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Epidemiological studies to critical environmental parameters favouring infection and development of disease

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Abstract
An experiment was laid out on epidemiological studies of stem rot of mustard predicting of infection and progressive development of the disease during 2014-15 and 2015-16 at experimental field, Department of Plant Pathology, RVSKVV, Gwalior (Madhya Pradesh). The meteorological parameters data was collected at weekly interval during crop season of both years from the Meteorological Department, College of Agriculture Gwalior. The data revealed that stem rot infection is negatively and significantly influenced by maximum temperature (r= -0.697*) and sunshine hrs (r= -0.855**), while, the maximum relative humidity (r= 0.883**) and minimum relative humidity (r= 0.871**) showed highly significant and positive correlation with the *Sclerotinia sclerotiorum* infection. Further, for predicting the impact of the individual meteorological parameters a regression study was carried out. Further, The regression equation Y=-40.518+0.475 X3 indicates that average maximum in relative humidity should be at least 85.3% and thereafter, with 1% increase in relative humidity the stem rot infection (girdle length) may increase by 0.47 cm. Similarly, the disease (girdle length) increases by 0.06 cm per unit in minimum relative humidity for the infection of stem rot of mustard. The relative humidity and rainfall emerge as major factors to successful establishment of disease infection (girdle length). Thereafter, plants goes to collapse and unable to produce poding formation. This study concluded that the data would be helpful for the predictions of stem rot infect and it's management.

Keywords: stem rot, infection, meteorological parameters, mustard, *Sclerotinia sclerotiorum*

Introduction
Sclerotinia stem rot of mustard caused by *Sclerotinia sclerotiorum* (Lib) de Bary has become an important problem in northern Madhya Pradesh. This disease locally called Polio disease in northern region of Madhya Pradesh. Earlier, sclerotinia stem rot considered as a minor problem in India but it has become a threat by the wide spread, destructive and serious problem not only India but throughout the world most mustard growing areas. Large numbers of sclerotia are formed in soil on dead organic matter, on roots, on and inside the pith of stem in rapeseed mustard crop, that is serve as source of primary inoculum for the next season. Stem rot has become an economically important yield reducing factor especially in raya (Brassica juncea) and is causing 40-80 per cent losses in yield (Mehta *et al*., 2010) [2]. The maximum Sclerotinia rot incidence recorded in field of mustard growers of Rajasthan was 90 per cent, Stem rot is a disease that has become significant in recent times in India and elsewhere. Hence, the aim of present investigation was undertaken to formulate the effective strategies to manage this emerging problem.

Materials and Methods
An experiment was laid out at experimental farm on five different dates of sowing started from 27th of October, 6th, 16th and 26th November and 6th December during 2014-15 and 2015-16. The meteorological parameters data on temperature, relative humidity (RH), rainfall and number of sunshine hrs were also recorded separately at weekly interval during crop season from the Meteorological Department of College of Agriculture Gwalior. The experiment treatments were laid out in Randomized block design and four times replicated with following recommended practices. Plants were inoculated by artificial mycelium bit placement, Plate 2 after 55 Days of sowing using the susceptible variety Rohini. Symptoms appeared 5-7 days after artificial inoculation on plant stem. Progressively development of symptoms on

plant was recorded at weekly interval. There after correlation and regression studies were carried out in between the girdle length on stem and individual metrological parameters. For creating high humidity in the field before and after inoculation the fields were irrigated thoroughly for 3 times at an interval of 15 days before flowering. The girdled length in individual plant was recorded on ten plants randomly selected and tagged and then correlation between girdled length and corresponding meteorological parameters were workout.

Result and Discussion

The meteorological parameters *viz.*, temperature, relative humidity, rainfall and sunshine hrs in a day, play a vital role in the infection and progressive development of stem rot in mustard. Infection of above ground plant parts results from ascosporic inoculum, where soil borne infection may result from either ascospores or sclerotia. Below ground infection however results from mycelial germination of soil borne sclerotia. Continuous moisture for about ten days is required for the optimum development of the stem rot. In this work, the infection by *S. sclerotiorum* on rapeseed mustard got aggravated by low temperature (<25 C), high relative humidity (>40%), heavy rainfall and either absence or less sunshine hrs in a day.

