Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(6): 699-705

Received: 26-09-2019
Accepted: 28-10-2019

Gyan Prakash Morya
Department of Entomology, B.R.D.P.G. College, Deoria, Uttar Pradesh, India

Rajnish Kumar
Department of Entomology, B.R.D.P.G. College, Deoria, Uttar Pradesh, India

Corresponding Author:
Gyan Prakash Morya
Department of Entomology, B.R.D.P.G. College, Deoria, Uttar Pradesh, India

Evaluation of some newer ecofriendly insecticides against major insect pests of rice under eastern Uttar Pradesh conditions

Gyan Prakash Morya and Rajnish Kumar

DOI: https://doi.org/10.22271/j.ento.2019.v7.i6l.9169

Abstract
An evaluation was conducted on the efficacy of some newer ecofriendly insecticides against major insect pests of rice under Eastern Uttar Pradesh conditions for the two consecutive years (2014 and 2015) at farmer field of district Deoria. This evaluation was observed most effective ecofriendly insecticides concerned to lowest infestation, lowest P: D ratio, and highest yield. There were 10 treatments (09 insecticides + 01 check) evaluated under randomized block design (RBD) by transplanting method of rice cultivation on localized popular rice cultivar Samba Mahsuri. The insecticide treatments comprise 9 insecticides (Cartap Hcl, 50 SP, Indoxacarb 14.5 SC, Imidacloprid 17.8 SL, Chlorpyriphos 20 EC, Thiamethoxam 25 WG, Chlorantraniliprole 18.5 SC, Azadirachtin (Neem Oil) 0.03 EC, *Bacillus thuringiensis kurstaki* (Btk) 3.5 WP, and combination of Neem Oil 0.03 EC + Btk 3.5 WP). The infestations of major insect pests of rice were observed for most serious insect pests, which were 1.Yellow stemborer (*Scirpophaga incertulus* Walker), 2.Common rice leaffolder (*Cnaphalocrosis medinalis* Guenee), 3.Brown planthopper (*Nilaparvata lugens* Stal), 4.Rice hispa (*Dicladispa armigera* Oliver), and 5.Rice earhead bug (*Leptocorisa acuta* Thunberg). There were 3 insecticides (Imidacloprid, Cartap Hcl, and Neem Oil + Btk) inference non-significant for lowest infestation; 2 insecticides (Neem Oil + Btk and Imidacloprid) inference non-significant for lowest P:D ratio; 3 insecticides (Imidacloprid, Cartap Hcl, and Neem Oil + Btk) inference non-significant for highest yield. There were 2 insecticides (Imidacloprid and Neem Oil + Btk) inference most effective eco-friendly insecticides for major insect pests of rice. Though, both the insecticides (Imidacloprid and Neem Oil + Btk) were being most effective ecofriendly insecticides, yet Neem Oil + Btk as biopesticides primarily would be the best choice before Imidacloprid for the most effective ecofriendly management of major insect pests of rice.

Keywords: Evaluation, ecofriendly insecticides, major insect pests of rice, Eastern Uttar Pradesh, India

Introduction
Rice is the most important staple food for more than half population of the India and world. About 90% of the world's rice is produced and consumed in the Asian region and most staple food of South East Asia. The rice fragrance spreads to the entire world. More than 110 countries grow rice on one fifth of the world food grain crop area. Rice shares 27 % of the world food grain production and occupies second position after wheat and 56 % of the India food grain production and occupies first position. India shares 21 % of the world rice production and occupies second position after China. Uttar Pradesh shares 15 % of the India rice production occupies second position followed by West Bengal (17%) and first in rice production area. Despite these above proud credentials, Uttar Pradesh is not appearing leading position. The main cause of low productivity of rice is ill cultivation practices and crop losses. The crop losses share about 32.1% losses by plant ailments (pests, diseases & weeds) and among them, about 10.8% losses caused by pests globally and India have been reported about 17.5% losses caused by insect pests. Historically, insect pest outbreaks have been causing extensive losses in rice crop production ranging from 60 to 95 % over world. India have been estimated rice crop losses by insect pests ranging from 21 to 51 %. (Pathak and Khan, 1994; Oerke, 2006; Dhaliwal *et al*., 2015; Sharma *et al*., 2017; Heinrichs and Muniappan, 2017; Pathak *et al*., 2018; DAC&FW, 2018; FAOSTAT, 2019) [19, 17, 8, 28, 12, 18, 5, 10].
There are numbers of research institutes, centers and projects, and also extension machineries are running in India for insect pest management in rice. Undoubtedly, these all are performing

his possible responsibilities. But it is sorry to say, the Uttar Pradesh state is under lag phase of adaptation of modern technologies of rice crop production, specially to insect pest management. Which contributes valuable share in India rice production. Though, Farmers are practicing all possible available methods and techniques for rice insect pest management as cultural, physical, biological, chemical and host resistance methods based on traditional knowledge, layman and salesman advice. While, all the management practices are concentrated to the farmers' perception about finishing approach of insect pests ignoring the significant role of bioagents in suppression of infestation rice insect pests. Of course, these management practices may be prevented 5.8% crop losses among of 21 % crop losses caused by insect pests. If it not managed in time, losses may be reached to the 51 %. Now to prevent, rest of 15.2 % (21 % - 5.8 % = 15.2%) losses require, powerful technique. (Pathak and Khan, 1994; Oerke, 2006; Dhaliwal *et al*., 2015; Sharma *et al*., 2017; Heinrichs and Muniappan, 2017) [19, 17, 8, 28, 12].

