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Field evaluation of different fungicides against *Uromyces ciceris-arietini* causing rust in chickpea in northern Karnataka

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Abstract
A field experiment was conducted to evaluate different fungicides against chickpea rust caused by *Uromyces ciceris-arietini* at Main Agricultural Research Station (MARS), Dharwad and ARS, Arabhavi during *Rabi* 2017 and 2018. The data on percent disease index and seed yield of chickpea for two years and two locations were pooled and revealed that, less percent disease index was observed in spray with Tebuconazole 50%+ Trifloxystrobin 25% w/w 75WG @ 0.5 g/l water and it was found effective in managing the disease with 15.81%. It was followed by Tebuconazole 25 EC @1.0 ml/l (16.60 %) and Propiconazole 25 EC @1 ml/l (18.06 %) and these are on par with each other. Highest percent disease index of 62.12 % was observed in untreated control. Seed yield of 12.38 q/ha was found in spray with Tebuconazole 50 %+ Trifloxystrobin 25% w/w 75WG @ 0.5 g/l water followed by 11.85 q/ha in spray with Tebuconazole 25 EC @1.0 ml/l water and 11.27 q/ha in spray with Propiconazole 25 EC @1 ml/l water. Minimum seed yield of 6.03 q/ha was found in untreated control.

Keywords: Chickpea, rust, percent disease index, seed yield

Introduction
Chickpea (*Cicer arietinum* L.) is most important cool season pulse crop of Indian dry lands. It is an important pulse crop of India with an area of 11.12 million hectares, production of 8.62 million tons and productivity of 2233 kg/ha (2018-19). It is an important source of protein, Carbohydrates, starch, soluble sugars, fat, crude fibre, ash and β-carotene (Gaur *et al*., 2010). Yield of chickpea is largely affected by both biotic and abiotic stresses in all growth stages. Among the biotic stresses, diseases and insect pests accounts for major losses. Among them, soil borne diseases caused by *Fusarium oxysporum* f. sp. *ciceri* and *Rhizoctonia bataticola* are major threats and may cause losses upto 60-70 per cent under favourable conditions for the disease development. Recently chickpea rust caused by *Uromyces ciceris-arietini,* a foliar fungal disease, is severely damage the crop under favourable conditions in northern Karnataka. First rust symptoms appears as small, round or ellipsoidal, cinnamon-brown, powdery pustules on the leaves. These pustules form on both leaf surfaces but more frequently on the lower surface of the leaves. In advanced stages, the sori also seen on upper surface of leaf, pods and occasionally on stem. Severe infection results in premature defoliation and possible death of the entire plant (Patil, 2013) [8]. Spread of the disease is mainly by airborne uredospores. The rust may perpetuate in the uredial state during summer on *Trigonella polycerata* (Lucern) in the hills where climatic conditions are favorable (Saksena and Prasad, 1955) [9].
The pathogen causing rust in chickpea was first detected and described in 1863 in France as *Uredo ciceris-arietini.* Boyer and Joczevski found the telial stage in 1893. Later the name was changed to *Uromyces ciceris-arietini* var. *aetnensis* by Scalia in 1899 and then to *Uromyces ciceris-arietini.* Nargund *et al.* (2011) [6] surveyed and reported that during 2009-10 chickpea suffered heavily due to rust caused by *Uromyces ciceris-arietini*. This disease was noticed in 2006-07 on Bheema genotype in sporadic manner in Dharwad location. During 2009-10 the severity of the disease was to such an extent that all the genotypes grown at Main Agriculture Research Station, Dharwad encompassing germplasm lines, ICRISAT collections, segregating populations and F_1 of several crosses showed highly susceptible reaction to rust. Khedekar (2012) [3] reported that during *Rabi* 2010-11, the rust of chickpea appeared very late in the season in late sown irrigated condition at A.R.S. Arabhavi, A-1 (70.40 PDI), Bheema (70.77 PDI) and JG 11 (60.57 PDI) recorded maximum PDI. Weather data analysis of the two seasons showed a change in rainfall pattern in November- December. Increase in relative humidity was an ideal condition for rust epidemic.

Chickpea rust disease develops in cool and moist weather conditions although rain is not essential for its development. Chickpea rust epidemic is observed in irrigated and late sown crop. Because of uneven rainfall pattern chickpea sowing was late during *Rabi* season, and the crop was irrigated during flowering to pod formation stage, so the yield components were affected by the rust infection. Still now there is no resistance source available for the disease and no much information on management of the disease, which is appearing in severe form in recent years in northern Karnataka and other states of India. Therefore, the field experiment was conducted to evaluate different fungicides against chickpea rust during 2017 and 2018 at Dharwad and Arabhavi.