Influence of meteorological parameters on infection

The relative humidity percent (maximum and minimum) and rainfall are the important meteorological parameters for infection of stem rot, Fig 1 and Plate 2. The maximum and minimum relative humidity percent showed a significant and positive relationship with the infection, this indicates that the infection increases with increase in the maximum and minimum relative humidity percent. The precipitation of rains also favours the infection and development of stem rot. The data revealed that the infection of stem rot is negatively and significantly influenced by maximum temp (r= -0.697*) and sunshine hrs (r= -0.855**), this indicated that the infection increases with decrease in average maximum temperature and sunshine hrs, Fig-1. In contrast to this, the maximum relative humidity (r= 0.883**) and minimum relative humidity (r= 0.871**) showed highly significant and positive correlation with the stem rot infection, which indicates that infection increases with increase in maximum and minimum relative humidity percent. Gupta *et al.* (2004) [3] observed the sowing on 21 October resulted in the greatest disease incidence (10.5% on average); and disease incidence decreased with the delay in sowing. The maximum (20.5-25.4´c) and minimum (3.9-10.7´c) temperatures at the flowering stage of crops established through sowing on 21 October were negatively correlated with the development of Sclerotinia blight. The minimum disease incidence was recorded where sowing was done in the last week of October. The growth of the fungus was significantly increased by the increasing RH%. The growth shows a linear increase in all the treatments with time indicating that the *S. sclerotiorum* require high relative humidity for good growth (Elgorban *et al.*, 2013) [4].

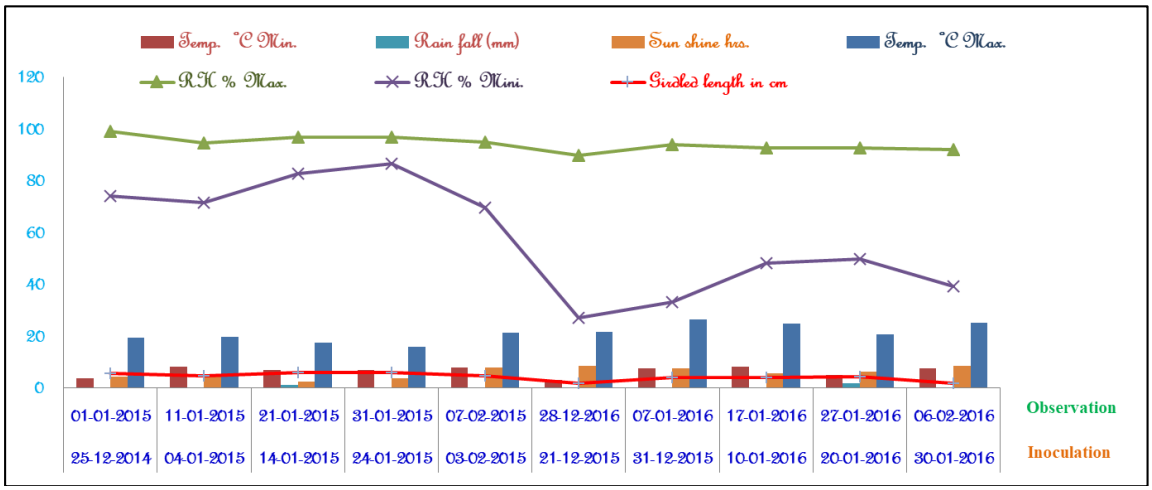

Fig 1: Influence of meteorological parameters on infection of stem rot of mustard

Further, prediction of impact of the individual meteorological parameters a regression study was carried out. The regression Y= 10.81-0.303 X1reveals that for the initiation of stem rot infection the average maximum temperature should be less than 35.7 ^{0}C and thereafter, per unit decrease in the maximum temperature, the stem rot infection (girdled length) may increase by 0.3 cm. The regression equation Y=-40.518+0.475 X3 indicates that average maximum relative humidity should be at least 85.3% and thereafter, with 1% increase relative humidity the stem rot infection may increase by 0.47 cm. Similarly, the disease increases by 0.06 cm per unit in minimum relative humidity. The regression equation Y= 7.9-0.587 X6 indicated that the sunshine hrs per day should be less than 13.5 hrs and thereafter, with per hrs decrease in the sunshine hrs of stem rot infection (Girdled length) may increase by 0.87 cm. All the regression equation may fit in the formula Yi = a +b x. Earlier, Ghasolia and Shivpuri (2005) [5] observed that sclerotia at upper surface of soil produced more apothecia. The prediction model developed for white stem rot as under: Y= –19.14 – 4.59 X_1 + 2.53 X_2 + 1.02 X_3 – 0.19 X_4 –0. 00 X_5 +0.63X_6, where, X_1 =Tmax.; X_2 = Tmin.; X_3=RHmor; X_4=RHeve; X_5=Sunshine h; X_6 RF.

