

Multiple Regression Analysis for Prediction of Bacterial Black Spot Disease in Mango (*Mangifera indica* L.)

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ABSTRACT

Mango (*Mangifera indica* L.) is an important fruit crop in India and is honored as the king of fruit in the country. Among the several abiotic and biotic factors, Bacterial Black Spot which is caused by *Xanthomonas campestris* is the most serious disease causes up to 60 percent yield losses and confines mango cultivation in tropical and subtropical countries worldwide. The purpose of this study was to carry out multiple regression analysis for the prediction of malformation disease of mango. The experiment was conducted on 15 years old plants of twenty cultivars of mango namely Pansinduri, Dashehari, Amarpalli, Neelum, Hathijhul, Rasgulla, Redtotapari, Langra, Nashpati, Ramkela, Gaurjeet, Golajafarani, Gulabkhas, Gorakhpurlangra, Kalahafus, Karela, Tamancha, Barahmasi, Husnara and Chausa in 2013 and 2014 at Horticulture Research Station (H.R.C.) of G. B. Pant University of Agriculture and Technology, Pantnagar, Distt. Udham Singh Nagar, Uttarakhand. Prevailing weather variables such as temperature, relative humidity, and rainfall were obtained corresponding to the mango seasons for both years (2013 and 2014) from an agrometeorological section of GBPUAT, Pantnagar. These data were also utilized for working out disease weather correlations. A significant correlation coefficient was used to work out multiple regressions for the prediction of malformation in mango. The coefficient of multiple determination (R^2) ranged from 94.6 to 99.1 percent. Maximum R^2 value (99.1%) was found in Chausa and minimum R^2 value (94.4%) in Dashehari.

Keywords- Mango, Bacterial Black Spot coefficient of multiple determinations R^2 , Prediction

Introduction

Mango (*Mangifera indica* L.) is an Indian sub continent-originated fruit crop (Muksheerjee and Litz, 2011) and belongs to the family Anacardiaceae. It is called king of the fruits and is considered the most important fruit among millions of people worldwide particularly in Egypt. (El-Meslamany *et al.*, 2020). It is one of the world's most important fruits of tropical and subtropical countries and is cultivated extensively as a commercial fruit crop in India, China, Indonesia, Thailand, and Mexico. The crop is grown in over 87 countries in the world. Mango occupies an area of 2309 000 Ha having annual production of 21285 MT in India. (NHB, 2019-20). It is nutritionally rich in carbohydrates (11.6-24.3%), protein (0.5-1.0%), fat (0.1-8%), vitamins A and C, amino acids, and fatty acids. A good mango variety contains 20 percent of total soluble sugars. The acid content of ripe desert fruit varies from 0.2 to 0.5 percent and the protein content is about 1 percent. Among all prevailing diseases, the Bacterial black spot disease of mango caused by *Xanthomonas campestris* is known as a plant disease of international importance.

Yield of any crop is mainly influenced by the factors like weather parameters and the input variables. The effect of weather on crop growth varies with the growth period of the crop. The influence of weather parameters on crop yield depends on the magnitude and distribution of the weather variables over the crop growth period. In the prediction approach for crop production, utilizing information on both weather parameters and input variables is advantageous. For accurate prediction,

long-term data on weather parameters and input variables are required but practically obtaining long-term time series data is very difficult. Therefore to overcome this problem one can build the model with less number of parameters taking into consideration the pattern or the distribution over the entire crop growth period. Approaches based on various weather-based regression analysis which captures the effect of climate variables on crop yields was proposed by (Noriega-Cantu *et al.*, 1998 Sharma *et al.*, 2020) observed that the explanatory power of the multiple regression models are much better and they express how weather conditions and crop yield are related to one another. The Multiple Linear Regression (MLR) models are applied when two or more independent variables are influencing the dependent variable. It uses few or all variables for prediction as necessary to get a reasonably accurate prediction.