Materials and methods

Field experiment was conducted during *Rabi* 2017 and 2018, at Main Agricultural Research Station (MARS), Dharwad and ARS, Arabhavi in order to find out the suitable fungicide in managing the rust and to estimate the percent disease index due to the chickpea rust. Twelve different treatments in three replications were used for the experiment. Randomized Block Design (RBD) was followed for statistical analysis. Treatments were imposed immediately after the appearance of the rust disease. The Per cent Disease Index (PDI) of chickpea rust was recorded by using 0-9 scale (Mayee and Datar, 1986) [4] (Fig. 1).

Table 1: Later Per cent Disease Index (PDI) was calculated by using formula given by Wheeler (1969) [11].

Rating value	Description	Reaction
0	No symptoms on leaves.	Immune
1	Uredosori covering 1% or less of leaf area.	Resistant
3	1-10% of the leaf area covered with brown powdery uredosori.	Moderately resistant
5	Uredosori covering 11-25% for leaf area.	Moderately susceptible
7	Uredosori covering 26-50% of leaf area.	Susceptible
9	Uredosori covering 51% or more of leaf area.	Highly susceptible

$$PDI = \frac{\text{Sum of individual disease rating}}{\text{Total No. of plants observed X Maximum disease rating}} \times 100$$

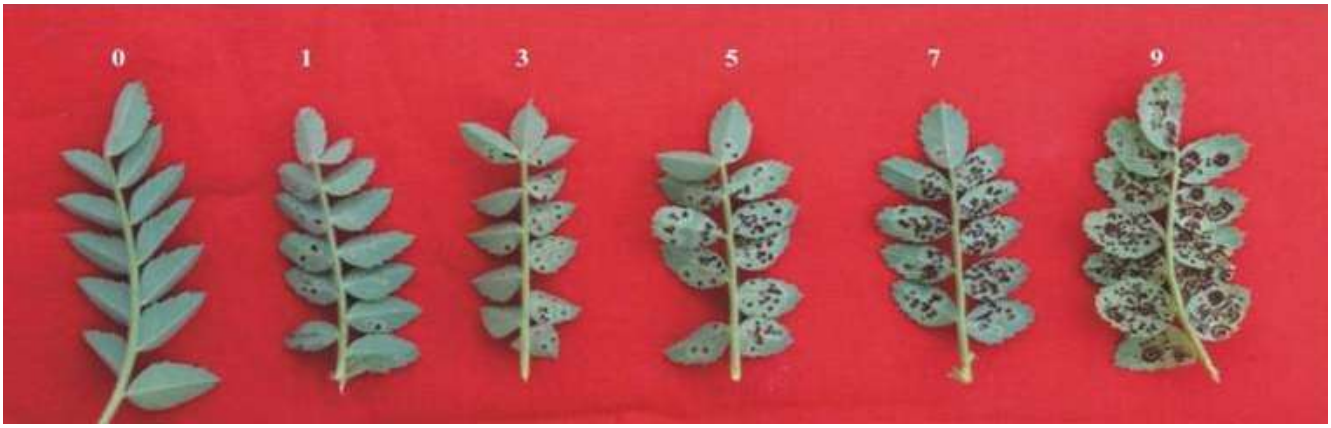

Fig 1: Severity of chickpea rust scoring: 0-9 scale (Sunilkumar S, 2015) [10].

Observations recorded

- **Per cent disease index (PDI):** Observations were recorded on rust severity by using 0-9 scale (Mayee and Datar, 1986) [4]. Later the per cent disease index was calculated and data was subjected to statistical analysis.
- **Seed yield:** Seed yield per plot was recorded by harvesting each treatment separately. Further seed yield per plot was converted to seed yield q/ha.
- **B: C ratio:** The economic return in the form of net income, benefit cost ratio was also worked out, taking into account actual cost of cultivation and fungicidal cost including labour charges for spraying.

Results and discussion:

Percent disease index of rust during 2017

Bioefficacy of eleven fungicides against chickpea rust was evaluated on JG 11 cultivar during *Rabi* 2017 at MARS, Dharwad and ARS, Arabhavi, the results were pooled over two locations and presented in Table 1.

