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# Safer novel insecticides for the management of yellow stem borer (*Scirpophaga incertulus* walker) in rice crop under eastern Uttar Pradesh conditions

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## Abstract
An evaluation was conducted on the bioefficacy of some novel insecticides for the ecofriendly management of yellow stem borer (*Scirpophaga incertulus* Walker) in rice crop 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 surveillance was conducted as per methodology of agro ecosystem analysis (AESA) (Pontius *et al*., 2002) modified as accessibility. The yellow stem borer is an endemic insect pest of rice and accounted for 10-60% 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 eco-friendly insecticides. Though, both the insecticides (Imidacloprid and Neem Oil + Btk) were being most effective eco-friendly insecticides, yet Neem Oil + Btk as biorationals primarily would be the best choice before Imidacloprid for the most effective eco-friendly management of yellow stem borer of rice.

**Keywords:** Bioefficacy, novel insecticides, yellow stem borer (*Scirpophaga incertulus* Walker), rice crop, Eastern Uttar Pradesh, India

## Introduction
Rice is a staple food for 70% population over the world and 65% population of the India. 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) [16, 14, 7, 24, 11, 15, 4, 9].

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 is under 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 as cultural, physical, biological, and 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. 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 yellow stem borer (*Scirpophaga incertulus* Walker) is a most series insect pest of rice, which has been accounted for 10-60% yield loss. Chakraborty (2011) [2] has been reported that, the infestation of yellow stem borer (*Scirpophaga incertulus*) was observed lowest in Imidacloprid. Kulagod *et al.* (2011) [12] have been studied on evaluation of efficacy of biorationals against yellow stem borer (*Scirpophaga incertulus*) of rice as Azadirachtin and *Bacillus thuringiensis* formulation lower the infestation. Rath *et al.* (2014) [21] has been reported that, plots treated with Imidacloprid recorded lowest infestation of yellow stem borer (*Scirpophaga incertulus*) followed by Thiamethoxam. Sarao *et al.* (2015) [22] and Tigga *et al.* (2018) [26] both have been found that, the damage of yellow stem borer (*Scirpophaga incertulus*) was recorded lowest in Imidacloprid. 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 bio efficacy of some novel ecofriendly insecticides for the management of yellow stem borer (*Scirpophaga incertulus* Walker) of rice under Eastern Uttar Pradesh conditions for the two consecutive years (2014 and 2015) at farmer field of 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 effectively. 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 yellow stem borer, abundance of bioagents, and yield to evaluate efficacy of treated safer novel 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 yellow stem borer and their bioagents.

Surveillance was conducted as per methodology of agro ecosystem analysis (AESA) (Pontius *et al*., 2002) [17] modified as accessibility. Taxonomic identification was verified with texts of reference, *i.e*., Dale (1994) [5], Barrion and Litsinger (1994) [1], Pathak and Khan (1994) [16], 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) [18], and Rangaswamy (2010) [19].

## Results and Discussion

The evaluation of bio efficacy of some novel ecofriendly insecticides was observed on infestation and their bioagents of yellow stem borer (*Scirpophaga incertulus* Walker) 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 yellow stem borer is an endemic insect pest of rice and accounted for 10-60% yield loss. The symptoms of damage were observed as dead hearts in young seedling to tilling stage and white ears in panicle stage. The dead hearts can be easily pulled out. The damaging stage is caterpillar, feeding inside the stem at the base and dried up of central shoot, leading to dead hearts. The female moths have yellowish forewings with a single dark spot at the center, while the male moths have numerous brown spots on the forewings. The eggs are laid in batches on leaf tips, covered with brown yellow hairs. The full-grown caterpillars are pale yellow with orange yellow head, found singly inside the stem and pupation takes place there.

Of the total observed infestation and their bioagents of yellow stem borer (*Scirpophaga incertulus* Walker) 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 (Neem Oil + Btk and Imidacloprid) 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 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) inference non-significant for highest suppression over check 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, 3 insecticides (Cartap Hcl, Imidacloprid, and Neem Oil + Btk) 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, Cartap Hcl > Imidacloprid > Neem Oil + Btk > Chlorantraniliprole > Indoxacarb > Btk > Thiamethoxam > Chlorpyriphos > Neem Oil 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 Cartap Hcl > Imidacloprid > Neem Oil + Btk > Chlorantraniliprole > Btk > Indoxacarb > Neem Oil > 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 yellow stem borer 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; 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 Chakraborty (2011) [2], Kulagod *et al.* (2011) [12], CRRI (2014) [3], Rath *et al.* (2014) [21], Sarao *et al.* (2015) [22], Tigga *et al.* (2018) [26], 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 yellow stem borer of rice. Though, both the insecticides were being most effective ecofriendly insecticides, the Imidacloprid a chemical insecticide, while Neem Oil + Btk is the biological insecticides (biorationals). Hence, Neem Oil + Btk as biorationals primarily would be the best choice before Imidacloprid for the ecofriendly management of yellow stem borer of rice. Though, Cartap Hcl was being most effective insecticides for yellow stem borer 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 (Neem Oil + Btk and Imidacloprid). Similar recommendation has also been reported by Gallagher *et al.* (2002) [10], Norton *et al.* (2010) [13], Prakash *et al.* (2014) [18], Heinrichs and Muniappan (2017) [11] and Rao (2019) [20]

