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Jayashree Bambalwad
Department of Plant Pathology, College of Agriculture, V. C. Farm, Mandya, Karnataka, India

Pankaja NS
Assistant Professor, Department of Plant Pathology, College of Agriculture, V. C. Farm, Mandya, Karnataka, India

Mahadev J
Assistant Professor, Department of Forestry and Environmental Sciences, College of Agriculture, V. C. Farm, Mandya, Karnataka, India

Sugeetha G
Assistant Professor, Department of Agricultural Entomology, College of Agriculture, V. C. Farm, Mandya, Karnataka, India

Benherlal PS
Assistant Professor, Department of Biochemistry, Division of Biotechnology, GKVK, Bangalore, Karnataka, India

Corresponding Author:
Jayashree Bambalwad
Department of Plant Pathology, College of Agriculture, V. C. Farm, Mandya, Karnataka, India

Assessment of disease severity at different planting dates and evaluation of fungicides for the management of cowpea rust disease

Jayashree Bambalwad, Pankaja NS, Mahadev J, Sugeetha G and Benherlal PS

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Abstract
Cowpea rust caused by *Uromyces phaseoli* var. *vignae* (Barclay) Arthur is one of the major production constraints in India. An experiment was laid out to assess the effect of different planting dates and fungicide treatments on the disease severity. The study was conducted during *Kharif* 2016-17. C-152, a susceptible cowpea variety was evaluated at 12 different sowing dates starting from July 18th of 2017 to November 5th of 2017. The observations were recorded at weekly intervals. The crop sown on 17.07.2020 recorded minimum disease severity of 4.65% at 77 days after sowing and maximum a of 45.2% at 105 DAS on 5.11.2017, indicating that a lower disease severity at first date of sowing than the later sowings. The analysis between disease severity and weather parameters revealed that maximum temperature, relative humidity and wind speed to be positively correlated and that minimum temperature and relative humidity morning to be negatively correlated with the disease severity. In another experiment six fungicides with two different concentrations were evaluated against the disease under field conditions. Among them propiconazole 25% EC at 0.2% was very effective in reducing the rust severity significantly compared to other fungicides. It also recorded highest average yield of 13q/ha.

Keywords: Rust disease, *Kharif*, weather, correlation, fungicides

Introduction
Cowpea is one of the most important leguminous crops grown in India. It is an annual legume adapted to warm conditions and sensitive to chilling hence, it is cultivated widely in tropics and subtropics during the warm season (Paithankar, D. H., *et al*., 2016) [6]. It has been reported that the nutrient content of this vegetable can provide 100% of the recommended daily allowance, for adult, calcium, iron, â-carotene and ascorbic acid and 40% of protein if 100 g of the fresh vegetable is consumed (Abukutsa Onyango, 2003) [2].

Cowpea cultivation is affected by various biotic and abiotic factors. Among the biotic factors, rust disease caused by *Uromyces phaseoli* var. *vignae* Barclay (Arth.) is economically important. The disease was first reported by Barclay in 1891 from Shimla. Himachal Pradesh. Further, it was reported by Butler and McRae in the year of 1909 from Tamil Nadu and Maharashtra. This disease was reported from Dharwad and Mysore by Rangaswami *et al*, (1970) [9].

Generally, disease appears severely on July sown crop during southwest monsoon period resulting in appreciable crop losses. (Chandrasekhar *et al*, 1989) [3]. The rust pustules appear on any part of the plant above ground. The infection appears on lower surface of the leaves in the form of small raised sori. Infection is evident first as minute almost white, slightly raised pustules which later became distinct, redish brown circular sori that are typical of rusts pustule. (Ramangoud B. Honnur *et al*, 2016) [8]. it is very well known that the disease occurrence and severity depends on the weather factors besides the presence of inoculum. The information regarding this is very sparse. Therefore, an experiment was laid out to determine the relation between disease and weather parameters at different sowing dates. Also, a field experiment was taken up to evaluate the fungicides against this disease.

Material and Methods

Effects of different dates of sowing on cowpea rust severity

The effect of weather parameters like temperature (maximum and minimum), relative humidity (morning and evening) and wind speed on rust severity was assessed under field conditions during 2016-17 at College of Agriculture, V. C. Farm, Mandya. The susceptible variety C-152 was sown on 12 different dates at 10 days interval starting from July 18th of 2017 to November 5th of 2017. A plot size of 2.5×1.5m with a spacing of 45×10cm and crop was raised with regular agronomic practices. The observations on disease severity were recorded at weekly interval starting from the date of sowing till the harvest of the crop. Observations on disease severity was recorded by following 0-9 scale as given by Mayee and Datara, 1986 [5] and then Per cent Disease Index was calculated.

