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Bio-efficacy of certain newer insecticides and fungicides alone and in combination against leaf folder and grain discoloration in rice

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Abstract
A field study was conducted at ARI main farm, PJTSAU, Rajendranagar, Hyderabad during *kharif* 2021 to evaluate the bio-efficacy of newer insecticides and fungicides alone and in combination against leaf folder and grain discolouration in rice. Among the different chemicals tested, 5 treatments *viz.*, T_2 tetraniliprole (8.71%), T_1 chlorantraniliprole (8.89%), T_3 cartap hydrochloride (9.23%), T_{12} tetraniliprole + (tebuconazole + trifloxystrobin) (9.27%) and T_{11} tetraniliprole + (azoxystrobin + Difenoconazole) (9.96%) recorded lowest incidence compared to control (20.90%) and were proved to be effective against leaf folder. Whereas highest incidence was recorded in T_4 (26.37%) on par with T_5 (25.80%) and T_6 (23.67%). While, significantly lowest per cent of discolored grains were recorded in T_6, tebuconazole + trifloxystrobin (22.18%) which is on par with T_{12}, tetraniliprole + (tebuconazole + trifloxystrobin) (23.68%) T_5, azoxystrobin + difenoconazole (24.90%) and T_{15}, cartap hydrochloride + (tebuconazole + trifloxystrobin) (24.98%). Whereas, highest per cent discolored grains were noticed in untreated control (T_{16}) 63.40% followed by T_3, cartap hydrochloride 42.20%.

Keywords: Bio-efficacy, leaf folder, grain discoloration, newer insecticides, fungicides

1. Introduction
Rice is an important cereal food crop in the world for more than one billion population. The statistics show that world rice acreage in crop year 2020 was around 164.19 million ha. India is the world's second largest producer of rice with approximately 44 million ha area, with the total production of 118.87 million tonnes accounting for 22% of world rice production (USDA, 2021). In Telangana state, rice is grown in 2.01 million ha with production of 7.43 million tonnes with productivity of 3694 kg/ha (Indiastat, 2019). Rice productivity is drastically affected by several biotic and abiotic stresses.

Up to 100 species of insects cause damage to rice, of which 20 are considered the main pests causing serious economic losses (Pathak and Khan, 1994). Among the major pests, stem borers and brown planthoppers are the worst pests, causing severe damage and reduced yield to rice plants at different growth stages. Among rice diseases, the main diseases are blight, rice blast, bacterial leaf blight, blight and associated grain discolouration. Farmers often use pesticides as tank mix without fully understanding the negative impact the combination can have on crops and the bio-efficacy of the targeted pest.

Although certain new insecticide and fungicide molecules are often used by farmers to manage biotic stress, information on the compatibility and bio-efficacy of these pesticides against major pests and rice diseases is scarce.

2. Material and Methods
The present field experiment was carried out at Agricultural Research Institute main farm, PJTSAU, Rajendranagar, Hyderabad during *kharif* 2021. This study comprises of 16 treatments involving 3 insecticides *viz.*, chlorantraniliprole, tetraniliprole, cartap hydrochloride and 3 fungicides *viz.*, picoxystrobin + tricyclazole, azoxystrobin + difenconazole, tebuconazole + trifloxystrobin alone and in combination and an untreated control evaluated in Randomised Block Design (RBD) with three replications.

Variety: Jagtial Vari-1 (JGL 24423); Spacing: 20×15 cm; Area of each plot: 20 m^2; Total plot area: 1500 m^2.