Influence of meteorological parameters on progressive development of disease

The periodical observations on the development of stem rot were taken after the establishment of the infection. The data revealed that the disease development is negative and significantly influenced by maximum and minimum temperature. The data are presented in Table -2 and their associations in Table- 3.

Table 1: Correlation coefficient of individual meteorological parameters with infection of stem rot

Factor	r (Correlation coefficient)	Regression equation
Max. temp.	-0.697*	Y= 10.81-0.303 X1
Mini. temp.	0.124 (NS)	Y=3.691+0.097 X2
Max. RH.	0.884 **	Y=-40.518+0.475 X3
Mini. RH	0.871 **	Y= 0.825+0.060 X4
Total Rainfall	0.276 (NS)	Y= 4.150+0.558 X5
Sunshine hrs	-0.856 **	Y= 7.9-0.587 X 6

Table 2: Role of meteorological parameters on progressive development of stem rot

Date of observation	Temp. ºC		RH %		Rain fall (mm)	Sunshine hrs.	Girdled length in cm
	Max.	Mini.	Max.	Mini.			
2014-15							
08-01-2015	18.75	10.80	94.85	78.14	3.00	2.94	8.40
15-01-2015	18.81	5.68	97.57	74.71	0.00	4.90	5.90
22-01-2015	17.01	7.50	97.00	84.00	1.40	1.98	5.10
18-01-2015	17.94	6.27	97.42	78.42	1.40	3.54	8.95
25-01-2015	17.12	7.54	97.00	87.28	19.00	1.95	9.50
01-02-2015	15.22	6.78	97.00	83.14	5.00	4.90	9.90
28-01-2015	15.44	8.77	97.00	91.14	24.00	1.77	7.80
04-02-2015	19.20	6.15	98.85	74.28	0.00	7.55	4.00
11-02-2015	22.84	9.25	95.71	73.14	0.00	6.75	2.40
07-02-2015	21.54	7.84	95.00	69.57	0.00	7.88	8.75
14-02-2015	23.38	8.94	95.85	73.85	0.00	6.61	8.90
21-02-2015	28.78	12.17	95.14	63.71	0.00	7.84	5.80
16-02-2015	28.51	9.24	94.42	65.85	0.00	7.97	3.50
23-02-2015	28.28	13.07	95.28	68.42	0.00	7.22	2.20
02-03-2015	27.80	13.35	90.42	72.57	18.40	4.71	1.20
2015-16							
04-01-2016	25.08	7.20	93.00	33.42	0.00	7.80	8.65
11-01-2016	27.01	8.94	90.42	32.14	0.00	8.31	6.75
18-01-2016	24.11	8.22	93.57	53.42	0.00	4.85	8.55
14-01-2016	27.32	8.84	89.85	34.00	0.00	7.71	5.20
21-01-2016	19.94	7.78	94.71	68.57	8.00	3.60	9.85
28-01-2016	21.75	5.04	91.71	44.57	0.00	6.71	6.00
24-01-2016	18.74	5.50	94.42	59.57	8.00	3.88	8.50
31-01-2016	25.45	7.18	91.85	42.71	0.00	8.57	6.20
07-02-2016	24.06	7.11	91.57	30.14	0.00	8.71	4.90
03-02-2016	26.44	9.18	89.71	42.42	0.00	7.85	6.65
10-02-2016	24.25	6.58	94.00	35.14	0.00	9.28	8.70
17-02-2016	27.08	10.32	85.71	38.71	0.00	8.14	5.70
13-02-2016	25.75	8.48	91.14	36.42	0.00	9.00	1.40
20-02-2016	27.32	11.58	83.28	42.00	0.00	6.85	1.50
27-02-206	29.44	11.61	87.28	29.57	0.00	11.01	0.80