MATERIALS AND METHODS

The present investigation entitled 'Multiple Regression Analysis for Prediction of Bacterial Black Spot Disease in Mango' was carried out at Horticulture Research Center (H.R.C.), Patharchatta, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar (U.S.Nagar) during 2013 and 2014.

Experimental Material

The experiment was conducted on 15 years old plants of twenty

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cultivars of mango namely Pantsinduri, Dashehari, Amarpalli, Neelum, Hathijhul, Rasgulla, Redtotapari, Langra, Nashpati, Ramkela, Gaurjeet, Golajafarani, Gulabkhas, Gorakhpurlangra, Kalahafus, Karela, Tamancha, Barahmasi, Husnara and Chausa in 2013 and 2014 at Horticulture Research Station (H.R.C.) of G. B. Pant University of Agriculture and Technology, Pantnagar, Distt. Udham Singh Nagar, Uttarakhand. Prevailing weather variables such as temperature, relative humidity, and rainfall corresponding to the mango seasons for both years (2013 and 2014) were obtained from the agrometeorological section of GBPUAT. These data were also utilized for working out disease weather correlations. Correlation coefficient analysis was used to work out multiple regressions.

Details of Experiment

An experiment was conducted to observe the progress of Bacterial black spots from a source point of infection in the field for two years, i.e. 2013 and 2014. Observations were recorded starting from the appearance (April) of the disease from the infection focus to observe its progression. Three uniform 15 years old trees in each of the twenty cultivars growing under uniform cultural practices were randomly selected. In both years, 30 current-year leaves were labeled in the first week of April before symptoms were detected. Data on disease incidence were recorded at regular intervals of ten days interval on a rating scale of 0-5 as proposed by Thirumalesh *et al.*, (2011)

Symptomatology and disease development

The disease appeared in 3rd week of April in both years. The characteristic symptom (Figure 1a) of the disease on leaves produces angular, water-soaked spots of 1-3mm in diameter, which are delimited by the veins. On fruit, lesions developed as water-soaked halos around lenticels or wound and soon become raised and then blacken and crack open with gummy infection (Figure 1b). The characteristic symptoms observed due to the disease were compared in the light of available literature and these were found to be similar to those documented by (Akhtar and Alam (2002), Pitkethley (2006), and Thirumalesh *et al.*, (2011) Gagnevin, L. and Pruvost, O. (2001), Pruvost Olivier *et al.*, 2016, Jean-martial *et al.*, 2021. Now this disease is persists in the entire mango-growing areas of Uttarakhand causing a threat to mango production. This disease makes its appearance every year; the severity of the attack mainly depends on environmental factors.

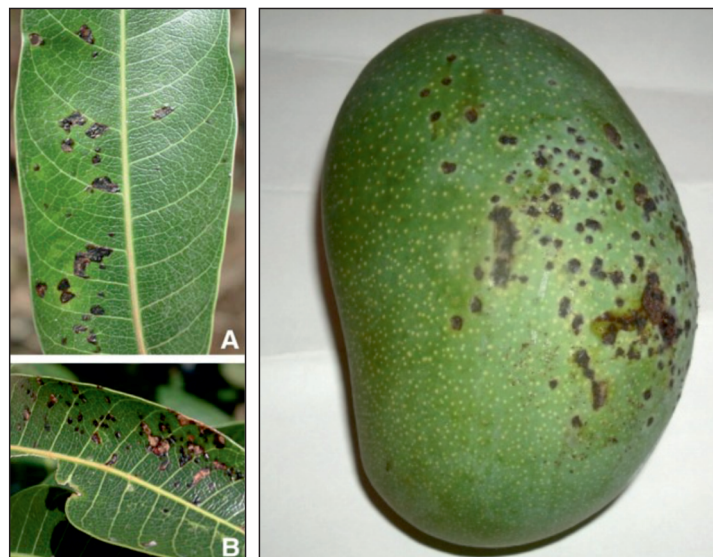
corresponding data were obtained for two years from the agrometeorological section of GBPUAT (Table.2). The effect of weather parameters on floral malformation disease was correlated by using SPSS version 16 software. The regression and R² values were also analyzed by using SPSS software.