Table 1: Treatment Details

Sl. No.	Insecticide/Fungicide	Treatment	Dosage (g/ml) per ha	Dosage (g/ml) per litre of water
1	Chlorantraniliprole 18.5% SC	T1	150 ml /ha	0.3ml/l
2	Tetraniliprole 200 SC	T2	200 ml/ha	0.4 ml/l
3	Cartap hydrochloride 50 SP	T3	1000 g/ha	2.0g/ l
4	Picoxystrobin 7.5%SC + Tricyclazole 22.5% SC	T4	1000 ml/ ha	2ml/l
5	Azoxystrobin 18.2% SC + Difenoconazole 11.4% SC	T5	500 ml/ha	1ml/l
6	Tebuconazole 50% WG + Trifloxystrobin 25 % WG	T6	200 g/ha	0.4g/l
7	(Chlorantraniliprole 18.5% SC) + (Picoxystrobin 7.5% SC + Tricyclazole 22.5% SC) (T1 + T4)	T7	150 ml /ha + 1000 ml/ ha	0.3ml/l + 2ml/l
8	(Chlorantraniliprole 18.5% SC) + (Azoxystrobin 18.2% SC +Difenconazole 11.4% SC) (T1+ T5)	T8	150 ml /ha + 500 ml/ha	0.3ml/l + 1ml/l
9	(Chlorantraniliprole 18.5% SC) + (Tebuconazole 50% WG + Trifloxystrobin 25% WG) (T1+ T6)	T9	150 ml /ha + 200 g/ha	0.3ml/l + 0.4g/l
10	(Tetraniliprole 200 SC) + (Picoxystrobin 7.5% SC + Tricyclazole 22.5% SC) (T2 + T4)	T10	200 ml/ha + 1000 ml/ ha	0.4 ml/l + 2ml/l
11	(Tetraniliprole 200 SC + (Azoxystrobin 18.2% SC + Difenconazole 11.4% SC (T2 + T5)	T_{11}	200 ml/ha + 500 ml/ha	0.4 ml/l + 1ml/l
12	(Tetraniliprole 200 SC) + (Tebuconazole 50% WG + Trifloxystrobin 25% WG) (T2 + T6)	T_{12}	200 ml/ha + 200 g/ha	0.4 ml/l + 0.4g/l
13	(Cartap hydrochloride 50 SP + (Picoxystrobin 7.5% SC + Tricyclazole 22.5% SC) (T3 + T4)	T_{13}	1000 g/ha + 1000 ml/ ha	2.0g/ l + 2ml/l
14	(Cartap hydrochloride 50 SP + (Azoxystrobin 18.2% SC +Difenconazole 11.4% SC) (T3 + T5)	T_{14}	1000 g/ha + 500 ml/ha	2.0g/ l + 1ml/l
15	(Cartap hydrochloride 50 SP + (Tebuconazole 50% WG + Trifloxystrobin 25% WG) (T3 + T6)	T_{15}	1000 g/ha + 200 g/ha	2.0g/l + 0.4g/l
16	Untreated control	T_{16}	-	-

The treatment plots were sprayed with the above pesticides alone and in combination twice at 45 DAT and 65 DAT after ETL's were ascertained. Observations were taken one day before spraying and 7 and 15 days after spraying. The data regarding total number of leaves and number of damaged leaves by leaf folder were recorded and per cent damaged leaves were assessed (Kaushik chakrabarty and Chandra, 2011) as given below.

$$\text{Damaged leaves (\%)} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \text{ x100}$$

Number of discoloured grains and total number of grains per panicle were calculated (Prajapati and Sachin Patel, 2013) as given below.

$$\text{Discolored grain (\%)} = \frac{\text{Number of discolored grains}}{\text{Total number of grains}} \text{ x100}$$

3. Results and Discussion

3.1 Incidence of Leaf Folder

The mean leaf folder incidence after spraying with insecticides, fungicides and their combinations (Table 2.) indicated that leaf folder damage across different treatments ranged from 8.71% to 26.37%. Among various treatments, 5 treatments *viz.*, T_2 tetraniliprole (8.71%), T_1 chlorantraniliprole (8.89%), T_3 cartap hydrochloride (9.23%), T_{12} tetraniliprole + (tebuconazole + trifloxystrobin) (9.27%) and T_{11} tetraniliprole + (azoxystrobin + Difenoconazole) (9.96%) recorded lowest incidence compared to control (20.90%) and were proved to be effective. Whereas highest incidence was recorded in T_4 (26.37%) on par with T_5 (25.80%) and T_6 (23.67%).

