Logistic Models of Yield Loss and Alternaria Blight Severity for Indian Mustard

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Abstract

Indian mustard, an important oilseed crop of India, is ravaged by a number of diseases, Alternaria blight being one of them. The Alternaria blight caused by *Alternaria brassicae* and A. Brassicicola has been reported from almost every continent of the world on oilseeds Brassica. Alternaria blight might be responsible for 10-70 per cent average yield losses in rapessed – mustard dependeing upon prevailing weather and disease situation. Experiments laid out at location Bharatpur. Yield loss and severity of disease on leaf and pod at crop age were forecasted for variety cv. Varuna and Rohini by logistic leaf method. On leaf, data revealed that for this location and variety age at first appearance of disease severity remained 77-91 days after sowing (d.a.s.) and due to age at peak disease severity yield losses remained 20-50%. Peak disease severity remained 98-120 d.a.s. and on pod disease severity appeared 98-130 d.a.s. Due to appearance of disease in its peak from 115-130 d.a.s. yield losses remained 18-50%. It was possible to provide the forecast in public interest at least one week prior to first appearance of disease, which allows farmers to either avaoid fungicidal spray or make timely and effective prophylactic sprays. This could thereby reduce unwanted fungicidal load on the crop.

Keywords: Chlorotic Lesion, Epidemic, Forcasting, Meterological Observatory, Severity.

Introduction

Rapeseed-Mustard are members of Cruciferae family that have been cultivated since 5000 BC in South and East Asia. It is now widely used as edible oil in human consumption and as an important source of protein for animal feed. Rapeseed-Mustard is among the major oilseed crops cultivated in India and around the world. Alternaria blight disease caused by *Alternaria brassicae* (Berk.) Sacc., damages arial plant part with visible symptoms of infection such as chlorotic and necrotic lesion on the leaf, petiole, stem, inflorescence, silique and seed (Verma *et al.* (1994). In India Alternaria blight is reported to be responsible for 10-70 percent losses, depending upon weather condition during later part of crop growth (Kolte (1995). In addition to direct losses, Alternaria blight can lower seed quality by reducing seed size causing discoloration and reduction in yield content (Kaushik *et al.* (1984). Total reduction in crop due to disease is 5-15% and reaches up to 47% (Kolte *et al.* (1987). Fungicides remain the only effective means to manage the disease (Chattopadhyay *et al.* (1984). Despite high consumption of fungicides on rapeseed-mustard crops in India (IASRI (2002), timing their application has not been optimal. Crops requiring treatment have been left unsprayed and other sprayed unnecessarily.

Efficient, economical and environment friendly control of the blight may be obtained through knowledge of its timing of attack in relation to weather factors, which may enable prediction of its occurrence so as to allow growers to take timely action in an efficient manner for disease management. Weather is an exceptionally important factor in the severity of Alternaria blight of oilseed *Brassica juncea and Brassica rapa* [Saharan *et al.* (1984), Sinha *et al.* (1992), Awasthi *et al.* (1994), Dang *et al.* (1995)]. Correlation study of the data revealed that Alternaria blight severity on leaves and pods of the plant was positively correlated with maximum daily temperature and morning Rh (Chattopadhyay (2005). Accurate forecast of the crop age at first appearance of the disease and the risk of a blight epidemic would enable farmers to decide on optimum timing of fungicide sprays and to avoid unnecessary pesticide application.

Object of Study

Hence, the present study was undertaken to develop forecasts for crops age at time of first appearance of Alternaria blight, for crop age when blight severity is maximum and for highest severity of the blight on the crop in the season.

Review of Literature

Development of logistic models was based on weather parameters and disease attack. Suitable plant protection measure could be taken up in time to protect the crops by the logistic model. It resulted that weather variability is another uncontrollable source of variability in yield (Agrawal and Mehta, 2007). By using composite weather variables, Fisher (1924) and Hendrick Sand Scholl (1943) have suggested models which require small number of parameters to be estimated while taking care of distribution pattern of weather over the crop season. The logistic model has been developed using partial crop season data considering all weather variables simultaneously (Agrawal and Mehta, 2007). The progress of *Fusarium* head blight (caused by *F. Graminearum [Gibberella zeae]* was studied in three wheat cultivars at 18, 21, 24, 27 and 30^{0}C. Data were tested by logistic, Gompertz, and Weibull method.

The Gompertz model effectively used for analysis of weather parameters and progress of *Alternaria* blight disease forecasting showed that the model can serve as an effective tool for decision making in selection of *Brassica* group for sowing in disease epidemic areas a Ueda *et al.,* 2010 well as for timing protection measure under conducive climatic factors (Sangwan *et al.,* 2000).

