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STUDIES ON EPIDEMIOLOGY OF RUST DISEASE IN CULTIVATED FIG (*FICUS CARICA* L.) CAUSED BY *CEROTELIUM FICI* (CAST) ARTH.

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ABSTRACT

Fig is the nutritious fruit grown in tropical and subtropical regions of the world. The rust disease caused by *Cerotelium fici* is the most significant disease affecting the crop productivity. The weather plays a significant role in the spread and establishment of the disease. Hence the study was conducted to know the influence of weather parameters such as temperature, relative humidity and rainfall on the disease severity of the fig. In the present investigation it was found that temperature plays as a significant limiting factor impacting the disease severity, relative humidity positively favors the disease and rainfall was found to have no significant role in the severity of the rust disease. Along with the weather, the host resistance plays a major role in the fig rust disease severity.

Key words : Fig rust, Temperature, Relative humidity, Rainfall, AUDPC.

Introduction

Fig (*Ficus carica* L.) is among the most important cultivated deciduous fruit species in the world. It belongs to the family, Moraceae, which consists of about 40 genera and 1400 species of trees and shrubs (Watson and Dalwitz, 2004). The figs are highly nutritious and rich in calories. The protein and calcium content in fig fruit is higher than that of the milk. Therefore, the fig has secured a significant place in the world due to its nutritional importance and there are many value-added products. The use of fig fruit as food, and of fig plants for ornamental purposes, have been recorded for thousands of years including in the Bible (Eisen, 1901). Turkey is the largest producer of figs in the world, contributing significantly to the global total of 1,315,588 tonnes in 2019, followed by Egypt and Algeria. Asia accounted for 43.8 per cent and Africa for 39.4 per cent of global fig production, with notable contributions from Mediterranean and Near Eastern regions (FAOSTAT, 2019). In subtropical regions, fig crops are grown to produce ripe figs to supply fresh fruit markets, or unripe

fruit to produce sweets and crystallized figs. Although fig originated in temperate regions (Pio *et al.*, 2019), it can adapt to different climates and soil conditions, which has boosted expansion of fig production to tropical and subtropical regions (Zhou and Qiao, 2024). However, when cultivated in subtropical regions, fig crops are vulnerable to a variety of diseases that can significantly impact their growth, yield, and overall fruit quality.

Fig rust (*Cerotelium fici* (Cast.) Arth.) is the important disease that affects fig crops (Galleti and Rezende, 2005). Symptoms of the disease on adaxial surfaces of fig leaves appear as angular yellow-green spots that progress to brown. On abaxial leaf surfaces orange-red pustules develop that contain powdery masses of spores. In severe infections, the leaves fall, and growth and ripening of the figs are halted. With the premature fall of leaves, there is a reduction in the accumulation of carbohydrates, which compromises the next fruit production cycle (Galleti and Rezende, 2005). Since the significant yield and quality losses are caused by the rust diseases appropriate management strategies involving the use of resistant

cultivars, timely fungicide applications, development of biological control agents, resistance inducers, appropriate pruning techniques or crop management techniques are critical. The interference with these measures is to be timely and is well shown using the disease triangle and quadrangle which gives the clear outline of the predisposing factors for disease development. The weather and the host plant play a significant role in the establishment of the pathogen and thereby the development of the disease. Hence the study was undertaken to know the effect of weather factors on the development of disease among the six popular fig varieties at the Fruit orchard, UHS Bagalkot and at the Department of Plant Pathology, College of Horticulture, Bagalkot, UHS, Bagalkot during the year 2017-18.

Materials and Methods

The influence of the temperature and relative humidity on the uredosori germination was studied *in-vitro* at the Department of Plant Pathology, College of Horticulture, Bagalkot. The investigation on the influence of weather parameters on the disease development among the different fig varieties was carried out at Sector No. 70, Fruit Orchard, UHS, Bagalkot. The symptomatology of the fig rust disease was studied through literature survey and by thorough investigation of the healthy and rust affected fig plants in the farmers' fields.