As per the data that is computed and presented in Fig.1 regarding the efficacy of different treatments *vis a vis* control against leaf folder revealed that five treatments *viz.*, T_2, tetraniliprole > T_1, chlorantraniliprole > T_3, cartap hydrochloride > T_{12} tetraniliprole + (tebuconazole + trifloxystrobin) > T_{11}, tetraniliprole + (azoxystrobin + Difenoconazole) were most effective over the untreated control in the order mentioned and efficacy ranged from 57.99% to 52.15%.

Table 2: Incidence of leaf folder, (*Cnaphalocrosis medinalis*) in different treatment plots

Treatment no	Treatment details	% damaged leaves by leaf folder					Mean
			1st spray		2nd spray		
		1DBS	7DAS	15DAS	7DAS	15DAS	
T_1	Chlorantraniliprole 18.5% SC	12.47^{abc} (20.45)	10.08^{ab} (18.44)	9.70^{ab} (18.02)	8.71^{ab} (17.14)	7.08^{a} (15.34)	8.89
T_2	Tetraniliprole 200 SC	11.08^{a} (19.38)	9.61^{a} (17.88)	9.60^{ab} (18.04)	8.16^{a} (16.29)	7.48^{ab} (15.84)	8.71
T_3	Cartap hydrochloride 50 SP	10.78^{a} (19.04)	10.00^{ab} (18.41)	9.62^{ab} (18.07)	8.78^{ab} (17.20)	8.52^{abc} (16.89)	9.23
T_4	Picoxystrobin 7.5% SC + Tricyclazole 22.5% SC	15.60^{cde} (23.25)	26.91^{f} (31.24)	28.44^{e} (32.20)	25.67^{f} (30.39)	24.48^{f} (29.65)	26.37

T_5	Azoxystrobin 18.2% SC + Difenoconazole 11.4% SC	17.04^{ab} (24.37)	25.17^{f} (30.08)	28.15^{e} (32.00)	25.45^{f} (30.29)	24.46^{f} (29.63)	25.80
T_6	Tebuconazole 50% WG + Trifloxystrobin 25 % WG	18.60^{e} (25.54)	23.20^{ef} (28.76)	23.69^{d} (27.96)	24.02^{ef} (29.33)	23.79^{f} (29.18)	23.67
T_7	(Chlorantraniliprole 18.5% SC) + (Picoxystrobin 7.5% SC + Tricyclazole 22.5% SC)	13.76^{abcd} (21.77)	13.01^{abc} (21.13)	13.21^{bc} (21.11)	11.65^{bcd} (19.94)	10.93^{bcde} (19.09)	12.20
T_8	(Chlorantraniliprole 18.5% SC) + (Azoxystrobin 18.2% SC +Difenoconazole 11.4% SC)	14.22^{abcde} (22.11)	12.44^{abc} (20.53)	13.05^{bc} (21.15)	11.03^{abcd} (19.16)	10.24^{abcde} (18.57)	11.69
T_9	(Chlorantraniliprole 18.5% SC) + (Tebuconazole 50% WG + Trifloxystrobin 25% WG)	15.50^{bcde} (23.16)	14.72^{bc} (22.14)	11.19^{abc} (19.34)	10.55^{abcd} (18.94)	9.30^{abcd} (17.60)	11.44
T10	(Tetraniliprole 200 SC) + (Picoxystrobin 7.5% SC + Tricyclazole 22.5% SC)	11.65^{abc} (19.95)	10.21^{ab} (18.41)	12.60^{abc} (20.77)	11.33^{bcd} (19.65)	11.31^{cde} (19.63)	11.36
T11	(Tetraniliprole 200 SC + (Azoxystrobin 18.2% SC + Difenoconazole 11.4% SC)	11.38^{ab} (19.70)	10.58^{abc} (18.96)	10.16^{ab} (18.45)	9.14^{ab} (17.57)	9.96^{abcde} (18.36)	9.96
T12	(Tetraniliprole 200 SC) + (Tebuconazole 50% WG + Trifloxystrobin 25% WG)	11.15^{a} (19.25)	10.40^{ab} (18.52)	8.64^{a} (17.07)	9.39^{abc} (17.82)	8.65^{abc} (16.77)	9.27
T13	(Cartap hydrochloride 50 SP + (Picoxystrobin 7.5% SC + Tricyclazole 22.5% SC)	14.13^{abcd} (21.89)	14.25^{bc} (22.16)	14.66^{c} (22.50)	13.88^{d} (21.80)	13.85^{e} (21.85)	14.16
T14	(Cartap hydrochloride 50 SP + (Azoxystrobin 18.2% SC +Difenoconazole 11.4% SC)	15.62^{cde} (23.27)	14.16^{de} (22.05)	13.82^{bc} (21.66)	12.99^{cd} (21.10)	12.36^{de} (20.56)	13.33
T15	(Cartap hydrochloride 50 SP + (Tebuconazole 50% WG + Trifloxystrobin 25% WG)	16.93^{de} (24.25)	14.65^{cd} (22.39)	12.93^{bc} (20.98)	11.63^{bcd} (19.87)	11.17^{bcde} (19.41)	12.58
T16	Untreated Control	18.18^{de} (25.18)	19.25^{de} (26.02)	21.66^{d} (27.73)	19.88^{e} (26.47)	22.88^{f} (28.57)	20.90
	SEm±	0.73	0.85	0.91	0.95	0.87	-
	CD (P = 0.05%)	3.46	3.82	3.85	3.35	3.63	-
	C.V.	9.42	10.26	10.36	9.38	10.35	-