**Table 1:** Mean Evaluation of Ecofriendly Insecticides for Yellow Stem borer (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 | 3.45 | 1.82 | 5.23 [1 NS] (2.29) | 3.93 (2.10) | 2.95 [1 NS] (1.85) | 4.78 (2.30) | 4.09 [1 NS] (2.07) | 4.36 (2.20) | 35.00 [1 NS] |
| 2.Indoxacarb | 3.42 | 1.84 | 6.65 (2.58) | 4.46 (2.22) | 3.93 (2.10) | 4.98 (2.34) | 5.29 (2.34) | 4.72 (2.28) | 31.74 |
| 3.Imidacloprid | 3.54 | 1.87 | 5.39 [2 NS] (2.31) | 3.15 [2 NS] (1.90) | 3.17 [3 NS] (1.91) | 4.22 [2 NS] (2.17) | 4.28 [2 NS] (2.11) | 3.66 [2 NS] (2.03) | 34.80 [2 NS] |
| 4.Chlorpyriphos | 3.98 | 1.94 | 7.64 (2.76) | 5.21 (2.39) | 4.57 (2.24) | 6.71 (2.68) | 5.99 (2.48) | 5.96 (2.54) | 31.72 |
| 5.Thiamethoxam | 4.22 | 1.92 | 7.24 (2.69) | 4.84 (2.30) | 4.21 (2.16) | 6.16 (2.58) | 5.73 (2.43) | 5.50 (2.44) | 31.37 |
| 6.Chlorantraniliprole | 3.71 | 1.88 | 6.21 (2.49) | 4.04 (2.12) | 4.09 (2.13) | 5.56 (2.46) | 5.15 (2.31) | 4.80 (2.29) | 31.75 |
| 7.Neem Oil | 3.98 | 1.87 | 7.41 (2.72) | 2.82 (1.82) | 5.11 (2.36) | 3.94 (2.10) | 6.38 (2.56) | 3.38 (1.96) | 31.39 |
| 8.Btk | 3.88 | 1.88 | 6.85 (2.61) | 2.48 (1.72) | 4.13 (2.14) | 3.68 (2.04) | 5.49 (2.38) | 3.08 (1.88) | 31.18 |
| 9.Neem Oil + Btk | 4.11 | 1.96 | 5.57 [3 NS] (2.36) | 2.75 [1 NS] (1.80) | 3.26 [2 NS] (1.93) | 3.84 [1 NS] (2.08) | 4.42 [3 NS] (2.15) | 3.29 [1 NS] (1.94) | 34.28 [3 NS] |
| 10.Untreated Check | 4.32 | 1.95 | 11.32 (3.36) | 2.98 (1.86) | 9.27 (3.12) | 4.37 (2.19) | 10.30 (3.24) | 3.67 (2.03) | 31.02 |
| $SE_{(m)}$ | – | | 0.05 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.25 |
| $CD_{(5\%)}$ | – | | 0.15 | 0.10 | 0.10 | 0.10 | 0.12 | 0.10 | 0.72 |
| $CV_{(\%)}$ | – | | 3.40 | 2.84 | 2.68 | 2.58 | 2.38 | 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.