Table 1: Scale for scoring the cowpea rust given by Mayee and Datar, 1986 [5]

Score	Description	Category
0	No symptoms on leaves	Immune (I)
1	Small, round, powdery brown uredospores covering 1% or less of leaf area	Resistant (R)
3	Typical uredospore covering 1-10% of the leaf area	Moderately Resistant (MR)
5	Typical uredospores covering 11-25% of the leaf area	Moderately Susceptible (MS)
7	Typical uredospores covering 26-50% of the leaf area	Susceptible (S)
9	Typical uredospores covering 51% or more of leaf area	Highly Susceptible (HS)

$$PDI = \frac{\text{Sum of all numerical ratings}}{\text{Total number of ratings} \times \text{Maximum disease grade}} \times 100$$

Correlation of weather parameters with Per cent Disease Index

The development of disease was correlated with weather parameters by subjecting to Pearson's rank correlation. Further the data were subjected to multiple linear regression analysis techniques (Pans and Sukhatme, 1985) [7] by fiiting different functions using software "SAS Syntax Reference Guide 2016, version 16.0 (SPSS), South Wacker Drive, Chicago, IL (SPSS, 2009). Ten days interval mean data on weather parameters was used for this study

In-vivo evaluation of fungicides against the pathogen

A field experiment was conducted during Kharif 2016-17 at College of Agriculture, V. C. Farm, Mandya. Thirteen treatments with three replications were taken up in Completely Randomized Block Design. The susceptible cowpea variety C-152 was sown and regular agronomic practices were followed. Observations were recorded on disease severity before spraying the fungicides and 10 days after first as well as second spray. The yield data were also recorded and Per cent Disease Index was calculated, further the data was statistically analysed.

Results and Discussion

The agricultural practices like planting date, planting geometry, planting density, drainage and mineral nutrition mainly influence the disease severity and play a vital role in many crops. Shaikmohammed and Dutt (1985) [10] reported that the effect of sowing dates is an important factor to be considered in managing the foliar diseases. In a field experiment conducted in order to determine effect of weather parameters on rust disease severity, the observations revealed that the crop sown on 18/07/2017 lowest disease severity of 4.65% at 77 Days after sowing (DAS), whereas, highest disease severity of 45.20% in the crop was sown on 05/11/2017 was recorded at 105 DAS. Thus, in the early sown crop (18/07/2017), the disease incidence appeared late at 77 DAS when compared to the crop that was sown in the subsequent days. This can be clearly seen in the crop sown at 25/10/2017 and 05/11/2017 where the disease incidence of 16.66 and 16.85%, respectively was recorded in the early stages of the crop growth i.e. at 21 DAS (Table 2). This may be due to the availability of adequate inoculum in the early stage of the crop along with the favourable climatic conditions may have led to increase in the disease severity in the subsequent dates of sowing.

The data also revealed that with the increase in the number of days of the crop the disease severity also increased in the crop sown at different dates. From among the different sowing dates, a lowest disease severity of 30% was recorded in the first sown crop on 18/07/2017 whereas, a highest of 45.25 % was recorded in the twelfth sowing (05/11/2017) at 105 DAS (Table 3). In a similar experiment conducted by Kale and Anahosur (1993) [4], reported that the severity of cowpea rust varied depending on the different dates of sowing and further reported that the Per cent Disease Index was significantly lower (30.82) in first date of sowing (08/06/1989) than on later sowings (32.66-78.76). This clearly indicates that the favourable climatic factors play an important role in the occurrence and severity of the rust disease than the age of the crop. Further, the occurrence of disease on the crop sown on 18/07/2017 (early sown crop) will escape from the disease than the subsequently sown crops.

Correlation and linear regression analysis between disease severity and weather parameters

The disease severity was recorded at weekly intervals at different dates of sowing and was correlated with the existing weather parameters. The results revealed that maximum temperature (r= 0.25), relative humidity afternoon (r= 0.54) and wind speed (r= 0.13) were positively correlated with disease severity. Whereas, minimum temperature (r= -0.72) and relative humidity morning (r= -0.28) were negatively correlated with disease severity (Table 4 and 5).

This indicates that as there is increase in maximum temperature, evening relative humidity and wind speed there will be increase in disease severity of 25, 54 and 13 per cent respectively, whereas the increase in minimum temperature and morning relative humidity there was decrease of 72 and 28 per cent disease severity respectively.

The regression models between weather parameters and disease severity indicate that for every °C of maximum temperature 0.93 per cent, for every unit percentage of afternoon relative humidity 0.52 per cent and for every unit kilo meter of wind speed 0.55 per cent of disease severity of rust increases. Whereas with every unit percentage of morning relative humidity 0.57 per cent and for every °C of minimum temperature 1.31 per cent of disease severity

decreases.

