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Influence of Weather Parameters on False Smut Disease Development in Rice

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ABSTRACT

False smut of rice caused by *Ustilaginoidea virens* (Cooke) Takahashi, is an emerging disease of rice. A field experiment was conducted during two consecutive *kharif* seasons (2019-20 and 2020-21) to find out the influence of weather parameters on disease development. The data so obtained was analyzed through correlation and regression individually and by pooling. The first symptom of false smut was appeared on 47th SMW where disease severity was 4.49 per cent (2019-20) and 0.44 per cent (2020-21) and reached the highest level of 44.49, 48.78 per cent and 23.59, 25.04 per cent on 51st and 52nd SMW, respectively. Correlation study between disease severity and weather parameters indicated that weather parameters played important role in development of false smut of rice. Moreover, maximum relative humidity, minimum relative humidity and minimum temperature found to play a dominant role in the disease development. Stepwise regression, R value *i.e.,* 0.79, 0.91 and 0.75 per cent and coefficient of determination, R^2 value *i.e.,* 61.70, 83.50 and 56.20 per cent were found high during 2019-20, 2020-21 and pooled data of two years, respectively. These high R-value indicated strong association between disease severity and weather parameters.

Keywords: False smut, Epidemiology, Correlation, Regression

RICE (*Oryza sativa*) belongs to the family graminae, recognized as 'Millennium Crop' contributing towards food security in the world, as it is one of the staple cereal crops and food for billions of people around the world (Bhavya and Shivakumar, 2018; Channannavar *et al*., 2020). Rice cultivation is affected by many biotic constraints such as diseases and pests. In the past decades, a number of minor diseases have attained the status of major importance in rice. One such disease is the rice false smut that affects yield and grain quality.

Ustilaginoidea virens, a pathogenic fungus, causes a devastating grain disease in rice, rice false smut (RFS). False smut was first reported from Tirunelveli district of Tamil Nadu, India in 1878. It infects and converts florets in to yellow colored smut balls. The disease incidence has been reported at many places in an alarming proportion (Manu *et al*., 2017). The fungus overwinters in soil as sclerotia and chlamydospores. Sclerotia produce ascospores, which are the primary source of infection to rice plants, whereas secondary infection comes from airborne chlamydospores (Ashizawa *et al*., 2010).

A roving survey was carried out during *kharif* 2016 in different rice growing ecosystems of Karnataka to ascertain the false smut disease of rice; the mean disease severity ranged from 4.44 to 17.12 per cent. The highest disease severity was observed in irrigated Bhadra ecosystem (17.12 %), whereas, irrigated Kaveri ecosystem recorded least disease severity (4.44 %). Yield loss estimation due to false smut disease on different rice varieties growing in different ecosystems revealed up to 4.25 per cent yield loss (Muniraju *et al*., 2017; Pramesh *et al*., 2020 and Sharanabasav *et al*., 2021). The climatic factors favoring rice false smut are cloudy weather, high relative humidity (>95 %), low temperature (25 to 30 °C), water stress and rainy days at the time of flowering (Raji *et al*., 2016; Sanghera *et al*., 2012). Besides, it was revealed that the disease incidence and disease severity index of false smut occurred at 23-32 ºC temperature, 66-90 per cent relative humidity,

5-8 mm rainfall and 4.81-6.20 h of sunshine. Such congenial environment is suitable for germination of sclerotia and superfluous dormant spores *i.e.,* chlamydospores (Bhargava *et al*., 2018). In damp weather, the disease can be severe and losses can reach 85 per cent as has been reported from Tamil Nadu on different rice cultivars (Ladhalakshmi *et al*., 2012; Pramesh *et al*., 2020 and Sharanabasav *et al*., 2021). Therefore, the present studies were done to know the effect of different weather parameters on the false smut disease incidence in rice.

Material and Methods

A field experiment was carried out for epidemiological studies during *kharif* 2019-20 and 2020-21 on false smut disease of rice at the AICRP-Rice, ARS, Gangavathi (15.4319° N, 76.5315° E), Karnataka. Rice cultivar GNV 10-89 was sown in the nursery and 30 days old seedlings were transplanted in plots of size 2.5 × 2.5 sq. m at a spacing of 20 cm × 15 cm. The crop was raised following standard agronomical practices for the region.

To determine the influence of various environmental factors on the development of rice false smut, the disease severity data was correlated with different meteorological parameters *viz*., relative humidity (RH), temperature, evaporation, rainfall and rainy days through analysis of correlation and regression.