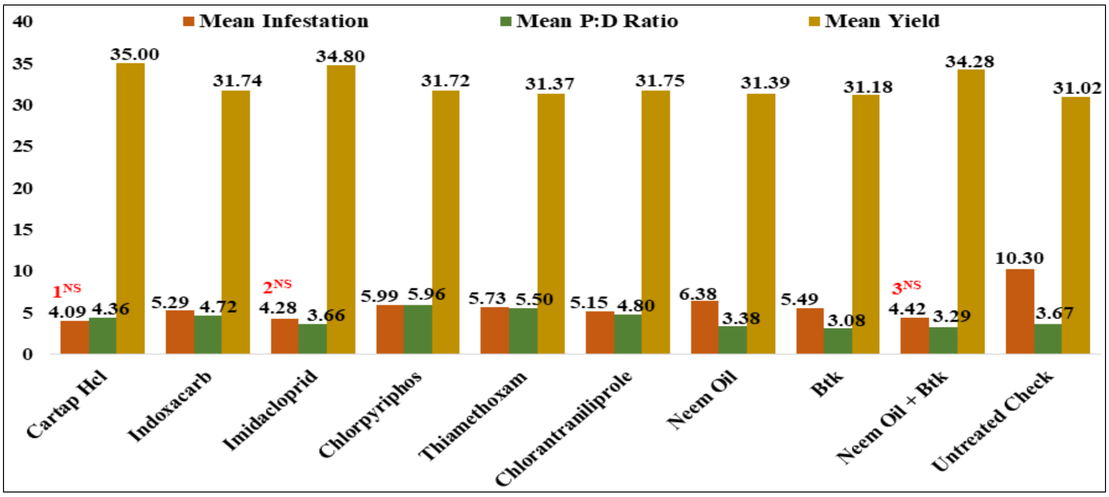


**Fig 1:** Mean Evaluation of Ecofriendly Insecticides for Yellow Stem borer (Pooled of 2014 & 15). (% Infestation (Infestation) and Pest: Defender Ratio (P: D)

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

| Treatments | First Application (ADBAP) Infestation | First Application (Mean) | | Second Application (Mean) | | Total Mean Infestation DAAP | Total Mean SPOC DAAP | Mean Yield (q/ha) |
|---|---|---|---|---|---|---|---|---|
| | | Infestation | SPOC | Infestation | SPOC | | | |
| 1.Cartap Hcl | 3.45 | 5.23 [1 NS] (2.29) | 53.17 [1 NS] (7.32) | 2.95 [1 NS] (1.85) | 70.52 [1 NS] (8.42) | 4.09 [1 NS] (2.07) | 61.85 [1 NS] (7.87) | 35.00 [1 NS] |
| 2.Indoxacarb | 3.42 | 6.65 (2.58) | 40.57 (6.40) | 3.93 (2.10) | 60.70 (7.81) | 5.29 (2.34) | 50.63 (7.10) | 31.74 |
| 3.Imidacloprid | 3.54 | 5.39 [2 NS] (2.31) | 52.62 [2 NS] (7.29) | 3.17 [2 NS] (1.91) | 66.29 [3 NS] (8.17) | 4.28 [2 NS] (2.11) | 59.45 [2 NS] (7.73) | 34.80 [2 NS] |
| 4.Chlorpyriphos | 3.98 | 7.64 (2.76) | 32.06 (5.70) | 4.57 (2.24) | 54.24 (7.39) | 5.99 (2.48) | 43.15 (6.55) | 31.72 |
| 5.Thiamethoxam | 4.22 | 7.24 (2.69) | 35.06 (5.94) | 4.21 (2.16) | 57.95 (7.63) | 5.73 (2.43) | 46.51 (6.78) | 31.37 |
| 6.Chlorantraniliprole | 3.71 | 6.21 (2.49) | 44.91 (6.73) | 4.09 (2.13) | 59.11 (7.71) | 5.15 (2.31) | 52.01 (7.22) | 31.75 |
| 7.Neem Oil | 3.98 | 7.41 (2.72) | 33.46 (5.78) | 5.11 (2.36) | 48.70 (7.00) | 6.38 (2.56) | 41.08 (6.39) | 31.39 |
| 8.Btk | 3.88 | 6.85 (2.61) | 38.54 (6.22) | 4.13 (2.14) | 58.76 (7.69) | 5.49 (2.38) | 48.65 (6.96) | 31.18 |
| 9.Neem Oil + Btk | 4.11 | 5.57 [3 NS] (2.36) | 50.62 [3 NS] (7.15) | 3.26 [3 NS] (1.93) | 67.32 [2 NS] (8.22) | 4.42 [3 NS] (2.15) | 58.97 [3 NS] (7.69) | 34.28 [3 NS] |
| 10.Untreated Check | 4.32 | 11.32 (3.36) | – | 9.27 (3.12) | – | 10.30 (3.24) | – | 31.02 |
| SE $_{(m)}$ | – | 0.05 | 0.20 | 0.03 | 0.10 | 0.04 | 0.15 | 0.25 |
| CD $_{(5\%)}$ | – | 0.15 | 0.57 | 0.10 | 0.29 | 0.12 | 0.45 | 0.72 |
| CV $_{(\%)}$ | – | 3.40 | 5.23 | 2.68 | 2.24 | 2.38 | 2.96 | 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.