The multiple regression models were obtained between weather parameters and disease severity. It was observed that 1.68 per cent of disease severity was increased for every °C of maximum temperature, 1.66 per cent of disease severity was decreased for every °C of minimum temperature, 0.60 per cent of disease severity was decreased for every percentage of morning relative humidity, 0.066 per cent of disease severity was increased for every percentage of afternoon relative humidity and 0.92 per cent of disease severity was decreased for every kilo meter of wind speed.

The R2 values indicated that the association of weather factors with disease severity showed 86.5% in cowpea crop infected with rust pathogen. This indicated that some unknown factors might be involved in disease development

***In-vivo* evaluation of fungicides against the pathogen**

The lowest average disease severity of 12.40% was recorded in propiconazole 25% EC at 0.2% followed by propiconazole 25% EC at 0.1% (14.36%), hexaconazole 5% EC at 0.2% (16.68%) and hexaconazole 5% EC at 0.1% (18.84%) and there was a significant difference among them (Table 6). However, the highest average disease severity of 63.50% was recorded in control followed by tebuconazole 25% EC at 0.5% (41.01%), tebuconazole 25% EC at 0.75% (38.44), difenconazole 25% EC at 0.1% (35.93%) and difenconazole 25% EC at 0.3% (33.14%) and was a significant difference among them.

The highest average yield of 13q/ha was obtained in treatment with propiconazole 25% EC at 0.2% followed by propiconazole 25% EC at 0.1% (12.88q/ha). There was no significant difference between them. This is followed by hexaconazole 5% EC at 0.2% (11.22q/ha) and hexaconazole 5% EC at 0.1% (10.76q/ha) with significant difference between them. Whereas the lowest yield of 6.98q/ha was obtained in control followed by tebuconazole 25% EC at 0.5% (7.09q/ha) and there was no significant difference between them. This is followed by tebuconazole 25% EC at 0.75% (7.96q/ha) and difenconazole 25% EC at 0.1% (8.21q/ha) and difenconazole 25% EC at 0.3% (8.32q/ha). With these results it is certain that the fungicide propiconazole 25% EC is effective in managing the rust disease and further it is evident that the treatment also resulted in highest yield compared to other fungicidal treatments. These results are in accordance with Ahmed *et al*., (2006) [1] who evaluated the efficacy of six fungicides against lentil rust (*Uromyces viciaefabae*), among them he reported propiconazole @ 0.05% was the most effective fungicide in managing the rust disease. Thus, it can be recommended for the cowpea growing farmers

Table 2: Rust disease severity on cowpea at different dates of sowing

S. No.	Date of sowing	PDI at different days after sowing														
		07	14	21	28	35	42	49	56	63	70	77	84	91	98	105
1.	18/07/2017	0	0	0	0	0	0	0	0	0	0	4.65	10.23	25.45	29.98	30.00
2.	28/07/2017	0	0	0	0	0	0	0	0	0	6.50	14.56	24.0	28.45	31.00	31.90
3.	06/08/2017	0	0	0	0	0	0	0	0	4.67	10.33	23.25	28.00	31.70	32.00	33.00
4.	16/08/2017	0	0	0	0	0	0	0	11.20	18.86	25.50	28.00	32.00	34.60	36.00	36.65
5.	26/08/2017	0	0	0	0	0	0	8.45	15.50	30.00	31.00	34.80	35.00	36.20	37.90	37.90
6.	05/09/2017	0	0	0	0	0	6.56	18.80	32.60	34.45	37.32	37.80	38.50	39.10	39.45	40.00
7.	15/09/2017	0	0	0	0	7.85	18.90	31.85	34.80	37.80	40.80	41.00	41.20	41.42	41.50	42.00
8.	25/09/2017	0	0	0	8.88	13.45	27.00	33.00	35.66	39.00	41.45	42.00	42.15	42.25	42.55	42.80
9.	05/10/2017	0	0	0	9.08	20.44	28.86	34.0	36.0	40.4	42.33	43.00	43.15	43.22	43.75	44.00
10.	15/10/2017	0	0	0	19.98	21.20	29.32	35.30	37.45	40.55	42.85	43.40	44.00	44.45	44.80	44.90
11.	25/10/2017	0	0	16.66	20.89	23.00	30.00	36.75	38.00	41.00	43.00	43.80	44.10	44.60	44.85	45.00
12.	05/11/2017	0	0	16.85	21.00	23.36	30.86	37.00	38.20	41.88	43.25	43.95	44.90	44.89	45.00	45.20

