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Evaluating the Bio-Efficacy of Pesticide Combinations on Natural Enemies in Rice Cultivation

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Rice cultivation is frequently threatened by pests, leading to the widespread use of chemical pesticides including organophosphates, carbamates, and synthetic pyrethroids. This study evaluates the bio-efficacy of various pesticide combinations in rice fields and their effects on natural enemies like spiders and coccinellids. Pesticides such as chlorantraniliprole, flubendiamide, Azoxystrobin, Tebuconazole, Difenconazole and cartap hydrochloride used alone or in combination were tested for their compatibility and safety. Results showed that these combinations do not significantly suppress natural enemies, making them suitable for Integrated

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pest management due to often carefully selected to target pests without affecting beneficial organisms. It supports the development of sustainable pest management strategies that minimize harm to beneficial organisms.

Keywords: Rice cultivation; pesticide combinations; natural enemies; bio-efficacy; integrated pest management; beneficial insects.

1. INTRODUCTION

Rice is one of the most important staple crops globally, providing a major source of food and livelihood for billions of people, particularly in Asia. However, rice cultivation faces significant challenges from various insect pests, diseases, and weeds, which can lead to substantial yield losses [1]. To manage these pests effectively, chemical pesticides are commonly used. The insecticides used in agriculture are grouped into different classes with different chemical bases and mode of action. Out of them, the most important inorganic insecticides used against the pests in rice belong to organophosphate, carbamates and synthetic pyrethroids [2]. There is a need to evaluate the compatibility and efficacy between these insecticides. A combination of pesticides is said to be compatible when the pesticides used in combination act without impairment of toxicity, physical properties or plant safety of either of the components, whereas incompatibility is a condition that may occur when two or more pesticides are used in combination with resultant loss or impairment of effectiveness of either component, development of undesirable physical properties and reduction of toxicity or the initiation of plant injury response. When any of these conditions occur the components of the combinations are said to be incompatible [3]. Incompatible combinations reduce the natural enemy population after application at the field level. Compatible combination of pesticides reduces the pests and diseases simultaneously and maintains the sustainable population of the natural enemies.

Natural enemies including beneficial insects such as spiders, lady beetles, and coccinellids play an essential role in regulating pest populations in rice fields Norris et al*.,* [4], Gurr et al*.,* 2012. The unintended effects of pesticide combinations on these beneficial organisms could undermine their ecological role and disrupt natural biological control processes. Pesticides and pesticide mixtures have an indirect impact on the physiology and behaviour of natural enemies by decreasing longevity, fecundity, reproduction, development time, mobility, foraging, feeding behaviour, predation, prey intake, emergence rates and sex ratio [5].

Therefore, it is important to evaluate the bio-efficacy of different pesticide combinations not only for their effectiveness against target pests but also for their potential to preserve natural enemies. This study aims to assess the bio-efficacy of various pesticide combinations used in rice cultivation and their effect on natural enemies. By understanding the interactions between pesticide combinations and beneficial insects, more sustainable and effective pest management strategies can be developed, leading to improved crop productivity and environmental conservation.

2. MATERIALS AND METHODS

The experiment was conducted in the experimental farm at Agriculture Research station, Nellore during late *kharif*, 2021 in a Randomized Block Design (RBD), having 12 treatments which were replicated thrice in a net experimental area of 15m^2 each. Nursery of rice variety NLR 34449 sown and transplanted with 20 cm x 15 cm spacing. All the agronomic practices were followed during crop growth period. The treatments were listed in the Table 1. The insecticides were applied as high-volume sprays @ 500 litres of spray fluid per ha. Individual pesticides and their combinations were sprayed at 40 DAT and 55 DAT (Days After Transplanting). Third spraying of pesticides *i.e.,* at 70 DAT was avoided as the damage due to insect pests reached below ETL (Economic Threshold Level). Data on number of predators such as ground beetles, spiders, and coccinellids were recorded from 15 randomly chosen plants in each plot at pre-treatment, 5 and 10 days after each spray in order to know the impact of the pesticide combinations against the natural enemies. The mean number of all predators per 15 clumps was statistically analysed using SPSS 20.

