

INFESTATION SUPPRESSION UNDER EVALUATION OF ECOFRIENDLY INSECTICIDES AGAINST MAJOR INSECT PESTS OF RICE IN EASTERN UTTAR PRADESH CONDITIONS

ABSTRACT

The present study was undertaken to analysis the suppression of infestation over check plot under evaluation of ecofriendly insecticides against major insect pests of rice in Eastern Uttar Pradesh conditions for the two consecutive years (2014 and 2015) at farmer field of district Deoria, India. This evaluation was observed most effective ecofriendly insecticides concerned to lowest infestation, highest suppression of infestation over check plot, and highest yield. The inferences of suppression over check plot and yield of rice crop were based on non-significant ecofriendly insecticides for lowest infestation. There were 2 insecticides (Cartap Hcl and Imidacloprid) inference non-significant for highest suppression of infestation over check. There were 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for lowest infestation and highest yield respectively. The mean ranking and inference of suppression over check were similar to inference of non-significant ecofriendly insecticides for lowest infestation as, Imidacloprid, Cartap Hcl, and Neem Oil + Btk respectively. 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 leaf folder (*Cnaphalocrosis medinalis* Guenee), 3.Brown planthopper (*Nilaparvata lugens* Stal), 4.Rice hispa (*Dicladyspa armigera* Oliver), and 5.Rice earhead bug (*Leptocorisa acuta* Thunberg).

Key words: Infestation suppression, Ecofriendly insecticides, Major Insect Pests of rice, Eastern Uttar Pradesh, India.

INTRODUCTION

Rice (*Oryza sativa* Linn.) is one of the most important staple foods of the world as well as India. The rice fragrance spreads to the entire world. It provides livelihood and food security to the about, 56% of the world population (7.46 billion) as well as 65% of the India population (1.32 billion). 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 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 %. About 800 insect pest species associated with rice crop over world. Among them about 250 insect pest species associated with rice crop in India and about 20 of them are major economic significance. Out of 20 major insect pests of rice, 12 of national significance and 08 of regional significance have been recognized respectively. The insect pests of rice infest all parts of the plant at all growth stages and transmit few viral diseases of rice. (Pathak and Khan, 1994; Oerke, 2006; Dhaliwal *et al.*, 2015; Heinrichs and Muniappan, 2017; Sharma *et al.*, 2017; DAC&FW, 2018; Pathak *et al.*, 2018; FAOSTAT, 2021).

Insect pest management is the continuous process varied among complex ecosystem of nature. The regular efforts are necessary to develop effective strategy for insect pest management with particular agroecosystem under changing climatic conditions. Though, Farmers are practicing all possible available methods and techniques for rice insect pest management, but 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. 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 novel chemical insecticides, and biological insecticides trending commonly in scientific community to evaluate their efficacy regarding ecofriendly approach, while

combination application of biological insecticides have been limited evaluation towards biorational approach of pest management. Therefore, this research work selected those novel 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.

Chakraborty (2011) and Chakraborty and Deb (2011) both have been reported that, the efficacy of Imidacloprid was observed lower the infestation of yellow stem borer (*Scirpophaga incertulus*) and common rice leaf folder (*Cnaphalocrocis medinalis*). Kulagod *et al.* (2011) studied on evaluation of efficacy of biorationals as Azadirachtin and *Bacillus thuringiensis* formulation against yellow stem borer (*Scirpophaga incertulus*) and common rice leaf folder (*Cnaphalocrocis medinalis*) of rice was observed lower the infestation. Rath *et al.* (2014) has been observed that, the lowest infestation of yellow stem borer (*Scirpophaga incertulus*) and rice earhead bug (*Leptocorisa acuta*) were recorded in Imidacloprid, and highest grain yield was recorded in Thiamethoxam treated plots. Sarao *et al.* (2015) and Tigga *et al.* (2018) both have been found that, the damage of yellow stem borer (*Scirpophaga incertulus*) and rice earhead bug (*Leptocorisa acuta*) were recorded lowest in Imidacloprid.