The uredosori were freshly collected from the rust affected fig leaves from Fruit Orchard, Bagalkot, in the early morning. The uredospores on the abaxial surface of the leaf were carefully brushed off using plant brush No. 10 on the white clean paper, which was then collected into 2 ml Eppendorf tubes.

Effect of temperature on uredospore germination

The cardinal temperature required for uredospore germination was carried out using cavity slide method. Uredospore suspension prepared in water agar (0.5% agar) containing 2.5 per cent sucrose. The cavity slides kept in the Petri plates lined with the moistened blotting paper incubated at temperature ranging from 10- 40°C in an incubator for 24 h. Three replications were maintained for each temperature and the observations were recorded after 24 h. The per cent spore germination was calculated as mentioned below,

$$\text{Per cent spore germination} = \frac{\text{No. of uredospores germinated}}{\text{Total no. of uredospores observed}} \times 100$$

Effect of relative humidity on uredospore germination

Two hundred µl of uredospore suspension was prepared in water agar (0.5%) containing 2.5 per cent sucrose solution was taken on cavity slide. The cavity slides were kept in the moist chamber and were incubated at 25°C by maintaining the relative humidity levels viz., 60, 65, 70, 75, 80, 85, 90 and 95 per cent by dissolving 38, 36, 33, 30, 27, 23, 18 and 11 per cent concentrated sulphuric acid (H₂SO₄), respectively in the desiccators containing distilled water. Cent per cent relative humidity was obtained using only distilled water without adding sulphuric acid (Solomon, 1951). Three replications were maintained for each treatment. Uredospore germination was observed after 24 h of incubation. The per cent germination was calculated.

Weather factors affecting fig rust disease severity among the fig varieties in natural epiphytotic conditions

Simple linear correlation and regression analysis

The rust disease severity on the six popular fig varieties viz., Bellary, Conadriya, Dienna, Dinakar, Excel and Poona grown at Sector No. 70, Fruit Orchard, UHS, Bagalkot was correlated with the weather parameters like relative humidity (morning and afternoon in %), temperature (maximum and minimum in °C) and rainfall (mm) during the year 2017-18. The meteorological data of the corresponding duration was collected from Agro-meteorology Division, Main Horticultural Research and Extension Centre, UHS Bagalkot. The data collected was averaged at seven days interval for the same week of disease severity, at seven days interval one week prior to the observed disease severity and at seven days interval two weeks prior to the observed disease severity. The data of the meteorological parameters averaged at periodical intervals were subjected to simple linear correlation and multiple regression analysis.

The observations of rust disease severity were recorded using the 0-9 scale (Prakashan and Thamburaj, 1991) and the Per cent Disease Index was calculated using the formula given by Wheeler (1969).

Scale (0-9) for recording observations

Rating	Description	Per cent leaf area covered
0	No symptoms on leaves	Nil
1	Minute orange-coloured pustules	<1
3	Typical brown-coloured pustules	1-10
5	Typical brown-coloured pustules	11-25
7	Typical brown-coloured pustules	26-50
9	Typical brown-coloured pustules	>51

$$\text{Per cent Disease Index} = \frac{\text{Sum of all disease ratings}}{\text{No. of samples assessed} \times \text{Maximum disease rating used}} \times 100$$

Area Under Disease Progress Curve (AUDPC) and infection rate (r)

Area Under Disease Progress Curve (AUDPC) is the progress of disease severity in any field over time. It summarizes disease severity data collected at multiple time points during a crop season and is commonly used to compare disease development across treatments, cultivars, or environments.

