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Bio-efficacy of insecticide and fungicide mixtures against leaf folder, stem borer, BPH and sheath blight of rice

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Abstract
Bio-efficacy assessment with four insecticides and two fungicides was carried out in Agricultural College farm, Naira during *kharif*, 2019 against leaf folder, stem borer, brown plant hopper (BPH) and sheath blight of rice. The treatments include four insecticides [Flonicamide 50 WG (0.4 g/l), Pymetrozine 50 WG (0.6 g/l), Chlorantraniliprole 18.5 SC (0.3 g/l), Acephate 75 SP (1.5 g/l)], two fungicides [(Difenoconazole 25 EC (0.5 ml/l), Azoxystrobin 23 EC (0.75 ml/l] and Untreated Control. Results indicated that treatment Chlorantraniliprole 18.5 SC (0.3 g/l) was effective against leaf folder (per cent leaf folder damage: 3.29) and stem borer (% DH: 1.17, % WE: 2.11) which was on par to both of its fungicide combinations *viz.*, Azoxystrobin 23 EC (0.75 ml/l) (per cent leaf folder damage: 3.02, % DH: 1.29, % WE: 2.51) and Difenoconazole 25 EC (0.5 ml/l) (3.85, 1.76, 2.64). Against brown planthopper, treatment Pymetrozine 50 WG + Difenoconazole 25 EC (0.6 g/l + 0.5 ml/l) (reduction over control-92.95%) was effective and pertinent to sheath blight, treatment chlorantraniliprole + azoxystrobin (PDI: 5.14) along with all the four test insecticide combinations of azoxystrobin proved their best.

Keywords: Rice, insecticides, fungicides, compatibility, combination

Introduction
Rice, globally with a production of 780 million tonnes, grown in an area of about 167 million hectares (FAO, 2018) forms a prominent part of the food of man in the world and proves to be a financial asset to thousands of rural households throughout the planet.

It is inevitable that insect pests and diseases like leaf folder, stem borer, BPH and sheath blight co-exist in the field. Pressurized by such an alarming co-existence, the farmer is compelled to go for spraying of insecticide and fungicidal mixtures in haste to put a check on the immediate crop loss - saving money, time, labour and energy, failing to check whether the tank mix is recommended or not. The inimical consequences of incompatible insecticide and fungicidal mixtures pave the way for incautious expenditure and appalling crop loss. To overcome these pernicious consequences and to enjoy the advantages of tank mixtures, the farmers must have a sound knowledge regarding the compatibility status of the insecticide and fungicidal mixture he desires to use. Reckoning with this fact, the present study was undertaken.

Materials and Methods
The present investigation was executed on the college farm of Agricultural College, Naira during *kharif*, 2019. Rice variety, MTU-7029 was selected for the experiment. This research was carried out in Randomized block design (RBD) with 15 treatments and three replications. Plots measuring a net area of 20 m^2 (5 m x 4 m) were made leaving 0.5 m in between the plots and replications for irrigation channels. The recommended doses of fertilizers application *i.e.*, 80 kg, 60 kg, 50 kg/ha of N-P-K respectively was adopted as per ANGRAU recommendations. The imposition of the first spray schedule was done when the pest reached ETL *i.e.*, on 28-9-2019 followed by the second spray schedule on 15-10-2019. The total number of damaged leaves per 20 randomly selected hills in each treatment, under each replication was recorded one day prior to spraying and on the 5^{th}, 10^{th} and 15^{th} day after spraying in order to assess leaf folder damage, while for BPH, the mean percent damaged leaves per hill were calculated using the following formula.

$$\text{Per cent damaged leaves} = \frac{\text{Number of damaged leaves / hill}}{\text{Total number of leaves / hill}} \times 100$$

The observations on stem borer damage were recorded as percent dead hearts (DH) at one day before spray, 5th and 10th day after first and second sprays and percent white ears (WE) at 15 days before harvest on 10 randomly selected hills. The following relations are used to calculate stem borer damage.

$$\text{(a) DH (\%)} = \frac{\text{Total no. of dead hearts (DH) in 10 hills}}{\text{Total no. of tillers (DH + healthy tillers) in 10 hills}} \times 100$$

$$\text{(b) WE (\%)} = \frac{\text{Total no. of white ear (WE) in 10 hills}}{\text{Total no. of panicles (WE + healthy panicles) in 10 hills}} \times 100$$

