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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

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

Bioefficacy of some newer ecofriendly insecticides against rice hispa (*Dicladispa armigera* Oliver) under rice ecosystem of eastern Uttar Pradesh

Gyan Prakash Morya and Rajnish Kumar

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Abstract
An evaluation was conducted on the bio efficacy of some ecofriendly insecticides for the management of rice hispa (*Dicladispa armigera* Oliver) under rice ecosystem of Eastern Uttar Pradesh 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 surveillance was conducted as per methodology of agro ecosystem analysis (AESA) (Pontius *et al*., 2002) modified as accessibility. The rice hispa is an endemic insect pest of rice and accounted for 25-65% yield loss. It was observed most serious insect pest and confined infestation over 15% during the study. 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). There were 3 insecticides (Cartap Hcl, Imidacloprid 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 (Cartap Hcl, Imidacloprid and Neem Oil + Btk) inference non-significant for highest yield. There were 2 insecticides (Imidacloprid and Neem Oil + Btk) inference most effective ecofriendly insecticides. Though, both the insecticides (Imidacloprid and Neem Oil + BTK) were being most effective ecofriendly insecticides, yet Neem Oil + BTK as biorationals primarily would be the best choice before Imidacloprid for the most effective ecofriendly management of common rice hispa.

Keywords: Biofficacy, ecofriendly insecticides, rice hispa (*Dicladispa armigera* Oliver), rice ecosystem, eastern Uttar Pradesh, India

Introduction

Rice is one of the most important staple foods of the world (70% of the population) and India (65% of the population). About 90% of the world's rice is produced and consumed in the Asian region and most staple food of South East Asia. It is grown in almost all the states of India and shares 21% of the world rice production. Uttar Pradesh shares 15% of the India rice production and occupies second position after West Bengal (17%) and first position in rice crop area. Despite this above proud credential, Uttar Pradesh is not appearing leading position. The main cause of low productivity is traditional and ill cultivation practices by losses 65% of yield of the highest productivity and shares 25% losses caused by insect pests itself. About 800 insect pest species associated with rice crop over world. Among them 250 insect pest species associated with rice crop in India and 20 of them are pests of major economic significance. The insect pests of rice infest all parts of the plant at all growth stages and transmit few viral diseases of rice. 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) [17, 15, 7, 24, 11, 16, 4, 9].

Uttar Pradesh is the fourth largest and first most populous state of the India. It has 11.56 million hectares of cultivated area, constituting 70% of the total geographical area of state. The rice production of Uttar Pradesh state is mostly concentrated to the Eastern Uttar Pradesh region. But the Uttar Pradesh state is under the lag phase of adaptation of modern technologies of rice crop production, especially 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 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 bio agents 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 bio rational 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.

The rice hispa (*Dicladispa armigera* Oliver) is a most series insect pest of rice, which has been accounted for 25-65% yield loss. Jena and Dani (2011) [12] have been reported that, the infestation of rice hispa (*Dicladispa armigera*) was observed reduce in Imidacloprid and Thiamethoxam. Karthick *et al.* (2015) [13] have been studied that, plots treated with Indoxacarb favor the high population of coccinellids and spiders respectively. It was also reported that, the overall mean population of coccinellids and spiders were found high in untreated check. Baehaki *et al.* (2017) [1] have been reported that, the application of Chlorantraniliprole + Thiamethoxam were observed safer insecticides for spiders, coccinellids and mirids. Sharanappa *et al.* (2019) [23] have been found that, the application of Imidacloprid observed favor the high population of coccinellids.

Materials and Methods

The evaluation was conducted on the efficacy of some ecofriendly insecticides against rice hispa (*Dicladispa armigera* Oliver) under rice ecosystem of Eastern Uttar Pradesh for the two consecutive years (2014 and 2015) at farmer field of district Dearie. 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 affectivity. 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 bio agents. 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 rice hispa, abundance of bio agents, and yield to evaluate efficacy of treated some 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 rice hispa and their bio agents.

