha^{-1};	T_5	:	Dinotefuron 20% SG @ 50g a.i. ha^{-1}
T_2	:	PII 1721 60% WG @ 160g a.i. ha^{-1};	T_6	:	Dinotefuron 20% SG @ 40g a.i. ha^{-1}
T_3	:	PII 1721 60% WG @ 200g a.i. ha^{-1};	T_7	:	Pymetrozine 50% WG @ 150g a.i. ha^{-1}
T_8	:	Untreated control			

ROC%=Per cent reduction over control

Values in parenthesis are square root transformations

3.2.2 Efficacy of treatments on incidence of sucking pests infesting rice during Summer, 2017-18

During Summer, 2017-18 (late *Rabi*) the population of BPH ranged from 1.0 to 64.4 no/hill. The WBPH ranged from 1.0 to 28.5 no./hill. The incidence of GLH and RB was comparatively lower.

3.2.2.1 Efficacy of treatments during first spray

The first spray was initiated during tillering stage and RB damage was not noticed. At 3 DAS among all the treatments the lowest population of BPH (1.94), WBPH (1.67) and GLH (0) were noticed in T_3 (PII 1721 60% WG @ 200 g a.i. ha^{-1}) as against highest in T_8 control with 22.5,9.5 and 5.5 no./hill of BPH, WBPH and GLH respectively. The results from analysed data revealed that all the chemical treatments were superior over control in harbouring the pest population. But, among all the T_3 (PII 1721 60% WG @200 g a.i. ha^{-1}) has noticed with less population of BPH and WBPH. As the population of GLH and RB were comparatively lower all the treatments found effective in suppressing those pests and found on par to each other. During active tillering stage the population of BPH was declined due to cloudy weather and hence to assess the efficacy 15 DAS artificial release of BPH @ 200/plot was done under supervision of PI Industries staff. As a result the population hiked and at 20 DAS T_3 (PII 1721 60% WG @ 200 g a.i. ha^{-1}) has harboured less number of BPH (5.8/hill) as against control with 20.5 no. /hill. It is a clear indication of efficacy of chemical treatments. The next better treatments in order of efficacy were $T_7 > T_6 > T_5$ with 6.2, 7.0 and 7.8 number of BPH/hill (Table 8).

Table 8: Efficacy of various treatments on population of sucking pests (no/hill) infesting rice during *Summer*, 2017-18 after 1st spray (mean no. of pest population/hill)

	3 DAS				7 DAS				10 DAS				15 DAS*				20 DAS			
Treatments	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB
T_1	8.5 (2.91)	6.5 (2.54)	0 (1.0)	0 (1.0)	5.5 (2.34)	2.5 (1.58)	0 (1.0)	0 (1.0)	4.8 (2.19)	2.5 (1.58)	0 (1.0)	0 (1.0)	2.8 (1.67)	0 (1.0)	0 (1.0)	0 (1.0)	13.8 (3.71)	2.5 (1.58)	2.8 (1.67)	0 (1.0)
T_2	7.0 (2.64)	5.8 (2.40)	0 (1.0)	0 (1.0)	6.5 (2.54)	0 (1.0)	0 (1.0)	0 (1.0)	5.5 (2.34)	2.0 (1.41)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	12.8 (3.57)	2.0 (1.41)	3.2 (1.78)	0 (1.0)
T_3	3.8 (1.94)	2.8 (1.67)	0 (1.0)	0 (1.0)	2.0 (1.41)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	1.2 (1.09)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	5.8 (2.40)	1.0 (1.0)	1.0 (1.0)	0 (1.0)
T_5	4.5 (2.12)	3.5 (1.87)	0 (1.0)	0 (1.0)	4.0 (2.0)	0 (1.0)	0 (1.0)	0 (1.0)	1.8 (1.34)	1.5 (1.22)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	7.8 (2.79)	2.5 (1.58)	2.0 (1.41)	0 (1.0)
T_6	4.0 (2.0)	3.0 (1.73)	0 (1.0)	0 (1.0)	3.8 (1.94)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	1.8 (1.34)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	7.0 (2.64)	3.0 (1.73)	1.8 (1.34)	0 (1.0)
T_7	4.0 (2.0)	3.0 (1.73)	0 (1.0)	0 (1.0)	3.5 (1.87)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	1.5 (1.22)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	6.2 (2.48)	3.5 (1.87)	1.8 (1.34)	0 (1.0)
T_8	22.5 (4.74)	9.5 (3.08)	5.5 (2.34)	0 (1.0)	35.5 (5.95)	5.8 (2.40)	0 (1.0)	0 (1.0)	38.5 (6.20)	8.5 (2.91)	0 (1.0)	0 (1.0)	22.5 (4.74)	0 (1.0)	0 (1.0)	0 (1.0)	20.5 (4.52)	28.5 (5.33)	2.5 (1.58)	0 (1.0)
CD	0.04	0.09	1.04	NS	0.39		NS	NS			NS	NS	0.55	NS	NS	NS	0.02	0.11	0.21	NS
CV	10.58	12.45	13.55		18.55	12.45			16.95	11.23			18.35				9.56	18.90	14.85	