The AUDPC was calculated by using the formula given by Wilcoxson *et al.*, 1986 for the fig varieties viz., Bellary, Conadriya, Dienna, Dinakar, Excel and Poona grown at Sector No. 70, Fruit Orchard, UHS, Bagalkot.

$$\text{AUDPC} = \sum_{n=1}^{i-1} \frac{(X_i + X_{i-1})}{2} \times d$$

Where, X_i = Rust severity at the end of i^{th} observation

K = Number of successive evaluations of rust severity

d = Interval between two evaluations in days

Rate of infection is the increase or decrease in disease severity per unit time. The rate of infection (r) for the fig varieties viz., Bellary, Conadriya, Dienna, Dinakar, Excel and Poona grown at Sector No. 70, Fruit Orchard, UHS, Bagalkot was worked out by using the formula given by Vanderplank (1963),

$$'r' \text{ per day} = (2.3/(t_2 - t_1)) \times \log (X_2/X_1)$$

Results

In-vitro studies on effect of temperature (°C) and relative humidity (%) on uredospore germination

The uredospore germination assay from temperature range of 10 to 40°C (Table 1) revealed, 25°C as congenial for uredospore germination with the mean maximum uredospore germination of 51.10 per cent. The least germination was observed at 40°C (1.22%) temperature. The table clearly shows that the uredospore germination

decreased rapidly with increasing temperature. The data on the uredospore germination at different levels of relative humidity (%) (Table 2) shows that the mean maximum uredospore germination was at 100 per cent relative humidity (60.38%) followed by 95 per cent (49.56%). The least uredospore germination was recorded at 70 per cent relative humidity (3.54%). At 65 per cent relative humidity uredospore germination was not observed.

Weather factors affecting fig rust disease severity among the fig varieties in natural epiphytotic conditions

Simple linear correlation

The observation on disease severity of rust were recorded on the fig varieties viz., Conadriya, Excel, Dienna, Dinakar, Bellary and Poona at weekly interval from October 2017 to May, 2018 and correlated with the weather parameters of the same week, one week prior to the observed data and two weeks prior.

The data of correlation between the weather parameters of the same week with the rust disease severity presented in the table 3a revealed that the weather parameter morning RH (%) and evening RH (%) was significantly positively correlated with the disease severity of all the six fig varieties. The minimum temperature was negatively significantly correlated with rust disease severity of all the fig varieties except Bellary where it was non-significant (-0.003). The maximum temperature was also negatively correlated with the rust disease severity of all the fig varieties except Bellary (-0.253), where the temperature was found non-significant.

To know the relation of the weather parameters on the disease severity of preceding week, correlation studies were conducted and the data is presented in the table 3b. The disease severity of Bellary was significantly positively correlated with morning RH (0.438) and afternoon RH (0.388), and non-significantly positively correlated with



Fig. 1 : Symptoms of fig rust disease caused by *Cerotelium fici* (Cast) Arth.

Table 1 : Effect of temperature on uredospore germination of *Cerotelium fici*.

S. no.	Temperature (°C)	Uredospore germination (%)
1	10	8.48(16.19)
2	15	14.45(22.32)
3	20	37.34(37.65)
4	25	51.10(45.61)
5	30	8.27(16.70)
6	35	6.71(14.95)
7	40	1.22(6.10)
	S. Em ±	0.72
	CD @ 0.01	2.21

*Values in the paranthesis are arc sine transformed.

Table 2 : Effect of relative humidity on uredospore germination of *Cerotelium fici*.

S. no.	Relative humidity (%)	Uredospore germination (%)
1	65	0.00(5.73)
2	70	3.54(10.83)
3	75	6.00(14.13)
4	80	10.16(18.56)
5	85	22.54(28.32)
6	90	24.17(29.42)
7	95	49.56(44.73)
8	100	60.38(50.96)
	S. Em ±	0.47
	CD @ 0.01	1.38

*Values in the paranthesis are arc sine transformed.