Surveillance was conducted as per methodology of agro ecosystem analysis (AESA) (Pontius *et al*., 2002) [18] modified as accessibility. Taxonomic identification was verified with texts of reference, *i.e*., Dale (1994) [5], Barrion and Litsinger (1994) [2], Pathak and Khan (1994) [17], David and Ananthakrishnan (2004) [6]; Rice knowledge management portal (RKMP); and Subject experts respectively. The statistical inferences were verified with texts of reference, *i.e*., Dhamu & Ramamoorthy (2007) [8], and Rangaswamy (2010) [20].

Results and Discussion

The evaluation of efficacy of some ecofriendly insecticides was observed on infestation and their bioagents of rice hispa (*Dicladispa armigera* Oliver) in rice crop for the two consecutive years 2014 and 2015 respectively. It was observed most serious insect pest and confined infestation over 15%. The rice hispa is an endemic insect pest of rice and accounted for 15-25% yield loss. The symptoms of damage were observed as whitish parallel streaks appearance in tilling to panicle stage. The damaging stages are grubs and beetles, mining the leaves by grubs and feeding upon the leaves by beetles, between the veins of leaf lamina, leading to drying of leaves and stunted growth. The beetles are bluish black with numerous short spines on the body. The eggs are laid in masses in the scraped portion of tender leaves. The grubs are legless. Creamy white, found inside the leaf mines and pupation takes place there.

Of the total observed infestation and their bioagents of rice hispa (*Dicladispa armigera* Oliver) 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 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 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. (Table & Figure 1). Of the total observed evaluation of ecofriendly insecticides under suppression over check for pooled of both the years 2014 and 2015, there were 2 insecticides (Cartap Hcl and Imidacloprid) and 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for highest suppression over check at intervals of 3, 7, and 14 days after application under first application (30 DAT) and second application (45 DAT) respectively, based on evaluation of non-significant ecofriendly insecticides for lowest infestation as, Cartap Hcl, Imidacloprid, and Neem Oil + Btk. The mean of evaluation under suppression over check was observed as, 1 insecticide (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 (Table & Figure 2). The ranking of evaluation was observed as, Imidacloprid > Cartap Hcl > Neem Oil + Btk > Chlorantraniliprole > Neem Oil > Indoxacarb > Chlorpyriphos > Thiamethoxam > 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 > Neem Oil + Btk > Cartap Hcl > Chlorantraniliprole > Neem Oil > Indoxacarb > Btk > Chlorpyriphos > Thiamethoxam for mean of infestation, P:D ratio, and yield respectively. (Table 3). Of the most effective ecofriendly insecticides observed on infestation and their bioagents of rice hispa 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 (Neem Oil + Btk and Imidacloprid) inference non-significant for lowest P:D ratio; 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for highest yield; and 2 insecticides (Imidacloprid and Neem Oil + Btk) inference most effective ecofriendly insecticides respectively. (Table 3). Similar results were also reported by Jena and Dani (2011) [12], CRRI (2014) [3], Karthick *et al.* (2015) [13], Baehaki *et al.* (2017) [1], and Sharanappa *et al.* (2019) [23].

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 rice hispa. Though, both the insecticides were being most effective ecofriendly insecticides, the Imidacloprid a chemical insecticide, while Neem Oil + Btk is the biological insecticides (biopesticides). Hence, Neem Oil + Btk as biopesticides primarily would be the best choice before Imidacloprid for the ecofriendly management of rice hispa. Though, Cartap Hcl was being most effective insecticides for rice hispa 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 (Neem Oil + Btk and Imidacloprid). The present research works recommend to conserve strength of bioagents build up and the insecticide application has to avoid first 40 days after transplanting. Similar recommendation has also been reported by Schoenly *et al.* (1996) [22], Gallagher *et al.* (2002) [10], Norton *et al.* (2010) [14], Prakash *et al.* (2014) [19], Heinrichs and Muniappan (2017) [11], and Rao (2019) [21].

