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Epidemiological Studies on Sheath Blight Disease of Rice in Chhattisgarh Plains Agroclimatic Zone of Chhattisgarh, India

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A B S T R A C T

Chhattisgarh state (a part of the eastern zone) is the most congenial for rice cultivation as well as for disease development. The rice crop is known to suffer by many biotic and abiotic stresses and among biotic stresses, diseases are pivotal one. In the present study, epidemiological aspect of sheath blight disease of rice carried out. Sheath blight disease progression and apparent infection rate (r) were maximum during observation period from 1-15 and 16-30 October in over the four years *kharif* season. During this period of time, crop growth stage of test variety 'Swarna' was in maximum tillering to panicle initiation stage coincide with the Tmax range (30.5-32.6^{o}C) and SSH range (4.2-9.6) which favours the maximum apparent rate of infection by *Rhizoctonia solani* and resulted in maximum sheath blight disease progression. In all the maximum value of AUDPC calculated in first date of sowing followed by second date of sowing and least in third date of sowing during *kharif* 2013, 2015 and 2016. In *kharif* 2014, it was maximum in first date of sowing followed by third date of sowing and least in second date of sowing. Year wise correlation analysis between weather parameters and sheath blight disease severity suggest that Tmax and SSH had positive effect in the development of sheath blight disease of rice during *kharif* season.

Keywords

Epidemiology, Sheath blight, Correlation, Weather variables.

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Introduction

Rice is an important integral part of Indian dietary and staple food of more than 60 per cent population in India. Chhattisgarh state, famous as "*Rice bowl*" of India, rice occupies an area of 3.7 million hectare with a production of 7.7 million metric tonnes (Anon., 2017). This state is very rich in rice germplasm and large number of indigenous collection is still maintained by the tribal farmers of the state. However, the productivity of rice in the state is much lower than national average productivity level. Chhattisgarh state (a part of the eastern zone) is the most congenial for rice cultivation as well as for disease development. The rice crop is known to suffer by many biotic and abiotic stresses and among biotic stresses, diseases are pivotal one. Among the diseases, bacterial blight, sheath blight, blast, sheath rot and false smut are the most important for this region causing economic yield losses. The rice diseases attack all the growth stages of the plant right from the nursery till the harvest of the crop.

Intensive methods of rice cultivation involving early season culture, double cropping, use of high doses of nitrogenous

fertilizer, dense plant population per unit area and growing early maturity, short culmed, high tillering and compact susceptible cultivars have intensified the severity of the disease in all the rice growing countries. The yield loss due to sheath blight was maximum when infection started 60 days after sowing (tillering stage) and continues to subsequent booting stage (Tsai, 1974). Under favourable conditions like low sunlight, high humidity (≥ 95%) and warm temperature (28-32°C), the infection spreads rapidly by means of runner hyphae to upper plant parts. Lesions may coalesce to encompass the entire leaf sheath and stem (Rush and Lee, 1992).

Abnormalities produced in plants by entities are aggravated by the abiotic factors i.e. environmental conditions. Such interaction is described by classic disease triangle in which two biotic factors i.e. susceptible host and virulent pathogens and an abiotic factor i.e. environmental factor play an important role in exhalation of disease in plant in time and space. Environmental factor like temperature (minimum and maximum), relative humidity (morning and evening), rainfall and sunshine hours greatly influence the plant disease in various hosts - pathogen interactions. These factors directly or indirectly favour the growth of host plants and pathogen population to build- up and subsequently cause disease (s) in host plant to great extent resulting in economic yield losses.

In the present study, attempt was made to find out the congenial period for sheath blight disease progression in different dates of sowing and its relation with various weather variables.

Materials and Methods

The previous three years *kharif* season data (2013-2015) on sheath blight disease severity were obtain from the AICRP on rice, IGKV, Raipur. Rice cultivar 'Swarna' was sown in 1×10 m plot size with three staggering dates from 1st June to 1st August, 2016 with one month intervals. Disease development in terms of disease severity of sheath blight and bacterial blight was recorded at fortnightly intervals on 50 randomly selected and tagged plants in each replication and date of sowing starting from first appearance of disease symptoms.

