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Multiple Regression Analysis for Prediction of Powdery Mildew in Mango (*Mangifera indica* L.)

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ABSTRACT: Mango (*Mangifera indica* L.) is one of the highly demanded fruit in India. However, the crop is vulnerable to numerous diseases at all stages of its development. Among these diseases, powdery mildew caused by *Oidium mangiferae* is one of the most serious and widespread disease. The purpose of this study was to investigate multiple regression analysis for prediction of powdery mildew in mango. The experiment was conducted on 15 years old plants of twenty cultivars of mango namely Pantsinduri, Dashehari, Amarpalli, Neelum, Hathijhul, Rasgulla, Redtotapari, Langra, Nashpati, Ramkela, Gaurjeet, Golajafrani, 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 (2013-2014) from agrometeorological section of GBPUAT, Pantnagar. These data were also utilized for working out disease weather correlations. Significant correlation coefficient was used to work out multiple regressions for prediction of powdery mildew in mango. The coefficient of multiple determinations (R^2) value of twenty cultivars showed that variation of disease incidence in the development of disease is up to 94% (maximum) in Nashpati cultivar and 84 % (minimum) in Pantsinduri. The observations were amply supported by the fact that the development of powdery mildew of mango under field conditions were recorded to be maximum (60-75%) during the month of March when average maximum and minimum temperature were 26.82°C to 16.75°C, coupled with high relative humidity to the extent of 61-95 per cent, respectively. This proves that the moderate temperature ranging between 16 to 20°C is most favorable for development of powdery mildew under field conditions. The results further indicate that data needs to be generated for a longer period and the model to be tested and validated at multilocations.

Keywords: Mango, powdery mildew, coefficient of multiple determinations R^2, Prediction.

INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most famous member of the family Anacardiaceae (Sarwar, 2015). 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 the tropical and subtropical countries and is cultivated extensively as a commercial fruit crop in India, China, Indonesia, Thailand and Mexico. The crop is grown over 87 countries in the world. Mango occupies an area of 2309 000 Ha having annual production of 21285 MT in India (National Horticultural Board, 2019-20). It is nutritionally rich in carbohydrates (11.6-24.3%), protein (0.5-1.0%), fat (0.1-8%), vitamin A and C, amino acids and fatty acids. A good mango variety contains 20 per cent of total soluble sugars. The acid content of ripe desert fruit varies from 0.2 to 0.5 percent and protein content is about 1 per cent. Among all prevailing diseases, powdery mildew caused by *Oidium mangiferae* Berthet is emerging as one of the most common, wide spread and serious diseases throughout the world causing significant yield losses. The most serious losses occur during flowering and growing stages which are infected under cool and dry conditions (Mehta *et al*., 2018). *O. mangiferae* attacks mango panicles, young fruits and leaves causing considerable crop loss. Mango is the only known host of this pathogen which can have a sporadic, but very severe incidence, causing up to 90% crop loss (Reuveni *et al*., 2018). The losses caused by this pathogen vary from 5-20% depending on the weather conditions and the affected fruits do not grow and may drop before attaining pea size. Powdery mildew is observed as a white powder consisting of mycelium and conidia, on leaves, petioles, inflorescences, and fruit (Nelson, 2008). The pathogen develops in dry and cold environments but reaches greater severity at 90% relative humidity (RH) and 20-25°C (Nasir *et al*., 2014). Raut *et al*., (2017) reported that in India, among the number of infections of Mango powdery mildew, leaf, flower and fruit infections are most serious resulting in yield loss up to 80%. The crop yield is mainly influenced by the factors like weather parameters and the input variables. The effect of weather on crop growth varies with growth period of the crop. The influence of weather parameters on crop yield depends on the magnitude and distribution of the weather variables over crop growth period. In 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 Agrawal *et al.*, (1986); Yang *et al.*, (1992); Dixon *et al*., (1994); Garde *et al.*, (2012); Rathod *et al.* (2012); Kandiannan *et al.*, (2002); Tannura *et al.*, (2008). Srinivasa *et al*., (2019) 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 powdery mildew 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).