MATERIALS AND METHODS

The present study was undertaken to analysis the suppression of infestation over check plot under evaluation of ecofriendly insecticides against major insect pests of rice in Eastern Uttar Pradesh conditions for the two consecutive years (2014 and 2015) at farmer field of district Deoria, India. This confined spot of study, represents the conducive 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, Chlorpyrifos 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 m². 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. 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 and yield of rice crop to evaluate efficacy of treated ecofriendly insecticides. This observation was analyzed the suppression of infestation over check plot of major insect pests of rice during evaluation most effective ecofriendly insecticides concerned to lowest infestation and highest yield respectively.

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), Barrion and Litsinger (1994), Pathak and Khan (1994), 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), and Rangaswamy (2010). The formula of suppression of infestation over check was adopted as follows,

Suppression of infestation over check (%) = (% of Infestation in treated plot over the check plot - 100)

$$\% \text{ of Infestation in treated plot over the check plot} = \frac{\text{Infestation of insect pest in treated plot} - \text{Infestation of insect pest in check plot}}{\text{Infestation of insect pest in check plot}} \times 100$$

RESULTS AND DISCUSSION

The suppression of infestation over check plot was observed under evaluation of efficacy of some novel ecofriendly insecticides on infestation 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 evaluation of ecofriendly insecticides on infestation of major insect pests of rice for pooled of both the years 2014 and

2015 were inference non-significant for highest suppression over check (SPOC) as, 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) for Yellow stemborer (*Scirpophaga incertulus* Walker), Common rice leaffolder (*Cnaphalocrosis medinalis* Guenee), and Brown planthopper (*Nilaparvata lugens* Stal); 1 insecticide (Imidacloprid) for Rice hispa (*Dicladispa armigera* Oliver); and 2 insecticides (Imidacloprid and Chlorpyrifos) for Rice earhead bug (*Leptocorisa acuta* Thunberg) respectively. (Table and Figure 1).

Of the total observed evaluation of ecofriendly insecticides against major insect pests of rice under suppression over check (SPOC) for pooled of both the years 2014 and 2015, there were 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for highest suppression over check (SPOC) under first application (30 DAT) and second application (45 DAT), based on evaluation of non-significant ecofriendly insecticides for lowest infestation as, Cartap Hcl, Imidacloprid, and Neem Oil + Btk respectively. The mean of evaluation under suppression over check was observed as, 2 insecticides (Cartap Hcl and Imidacloprid) inference non-significant for highest suppression over check under mean of first application and second application, based on mean evaluation of non-significant ecofriendly insecticides for lowest infestation as, Cartap Hcl, Imidacloprid, and Neem Oil + Btk respectively. Of the total observed infestation 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 under first application (30 DAT); and 4 insecticides (Cartap Hcl, Imidacloprid, Chlorantraniliprole, and Neem Oil + Btk) inference non-significant for lowest infestation 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 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. Of the most effective ecofriendly insecticides observed on infestation of major insect pests of rice for pooled of both the years 2014 and 2015, there were 2 insecticides (Cartap Hcl and Imidacloprid) inference non-significant for highest suppression over check (SPOC); 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for lowest infestation; and 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for highest yield for mean of major insect pests of rice respectively. (Table and Figure 2). The ranking of evaluation under

suppression over check was observed as, Imidacloprid > Cartap Hcl > Neem Oil + Btk > Chlorantraniliprole > Indoxacarb > Chlorpyrifos > Thiamethoxam > Neem Oil > Btk for highest suppression over check; Imidacloprid > Cartap Hcl > Neem Oil + Btk > Chlorantraniliprole > Indoxacarb > Chlorpyrifos > Thiamethoxam > Neem Oil > Btk for lowest infestation; Cartap Hcl > Imidacloprid > Neem Oil + Btk > Chlorantraniliprole > Indoxacarb > Chlorpyrifos > Neem Oil > Thiamethoxam > Btk for highest yield; and Imidacloprid > Cartap Hcl > Neem Oil + Btk > Chlorantraniliprole > Indoxacarb > Chlorpyrifos > Thiamethoxam > Neem Oil > Btk for mean of infestation, suppression over check (SPOC), and yield respectively. (Table 3). Similar findings were reported by Chakraborty (2011), Chakraborty and Deb (2011), Kulagod *et al.* (2011), CRRRI (2014), Rath *et al.* (2014) Sarao *et al.* (2015), and Tigga *et al.* (2018).