the minimum temperature (0.015) and non-significantly correlated with the maximum temperature (-0.250) and non-significantly positively correlated with the rainfall (0.267). The diseaseseverity in Conadria showed significant positive correlation with morning RH (0.583) and afternoon RH (0.535), significant negative correlation with minimum temperature (-0.695) and maximum temperature (-0.794) and non-significantly positively correlated with the rainfall (0.075). The rust disease in Dienna showed significant positive correlation with morning RH (0.440) and afternoon RH (0.540), significant negative correlation with minimum temperature (-0.609) and maximum temperature (-0.741) and non-significantly negatively correlated with rainfall (-0.131). The disease on Dinakar variety showed significant positive correlation with morning RH (0.545), afternoon RH (0.484), significant negative correlation with minimum temperature (-0.383) and maximum temperature (-0.637) and non-significant positive correlation with rainfall (0.021). In Excel the disease progression showed

significant positive correlation with morning RH (0.604), afternoon RH (0.548), significant negative correlation with minimum temperature (-0.628), maximum temperature (-0.841) and non-significantly negatively correlated with rainfall (-0.033). The disease severity in the variety Poona was significantly positively correlated with morning RH (0.505) and afternoon RH (0.678), non-significantly negatively correlated with minimum temperature (-0.269) significantly negatively correlated with maximum temperature (-0.605) and non-significantly positively correlated with rainfall (0.068).

The results presented in the table 3c shows the relationship between the weather parameters prevailing two weeks before observed disease severity. The data revealed that morning and afternoon relative humidity were significantly positively correlated with disease severity of Conadriya (0.625, 0.565), Dienna (0.526, 0.519), Dinakar (0.590, 0.491), Excel (0.628, 0.546), Poona (0.550, 0.692) except for Bellary in which the disease showed significant positive correlation with morning RH (0.410) and non-significant positive correlation with afternoon RH (0.297). The minimum and maximum temperature was significantly negatively correlated with the rust disease severity in Conadriya (-0.535, -0.837), Dienna (-0.533, -0.750), Dinakar (-0.320, -0.620), Excel (-0.563, -0.788) and Poona (-0.180, -0.541) showed non-significant negative correlation with minimum temperature and significant negative correlation with maximum temperature. In Bellary the disease showed non-significant positive correlation with minimum temperature (0.016) and non-significant negative correlation with maximum temperature (-0.233). The rainfall was non significantly positively correlated with Bellary (0.248), Dienna (0.039), Dinakar (0.110), Excel (0.106) and Poona (0.184) and was negatively correlated with Conadria (-0.009).

Multiple linear regression

The occurrence and growth of rust disease depends on several weather parameters. Therefore, to know the influence of metrological parameters on rust disease severity, regression analysis was conducted.

The regression equation for the fig rust severity determined from the weather factors of the same week, one week prior and two weeks prior is presented in the table 4.

The regression equations determined from the weather factors of the same week (W_1)

Regression equation for Bellary was $Y = 46.33 + 0.21MRH + 0.05ARH + 1.35T_{min} - 1.19T_{max} - 1.01RF$, Conadriya was $Y = 126.08 + MRH - 0.11ARH -$

Table 3a : Correlation co-efficient between meteorological factors and rust disease in different fig varieties.

S. no.	Weather parameters	r values					
		Conadriya	Excel	Dienna	Dinakar	Bellary	Poona
1	Relative humidity (am) %	0.477**	0.516**	0.435*	0.610**	0.470**	0.552**
2	Relative humidity (pm) %	0.488**	0.538**	0.491**	0.496**	0.425*	0.611**
3	Temperature (Min) °C	-0.806**	-0.798**	-0.684**	-0.522**	-0.003	-0.395*
4	Temperature (Max) °C	-0.875**	-0.885**	-0.753**	-0.738**	-0.253	-0.656**
5	Rainfall (mm)	-0.018	-0.254	-0.256	-0.064	-0.076	-0.040

** Significance at 0.01 (r=0.456); *Significance at 0.05 (r=0.355).

Table 3b : Correlation co-efficient between one-week prior meteorological factors and rust disease in different fig varieties.

S. no.	Weather parameters	r values					
		Conadriya	Excel	Dienna	Dinakar	Bellary	Poona
1	Relative humidity (am) %	0.583**	0.604**	0.440*	0.545**	0.438*	0.505**
2	Relative humidity (pm) %	0.535**	0.548**	0.540**	0.484**	0.388*	0.678**
3	Temperature (Min) °C	-0.695**	-0.628**	-0.609**	-0.383*	0.015	-0.269
4	Temperature (Max) °C	-0.794**	-0.841**	-0.741**	-0.637**	-0.250	-0.605**
5	Rainfall (mm)	0.075	-0.033	-0.131	0.021	0.267	0.068

** Significance at 0.01 (r=0.456); *Significance at 0.05 (r=0.355).

Table 3c : Correlation co-efficient between two-week prior meteorological factors and rust disease in different fig varieties.