No doubt, Insecticides are the most powerful tool available for use in pest management and continue to be the foreseeable future. Insecticides are most common pesticides used widely in crop production. The role of pesticides in crop production to augment output has been well perceived and these have been considered essential inputs in crop production. There have been bunch of insecticides including conventional and newer chemical insecticides, and biopesticides trending commonly in scientific community to evaluate their efficacy regarding ecofriendly approach, while combination application of biopesticides have been limited evaluation towards biorational approach of pest management. Therefore, this research work selected those insecticides and their combinations to evaluate their efficacy regarding the ecofriendly approach, which has been commonly trending among the scientific community and as well as market availability among Eastern Uttar Pradesh conditions. The objective was aimed to revival of ecofriendly insecticides against major insect pests of rice under Eastern Uttar Pradesh conditions that could become the effective information for rice insect pest management strategies.

Chakraborty (2011) [2] and Chakraborty and Deb (2011) [3] both have been reported that, the infestation of yellow stemborer (*Scirpophaga incertulus*) and common rice leaffolder (*Cnaphalocrocis medinalis*) were observed lowest in Imidacloprid. Kulagod *et al.* (2011) [15] studied on evaluation of efficacy of biorationals against yellow stemborer (*Scirpophaga incertulus*) and common rice leaffolder (*Cnaphalocrocis medinalis*) of rice as Azadirachtin and *Bacillus thuringiensis* formulation lower the infestation. Rath *et al.* (2014) [23] has been reported that, plots treated with Imidacloprid recorded lowest infestation of yellow stemborer (*Scirpophaga incertulus*) and rice earhead bug (*Leptocorisa acuta*) and highest grain yield followed by Thiamethoxam. Sarao *et al.* (2015) [25] and Tigga *et al.* (2018) [30] both have been found that, the damage of yellow stemborer (*Scirpophaga incertulus*) and rice earhead bug (*Leptocorisa acuta*) were recorded lowest in Imidacloprid. Sharanappa *et al.* (2019) [27] have been found that, the application of Imidacloprid observed favour the high population of coccinellids.

Materials and Methods

The evaluation was conducted on the efficacy of some newer ecofriendly insecticides against major insect pests of rice under Eastern Uttar Pradesh conditions for the two consecutive years (2014 and 2015) on farmer's field at district Deoria. This confined spot of study, represents the conductive environment for survival and proliferation of insect pests in rice ecosystem under Eastern Uttar Pradesh conditions. There were 10 treatments (09 insecticides + 01 check) evaluated under randomized block design (RBD) by transplanting method of rice cultivation on localized popular rice cultivar 'Samba Mahsuri'. The insecticide treatments comprise 9 insecticides (Cartap Hcl, 50 SP, Indoxacarb 14.5 SC, Imidacloprid 17.8 SL, Chlorpyriphos 20 EC, Thiamethoxam 25 WG, Chlorantraniliprole 18.5 SC, Azadirachtin (Neem Oil) 0.03 EC, *Bacillus thuringiensis kurstaki* (Btk) 3.5 WP, and combination of Neem Oil 0.03 EC + Btk 3.5 WP). The Spray formulations selected as recommended for lowland rice ecosystems to avoid leaching and toxicity to beneficial soil inhabitants of granular formulations despite effectivity. Application of insecticides spraying were taken for two times at 30 days and 45 days after transplanting (30 DAT and 45 DAT). Samples were taken 03 times at 03, 07 and 14 days after spraying per spray of insecticides and single sample before first spray of insecticides respectively. The duration of rice crops started from pre week of August to mid-week of November for about 110 days. There were 5 samples collected per plot at the size of 20 m^2. Each plot was selected 5 spots (4 in the corner and one in the center) at 01 hill/spot to observe infestation, and also at each plot, 05 net sweeps were made randomly at every 05 steps to observe abundance of insect pest species and their bioagents. The size of sweep net were 25 cm diameter and 70 cm handle and made up of nylon. The spraying of insecticides was made by manually operated knapsack sprayer with hollow cone nozzle @ 500 l/ha spray volume. The timing of sampling was 9.30 A.M. to 12.30 P.M. and timing of spraying was 2.30 P.M. to 4.30 P.M. respectively. Each observation was recorded infestation of major insect pests, abundance of bioagents, and yield to evaluate efficacy of treated ecofriendly insecticides. This observation was evaluated most effective ecofriendly insecticides concerned to lowest infestation, lowest P:D ratio, and highest yield. P: D ratio refers the ratio between the population of insect pests and their bioagents.

Surveillance was conducted as per methodology of agroecosystem analysis (AESA) (Pontius *et al*., 2002) modified as accessibility. Taxonomic identification was verified with texts of reference, *i.e*., Dale (1994) [6], Barrion and Litsinger (1994) [1], Pathak and Khan (1994) [19], David and Ananthakrishnan (2004); Rice knowledge management portal (RKMP); and Subject experts respectively. The statistical inferences were verified with texts of reference, *i.e*., Dhamu & Ramamoorthy (2007) [9], and Rangaswamy (2010) [24].