Present research work was adopted the non-significant lowest infestation for observation of highest suppression of infestation over check plot as scale to confined efficacy of insecticides as ecofriendly. There were 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for lowest infestation and highest yield respectively. Though, Cartap Hcl was being most effective insecticides for major insect pests of rice among 3 insecticides (Cartap Hcl, > Imidacloprid > Neem Oil + Btk) as inference non-significantly for highest yield, but this observation was changed in highest suppression of infestation over check plot most effectively as, Imidacloprid > Cartap Hcl > Neem Oil + Btk respectively. The mean ranking and inference of suppression over check were similar to inference of non-significant ecofriendly insecticides for lowest infestation as, Imidacloprid > Cartap Hcl > Neem Oil + Btk respectively. Though, all these 3 insecticides were being most effective ecofriendly insecticides as, the Imidacloprid and Cartap Hcl are the chemical insecticides, while Neem Oil + Btk are the biological insecticides (biorationals). Hence, Neem Oil + Btk as biorationals primarily would be the best choice before Imidacloprid and Cartap Hcl for the ecofriendly management of major insect pests of rice. Similar recommendation has also been reported by Schoenly *et al.* (1996), Heong *et al.* (1998), Gallagher *et al.* (2002), Norton *et al.* (2010), Prakash *et al.* (2014), Heinrichs and Muniappan (2017) and Rao (2019).

Table 1. Mean Evaluation of Ecofriendly Insecticides for Major Insect Pests (Pooled of 2014 & 15)*
 (% Infestation (Infestation) and % Suppression of Infestation over Check (SPOC))

Treatments	Yellow Stemborer	Common Rice Leaffolder	Brown Planthopper	Rice Hispa	Rice Earheadbug	Total Mean SPOC DAAp	Total Mean Infestation DAAp
	SPOC	SPOC	SPOC	SPOC	SPOC		
1.Cartap Hcl	61.85 ^{1NS} (7.87)	53.19 ^{1NS} (7.28)	40.04 ^{2NS} (6.36)	49.59 (7.05)	69.62 (8.32)	54.86 ^{2NS} (7.38)	3.39 ^{2NS} (1.91)
2.Indoxacarb	50.63 (7.10)	39.27 (6.23)	26.87 (5.20)	37.39 (6.12)	69.02 (8.29)	44.64 (6.59)	4.16 (2.09)
3.Imidacloprid	59.45 ^{2NS} (7.73)	48.97 ^{3NS} (7.00)	41.81 ^{1NS} (6.50)	50.83 ^{1NS} (7.14)	75.95 ^{2NS} (8.71)	55.41 ^{1NS} (7.44)	3.38 ^{1NS} (1.90)
4.Chlorpyrifos	43.15 (6.55)	25.32 (5.03)	28.94 (5.42)	34.98 (5.93)	83.91 ^{1NS} (9.18)	42.71 (6.38)	4.39 (2.12)
5.Thiamethoxam	46.51 (6.78)	33.75 (5.79)	26.74 (5.21)	33.58 (5.80)	66.18 (8.11)	41.43 (6.35)	4.41 (2.14)
6.Chlorantraniliprole	52.01 (7.22)	38.99 (6.24)	33.57 (5.83)	41.93 (6.48)	63.41 (7.92)	46.72 (6.74)	4.03 (2.06)
7.Neem Oil	41.08 (6.39)	28.78 (5.36)	29.61 (5.48)	38.07 (6.17)	54.21 (7.30)	38.91 (6.18)	4.52 (2.18)
8.Btk	48.65 (6.96)	36.09 (6.00)	23.85 (4.92)	31.16 (5.58)	41.57 (6.39)	36.47 (5.99)	4.65 (2.21)
9.Neem Oil + Btk	58.97 ^{3NS} (7.69)	50.63 ^{2NS} (7.10)	38.21 ^{3NS} (6.22)	46.66 (6.83)	55.36 (7.38)	49.97 (7.04)	3.68 ^{3NS} (1.98)
10.Untreated Check	-	-	-	-	-	-	7.27 (2.73)
SE _(m)	0.15	0.15	0.14	0.02	0.20	0.04	0.03
CD _(5%)	0.45	0.46	0.41	0.05	0.59	0.11	0.08
CV _(%)	2.96	3.47	3.40	0.38	3.50	0.78	1.90

* Values in parentheses are square root transformation ($\sqrt{x + 0.5}$) 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.