Experimental Material: The experiment was conducted on 15 years old plants of twenty cultivars of mango namely Pantsinduri, Dashehari, Amarpalli, Neelum, Hathijhul, Rasgulla, Redtotapari, Langra, Nashpati, Ramkela, Gaurjeet, Golajafrani, Gulabkhas, Gorakhpurlangra, Kalahafus, Karela, Tamancha, Barahmasi, Husnara and Chausa in 2013-2014 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 (2013-2014) from 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: The experiment was laid out in randomized block design with three replications. Observations were recorded for twenty cultivars at 10 days interval starting from its appearance from 23 January to 15 June during 2013-2014 for powdery mildew disease.

Symptomatology and disease development: The symptomatology and disease development was done at the horticulture research centre, Pattarchatta during 2013-2014. Regular monitoring was conducted for recording the time of first appearance, progression, maximum development of powdery mildew under natural epiphytotic conditions. In both years, 30 current year panicles of 15 years old tree of twenty cultivars were labeled at the beginning of February before symptoms were detected. Disease incidence was recorded at weekly interval starting from its appearance (23 January) on linear spread of the disease from the infection focus to observe its progression. The Per cent disease incidence was calculated as follows:

$$\text{Disease incidence} = \frac{\text{No. of diseased inflorescence}}{\text{Total number of inflorescence examined}} \times 100$$

The data on the development of powdery mildew on twenty cultivars were recorded on the 30 marked inflorescences in each geographical direction of each mango tree according to the disease development and symptomatology of the disease was studied and 0-5 scale was also devised to record the data on disease severity/index. The per cent disease index/intensity (PDI) was calculated (Naqvi *et al.*, 2014) as follows:

$$\text{DI} = \frac{\text{Sum of rating of inflorescence observed}}{\text{Number of inflorescence observed} \times \text{Maximum disease rating}} \times 100$$

Data on disease severity were recorded on 0-5 rating scale at weekly interval and cultivars were grouped in six categories as under:

Per cent infection	Disease reaction
0	Immune
0.1-10	Resistant
11-20	Moderately Resistant
21-40	Moderately susceptible
41-60	Susceptible
61-100	Highly susceptible

Reaction of 20 cultivars to powdery mildew evaluated exhibited mean disease severity/ incidence and were categorized as different level of resistance and susceptibility.

Disease progression in relation to weather variables: Prevailing weather variables such as temperature, relative humidity and rainfall were obtained corresponding to the mango seasons for both years (2013-2014) from agrometerological section of GBPUAT. These data were also utilized for working out disease weather correlations. Significant correlation coefficient was used to work out multiple regressions.

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 upon various abiotic factors. The regression analysis of disease incidence as an independent variable with weather parameters were analyzed using SPSS 16 which was useful in the prediction of this disease. The multiple regression equations (Table 1) calculated for twenty cultivars of mango showed highly significant values of coefficient of multiple determination (R^2) which ranged from 85.6 to 94.2 per cent. Thus regression equation revealed that abiotic factors was found to be most influencing factor, which contributed 85.6 to 94.2 per cent range of variation in disease incidence of powdery mildew of different cultivars in mango. Maximum R^2 value (94.2%) was found in Nashpati and minimum R^2 value (84.1%) in Pantsinduri. In the study, it was found that powdery mildew prefers temperature range between 18°C to 26°C for infecting panicle shoot, developmental stages of inflorescences and sporulation. The observations were amply supported by the fact that the development of powdery mildew of mango under field conditions were recorded to be maximum (60-75%) during the month of March when average maximum and minimum temperature were 26.82°C to 16.75°C, coupled with high relative humidity to the extent of 61-95 per cent, respectively. This proves that the moderate temperature ranging between 16 to 2°C is most favorable for development of powdery mildew under field conditions. Our results are in accordance with (Srinivas *et al*., 2019). The results further indicate that data needs to be generated for a longer period and the model to be tested and validated at multilocations.

Table 1: Multiple regressions analysis for prediction of Powdery mildew of mango.

