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Correlation studies of soil and weather factors with stem rot of paddy under natural condition

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Abstract
Rice (*Oryzae sativa* L.) is a versatile crop that may be produced in various agro-climatic conditions worldwide. Rice is India's most prominent cereal food crop, and it plays critical role to the country's food grain supply. Among the diseases, stem rot [*Magnaporthe salvinii* (anamorph: *Sclerotium oryzae*) Catt.] has emerged as a serious threat to rice cultivation has become the most devastating disease, causing significant yield losses in the rice crop. To know the correlation of weather and soil variables with the incidence of stem rot during the entire crop season on susceptible variety BPT-5204 at ARS, Gangavathi. The observations were recorded at weekly interval (SMW - Standard Meteorological Weeks) till harvest. Soil temperature, soil moisture, rainfall and rainy days were recorded at weekly interval to find out correlation with the stem rot. The maximum soil temperature (0.88**) during *Kharif* 2017-18 followed by minimum soil temperature and maximum soil temperature (0.69** and 0.86**) during *Rabi*/summer 2017-18 were positively correlated with disease incidence. During *Kharif* 2017-18, minimum soil temperature (-0.74**), rainfall (-0.60**), and rainy days (-0.64**) were negatively correlated with disease incidence. During *Kharif* 2018-19, minimum soil temperature (-0.60*) and rainy days (-0.51*) were negatively correlated with disease incidence. The Area Under Disease Progress Curve (AUDPC) was be calculated for stem rot incidence on BPT-5204. The *Rabi*/summer 2017-18 season had a low AUDPC score (1365.40), indicating a lower incidence of terminal disease (33.6%). In *Kharif* 2017, a high AUDPC score of 1510.60 was observed, indicating a high incidence of terminal disease (42.00%).

Keywords: correlation, paddy, soil and weather variables and stem rot

Introduction
Rice (*Oryzae sativa* L.) is a versatile crop that may be produced in various agro-climatic conditions worldwide. Rice is India's most prominent cereal food crop, and it plays critical role to the country's food grain supply. Various biotic and abiotic stress factors have a substantial impact on the production potential of most rice cultivars. Among the soil-borne diseases, stem rot [*Magnaporthe salvinii* (anamorph: *Sclerotium oryzae*) Catt.] has emerged as a serious threat to rice cultivation and heavy nitrogen fertilizer use has become the most devastating disease, causing significant yield losses in the rice crop. Most of the world's rice growing regions have reported the disease. With the extensive cultivation of semi dwarf, high yielding and nitrogen responsive cultivars in India, the disease has spread to nearly all the major rice growing regions of the country. The disease has been documented in nearly all of the world's rice growing regions. By knowing the economic importance of the disease, the research on correlation studies between paddy stem rot incidence with soil and weather factors under natural field condition was carried out. Usmani and Ghaffar, (1986) [19] observed that the sclerotium of *S. oryzae* in dry soil and lower temperatures inhibit the growth of *Sclerotium* completely. Palakshappa *et al.* (1987) [13] reported that *S. rolfsii* causing foot rot in betel vine made maximum saprophytic activity at 0.4 dS/m electrical conductivity (EC) level. However, it was zero at 10 dS/m EC level. Mundhe (2005) [10] reported that the maximum incidence of root rot disease on finger millet was noticed during the rainy season. According to Krishnaveni and Laha (2009) [6], changes in agricultural practices, high relative humidity (>80%), high temperature (30 to 35 ^{0}C), and waterlogged conditions have indeed contributed to an alarming increase in stem rot disease. Shamsi *et al.* (2011) [16] observed that, stem rot incidence was associated the maximum tillering stage. Manu *et al.* (2012) [9] reported the foot rot disease of finger millet has been an increasing problem, especially in irrigated and heavy rainfall areas. The plants are more susceptible at the internode elongation stage, and the disease is favored by high humidity and high temperature, nitrogenous fertilizer, dense planting and attack of stem borer, node blast, brown plant hopper and jassids (Laha *et al*., 2017) [7].

Material and Methods

To know the crop stage for initiation and progress of stem rot during the entire crop season on susceptible variety BPT-5204, the study was carried out in fixed plot (10 m×10 m) at ARS, Gangavathi. The crop was transplanted on 06.09.2017, 04.01.2018 and 27.08.2018 during *Kharif* 2017-18, *Rabi* / Summer 2017-18 and *Kharif* 2018-19, respectively and all recommended agronomic practices were followed. This plot was kept free from any fungicidal application. The observations of stem rot initiation and its development was recorded, starting from transplanting to the harvesting of the crop. The observations were recorded at weekly interval (SMW - Standard Meteorological Weeks) till harvest on paddy *cv.* BPT-5204. For recording the stem rot incidence in the plot, five sites (1m×1m) were selected randomly the total numbers of plants present and number of plants showing wilting symptoms due to *Sclerotium* at each spot was counted and recorded in each plot. The disease incidence (%) was calculated by using the following formula.

$$\text{Stem rot incidence } (\%) = \frac{\text{No. of infected hills}}{\text{Total number of hills or plants observed}} \times 100$$