DBS – Days before spray**; DAS –** Days after spray**; Mean –** Mean of four observations after spraying
Figures in parentheses are angular transformed values

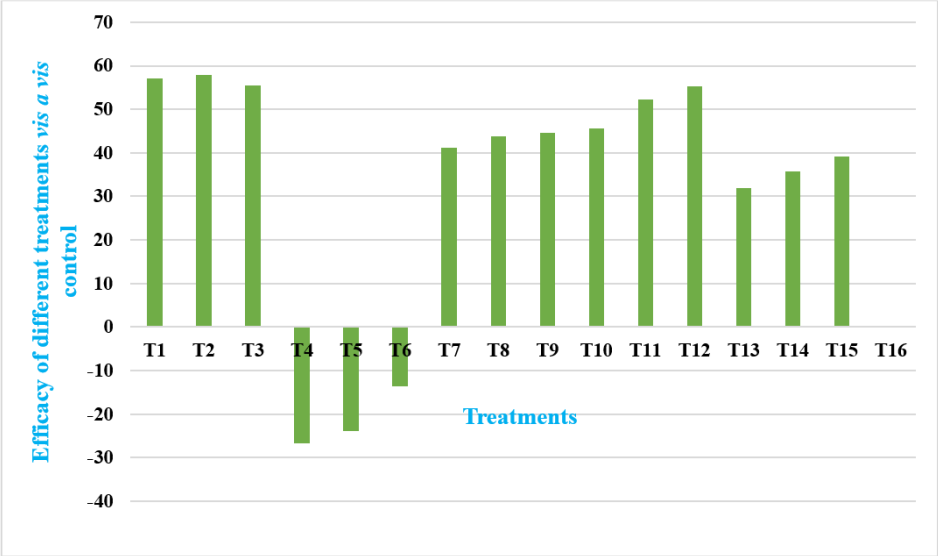

Fig 1: Efficacy of different treatments *vis a vis* control against Rice Leaf folder (*C. medinalis*)

Treatment no	Chemical
T_1	Chlorantraniliprole
T_2	Tetraniliprole
T_3	Cartap hydrochloride
T_4	Picoxystrobin + Tricyclazole
T_5	Azoxystrobin + Difenoconazole
T_6	Tebuconazole + Trifloxystrobin
T_7	T_1 + T_4
T_8	T_1 + T_5
T_9	T_1 + T_6
T10	T_2 + T_4
T11	T_2 + T_5
T12	T_2 + T_6
T13	T_3 + T_4
T14	T_3 + T_5
T15	T_3 + T_6
T16	Untreated control