Table 1: Mean Evaluation of Ecofriendly Insecticides for Rice Hispa (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			
Cartap Hcl	2.79	1.82	4.51 ^{2NS} (2.23)	3.93 (2.10)	2.57 ^{2NS} (1.74)	4.78 (2.30)	3.54 $^{2\,NS}$ (1.98)	4.36 (2.20)	35.00 $^{1\,NS}$
Indoxacarb	2.59	1.84	5.34 (2.41)	4.46 (2.22)	3.30 (1.94)	4.98 (2.34)	4.32 (2.17)	4.72 (2.28)	31.74
Imidacloprid	2.66	1.87	4.41 ^{1NS} (2.21)	3.15 $^{2\,NS}$ (1.90)	2.50 ^{1NS} (1.71)	4.22 $^{2\,NS}$ (2.17)	3.45 $^{1\,NS}$ (1.96)	3.66 $^{2\,NS}$ (2.03)	34.80 $^{2\,NS}$
Chlorpyriphos	2.75	1.94	5.50 (2.44)	5.21 (2.39)	3.44 (1.97)	6.71 (2.68)	4.47 (2.21)	5.96 (2.54)	31.72
Thiamethoxam	2.76	1.92	5.60 (2.46)	4.84 (2.30)	3.52 (1.99)	6.16 (2.58)	4.56 (2.23)	5.50 (2.44)	31.37
Chlorantraniliprole	2.67	1.88	5.07 (2.35)	4.04 (2.12)	3.01 (1.86)	5.56 (2.46)	4.04 (2.10)	4.80 (2.29)	31.75
Neem Oil	2.89	1.87	5.32 (2.41)	2.82 (1.82)	3.24 (1.92)	3.94 (2.10)	4.28 (2.16)	3.38 (1.96)	31.39
Btk	2.98	1.88	5.77 (2.49)	2.48 (1.72)	3.67 (2.03)	3.68 (2.04)	4.72 (2.26)	3.08 (1.88)	31.18
Neem Oil + Btk	2.66	1.96	4.73 ^{3NS} (2.28)	2.75 $^{1\,NS}$ (1.80)	2.73 ^{3NS} (1.78)	3.84 $^{1\,N}$ (2.08)	3.73 $^{3\,NS}$ (2.03)	3.29 $^{1\,NS}$ (1.94)	34.28 $^{3\,NS}$
Untreated Check	2.95	1.95	7.75 (2.86)	2.98 (1.86)	5.91 (2.52)	4.37 (2.19)	6.83 (2.69)	3.67 (2.03)	31.02
S.E $_{(m)}$	–		0.02	0.03	0.02	0.03	0.02	0.03	0.25
CD $_{(5\%)}$	–		0.07	0.10	0.07	0.10	0.07	0.10	0.72
CV $_{(\%)}$	–		1.71	2.84	2.22	2.58	1.45	2.16	1.33

***** Values in parentheses are square root transformation ($\sqrt{(x + 0.5)}$) for uniform sample size (Steel and Torrie, 1960) [25]; 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.