*Due to rainfall population was declined

T_1	PII 1721 60% WG @ 120g a.i. ha^{-1};	T_5	Dinotefuron 20% SG @ 50g a.i. ha^{-1}
T_2	PII 1721 60% WG @ 160g a.i. ha^{-1};	T_6	Dinotefuron 20% SG @ 40g a.i. ha^{-1}
T_3	PII 1721 60% WG @ 200g a.i. ha^{-1};	T_7	Pymetrozine 50% WG @ 150g a.i. ha^{-1}
T_8	Untreated control		

Rice ear head bug damage was not seen during first spray as the crop is at tillering stage

Values in parenthesis are square root transformations; if the value is 0 then $\sqrt{0+1}$ transformation was made.

3.2.2.2 Efficacy of treatments during second spray

After twenty days of first spray second spray was made at panicle initiation stage. All the treatments exhibited significant superiority over control at 3, 7, 10, 15 and 20 DAS. The lowest population of BPH was recorded in T_3 (PII 1721 60% WG @200 g a.i. ha^{-1}) with 5.0, 2.5, 1.0, 1.0, and 16.5 as against highest in T_8 (control) with 35.5, 45.5, 12.5, 16.5 and 64.4 at 3, 7, 10, 15 and 20 DAS. From 100 DAT the BPH incidence was increased coinciding with high temperature and relative humidity. Similar trend was also observed with WBPH and GLH. However, T_1 (PII 1721 60% WG @ 120 g a.i. ha^{-1}) found to be inferior in comparison to other treatments. Sub lethal dosages may sometimes lead to pest resistance or resurgence and hence in the plots treated with T_1 the pest population of BPH, WBPH, GLH and RB were found to higher. All the treatments revealed superiority in harbouring less pest population and among all the order of efficacy for BPH at 7 DAS was T_3 (2.5) > T_7 (2.65)> T_6 (2.7)> T_5 (3.0)>T_2 (8.5)> T_1 (10.5)> T_8 (45.5). At 15 DAS artificial release of BPH was made and among all the treatments T_3 (PII 1721 60% WG @200 g a.i. ha^{-1}) was found superior with 16.5 (lowest) number of BPH/hill as against control with more than 64.4 no./hill at 20 DAS (Table 9). The grain damage by ear head bug was quantified using SES scale and results revealed that T_3 and T_7 has rated with scale 0 (no damage), T_1, T_2, T_5 and T_6 were rated with scale 1 (2.0-2.8 per cent grain damage) and T_8 was rated with scale 3 exhibiting a damage percent ranging from 5.0 to 6.3.

Table 9: Efficacy of various treatments on population of sucking pests (no/hill) infesting rice during *Summer*, 2017-18 after 2nd spray (mean no. of pest population/hill)

	3DAS				7DAS				10 DAS				15 DAS *				20 DAS			
Treatments	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB	BPH	WBPH	GLH	RB
T_1	13.5 (3.67)	5.8 (2.40)	3.5 (1.87)	2.8 (1.67)	10.5 (3.24)	2.8 (1.67)	1.2 (1.09	1.0 (1)	5.5 (2.34)	0 (1.0)	0 (1.0)	0 (1.0)	38.5 (6.20)	2.5 (1.58)	0 (1.0)	2.8 (1.67)	40.5 (6.36)	2.8 (1.67)	0 (1.0)	6.5 (2.54)
T_2	17.8 (4.21)	5.0 (2.23)	4.5 (2.12)	1.5 (1.22)	8.5 (2.91)	0 (1.0)	0 (1.0)	0 (1.0)	3.5 (1.87)	0 (1.0)	0 (1.0)	0 (1.0)	28.5 (5.33)	1.5 (1.22)	0 (1.0)	1.5 (1.22)	22.5 (4.74)	1.8 (1.34)	0 (1.0)	5.4 (2.32)
T_3	5.0 (2.23)	3.5 (1.87)	1.2 (1.09)	0 (1.0)	2.5 (1.58)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	15.0 (3.87)	1.0 (1.0)	0 (1.0)	0 (1.0)	16.5 (4.06)	1.0 (1)	0 (1.0)	0 (1.0)
T_5	6.8 (2.60)	7.5 (2.73)	1.8 (1.34)	0 (1.0)	3.0 (1.73)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	18.5 (4.30)	1.0 (1.0)	0 (1.0)	0 (1.0)	19.0 (4.35)	1.0 (1.0)	0 (1.0)	0 (1.0)
T_6	7.5 (2.73)	4.0 (2.0)	1.8 (1.34)	0 (1.0)	2.7 (1.64)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	21.0 (4.58)	1.0 (1)	0 (1.0)	0 (1.0)	21.5 (4.63)	1.0 (1.0)	0 (1.0)	0 (1.0)
T_7	6.8 (2.60)	4.5 (2.12)	2.0 (1.41)	0 (1.0)	2.65 (1.62)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	0 (1.0)	15.8 (3.97)	1.0 (1.0)	0 (1.0)	0 (1.0)	20.5 (4.52)	1.0 (1.0)	0 (1.0)	0 (1.0)
T_8	35.5	9.0	5.0	4.8	45.5	11.5	6.2	3.5	12.5	0	0	0	16.5	18.5	11.4	5.5	64.4	11.5	8.9	12.6