Disease Observations

Weekly observations on disease were recorded from flowering. Various parameters such as, per cent infected panicles and grains and disease severity were calculated as per the formulae given below (Mandhare *et al*., 2008; Singh and Dube, 1978).

$$\text{Per cent of infected panicles} = \frac{\text{Number of infected panicles/m2}}{\text{Total number of panicles/m2}} \times 100$$

$$\text{Per cent of spikelet infected/ panicles} = \frac{\text{Number of infected spikelets/panicle}}{\text{Total number of spikelets/panicle}} \times 100$$

Disease severity (%) = Infected tillers (%) x Smutted grains (%)

Results and Discussion

The data on weather and disease recorded during *kharif* 2019-20 and 2020-21 at ARS Gangavathi are presented in Table 1 & 2 and Fig. 1 & 2. The first symptom of disease was recorded on 25th November of 2019 *i.e.* in the 47th meteorological standard week (SMW) which was sown on 27th August 2019 and transplanted on 27th September of 2019. From this date the disease increased in linear manner during the entire

Table 1

Disease severity of false smut and weather conditions during *kharif* 2019

SMW	Date	Disease severity (%)	Relative humidity (%)		Temperature (ºC)		Evaporation (mm)	Rain fall (mm)	Rainy days
			Max	Min	Max	Min			
44	04-11-19	0	84.13	54.89	29.43	21.57	2.29	6.55	1.00
45	11-11-19	0	69.04	47.97	31.43	20.43	3.00	0.00	0.00
46	18-11-19	0	87.39	42.63	29.86	19.14	3.00	0.00	0.00
47	25-11-19	4.49	88.66	42.89	29.29	18.43	3.00	0.00	0.00
48	02-12-19	22.91	85.63	52.13	28.43	19.43	2.29	2.40	1.00
49	09-12-19	32.82	95.36	48.14	27.57	18.14	2.86	1.50	0.00
50	16-12-19	41.41	90.61	36.54	29.43	16.57	2.71	0.00	0.00
51	23-12-19	44.49	86.23	36.00	28.57	16.29	2.86	0.00	0.00
52	30-12-19	48.78	84.60	36.13	29.43	18.14	2.71	0.00	0.00

* SMW- Standard Meteorological week

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TABLE 2

Disease severity of false smut and weather conditions prevailed during Kharif 2020

SMW	Date	Disease severity (%)	Relative humidity (%)		Temperature (ºC)		Evaporation (mm)	Rain fall (mm)	Rainy days
			Max	Min	Max	Min			
44	03-11-20	0	55.11	17.90	32.29	20.00	2.43	0.00	0.00
45	10-11-20	0	49.06	25.41	30.43	18.43	2.43	0.00	0.00
46	17-11-20	0	68.83	21.89	30.29	18.71	2.00	0.00	0.00
47	24-11-20	0.44	64.03	15.64	30.86	17.71	2.29	0.00	0.00
48	01-12-20	2.87	72.79	28.30	26.86	18.57	1.43	5.50	1.00
49	08-12-20	18.22	43.29	16.77	29.86	17.14	2.14	0.00	0.00
50	15-12-20	18.85	60.37	21.86	30.00	15.14	2.00	0.00	0.00
51	22-12-20	23.59	67.07	12.69	29.00	15.14	2.00	0.00	0.00
52	29-12-20	25.04	60.93	10.27	29.29	14.86	2.14	0.00	0.00

crop season *i.e.* on 50 and 51st SMW (41.41% and 44.49%) and reached the peak point on 30th December of 52nd SMW (48.78%) during 2019. Whereas in 2020, first appearance of symptom was on 22nd November *i.e.* 47th SMW in the crop that was sown on 29th August and transplanted on 26th September. The same trend in 2019 was observed, but the disease was not as severe as it was during 2019. The disease increased during the final stage of the crop *i.e.* on 51st SMW (23.59%) and reached its highest point on 29th December *i.e.* 52nd SMW (25.04%) of 2020.

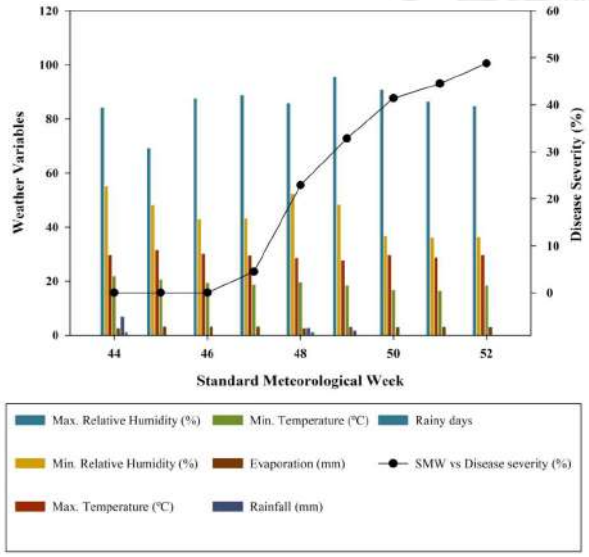

Fig. 1 : Weather conditions and disease severity of false smut during *kharif* 2019