Table 1. Details of the treatments for bioefficacy of pesticide combinations against natural enemies in rice

Treatment	Name of the pesticide/ pesticide combination	Dosage (gm/l or ml/l)
T_1	Chlorantraniliprole	0.4 ml/l
T_2	Flubendiamide	0.1 ml/l
T_3	Cartap hydrochloride	2.0 gm/l
T_4	Azoxystrobin + tebuconazole	1.50 ml/l
T_5	Azoxystrobin + difenconazole	1.25 ml/l
T_6	Chlorantraniliprole + azoxystrobin + tebuconazole	0.4 ml/l + 1.50 ml/l
T_7	Chlorantraniliprole + azoxystrobin + difenconazole	0.4 ml/l +1.25 ml/l
T_8	Flubendiamide + azoxystrobin + tebuconazole	0.1 ml/l + 1.50 ml/l
T_9	Flubendiamide + azoxystrobin + difenconazole	0.1 ml/l + 1.25 ml/l
T_{10}	Cartap hydrochloride + azoxystrobin + tebuconazole	2.0 gm/l + 1.50 ml/l
T_{11}	Cartap hydrochloride + azoxystrobin + difenconazole	2.0 gm/l + 1.25 ml/l
T_{12}	Untreated control	200 ml of distilled water

3. RESULTS AND DISCUSSION

The data was recorded for natural enemies like spiders, ground beetles, coccinellids *etc.,* from 15 clumps per plot at pre spraying, 5 and 10 days after spraying. Data was collected irrespective of the species discrimination. Mostly spiders and coccinellids were witnessed in the field but no ground beetles (Fig. 1).

3.1 Spray at 40 DAT

The occurrence of Natural enemies was uniform among the treatments. Regarding the prevalence of natural enemies, no significant difference was observed between the treated plots and untreated plots. The natural enemies population ranged from 2.66 - 3.33 and 2.66 - 4.33 at 5 and 10 DAS respectively. In contrary, bioefficacy studies of insecticides against YSB (Yellow Stem Borer) and their effect on non-target insects like natural enemies was conducted by Rahaman and Stout, 2019. Application of chlorantraniliprole (0.4%) G, methoxyfenozide (24%) SC, dinotefuran (20%) SG, carbofuran 5 G, and quinalphos 25 EC. All the insecticides resulted in reduction of the numbers of predators *viz.*, lady bird beetles, wolf spiders, carabid beetles, earwigs, green mirid bugs, and damselflies.

Chormule et al. [2] evaluated the new molecules of insecticides *viz*., both chemical bases of pesticides like flubendiamide 480 SC, indoxacarb 14.5 SC, fipronil 5 SC, imidacloprid 17.8 SL, lambda cyhalothrin 5EC, cartap hydrochloride 50 SP, *Metarhizium anisopliae* and *Bacillus thuringiensis* against yellow stem borer, *Scirpophaga incertulas* infesting rice. The treatments with *M. anisopliae* and *B. thurengenesis* were observed to be relatively safe to natural enemies. whereas flubendiamide 480 SC @ 30 g a.i./ha was moderately safer to natural enemies.

3.2 Spray at 55 DAT

The same trend was observed at 5 and 10 days after second spray, significant differences were not observed regarding the natural enemies at 55 DAT. However, there was an increase in the mean population of natural enemies which ranged from 2.66 - 5.0 in pre-treatment as well as at 5 DAS (Days After Spraying) observations and 3.0 - 5.66 at 10 DAS (Table 2). From the above results it was understood that there is no suppressing impact of the pesticides and their combinations on prevalence and survival of natural enemies. The pesticide and their combinations proved to be safer to natural enemies as no significant difference were observed in the mean population of natural enemies.