Calculation of disease severity

It is the measure of sickness of diseased plant. It is a quantitative, which measures amount of disease on a plant in terms of intensity of symptoms or damage. Disease severity (DS) can be calculated by using formula-

$$\text{Disease severity (\%)} = \frac{\text{Area of plant tissues affected}}{\text{Total area}} \times 100$$

Calculation of apparent infection rate (r)

Apparent infection rate is the increase and decrease in disease per unit time. Vanderplank (1963) derived following formula for calculation of infection rate-

$$r = \frac{1}{t_2 - t_1} loge \frac{x_2(1 - x_1)}{x_1(1 - x_2)}$$

Where-

r = apparent infection rate/ unit/ day
t_1 = first date for recording disease severity
t_2 = second date for recording disease severity
x_1 = disease severity at time t_1
x_2 = disease severity at time t_2

Calculation of AUDPC

The area under disease progress curve (AUDPC) which was estimated as per the equation suggested by Shaner and Finnay (1977) as-

$$AUDPC = \sum_{i=1}^{n} \left(\frac{y_i + y_{i+1}}{2}\right)(t_{i+1} - t_i)$$

In which

n= total number of observations
y_i = disease severity at the i^{th} observation
t = time at the i^{th} observation

Calculation of correlation coefficient

The progression of the diseases was analyzed with prevailing weather variables such as temperature (Tmax and Tmin), rainfall (RF), relative humidity (RHm and RHe) and sunshine hours (SSH).

The correlation coefficients between various weather parameters and sheath blight disease severity were calculated. Correlation coefficient measures the severity strength of the linear relationship between two variables X and Y (Y is the disease severity and X is the different weather parameters). It is calculated by using following formula-

$$r = \frac{\Sigma(x - \bar{x})(y - \bar{y})}{\sqrt{[\Sigma(x - \bar{x})^2 (y - \bar{y})^2]}}$$

Results and Discussion

During disease development, trend and its relation to weather variables were analyzed in three staggering dates of sowing, pooled as well as year wise to validate the previous years' data with the data collected during *kharif* 2016.

Disease development

In the year 2013, sheath blight disease development during first date of sowing varied from 5.04 to 30.04% and 4.77 to 29.39% and 11.37 to 32.53% during second and third date of sowing, respectively.

Sheath blight disease development in the year 2014 varied in all three dates of sowing. During first date of sowing, it ranges from 20.78 to 82.20%. During second date of sowing, it was 4.21 to 44.13% and 1.91 to 37.64% in third date of sowing.

In the year 2015, sheath blight disease development varied from 7.35 to 45.51%, 7.08 to 34.73% and 5.5 to 41.73% during first, second and third date of sowing, respectively.

The data presented in Table 1 reveal that the disease development during first date of sowing in *kharif* 2016 was varied from 5.63 to 80.57%. In second and third date of sowing, it was 5.31 to 60.33% and 5.20 to 50.17%, respectively.

Disease progression

As far as the sheath blight disease progression was concerned, irrespective of dates of sowing the maximum progression (13.76%) was observed during 16-30 October in *kharif* 2013. The progression of disease was ranges between 0.05 to 13.11% in the first date of sowing with maximum 13.11% during 1-15 October, 2013. During second date of sowing, it was ranges from 0.12 to 11.69% with maximum 11.69% during 1-15 October, 2013. Disease progression in third date of sowing ranges from 7.4 to 13.76% with intermediate of 11.37% during 1-15 October, 2013. So, it was appeared that sheath blight progression was almost maximum during 1-15 October in *kharif* 2013. During this period, average Tmax was 30.6^{o}C, Tmin 24.9^{o}C, RHm 92.6%, RHe 73.7%, RF 5.5 mm and SSH 4.4.