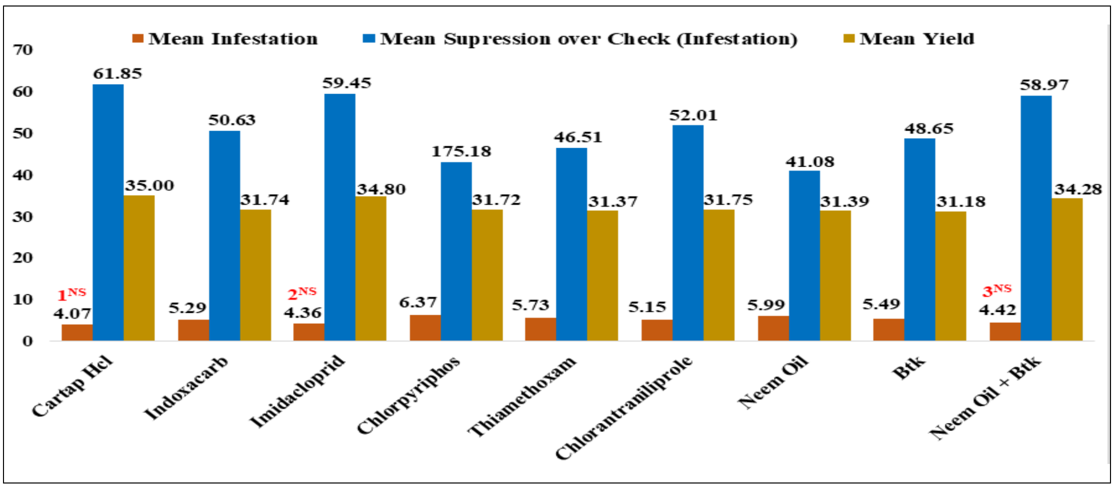


**Fig 2:** Mean Evaluation of Ecofriendly Insecticides for Yellow Stem borer (Pooled of 2014 & 15). (% Infestation (Infestation) and % Suppression of infestation over Check (SPOC))

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

| Rank | Infestation (%) (Lowest) | P: D (Ratio) (Lowest) | Yield (q/ ha) (Highest) | Mean Rank |
|---|---|---|---|---|
| 1 | Cartap Hcl 4.09 1 NS (2.07) | Btk 3.08 (1.88) | Cartap Hcl 35.00 1 NS | Cartap Hcl 2.33 1 NS |
| 2 | Imidacloprid 4.28 2 NS (2.11) | Neem Oil + Btk 3.29 1 NS (1.94) | Imidacloprid 34.80 2 NS | Imidacloprid 2.67 2 NS |
| 3 | Neem Oil + Btk 4.42 3 NS (2.15) | Neem Oil 3.38 (1.96) | Neem Oil + Btk 34.28 3 NS | Neem Oil + Btk 2.67 3 NS |
| 4 | Chlorantraniliprole 5.15 (2.31) | Imidacloprid 3.66 2 NS (2.03) | Chlorantraniliprole 31.75 | Chlorantraniliprole 5.00 |
| 5 | Indoxacarb 5.29 (2.34) | Cartap Hcl 4.36 (2.20) | Indoxacarb 31.74 | Btk 5.33 |
| 6 | Btk 5.49 (2.38) | Indoxacarb 4.72 (2.28) | Chlorpyriphos 31.72 | Indoxacarb 5.33 |
| 7 | Thiamethoxam 5.73 (2.43) | Chlorantraniliprole 4.80 (2.29) | Neem Oil 31.39 | Neem Oil 6.33 |
| 8 | Chlorpyriphos 5.99 (2.48) | Thiamethoxam 5.50 (2.44) | Thiamethoxam 31.37 | Chlorpyriphos 7.67 |
| 9 | Neem Oil 6.38 (2.56) | Chlorpyriphos 5.96 (2.54) | Btk 31.18 | Thiamethoxam 7.67 |
| $SE_{(m)}$ | 0.04 | 0.03 | 0.25 | – |
| CD (5%) | 0.12 | 0.10 | 0.72 | – |
| CV (%) | 2.38 | 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.

## Conclusion

There were 2 insecticides (Imidacloprid and Neem Oil + Btk) inference most effective eco-friendly insecticides for yellow stem borer (*Scirpophaga incertulus* Walker) of rice. 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. Though, Cartap Hcl was being most effective insecticides for yellow stem borer 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). Though, both the insecticides (Imidacloprid and Neem Oil + Btk) were being most effective eco-friendly 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 as chemical insecticide for the most effective eco-friendly management of yellow stem borer of rice. 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.

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