Minimum percent disease index of 15.43 % was observed in treatment with Tebuconazole 50%+ Trifloxystrobin 25% w/w 75WG @ 0.5 g/l water and it was found effective in managing the disease followed by Tebuconazole 25 EC @1.0 ml/l (15.85%) and Propiconazole 25 EC @1 ml/l (16.93%) and these are on par with each other. All the treatments were significantly superior to untreated check (57.87%). Highest seed yield of 12.19 q/ha was observed in treatment with Tebuconazole 50 %+ Trifloxystrobin 25% w/w 75WG @ 0.5 g/l water followed by Tebuconazole 25 EC @1.0 ml/l (12.04 q/ha) and Propiconazole 25 EC @1 ml/l (11.42 q/ha) and these three treatments are on par with each other and significantly superior to rest of the treatments. Lowest seed yield of 6.16 q/ha was observed in untreated check.

Percent disease index of rust during 2018

The same experiment was repeated during *Rabi*, 2018 and same trend of results were obtained as in 2017. All the treatments were significantly superior to untreated control. Pooled data of two locations were presented in table 1.

Among the treatments spray with Tebuconazole 50%+ Trifloxystrobin 25% w/w 75WG @ 0.5 g/l water recoded the minimum percent disease index of 6.47 % followed by Tebuconazole 25 EC @1.0 ml/l (7.02%) and Propiconazole 25 EC @1 ml/l (8.05%) and these were on par with each

other. Significantly superior seed yield of 10.81 q/ha was observed in treatment with Tebuconazole 50 %+ Trifloxystrobin 25% w/w 75WG @ 0.5 g/l water followed by Tebuconazole 25 EC @1.0 ml/l (10.22 q/ha) and Propiconazole 25 EC @1 ml/l (9.78 q/ha) and these three treatments were on par with each other. Lowest seed yield of 5.97 q/ha was observed in untreated check.

Pooled percent disease index and seed yield (MARS, Dharwad and ARS, Arabhavi during 2017 and 2018, *Rabi*)

Percent disease index and seed yield was pooled over two locations (MARS, Dharwad and ARS, Arabhavi) for two years (2017 and 2018) revealed that, all the treatments were significantly superior to untreated control (table 2). Minimum percent disease index of 10.95% was observed in spray with Tebuconazole 50 %+ Trifloxystrobin 25% w/w 75WG @ 0.5 g/l water and it was found effective in managing the disease. It was followed by Tebuconazole 250 EC @1.0 ml/l (11.43%) and Propiconazole 25 EC @1 ml/l (12.49%) and these were on par with each other. Significantly highest seed yield of 11.5 q/ha was obtained in spray with Tebuconazole 50 %+ Trifloxystrobin 25% w/w 75WG @ 0.5 g/l water (11.5 q/ha) and Tebuconazole 25 EC @1.0 ml/l (11.13q/ha) and it was followed by Propiconazole 25 EC @1 ml/l (10.60q/ha). Whereas, lowest seed yield (6.06 q/ha) was obtained in untreated check.

Similar observations were observed by, Alam *et al.* (2007) [1] studied efficacy of eight different fungicides against of rust and powdery mildew of garden pea management. Among all fungicides Propiconazole performed better than other fungicides and untreated control. Mishra and Pandey (2009) reported that four sprays of Propiconazole (0.1%) at 7 days interval resulted in lowest disease severity (20.5%) of pea rust caused by *Uromyces fabae* with highest grain yield (1037.50 kg / ha) followed by Hexaconazole (0.1%) and Benomyl (0.2%). Emeran *et al.* (2011) [2] reported that application of Triazoles (Difenconazole, Epaxiconazole and Tebuconazole) and their mixture with Benzimidazoles (Carbandazim-Flutriafol and Carbandazim-Flusilazole) were shown better curative effect against bean rust (*Uromyces viciae-fabae*). They were followed by Dithiocarbomates, Copper dithiocarbomate mixture, Carboxamide and Chlorothalonil. Triazoles, Benzimidazole- Triazole mixtures and Carboxamide maintained their effect 15 days after application. Triazoles and Benzimidazole-Triazole mixtures provide significant yield increases (15.6 - 22.7%) when applied twice. Dithiorcabomates (Thiram, Maneb or Mancozeb) or Chlorothalonil reduced the rust severity but does not provide a significant yield increase. Papur *et al.* (2013) [7] reported that the application of Tebuconazole (20 ml/15 l) three times reduced snap bean rust severity to the extent of 5.7 per cent and 2.4 per cent in 2010 and 2011 respectively.

Benefit cost ratio (B: C)

In the experiment, economics were calculated by considering cost of cultivation, cost of treatment and gross returns and net returns. The highest B:C of 2.47 was obtained in spray with Tebuconazole 50 %+ Trifloxystrobin 25% w/w 75WG @ 0.5 g/l water followed by Tebuconazole 250 EC @1.0 ml/l (2.46) and Propiconazole 25 EC @1 ml/l (2.43) (Table 2).