From the above results it was understood that there is no suppressing impact of the pesticides and their combinations on prevalence and survival of natural enemies. The pesticides and their combinations proved to be safer to natural enemies as no significant difference were observed in the mean population of natural enemies.0000000 This may be due to the insecticides used in the current study are highly specific towards lepidopteran pests and observations revealed that the natural enemies recorded belongs to coleoptera which are non-target organisms for the pesticides. On contrary, higher concentrations of flubendiamide may possess little antagonistic effect on the natural

Table 2. Efficiency of pesticide combinations against Natural enemies during late *Kharif* 2021

Treatments		I spray							II spray						
		Pre treatment		5 DAS		10 DAS			Pre treatment		5 DAS		10 DAS		
	N	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Overall mean	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Overall mean
T_1: Chlorantraniliprole @ 0.4 ml/L	3	2.33	0.58	2.67	0.58	3.67	0.58	2.89^{abc}	3.33	0.58	3.33	0.58	3.33	0.58	3.33^{a}
T_2: Flubendiamide @ 0.1 ml/L	3	2.00	1.00	2.33	0.58	3.33	0.58	2.56^{a}	3.33	1.53	3.67	1.15	4.00	1.00	3.67^{ab}
T_3: Cartap hydrochloride @ 2.0 gm/L	3	2.33	0.58	2.00	1.00	3.67	0.58	2.67^{a}	3.67	0.58	4.00	1.00	4.33	1.15	4.00^{ab}
T_4: Azoxystrobin + Tebuconazole @ 1.5 ml/L	3	2.67	0.58	2.67	0.58	2.67	0.58	2.67^{ab}	2.67	0.58	3.00	1.00	3.00	1.00	2.89^{a}
T_5: Azoxystrobin + Difenconazole @ 1.25 ml/L	3	2.33	1.15	2.33	0.58	3.00	1.00	2.56^{a}	3.33	0.58	3.67	0.58	3.67	0.58	3.56^{ab}
T_6: Chlorantraniliprole @ 0.4ml/L + Azoxystrobin + Tebuconazole @ 1.5 ml/L	3	3.33	0.58	3.33	0.58	4.33	0.58	3.67^{bc}	5.00	1.00	5.00	1.00	5.67	0.58	5.22^{b}
T_7: Chlorantraniliprole @ 0.4ml/L + Azoxystrobin + Difenconazole @ 1.25 ml/L	3	3.67	0.58	2.67	0.58	3.67	1.53	3.33^{abc}	3.67	2.08	4.00	1.73	4.33	1.53	4.00^{ab}
T_8: Flubendiamide @ 0.1 ml/L + Azoxystrobin + Tebuconazole @ 1.5 ml/L	3	4.00	1.00	3.00	0.00	4.33	0.58	3.78^{c}	3.33	0.58	3.33	0.58	3.67	0.58	3.44^{ab}
T_9: Flubendiamide @ 0.1 ml/L+ Azoxystrobin + Difenconazole@ 1.25 ml/L	3	2.33	0.58	3.33	0.58	3.00	1.00	2.89^{abc}	3.00	1.00	3.67	0.58	3.67	0.58	3.44^{ab}
T_{10}: Cartap	3	2.67	0.58	2.33	0.58	3.67	0.58	2.89^{abc}	3.67	0.58	4.00	1.00	4.33	1.15	4.00^{ab}

Treatments	I spray								II spray						
		Pre treatment		5 DAS		10 DAS			Pre treatment		5 DAS		10 DAS		
	N	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Overall mean	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Overall mean
hydrochloride @ 2.0 gm/L + Azoxystrobin + Tebuconazole @ 1.5 ml/L															
T_{11}: Cartap hydrochloride @ 2.0 gm/L + Azoxystrobin + Difenconazole @ 1.25 ml/L	3	2.67	0.58	2.33	0.58	3.33	0.58	2.78^{abc}	2.33	0.58	2.67	1.15	3.00	1.73	2.67a
T_{12}: Untreated control	3	2.67	0.58	2.67	0.58	4.00	1.00	3.11^{abc}	3.67	0.58	4.00	0.00	4.00	0.00	3.89^{ab}

