# PEST-DEFENDER ABUNDANCE 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 abundance of pest: defender ratio (P:D) 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 pest: defender ratio (P:D), lowest abundance of pest: defender ratio (P:D) over check plot, and highest yield. The inferences of abundance of pest: defender ratio (P:D) over check plot and yield of rice crop were based on non-significant ecofriendly insecticides for lowest pest: defender ratio (P:D). There were 2 insecticides (Neem Oil + Btk and Imidacloprid) inference non-significant for lowest abundance of pest: defender ratio (P:D) over check plot. The mean ranking and inference of abundance of pest: defender ratio (P:D) over check were similar to inference of non-significant ecofriendly insecticides for lowest pest: defender ratio (P:D) as, Neem Oil + Btk and Imidacloprid 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 leaffolder (*Cnaphalocrosis medinalis* Guenee), 3.Brown planthopper (*Nilaparvata lugens* Stal), 4.Rice hispa (*Dicladispa armigera* Oliver), and 5.Rice earhead bug (*Leptocorisa acuta* Thunberg).


**Key words**: Abundance of pest-defender, Ecofriendly insecticides, Major Insect Pests of rice, Eastern Uttar Pradesh, India.

**INTRODUCTION**

Rice (*Oryza sativa* Linn.) is the most important staple food for more than half population of the India and world. 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. It is grown in almost all the states of India and shares 21% of the world rice production. Rice is cultivated in India since Indus valley civilization and worshipped for wealth prosperity. 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. India have been estimated rice crop losses by insect pests ranging from 21 to 51 %. About 250 insect pest species associated with rice crop in India and about 20 of them are major economic significance. Bioagents are natural enemies, which attack various life stages of insects to kill as a prey or host to complete their life cycle. They are silent suppression factors of insect pests in rice ecosystem. About 550 arthropod bioagent species associated with rice insect pests in India and about 20 of them are major economic significance. (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).

The regular efforts are necessary to develop effective strategy for insect pest management with particular agroecosystem. 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. To achieve the goal of ecofriendly insect pest management, it necessary to analyses pest-defender abundance under evaluation of ecofriendly insecticides against major insect pests of rice.

Kulagod *et al.* (2011) studied on evaluation of efficacy of biorationals as Azadirachtin and *Bacillus thuringiensis* formulation against Yellow stemborer (*Scirpophaga incertulus*) and Common rice leaffolder (*Cnaphalocrocis medinalis*) of rice was observed lower the infestation. Rath *et al.* (2014) has been observed that, the lowest infestation of Yellow stemborer (*Scirpophaga incertulus*) and Rice earheadbug (*Leptocorisa acuta*) were recorded in Imidacloprid, and highest grain yield was recorded in Thiamethoxam treated plots. Karthick *et al.* (2015) have been studied that, plots treated with indoxacarb favour the high population of coccinellids and spiders respectively. Sarao *et al*. (2015) and Tigga *et al.* (2018) have been found that, the Imidacloprid has been recorded lowest damage of Yellow stemborer (*Scirpophaga incertulus*) and Rice earheadbug (*Leptocorisa acuta*). Sharanappa *et al.* (2019) have been found that, the application of Imidacloprid observed favour the high population of coccinellids.

## MATERIALS AND METHODS

The present study was undertaken to analysis the abundance of pest: defender ratio (P:D) 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 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 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 abundance of major insect pests and their bioagents and yield of rice crop to evaluate efficacy of treated ecofriendly insecticides. This observation was analyzed the abundance of pest: defender ratio (P:D) over check plot of major insect pests of rice during evaluation most effective ecofriendly insecticides concerned to lowest pest: defender ratio (P:D) 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,

$$\text{Abundance of P:D ratio over check (\%)} = \frac{\text{Abundance of P:D ratio in treated plot}}{\text{Abundance of P:D ratio in check plot}} \times 100$$