Results and Discussion

The evaluation of efficacy of some newer ecofriendly insecticides was observed on infestation and their bioagents of major insect pests of rice for the two consecutive years 2014 and 2015 respectively. The infestations of major insect pests of rice were observed for most serious insect pests, which were 1.Yellow stemborer (*Scirpophaga incertulus* Walker), 2.Common rice leaffolder (*Cnaphalocrosis medinalis* Guenee), 3.Brown planthopper (*Nilaparvata lugens* Stal), 4.Rice hispa (*Dicladispa armigera* Oliver), and 5.Rice earhead bug (*Leptocorisa acuta* Thunberg). Of the total observed infestation and their bioagents of major insect pests

of rice for pooled of both the years 2014 and 2015, there were 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for lowest infestation and 2 insecticides (Imidacloprid and Neem Oil + Btk) inference non-significant for lowest P:D ratio under first application (30 DAT); and 4 insecticides (Cartap Hcl, Imidacloprid, Chlorantraniliprole, and Neem Oil + Btk) inference non-significant for lowest infestation and 2 insecticides (Imidacloprid and Neem Oil + Btk) confined non-significant for lowest P:D ratio under second application (45 DAT) respectively. The mean of evaluation was observed as, 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for lowest infestation and 2 insecticides (Imidacloprid and Neem Oil + Btk) inference non-significant for lowest P:D ratio under mean of major insect pests of rice and mean of first application and second application; and along with 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) were also inference non-significant for highest yield respectively. The ranking of evaluation was observed as, Imidacloprid > Cartap Hcl > Neem Oil + Btk > Chlorantraniliprole > Indoxacarb > Chlorpyriphos > Thiamethoxam > Neem Oil > Btk for lowest infestation; Btk > Neem Oil + Btk > Neem Oil > Imidacloprid > Cartap Hcl > Indoxacarb > Chlorantraniliprole > Thiamethoxam > Chlorpyriphos for lowest P:D ratio; Cartap Hcl > Imidacloprid > Neem Oil + Btk > Chlorantraniliprole > Indoxacarb > Chlorpyriphos > Neem Oil > Thiamethoxam > Btk for highest yield; and Imidacloprid > Cartap Hcl > Neem Oil + Btk > Chlorantraniliprole > Indoxacarb > Neem Oil > Btk > Chlorpyriphos > Thiamethoxam for mean of infestation, P:D ratio, and yield respectively. (Table & Figure 1 and 2).

Of the most effective ecofriendly insecticides observed on infestation and their bioagents of major insect pests of rice for pooled of both the years 2014 and 2015, there were 3 insecticides (Imidacloprid, Cartap Hcl, and Neem Oil + Btk) inference non-significant for lowest infestation; 2 insecticides (Imidacloprid and Neem Oil + Btk) inference non-significant for lowest P:D ratio; 3 insecticides (Imidacloprid, Cartap Hcl, and Neem Oil + Btk) inference non-significant for highest yield; and 2 insecticides (Imidacloprid and Neem Oil + Btk) inference most effective ecofriendly insecticides for mean of major insect pests of rice respectively. There were 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for lowest infestation and 2 insecticides (Imidacloprid and Neem Oil + Btk) inference most effective ecofriendly insecticides against yellow stemborer (*Scirpophaga incertulus* Walker), Common rice leaffolder (*Cnaphalocrosis medinalis* Guenee), Brown planthopper (*Nilaparvata lugens* Stal), and Rice hispa (*Dicladispa armigera* Oliver), except Rice earhead bug (*Leptocorisa acuta* Thunberg) was inference non-significant for lowest infestation for 6 insecticides (Chlorpyriphos, Imidacloprid, Cartap Hcl, Indoxacarb, Thiamethoxam, and Chlorantraniliprole) and 1 insecticide (Imidacloprid) for most effective ecofriendly insecticides. There were 2 insecticides (Imidacloprid and Neem Oil + Btk) inference non-significant for lowest P:D ratio and 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for highest yield against yellow stemborer (*Scirpophaga incertulus* Walker), Common rice leaffolder (*Cnaphalocrosis medinalis* Guenee), Brown planthopper (*Nilaparvata lugens* Stal), and Rice hispa (*Dicladispa armigera* Oliver), except Rice earhead bug (*Leptocorisa acuta* Thunberg) was inference 1 insecticide (Imidacloprid) for lowest P:D ratio and 2 insecticides (Cartap Hcl and Imidacloprid) for highest yield respectively. (Table 3). Similar findings were reported by Chakraborty (2011) [2], Chakraborty and Deb (2011) [3], Jena and Dani (2011) [14], Kulagod *et al.* (2011) [15], CRRI (2014) [4], Rath *et al.* (2014) [23] Sarao *et al.* (2015) [25], Tigga *et al.* (2018) [30], and Sharanappa *et al.* (2019) [27].

Present research work was adopted the lowest P:D ratio, respective to non-significant lowest infestation as scale to confined efficacy of insecticides as ecofriendly. Therefore, 2 insecticides (Imidacloprid and Neem Oil + Btk) were confined most effective ecofriendly insecticides as inference non-significantly for lowest P:D ratio for the management of major insect pests of rice. Though, both the insecticides (Imidacloprid and Neem Oil + Btk) were being most effective ecofriendly insecticides, Imidacloprid as the chemical insecticide, while Neem Oil + Btk as the biological insecticides (biopesticides). Therefore, Neem Oil + Btk as biopesticides primarily would be the best choice before Imidacloprid for the ecofriendly management of major insect pests of rice. Though, Cartap Hcl was being most effective insecticides for major insect pests of rice among 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) as inference non-significantly for lowest infestation, but interestingly this observation was changed in P:D ratio as it did not inference non-significantly for lowest P:D ratio with 2 insecticides (Imidacloprid and Neem Oil + Btk). (Table 3). Similar recommendation has also been reported by Schoenly *et al.* (1996) [26], Heong *et al.* (1998) [13], Gallagher *et al.* (2002) [11], Norton *et al.* (2010) [16], Prakash *et al.* (2014) [21], Heinrichs and Muniappan (2017) [12] and Rao (2019) [22].