	(5.95)	(3.0)	(2.23)	(2.19)	(6.74)	(3.39)	(2.48)	(1.87)	(3.53)	(1.0)	(1.0)	(1.0)	(4.06)	(4.30)	(3.37)	(2.34)	(8.02)	(3.39)	(2.98)	(3.54)
CD	0.32	0.10	0.05	0.18	0.02	1.12	1.41	1.54	1.12	NS	NS	NS	1.01	1.28	1.93	1.17	0.04	1.24	1.05	1.57
CV	11.528	16.58	10.64	18.55	9.60	5.48	15.98	19.58	12.55				10.52	11.58	9.58	16.58	18.54	10.55	13.58	12.12

Artificial release of BPH

T_1	:	PII 1721 60% WG @ 120g a.i. ha^{-1};	T_5	:	Dinotefuron 20% SG @ 50g a.i. ha^{-1}
T_2	:	PII 1721 60% WG @ 160g a.i. ha^{-1};	T_6	:	Dinotefuron 20% SG @ 40g a.i. ha^{-1}
T_3	:	PII 1721 60% WG @ 200g a.i. ha^{-1};	T_7	:	Pymetrozine 50% WG @ 150g a.i. ha^{-1}
T_8	:	Untreated control			

Values in parenthesis are square root transformations; if the value is 0 then √0+1 transformation was made.

3.2.2.3 Efficacy of treatments (Pooled mean) in terms of per cent reduction over control

As the incidence of BPH was found to be predominant among sucking pests of rice, the efficacy of various treatments in terms of per cent reduction over control was calculated. The mean of first and second spray during *Summer*, 2016-17 were pooled and the data revealed that among all the treatments T_3 (PII 1721 60% WG @200 g a.i. ha^{-1}) has exhibited highest per cent reduction of BPH (no/hill) with 84.83, 94.44, 80.2, 61.54 and 73.73 per cent at 3,7,10,15 and 20 days after spray. The next better treatment in order of efficacy was T_7 (Pymetrozine 50% WG @ 150g a.i. ha^{-1}) with 81.40, 92.41, 80.2, 59.49 and 68.60 per cent at 3, 7, 10, 15 and 20 days after spray (Table 10).

Table 10: Efficacy of various treatments on population BPH (no/hill) infesting rice during *summer*, 2017-18 (Pooled mean)

Treatments	3DAS	%ROC	7DAS	%ROC	10DAS	%ROC	15DAS	%ROC	20DAS	%ROC
T_1	11.0(3.32)	62.07	8.0(2.83)	80.24	5.15(2.27)	79.80	19.2(4.54)	0.01	27.15(5.21)	36.04
T_2	12.4(3.52)	57.24	7.5(2.74)	81.48	4.5(2.12)	82.35	14.25(3.80)	26.92	17.65(4.20)	58.42
T_3	4.40(2.10)	84.83	2.25(1.50)	94.44	0(1.0)	80.2	7.5(2.7)	61.54	11.15(3.34)	73.73
T_5	5.65(2.40)	80.52	3.5(1.87)	91.36	0.9(1.0)	96.47	9.25(3.04)	52.56	13.4(3.66)	68.43
T_6	5.75(2.40)	80.17	3.25(1.80)	92.0	0(1.0)	80.2	10.5(3.24)	46.15	14.25(3.78)	66.43
T_7	5.40(2.32)	81.40	3.07(1.75)	92.41	0(1.0)	80.2	7.9(2.81)	59.49	13.35(3.65)	68.60
T_8	29.0(5.40)	-	40.5(6.36)	-	25.5(5.05)	-	19.5(4.42)	-	42.45(6.5)	-
CD (P=0.05)	0.02		0.19		0.10		0.04		0.15	
CV	18.65		13.95		19.41		17.51		12.88	

