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Bio-efficacy of new fungicide Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE against coffee leaf rust disease in hill zone of Karnataka

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Abstract
Coffee leaf rust (CLR) is caused by the fungal pathogen, *Hemileia vastatrix* Berk. & Br. and it is the major disease of coffee in all the coffee growing regions. In the present investigation, evaluation of a new combiproduct fungicide molecule against coffee leaf rust disease was carried out in field conditions during *Rabi* 2018 and *Rabi* 2019. The results revealed that, in Rabi 2018 and Rabi 2019, Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE @ 1.50 ml/L showed the least coffee leaf rust disease severity 18.38 PDI and 13.17 PDI respectively which was on par with its higher concentrations (1.75, 3.00 and 4.50 ml/L). Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE @ 1.50 ml/L recorded maximum yield of 690 and 792.66 kg/ha in Rabi 2018 and Rabi 2019 respectively which was on par with other treatments. Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 1.5 ml/L can be adopted in spray schedule for integrated disease management of leaf rust (CLR) in coffee.

Keywords: Coffee, leaf rust, Pyraclostrobin + Epoxiconazole, *Hemileia vastatrix*

1. Introduction
Genus *Coffea* (family: Rubiaceae) includes several species of plants. Among them, *C. arabica* and *C. canephora* are predominantly cultivated for their beans (seeds), that are used to make the stimulatory drink (Cannell, 1985) [4]. In India, during the year 2013-14, the total area under coffee cultivation was 4,15,341 ha which included 2,05,775 ha under arabica coffee and 2,09,566 ha under robusta coffee. The production accounted for 3,11,500 MT with an average productivity of 846 kg per ha (Anon., 2014b) [2]. In Karnataka state, coffee is cultivated in Chikmagalur, Kodagu and Hassan districts spread over an area of 2,30,333 ha which includes 1,09,003 ha under Arabica coffee and 1,13,063 ha under robusta coffee with the production of 2,30,225 MT and 1079 kg per ha productivity (Anon., 2014a) [1].
The coffee (*Coffea arabica* L.) leaf rust caused by *Hemileia vastatrix* Berkeley and Broome was first identified in 1869 attacking coffee trees in Sri Lanka. Since then, this disease has led to high losses in coffee farming. Coffee leaf rust has characteristic symptoms of yellow-orange powdery spots on underside of leaves and corresponding yellow-white patches on upper surface of leaf. The management of coffee leaf rust is usually performed during the rainy season. The disease attacks after the first rains and continues to develop with the progress of the rainy season until it peaks at nine to ten months, during the harvest period (Avelino *et al*., 2015) [3]. The disease causes early leaf fall, resulting in a die-back of productive branches and fruits. Consequently, in the following year, the plants have a low fruit load. In the absence of control measures, the rust can cause losses from 35 to 50 per cent of the Brazilian production (Zambolim, 2016) [12]. Among the chemicals used for the control of the coffee leaf rust, protective or residual action products act to prevent the fungal penetration on the leaf surface. These include the Bordeaux mixture that has been used for over 140 years, inorganic fungicides (oxychloride, hydroxide, copper oxides and sulfates), systemic fungicides (triazoles), and strobilurins (Zambolim *et al*., 2008; Zambolim, 2016) [13, 12]. In present investigation, new combiproduct fungicide molecule Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE was evaluated against coffee rust disease to know its bio-efficacy.

2. Materials and Methods

The field experiment was laid out in Randomized Block Design (RBD) with eight treatments and three replications during *Rabi* 2018 and *Rabi* 2019 at Zonal Agricultural and Horticultural Research Station, Mudigere, Karnataka. The experiments were conducted on existing coffee plantation (spacing at 2 x 3 m). The treatments details are presented here under.