Meanwhile, the observation of the present investigations under untreated check revealed the infestation of major insect pests of rice was decreased, and the abundance of P:D ratio was increased in second application of insecticides (45 days after transplanting) followed by first application of insecticides (30 days after transplanting) respectively. (Table & Figure 2). It means, if the abundance of bioagents population would not be increased after first application of insecticides, the infestation of major insect pests of rice could not be decreased at lower level. So, the abundance of bioagents population have important role to suppress the infestation of insect pests of rice during 20-50 days after transplanting, when bioagents were strengthening their build up. The food chain of bioagents shortening have been continued for about 40 days after the first application of insecticides (30 days after transplanting) and tends to remove bioagents, making the rice more susceptible to secondary insect pests. Insecticides would then have to be sprayed again for the secondary insect pests become uneconomical. So primarily, the insecticide application has to avoid first 40 days after transplanting for strengthening the buildup of bioagents abundance. If insecticide application is necessary, apply most effective ecofriendly insecticides after 40 days of transplanting as single application. Hence, two insecticides, *i.e.*, Imidacloprid and Neem Oil + Btk were found most effective ecofriendly insecticides for the management of major insect pests of rice, but Neem Oil + Btk as biopesticides primarily would be the best choice before Imidacloprid as chemical insecticide for the ecofriendly management of major insect pests of rice after 40 days of transplanting as single application to strengthening the buildup of bioagents abundance.

Table 1: Evaluation of Ecofriendly Insecticides for Major Insect Pests of Rice (Pooled of 2014 & 15) * (% Infestation (Infestation) and Pest: Defender Ratio (P: D))

Treatments	A Day before Application (ADBAp)		Yellow Stem Borer	Common Rice Leaf folder	Brown Plant hopper	Rice Hispa	Rice Earhead bug	Total Mean Infestation DAAp	Total Mean P:D DAAp
	Infestation	P: D	Infestation	Infestation	Infestation	Infestation	Infestation		
1.Cartap Hcl	3.40	1.82	4.09 $^{1\ NS}$ (2.07)	3.00 $^{1\ NS}$ (1.82)	4.94 $^{2\ NS}$ (2.31)	3.54 $^{2\ NS}$ (1.98)	1.37 $^{3\ NS}$ (1.34)	3.39 $^{2\ NS}$ (1.91)	4.36 (2.20)
2.Indoxacarb	3.39	1.84	5.29 (2.34)	3.88 (2.05)	5.88 (2.51)	4.32 (2.17)	1.42 $^{4\ NS}$ (1.36)	4.16 (2.09)	4.72 (2.28)
3.Imidacloprid	3.33	1.87	4.28 $^{2\ NS}$ (2.11)	3.22 $^{3\ NS}$ (1.88)	4.83 $^{1\ NS}$ (2.28)	3.45 $^{1\ NS}$ (1.96)	1.14 $^{2\ NS}$ (1.25)	3.38 $^{1\ NS}$ (1.90)	3.66 $^{2\ NS}$ (2.03)
4.Chlorpyriphos	3.53	1.94	5.99 (2.48)	4.60 (2.23)	5.79 (2.48)	4.47 (2.21)	1.09 $^{1\ NS}$ (1.24)	4.39 (2.12)	5.96 (2.54)
5.Thiamethoxam	3.57	1.92	5.73 (2.43)	4.09 (2.10)	5.97 (2.52)	4.56 (2.23)	1.60 $^{5\ NS}$ (1.42)	4.41 (2.14)	5.50 (2.44)
6.Chlorantraniliprole	3.40	1.88	5.15 (2.31)	3.79 (2.03)	5.43 (2.41)	4.04 (2.10)	1.72 $^{6\ NS}$ (1.46)	4.03 (2.06)	4.80 (2.29)
7.Neem Oil	3.61	1.87	6.38 (2.56)	4.33 (2.16)	5.72 (2.47)	4.28 (2.16)	2.04 (1.57)	4.52 (2.18)	3.38 (1.96)
8.Btk	3.62	1.88	5.49 (2.38)	3.92 (2.07)	6.19 (2.56)	4.72 (2.26)	2.90 (1.80)	4.65 (2.21)	3.08 (1.88)
9.Neem Oil + Btk	3.57	1.96	4.42 $^{3\ NS}$ (2.15)	3.14 $^{2\ NS}$ (1.86)	5.12 $^{3\ NS}$ (2.34)	3.73 $^{3\ NS}$ (2.03)	2.00 (1.55)	3.68 $^{3\ NS}$ (1.98)	3.29 $^{1\ NS}$ (1.94)
10.Untreated Check	3.74	1.95	10.30 (3.24)	5.95 (2.51)	8.18 (2.92)	6.83 (2.69)	5.08 (2.30)	7.27 (2.73)	3.67 (2.03)
$SE_{(m)}$	–		0.04	0.07	0.02	0.02	0.10	0.03	0.03
CD $_{(5\%)}$	–		0.12	0.20	0.06	0.07	0.29	0.08	0.10
CV $_{(\%)}$	–		2.38	8.50	1.07	1.45	9.09	1.90	2.16

* Values in parentheses are square root transformation (√ (x + 0.5)) for uniform sample size (Steel and Torrie, 1960); 1, 2, 3 numerals are rank orders and NS stands for non-significant respectively; Comparison of all data respective to the non-significant lowest insect pest infestation.