Soil temperature, soil moisture, rainfall and rainy days were recorded at weekly interval to find out correlation with the stem rot. The other soil parameters *viz.*, soil pH and soil electrical conductivity (EC) was also recorded. The standard methods for these observations were followed. The weekly data of rainfall and rainy days were collected from the observatory of ARS, Gangavathi for the entire crop season starting from the transplanting to the harvesting of the crop. Correlation analysis was done as per the methods described by Gomez and Gomez (1984) [2] and Snedecor and Cochran (1967) [18]. Stem rot incidence was correlated with the observation of corresponding week on soil temperature, soil moisture, rainfall and rainy days and correlation matrix was worked out. Area Under Disease Progress Curve (AUDPC) was be calculated for BPT-5204 genotype in all seasons using the formula as suggested by Wilcoxson *et al.* (1975) [20].

Result and Discussion

Correlations and regression of selected soil variables on per cent disease incidence of stem rot of paddy have been assessed for all the above three season data. The weather and soil variables such as soil temperatures, soil moisture, soil pH, soil EC, rainfall and rainy days has been considered to determine the disease development in all three seasons. When correlation coefficient (r) values were assessed during *Kharif* 2017-18, the maximum soil temperature (0.88**) was positively correlated with stem rot disease incidence. Whereas, minimum soil temperature (-0.74**), rainfall (-0.60*), and rainy days (-0.64**) were negatively correlated with disease incidence (Table 1). During *Rabi*/summer 2017-18, minimum soil temperature and maximum soil temperature (0.69** and 0.86**) were positively correlated with disease incidence when correlation coefficient (r) values were assessed (Table 2). During *Kharif* 2018-19, minimum soil temperature (-0.60*) and rainy days (-0.51*) were negatively correlated with disease incidence when correlation coefficient (r) values were assessed (Table 3). All of the selected weather parameters studied were associated and correlated with disease incidence and there was also a substantial relationship with significant correlation was noticed between the weather parameters.

Global spread of the fungus is influenced by soil temperature and moisture. The current investigation detected the highest stem rot incidence at maximum soil temperature, indicating that this would be the optimum temperature for fungus growth. Harlapur (1988) [3] reported that *S. rolfsii* caused wheat foot rot could survive soil temperatures of 25 to 45 °C. The temperatures of 25-30 °C, 30 per cent soil moisture and pH of 5.5 to 9.0 were ideal for pathogen growth (Kulkarni, 2007) [6]. The fungus fared better in low moisture soils than in high moisture soils. The current investigation reported the highest incidence activity of stem rot with soil moisture around 27 to 29 per cent. The saprophytic ability of *S. oryzae* was reduced when the soil moisture content was high. This might be due to a shortage of oxygen in soils with high moisture content. *Sclerotium* is a pathogen that thrives in a high oxygen environment. The current findings are comparable to the findings Ramarao and Raja (1980) [15] who found that at 25 per cent soil moisture, the foot rot (*S. rolfsii*) pathogen killed most of the wheat seedlings. Palakshappa (1986) [12] also observed that at 20 to 40 per cent soil moisture levels, *S. rolfsii*, the causal agent of betelvine foot rot, had a higher chance of surviving. *S. rolfsii* colonization was highest (74%) at 25 per cent moisture holding capacity (Latha *et al.*, 2006) [8]. High humidity and high temperature have been reported to make plants more vulnerable at the internode elongation stage (Laha *et al.*, 2017) [7]. The current findings are consistent with those reported by Palakshappa (1986) [12] and Harlapur (1988) [3] for *S. rolfsii* on betel vine and wheat, respectively. As a result, even a little variation in soil pH has no effect on the disease occurrence. The highest collar rot disease of tomato (100%) was recorded by Banyal *et al.* (2008) [1] at a soil moisture level of 15 per cent, while at moisture level of 35 per cent disease incidence is the lowest (26.7%). The pathogen favoured by near acidic to alkaline soils for its development and proliferation, as seen by greater incidence at pH 5.5 to 7.5, although growing on a pH range of 5.5 to 9.0. *In vitro*, Prasad *et al.* (1986) [14] discovered that the pH range of 5.0 to 7.0 is optimal for sclerotial development at various temperatures. However, Kulkarni and Kulakrni (1998) [5] found that pH 6.0 is optimal for *S. rolfsii* development, which is quite similar to the current research. Singh and Gandhi (1991) [17] found that the highest mortality of guar seedlings caused by *S. rolfsii* occurred at pH 6.1, and as the pH increased to 8.4 decreased the disease incidence substantially.

The incidence of paddy stem rot was recorded at seven day intervals for three seasons, and the findings are presented in Table 4. In *Kharif* 2017-18, there was a high AUDPC score of 1510.60, corresponding to a high incidence of terminal disease (42.00 per cent). The *Rabi*/summer 2018-19 seasons had a low AUDPC (1359.40) score, indicating a lower incidence of 36.40 per cent. Similarly, the AUDPC score for *Kharif* 2018-19 was 1400.00, with 38.40 per cent disease incidence. As per the result compared to other seasons, late *Rabi* planting was not much favourable for pathogen. The regression equation established by Nitesh Bhukal *et al.* (2015) [11] reveals that minimum temperature had a substantial influence on the development of rice sheath blight. The most outstanding AUDPC value (467.05) was obtained on the first day of transplantation on Basmati CSR 30, whereas the maximum AUDPC values (422.92 and 404.42) were observed on variety HKR 127 on the second and third days of transplanting. The AUDPC value of Basmati CSR 30 dropped in the second and third transplanting dates, but HKR 127 displayed the opposing tendency.