S. no.	Weather parameters	r values					
		Conadriya	Excel	Dienna	Dinakar	Bellary	Poona
1	Relative humidity (am) %	0.625**	0.628**	0.526**	0.590**	0.410*	0.550**
2	Relative humidity (pm) %	0.565**	0.546**	0.519**	0.491**	0.297	0.692**
3	Temperature (Min) °C	-0.535**	-0.563**	-0.533**	-0.320	0.016	-0.180
4	Temperature (Max) °C	-0.837**	-0.788**	-0.750**	-0.620**	-0.233	-0.541**
5	Rainfall (mm)	-0.009	0.106	0.039	0.110	0.248	0.184

** Significance at 0.01 (r=0.456); *Significance at 0.05 (r=0.355)

$0.46T_{\min} - 2.31T_{\max} - 1.37RF$, Excel was $Y = 130.73 + 0.22MRH - 0.06ARH - 0.62T_{\min} - 2.24T_{\max} - 0.53RF$, Dienna was $Y = 104.78 + 0.18MRH - 0.01ARH - 0.70T_{\min} - 1.41T_{\max} + 0.71RF$, Dinakar was $Y = 103.80 + 0.08MRH - 0.06ARH - 0.57T_{\min} - 2.07T_{\max} + 0.79RF$ and Poona was $Y = 90.60 + 0.07MRH + 0.02ARH + 1.09T_{\min} - 2.25T_{\max} - 0.13RF$. Here MRH depicts the morning relative humidity (%), ARH- afternoon relative humidity (%), $T_{\min}$ - minimum temperature (°C), $T_{\max}$ - maximum temperature (°C) and RF- rainfall (mm). The relative contribution of each weather factor to the disease severity (Y) could be predicted from the above equation and the influence of these factors differed among the varieties.

The coefficient of determinative value (R^2) was found to be indicating that 32 per cent on Bellary, 82 per cent on Conadriya, 58 per cent on Dienna, 67 per cent on Dinakar, 81 per cent on Excel and 56 per cent on Poona

of variation in disease severity was accounted by linear function (Table 4).

Regression equations determined by weather factors prevailing one week prior (W_2)

The regression equation for Bellary was $Y = 30.86 + 0.14MRH + 0.12ARH + 0.03T_{\min} + 0.16T_{\max} + 1.32RF$, R^2 value of which was indicating 24 per cent variation in disease severity was ascribed to the linear function. The regression equation for Conadriya was $Y = 103.12 + 0.19MRH + 0.02ARH - 1.74T_{\min} - 0.90T_{\max} + 2.76RF$, which shows the morning and afternoon relative humidity and rainfall are having positive influence whereas minimum and maximum temperature having negative influence. These factors were accountable to the extent of 83 per cent. Regression equation of Dienna was $Y = 102.41 + 0.41MRH + 0.04ARH - 0.91T_{\min} - 1.22T_{\max} - 0.54RF$, 61 per cent of variation in decisive variety was attributed to this linear function. Regression equation of

Table 4 : Regression equation for rust severity in six varieties of fig in relation to weather parameters.