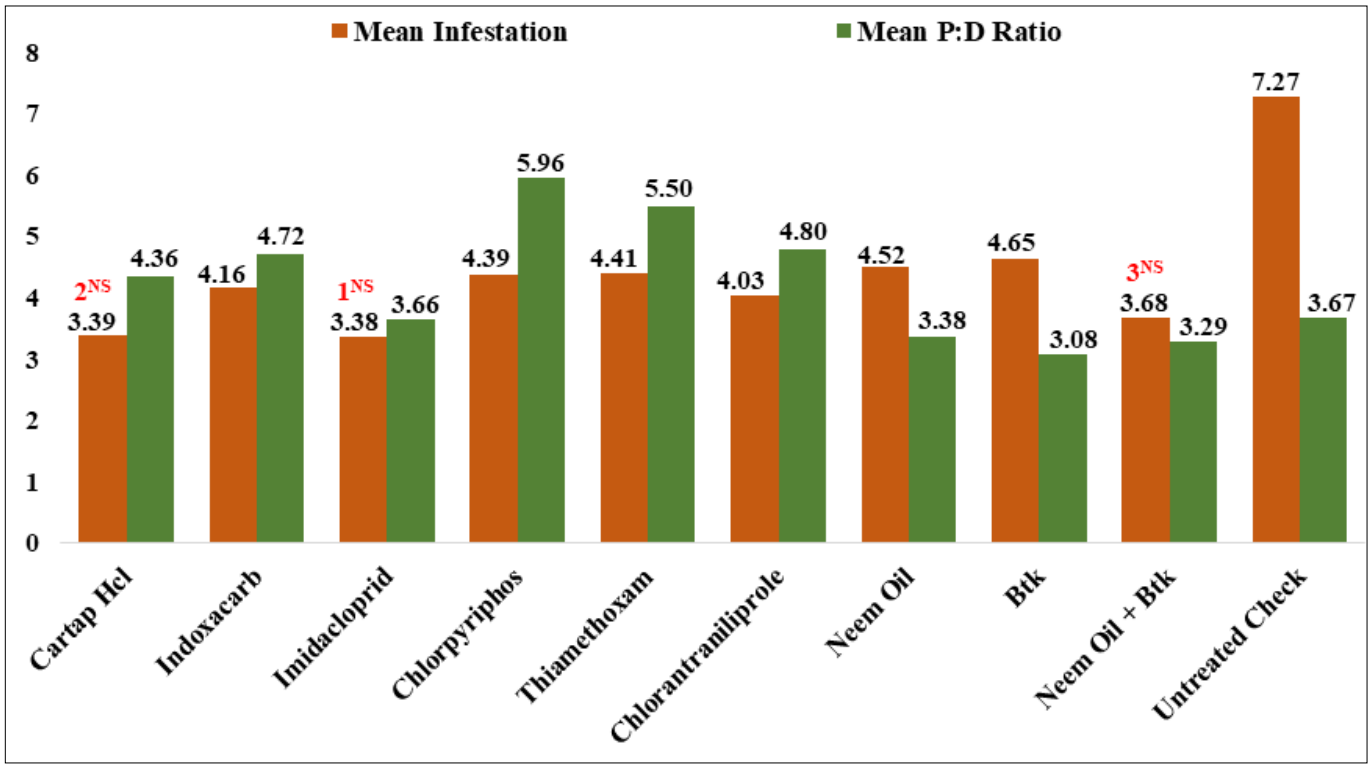

Fig 1: Evaluation of Ecofriendly Insecticides for Major Insect Pests of Rice (Pooled of 2014 & 15) * (% Infestation (Infestation) and Pest: Defender Ratio (P: D))

Table 2: Evaluation of Ecofriendly Insecticides for Major Insect Pests of Rice (Pooled of 2014 & 15) * (% Infestation (Infestation) and Pest: Defender Ratio (P: D))

Treatments	First Application (ADBAp)		First Application (Mean)		Second Application (Mean)		Total Mean Infestation DAAp	Total Mean P: D DAAp	Mean Yield (q/ha)
	Infestation	P: D	Infestation	P: D	Infestation	P:D			
1.Cartap Hcl	3.40	1.82	4.26 $^{2\ NS}$ (2.10)	3.93 (2.10)	2.52 $^{1\ NS}$ (1.71)	4.78 (2.30)	3.39 $^{2\ NS}$ (1.91)	4.36 (2.20)	35.00 $^{1\ NS}$
2.Indoxacarb	3.39	1.84	5.10 (2.27)	4.46 (2.22)	3.22 (1.90)	4.98 (2.34)	4.16 (2.09)	4.72 (2.28)	31.74
3.Imidacloprid	3.33	1.87	4.23 $^{1\ NS}$ (2.08)	3.11 $^{2\ NS}$ (1.90)	2.53 $^{2\ NS}$ (1.72)	4.22 $^{2\ NS}$ (2.17)	3.38 $^{1\ NS}$ (1.90)	3.66 $^{2\ NS}$ (2.03)	34.80 $^{2\ NS}$
4.Chlorpyriphos	3.53	1.94	5.37 (2.31)	5.21 (2.39)	3.41 (1.94)	6.71 (2.68)	4.39 (2.12)	5.96 (2.54)	31.72
5.Thiamethoxam	3.57	1.92	5.35 (2.32)	4.84 (2.30)	3.46 (1.95)	6.16 (2.58)	4.41 (2.14)	5.50 (2.44)	31.37
6.Chlorantraniliprole	3.40	1.88	4.87 (2.23)	4.04 (2.12)	3.18 $^{4\ NS}$ (1.89)	5.56 (2.46)	4.03 (2.06)	4.80 (2.29)	31.75
7.Neem Oil	3.61	1.87	5.41 (2.35)	2.82 (1.82)	3.64 (2.01)	3.94 (2.10)	4.52 (2.18)	3.38 (1.96)	31.39
8.Btk	3.62	1.88	5.45 (2.36)	2.48 (1.72)	3.84 (2.06)	3.68 (2.04)	4.65 (2.21)	3.08 (1.88)	31.18
9.Neem Oil + Btk	3.57	1.96	4.52 $^{3\ NS}$ (2.17)	2.75 $^{1\ NS}$ (1.80)	2.83 $^{3\ NS}$ (1.80)	3.84 $^{1\ NS}$ (2.08)	3.68 $^{3\ NS}$ (1.98)	3.29 $^{1\ NS}$ (1.94)	34.28 $^{3\ NS}$
10.Untreated Check	3.74	1.95	7.92 (2.83)	2.98 (1.86)	6.61 (2.63)	4.37 (2.19)	7.27 (2.73)	3.67 (2.03)	31.02
SE (m)	–		0.04	0.03	0.06	0.03	0.03	0.03	0.25
CD (5%)	–		0.12	0.10	0.18	0.10	0.08	0.10	0.72
CV (%)	–		4.05	2.84	7.26	2.58	1.90	2.16	1.33