Table 1: Treatments details

S. No.	Treatment	Dose formulated product (ml or g/ ha)	Dosage (ml/g/L)
1	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	625	1.25
2	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	750	1.5
3	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	875	1.75
4	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	1500	3.0
5	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	2250	4.5
6	Check 1: *Opera* (Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE)	750	1.5
7	Check 2: Copper oxychloride 50% WP	5500	11
8	Untreated Control	--	-

2.1 Observations on bio-efficacy of fungicides

Eight different treatments comprising of Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE, at different concentrations with two standard chemical checks (Opera: Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE-Market sample and Copper oxychloride 50% WP) and one untreated control check were evaluated against Rust (CLR). Observations on coffee leaf rust (CLR) severity were recorded as per the scale (1-5) of Muthappa (1974) [7]. For scoring the intensity of Rust (CLR), five plants were randomly selected at before application, 14 days after each application. The first spray of fungicides was done after the first appearances of disease symptoms. The same concentrations were also followed during second and third spray applications with an interval of 15 days. Water sprayed plots were served as untreated check.

2.2 Assessment of PDI (Per cent Disease Index)

Percent disease index (PDI) was calculated by using the formula given by Wheeler (1969) [11].

$$PDI = \frac{\text{Sum of numerical values}}{\text{Number of leaves observed}} X \frac{100}{\text{Maximum disease grade}}$$

3. Results and Discussion

The experiments were conducted at the Zonal Agricultural and Horticultural Research Station, Mudigere during *Rabi*, 2018 and *Rabi*, 2019. Eight different treatments comprising of Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE, at different concentrations with three applications were evaluated against coffee rust (CLR) for bio-efficacy studies.

3.1 Effect of fungicides on severity of coffee leaf rust

In *Rabi* 2018, spraying with Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 4.5 ml/L recorded minimum Per cent Disease Index (PDI) (16.57 PDI) followed by Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 3.0 ml/L (17.25 PDI), Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 1.75 ml/L (18.38 PDI), Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 1.5 ml/L (18.48 PDI) which are on par with lower dose of Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 1.25 ml/L (24.06 PDI) after third spray. The untreated check recorded maximum PDI (47.85) (Table 2). Similar results were recorded in *Rabi* 2019, spraying with Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 4.5 ml/L recorded minimum Per cent Disease Index (PDI) (9.91 PDI) followed by Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 3.0 ml/L (11.10 PDI), Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 1.75 ml/L (12.27 PDI), Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 1.5 ml/L (13.17 PDI) which are on par with other dose of Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 1.25 ml/L (15.33 PDI) after third spray. The untreated check recorded maximum PDI (35.08) (Table 2). The results are in agreement with Souza *et al*. (2011) [9], wherein they reported that, two foliar application of Epoxiconazole managed the coffee leaf rust more effectively than four foliar application of protective fungicide Copper oxychloride. In similar manner, Fernandes *et al*. (2009) [5] revealed that, foliar application of Azoxystrobin + Cyproconazole + Nimbus at 0.5 l/ha (in three applications) successfully controlled coffee leaf rust severity. Similarly, Santoshreddy *et al*. (2019) [8] revealed that, foliar application of fluxapyroxad 167 g/l + pyraclostrobin 333 g/l @ 0.6 ml/l was effective against coffee leaf rust disease. Thammaiah and Swamy (2017) [10] showed that, three sprays of pyraclostrobin 13.3% + epoxyconazole 5% (Opera 18.3%)@0.10 per cent effectively controlled the sigatoka leaf spot disease of banana.