Sr.No.	Cultivars	Multiple regression equation	R^2 (Coefficient of multiple determination)
1.	Pantsinduri	$Y= -249.32+(5.34_{X1})+(1.24_{X2})+(1.45_{X3})+(0.287_{X4})$	0.841
2.	Dashehari	$Y= -263.79+(5.53_{X1})+(1.77_{X2})+(1.52_{X3})+(0.412_{X4})$	0.880
3.	Amarpalli	$Y= -266.07+(5.39_{X1})+(1.82_{X2})+(1.56_{X3})+(1.22_{X4})$	0.900
4.	Neelum × Chausa	$Y= -273.87+(5.28_{X1})+(1.59_{X2})+(1.67_{X3})+(0.944_{X4})$	0.880
5.	Hathijhul	$Y= -287.33 +(5.18_{X1})+(1.76_{X2})+(1.81_{X3})+(1.10_{X4})$	0.904
6.	Rasgulla	$Y= -315.73 +(5.49_{X1})+(1.91_{X2})+(2.08_{X3})+(1.05_{X4})$	0.911
7.	Redtotapari	$Y= -254.32 +(5.18_{X1})+(1.30_{X2})+(1.53_{X3})+(0.321_{X4})$	0.856
8.	Langra	$Y= -275.34 +(4.61_{X1})+(1.89_{X2})+(1.83_{X3})+(1.59_{X4})$	0.928
9.	Nashpati	$Y= -294.79+(4.70_{X1})+(2.01_{X2})+(2.10_{X3})+(1.58_{X4})$	0.942
10.	Ramkela	$Y= -243.74 +(4.29_{X1})+(1.54_{X2})+(1.55_{X3})+(0.880_{X4})$	0.908
11.	Gaurjeet	$Y= -222.56 +(4.10_{X1})+(1.50_{X2})+(1.43_{X3})+(0.888_{X4})$	0.922
12.	Golajafrani	$Y= -284.28 +(4.99_{X1})+(1.76_{X2})+(1.88_{X3})+(1.05_{X4})$	0.917
13.	Gulabkhas	$Y= -249.97+(5.29_{X1})+(1.29_{X2})+(1.48_{X3})+(0.352_{x4})$	0.842
14.	Gorakhpurlangra	$Y= -261.07+(4.69_{X1})+(1.56_{X2})+(1.68_{X3})+(0.805_{x4})$	0.901
15.	Kalahafus	$Y= -323.45 +(5.06_{X1})+(2.01_{X2})+(2.21_{X3})+(1.23_{X4})$	0.942
16.	Karela	$Y= -285.59+(5.10_{X1})+(1.71_{X2})+(1.84_{X3})+(0.905_{X4})$	0.907
17.	Tamancha	$Y= -262.71 +(4.90_{X1})+(1.58_{X2})+(1.66_{X3})+(1.07_{X4})$	0.886
18.	Barahmasi	$Y= -279.98 +(4.98_{X1})+(1.80_{X2})+(1.81_{X3})+(1.21_{X4})$	0.912
19.	Husnara	$Y= -273.7+(4.83_{X1})+(1.74_{X2})+(1.76_{X3})+(0.968_{X4})$	0.919
20.	Chausa	$Y= -248.49+(4.53_{X1})+(1.53_{X2})+(1.57_{X3})+(0.635_{X4})$	0.906

Where, X1=Maximum Temperature (°C); X2= Minimum Temperature (°C); X3= Maximum Relative Humidity (%); X4= Rain Fall (mm)

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

Standard weeks	Temperature (˚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 the Mango growers to control powdery mildew of Mango caused by *Odium mangiferae*. Very little work has been conducted on powdery mildew of Mango. Based on the results obtained in this study one can conclude that the multiple regression analysis for prediction of powdery mildew disease in mango, performed better. The reason for better performance of multiple regression models may be due to 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 is up to 94% (maximum) in Nashpati and Minimum in Pantsinduri (84%).

FUTURE SCOPE

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

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Conflict of Interest. Nil.

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