Impulsive logistic model was used to simulate epidemic process of gray leaf spots caused by *C. Zeae-maydis*. The derivation result from model was consistent with the development biological laws of *C. Zeae-maydi.* (Wang. *et al.,* 2010). Four non-linear mechanistic growth models, i.e. monomolecular, logistic, Gompertz and mixed-influence models were used to examine the pattern of wheat productivity from 1973/74 to 1996/97 in Punjab, Haryana, Uttar Pradesh, Rajasthan and all-India.

The model was produced using logistic regression analysis, and includes total rainfall, average minimum temperature, and number of rainy days in the first half of June, July, and August, respectively, as predictors and explained 85% of the variability. Results from the study suggest that in-season macro-weather variables could be used to predict the rick of white mold, which in-turn could help growers make better-informed decisions on whether or not to apply fungicides for white mold control. This disease-forecasting model was developed to help growers with their decision to apply these fungicides. The model was built using weather variables (Harikrishnan and Rio, 2008).

Logistic model was also developed by Mehta *et al.,* 2001 for mango fruit fly. Logistic regression was used to estimate the probability of stem rot prevalence of Soybean Sclerotinia stem rot (SSR), caused *by Sclerotinia sclerotiorum* (Mila *et al.,* 2004). The logistic model presented a satisfactory behaviour to define the order of magnitude of estimated dry matter and macro-nutrient uptake by the rice crop and maximum N and K uptake rates. Logistic and Gompertz was used for determined intensity of potato early blight. The model Gompertz turned out to be more efficient than the Logistic one to characterize and to explain the behaviour of the intensity of potato early blight depending on the age of the crop (Castellanos *et al.,* 2005).

Concepts and Hypothesis (Method Logistic Model)

Logistic regression is normally recommended when the independent variable do not satisfy the multivariate normal assumption. The Illustration is then extended to the case where the independent variables are a mixture of categorical and continuous variables and the best variable(s) is selected via stepwise logistic regression analysis. Model was developed in format given below.

P=1/1+exp-L

L=linear coordination of weather variable

$L=a_1 + a_2\ x1+a_3\ x_2$---------------$+a_9\ x_8$

(P=Y)

Model Development

We can forecast or predict age of first appearance age of peak appearance, highest severity with the help of logistic model on leaf for location (Bharatpur and varieties Brassica juncea (Varuna, Rohini) Data (weather and disease severity) was formatted and value of size (0-1) was given to the disease data for three parameters (age at first appearance, age at peak severity and highest disease severity on leaf. Forecasting or prediction was done with following parameters –

1. Crop age at first appearance
2. Crop age at peak disease severity
3. Highest disease severity on the crop
4. Yield loss

In the first step, labelling to be done to the formatted disease severity data (for each parameter viz., age at first appearance of disease, age at peak disease severity and highest disease severity on leaf in the season) in 0 and 1. In the model weather parameter [maximum temperature, minimum temperature, relative humidity (Rh morning, and Rh afternoon] were used as independent variables and disease severity data (on leaf) as dependent variable.

Assessment of Model by Different Methods

Assessment of model was based on the value of size (0-1). The logistic regression model was formed using the value of size (0-1) as the predictor. The first step was to assess the overall fitness of the model to the data obtained by observed value of size (0-1) for analysis. The second step was for validation of model to compare predicted value of size (0-1) with observed data for locations (Bharatpur) varieties *Brassica juncea*. (Varuna, Rohini), taking parameters, age at first appearance of the disease, age at peak disease severity and highest disease severity on leaf R^2 value for the variable (age at first appearance of the disease, age at peak disease severity) to be predicted was considered, which were mostly above 0.50 and were unable to conclude whether the model has goodness of fit. Value of chi square test being not significant 0.50 suggesting that the models were fit. (Table 1).

Research Design

All field experiments and data analysis were conducted in Plant Pathology Laboratory of the

Directorate of Rapeseed-Mustard Research (DRMR), erstwhile National Research Centre on Rapeseed Mustard (NRCRM), ICAR, Sewar, Bharatpur (Rajasthan) to study forecasting of Alternaria blight and yield loss assessment *vis-a-vis* yield in rapeseed-mustard. Weather data [maximum temperature, minimum temperature, relative humidity (Rh) morning, afternoon] and Alternaria blight disease severity (on leaf, pod) were taken from the reports of All India Co-ordinated Research Project on Rapeseed-Mustard (AICRP-RM) and Sub-project Mission Mode III-17 of National Agricultural Technology Project for locations Bharatpur on *Brassica juncea* (cv. Varuna, Rohini). Bharatpur is located at $27^0$15'N latitude and $77^0$30' E longitude. Temperature and relative humidity were recorded from standard meteorological observatory at location DRMR Sewar, Bharatpur.