Table 3: Relationship between cowpea rust disease severity and weather parameters at different dates of sowing

Dates of sowing	PDI 105 DAS	Temperature (°C)		Relative humidity (%)		Wind speed (km/hr)
		Maximum	Minimum	Morning	Afternoon	
18/07/2017	30.00	29.00	19.00	91.00	74.00	4.0
28/07/2017	31.90	30.00	20.00	95.00	65.00	0.0
06/08/2017	33.00	30.00	19.50	91.00	77.00	0.0
16/08/2017	36.65	30.50	19.00	95.00	81.00	0.0
26/08/2017	37.90	29.50	16.00	91.00	77.00	0.0
05/09/2017	40.00	28.00	16.50	89.00	71.00	0.0
15/09/2017	42.00	27.00	12.50	94.00	75.00	0.0
25/09/2017	42.80	30.00	11.00	94.00	75.00	1.91
05/10/2017	44.00	29.50	12.50	95.00	74.00	2.15
15/10/2017	44.90	30.00	13.50	89.00	88.00	1.61
25/10/2017	45.00	32.00	17.00	87.00	81.00	2.29
05/11/2017	45.20	32.50	17.00	90.00	81.00	1.70

Table 4: Correlation between weather parameters and rust disease severity in cowpea

S. No.	Weather parameters	Correlation coefficient (r)
1	Maximum temperature (°C)	0.25
2	Minimum temperature (°C)	-0.72
3	Relative humidity (%) morning	-0.28
4	Relative humidity (%) afternoon	0.54
5	Wind speed (km/hr)	0.13

Table 5: Regression analysis between weather parameters and rust disease severity in cowpea

Variable	Y=aX+b	R2
Maximum temperature (°C)	Y=0.93X+11.41	0.06
Minimum temperature (°C)	Y=-1.31X+60.54	0.52
Relative humidity (%) morning	Y=-0.57X+92.01	0.08
Relative humidity (%) afternoon	Y=0.52X-0.58	0.29
Wind speed (km/hr)	Y=0.55X+38.74	0.017
Multiple linear regression model		
weather parameters combined	Y= 1.68X1-1.66X2-0.60X3+0.066X4-0.92X5+67.69	0.865

Note: X1- Maximum temperature (°C) X2- Minimum temperature (°C)
X3- Relative humidity (%) morning X4- Relative humidity (%) afternoon
X5- Wind speed (km/hr)

Table 6: Effect of different fungicide treatment on disease severity and yield of cowpea

Treatments	Fungicides	Concentration (%)	PDI (10 days before 1st spray)	PDI (10 days after 1st spray)	PDI (10 days after 2nd spray)	Yield (q/ha)
T1	Chlorothalonil (75%WP)	0.15	44.15	40.20	30.10	8.48
T2	Chlorothalonil (75%WP)	0.20	41.70	37.93	27.51	8.60
T3	Mancozeb (75%WP)	0.20	39.66	35.55	24.14	8.75
T4	Mancozeb (75%WP)	0.30	36.33	32.29	21.11	9.08
T5	Propiconazole (25%EC)	0.10	29.07	23.51	14.36	12.88
T6	Propiconazole (25%EC)	0.20	26.18	21.22	12.40	13.00
T7	Difenconazole (25%EC)	0.10	50.07	45.66	35.93	8.21
T8	Difenconazole (25%EC)	0.30	47.40	43.07	33.14	8.32
T9	Tebuconazole (25%EC)	0.50	56.96	52.80	41.01	7.09
T10	Tebuconazole (25%EC)	0.75	53.75	49.02	38.44	7.96
T11	Hexaconazole (5%EC)	0.10	34.18	29.03	18.84	10.76
T12	Hexaconazole (5% EC)	0.20	31.66	25.92	16.68	11.22
T13	Control		63.50	63.50	63.50	6.98
S. Em±			0.58	0.43	0.29	0.26
CD (P=0.05)			1.71	1.27	0.87	0.75

Conclusion

The present study to assess the disease severity at different dates of sowing reveals that as the crop is sown early (18.07.2017) it escaped from the disease incidence in its early growth stages and that it is seen only in the later part of its growth stages in comparison to the crops sown subsequently. Thus, the experiment infers that the weather parameters like maximum and minimum temperature, morning and afternoon relative humidity and wind speed greatly influences the disease occurrence and its development. The data regarding disease severity percentage when recorded after 10 days after the application of fungicide reveals that the fungicide propiconazole 25% EC at 0.2% caused significant reduction in rust infection when compared to other treatments, also a highest average yield was also obtained in this treatment compared to others.

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