3.2 Influence of fungicides on yield of coffee

Maximum yield of 702 kg/ha and 804.86 kg/ha was recorded in Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 4.5 ml/L in *Rabi* 2018 and *Rabi* 2019 respectively followed by Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 3.0 ml/L (701 kg/ha & 807.27 kg/ha in *Rabi* 2018 & *Rabi* 2019, respectively) and differed significantly from rest of other treatments. The other treatments which recorded better yields were Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 1.75 ml/L (697 kg/ha and 799.44 kg/ha) followed by Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 1.5 ml/L (690 kg/ha and 792.66 kg/ha), Opera (Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE) @ 1.5ml/L (667 kg/ha & 742.15 kg/ha). However, minimum yield of 570 kg/ha and 651 kg/ha was recorded in untreated check in *Rabi* 2018 & *Rabi* 2019, respectively (Table 3). Honorato Junior *et al.* (2015) [6] showed that coffee plants sprayed with either Epoxiconazole or Pyraclostrobin maintained the good photosynthetic performance with optimal conditioning of their antioxidant systems along with less severity of rust disease.

Table 2: Bio-efficacy of Pyraclostrobin 133g/L + Epoxiconazole 50g/L SE against coffee leaf rust disease

S. No.	Treatments	Dosage (g or ml /L)	Coffee Leaf Rust Disease(PDI)							
			2018-19			% reduction over control	2019-20			% reduction over control
			After 1st Spray	After 2nd Spray	After 3rd Spray		After 1st Spray	After 2nd Spray	After 3rd Spray	
1	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	1.25	19.23 (26.01)	22.07 (28.02)	24.06 (29.37)	49.73	12.80 (20.92)	14.66 (22.50)	15.33 (23.04)	56.29
2	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	1.50	15.77 (23.40)	17.50 (24.73)	18.38 (25.39)	61.60	11.48 (19.79)	12.14 (20.37)	13.17 (21.24)	62.45
3	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	1.75	15.17 (22.92)	17.60 (24.80)	18.48 (25.46)	61.38	10.46 (18.86)	11.81 (20.09)	12.27 (20.50)	65.02
4	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	3.00	14.60 (22.46)	16.43 (23.91)	17.25 (24.54)	63.95	9.27 (17.68)	10.64 (19.02)	11.10 (19.44)	68.35
5	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	4.50	14.63 (22.49)	15.78 (23.41)	16.57 (24.02)	65.38	8.52 (16.95)	9.44 (17.88)	9.91 (18.30)	71.75
6	Check 1: Opera (Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE)	1.50	17.13 (24.45)	20.77 (27.11)	22.43 (28.27)	53.12	12.41 (20.62)	14.10 (22.04)	14.93 (22.71)	57.44
7	Check 2: Copper oxychloride 50% WP	11.0	20.90 (27.20)	24.67 (29.78)	26.89 (31.24)	43.81	13.28 (21.30)	15.73 (23.34)	16.21 (23.71)	53.79
8	Control	-	35.60 (36.63)	40.90 (39.76)	47.85 (43.77)	--	26.33 (30.85)	29.19 (32.68)	35.08 (36.31)	--
S. Em+			0.537	0.629	0.787	--	0.91	2.49	2.38	--
CD (5%)			1.644	1.927	2.409	--	2.77	3.46	3.30	--
CV			4.862	4.960	5.680	--	7.57	6.40	5.87	--

* Figures in parenthesis are arc sine values

Table 3: Influence of Pyraclostrobin 133g/L + Epoxiconazole 50g/L SE on yield of coffee

S. No.	Treatments	Dosage (g or ml /L)	Yield	
			Rabi 2018	*Rabi* 2019
1	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	1.25	647	729.35
2	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	1.50	690	792.66
3	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	1.75	697	799.44
4	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	3.00	701	807.27
5	Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE	4.50	702	804.86
6	Check 1: Opera (Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE)	1.50	667	742.15
7	Check 2: Copper oxychloride 50% WP	11.0	630	704.42
8	Control	-	570	651.00
S. Em+			3.519	26.60
CD (5%)			10.776	72.61
CV			7.19	6.03

4. Conclusion

Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 1.5-4.5 ml/L recorded minimum severity of CLR diseases and maximum yield. Therefore, Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE @ 1.5 ml/L can well be adopted as one of the component in developing integrated disease management strategies for minimizing the losses due to leaf rust (CLR) in Coffee.

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