Results and Discussion

Multiple regression analysis is a set of statistical methods used for the estimation of relationships between a dependent variable and one or more independent variables. The multiple regression equation was designed based on data obtained over two years to predict the disease incidence depending on various abiotic factors. The regression analysis of disease incidence as an independent variable with weather parameters was analyzed using SPSS 16 which was useful in the prediction of this disease. The multiple regression equations (Table 1) were calculated for twenty cultivars of mango. The coefficient of multiple determinations (R²) value of twenty cultivars showed that variation of disease incidence in the development of disease was maximum (up to 99.1%) in Chausa and Minimum (94.6%) in Dashehari. These results are in accordance with (Manicom, B 2008). The results further indicate that data needs to be generated for a longer period and the model to be tested and validated at multi locations.

Table 1: Multiple regressions analysis for prediction of Bacterial Black Spot of mango

SI. No.	Cultivars	Multiple regression equation	R ² (Coefficient of multiple determination)
1	Pantsinduri	$Y = -35.18 + (0.385x_1) + (0.669x_2) + (0.204x_3) + (-0.015x_4)$	0.950



A. Symptoms on leaves

B. Symptoms on fruit

Figure 1: Bacterial Black Spot

Based on the symptom development, the following scale was devised for the assessment of disease severity/ index and were categorized as different levels of resistance and susceptibility

Rating scale	Lesions (Number/ leaf)
0	No lesions
1	1-10 small and dispersed spots
2	11-25 small and dispersed spots
3	26-45 small and dispersed spots
4	>45 dispersed black spots

PDI was also calculated as following:

$$PDI = \frac{\text{Sum of rating of leaves observed}}{\text{Number of leaves observed} \times \text{Maximum disease grade}} \times 100$$

Disease progression in relation to weather variables

To study the pre-disposing meteorological factors viz. average atmospheric temperature, relative humidity, and rainfall on the development of floral malformation disease in the field,

2	Dashehari	$Y = -38.064 + (0.423_{X1}) + (0.676_{X2}) + (0.228_{X3}) + (-0.061_{X4})$	0.946
3	Amarpalli	$Y = -23.63 + (0.230_{X1}) + (0.577_{X2}) + (0.129_{X3}) + (0.197_{X4})$	0.947
4	Neelum X Chausa	$Y = -34.42 + (0.328_{X1}) + (0.566_{X2}) + (0.234_{X3}) + (0.258_{X4})$	0.962
5	Hathijhul	$Y = -23.03 + (0.213_{X1}) + (0.633_{X2}) + (0.101_{X3}) + (0.326_{X4})$	0.971
6	Rasgulla	$Y = -31.85 + (0.322_{X1}) + (0.589_{X2}) + (0.195_{X3}) + (0.200_{X4})$	0.961
7	Redtotapari	$Y = -37.14 + (0.381_{X1}) + (0.649_{X2}) + (0.238_{X3}) + (0.162_{X4})$	0.958
8	Langra	$Y = 0.723 + (0.090_{X1}) + (0.844_{X2}) + (-0.237_{X3}) + (0.966_{X4})$	0.962
9	Nashpati	$Y = -35.23 + (0.277_{X1}) + (0.682_{X2}) + (0.266_{X3}) + (0.095_{X4})$	0.985
10	Ramkela	$Y = -37.28 + (0.286_{X1}) + (0.692_{X2}) + (0.268_{X3}) + (0.032_{X4})$	0.980
11	Gaurjeet	$Y = -25.47 + (0.295_{X1}) + (0.599_{X2}) + (0.144_{X3}) + (0.092_{X4})$	0.953
12	Golajafrani	$Y = 3.892 + (-0.040_{X1}) + (0.790_{X2}) + (-0.202_{X3}) + (0.789_{X4})$	0.965
13	Gulabkhas	$Y = -24.96 + (0.269_{X1}) + (0.536_{X2}) + (0.125_{X3}) + (0.220_{X4})$	0.973
14	Gorakhpur langra	$Y = -19.97 + (0.234_{X1}) + (0.612_{X2}) + (0.087_{X3}) + (0.247_{X4})$	0.960
15	Kalahafus	$Y = -25.048 + (0.170_{X1}) + (0.587_{X2}) + (0.162_{X3}) + (0.380_{X4})$	0.990
16	Karela	$Y = -23.80 + (0.206_{X1}) + (0.605_{X2}) + (0.133_{X3}) + (0.223_{X4})$	0.976
17	Tamancha	$Y = -26.30 + (0.165_{X1}) + (0.648_{X2}) + (0.172_{X3}) + (0.198_{X4})$	0.988
18	Barahmasi	$Y = -31.50 + (0.299_{X1}) + (0.549_{X2}) + (0.226_{X3}) + (-0.014_{X4})$	0.987
19	Husnara	$Y = 1.65 + (-0.013_{X1}) + (0.707_{X2}) + (-0.153_{X3}) + (0.886_{X4})$	0.961
20	Chausa	$Y = -27.33 + (0.207_{X1}) + (0.555_{X2}) + (0.186_{X3}) + (0.450_{X4})$	0.991