## RESULTS AND DISCUSSION

The abundance of pest: defender ratio (P:D) 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 against major insect pests of rice under abundance of pest: defender ratio over check (ABOC) for pooled of both the years 2014 and 2015, there were 1 insecticide (Neem Oil + Btk) inference non-significant for lowest abundance of pest: defender ratio over check (ABOC) under first application (30 DAT) and 2 insecticides (Neem Oil + Btk and Imidacloprid) under second application (45 DAT), based on evaluation of non-significant ecofriendly insecticides for lowest pest: defender ratio as, Neem Oil + Btk and Imidacloprid respectively. The mean of evaluation under abundance of pest: defender ratio over check (ABOC) was observed as, 2 insecticides ((Neem Oil + Btk and Imidacloprid)) inference non-significant for lowest abundance of pest: defender ratio over check (ABOC) under mean of first application and second application, based on mean evaluation of non-significant ecofriendly insecticides for lowest pest: defender ratio as, Neem Oil + Btk and Imidacloprid respectively. Of the total observed pest: defender ratio for major insect pests of rice for pooled of both the years 2014 and 2015, there were 2 insecticides (Neem Oil + Btk and Imidacloprid) inference non-significant for lowest pest: defender ratio under first application (30 DAT) and second application (45 DAT) respectively. The mean of evaluation was observed as, 2 insecticides (Neem Oil + Btk and Imidacloprid) inference non-significant for lowest pest: defender ratio under mean of major insect pests of rice and mean of first application and second application respectively. (Table and Figure 1).

Of the most effective ecofriendly insecticides observed on abundance of pest: defender ratio over check for major insect pests of rice for pooled of both the years 2014 and 2015, there were 2 insecticides (Neem Oil + Btk and Imidacloprid) inference non-significant for lowest abundance of pest: defender ratio over check (ABOC), lowest pest: defender ratio, and highest yield for mean of major insect pests of rice based on non-significant ecofriendly insecticides for lowest pest: defender ratio respectively. (Table and Figure 1). The ranking of evaluation under abundance of pest: defender ratio over check was observed as, Btk > Neem Oil + Btk > Neem Oil > Imidacloprid > Cartap Hcl > Indoxacarb > Chlorantraniliprole > Thiamethoxam > Chlorpyriphos for lowest pest: defender ratio and abundance of pest: defender ratio over check: Cartap Hcl > Imidacloprid > Neem Oil + Btk > Chlorantraniliprole > Indoxacarb > Chlorpyriphos > Neem Oil > Thiamethoxam > Btk for highest yield; and Neem Oil + Btk > Imidacloprid > Cartap Hcl > Btk > Neem Oil > Indoxacarb > Chlorantraniliprole > Chlorpyriphos > Thiamethoxam for mean of pest: defender ratio (P:D), abundance of pest: defender ratio over check (ABOC), and yield respectively. (Table 2). Similar findings were reported by Kulagod *et al.* (2011), CRRI (2014), Prakash *et al.* (2014), Rath *et al.* (2014), Karthick *et al.* (2015), Sarao *et al.* (2015), Tigga *et al.* (2018), and Sharanappa *et al.* (2019).

Present research work was adopted the non-significant pest: defender ratio for observation of lowest abundance of pest: defender ratio over check plot as scale to confined efficacy of insecticides as ecofriendly. There were 2 insecticides (Neem Oil + Btk and Imidacloprid) inference non-significant for lowest pest: defender ratio, and highest yield respectively. The mean ranking and inference of abundance of pest: defender ratio over check were not similar. There were 2 insecticides (Neem Oil + Btk and Imidacloprid) inference non-significant for abundance of pest: defender ratio over check based on non-significant ecofriendly insecticides for lowest pest: defender ratio. Though, both the insecticides were being most effective ecofriendly insecticides as, the Neem Oil + Btk are the biological insecticides (biorationals), while Imidacloprid is the chemical insecticide. Hence, Neem Oil + Btk as biorationals primarily would be the best choice before Imidacloprid for the ecofriendly management of major insect pests of rice. Meanwhile, the observation of the present investigations under untreated check revealed the abundance of P:D ratio was increased in 45 days after transplanting followed by 30 days after transplanting respectively. (Table & Figure 1). It means, if the abundance of bioagents population would not be increased after first application of insecticides, the populatin 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 population of insect pests of rice during 20-50 days after transplanting. 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. If insecticide application is necessary, apply most effective ecofriendly insecticides at 40 days after transplanting as single application. 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)***
**(Pest: Defender Ratio (P:D) and % Abundance of P:D Ratio over Check (ABOC))**

