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RESEARCH ARTICLE

Weather-based epidemiological models for Sclerotinia rot of oilseed Brassicas for Rajasthan

M.S. YADAV[1]*, AMRENDER KUMAR[2], S. GODIKA[3], N. AHMAD[1], N. MEHTA[1], D.K. YADAVA[4] AND C. CHATTOPADHYAY[5]

[1]*National Research Centre on Integrated Pest Management, Pusa Campus, New Delhi 110 012*

[2]*Agricultural Knowledge Management Unit and* [4]*Division of Seed Science and Technology, Indian Agricultural Research Institute, New Delhi 110 012, India*

[3]*Department of Plant Pathology, Sri Karan Narendra Agriculture University, Jobner 303 329, Rajasthan, India*

[5]*Ureas Banga Krishi Viswa Vidyalaya, Pundibati, Kooch Bihar-736165, West Bengal*

ABSTRACT: Sclerotinia rot {*Sclerotinia sclerotiorum (Lib.*) de Bary} of oilseed Brassicas is an emerging problem in Rajasthan. Quantitative models were developed for prediction of Sclerotinia rot on Brassicas. Historical data from 2004-05 to 2014-15 on per cent Sclerotinia rot and weekly weather variables of SKRAU, Agricultural Research Stations in Alwar and Sriganaganagar, Rajasthan were considered for model fitting. Weather-based indices were generated which were used as explanatory variables. Different weather variables *viz.*, minimum and maximum temperatures and afternoon relative humidity were identified as critical factors which significantly affected the development of Sclerotinia rot of oilseed Brassicas. The coefficient of determination (R^2) were maximum 0.93 and 0.88 at Sriganganagar and Alwar, respectively. Prediction-based management advisory to farmers could be issued with information for timely application interventions of pesticides to manage Sclerotinia rot.

Key words: Brassicas, *Sclerotinia sclerotiorum*, rots, epidemiological models,

Oilseed Brassicas are economically affected by *Sclerotinia sclerotiorum* (Lib.) de Bary worldwide. The pathogen is reported to have a wide host range, known to infect above 400 plant species (Chattopadhyay *et al.*, 2015) with no proven source of resistance against the disease reported till date in any of the hosts. The highest Sclerotinia rot incidence recorded in field of mustard growers was 66% where seed yield was reduced to 40% which indicates the importance of the disease (Yadav *et al*., 2011). Sharma et al., (2009) evaluated environmental variables for forecasting Sclerotinia rot of Indian Mustaid indicated that soil moisture was most closely associated with the development of disease when petal infestation was high. Knowledge of the Sclerotinia rot-plant relationships in relation to environmental conditions is limited. Efficient, economical and environmental friendly management of Sclerotinia rot may be obtained through knowledge of its timing of infection in relation to weather factors, which may enable development of epidemiological models so as to allow growers to take timely action in an efficient manner for crop protection. Weather is an important factor for development of *Sclerotinia* rot. Empirical models have been developed to relate Sclerotinia rot on oilseed Brassicas to temperature, relative humidity and bright sunshine hours. However, they provide no insight into quantitative prediction of Sclerotinia rot. Infections of the disease are dependent upon weather factors and suitable crop-weather-disease relationship can be developed to assess the risk of the disease (Manapaira and Das, 2014). The weather based modeling for early forewarning of disease may provide appropriate tools for predicting disease status (Kumar, 2013) that further may enable guiding farmers to take timely protection measures. Hence, the present study was undertaken to develop weather-based epidemiological models for Sclerotinia rot of oilseed Brassicas of Rajasthan.