Where, $X1$ =Maximum Temperature ($^{\circ}C$), $X2$ = Minimum Temperature ($^{\circ}C$), $X3$ = Maximum Relative Humidity (%), $X4$ = Rain Fall (mm)

Table: 2 Meteorological data at Pantnagar during cropping season pooled 2013-2014

Standard weeks	Temperature ($^{\circ}C$)		Relative Humidity (%)	Rain fall (mm)
	Max.	Min.	Max.	
1	20.75	6.05	95.00	0.80
2	20.15	8.20	88.5	1.80
3	19.30	8.85	94.0	52.90
4	16.75	8.05	95	0.70
5	19.25	8.20	94.00	0.00
6	22.10	9.35	93.00	25.15
7	20.95	8.25	93.00	76.40
8	22.55	10.15	91.00	12.10
9	24.45	11.05	92.00	40.70
10	26.95	11.75	89.00	0.00
11	28.50	13.45	87.50	13.10
12	29.30	14.70	85.50	0.00
13	30.85	14.65	87.50	0.00
14	32.90	14.95	80.50	1.10
15	35.10	16.65	70.00	0.30

16	33.60	16.80	68.00	9.30
17	36.25	18.60	65.50	0.00
18	37.95	19.80	61.00	7.20
19	37.85	20.20	59.85	2.30
20	37.50	22.15	63.7	0.00
21	38.90	26.00	64.50	0.00
22	37.64	26.19	67.57	1.51
23	38.08	26.82	70.00	11.80
24	35.93	25.46	75.57	61.59

Conclusion

The research is very useful for Mango growers to predict and control the Bacterial Black Spot disease of Mango caused by *Xanthomonas campestris*. Very little work has been conducted on the Bacterial Black Spot disease of Mango. Based on the results obtained in this study one can conclude that the multiple regression analysis for prediction of Bacterial Black Spot disease in mango performed better. The reason for the better performance of multiple regression models may be due to the consideration of various weather variables. The coefficient of multiple determinations (R^2) value of twenty cultivars showed that variation of disease incidence in the development of disease was maximum (up to 99.1%) in Chausa and Minimum (94.6%) in Dashehri.

Future Scope

The research is very useful for Mango growers to control the Bacterial Black Spot of Mango caused by *Xanthomonas campestris*. Very little work has been conducted on multiple regressions for the prediction of Bacterial Black Spots of Mango. More research is needed to introduce prediction using the multiple regression model as it is a rational and scientific way of predicting future occurrences in agriculture and the level of production effects. Its main purpose is to reduce the risk in the decision-making process affecting the yield in terms of quantity and quality. It is used to provide support to decision-makers and in planning various plant disease management tactics for the future effectively and efficiently.

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