Figure 1. Mean 1 Evaluation of Ecofriendly Insecticides for Major Insect Pests (Pooled of 2014 & 15).
 (% Infestation (Infestation) and % Suppression of infestation over Check (SPOC))

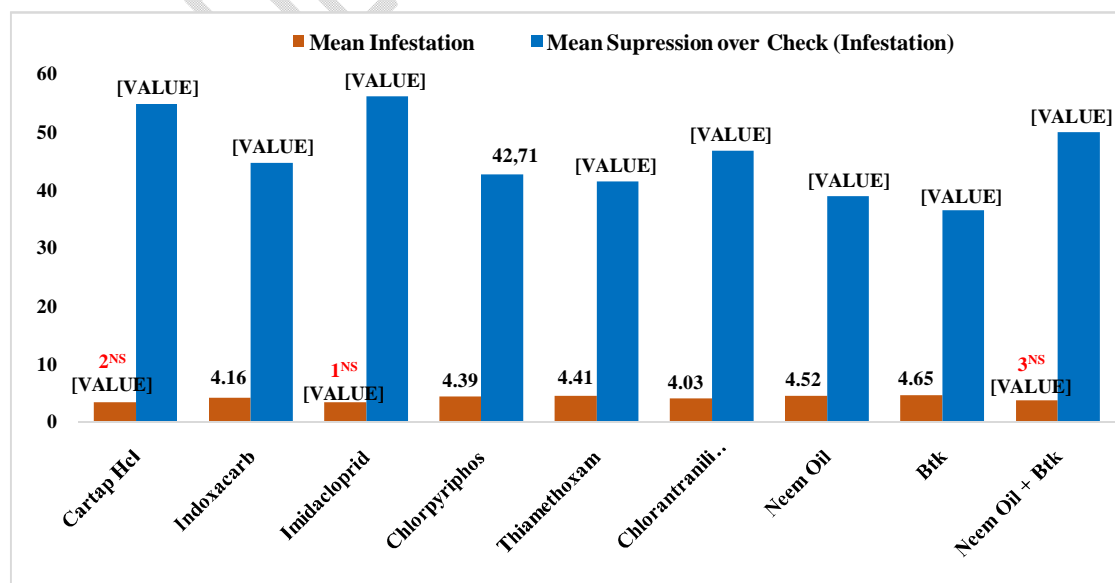
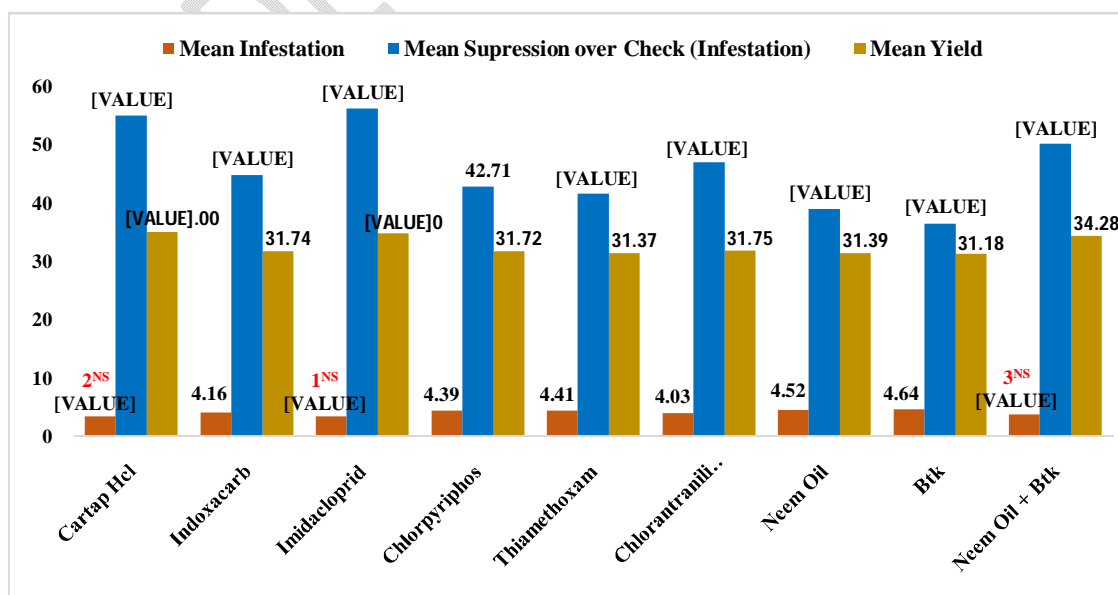