*Corresponding author: dr.msyadav65@gmail.com

MATERIALS AND METHODS

Selection of centres for study was based on the maximum area of crop in state of Rajasthan and importance of Sclerotinia rot as a major constraint in cultivation of oilseed Brassicas in the region. All experiments relied entirely on natural infection of *Sclerotinia sclerotiorum*. Field trials were sown in the Ist week of November of Swami Keshwanand Rajasthan Agricultural University (SKRAU), Agricultural Research Stations (ARS) at Sriganganagar (29°55'N; 75°53'E) and Navgaon, Alwar, Rajasthan (27°38'N; 76°50'E) from 2004-05 to 2011-12 in post-rainy *Rabi* season with cultivar Varuna (*Brassica juncea*). Each plot measured 1.5m x 5m with plant spaced at 10cm intervals in rows 30cm apart with recommended dose of N and P fertilizers applied. Per cent Sclerotinia rot incidence was observed 20 days before harvest of crop. Data of weather variables *viz.*, weekly mean temperatures (maximum and minimum), relative humidity (morning and afternoon) were obtained from agrometeorological observatory of SKRAU, ARS, Sriganganagar for 2004-05 to 2011-12 and 2014-15 and Navgaon, Alwar for period 2004-05 to 2006-07, 2008-09 to 2011-12 situated at nearby experimental fields vis-a vis Sclerotinia rot incidence. Weather indices were obtained and used as predictors for model development. In this type of model, for each weather variable two indices were developed i.e., simple total of values of weather variables in different weeks and weighted total, weights being correlation coefficients between variable to forecast and weather variable in respective weeks. Hence, development of models for quantitative data has been attempted. The first index represents the total amount of different weather variables received by the crop during the period under consideration while the other one takes care of distribution of weather variables with special reference to its importance in different weeks in relation to the variable to forecast. Similarly, for joint effects of weather variables, weather indices were developed as weighted accumulations of product of weather variables (taking two at a time), weights being correlation coefficients between variable to forecast and product of weather variables considered in respective weeks [Kumar, 2013]. The form of the model was

$$Y = a_0 + \sum_{i=1}^{p}\sum_{j=0}^{1} a_{ij} Z_{ij} + \sum_{i \neq i'}^{p}\sum_{j=0}^{1} b_{ii'j} Z_{ii'j} + \varepsilon$$

$$Z_{ij} = \sum_{w=n_1}^{n_2} r_{iw}^{j} X_{iw}$$

$$Z_{ii'j} = \sum_{w=n_1}^{n_2} r_{ii'w}^{j} X_{iw} X_{i'w}$$

Where

Y variable to forecast

X_{iw} value of i th weather variable in wth week

r_{iw} correlation coefficient between Y and X_{iw}

$r_{ii'w}$ correlation coefficient between Y and product of X_{iw} and $X_{i'w}$

p number of weather variables considered

n_1 initial week for which weather data were included in the model

n_2 final week for which weather data were included in the model

∑ error term

Weather variables on maximum and minimum temperatures, morning and afternoon relative humidity were considered for model development. Stepwise regression technique was used for selection of significant variables. The performance evaluation measures such as coefficient of determination (R^2) and root mean squared error (RMSE) were considered in this study.

RESULTS

With view to predict epidemic status well in advance, models were attempted based on different groups of weeks starting from 46th standard meteorological week (SMW) onwards, were developed by taking weather data for the period from 2004-05 to 2014-15 for Sriganganagar and 2004-05 to 2011-12 for Alwar in Rajasthan. Two weather variables i.e. maximum temperature and afternoon relative humidity captured the phenomenon well at Sriganganagar (Table 1). Maximum coefficient of determination (R^2) 0.93 and minimum root mean square error of 2.74 were for the group of week starting from 46 to 52. Weighted index of interaction of maximum temperature and afternoon relative humidity was found to be important. Using this model, predictions are presented in Fig. 1. The results indicate that for most of the years (93%) the approach has predicted epidemic accurately.

In Alwar, Rajasthan, models were attempted by taking weather data for the period from 2004-05 to 2011-12 One weather variable i.e. minimum temperature captured the phenomenon well (Table 2). Maximum coefficient of determination (R^2) 0.88 and minimum root mean square error of 0.77 were for the group of week starting from 46 to 3. Weighted minimum temperature was found to be important. For most of the years (88%) the approach has predicted the epidemics accurately (Fig. 2).

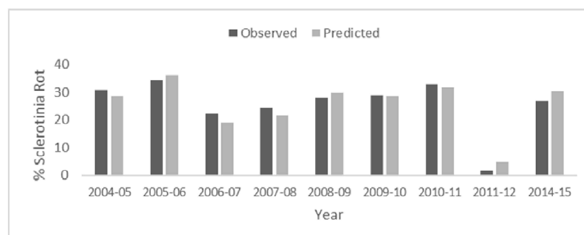

Fig. 1. Prediction of Sclerotinia rot at Sriganganagar during SMW 46-52

Table 1: Models for predicting % Sclerotinia rot at different weeks in Sriganganagar, Rajasthan