In the *kharif* 2014, maximum disease progression 28.14% was observed during 1-15 November irrespective of dates of sowing. Disease progression ranges between 0.77 to 28.14% in the first date of sowing. During second date of sowing, it was varied from

0.63 to 17.54% with maximum of 17.54% during 16-30 October, 2014. In third date of sowing, it ranges between 1.91 – 14.96% with maximum of 14.96% during 1-15 October, 2014. It appeared that period from 01 October to 15 November was favourable for maximum sheath blight progression during *kharif* 2014. During this period, fortnightly average Tmax ranges from 32.6 to 32.8^{o}C, Tmin 14.82 to 21.0^{o}C, RHm 87.8 to 91.1%, RHe 30.46 to 54.6 % and SSH 7.56 to 8.13.

Maximum sheath blight disease progression was observed 14.02% irrespective of dates of sowing. Disease progression was ranges from 2.53 to 10.11% in first date of sowing with maximum 10.11 % during 16-30 October, 2015. During this period, maximum disease progression was observed i.e. 8.81 % in second date of sowing and it ranges between 2.87 to 8.81%. In third date of sowing, it varied between 5.05 to 14.02% with maximum 14.02% during 1-15 October. It appeared that period from 1-30 October was favourable for maximum sheath blight progression during *kharif* 2015. During this period, fortnightly Tmax ranges from 31.9 to 32.4^{o}C, Tmin 24.8 to 25.5^{o}C, RHm 92.8to 93.7%, RHe 64.2 to 69.5%, RF 1.5 to 13.6 mm and SSH 5.7 to 8.2.

During *kharif* 2016, maximum sheath blight disease progression was recorded as 20.15% irrespective of dates of sowing. In first date of sowing, it ranges from 5.63 to 20.15% with maximum 20.15% during 1-15 October followed by 19.87 during 16-30 October. It was varied from 5.31 to 17.63% during second date of sowing with the maximum of 17.63% during 1-15 October. In third date of sowing, it ranges between 5.20 to 13.84% with maximum of 13.84% during 1-15 October, 2016. During *kharif* 2016, it appeared that period from 1 to 15 October favours the sheath blight disease progression irrespective of dates of sowing. During this period, fortnightly Tmax was 31.2^{o}C, Tmin 24.8^{o}C, RHm 94.7%, RHe 63.2% and SSH 4.9 (Table 2).

Apparent infection rate (r)

The apparent infection rate (r) for sheath blight disease development was calculated and presented in Table 3. During *kharif* 2013, maximum r value 0.095 was recorded in between 16-30 September to 1-15 October in first date of sowing, in second date of sowing 0.090 and 0.064 in third date of sowing in between 1-15 October to 16-30 October.

Apparent infection rate was maximum 0.091 in between 16-30 October and 1-15 November in first date of sowing during *kharif* 2014. In second date of sowing, it was maximum 0.107 in between 1-15 October and 16-30 October and 0.56 in between 16-30 September 1-15 October in third date of sowing.

Maximum r value calculated as 0.029 in between 1-15 October and 16-30 October in first date of sowing during *kharif* 2015. In second date of sowing, it was maximum 0.037 and in third date of sowing, maximum r value was 0.068 in between 16-30 September to 1-15 October.

During *kharif* 2016, apparent infection rate was maximum 0.057 in between 16-30 September and 1-15 October in first date of sowing, 0.053 in second date of sowing and 0.102 in third date of sowing.

In the present study, sheath blight disease progression and apparent infection rate (r) were maximum during observation period from 1-15 and 16-30 October in over the four years *kharif* season. At this time, the variety Swarna was in between maximum tillering and panicle initiation stage. Findings of several other workers support the findings of

present study (Viswanathan 1979; Roy 1984 and 1986; Dath, 1989; Sarkar *et al.*, 1993; Tan *et al.*, 1995; Lakpale *et al.*, 1996; Tiwari and Choure, 1997; Zhang *et al.*, 1999; Biswas, 2001 panicle initiation; Thind, 2008).

Whereas some other workers were found different growth stages susceptible for infection. Shahjahan *et al.*, (1990) reported panicle initiation to booting; Chang and Dath (1996) flowering; Cu *et al.*, (1996) panicle initiation, flowering and booting; Vanitha *et al.*, (1996) found booting and flowering stage; Sharma and Teng (1996) flowering and panicle initiation stage; Munshi and Singh (2000) flowering and Pal *et al.*, (2016) found grain filling stage as most susceptible for sheath blight disease to occur.