* Values in parentheses are square root transformation (√ (x + 0.5)) for uniform sample size (Steel and Torrie, 1960); 1, 2, 3 numerals are rank orders and NS stands for non-significant respectively; Comparison of all data respective to the non-significant lowest insect pest infestation.

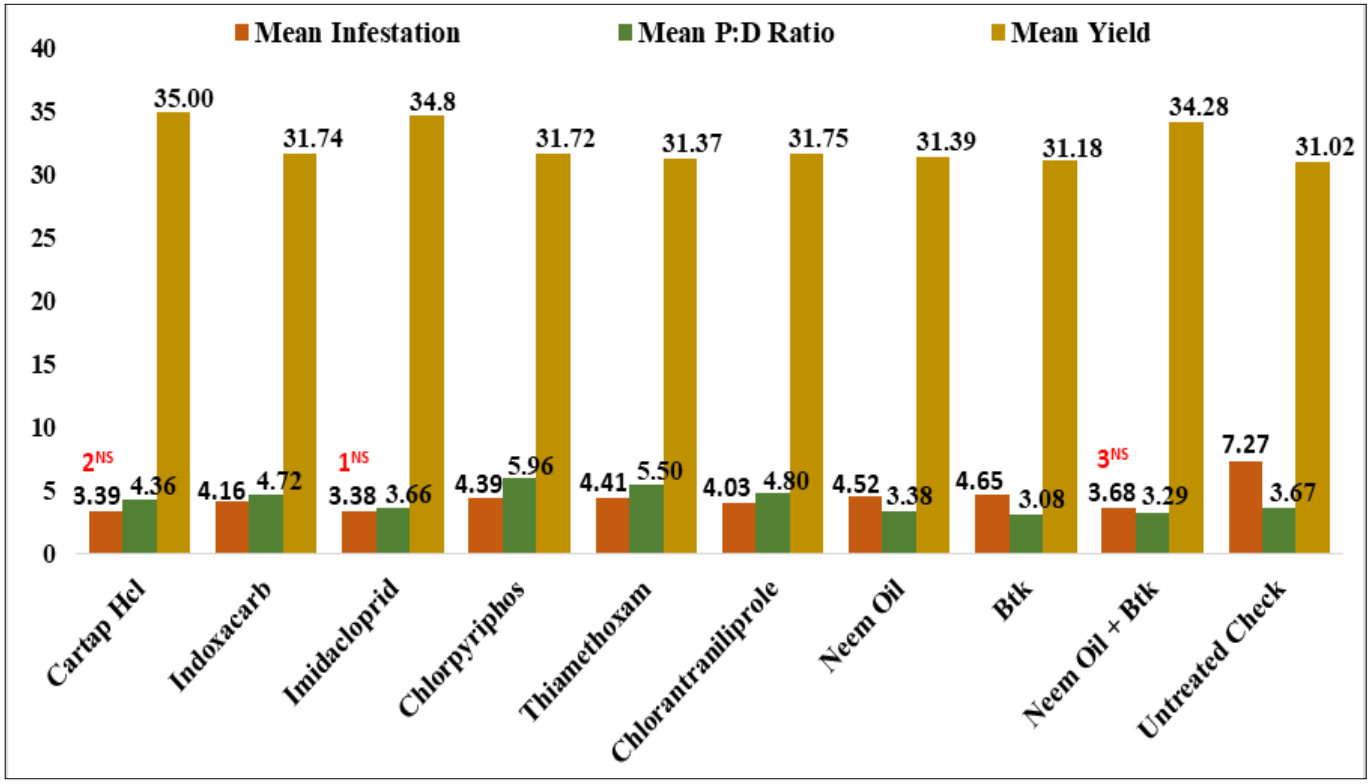

Fig 2: Evaluation of Ecofriendly Insecticides for Major Insect Pests of Rice (Pooled of 2014 & 15) * (% Infestation (Infestation) and Pest: Defender Ratio (P: D))

Table 3: Most Effective Ecofriendly Insecticides for Major Insect Pests of Rice (Pooled of 2014 & 15) (Infestation/ P: D Ratio/ Yield/ Common)