The observations on BPH were taken as the number of BPH found on 10 randomly selected hills per plot at one day before spray, 5, 10 and 15 days after spray and the data obtained is reduced to a number of BPH per hill. The percent reduction in population was worked out in accordance with the following formula (modified Abbot's formula by Fleming and Ratnakaran, 1985) [3].

$$\text{Per cent Reduction in Population} = \left[1 - \left(\frac{\text{Post treatment count in treatment}}{\text{Pre treatment count in treatment}} \times \frac{\text{Pre treatment count in untreated check}}{\text{Post treatment count in untreated check}} \times 100\right)\right]$$

The incidence of sheath blight was recorded as per the following procedure (Standard Evaluation System for Rice, IRRI, November, 2002) [5]. Data was collected from 5 spots of 1 m^2 area *i.e.*, in four corners and in the middle of each treatment before spraying and on the 10th day after each spraying (Plate 3.13). Finally, percent sheath blight incidence was calculated using PDI (Percent Disease Index) as detailed in Table 1.

Table 1: Disease Rating Scale for Sheath blight (Ahn and Pena, 1986.) [1]

Scale (based on relative lesion length)	
0	No infection was observed.
1	Leisons are limited to a lower 20% of the plant height.
3	20-30%
5	31-45%
7	46-65%
9	More than 65%

The statistical analysis package, OPSTAT was used in the present investigation. The data were subjected to angular transformation or square root transformation (wherever necessary) and further the transformed values were subjected to ANOVA to test the significance between the treatments.

Results and Discussion

Experiments done to assess the bio-efficacy of straight and also their combinations of test pesticides illustrates that insecticide chlorantraniliprole (per cent leaf folder damage: 3.29, per cent reduction over control : 92.26) worked best against leaf folder (plate 2) and this insecticide was on par to both of its mixtures with fungicides-azoxystrobin (per cent leaf folder damage: 3.02, per cent reduction over control: 92.91) and difenoconazole (per cent leaf folder damage: 3.85, per cent reduction over control: 90.63). The per cent leaf folder damage in untreated control was 30.07 (Table 2). It was also noted that chlorantraniliprole's action individually was on par with that of the both tested fungicides *i.e.*, fungicides mixed in chlorantraniliprole did not alter the efficacy of the individual insecticide, chlorantraniliprole. Against stem borer (plate 3 & 4), the treatments *viz.*, chlorantraniliprole (per cent dead hearts: 1.17, per cent white ears: 2.11, per cent reduction over control: 95.56), chlorantraniliprole + azoxystrobin (per cent dead hearts: 1.29, per cent white ears: 2.51, per cent reduction over control: 98.47), chlorantraniliprole + difenoconazole (per cent dead hearts: 1.76, per cent white ears: 2.64, per cent reduction over control: 93.21) were significantly superior to all other treatments (Table 2) like acephate + azoxystrobin (1.5 g/l + 0.75 ml/l), acephate (1.5 g/l), acephate + difenoconazole (1.5 g/l + 0.5 ml/l, pymetrozine (0.6 g/l), pymetrozine + azoxystrobin (0.6 g/l + 0.75 ml/l), pymetrozine + difenoconazole (0.6 g/l + 0.5 ml/l), flonicamide + azoxystrobin (0.4 g/l + 0.75 ml/l), flonicamide (0.4 g/l) and flonicamide + difenoconazole (0.4 g/l + 0.5 ml/l) which recorded 4.26%, 4.38%, 4.42%, 8.61%, 8.85%, 9.35%, 10.59%,11.24%, 11.38% dead hearts, 4.39%, 4.95%, 4.84%, 7.26%, 7.59%, 7.96%, 8.1%, 8.39%, 9.15% white ears, 83.56%, 83.09%, 82.68%, 66.21%, 64.88%, 60.83%, 55.34%, 52.58%, 51.84% reduction over control respectively. The untreated control recorded 24.06% dead hearts and 16.58% white ears. Against Brown Planthopper (plate 1), insecticides pymetrozine and flonicamide along with their fungicidal mixtures proved the best in exhibiting efficacy, those treatments include pymetrozine + difenoconazole (0.6 g/l + 0.5 ml/l) (reduction over control- 92.95%, 3.96 BPH/hill), pymetrozine (0.6 g/l) (92.90%, 4.66), pymetrozine + azoxystrobin (0.6 g/l + 0.75 ml/l) (92.55%, 3.50), flonicamide (0.4 g/l) (90.50%), flonicamide + difenoconazole (0.4 g/l + 0.5 ml/l) (89.35%, 4.86), flonicamide + azoxystrobin (0.4 g/l + 0.75 ml/l) (87.82%, 5.65) (Table 2). They managed the population of BPH significantly as compared to untreated control which recorded 45.26 BPH/hill at an average. Against sheath blight (plate 5), fungicide azoxystrobin (PDI: 5.14) was on par to all of its insecticidal mixtures *viz.*, chlorantraniliprole + azoxystrobin (5.14), acephate + azoxystrobin (6.60), pymetrozine + azoxystrobin (7.17) and flonicamide + azoxystrobin (7.62) (Table 2) whereas untreated control recorded PDI of 39.59.