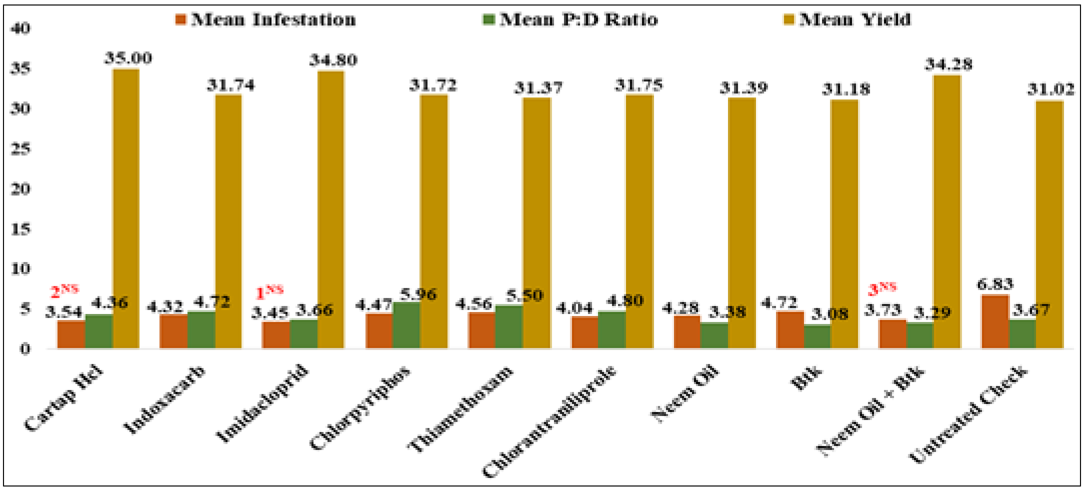

Fig 1: Mean Evaluation of Ecofriendly Insecticides for Rice Hispa (Pooled of 2014 & 15). (% Infestation (Infestation) and Pest: Defender Ratio (P: D))

Table 2: Mean Evaluation of Ecofriendly Insecticides for Rice Hispa (Pooled of 2014 & 15).* (% Infestation (Infestation) and % Suppression of Infestation over Check (SPOC))

Treatments	First Application (ADBAP)	First Application (Mean)		Second Application (Mean)		Total Mean Infestation DAAP	Total Mean SPOC DAAP	Mean Yield (q/ha)
	Infestation	Infestation	SPOC	Infestation	SPOC			
1.Cartap Hcl	2.79	4.51 2 NS (2.23)	41.76 2 NS (6.49)	2.57 2 NS (1.74)	57.41 2 NS (7.60)	3.54 2 NS (1.98)	49.59 (7.05)	35.00 1 NS
2.Indoxacarb	2.59	5.34 (2.41)	30.60 (5.56)	3.30 (1.94)	44.18 (6.68)	4.32 (2.17)	37.39 (6.12)	31.74
3.Imidacloprid	2.66	4.41 1 NS (2.21)	43.01 1 NS (6.59)	2.50 1 NS (1.71)	58.66 1 NS (7.69)	3.45 1 NS (1.96)	50.83 1 NS (7.14)	34.80 2 NS
4.Chlorpyriphos	2.75	5.50 (2.44)	28.54 (5.37)	3.44 (1.97)	41.42 (6.48)	4.47 (2.21)	34.98 (5.93)	31.72
5.Thiamethoxam	2.76	5.60 (2.46)	27.09 (5.23)	3.52 (1.99)	40.07 (6.37)	4.56 (2.23)	33.58 (5.80)	31.37
6.Chlorantraniliprole	2.67	5.07 (2.35)	34.28 (5.89)	3.01 (1.86)	49.57 (7.07)	4.04 (2.10)	41.93 (6.48)	31.75
7.Neem Oil	2.89	5.32 (2.41)	30.88 (5.58)	3.24 (1.92)	45.26 (6.76)	4.28 (2.16)	38.07 (6.17)	31.39
8.Btk	2.98	5.77 (2.49)	24.90 (5.01)	3.67 (2.03)	37.43 (6.15)	4.72 (2.26)	31.16 (5.58)	31.18
9.Neem Oil + Btk	2.66	4.73 3 NS (2.28)	38.63 (6.24)	2.73 3 NS (1.78)	54.68 3 NS (7.42)	3.73 3 NS (2.03)	46.66 (6.83)	34.28 3 NS
10.Untreated Check	2.95	7.75 (2.86)	–	5.91 (2.52)	–	6.83 (2.69)	–	31.02
SE $_{(m)}$	–	0.02	0.10	0.02	0.14	0.02	0.02	0.25
CD $_{(5\%)}$	–	0.07	0.28	0.07	0.40	0.07	0.05	0.72
CV $_{(\%)}$	–	1.71	2.91	2.22	3.44	1.45	0.38	1.33

***** Values in parentheses are square root transformation ($\sqrt{(x + 0.5)}$) for uniform sample size (Steel and Torrie, 1960) [25]; 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.