Major Insect Pests of Rice	Infestation (%) (Lowest)	P: D (Ratio) (Lowest)	Yield (q/ ha) (Highest)	Most Effective
1. Yellow Stemborer (CD (5%) for Infestation- 0.12)	Cartap Hcl 4.09 (2.07)	Neem Oil + Btk 3.29 (1.94)	Cartap Hcl 35.00	1. Imidacloprid 2. Neem Oil + Btk
	Imidacloprid 4.28 (2.11)	Imidacloprid 3.66 (2.03)	Imidacloprid 34.80	
	Neem Oil + Btk 4.42 (2.15)	–	Neem Oil + Btk 34.28	
2. Common Rice Leaffolder (CD (5%) for Infestation- 0.20)	Cartap Hcl 3.00 (1.82)	Neem Oil + Btk 3.29 (1.94)	Cartap Hcl 35.00	1. Imidacloprid 2. Neem Oil + Btk
	Neem Oil + Btk 3.14 (1.86)	Imidacloprid 3.66 (2.03)	Imidacloprid 34.80	
	Imidacloprid 3.22 (1.88)	–	Neem Oil + Btk 34.28	
3. Brown Planthopper (CD (5%) for Infestation- 0.06)	Imidacloprid 4.83 (2.28)	Neem Oil + Btk 3.29 (1.94)	Cartap Hcl 35.00	1. Imidacloprid 2. Neem Oil + Btk
	Cartap Hcl 4.94 (2.31)	Imidacloprid 3.66 (2.03)	Imidacloprid 34.80	
	Neem Oil + Btk 5.12 (2.34)	–	Neem Oil + Btk 34.28	
4. Rice Hispa (CD (5%) for Infestation- 0.07)	Imidacloprid 3.45 (1.96)	Neem Oil + Btk 3.29 (1.94)	Cartap Hcl 35.00	1. Imidacloprid 2. Neem Oil + Btk
	Cartap Hcl 3.54 (1.98)	Imidacloprid 3.66 (2.03)	Imidacloprid 34.80	
	Neem Oil + Btk 3.73 (2.03)	–	Neem Oil + Btk 34.28	
5. Rice Earheadbug (CD (5%) for Infestation- 0.29)	Chlorpyriphos 1.09 (1.24)	Imidacloprid 3.66 (2.03)	Cartap Hcl 35.00	1. Imidacloprid
	Imidacloprid 1.14 (1.25)	–	Imidacloprid 34.80	
	Cartap Hcl 1.37 (1.34)	–	–	
	Indoxacarb 1.42 (1.36)	–	–	
	Thiamethoxam 1.60 (1.42)	–	–	
	Chlorantraniliprole 1.72 (1.46)	–	–	
6. Mean of Major Insect Pests (CD (5%) for Infestation- 0.08)	Imidacloprid 3.38 (1.90)	Neem Oil + Btk 3.29 (1.94)	Cartap Hcl 35.00	1. Imidacloprid 2. Neem Oil + Btk
	Cartap Hcl 3.39 (1.91)	Imidacloprid 3.66 (2.03)	Imidacloprid 34.80	
	Neem Oil + Btk 3.68 (1.98)	–	Neem Oil + Btk 34.28	
CD (5%)	–	0.10	0.72	–

* Values in parentheses are square root transformation (√ (x + 0.5)) for uniform sample size (Steel and Torrie, 1960); Comparison of all data respective to the non-significant lowest insect pest infestation.

Conclusion

There were 3 insecticides (Imidacloprid, Cartap Hcl, and Neem Oil + Btk) inference non-significant for lowest infestation; 2 insecticides (Neem Oil + Btk and Imidacloprid) inference non-significant for lowest P:D ratio; 3 insecticides (Imidacloprid, Cartap Hcl, and Neem Oil + Btk) inference non-significant for highest yield. There were 2 insecticides (Imidacloprid and Neem Oil + Btk) inference most effective eco-friendly insecticides for major insect pests of rice. Though, Cartap Hcl was being most effective insecticides for major insect pests of rice among 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) as inference non-significantly for lowest infestation, but interestingly this observation was changed in P:D ratio as it did not inference non-significantly for lowest P:D ratio with 2 insecticides (Imidacloprid and Neem Oil + Btk). The present research works recommend to conserve strength of bioagents build up and the insecticide application has to avoid first 40 days after transplanting. If insecticide application is necessary, apply most effective eco-friendly insecticides after 40 days of transplanting as single application. Though, both the insecticides (Imidacloprid and Neem Oil + Btk) were being most effective ecofriendly insecticides, while Imidacloprid is the chemical insecticide and Neem Oil + Btk is the biological insecticides (biopesticides). Hence, Neem Oil + Btk as biopesticides primarily would be the best choice before Imidacloprid for the most effective ecofriendly management of major insect pests of rice.

References

1. Barrion AT, Litsinger JA. Taxonomy of rice insect pests and their arthropod parasites and predators. In: Biology and Management of Rice Insects, E.A. Heinrichs (ed.). Wiley Eastern, New Delhi, India; c1994. p. 13-359.
2. Chakraborty K. Extent of suppression of yellow stem borer, *Scirpophaga incertulus* Walker, population by