Note: Means followed by same letter don't differ significantly followed by DMRT

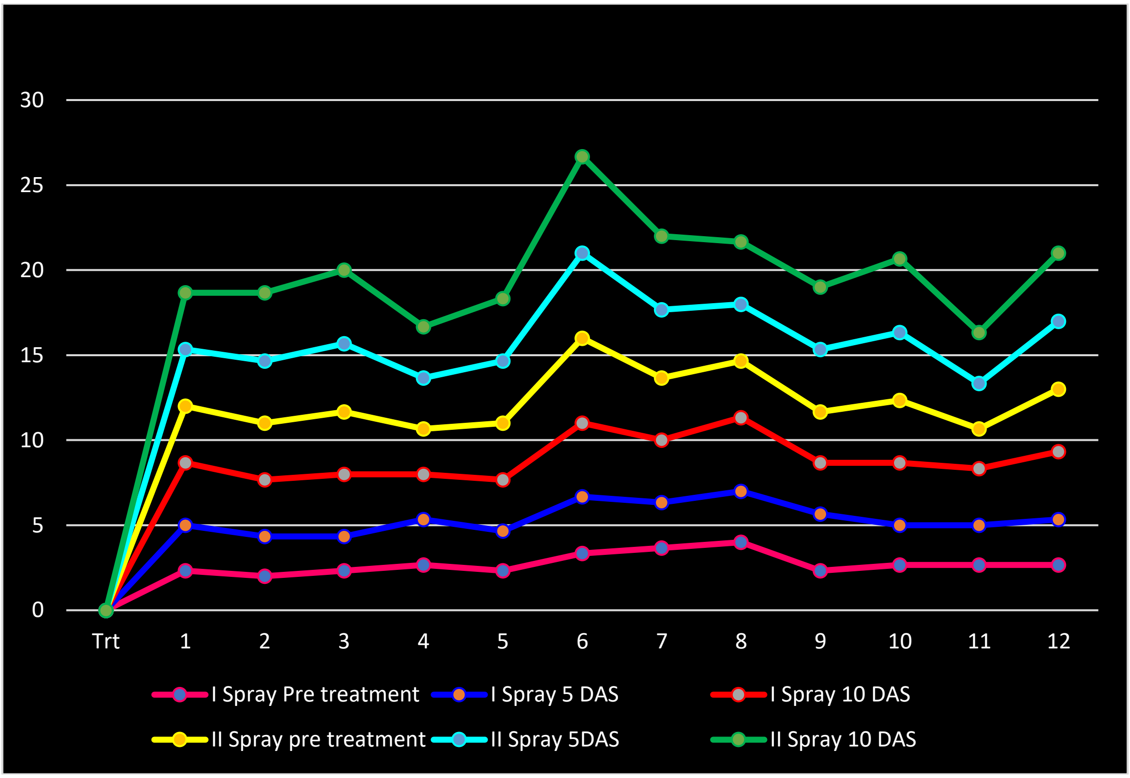

Fig. 1. Bioefficacy of pesticide combinations against Natural enemies

enemies. Paul et al. [6] carried out research on two rice varieties, IET 4786 and Satabdhi to study the bio-efficacy of the formulations of fipronil (5%) SC and acetamiprid (20%) SP at three different doses (20, 50 and 100 gm a.i./ha and 10, 20 and 40 gm a.i./ha respectively) against different insect pest complex. Results of the experiment revealed that, both the insecticides did not have any severe depressing effect on the natural enemies in the field when applied at recommended doses.

Katare et al. [7] carried investigations to determine the efficacy of seven different insecticides viz., imidacloprid 200 SL, thiamethoxam 25WG, flubendiamide 480 SC, quinalphos 25 EC, dimethoate 30 EC, acetamiprid 20 SP and clothianidin 50 WDG were tested for two years along with untreated control and disclosed that they were safer to natural enemies and concluded that they fit best in integrated pest management. Randhawa et al. [8,9] evaluated the efficacy of chlorantraniliprole 20 SC, flubendiamide 480 SC, spinosad 45 SC and fipronil 80 WG @ 150, 50, 150 ml and 37.5 g/ha, respectively on natural enemies and concluded that flubendiamide was safer to predaceous spiders and minimized the yield loss in basmati rice by 25% [10-12].

4. CONCLUSION

The pesticide treatments for bioefficacy study not shown any negative impact over the natural enemies. The natural enemies showed a striking increase in population in all the treatments concluded that these pesticides and their combinations are compatible and there is no negative impact over the non-target insect survival. There is no suppressing action on predators like ground beetles, coccinellids, spiders *etc.,* this may be due to, these insecticides are highly specific to lepidopteran pests.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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