Table 2. Mean Evaluation of Ecofriendly Insecticides for Major Insect Pests (Pooled of 2014 & 15)*
 (% Infestation (Infestation) and % Suppression of Infestation over Check (SPOC))

Treatments	First Application (Mean)		Second Application (Mean)		Total Mean SPOC DAAP	Total Mean Infestation DAAP	Mean Yield (q/ha)
	SPOC	Infest	SPOC	Infest			
1.Cartap Hcl	48.96 ^{2NS} (6.98)	4.26 ^{2NS} (2.10)	60.75 ^{1NS} (7.77)	2.52 ^{1NS} (1.71)	54.86 ^{2NS} (7.38)	3.39 ^{2NS} (1.91)	35.00 ^{1NS}
2.Indoxacarb	39.58 (6.22)	5.10 (2.27)	49.70 (6.96)	3.22 (1.90)	44.64 (6.59)	4.16 (2.09)	31.74
3.Imidacloprid	50.59 ^{1NS} (7.08)	4.23 ^{1NS} (2.08)	60.22 ^{2NS} (7.75)	2.58 ^{2NS} (1.73)	55.41 ^{1NS} (7.44)	3.38 ^{1NS} (1.90)	34.80 ^{2NS}
4.Chlorpyriphos	38.14 (6.03)	5.37 (2.31)	48.38 (6.81)	3.52 (1.97)	42.71 (6.38)	4.39 (2.12)	31.72
5.Thiamethoxam	36.63 (5.96)	5.35 (2.32)	46.08 (6.72)	3.43 (1.95)	41.43 (6.35)	4.41 (2.14)	31.37
6.Chlorantraniliprole	41.32 (6.39)	4.87 (2.23)	52.20 ^{4NS} (7.09)	3.18 ^{4NS} (1.90)	46.72 (6.74)	4.03 (2.06)	31.75
7.Neem Oil	33.37 (5.75)	5.41 (2.35)	44.33 (6.53)	3.53 (1.99)	38.91 (6.18)	4.52 (2.18)	31.39
8.Btk	32.11 (5.65)	5.45 (2.36)	40.42 (6.30)	3.82 (2.06)	36.47 (5.99)	4.65 (2.21)	31.18
9.Neem Oil + Btk	43.49 ^{3NS} (6.60)	4.52 ^{3NS} (2.17)	56.44 ^{3NS} (7.48)	2.83 ^{3NS} (1.80)	49.97 (7.04)	3.68 ^{3NS} (1.98)	34.28 ^{3NS}
10.Untreated Check	–	7.92 (2.83)	–	6.61 (2.63)	–	7.27 (2.73)	31.02
SE (m)	0.20	0.04	0.24	0.06	0.04	0.03	0.25
CD (5%)	0.56	0.12	0.69	0.18	0.11	0.08	0.72
CV (%)	6.98	4.05	7.74	7.26	0.78	1.90	1.33

* Values in parentheses are square root transformation ($\sqrt{(x + 0.5)}$) 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.