| Treatments | A Day before Application (ADBAp) | First Application (Mean) | | Second Application (Mean) | | Total Mean P:D DAAp | Total Mean ABOC DAAp | Mean Yield (q/ha) |
|---|---|---|---|---|---|---|---|---|
| | P:D | P:D | ABOC | P:D | ABOC | | | |
| **1.Cartap Hcl** | 1.82 | 3.93 (2.10) | 131.88 (11.50) | 4.78 (2.30) | 113.01 (10.62) | 4.36 (2.20) | 122.44 (11.06) | 35.00 |
| **2.Indoxacarb** | 1.84 | 4.46 (2.22) | 149.43 (12.23) | 4.98 (2.34) | 116.41 (10.80) | 4.72 (2.28) | 132.92 (11.52) | 31.74 |
| **3.Imidacloprid** | 1.87 | 3.11 $^{2 NS}$ (1.90) | 108.86 (10.45) | 4.22 $^{2 NS}$ (2.17) | 97.47 $^{2 NS}$ (9.89) | 3.66 $^{2 NS}$ (2.03) | 103.16 $^{2 NS}$ (10.17) | 34.80 $^{1 NS}$ |
| **4.Chlorpyriphos** | 1.94 | 5.21 (2.39) | 175.18 (13.25) | 6.71 (2.68) | 159.00 (12.59) | 5.96 (2.54) | 167.09 (12.92) | 31.72 |
| **5.Thiamethoxam** | 1.92 | 4.84 (2.30) | 162.40 (12.76) | 6.16 (2.58) | 145.02 (12.04) | 5.50 (2.44) | 153.71 (12.40) | 31.37 |
| **6.Chlorantraniliprole** | 1.88 | 4.04 (2.12) | 135.22 (11.64) | 5.56 (2.46) | 131.40 (11.45) | 4.80 (2.29) | 133.31 (11.55) | 31.75 |
| **7.Neem Oil** | 1.87 | 2.82 (1.82) | 95.16 (9.78) | 3.94 (2.10) | 91.67 (9.59) | 3.38 (1.96) | 93.41 (9.69) | 31.39 |
| **8.Btk** | 1.88 | 2.48 (1.72) | 83.57 (9.17) | 3.68 (2.04) | 86.12 (9.29) | 3.08 (1.88) | 84.85 (9.23) | 31.18 |
| **9.Neem Oil + Btk** | 1.96 | 2.75 $^{1 NS}$ (1.80) | 92.29 $^{1 NS}$ (9.63) | 3.84 $^{1 NS}$ (2.08) | 89.23 $^{1 NS}$ (9.47) | 3.29 $^{1 NS}$ (1.94) | 90.76 $^{1 NS}$ (9.55) | 34.28 $^{2 NS}$ |
| **10.Untreated Check** | 1.95 | 2.98 (1.86) | – | 4.37 (2.19) | – | 3.67 (2.03) | – | 31.02 |
| **SE $_{(m)}$** | – | 0.03 | 0.17 | 0.03 | 0.20 | 0.03 | 0.24 | 0.25 |
| **CD $_{(5\%)}$** | – | 0.10 | 0.49 | 0.10 | 0.57 | 0.10 | 0.70 | 0.72 |
| **CV $_{(\%)}$** | – | 2.84 | 2.63 | 2.58 | 3.18 | 2.16 | 3.06 | 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.

**Figure 1. Mean Evaluation of Ecofriendly Insecticides for Major Insect Pests (Pooled of 2014 & 15).**
**(Pest: Defender Ratio (P:D) and % Abundance of P:D Ratio over Check (ABOC))**

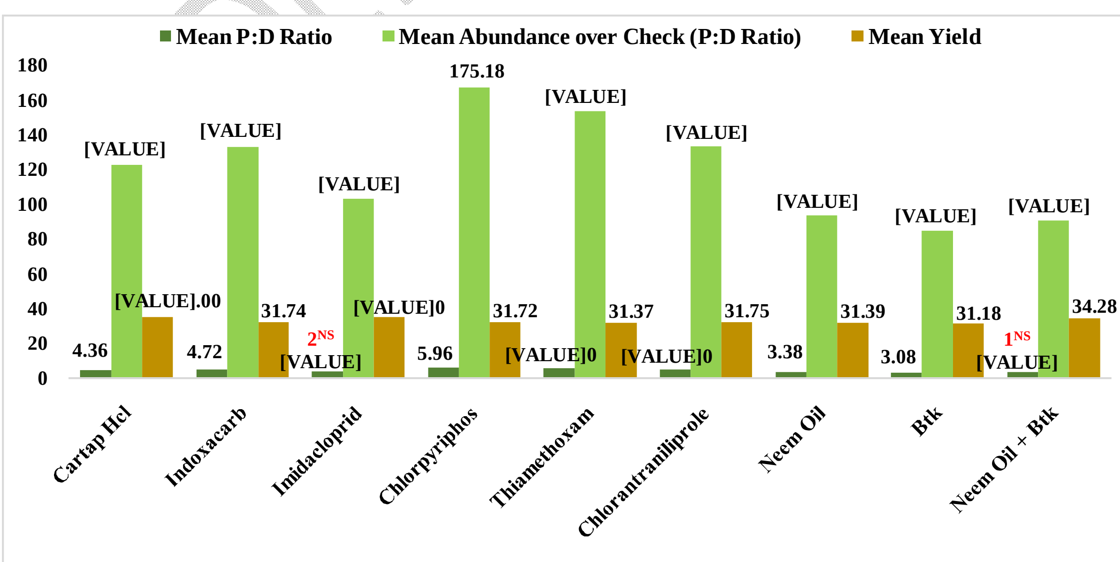

**Table 2. Rank Evaluation of Ecofriendly Insecticides for Major Insect Pests (Pooled of 2014 & 15)***
**(P:D Ratio/ ABOC/ Yield/ Mean)**