Week	Variety	Regression equation	R ² value
W ₁	Conadriya	$Y=126.08 + 0.26 \text{ MRH} - 0.11 \text{ ARH} - 0.46 T_{\min} - 2.31 T_{\max} - 1.37 \text{ RF}$	0.82
	Excel	$Y=130.73 + 0.22 \text{ MRH} - 0.06 \text{ ARH} - 0.62 T_{\min} - 2.24 T_{\max} - 0.53 \text{ RF}$	0.81
	Dienna	$Y=104.78 + 0.18 \text{ MRH} - 0.01 \text{ ARH} - 0.70 T_{\min} - 1.41 T_{\max} + 0.71 \text{ RF}$	0.58
	Dinakar	$Y=103.80 + 0.08 \text{ MRH} - 0.06 \text{ ARH} - 0.57 T_{\min} - 2.07 T_{\max} + 0.79 \text{ RF}$	0.67
	Bellary	$Y=46.33 + 0.21 \text{ MRH} + 0.05 \text{ ARH} + 1.35 T_{\min} - 1.19 T_{\max} - 1.01 \text{ RF}$	0.32
	Poona	$Y=90.60 + 0.07 \text{ MRH} + 0.02 \text{ ARH} + 1.09 T_{\min} - 2.25 T_{\max} - 0.13 \text{ RF}$	0.56
W ₂	Conadriya	$Y=103.12 + 0.19 \text{ MRH} + 0.02 \text{ ARH} - 1.74 T_{\min} - 0.90 T_{\max} + 2.76 \text{ RF}$	0.83
	Excel	$Y=104.30 + 0.35 \text{ MRH} - 0.04 \text{ ARH} - 0.98 T_{\min} - 1.5 T_{\max} - 0.62 \text{ RF}$	0.79
	Dienna	$Y=102.41 + 0.41 \text{ MRH} + 0.04 \text{ ARH} - 0.91 T_{\min} - 1.22 T_{\max} - 0.54 \text{ RF}$	0.61
	Dinakar	$Y=61.05 + 0.18 \text{ MRH} + 0.0002 \text{ ARH} - 0.19 T_{\min} - 0.54 T_{\max} - 0.58 \text{ RF}$	0.47
	Bellary	$Y=30.86 + 0.14 \text{ MRH} + 0.12 \text{ ARH} + 0.03 T_{\min} + 0.16 T_{\max} + 1.32 \text{ RF}$	0.24
	Poona	$Y=55.85 + 0.012 \text{ MRH} + 0.15 \text{ ARH} + 0.04 T_{\min} - 0.60 T_{\max} + 0.62 \text{ RF}$	0.51
W ₃	Conadriya	$Y=93.10 + 0.39 \text{ MRH} - 0.05 \text{ ARH} - 0.29 T_{\min} - 1.83 T_{\max} + 0.79 \text{ RF}$	0.79
	Excel	$Y=87.01 + 0.41 \text{ MRH} - 0.03 \text{ ARH} - 1.06 T_{\min} - 1.13 T_{\max} - 0.58 \text{ RF}$	0.73
	Dienna	$Y=96.04 + 0.28 \text{ MRH} - 0.01 \text{ ARH} - 0.77 T_{\min} - 1.34 T_{\max} + 0.69 \text{ RF}$	0.62
	Dinakar	$Y=54.15 + 0.22 \text{ MRH} + 0.002 \text{ ARH} - 0.18 T_{\min} - 0.44 T_{\max} - 0.51 \text{ RF}$	0.48
	Bellary	$Y=30.31 + 0.20 \text{ MRH} + 0.04 \text{ ARH} + 0.05 T_{\min} + 0.13 T_{\max} + 0.21 \text{ RF}$	0.17
	Poona	$Y=35.37 + 0.10 \text{ MRH} + 0.17 \text{ ARH} + 0.063 T_{\min} - 0.19 T_{\max} + 0.51 \text{ RF}$	0.51

W₁ – Same week at seven days interval

W₃ – Two week prior to the observed disease severity

MRH- Morning relative humidity (%)

T_{min} - Minimum temperature (°C)

Dinakar was $Y=61.05+0.18\text{MRH}+0.0002\text{ARH}-0.19T_{\min}-0.54T_{\max}-0.58\text{RF}$ this owed 47 per cent variation in disease severity. Regression equation of Excel was $Y=104.30+0.35\text{MRH}-0.04\text{ARH}-0.98T_{\min}-1.5T_{\max}-0.62\text{RF}$ and Poona was $Y=55.85+0.012\text{MRH}+0.15\text{ARH}+0.04T_{\min}-0.60T_{\max}+0.62\text{RF}$, R² value of which was indicating that 73 per cent and 51 per cent of variation in disease variety was accounted to the linear function respectively (Table 4).