Table 1: Correlation studies between paddy stem rot incidence and of weather, soil factors during *Kharif* 2017-18

Parameters	Soil temperature minimum (ºC)	Soil temperature maximum (ºC)	Soil moisture (%)	Soil pH	Soil EC	Rainfall (mm)	Rainy days /week	Stem rot incidence (%)
Soil temperature minimum (ºC)	1.00							
Soil temperature maximum (ºC)	-0.78**	1.00						
Soil moisture (%)	-0.32	0.22	1.00					
Soil pH	-0.21	0.28	0.57	1.00				
Soil EC	-0.20	0.14	0.65**	0.86**	1.00			
Rainfall (mm)	0.37	-0.40	-0.39	-0.43	-0.27	1.00		
Rainy days /week	0.37	-0.45	-0.42	-0.48*	-0.32	0.92**	1.00	
Stem rot incidence (%)	-0.74**	0.88**	0.34	0.37	0.30	-0.60*	-0.64**	1.00

**Significant at 1% level
*Significant at 5% level
N=17
r tab= 0.606 (1%) & 0.482 (5%)

Table 2: Correlation studies between paddy stem rot incidence and of weather, soil factors during *Rabi*/summer 2017-18

Parameters	Soil temperature minimum (ºC)	Soil temperature maximum (ºC)	Soil moisture (%)	Soil pH	Soil EC	Rainfall (mm)	Rainy days /week	Stem rot incidence (%)
Soil temperature minimum (ºC)	1.00							
Soil temperature maximum (ºC)	0.72**	1.00						
Soil moisture (%)	-0.17	-0.05	1.00					
Soil pH	0.00	-0.10	0.69**	1.00				
Soil EC	-0.14	-0.27	0.65**	0.89**	1.00			
Rainfall (mm)	0.50*	0.42	-0.29	-0.18	-0.43	1.00		
Rainy days /week	0.61**	0.50*	-0.21	-0.22	-0.40	0.93**	1.00	
Stem rot incidence (%)	0.69**	0.86**	0.01	0.09	-0.21	0.41	0.40	1.00

**Significant at 1% level
*Significant at 5% level
N=17
r tab= 0.606 (1%) & 0.482 (5%)

Table 3: Correlation studies between paddy stem rot incidence and of weather, soil factors during *Kharif* 2018-19

Parameters	Soil temperature minimum (ºC)	Soil temperature maximum (ºC)	Soil moisture (%)	Soil pH	Soil EC	Rainfall (mm)	Rainy days /week	Stem rot incidence (%)
Soil temperature minimum (ºC)	1.00							
Soil temperature maximum (ºC)	0.40	1.00						
Soil moisture (%)	0.00	0.56*	1.00					
Soil pH	0.51*	0.33	0.42	1.00				
Soil EC	0.29	0.41	0.60*	0.86**	1.00			
Rainfall (mm)	0.26	0.06	-0.27	-0.13	-0.29	1.00		
Rainy days /week	0.06	-0.23	-0.32	-0.15	-0.30	0.77**	1.00	
Stem rot incidence (%)	-0.60*	0.13	0.31	-0.28	-0.11	-0.37	-0.51*	1.00

**Significant at 1% level
*Significant at 5% level
N=17
r tab= 0.606 (1%) & 0.482 (5%)

Table 4: AUDPC values of paddy stem rot in different seasons at ARS Ganagavati

Sl. No.	Season	Date of transplanting	First observation of disease		Terminal disease incidence (%)	AUDPC values
			Date	Age of the crop		
01.	*Kharif* 2017-18	06.09.2017	01 Oct – 07 Oct	35	42.00	1510.60
02.	*Rabi*/summer 2017-18	04.01.2018	29 Jan – 04 Feb	35	36.40	1359.40
03.	*Kharif* 2018-19	27.08.2018	24 Sep – 30 Sep	35	38.40	1400.00

Conclusion

The maximum soil temperature (0.88**) during *Kharif* 2017-18 followed by minimum soil temperature and maximum soil temperature (0.69** and 0.86**) during *Rabi*/summer 2017-18 were positively correlated with disease incidence. During *Kharif* 2017-18, minimum soil temperature (-0.74**), rainfall (-0.60**) and rainy days (-0.64**) were negatively correlated with disease incidence. During *Kharif* 2018-19, minimum soil temperature (-0.60*) and rainy days (-0.51*) were negatively correlated. The *Rabi*/summer 2017-18 season had a low AUDPC score (1365.40), indicating a lower incidence of terminal disease (33.6%). In *Kharif* 2017, a high AUDPC score of 1510.60 was observed, indicating a high incidence of terminal disease (42.00%).

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