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Impact of Weather Factors on Development of Red Rot Disease of Sugarcane Agro-Ecosystem

Sudhir Paswan[1*], Md. Minnatullah[2], Mahesh Kumar[3] and Abdus Sattar[4]

[1]Department of Statistics, SRI, DRPCAU, Pusa, Bihar – 848125, India
[2]Department of Plant pathology, SRI, DRPCAU, Pusa, Bihar – 848125, India
[3]Faculty of BS&H, DRPCAU, Pusa, Bihar – 848125, India
[4]Department of Meteorology, DRPCAU, Pusa, Bihar – 848125, India

**Corresponding author*

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A B S T R A C T

The model of forewarning about the infection of red rot disease in sugarcane was studied and observations were recorded at fortnight interval starting from June upto December during each year of experimentation. The maximum infection was recorded during 2nd fortnight of July while minimum (1.4%) was at 1st fortnight of June. Using the original data on the response variable i.e. infection of red rot disease, the simple linear regression model was fitted with fortnightly as explanatory variable and describe the severity of the infection of red rot disease during the fortnight. The value of multiple correlations for red rot disease was 0.7159. We also include meteorological factors i.e. maximum temperature, minimum temperature (^{0}C), relative humidity percentage (at 7.00 hrs and 14.00 hrs) and sunshine hours in the model. This model provides the severity of infection of the above mentioned disease forewarning. Meteorological factors played an important role in seasonal infection, distribution and disease build up. It is difficult to give a direct cause and effect relationship between any single factor and disease incidence because the impact of meteorological factors is usually compounded.

Introduction

Sugarcane (*Saccharum sp.* Hybrid) is one of the major tropical C4 plant that is cultivated in the tropical and subtropical regions globally and contributes to 75% of the world's sugar (Singh *et al.*, 2011). It contributes nearly 70 percent of world sugar production and provides raw material for many other by products (Gawade *et al.*, 2012). Among the various factors lowering down the production and productivity of sugarcane, the prevalence and infection of disease are one of them. About 100 diseases of sugarcane caused by fungi, bacteria, virus and phytoplasma have been reported from different parts of the world, out of which 55 diseases reported from India (Rott *et al.*, 2000) and 25 diseases from Bihar.

Among the various diseases affecting sugarcane, the red rot disease is a major constraint for sugarcane production. In India and the subcontinent faced many epidemics in

the past resulting in elimination of many popular varieties from cultivation (Viswanathan, 2010). Diseases are the major factors for reduction in crop yield of sugarcane, among them red rot disease is major concern and it causes the losses of 10-25 per cent to the sugarcane crop (Mohanraj *et al.,* 2003). In severe infection whole crop may be destroyed. The affected canes recorded 25-75% reduced sucrose content than the healthy canes (Viswanathan and Samiyappan, 1999). If information about time, severity and outbreak of disease are available in advance, timely control measures can be taken up so losses may be reduced. Weather plays an important role in disease development. Therefore, weather based models can be an effective scientific tool for forewarning diseases in advance. Forewarning of disease is important for crop production management and taking timely plant protection measures. Information of whether and disease status is expected to be below or above the threshold level is used for models building. Ramasubramaniun *et al.,* (2006) developed statistical models for forewarning about infestation of paddy crops using step-wise regression technique and weather indices modeling technique without using transformation of data.

Materials and Methods

To assess the impact of different weather parameters i.e. temperature (^{0}C), relative humidity (%), rainfall (mm), sunshine (hrs.) on the development of red rot disease incidence in sugarcane crop. The observations on red rot incidence were recorded through an extensive survey conducted over eleven years (2006-16) at fortnightly interval on clump basis. The incidence was calculated on plot basis irrespective of number of clumps showing infection in the plot. The per cent incidence of disease was worked out by using formula.

Per cent red rot infection = $\frac{\text{No.of infected clumps}}{\text{Total no.of clumps}} X\ 100$

Statistical analysis

Weather data collected from department of Agro-meteorology, DRPCAU, Pusa, Samastipur was subjected to correlation and regression analysis with disease incidence.

The following statistical model was used to assess the impact of weather factors on disease incidence.

$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6$

Where,

Y = Dependent variable (Disease incidence)

a= Pure constant

b_1= Regression coefficient for maximum temperature (X_1)

b_2= Regression coefficient for minimum temperature (X_2)

b_3=Regression coefficient for RH at 7 hrs. (X_3)

b_4= Regression coefficient for RH at 14 hrs. (X_4)

b_5= Regression coefficient for rainfall (X_5)

b_6=Regression coefficient for sunshine (X_6)

Results and Discussion

The data of disease incidence is presented in table 1, reflected that the disease appeared on the crop appeared in 1st fortnight of June up to 2nd fortnight of December during course of investigation.