Figure 2. Mean Evaluation of Ecofriendly Insecticides for Major Insect Pests (Pooled of 2014 & 15).
 (% Infestation (Infestation) and % Suppression of infestation over Check (SPOC))



**Table 3. Rank Evaluation of Ecofriendly Insecticides for Major Insect Pests (Pooled of 2014 & 15)*
(Infestation/ SPOC/ Yield/ Mean)**

Rank	Infestation (%) (Lowest)	SPOC (%) (Highest)	Yield (q/ ha) (Highest)	Mean Rank
1	Imidacloprid 3.38 ^{1 NS} (1.90)	Imidacloprid 55.41 ^{1 NS} (7.44)	Cartap Hcl 35.00 ^{1 NS}	Imidacloprid 1.33 ^{1 NS}
2	Cartap Hcl 3.39 ^{2 NS} (1.91)	Cartap Hcl 54.86 ^{2 NS} (7.38)	Imidacloprid 34.80 ^{2 NS}	Cartap Hcl 1.67 ^{2 NS}
3	Neem Oil + Btk 3.68 ^{3 NS} (1.98)	Neem Oil + Btk 49.97 (7.04)	Neem Oil + Btk 34.28 ^{3 NS}	Neem Oil + Btk 3.00 ^{3 NS}
4	Chlorantraniliprole 4.03 (2.06)	Chlorantraniliprole 46.92 (6.76)	Chlorantraniliprole 31.75	Chlorantraniliprole 4.00
5	Indoxacarb 4.16 (2.09)	Indoxacarb 44.64 (6.59)	Indoxacarb 31.74	Indoxacarb 5.00
6	Chlorpyriphos 4.39 (2.12)	Chlorpyriphos 42.71 (6.38)	Chlorpyriphos 31.72	Chlorpyriphos 6.00
7	Thiamethoxam 4.41 (2.14)	Thiamethoxam 41.43 (6.35)	Neem Oil 31.39	Thiamethoxam 7.33
8	Neem Oil 4.52 (2.18)	Neem Oil 38.91 (6.18)	Thiamethoxam 31.37	Neem Oil 7.67
9	Btk 4.65 (2.21)	Btk 36.47 (5.99)	Btk 31.18	Btk 9.00
SE_(m)	0.03	0.04	0.25	–
CD_(5%)	0.08	0.11	0.72	–
CV (%)	1.90	0.78	1.33	–

* Values in parentheses are square root transformation ($\sqrt{x + 0.5}$) 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.

CONCLUSION

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).

The inferences of suppression over check were based on non-significant ecofriendly insecticides for lowest infestation. There were 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for lowest infestation and highest yield respectively. The mean ranking and inference of suppression over check were similar to inference of non-significant ecofriendly insecticides for lowest infestation as, Imidacloprid, Cartap Hcl, and Neem Oil + Btk respectively. Though, all these 3 insecticides were being most effective ecofriendly insecticides as, the Imidacloprid and Cartap Hcl are chemical insecticides, while Neem Oil + Btk are the biological insecticides (biorationals). Hence, Neem Oil + Btk as biorationals primarily would be the best choice before Imidacloprid and Cartap Hcl for the ecofriendly management of major insect pests of rice.

REFERENCES

- Barrion, A.T. and Litsinger, J.A. (1994).** 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. pp. 13-359.
- Chakraborty, K. (2011).** Extent of suppression of yellow stem borer, *Scirpophaga incertulus* Walker, population by insecticides in field of scented local paddy. *Annals of plant Protection Sciences*, 19(1): 63-66.
- Chakraborty, K. and Deb, D.C. (2011).** 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*, 1(3): 142-149.
- CRRI (2014).** Rice pests and diseases- emerging problems and their management. In: *CRRI Annual Report 2013-14*. Central Rice Research Institute-ICAR, Cuttack, India. pp. 83-100.
- DAC&FW (2018).** Agricultural statistics at a glance 2018. Department of Agriculture, Cooperation & Farmers Welfare, Government of India, New Delhi, India. 468 pp.
- Dale, D. (1994).** 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. pp. 363-485.