insecticides in field of scented local paddy. Annals of plant Protection Sciences. 2011;19(1):63-66.
3. Chakraborty K, Deb DC. Extent of suppression of leaf folder, *Cnaphalocrocis medinalis*, Geun. Population by some selected insecticides in the field of scented local paddy cultivar Tulaipanji at Raiganj, Uttar Dinajpur, West Bengal, India. International Journal of Plant, Animal and Environmental Sciences. 2011;1(3):142-149.
4. CRRI. Rice pests and diseases- emerging problems and their management. In: CRRI Annual Report 2013-14. Central Rice Research Institute-ICAR, Cuttack, India; c2014. p. 83-100.
5. DAC, FW. Agricultural statistics at a glance 2018. Department of Agriculture, Cooperation & Farmers Welfare, Government of India, New Delhi, India; c2018. p. 468.
6. Dale D. Insect pests of the rice plant-their biology and ecology. In: Biology and management of rice insects, E.A. Heinrichs (ed.), Wiley Eastern, New Delhi, India; c1994. p. 363-485.
7. David BV, Ananthkrishnan TN. General and applied entomology, 2nd Edition. Mc Graw Hill Publication (India) Pvt. Ltd., New Delhi, India; c2004. p. 1184.
8. Dhaliwal GS, Jindal V, Mohindri B. Crop losses due to insect pests: Global and Indian scenario. Indian Journal of Entomology. 2015;77(2):165-168.
9. Dhamu KP, Ramamoorthy K. Statistical methods. Agrobios (India), Jodhpur, India; c2007. p. 359.
10. FAOSTAT. Statistical data of world rice production. In: Data; c2019. Retrieved from http://www.fao.org/faostat/en3/#data/QC.
11. Gallagher KD, Ooi PAC, Mew TW, Borromeo E, Kenmore PE. Integrated pest management in rice. International Rice Commission Newsletter. 2002;51(2002):1-17.
12. Heinrichs EA, Muniappan R. IPM for tropical crops: rice. CAB Reviews. 2017;12(30):1-31.
13. Heong KL, Escalada MM, Huan NH, Mai V. Use of communication media in changing rice farmers' pest management in the Mekong Delta, Vietnam. Crop Protection. 1998;17:413-425.
14. Jena M, Dani RC. Evaluation of insecticides against rice hispa, *Dicladispa armigera* Oliver (Coleoptera: Chrysomelidae). Oryza. 2011;48(3):255-257.
15. Kulagod SD, Nayak GV, Vastrad AS, Hugar PS, Basavanagoud K. Evaluation of insecticides and bio-rationals against yellow stem borer and leaf folder on rice crop. Karnataka Journal of Agricultural Science. 2011;24(2):244-246.
16. Norton GW, Heong KL, Johnson D, Savary S. Rice pest management: issues and opportunities. In: Rice in the Global Economy: Strategic Research and Policy Issues for Food Security. S. Pandey, D Byerlee, D Dawe, A Dobermann, S. Mohanty, S. Rozelle, and B. Hardy (eds). International Rice Research Institute, Manila, Philippines; c2010. p. 297 - 332.
17. Oerke EC. Crop losses to pests. Journal of Agricultural Science. 2006;144:31-43.
18. Pathak H, Samal P, Sahid M. Revitalizing rice systems for enhancing productivity, profitability and climate resilience. In: Rice research for enhancing productivity, profitability and climate resilience, H. Pathak, A.K. Nayak, M. Jena, O.N. Singh, P. Samal and S.G. Sharma (eds.). ICAR-National Rice Research Institute, Cuttack, India; c2018. p. 1-17.
19. Pathak MD, Khan ZR. Insect pests of rice. International Rice Research Institute, Manila, Philippines; c1994. p. 89.
20. Pontius J, Dilkts R, Bartlett A. Ten years training in Asia: from farmer field school to community IPM. FAO Regional office for Asia and the Pacific, Bangkok, Thailand; c2002. p. 101.
21. Prakash A, Bentur JS, Prasad MS, Tanwar RK, Sharma OP, Bhagat S, *et al*. Integrated pest managment for rice. National Centre for Integrated Pest Management, New Delhi, India; c2014. p. 43.
22. Rao CS. Ecological sustainable strategies for pest management. Extension Digest. 2019;3(1):26.
23. Rath PC, Lenka S, Mohapatra SD, Jena M. Field evaluation of selected insecticides against insect pests of wet season transplanted rice. Oryza. 2014;51(4):324-326.
24. Rangaswamy R. A textbook of agricultural statistics, 2nd edition. New Age International (P) Limited, Publishers, New Delhi, India; c2010. p. 531.
25. Sarao PS, Shera PS, Singh P. Impact of multiple insect-pest incidence on yield in basmati rice. Global Research Communications. 2015;43(2):260-271.
26. Schoenly KG, Cohen JE, Heong KL, Arida GS, Barrion AT, Litsinger JA. Quantifying the impact of insecticides on food web structure of rice-arthropod populations in a Philippine farmer's irrigated field: a case study. In: Food Webs: Integration of Patterns and Dynamics, G.A. Polis and K.O. Winemiller (eds.). Chapman and Hall, New York, USA; c1996. p. 343-351.
27. Sharanappa AK, Sahu R, Khan HH. Effect of certain insecticides on natural enemies of rice stem borer, *Scirpophaga incertulus* (Walker) on rice, *Oryza sativa* L. Journal of Entomology and Zoology Studies. 2019;7(1):1100-1104.
28. Sharma S, Kooner R, Arora R. Insect pests and crop losses. In: Breeding insect resistant crops for sustainable agriculture, R. Arora and S. Sandhu (eds.). Springer Nature, Singapore, Republic of Singapore; c2017. p. 45-66.
29. Steel RGD, Torrie JH. Principles and procedures of statistics. McGraw-Hill Book Company, Inc., New York, USA; c1960. p. 481.
30. Tigga V, Kumar A, Sahu PS, Khan HH, Naz H. Assessment of the efficacy of certain chemical insecticides against rice gundhi bug, *Leptocorisa acuta* (Thun.) in Naini, Allahabad region. International Journal of Chemical Studies. 2018;6(1):959-961.