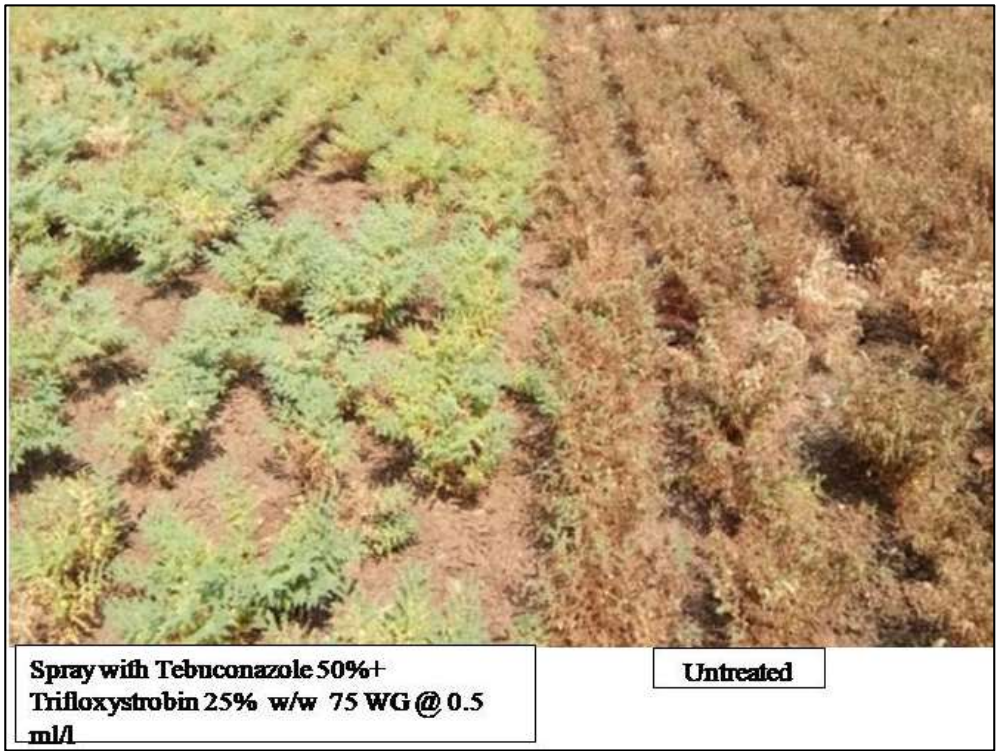

Fig 2: Management of chickpea Rust

Table 1: Evaluation of different chemicals for the management of chickpea rust (pooled 2017 and 2018)

Trt. No.	Treatment details	Percent disease index						Seed Yield (q/ha)					
		2017			2018			2017			2018		
		Dharwad	Arabhavi	Pooled	Dharwad	Arabhavi	Pooled	Dharwad	Arabhavi	Pooled	Dharwad	Arabhavi	Pooled
T_1	Hexaconazole 5 EC @1 ml/l	36.79* (37.36)	7.15 (15.51)	21.97 (26.43)	13.1 (21.19)	14.86 (22.68)	13.98 (21.94)	8.12	9.82	8.97	9.35	7.76	8.56
T_2	Propiconazole 25 EC @1 ml/l	28.00 (31.96)	5.86 (14.01)	16.93 (22.99)	8.12 (16.55)	7.98 (16.41)	8.05 (16.48)	12.33	10.52	11.42	10.21	9.35	9.78
T_3	Tebuconazole 25 EC @1 ml/l	26.85 (31.22)	4.85 (12.73)	15.85 (21.97)	6.35 (14.59)	7.69 (16.09)	7.02 (15.34)	13.25	10.82	12.04	10.46	9.98	10.22
T_4	Difenconazole 25 EC@1 ml/l	28.39 (32.21)	6.51 (14.79)	17.45 (23.49)	9.22 (17.68)	8.83 (17.3)	9.03 (17.49)	11.10	9.65	10.38	9.53	9.13	9.33
T_5	Pyraclostrobin 25 EC @1 ml/l	31.09 (33.91)	8.94 (17.4)	20.02 (25.66)	10.94 (19.32)	9.4 (17.86)	10.17 (18.6)	11.54	9.02	10.28	9.10	8.78	8.94
T_6	Trifloxystrobin @1 ml/l	29.21 (32.73)	8.25 (16.7)	18.73 (24.72)	11.41 (19.74)	11.56 (19.89)	11.48 (19.81)	9.97	9.20	9.58	9.20	8.56	8.88
T_7	Mancozeb 75 WP @ 2 g/l	37.5 (37.78)	14.25 (22.18)	25.88 (29.98)	17.39 (24.66)	17.6 (24.8)	17.5 (24.73)	7.50	7.10	7.30	7.25	7.20	7.23
T_8	Zineb 68% + Hexaconazole 4% WP @ 2 g/l	37.81 (37.96)	12.47 (20.68)	25.14 (29.32)	15.31 (23.04)	15.4 (23.11)	15.36 (23.08)	7.27	7.45	7.36	7.50	7.32	7.41
T9	Carbendazim 12% + Mancozeb 63% WP @ 1 g/l	36.94 (37.45)	14.94 (22.74)	25.94 (30.09)	17.49 (24.72)	18.85 (25.74)	18.17 (25.23)	7.69	7.00	7.35	7.21	7.17	7.19
T10	Fluopyram 17.7%+ Tebuconazole17.7% @ 1ml/l	29.2 (32.72)	9.28 (17.74)	19.24 (25.23)	13.02 (21.12)	13.25 (21.36)	13.13 (21.24)	10.84	8.90	9.87	8.43	8.13	8.28
T_{11}	Tebuconazole 50 % + Trifloxystrobin 25% w/w 75WG @ 0.5 g/l	26.09 (30.73)	4.77 (12.62)	15.43 (21.66)	5.53 (13.6)	7.4 (15.79)	6.47 (14.7)	13.33	11.05	12.19	10.73	10.90	10.81
T12	Control	84.22 (66.62)	31.52 (34.14)	57.87 (50.41)	40.02 (39.26)	29.5 (32.91)	34.76 (36.08)	5.43	6.90	6.16	6.64	5.29	5.97
	SEm±	1.00	0.66	1.00	0.73	0.69	0.84	0.38	0.26	0.28	0.34	0.24	0.17
	CD (5%)	2.89	1.91	2.91	2.11	2.00	2.43	1.10	0.76	0.80	0.98	0.71	0.50