These results were in concordance with the findings of Kumar (2015) [6] stating that chlorantraniliprole 18.5 SC + isoprothiolane 40 EC was the most effective treatment against rice leaf folder by reporting 6.89 mean percent leaf damage and 83.04% reduction over control followed by the treatment chlorantraniliprole 18.5 SC alone with 7.37 mean percent leaf damage and 81.86% reduction over control. Bhuvaneswari and Raju (2013) [2] reported that chlorantraniliprole 18.5 SC (Coragen) + hexaconazole 5 EC was the leading mixture in managing stem borer by recording 6.3% of white ears, they also worked upon fungicides azoxystrobin and difenoconazole in managing sheath blight and concluded that the combination of these two fungicides, azoxystrobin 18.2 SC + difenoconazole 11.4 SC recorded minimum sheath blight incidence of 9.36%, while azoxystrobin 23 SC alone recorded 27.06 PDI. Rajendra *et al.* (2018) [9] confirmed that pymetrozine 50 WG (GSP sample) @ 300 (Mean BPH count per 5 hills- 25.63) and 400 g/ha (Mean BPH count per 5 hills-

20) were very effective in managing BPH, WBPH and GLH. Pal *et al*. (2018) [7] reported that the insecticide and fungicide combination, validamycin 3 SL + rynaxypyr (chlorantraniliprole) 18.5 SC was able to manage leaf folder, stem borer and sheath blight (5.74 PDI) simultaneously. Visalakshmi *et al.* (2016) [11] reported that the combination of chlorantraniliprole 18.5 SC + propiconazole 25 EC recorded a percent leaf damage of 2.02. Pallavi *et al.* (2018) [8] who inferred that chlorantraniliprole 0.4 GR recorded the lowest stem borer infestation percent (% DH: 7.20, % WE: 6.67) compared to all other chemicals, which included acephate too. From the above results and discussions, it can be inferred that particular fungicides/insecticides and their combinations with insecticides/fungicides had no significant difference within them. Sabitha *et al*. (2020) [10] proved that these combinations did not cause any phytotoxic symptoms over rice foliage under field conditions. Their mixtures were physically incompatible when tested which implies that all the test insecticides and fungicides were compatible to each other. Hence, all these test combinations are safe for tank mixtures in case of a simultaneous attack of leaf folder, BPH, stem borer and sheath blight. Thus the bio-efficacy of tested insecticide remained unaltered upon it's mixture with fungicide and vice-versa was also true. Knowing the undesirable consequences of incompatible combinations of mixtures, it must be seen that suitable tests may be done to know the nature of compatibility among the desired combinations without a haste to mix up two single better performing chemicals, which would pose a huge loss to a farmer if their mixture is incompatible. The pesticide mixtures compatibility studies must not be summed up by mere checking their physical compatibility but must be further proceeded to know their respective bio-efficacies against the combination of pests at field level.