Table.1 Means of observations on explanatory variable for eleven (11) years (2006 to 2016)

Months	Fortnight	Disease incidence (%)	Temperature (^{0}C)		Relative humidity (%)		Rainfall (mm) (X5)	Sunshine (hrs) (X6)
			Max (X1)	Min. (X2)	7.00 hrs (X3)	14.00 hrs (X4)		
January	I	0.0	19.7	8.4	90.2	59.4	5.1	3.6
	II	0.0	10.0	8.9	91.0	57.5	2.8	4.3
February	I	0.0	23.2	9.7	87.8	52.3	0.7	5.9
	II	0.0	25.3	12.3	86.6	52.3	8.6	6.3
March	I	0.0	28.3	13.5	83.1	47.1	4.1	7.2
	II	0.0	31.5	15.7	82.4	39.6	0.8	7.9
April	I	0.0	35.5	18.7	77.2	36.7	6.1	7.9
	II	0.0	36.2	21.2	72.7	36.8	7.6	8.0
May	I	0.0	36.7	23.1	74.7	42.7	9.4	8.2
	II	0.0	36.7	24.2	74.8	43.5	68.6	8.7
June	I	1.4	35.4	25.2	82.7	54.6	50.3	7.5
	II	3.2	35.8	26.5	83.6	58.5	54.7	7.3
July	I	12.5	34.4	26.8	86.7	66.7	93.6	4.9
	II	15.6	33.3	26.8	88.1	70.4	135.8	4.8
August	I	9.2	32.7	26.4	91.1	73.8	138.7	5.9
	II	13.5	33.5	26.8	89.2	68.5	91.3	6.4
September	I	5.3	32.7	26.1	89.8	73.2	161.8	4.4
	II	6.1	33.6	26.5	89.3	68.6	79.6	5.7
October	I	5.8	32.7	25.8	90.1	71.3	63.4	5.8
	II	9.1	32.5	24.8	91.3	65.6	130.8	6.5
November	I	7.2	32.0	22.8	90.2	55.7	56.0	6.7
	II	8.0	31.1	19.2	90.3	50.1	0.6	6.5
December	I	2.7	28.5	16.2	90.3	51.3	2.2	5.5
	II	1.5	27.1	13.0	88.1	44.0	0.00	4.9

Table.2 Correlation matrix of weather parameter on Red Rot disease in Sugarcane

Incidence (%)	No. of observation	Weather parameter					
		Temperature (^{0}C)		Relative humidity (%)		Rainfall (mm) (X_5)	Sunshine (hrs) (X_6)
		Max. (X_1)	Min (X_2)	7.00 hrs. (X_3)	14.00 hrs. (X_4)		
Red rot (Y)	24	0.292	0.60**	0.483*	0.531**	0.722**	-0.362

* - Significant at 5% probability
**-Significant at 1% probability

Table.3 Multiple linear regression models for weather parameter on Red Rot incidence in sugarcane

Incidence (%)	No. of observation	Pure constant	Weather parameter						R^2
			Temperature (^{0}C)		Relative humidity (%)		Rainfall (mm) (X_5)	Sunshine (hrs) (X_6)	
			Max. (X_1)	Min (X_2)	7.00 hrs. (X_3)	14.00 hrs. (X_4)			
Red rot (Y)	24	-40.8668	0.6608	-0.0293	0.3938	-0.0376	0.0236	-1.2976	0.7159

The maximum disease incidence (15.6%) was recorded during 2nd fortnight of July when the maximum and minimum temperature was 33.3^{0}C and 26.8^{0}C with relative humidity at 07 hrs. and 14 hrs. was 88.1 per cent and 70.4 per cent, respectively with rainfall was 135.8 mm coupled with sunshine was 4.8 hrs. Whereas minimum (1.4%) was recorded during 1st fortnight of June when the maximum and minimum was 35.4^{0}C and 25.2^{0}C, respectively and relative humidity at 07 hrs. (82.7%) and 14 hrs. (54.6%) with rainfall was 50.3 mm and sunshine hrs. being 7.5. The incidence of disease is appeared in 1st fortnight of June which was lowest (1.4%) among the moths of observations. Thereafter, gradually increasing trend was observed and its peak (15.6%) was observed during 2nd fortnight of July. Later on clear pattern was not seen, but during winter season disease severity was decreased as compared to rainy season. From the month of January to May the disease was not appeared on the crop during eleven years of study.

Correlation co-efficient of red rot incidence with weather parameters were worked out and presented in table 2, which indicated that the weather parameters exhibited positive correlation except sunshine. Minimum temperature, morning and afternoon relative humidity and rainfall showed significant positive correlation with disease development. There was not significant positive correlation of maximum temperature with red rot incidence indicating possible lesser disease incidence with lower day temperature. Minimum temperature and rainfall appeared to be most significant weather parameters contributing to the favourable condition for disease development.

Multiple regression equations involving weather parameters as independent variables and red rot incidence as depended variable were developed based on the data recorded during the study period. The regression equation has been presented in table 3. R^2 of the model was able to explain about 71 per cent variables in the incidence of red rot diseases involving maximum and minimum temperature, morning and afternoon relative humidity, rainfall and bright sunshine hours. The R^2 value of the model was significant at 5 per cent level of significance. Neumeister, (2010) reported that a shift in temperature due to climate change will have an effect on some of biotic factors like diseases, insect pest and weeds in sugarcane production. Prateeksha and Sahu (2015) observed that hot and humid climate are conducive for the development of various diseases. In case of smut disease incidence the maximum temperature showed positive significant correlation (0.074) while, relative humidity showed negatively significant correlation (-0.683) and there was non-significant correlation obtained in case of rainfall, wind velocity and sunshine.

Multiple regression models for red rot disease

Red rot (Y) = -40.8668 + $0.6608X_1$-$0.0293X_2$+$0.3938X_3$-$0.0376X_4$+$0.0236X_5$-$1.2976X_6$

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