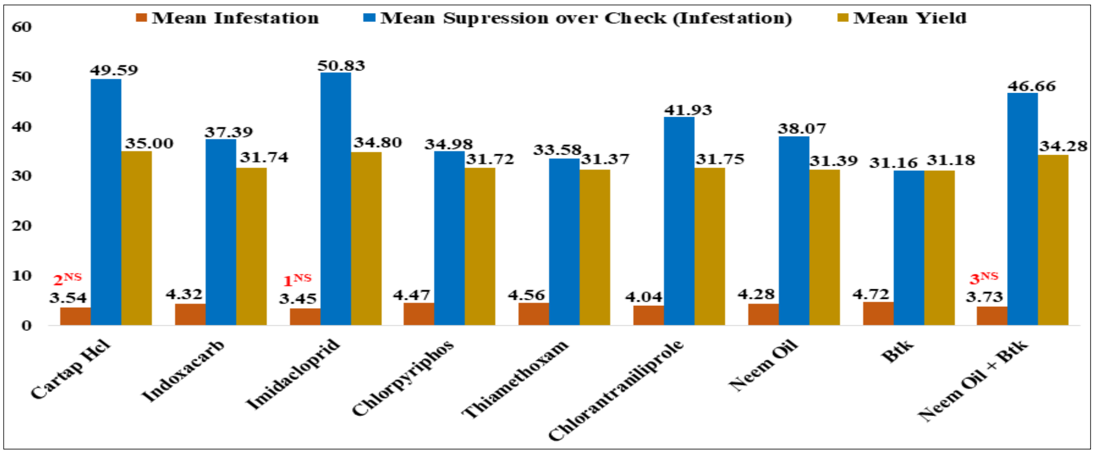

Fig 2: Mean Evaluation of Ecofriendly Insecticides for Rice Hispa (Pooled of 2014 & 15). (% Infestation (Infestation) and % Suppression of infestation over Check (SPOC))

Table 3: Rank Evaluation of Ecofriendly Insecticides for Rice Hispa (Pooled of 2014 & 15).* (Infestation/ P: D Ratio/ Yield/ Mean)

Rank	Infestation (%) (Lowest)	P: D (Ratio) (Lowest)	Yield (q/ ha) (Highest)	Mean Rank
1	Imidacloprid 3.45 1 NS (1.96)	Btk 3.08 (1.88)	Cartap Hcl 35.00 1 NS	Imidacloprid 2.33 1 NS
2	Cartap Hcl 3.54 2 NS (1.98)	Neem Oil + Btk 3.29 1 NS (1.94)	Imidacloprid 34.80 2 NS	Neem Oil + Btk 2.67 1 NS
3	Neem Oil + Btk 3.73 3 NS (2.03)	Neem Oil 3.38 (1.96)	Neem Oil + Btk 34.28 3 NS	Cartap Hcl 2.67 1 NS
4	Chlorantraniliprole 4.04 (2.10)	Imidacloprid 3.66 2 NS (2.03)	Chlorantraniliprole 31.75	Chlorantraniliprole 5.00
5	Neem Oil 4.28 (2.16)	Cartap Hcl 4.36 (2.20)	Indoxacarb 31.74	Neem Oil 5.00
6	Indoxacarb 4.32 (2.17)	Indoxacarb 4.72 (2.28)	Chlorpyriphos 31.72	Indoxacarb 5.67
7	Chlorpyriphos 4.47 (2.21)	Chlorantraniliprole 4.80 (2.29)	Neem Oil 31.39	Btk 6.33
8	Thiamethoxam 4.56 (2.23)	Thiamethoxam 5.50 (2.44)	Thiamethoxam 31.37	Chlorpyriphos 7.33
9	Btk 4.72 (2.26)	Chlorpyriphos 5.96 (2.54)	Btk 31.18	Thiamethoxam 8.00
SE(m)	0.02	0.03	0.25	–
CD (5%)	0.07	0.10	0.72	–
CV (%)	1.45	2.16	1.33	–