Regression equations determined by weather factors prevailing two weeks prior (W₃)

Regression equation for Bellary was $Y=30.31+0.20\text{MRH}+0.04\text{ARH}+0.05T_{\min}+0.13T_{\max}+0.21\text{RF}$, Conadriya was $Y=93.10+0.39\text{MRH}-0.05\text{ARH}-0.29T_{\min}-1.83T_{\max}+0.79\text{RF}$, Dienna was $Y=96.04+0.28\text{MRH}-0.01\text{ARH}-0.77T_{\min}-1.34T_{\max}+0.69\text{RF}$, Dinakar was $Y=54.15+0.22\text{MRH}+0.002\text{ARH}-0.18T_{\min}-0.44T_{\max}-0.51\text{RF}$, Excel was $Y=87.01+0.41\text{MRH}-0.03\text{ARH}-1.06T_{\min}-1.13T_{\max}-0.58\text{RF}$ and Poona was $Y=35.37+0.10\text{MRH}+0.17\text{ARH}+0.063T_{\min}-0.19T_{\max}+0.51\text{RF}$.

W₂ – One week prior to the observed disease severity

Y- Per cent disease index (PDI)

ARH- Afternoon relative humidity (%)

The co-efficient of determinative (R²) value was found to be 17 per cent Bellary, 79 per cent on Coinadriya, 62 per cent on Dienna, 48 per cent on Dinakar, 73 per cent on Excel and 51 per cent on Poona (Table 4).

Area under disease progress curve (AUDPC) and infection rate (r)

The AUDPC values and apparent rate of infection of rust disease of six fig varieties is presented in the table5. The maximum area under disease progress curve was found in Excel, (3207.65), followed by Dienna (3157.99) and Bellary (3155.88). The least AUDPC value was observed in Poona (2005.99), followed by Dinakar (2605.52) and Conadriya (3067.29).

The apparent rate of infection differed among the fig varieties in which the variety Dienna recorded the maximum average r value (0.089), followed by Dinakar (0.070). The least infection rate was observed in Bellary. The r value of Bellary was 0.136, 0.027, 0.026 and 0.006 at 7th, 14th, 21st and 28th day after infection respectively. The r value of Conadria was 0.155, 0.060, 0.023 and 0.003 at 7th, 14th, 21st and 28th day after infection

Table 5 : Apparent rate of infection (r) and area under disease progress curve (AUDPC) values of fig rust caused by *C. fici* in different fig varieties.

S. no.	Variety	r values					AUDPC
		7 DAI	14 DAI	21 DAI	28 DAI	Average r	
1	Conadriya	0.155	0.060	0.023	0.003	0.060	3067.29
2	Excel	0.180	0.048	0.013	0.001	0.061	3207.65
3	Dienna	0.297	0.050	0.005	0.003	0.089	3157.99
4	Dinakar	0.188	0.038	0.027	0.029	0.070	2605.52
5	Bellary	0.136	0.027	0.026	0.006	0.049	3155.88
6	Poona	0.130	0.020	0.040	0.050	0.061	2005.99

T_{max} - Maximum temperature (°C)

RF- Rainfall (mm)

DAI- Days After Initial infection

respectively. Dienna recorded the r value of 0.297, 0.050, 0.005, and 0.003 at 7th, 14th, 21st and 28th day after infection respectively. The r value of Dinakar was 0.188, 0.038, 0.0827 and 0.029 at 7th, 14th, 21st and 28th day after infection, respectively. On the variety Excel, the r value observed was 0.180, 0.048, 0.13 and 0.001 at 7th, 14th, 21st and 28th after infection respectively. The r value of Poona was 0.130, 0.02, 0.04 and 0.05 at 7th, 14th, 21st and 28th day after infection, respectively.