T_1	:	PII 1721 60% WG @ 120g a.i. ha^{-1};	T_5	:	Dinotefuron 20% SG @ 50g a.i. ha^{-1}
T_2	:	PII 1721 60% WG @ 160g a.i. ha^{-1};	T_6	:	Dinotefuron 20% SG @ 40g a.i. ha^{-1}
T_3	:	PII 1721 60% WG @ 200g a.i. ha^{-1};	T_7	:	Pymetrozine 50% WG @ 150g a.i. ha^{-1}
T_8	:	Untreated control			

ROC%=Per cent reduction over control

Values in parenthesis are square root transformations.

Table 11: Efficacy of various treatments on yield (Kg/ha)

Treatments	*Rabi* 2017-18	*Summer* 2017-18
T_1: PII 1721 60% WG @ 120g a.i. ha^{-1}	4652	4550
T_2: PII 1721 60% WG @ 160g a.i. ha^{-1}	5050	4950
T_3: PII 1721 60% WG @ 200g a.i. ha^{-1}	5255	5350
T_5: Dinotefuron 20% SG @ 50g a.i. ha^{-1}	5185	5190
T_6: Dinotefuron 20% SG @ 40g a.i. ha^{-1}	5000	5100
T_7: Pymetrozine 50% WG @ 150g a.i. ha^{-1}	5150	5215
T_8: Untreated control	No yield Total hopper burn	2440
CD	94.3	104.8
CV	21.56	18.35

3.3 Efficacy of various treatments on yield

The yield from various treated plots was recorded and converted in to Kg/ha. Among various treatments evaluated the highest and lowest yield was recorded in T_3 (5255 & 5350) and T_8 (0 & 2440) during *Rabi* and *Summer*, 2017-18 respectively. The yield in order of efficacy during *Rabi*, 2017-18 represents T_3 (5255) > T_5 (5185) > T_7 (5150) > T_2 (5050) > T_6 (5000) > T_1 (4650)> T_8 (0). The yield in order of efficacy during *Summer*, 2017-18 represents T_3 (5350) > T_7 (5215) > T_5 (5190) > T_6 (5100) > T_2 (4950) > T_1 (4550)> T_8 (2440).

Similar investigations by Deekshitha *et al.* (2017) [8] also reported that Pymetrozine 50 WG @ 0.5 g l-1 and dinotefuron 20 SG @ 0.4 g l-1 had proven to best chemicals in suppressing BPH population infesting rice with 62.98 and 59.60 per cent reduction over control, respectively. Similarly Atanu and Bhima, 2017 [9] also inferred that Pymetrozine 50 WG @ 150 g a.i. ha^{-1} had registered highest per cent reduction (76.0) of BPH over control with highest number of spiders (3.71 per 10 hills at DAT of last spray) and 46.56 per cent increase of grain yield over control. Gui *et al*., 2009 [10] also indicated that the pymet rozine @ 24 g a.i. ha^{-1} against rice BPH had recorded 73.69 and 64.92 per cent reduction over control at three and seven days after spray, respectively. Vasantha, 2015 [11] evaluated various insecticides with different modes of actions against sucking pests of rice and the results notified that pymetozine 50 WG had recorded more than 90 per cent reduction in the both BPH and WBPH population (no./hill) over control and found superior to neonicotinoids like imidacloprid and thiamethoxam 25 g a.i./ha and chitin bio-synthesis inhibitor like buprofezin 25 SC

@ 125 g a.i./ha. Studies on potential toxicity of selected insecticides by Jhansi *et al*. (2010) [12] inferred that Spinosad was moderately toxic to BPH followed by flubendamide while ethiprole and indoxacarb were not effective against BPH, WBPH and GLH infesting rice.

4. Phytotoxicity
None of the treatments exhibited phytotoxic symptoms

5. Conclusions
Among the various treatments evaluated for efficacy against sucking pests infesting rice, the treatment T_3 (PII 1721 60% WG @200 g a.i. ha^{-1}) was found effective in suppressing the BPH, WBPH, GLH and RB. However, all the treatments exhibited superiority over control in suppressing the sucking pests. The data on per cent reduction over control for BPH, the predominant sucking pest of rice revealed that, among all the T_3 (PII 1721 60% WG @200 g a.i. ha^{-1}) has expressed highest reduction over control both during *Rabi* and *Summer*, 2017-18 with 86.3 & 84.8, 94.3 & 94.4, 93.6 & 80.2, 96.5 & 61.54 and 92.6 & 73.73 at 3, 7, 10, 15 and 20 DAS

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