Plate 1: BPH observed on the lower portion of the crop

Plate 2: Leaf folder infested leaf along with frass

Plate 3: White Ears due to Stem Borer

Plate 4: Dead heart due to Stem borer

Plate 5: Sheath blight infected Rice Plant

Table 2: Bio-efficacy of Insecticide and fungicide combinations against major insect-pests and disease in rice

Tr. No.	Insecticide + Fungicide Combination	Leaf Folder Leaf damage (%)	Stem borer Damage		BPH damage		Sheath Blight Mean Percent Disease Index
			% DH	% WE	BPH/hill	Mean Percent reduction over control	
T_1	Flonicamide 50 WG	10.84 *(19.21)^c	11.24 (19.58)^c	8.39 (16.83)^c	4.86	90.50 (72.02)^a	38.74 (38.48)^c
T_2	Pymetrozine 50 WG	11.16 (19.51)^c	8.61 (17.06)^c	7.26 (15.62)^c	4.66	92.90 (74.52)^a	37.62 (37.82)^c
T_3	Chlorantraniliprole 18.5 SC	3.29 (10.45)^a	1.17 (6.21)^a	2.11 (8.35)^a	44.36	30.07 (33.24)^c	36.78 (37.32)^c
T_4	Acephate 75 SP	7.00 (15.33)^b	4.38 (12.08)^b	4.95 (12.85)^b	14.79	72.57 (58.39)^b	36.99 (37.44)^c
T_5	Difenoconazole 25 EC	24.26 (29.5)^d	17.70 (24.87)^d	12.65 (20.83)^d	52.83	5.19 (13.17)^d	13.94 (21.91)^b
T_6	Azoxystrobin 23 EC	22.84 (28.54)^d	16.74 (24.14)^d	12.22 (20.45)^d	52.44	2.10 (8.33)^d	5.14 (13.09)^a
T_7	Flonicamide 50 WG + Difenoconazole 25 EC	11.22 (19.57)^c	11.38 (19.71)^c	9.15 (17.6)^c	5.65	89.35 (70.92)^a	13.92 (21.89)^b
T_8	Pymetrozine 50 WG + Difenoconazole 25 EC	11.44 (19.76)^c	9.35 (17.8)^c	7.96 (16.38)^c	3.96	92.95 (74.57)^a	14.3 (22.21)^b
T_9	Chlorantraniliprole 18.5 SC + Difenoconazole 25 EC	3.85 (11.31)^a	1.76 (7.63)^a	2.64 (9.35)^a	49.21	23.43 (28.94)^c	13.94 (21.91)^b
T_{10}	Acephate 75 SP + Difenoconazole 25 EC	7.26 (15.62)^b	4.42 (12.13)^b	4.84 (12.7)^b	24.24	73.3 (58.87)^b	14.19 (22.12)^b
T_{11}	Flonicamide 50 WG + Azoxystrobin 23 EC	11.04 (19.4)^c	10.59 (18.98)^c	8.1 (16.53)^c	6.18	87.82 (69.55)^a	8.07 (16.5)^a
T_{12}	Pymetrozine 50 WG + Azoxystrobin 23 EC	11.06 (19.42)^c	8.85 (17.3)^c	7.59 (15.99)^c	3.50	92.55 (74.14)^a	7.62 (16.02)^a
T_{13}	Chlorantraniliprole 18.5 SC + Azoxystrobin 23 EC	3.02 (10.01)^a	1.29 (6.53)^a	2.51 (9.11)^a	44.18	17.71 (24.88)^c	6.60 (14.88)^a
T_{14}	Acephate 75 SP + Azoxystrobin 23 EC	7.11 (15.46)^b	4.26 (11.91)^b	4.39 (12.09)^b	11.86	68.98 (56.13)^b	7.17 (15.53)^a
T_{15}	Untreated Control	30.07 (33.24)^e	24.06 (29.36)^e	16.58 (24.02)^e	45.26	-	42.02 (40.39)^c
	F test	Sig.	Sig.	Sig.		Sig.	Sig.
	SEm ±	1.28	1.16	0.89		2.74	1.77
	CD (p= 0.05)	3.71	3.51	2.57		7.94	5.38
	CV (%)	11.70	10.01	10.09		9.94	10.00

*Figures in the parenthesis are Angular or Arc-sine transformed values
Means followed by same letter do not differ significantly following DMRT
DH = dead hearts
WE= white ears

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