Year and varieties-Five-year data (disease and weather) from-2001-02, 02-03, 03-04, 04-05, 05-06) were used for model development and last two year data 2006-07, 07-08 were used in validation of developed model.

Data used in Model Development

1. Weather data-maximum temperature, minimum temperature, relative humidity (RH) morning, afternoon.
2. Yield data.
3. Alternaria blight severity (leaf, pod).

Observation

Initial date of Alternaria blight appearance in each plot and disease progress recorded from 10-tagged plants. l Disease progress recorded randomly in experimental plot for percent disease severity (PDS) twice a week (Tuesday, Friday) till harvest on leaves, pods following scale of (Conn *et al.* (1990).

Software Used for Development of Model for Disease Severity and Yield Loss

Weather and disease data were analyzed statistically for development of forecasting models (disease severity and yield loss assessment) by using statistical software.

Weather data (maximum temperature, minim temperature, and Rh morning, Rh afternoon) was taken from 40^{th} Standard Meteorological Week (SMW) from sowing to week when disease severity reached its peak.

The weekly average of disease data were calculated from 40^{th} SMW (from sowing) to week when disease severity reached its peak for development of models.

SPSS Version 15 and 17 available at DRMR, Bharatpur. Stepwise regression method was used for development of forecasting model for disease severity and yield loss. (Table 1).

Table - 1

Logistic Model on Leaf to Forecast *Alternaria* Blight Severity in Oilseed *Brassica* for Different Locations, Cultivars and Their Test

Location	Cultivars	Crop Age (Week) of Prediction	Model	R^2	Success
Bharatpur	Varuna	7	$Y=1/1+exp-.403-002\times_{Z\ max\text{-}temp.w.} -.001\times_{Zmax.temp.x.rh\ aft.u}$	0.54	0.85
	Rohini	7	$Y=1/1+exp-50.04+.110\times Z_{max.temp.u}+.00\times Z_{min.temp.\times rh.mor.u.}+.001\times Z_{rh.mor.\times rh.aft.u.}+.268\times Z_{max.temp.w}+.007\times Z_{max.temp.\times rh.aft.w}$	0.67	0.98

Findings

Observed and Forecasted Values of Crop Age at First Appearance of *Alternaria* Blight Disease Severity

At location Bharapur for variety Varuna it was observed that first appearance of disease on leaf was 91 d.a.s. and predicted value of first appearance of disease remained 87 days after sowing (d.a.s.). For Rohini it was observed that first appearance of disease on leaf was 77 d.a.s. and predicted value of first appearance of disease severity remained 74 d.a.s.

Chi square value of all location and variety was above 0.50 which was not significant. (Table 2).

Table- 2

Forecasted and Observed Values of Crop Age at First Appearance of *Alternaria* Blight and Yield Loss. Prediction in Oilseed *Brassica* on Leaf

Location	Cultivars	Saverity		Yield (kg/ha)			
		(O)	(P)	(O)	(P)	s.v.y.	y.l.p.
Bharatpur	Varuna	91	89	1883.5	1682.2	2100	20
		82	87	1826.5	1574.2	2100	25
Bharatpur	Rohini	77	74	1989.2	1626.1	2500	35
		72	70	1826.3	1599.8	2500	36

S= Severity O = Observed P=Predicted

s.v.y = standard value of yield (kg/ha) y.l.p. = yield loss percentage

Impact of Age at First Appearance of *Alternaria* Blight Disease Severity on Yield

At location Bharatpur for variety Varuna it was observed that first appearance of disease was 91 d.a.s. and yield was 1826 kg/ha and predicted value of first appearance of disease severity remained 87 days after sowing (d.a.s.) and due to this yield predicted was 1574 kg/ha. Yield loss remained 25%. Difference between observed and predicted values was not significant. For variety Rohini it was observed that first appearance of disease occurred 72 d.a.s. and yield was 1826 kg/ha and predicted value of first appearance of disease severity remained 70 d.a.s. and due to this yield predicted was 1599 kg/ha. Yield loss remained 36%. Difference between observed and predicted value was not significant. (Table 2).

Observed and Forecasted Values of Crop Age at Peak Appearance of Diseases Severity

At location Bharatpur for variety Varuna observed age of peak disease severity remained 90 d.a.s. and predicted value of age of peak disease severity remained 98 d.a.s. In Rohini it was observed that age of peak disease severity occurred 125 d.a.s. and predicted age of peak disease severity remained 120 d.a.s. (Table 3).