Table.1 Sheath blight disease severity in four years *kharif* season (2013-2016)

Year	Observation period	Disease severity (%)		
		1st DOS	2nd DOS	3rd DOS
2013	01-15 August	0.00	0.00	0.00
	16-30 August	0.00	0.00	0.00
	01-15 September	5.04	4.77	0.00
	16-30 September	5.09	4.89	0.00
	01-15 October	18.20	16.58	11.37
	16-30 October	23.02	21.85	25.13
	01-15 November	30.04	29.39	32.53
2014	01-15 August	20.78	0.00	0.00
	16-30 August	29.37	4.21	0.00
	01-15 September	30.14	4.84	1.91
	16-30 September	34.56	20.22	16.87
	01-15 October	37.97	25.74	23.61
	16-30 October	54.06	43.28	33.15
	01-15 November	82.2	44.13	36.13
	16-30 November	0.00	0.00	37.64
2015	01-15 August	7.35	0.00	0.00
	16-30 August	17.01	7.08	0.00
	01-15 September	21.37	11.68	5.5
	16-30 September	25.28	14.55	10.55
	01-15 October	32.87	18.39	24.57
	16-30 October	42.98	27.2	34.2
	01-15 November	45.51	34.73	41.73
2016	01-15 August	5.63	0.00	0.00
	16-30 August	15.12	5.31	5.20
	01-15 September	20.71	15.08	16.52
	16-30 September	30.08	25.90	26.74
	01-15 October	50.23	43.53	40.63
	16-30 October	70.10	50.79	50.17
	01-15 November	80.57	60.33	0.00

Table.2 Fortnightly disease progression (%) of sheath blight during four years *kharif* season (2013-2016)

Observation period	2013			2014			2015			2016		
	1st DOS	2nd DOS	3rd DOS	1st DOS	2nd DOS	3rd DOS	1st DOS	2nd DOS	3rd DOS	1st DOS	2nd DOS	3rd DOS
16-30 July	0	0	0	0	0	0	0	0	0	0	0	0
01-15 August	0	0	0	20.78	0	0	7.35	0	0	5.63	0	0
16-30 August	0	0	0	8.59	4.21	0	9.66	7.08	0	9.49	5.31	5.2
01-15 September	5.04	4.77	0	0.77	0.63	0	4.36	4.6	5.5	5.59	9.77	11.32
16-30 September	0.05	0.12	0	4.42	15.38	1.91	3.91	2.87	5.05	9.37	10.82	10.27
01-15 October	**13.11**	**11.69**	11.37	3.41	5.52	**14.96**	7.59	3.84	**14.02**	**20.15**	**17.63**	**13.84**
16-30 October	4.82	5.27	**13.76**	16.09	**17.54**	6.74	**10.11**	**8.81**	9.63	19.87	7.26	9.54
01-15 November	7.02	7.54	7.4	**28.14**	0.85	9.54	2.53	7.53	7.53	10.47	9.54	9.54
16-30 November						2.98						

Table.3 Apparent infection rate (r) of sheath blight disease development during four years *kharif* season (2013-2016)

Observation period	2013			2014			2015			2016		
	1st DOS	2nd DOS	3rd DOS	1st DOS	2nd DOS	3rd DOS	1st DOS	2nd DOS	3rd DOS	1st DOS	2nd DOS	3rd DOS
16-30 July	0	0	0	0	0	0	0	0	0	0	0	0
01-15 August	0	0	0	0.031	0	0	0.020	0	0	0.032	0	0
16-30 August	0	0	0	0.002	0.010	0	0.019	0.034	0	0.033	0.027	0
01-15 Sept.	0.001	0.002	0	0.013	0.053	0	0.015	0.017	0.047	0.026	0.045	0
16-30 Sept.	**0.095**	**0.090**	0.0	0.010	0.021	**0.56**	0.025	0.019	0.031	**0.057**	**0.053**	**0.102**
01-15 October	0.020	0.023	**0.064**	0.044	**0.107**	0.028	**0.29**	**0.037**	**0.068**	0.056	0.019	0.036
16-30 October	0.024	0.027	0.024	**0.091**	0.002	0.032	0.007	0.024	0.021	0.053	0.026	0.030
01-15 November	0	0	0	0	0	0.009	0	0	0	0.036	0	0.026
16-30 November	0	0	0	0	0	0.004	0	0	0	0	0	0