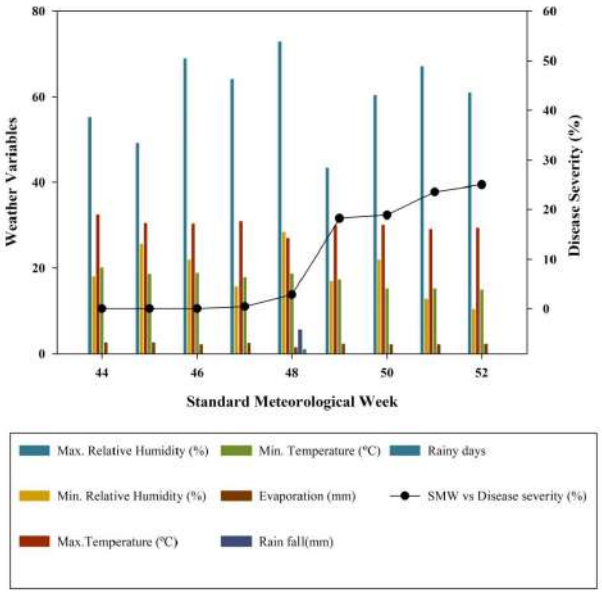

Fig. 2 : Weather conditions and disease severity of false smut during *kharif* 2020

During 2020, there was less false smut disease incidence than in 2019, which may be due to the more congenial weather conditions during 2019 than in 2020.

Correlation of Weather Parameters with False Smut Severity

The disease started appearing after flowering stage of the crop and hence the data recording disease

severity and corresponding weather parameters started from that point till final stage of the crop at weekly intervals and is presented in Table 3.

TABLE 3

Correlation of disease severity with weather parameters

Variables	Weather parameter	Correlation		
		2019	2020	Pooled
X_1	Maximum relative humidity	.414	-.098	.387
X_2	Minimum relative humidity	-.643	-.620	.058
X_3	Maximum temperature	-.514	-.314	-.435
X_4	Minimum temperature	-.786 *	-.914 **	-.547 *
X_5	Evaporation	-.082	-.146	.206
X_6	Rain fall	-.333	-.236	-.225
X_7	Rainy days	-.277	-.236	-.191

*Correlation significant at the 0.05 level, ** Correlation significant at the 0.01 level

During 2019, the disease was initiated on 47th SMW. Previous SMW 44, 45 and 46 recorded maximum relative humidity of 84.13, 69.04 and 87.39 per cent, temperature of 29.43, 31.43 and 29.86 ºC, evaporation of 2.29, 3.00 and 3.00 mm, rain fall of 6.55, 0 and 0 mm and rainy days 1, 0 and 0 respectively. These conditions favoured the initiation of the disease during flowering stage. While, weather conditions like maximum relative humidity *i.e.,* 88.66, 85.63 and 95.36 per cent, maximum temperature *i.e.,* 29.29, 28.43 and 27.57 ºC, minimum temperature *i.e.,* 18.43, 19.43 and 18. 14 ºC, evaporation 3.00, 2.29 and 2.86 mm and rain fall 0, 2.40 and 1.50 mm respectively led to the progression of the disease during 47, 48 and 49th SMW. After 47th SMW till final stage of the crop, disease severity increased up to 48.78 per cent. Correlation matrix was worked out for the year 2019 and it showed that maximum relative humidity (0.414) found positively correlated while, minimum relative humidity (-0.643), maximum temperature (-0.514), evaporation (-0.082), rain fall (-0.333) and rainy days (-0.277) were negatively correlated whereas, minimum temperature (-0.786) was significant and negatively correlated with false smut severity. Thus, maximum relative humidity plays an important role in the disease development compared to other weather parameters.