Data used (SMW)	Model	R^2	Root mean square error
46 to 52	$Y=44.30 + 0.052\ Z_{241} - 0.0023\ Z_{341}$	0.93	2.74
46 to 1	$Y=44.05 + 5.218\ Z_{21} - 0.0659\ Z_{121}$	0.89	3.41
46 to 2	$Y=39.56 + 0.058\ Z_{241} - 0.0036\ Z_{341}$	0.89	3.43
46 to 3	$Y= 24.65 + 0.0087\ Z_{450} - 0.0442\ Z_{241}$	0.89	3.33
46 to 4	$Y= 57.70 + 2.508\ Z_{21} - 0.2407\ Z_{451}$	0.86	3.96

Z_{241} is weighted interaction of maximum temperature and afternoon relative humidity; Z_{341} is weighted interaction of relative humidity in morning with relative humidity in afternoon; Z_{21} is weighted maximum temperature, Z_{121} is a weighted interaction of minimum and maximum temperature; Z_{450} is unweighted interaction of afternoon relative humidity and sunshine hours; Z_{451} is weighted interaction of afternoon relative humidity

Table 2. Models for predicting %Sclerotinia rot at different weeks in Navgaon, Alwar, Rajasthan

Data used (SMW)	Model	R^2	Root mean square error
46 to 52	$Y=-41.58 + 0.578\ Z_{11} - 0.29328\ Z_{21}$	0.80	1.00
46 to 1	$Y=-10.48 + 0.182\ Z_{11}$	0.75	1.14
46 to 2	$Y=-14.57 + 0.121\ Z_{10}$	0.82	0.97
46 to 3	$Y=-10.91 + 0.150\ Z_{11}$	0.88	0.77
46 to 4	$Y=-8.52 + 0.119\ Z_{11}$	0.87	0.81

$Z_{11}$is weighted minimum temperature; Z_{21} is weighted maximum temperature; Z_{10} is unweighted minimum temperature

DISCUSSION

Maximum coefficient of determination (R^2) was 0.93 at Sriganganagar, Rajasthan in group of weeks starting 46-52 SMW. Therefore, model of group of these weeks

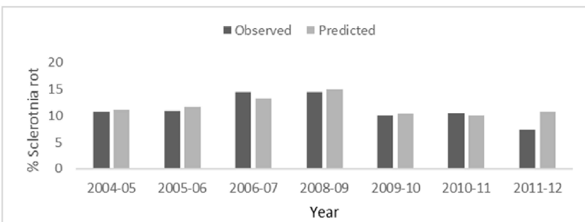

Fig. 2. Prediction of Sclerotinia rot at Alwar during SMW 46-3

was used for prediction of per cent Sclerotinia rot incidence. In this model weighted index of interaction of maximum temperature and afternoon relative humidity was found important. Overall prediction for Sriganganagar can be provided at 52nd SMW using data of maximum temperature and afternoon relative humidity. Yadav *et al.* (2010) observed rapid progress of other diseases at Sriganganagar during 6th and 7th standard meteorological week of 2007, when there was rainfall and low weekly mean maximum temperature. In Alwar, Rajasthan, R^2 was fluctuating between 0.75 to 0.82 in group of weeks 46 to 52, 46 to 1 and 46 to 2 and was found maximum 0.88 in 46 to 3 SMW and weighted minimum temperature was found to be important. Reliable quantitative prediction for per cent Sclerotinia rot at Navgaon, Alwar can be obtained at 3rd SMW using data on minimum temperature. Bhattacharya and Chattopadhyay (2013) also reported that persistent spell of temperature lower than normal in second fortnight of January driven by snowfall in the neighbouring Himalayas triggered Sclerotinia outbreak. Thus, our observations support earlier findings of Bhattacharya and Chattopadhyay (2013). Field data showed that there is also other external effect of weather to be understood before prediction of Sclerotinia rot. Our results indicated the need of knowledge of its timing of infection in relation to weather factors for development of epidemiological models so as to allow growers to take timely action in an efficient manner for crop protection. Keeping in view of these and earlier reports (Yadav *et. al.,* 2011) of disease prevalence and severity, our observations find significance. Being a polyphagous pathogen, the disease once introduced is difficult to get eradicated. Field studies conducted by Yadav *et al*. (2012) have shown that Sclerotinia rot of Indian mustard could be effectively and economically managed by seed treatment @10g/kg, soil application @ 2.5kg/ha and two foliar spray @ 0.2% at 50 and 70 DAS with talc based mixed formulation ($2x10^9$ cfu/g) of *T. hamatum* + *T. viride* in ratio of 1:1 (w/v).

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