Discussion

The rust caused by *Cerotelium fici* (Cast.) Arth. is the most important fungal disease of cultivated fig (*Ficus carica*) and was reported in India for the first time in 1914 (Butler, 1914). The phylogenetic relationship of the genus says that it is closely related to *Phakopsora* genus parasitizing the leguminous crops (Ono *et al.*, 1992). In recent times *Phakopsora nishidana* is reported as causal organism of fig rust in New Zealand (Padamsee and McKenzie, 2024), concluding that both the organisms are responsible for the rust symptoms. The disease symptoms develops as tiny yellow spots on under side of the leaves. They enlarge to form reddish brown angular spots visible on lower and upper leaf surface. The leaves are the severely affected plant part by the rust disease. However, under congenial condition symptoms also appear on petiole, shoots and fruits. Severe disease incidence results in leaf drying and defoliation. About 50 per cent losses have been reported by earlier workers (Gaikwad and Nimbalkar, 2004), indicating the seriousness of rust disease in fig. The germination of the primary inoculum such as uredospores initiates the infection chain (Chaube and Pundhir, 2025). The disease is favoured by warm and humid weather. Successful uredospore germination and penetration is dependent on the duration of leaf wetness and temperature (Kushalappa and Eskes, 1989). Here in the study, it is evident that uredospore germination was maximum at 25°C temperature. The present study

has clearly showed that temperature from 15 to 25°C promotes the spore germination and 25°C is optimum to initiate the uredospore germination and beyond which the germination decreases gradually. Doodley (1984) reported that uredospores were killed when exposed to 30°C for 6 hour and at 35 °C for 30 minutes, which might be one of the reasons for decrease in uredospores germination with the increasing temperature above 25°C. Similar to the temperature, relative humidity is one of the important environmental factors influencing

rates for germination. In the present investigation, the maximum germination was observed at 100 per cent relative humidity, followed by 90 per cent and at 65 per cent no germination was reported. The results are in conformity with the results of Doodley (1984) and Veena and Adiver (2015).

Weather factors affecting fig rust disease severity among fig varieties under natural epiphytotic conditions

The influence of temperature, relative humidity, and rainfall on fig rust disease severity was assessed under field conditions during 2017–18. Considerable variation in disease severity was observed among the evaluated fig varieties, with correlation coefficients indicating that, besides weather parameters, host factors also played a significant role.

Pooled correlation data revealed that both morning and afternoon relative humidity were significantly and positively correlated with disease severity, whereas minimum and maximum temperatures were significantly and negatively correlated. Rainfall exhibited no significant correlation and was negatively related to disease severity. These results agree with the findings of Tessmann *et al.* (2001), Beest *et al.* (2008), and Barerra *et al.* (2013), who reported that temperature exerts the greatest influence on rust disease, and with Kanade *et al.* (2015), who also observed a significant negative correlation between minimum temperature and groundnut rust severity. The observed influence of relative humidity aligns with Srikantswamy *et al.* (2006), while Kanade *et al.* (2015) reported that morning relative humidity was positively correlated and evening relative humidity negatively correlated with groundnut rust severity. The present findings that rainfall had no significant relationship with fig rust severity also concur with Kanade *et al.* (2015).

Overall, higher temperatures were found to limit rust

severity, while warm and humid conditions favored disease development (Latinovic *et al.*, 2015). The variation in coefficient of determination (R^2) values among varieties suggests that, in addition to correlated weather parameters (morning and afternoon RH, minimum and maximum temperatures, and rainfall), other factors such as host resistance, inoculum load, wind direction, and crop management practices also influence disease severity. Among the weather factors, relative humidity positively influenced disease, temperature had a negative influence, and rainfall had minimal effect. The area under the disease progress curve (AUDPC) can be positively correlated with the percent disease index and negatively with resistance (Chand *et al.*, 2006; Draz *et al.*, 2015). Under natural epiphytotic conditions, the six fig varieties recorded AUDPC values ranging from 2005.99 to 3207.65, clearly indicating differences in their resistance levels to fig rust.

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