3.2 Grain discoloration

By examining the data (Table 3.) it is evident that the discoloured grains ranged from 22.18 to 63.40 per cent across different treatments. Among the different chemicals tested, significantly lowest per cent of discoloured grains were recorded in T_6, tebuconazole + trifloxystrobin (22.18%) which is on par with T_{12}, tetraniliprole + (tebuconazole + trifloxystrobin) (23.68%) T_5, azoxystrobin + difenoconazole (24.90%) and T_{15}, cartap hydrochloride + (tebuconazole + trifloxystrobin) (24.98%). These are followed by T_{11} (25.38%), T_{14} (25.58%), T_4 (25.70%), T_7 (26.10%), T_8 (26.20%), T_9 (26.99%), T_{10} (27.69%), T_{13} (28.51%). Whereas, highest per cent discoloured grains were noticed in untreated control (T_{16}) 63.40% followed by T_3, cartap hydrochloride 42.20%.

The per cent efficacy of different treatments over control in terms of grain discolouration was analysed and presented in Fig 2. The data showed that T_6 (tebuconazole + trifloxystrobin), T_{12} (tetraniliprole + (tebuconazole + trifloxystrobin)), T_5 (azoxystrobin + difenoconazole), T_{15} (cartap hydrochloride + (tebuconazole + trifloxystrobin), T_{11} (Tetraniliprole + (azoxystrobin + difenoconazole) reduced the grain discolouration by 59.96 to 65.01 per cent over control.

Table 3: Effect of different treatments on incidence of grain discolouration

Treatment no	Treatment details	% H.G.	% D.G.	Mean per cent reduction over control
T_1	Chlorantraniliprole 18.5% SC	57.92^{bc} (49.60)	42.08^{cd} (40.39)	33.62
T_2	Tetraniliprole 200 SC	59.10^{bcd} (50.35)	40.90^{bcd} (39.64)	35.48
T_3	Cartap hydrochloride 50 SP	57.80^{b} (49.49)	42.20^{d} (40.50)	33.43
T_4	Picoxystrobin 7.5% SC + Tricyclazole 22.5% SC	74.30^{e} (59.81)	25.70^{a} (30.18)	59.46
T_5	Azoxystrobin 18.2% SC + Difenoconazole 11.4% SC	75.10^{e} (60.28)	24.90^{a} (29.71)	60.72
T_6	Tebuconazole 50% WG + Trifloxystrobin 25 % WG	77.82^{e} (62.03)	22.18^{a} (27.96)	65.01
T_7	(Chlorantraniliprole 18.5% SC) + (Picoxystrobin 7.5% SC + Tricyclazole 22.5% SC)	73.90^{de} (59.08)	26.10^{a} (30.69)	58.83
T_8	(Chlorantraniliprole 18.5% SC) + (Azoxystrobin 18.2% SC +Difenoconazole 11.4% SC)	73.80^{e} (59.25)	26.20^{a} (30.75)	58.67
T_9	(Chlorantraniliprole 18.5% SC) + (Tebuconazole 50% WG + Trifloxystrobin 25% WG)	73.01^{de} (58.99)	26.99^{ab} (31.00)	57.42
T10	(Tetraniliprole 200 SC) + (Picoxystrobin 7.5% SC + Tricyclazole 22.5% SC)	72.31^{cde} (58.26)	27.69^{abc} (31.68)	56.32
T11	(Tetraniliprole 200 SC + (Azoxystrobin 18.2% SC + Difenoconazole 11.4% SC)	74.62^{e} (59.92)	25.38^{a} (30.08)	59.96
T12	(Tetraniliprole 200 SC) + (Tebuconazole 50% WG + Trifloxystrobin 25% WG)	76.32^{e} (61.26)	23.68^{a} (28.73)	62.64
T13	(Cartap hydrochloride 50 SP) + (Picoxystrobin 7.5% SC + Tricyclazole 22.5% SC)	71.49^{bcde} (57.73)	28.51^{abcd} (32.26)	55.03
T14	(Cartap hydrochloride 50 SP) + (Azoxystrobin 18.2% SC + Difenoconazole 11.4% SC)	74.42^{e} (59.96)	25.58^{a} (30.03)	59.65
T15	(Cartap hydrochloride 50 SP) + (Tebuconazole 50% WG + Trifloxystrobin 25% WG)	75.02^{e} (60.27)	24.98^{a} (29.72)	60.59
T16	Untreated control	36.60^{e} (37.13)	63.40^{e} (52.88)	-
	SEm±	0.88	1.15	-
	CD (P=0.05%)	3.27	3.02	-
	CV	9.30	15.67	-