In 2020, though similar trend was recorded in the progress of the disease but, the disease severity was not as high as in 2019. The disease was initiated on 47th SMW and the previous two to three weeks 44, 45 and 46th SMW recorded maximum relative humidity *i.e.,* 55.11, 49.06 and 68.83 per cent, maximum temperature *i.e.,* 32.29, 30.43 and 30.29 ºC, minimum temperature 20.00, 18.43 and 18.71 ºC, evaporation 2.43, 2.43 and 2.00 mm respectively with no rain fall and zero rainy days. Some of these weather parameters favoured the initiation of the disease during flowering stage. While, weather conditions such as maximum relative humidity *i.e.,* 64.03, 72.79 and 43.29 per cent, maximum temperature *i.e.,* 30.86, 26.86 and 29.86 ºC, minimum temperature *i.e.,* 17.71, 18.57 and 17. 14 ºC, evaporation 2.29, 1.43 and 2.14 mm, rainfall of 0, 5.50 and 0 mm and rainy days 0, 1 and 0 led to the progression of the disease during 47, 48 and 49th SMW. After 47th SMW till final stage of the crop the disease progressed and recorded severity of 25.04 per cent. Correlation matrix was worked out for the year 2020 and it showed that maximum relative humidity (-0.098), minimum relative humidity (-0.620), maximum temperature (-0.314), evaporation (-0.146), rainfall (-0.236) and rainy days (-0.236) were found negatively correlated while, minimum temperature (-0.914) was found highly significant and negatively correlated with false smut severity.

From the results of two years, it is indicated that the false smut disease is a major threat to the rice crop if the weather conditions like relative humidity (RH), temperature, evaporation, rainfall and rainy days are congenial. Correlation matrix was worked out for the pooled data and it showed that maximum relative humidity (0.387), minimum relative humidity (0.058) and evaporation (0.206) were found positively correlated while, maximum temperature (-0.435), rainfall (-0.225) and rainy days (-0.191) were negatively correlated whereas, minimum temperature (-0.547) was significant and negatively correlated with false smut severity. Maximum relative humidity, minimum relative humidity and evaporation play an important role in the development of false smut disease.

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Stepwise Regression Equation for Rice False Smut on different Weather Parameters

The regression coefficient based on regression analysis for false smut severity of rice with respect to weather parameters have been worked out and presented in Table 4.

TABLE 4

Stepwise regression equation for rice false smut on different weather parameters during 2019

Regression equation	R	Co-efficient of determination (R^2)
$Y=202.107 - 9.659(X_4)$	0.79	61.7
$Y=104.917 – 5.493(X_4)$	0.91	83.5
$Y=150.523 -8.870(X_4) + 0.787(X_2)$	0.75	56.2

Y= Predicted disease severity, $X_{4=}$ Minimum temperature, $X_{2=}$ Minimum relative humidity

The results presented (Table 4) indicated that the R-value was high (0.79) indicating a strong association between per cent disease severity and minimum temperature. The co-efficient of determination value was found to be 61.70 per cent clearly indicating that at least 79 per cent of variation in false smut severity can be explained by the function of the weather parameter which is minimum temperature, during 2019. It is also observed that R-value was high (0.91) indicating a strong association between per cent disease severity and minimum temperature. The co-efficient of determination value was found to be 83.5 per cent indicating that at least 91 per cent of the variation in false smut severity can be explained by the function of the weather parameter which is minimum temperature, during 2020 also.

Stepwise regression presented in Table 4 showed that R-value was high (0.75) indicating a strong association between per cent disease severity to minimum temperature and minimum relative humidity. The co-efficient of determination value was found to be 56.20 per cent. This clearly indicates that at least 75 per cent of variation in false smut severity can be explained by the function of the weather parameter *viz*., minimum temperature and minimum relative humidity.

These results are in conformity with Singh and Pophaly (2010) who reported that the intermittent rains in September and October (at flowering stage) and the associated increased humidity probably favored the disease. However, minimum and maximum temperature ranges recorded in October 2007 were 23–25 °C and 30–32 °C, respectively. Kapse *et al*. (2012) recorded the incidence of false smut from 3.0 to 12.0 per cent. During the period of observation minimum temperature was 17 °C, while maximum temperature 31 °C with corresponding average, relative humidity of 52 to 88 per cent. Bhargava *et al*. (2018) recorded optimum temperature (31.36 to 23.14 °C), high relative humidity (88.85 to 73.50%), least rainfall (6.66mm) and bright sunshine hours (6.20 hrs.) as more favorable weather conditions for the development of false smut in rice. Stepwise regression, R-value *i.e.,* 0.89, 0.80 and 0.75 per cent and coefficient of determination, R^2 value *i.e.,* 79.90, 64.70 and 56.90 per cent were found high during 2017, 2018 and pooled data of two year, respectively. These high R value indicated strong association between disease incidences to weather parameters (Chaudhari *et al*., 2019).

In conclusion, it is very clear that rice false smut disease is becoming a major disease. The variety GNV-10-89 is susceptible. The weather prevailing during *Kharif* is the most congenial and favors false smut disease development. However, maximum relative humidity, minimum relative humidity and minimum temperature play a dominant role in the disease development. The management measures if any must be initiated prior to infection *i.e.* at pre-flowering stage to avoid losses.

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