* Figures in the parenthesis are arc sin transformed values

Table 2: Benefit cost ratio for Evaluation of different chemicals for the management of chickpea rust Pooled 2017 and 2018 at Dharwad and Arabhavi

Treatment No.	Treatment details	Pooled percent disease index (2017 and 2018)	Pooled seed yield q/ha(2017 and 2018)	Cost of cultivation	Gross Returns	Net Returns	BCR
T_1	Hexaconazole 5 EC @1 ml/l	17.97(25.09)	8.76	19850	40473	20623	2.04
T_2	Propiconazole 25 EC @1 ml/l	12.49(20.7)	10.60	20150	48978	28828	2.43
T_3	Tebuconazole 25 EC @1 ml/l	11.43(19.77)	11.13	20915	51407	30492	2.46
T_4	Difenconazole 25 EC@1 ml/l	13.24(21.34)	9.85	20850	45507	24657	2.18
T_5	Pyraclostrobin 25 EC @1 ml/l	15.09(22.87)	9.61	20950	44394	23444	2.12
T_6	Trifloxystrobin @1 ml/l	15.11(22.88)	9.23	21050	42650	21600	2.03
T_7	Mancozeb 75 WP @ 2 g/l	21.69(27.76)	7.26	20650	33553	12903	1.62
T_8	Zineb 68% + Hexaconazole 4% WP @ 2 g/l	20.25(26.75)	7.38	20560	34115	13555	1.66
T_9	Carbendazim 12% + Mancozeb 63% WP @ 1 g/l	22.05(28.02)	7.27	20230	33578	13348	1.66
T_{10}	Fluopyram 17.7%+ Tebuconazole17.7% @ 1ml/l	16.19(23.72)	9.07	22550	41917	19367	1.86
T_{11}	Tebuconazole 50 % + Trifloxystrobin 25% w/w 75WG @ 0.5 g/l	10.95(19.32)	11.50	21525	53142	31617	2.47
T_{12}	Control	46.32(42.9)	6.06	19650	28015	8365	1.43
	SEm±	0.70	0.16				
	CD (5%)	2.01	0.45				

* Figures in the parenthesis are arc sin transformed values

Conclusion

Chickpea rust is a foliar fungal disease; normally its epidemic is observed sporadically and begins late in the season so yield components are usually less affected by the infection. However, early infection leads to greater yield loss. As chickpea rust is appearing in severe form in recent days due to heavy rainfall during sowing season and the crop was sown late in northern Karnataka, yield is affected. The present study revealed that, the rust disease has appeared in moderate to severe form in northern Karnataka. Lentil and lucern found to be the collateral hosts of chickpea rust. Screening of Germplasm lines for rust resistance is very much necessary for identification of resistance sources as all the popular varieties are susceptible to disease.

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