* Values in parentheses are square root transformation (√ (x + 0.5)) for uniform sample size (Steel and Torrie, 1960) [25]; 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

There were 2 insecticides (Imidacloprid and Neem Oil + Btk) inference most effective ecofriendly insecticides for the management of rice hispa (*Dicladispa armigera* Oliver). 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 (Cartap Hcl, Imidacloprid and Neem Oil + Btk) inference non-significant for highest yield. Though, Cartap Hcl was being most effective insecticides for rice hispa among 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) as inference non-significantly for highest yield, 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). 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 are the biological insecticides (biorationals). Hence, Neem Oil + Btk as biorationals primarily would be the best choice before Imidacloprid for the most effective ecofriendly management of rice hispa. 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 insecticide application has to avoid first 40 days after transplanting. If insecticide application is necessary, apply most effective ecofriendly insecticides after 40 days of transplanting as single application.

References

1. Baehaki SE, Surahmat EC, Susetyo A, Senn R. Safety selected insecticides to predators and egg parasitoids of planthoppers in rice ecosystem. American Journal of Engineering Research. 2017;6(6):174-182.
2. 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.
3. 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.
4. DAC FW. Agricultural statistics at a glance 2018. Department of Agriculture, Cooperation & Farmers Welfare, Government of India, New Delhi, India; c2018.p. 468.
5. 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.
6. David BV, Ananthkrishnan TN. General and applied entomology, 2nd Edition. Mc Graw Hill Publication (India) PVT. Ltd., New Delhi, India; c2004. p. 1184.
7. 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.
8. Dhamu KP, Ramamoorthy K. Statistical methods. Agrobios (India), Jodhpur, India; c2007.p. 359.
9. FAOSTAT. Statistical data of world rice production. In: Data; c2019. Retrieved from

http://www.fao.org/faostat/en3/#data/QC.
10. Gallagher KD, Ooi PAC, Mew TW, Borromeo E, Kenmore PE. Integrated pest management in rice. International Rice Commission Newsletter. 2002;51:1-17.
11. Heinrichs EA, Muniappan R. IPM for tropical crops: rice. CAB Reviews. 2017;12(30):1-31.
12. Jena M, Dani RC. Evaluation of insecticides against rice hispa, *Dicladispa armigera* Oliver (Coleoptera: Chrysomelidae). *Oryza.* 2011;48(3):255-257.
13. Karthick KS, Kandibane M, Kumar K. Effect of newer insecticides to natural enemies in the coastal rice ecosystem of Karaikal district, Union Territory of Puducherry. Asian Journal of Bio Science. 2015;10(1):39-42.
14. 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.
15. Oerke EC. Crop losses to pests. Journal of Agricultural Science. 2006;144:31-43.
16. 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.
17. Pathak MD, Khan ZR. Insect pests of rice. International Rice Research Institute, Manila, Philippines; c1994. p. 89.
18. 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.
19. Prakash A, Bentur JS, Prasad MS, Tanwar RK, Sharma OP, Bhagat S, *et al*. Integrated pest management for rice. National Centre for Integrated Pest Management, New Delhi, India; c2014. p. 43.
20. Rangaswamy R. A textbook of agricultural statistics, 2nd edition. New Age International (P) Limited, Publishers, New Delhi, India; c2010. p. 531.
21. Rao CS. Ecological sustainable strategies for pest management. Extension Digest. 2019;3(1)26.
22. 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.
23. Sharanappa AK, Sahu R, Khan HH. Effect of certain insecticides on natural enemies of rice stem borer, *Scirpophaga incertulas* (Walker) on rice, *Oryza sativa* L. Journal of Entomology and Zoology Studies. 2019;7(1):1100-1104.
24. 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.
25. Steel RGD, Torrie JH. Principles and procedures of statistics. McGraw-Hill Book Company, Inc., New York, USA; c1960. p. 481.