Table.4 Value of area under disease progress curve (AUDPC) in four years *kharif* season (2013-2016)

Year	DOS	Sheath Blight	Rank
2013	1st DOS	1220.85	I
	2nd DOS	1162.20	II
	3rd DOS	1035.45	III
2014	1st DOS	4336.2	I
	2nd DOS	2136.3	III
	3rd DOS	2239.65	II
2015	1st DOS	2885.55	I
	2nd DOS	1748.25	II
	3rd DOS	1704.45	III
2016	1st DOS	4131.60	I
	2nd DOS	3014.10	II
	3rd DOS	2198.25	III

Table.5 Year wise correlation coefficient between weather parameters and sheath blight disease severity over four years *kharif* season (2013-2016)

DOS	r- value	Tmax ^{0}C	Tmin^{0}C	RHm(%)	RHe(%)	R.F. (mm)	S.S.(Hr)
			2013				
Ist DOS	**r=0.950**	-0.27	-0.65	-0.88	-0.66	-0.49	0.36
IInd DOS	**r=0.878**	0.36	-0.89*	-0.43	-0.82	-0.89*	0.71
IIIrd DOS	**r=0.950**	0.25	-0.94	-0.59	-0.90	-1.00*	0.85
			2014				
Ist DOS	**r=0.754**	0.62	-0.95*	-0.90*	-0.94*	-0.68	0.77*
IInd DOS	**r=0.811**	0.64	-0.94*	-0.90*	-0.97*	-0.82*	0.89*
IIIrd DOS	**r=0.811**	0.84*	-0.91*	-0.92*	-0.95*	-0.94*	0.97*
			2015				
Ist DOS	**r=0.754**	0.37	-0.53	0.40	-0.67	-0.48	0.91*
IInd DOS	**r=0.811**	0.06	-0.74	-0.22	-0.77	-0.51	0.85*
IIIrd DOS	**r=0.878**	0.10	-0.67	0.03	-0.51	-0.44	0.89*
			2016				
Ist DOS	**r=0.754**	0.37	-0.85*	-0.33	-0.94*	-0.66	0.92*
IInd DOS	**r=0.811**	0.11	-0.86*	-0.29	-0.85*	-0.51	0.82*
IIIrd DOS	**r= 0.878**	0.79	-0.96*	-0.85	-0.91*	-0.66	0.66

Area under disease progress curve

The data presented in Table 4 regarding area under disease progress curve (AUDPC) revealed that maximum AUDPC value 1220.85 was calculated in first date of sowing followed by 1162.2 in second date of sowing and 1035.45 in third date of sowing during *kharif* 2013. During *kharif* 2014, maximum AUDPC value 4336.2 was calculated in first date of sowing followed by 2239.65 in third date of sowing and 2136.3 in second date of sowing.

During *kharif* 2015, AUDPC value 2885.55 was calculated in first date of sowing

followed by 1748.25 in second date of sowing and 1704.45 in third date of sowing.

The trend was similar in *kharif* 2016, the maximum AUDPC value was calculated in first date of sowing 4131.6 followed by 3014.1 in second date of sowing and 2198.25 in third date of sowing.

In all the maximum value of AUDPC calculated in first date of sowing followed by second date of sowing and least in third date of sowing during *kharif* 2013, 2015 and 2016. In *kharif* 2014, it was maximum in first date of sowing followed by third date of sowing and least in second date of sowing.

The above results clearly indicate that early sowing of paddy favours sheath blight disease development.

This finding was in agreement with finding of Hori, 1984; Chang *et al.*, 1985; Kaur *et al.*, 2015; Bhukal *et al.*, 2015 and Pal *et al.*, 2016 as they also reported early sowing favours the sheath blight disease development.