- David, B.V. and Ananthkrishnan, T.N. (2004).** General and applied entomology, 2nd Edition. Mc Graw Hill Publication (India) Pvt. Ltd., New Delhi, India. 1184 pp.
- Dhaliwal, G.S., Jindal, V. and Mohindri, B. (2015).** Crop losses due to insect pests: Global and Indian scenario. *Indian Journal of Entomology*, 77(2): 165-168.
- Dhamu, K.P. and Ramamoorthy, K. (2007).** Statistical methods. Agrobios (India), Jodhpur, India. 359 pp.
- FAOSTAT (2021).** Statistical data of world rice production. In: *Data*. Retrieved from <http://www.fao.org/faostat/en3/#data/QC>.
- Gallagher, K.D., Ooi, P.A.C., Mew, T.W., Borromeo, E., Kenmore, P.E. (2002).** Integrated pest management in rice. *International Rice Commission Newsletter*, 51(2002): 1-17.
- Heinrichs, E.A. and Muniappan, R. (2017).** IPM for tropical crops: rice. *CAB Reviews*, 12(30): 1-31.
- Heong, K.L., Escalada, M.M., Huan, N.H., Mai, V. (1998).** Use of communication media in changing rice farmers' pest management in the Mekong Delta, Vietnam. *Crop Protection*, 17: 413–25.
- Kulagod, S.D., Nayak, G. V., Vastrad, A. S., Hugar, P. S., and Basavanagoud, K. (2011).** Evaluation of insecticides and bio-rationals against yellow stem borer and leaf folder on rice crop. *Karnataka Journal of Agricultural Science*, 24 (2): 244-246.
- Norton, G. W., Heong, K.L., Johnson, D., and Savary, S. (2010).** 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. pp. 297 - 332.
- Oerke, E.C. (2006).** Crop losses to pests. *Journal of Agricultural Science*, 144: 31-43.
- Pathak, H., Samal, P. and Sahid, M. (2018).** 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. pp. 1-17.

- Pathak, M.D. and Khan, Z.R. (1994).** Insect pests of rice. International Rice Research Institute, Manila, Philippines. 89 pp.
- Pontius, J., Dilks, R. and Bartlett, A. (2002).** Ten years training in Asia: from farmer field school to community IPM. FAO Regional office for Asia and the Pacific, Bangkok, Thailand. 101 pp.
- Prakash, A., Bentur, J. S., Prasad, M. S., Tanwar, R. K., Sharma, O. P., Bhagat, S., Sehgal, M., Singh, S. P., Singh, M., Chattopadhyay, C., Sushil, S. N., Sinha, A. K., Asre, R., Kapoor, K. S., Satyagopal, K., and Jeyakumar, P. (2014).** Integrated pest management for rice. National Centre for Integrated Pest Management, New Delhi, India. 43 pp.
- Rangaswamy, R. (2010).** A textbook of agricultural statistics, 2nd edition. New Age International (P) Limited, Publishers, New Delhi, India. 531 pp.
- Rao, C.S. (2019).** Ecological sustainable strategies for pest management. *Extension Digest*, 3(1), 26 pp.
- Rath, P.C., Lenka, S., Mohapatra, S.D. and Jena, M. (2014).** Field evaluation of selected insecticides against insect pests of wet season transplanted rice. *Oryza*, 51(4): 324-326.
- Sarao, P.S., Shera, P.S. and Singh, P. (2015).** Impact of multiple insect-pest incidence on yield in basmati rice. *Global Research Communications*, 43(2): 260-271.
- Schoenly, K.G., Cohen, J.E., Heong, K.L., Arida, G.S., Barrion, A.T., Litsinger, J.A. (1996).** 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. pp. 343-351.
- Sharma, S., Kooner, R. and Arora, R. (2017).** 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. pp. 45-66.
- Steel, R.G.D. and Torrie, J.H. (1960).** Principles and procedures of statistics. McGraw-Hill Book Company, Inc., New York, USA. 481 pp.
- Tigga, V., Kumar, A., Sahu, P.S., Khan, H.H. and Naz, H. (2018).** Assessment of the efficacy of certain chemical insecticides against rice gundhi bug, *Leptocorisa*

acuta (Thun.) in Naini, Allahabad region. *International Journal of Chemical Studies*, 6(1): 959-961.

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