D.G= Discolored grains, H.G = Healthy grains.
Figures in the parentheses are angular transformed values

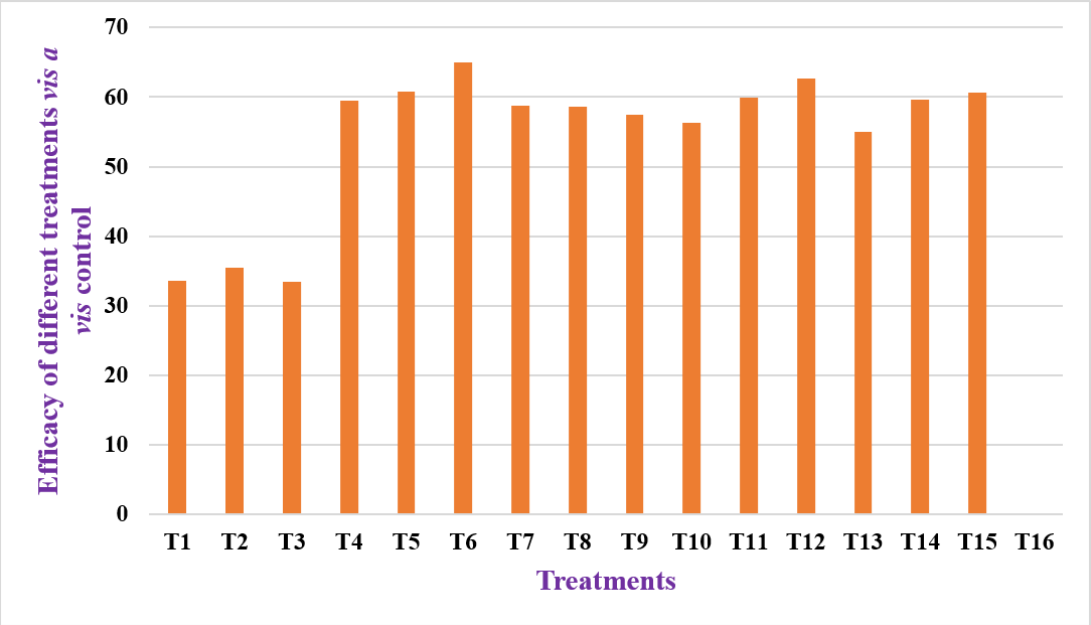

Fig 2: Efficacy of different treatments *vis a vis* control against Grain discolouration

4. Conclusion

All the 9 combinations of insecticides and fungicides and 3 insecticides alone that are tested against leaf folder are more effective and recorded lower incidence than the untreated control while the 3 fungicides alone recorded highest incidence on par with untreated control. The results on grain discoloration stated that that T_6 (tebuconazole + trifloxystrobin), T_{12} (tetraniliprole + (tebuconazole + trifloxystrobin)), T_5 (azoxystrobin + difenoconazole), T_{15} (cartap hydrochloride + (tebuconazole + trifloxystrobin), T_{11} (Tetraniliprole + (azoxystrobin + difenoconazole) were most effective.

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