Correlation analysis

Correlation between weather parameters and sheath blight disease severity was calculated year wise also from 2013 to 2016 in all three date of sowing individually and data presented in Table 5.

Tmax

In *kharif* 2013, correlation between Tmax with sheath blight disease severity was positive in second and third date of sowing whereas it was negative in first date of sowing. During kharif 2014, correlation was positive in all three dates of sowing and significant in third date of sowing. In *kharif* 2015, correlation was positive in all three date of sowing.

Similarly in *kharif* 2016, correlation was positive in all three date of sowing which was almost confers that Tmax had positive effect for the development of sheath blight of rice in previous three years kharif season.

Tmin, RHm, RHe and RF

Correlation between Tmin, RHm, RHe, RF and sheath blight disease severity reveal that correlation was negative in all three date of sowing in all *kharif* seasons of 2013-2016.

SSH

Correlation between SSH and sheath blight severity was positive in all three dates of sowing in the *kharif* season of 2013-2016 which was significant in all three dates of sowing in *kharif* 2014-2016 and all three date of sowing in *kharif* 2014-2015 and first and second date of sowing in *kharif* 2016. From the above, it appears that SSH had direct effect on sheath blight development during *kharif* season of 2013-16.

Year wise correlation analysis between weather parameters and sheath blight disease severity suggest that Tmax and SSH had positive effect in the development of sheath blight disease of rice during *kharif* season. During the period from 16 September to 30 October in kharif season of 2013-16, crop growth stage was in maximum tillering to panicle initiation stage coincide with the Tmax range (30.5-32.6^{o}C) and SSH range (4.2-9.6) which favours the maximum apparent rate of infection by *Rhizoctonia solani* and resulted in maximum sheath blight disease progression (Table 2 and 3).

Findings of earlier researchers are in close proximity of findings of present study. Nandi and Chakrabarti (1977) reported mean weekly temperature 23.1 to 33.9^{0}C and mean relative humidity 65-93 %; Yuno *et al.*, (1978)

maximum and minimum temperature and rate of evaporation; Hashiba *et al.,* (1982) temperature 28^{0}C, RH 100% continuous low RF; Gangopadhyay (1983) and Ou (1985) temperature 30-32^{0}C and RH 81-92%; Kataria and Grover (1987); Tsai *et al.,* (1994) accumulated solar radiation; Castilla *et al.,* (1996) maximum air temperature and RHm; Tiwari (1997) 30^{0}C for *Sclerotia* formation; Singh (1998) temperature 30-32^{0}C and RH 96-97%; Sarkar *et al.,* (2000) high temperature; Rangaswami and Mahadevan (2005) high humidity and warm temperature; Wrather *et al.,* (2007) humidity 96-97%; Thind *et al.,* (2008) temperature 25-30^{0}C and RH 80-100 %; Biswas *et al.,* (2011) maximum air temperature 34^{0}C and RHm more than 90% ; Dutta and Kalha (2011) temperature 30^{0}C and RH > 90%; Henry and Devasahayam (2011) RH 96-97% and temperature 30-32^{0}C; Bhukal *et al.,* (2015) temperature 31-33^{0}C, RHm and RHe > 90%; Singh *et al.,* (2016) RH > 80% and 28^{0}C temperature; Pal *et al.,* (2016) maximum temperature 31-34^{0}C favours the development of sheath blight disease. On the contrary, Mathai *et al.,* (1986) found maximum temperature was non-significant and Reddy *et al.,* (2001) reported temperature and sunshine negatively correlated with sheath blight disease.

In the present study, minimum temperature, RHe and rainfall were negatively correlated with sheath blight disease severity. But some other workers found that the above weather parameters were conducive for disease development. Yuno *et al.,* (1978) reported minimum temperature; Mathai *et al.,* (1986) minimum temperature; Savary *et al.,* (2001) rainfall; Lenka *et al.,* (2008) minimum temperature and evaporation rate; Dutta and Kalha (2011) high and frequent rains; Bhukal *et al.,* (2015) minimum temperature; Kaur *et al.,* (2015) minimum temperature, evening relative humidity and rainfall and Singh *et al.,* (2015) found rainfall favoured the sheath blight disease development.

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