Table 3: Correlation coefficient of individual meteorological parameters with progressive development of Sclerotinia stem rot

Factor	r (Correlation coefficient)		Regression equation	
	2014-15	2015-16	2014-15	2015-16
Max. temp.	-0.650**	-0.647**	Y= 14.478-0.389 X1	Y= 21.670-0.630 X1
Mini. temp.	-0.508*	-0.627*	Y= 11.539-0.605 X2	Y= 13.520-0.918 X 2
Max. RH.	0.439	0.741**	Y= -57.336+0.662 X3	Y= -52.362+0.642 X3
Mini. RH	0.501*	0.531**	Y= -8.164+0.188 X4	Y= 0.378+0.134 X 4
Total Rainfall	0.116	0.459	Y= 5.954+0.041 X5	Y= 5.461+0.464 X5
Sunshine hrs	-0.390	-0.593*	Y= 8.729-0.492 X6	Y= 12.158-0.828 X6

Note:-. X1 – Average maximum temperature
X2 – Average minimum temperature
X3- Average maximum relative humidity (%)
X4 – Average minimum relative humidity (%)
X5- Total rainfall in mm
X6- Average sunshine hrs in a day
Y – Girdled length in cm
***** Significant at 5% prob. Level
****** Highly significant at 5% prob. Level
NS - Non Significant
Association- (X1 Vs Y, X2 Vs Y, X3 Vs Y, X4 Vs Y, X5 Vs Y and X6 Vs Y)

The correlation coefficient (r) between meteorological factors and disease development was made, Table 2 during 2014-15 and 2015-16. The development of the disease (girdled length) was gradually accelerated at the maximum temperature. Similar to, the minimum temperature also showed significant negative correlation coefficient in both years. This also indicates that the girdled length increases with decrease in average minimum temperature. In contrast to temperature, the relative humidity (Maximum and Minimum) showed a strong positive association with disease development. The value of r between maximum relative humidity and disease development was r=0.439 NS and r=0.741** during 2014-15 and 2015-16 respectively. This correlation coefficient reveals that the girdled length during 2015-16 increases fastly with the increase in maximum relative humidity. Similarly, the girdled length was also increase in 2014-15 with increase maximum relative humidity but the result was not significant. Though, the association of rain fall with disease development was positive in both the years but it was not significant. The average sunshine hrs per day had a negative impact on disease development, the girdled length significant increase with decrease in sunshine hrs. Mehta (2014) [1] reported that the white stem rot or Sclerotinia rot disease progression is favoured by high in relative humidity (>80 %), temperature maximum up to 25 C and temperature minimum of 5-12 C.

During 2014-15, the regression equations between meteorological factors and progressive disease development were worked out and presented in Table 4. The regression equation Y1= 14.478-0.389 X1 reveals that the temperature should be 37^0C - 19 ^{0}C for the development of the disease and thereafter with 1unit decrease in average maximum temperature the lesion increases by 0.389 cm, thereafter 1^0C decrease in minimum temperature may result and increase of girdle length by 0.60 cm. The regression equation between minimum relative humidity and progressive increase in girdle length Y1 = -8.164 +0.188 X4 reveals that the average minimum relative humidity should be more 43% for the development of lesion and thereafter with 1% increase in relative humidity the girdle length may increase by 0.04 cm. Aghajani *et al.,* (2010) [7] from Iran reported that Gompertz model with a mean R of 94.69 was selected as most appropriate model for determining Sclerotinia stem rot progress in the field. Often prediction models developed at one location may not fit at other locations. It indicates that data need to be generated for a longer period and the model be tested at multilocations. For greater efficiency, the disease-forecasting models must be developed by taking into account the crop variety, the prevalence of a particular pathotype and the microclimatic factors, Mehta (2014) [1].

Conclusions

The stem rot disease, maximum appeared in first date of sowing *i.e.* last week of October, while, minimum disease appeared at first week of December. The stem rot was influenced by maximum temperature and sunshine hrs towards. The disease increased by increase in relative humidity and rain fall.

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