Yield Loss Due to Age at Peak Appearance of *Alternaria* Blight Disease Severity on Crop

At location Bharatpur for variety Varuna it was observed that peak disease severity occurred 90 d.a.s. and yield was 1883 kg/ha and predicted age of peak disease severity remained 9 d.a.s. and due to this yield was 1352 kg/ha. Yield loss remained 30%. In Rohini it was observed that age at peak disease severity occurred 125 d.a.s. and yield was 1826 kg/ha and predicted age at peak severity remained 120 d.a.s. and due to this yield remained 1952 kg/ha. Yield loss forecasted was 22%. (Table 3).

Table- 3

Forecasted and Observed Values of Crop Age at Peak Appearance of *Alternaria* Blight and Yield Loss. Prediction in Oilseed *Brassica* on Leaf

Location	Cultivars	Saverity		Yield (kg/ha)			
		(O)	(P)	(O)	(P)	s.v.y.	y.l.p.
Bharatpur	Varuna	125	133	1883.2	1352.7	2100	36
		90	98	1826.5	1462	2100	30
Bharatpur	Rohini	138	120	1989.2	2065	2500	18
		125	120	1826.3	1952	2500	22

S= Severity O = Observed P=Predicted

s.v.y = standard value of yield (kg/ha) y.l.p. = yield loss percentage

Observed and Forecasted Values of Highest Severity Percentage of *Alternaria* Blight Disease on Leaves of Mustard Crop

Highest disease severity percentage affects the yield of the crop. When disease severity was higher then the yield loss was commensurately higher.

For variety Varuna at Bharatpur it was observed that highest disease severity was 12.5% and predicted highest disease severity was 9.2%. In variety Rohini at Bharatpur it was observed that highest disease severity was 11% and predicted highest disease severity was 7.6% on leaves. (Table 4).

Yield Loss Assumption by Observed and Predicted Value of Highest Severity Percentage of *Alternaria* Blight on Crop

For variety Varuna at Bharatpur it was observed that highest disease severity was 12.5% and yield was 1883 kg/ha and predicted value of highest disease severity was 9.2% and due to this yield forecasted was 1552 kg/ha. Yield loss forecasted was 26%. In variety Rohini at Bharatpur it was observed that highest disease severity was 11%, yield was 1989 kg/ha and predicted highest disease severity was 7.6% on leaf. And due to this yield was 1875 kg/ha. Yield loss forecasted was 25%. (Table 4).

Table- 4

Forecasted and Observed Values of Highest Severity Per Centage of *Alternaria* Blight and Yield Loss Prediction in Oilseed *Brassica* on Leaf

Location	Cultivars	Saverity		Yield (kg/ha)			
		(O)	(P)	(O)	(P)	s.v.y.	y.l.p.
Bharatpur	Varuna	12.5	9.2	1883.5	1552.7	2100	26
		2.1	2	1826.5	1994	2100	5
Bharatpur	Rohini	11	7.6	1989.2	1875.2	2500	25
		2.1	2.5	1826.2	1925.7	2500	23

S= Severity O = Observed P=Predicted

s.v.y = standard value of yield (kg/ha) y.l.p. = yield loss percentage

Conclusion

Susceptibility at Alternaria blight severity increases with the age of the plant and disease become more severe in the later stage of crop growth and disease appear in its severe from in 10th week after sowing. Our results from logistic model were similar with findings of Chahal *et al.* (1979) and Sarkar and Sengupta (1978), that high temperature and Rh appear more important factor for spread of Alternaria blight infection on pods and disease appeared in severe from after mid of January.

The logistic model revealed that disease appears mostly 3 week after the sowing of the crop and reach its peak in s10 week after slowing and results revealed that in variety Varuna disease appear much earlier than Rohini (Table 1). Disease appeared in peak from when maximum temperature was about 15-20^{0}C and Rh was 85-90% and disease severity progress declined in February. Results from logistic model revealed that disease severity appeared mostly during Ist week of December to 2nd week of February and peak severity of disease appeared mostly in 2nd week of January to 3rd week of January depending on variety and location. Present investigations from logistic model match with findings of Meena et al. (2004) and Sinha *et al. (*2002), that on leaf for this location and variety first appearance of disease occurred 75-90 d.a.s. fungicidal spray should be sprinkled according to forecasted value of first appearance of disease (70 d.a.s.), so that yield losses remain minimum. The results from regression model matched with earlier findings and assumed that spray and other control devices could be used at 45, 60, 90, 120 d.a.s. so that disease did not reach at its peak from and yield loss remain minimum.

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