| Rank | P:D (Ratio) (Lowest) | ABOC (%) (Lowest) | Yield (q/ ha) (Highest) | Mean Rank |
|---|---|---|---|---|
| **1** | **Btk**<br>**3.08**<br>(1.88) | **Btk**<br>**84.85**<br>(9.23) | **Cartap Hcl**<br>**35.00** | **Neem Oil + Btk**<br>**2.33** [1 NS] |
| **2** | **Neem Oil + Btk**<br>**3.29** [1 NS]<br>(1.94) | **Neem Oil + Btk**<br>**90.76** [1 NS]<br>(9.55) | **Imidacloprid**<br>**34.80** [1 NS] | **Imidacloprid**<br>**3.33** [2 NS] |
| **3** | **Neem Oil**<br>**3.38**<br>(1.96) | **Neem Oil**<br>**93.41**<br>(9.69) | **Neem Oil + Btk**<br>**34.28** [2 NS] | **Cartap Hcl**<br>**3.67** |
| **4** | **Imidacloprid**<br>**3.66** [2 NS]<br>(2.03) | **Imidacloprid**<br>**103.16** [2 NS]<br>(10.17) | **Chlorantraniliprole**<br>**31.75** | **Btk**<br>**3.67** |
| **5** | **Cartap Hcl**<br>**4.36**<br>(2.20) | **Cartap Hcl**<br>**122.44**<br>(11.06) | **Indoxacarb**<br>**31.74** | **Neem Oil**<br>**4.33** |
| **6** | **Indoxacarb**<br>**4.72**<br>(2.28) | **Indoxacarb**<br>**132.92**<br>(11.52) | **Chlorpyriphos**<br>**31.72** | **Indoxacarb**<br>**5.67** |
| **7** | **Chlorantraniliprole**<br>**4.80**<br>(2.29) | **Chlorantraniliprole**<br>**133.31**<br>(11.55) | **Neem Oil**<br>**31.39** | **Chlorantraniliprole**<br>**6.00** |
| **8** | **Thiamethoxam**<br>**5.50**<br>(2.44) | **Thiamethoxam**<br>**153.71**<br>(12.40) | **Thiamethoxam**<br>**31.37** | **Chlorpyriphos**<br>**8.00** |
| **9** | **Chlorpyriphos**<br>**5.96**<br>(2.54) | **Chlorpyriphos**<br>**167.09**<br>(12.92) | **Btk**<br>**31.18** | **Thiamethoxam**<br>**8.00** |
| **$SE_{(m)}$** | **0.03** | **0.03** | **0.25** | – |
| **$CD_{(5\%)}$** | **0.10** | **0.10** | **0.72** | – |
| **$CV_{(\%)}$** | **2.16** | **2.16** | **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 abundance of pest: defender ratio for 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 abundance of pest: defender ratio over check were based on non-significant ecofriendly insecticides for lowest pest: defender ratio. There were 2 insecticides (Neem Oil + Btk and Imidacloprid) inference non-significant for lowest pest: defender ratio, and highest yield respectively. The mean ranking and inference of abundance of pest: defender ratio over check were not similar. There were 2 insecticides (Neem Oil + Btk and Imidacloprid) inference non-significant for abundance of pest: defender ratio over check based on non-significant ecofriendly insecticides for lowest pest: defender ratio. Though, both the insecticides were being most effective ecofriendly insecticides as, the Neem Oil + Btk are the biological insecticides (biorationals), while Imidacloprid is the chemical insecticide. Hence, Neem Oil + Btk as biorationals primarily would be the best choice before Imidacloprid for the ecofriendly management of major insect pests 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 at 40 days after transplanting as single application.

## 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.

**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.

**Karthick, K.S., Kandibane, M. And Kumar, K. (2015).** Effect of newer insecticides to natural enemies in the coastal rice ecosystem of Karaikal district, Union Territory of Puducherry. *Asian Journal of Bio Science,* 10 (1): 39-42.

**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., Dilkts, 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 managment 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.

**Sharanappa, A.K., Sahu, R. and Khan, H.H. (2019).** 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*, 7(1): 1100-1104.

**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.