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Multiple Regression Analysis for Prediction of Floral Malformation Disease in Mango (*Mangifera indica* L.)

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ABSTRACT

Mango (*Mangifera indica* L.) is an important fruit crop in India and honored as king of fruit in the country. Among the several abiotic and biotic factors, mango malformation which is caused by *Fusarium moniliforme* pv *subglutinans* is the most serious disease causes up to 60% yield losses and confines the mango cultivation in tropical and subtropical countries of the worldwide. The purpose of this study was to carry out multiple regression analysis for prediction of malformation disease of 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 (HRC) 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 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 malformation in mango. The coefficient of multiple determination (R^2) which ranged from 72.7 to 99.9%. Thus regression equation revealed that abiotic factors was found to be most influencing factor, which contributed 72.7 to 99.9% range of variation in disease incidence of floral malformation disease of different cultivars in mango. Maximum R^2 value (99.9%) was found in Langra and minimum R^2 value (72.7%) in Karela.

Keywords Mango, Malformation, Coefficient of multiple determinations R^2, Prediction, *Mangifera indica.*

INTRODUCTION

Mango (*Mangifera indica* L.) is an Indian sub continent originated fruit crop (Mukherjee and Litz 2011) and belongs to 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 the tropical and subtropical countries and is cultivated extensively as a commercial fruit crop in India, China, Indonesia,

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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 (NHB, 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% of total soluble sugars. The acid content of ripe desert fruit varies from 0.2 to 0.5% and protein content is about 1%. Among all prevailing diseases, Floral Malformation disease of mango induced by *Fusarium moniliforme* pv *subglutinans* Wollenewb and Reinking is known as a plant disease of international importance. Floral malformation, in contrast to vegetative one, is very virulent and can cause the loss of the entire crop. Affected panicles either do not set fruits or abort shortly after they have set, hence, could reduce the yield by 50-80% (Kumar *et al*. 2011). The malformed panicles are compact and overcrowded due to larger flowers and looks like a compact mass and are more green and sturdy and it bends down due to its own weight. These infected panicles do not set fruits (Ploetz 2001, Youssef *et al*. 2007, Ploetz and Freeman 2009, Chakrabarti 2011).

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 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 (Noriega-Cantu *et al*. 1999 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 Floral Malformation disease in Mango was carried out at Horticulture Research Center (HRC), Patharchatta, College of Agriculture, GB Pant University of Agriculture and Technology, Pantnagar (US Nagar) during 2013 and 2014.

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 and 2014 at Horticulture Research Station (HRC) of GB 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 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 to observe the progress of floral malformation from a source point of infection in the field for two years, i.e. 2013 and 2014. Observation were recorded starting from its appearance (February) of the disease from the infection source to observe its progression. The plants were 15±5 years old. In both years, 30 randomly selected current year panicles from all the four sides of the test plants were labeled at the 1nd week of February before symptoms were detected. The malformed shootlets were record-

Fig. 1. Floral mango malformation.

ed at ten days interval on a rating scale of 0 to 5 as proposed by (Chakrabarti 2011).

Symptomatology and disease development

The disease appeared in 4th week of Feb in 2013 while, 3rd week of Feb in 2014. The characteristic symptom (Fig.1) of the disease appeared in the primary, secondary and tertiary rachises are short, thickened and much enlarged or hypertrophied and highly branched. Such panicles are greener and heavier with increased crowded branching, possess numerous flowers that remain unopened, are male and rarely bisexual. The characteristic symptoms observed due to the disease were compared with the available literature and these were found to be similar to those documented by Ploetz (2001), Youssef *et al*. (2007), Ploetz and Freeman (2009) and Chakrabarti (2011). Now this disease is prevalent in the entire mango growing areas of Uttarakhand causing a serious threat to mango production. This disease makes its appearance every year; the severity of attack mainly depends on the climatic conditions.

Based on the symptom development, following

Rating scale	Range of panicles (%)
0	Panicles free from malformation
1	0.1-5.0 % infected panicles
2	5.1-10 % infected panicles
3	10.1-20 % infected panicles
4	21.1-50 % infected panicles
5	>50.1 % infected panicles

scale was devised for the assessment of disease severity/ index and were categorized as different level of resistance and susceptibility.

PDI was also calculated as following:

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

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 field, corresponding data were obtained for two years from agrometeorological section of GBPUAT (Table 1). The effect of weather parameters on floral malformation disease was correlated by using SPSS version 16 software. The regression and R^2 values were also analyzed by using SPSS software.

Table 1. Meteorological data at Pantnagar during cropping season pooled 2013-2014.

Standard weeks	Temperature (˚C)		Relative humidity (%)	Rainfall (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

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 2) calculated for twenty cultivars of mango. 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 99.9%) in Langra and Minimum (72.7%) in Karela. These results are in accordance with (Srinivasa *et al*. 2019, Youssef *et al*. 2007, Sharma *et al*. 2020). 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 2. Multiple regressions analysis for prediction of Malformation of mango. Where, X1=Maximum temperature (°C), X2= Minimum temperature (°C), X3= Maximum relative humidity (%), X4= Rainfall (mm).

SI. No.	Cultivars	Multiple regression equation	R^2 (Coefficient of multiple determination)
1	Pantsinduri	$Y= 11.94+(0.465_{X1})+(0.635_{X2})+(-0.273_{X3})+(-0.444_{X4})$	0.996
2	Dashehari	$Y= -8.04+(0.741_{X1})+(0.676_{X2})+(-0.133_{X3})+(-0.127_{X4})$	0.997
3	Amarpalli	$Y= -9.88+(0.901_{X1})+(1.52_{X2})+(-0.268_{X3})+(0.105_{X4})$	0.990
4	Neelum	$Y= 2.73+(0.172_{X1})+(0.114_{X2})+(-0.082_{X3})+(-0.024_{X4})$	0.973
5	Hathijhul	$Y= -2.98+(0.643_{X1})+(0.310_{X2})+(-0.157_{X3})+(0.211_{X4})$	0.998
6	Rasgulla	$Y= -2.11+(0.590_{X1})+(0.322_{X2})+(-0.131_{X3})+(-0.094_{X4})$	0.990
7	Redtotapari	$Y= -9.58+(0.759_{X1})+(0.690_{X2})+(-0.143_{X3})+(0.064_{X4})$	0.997
8	Langra	$Y= -2.34+(0.694_{X1})+(0.258_{X2})+(-0.170_{X3})+(-0.159_{X4})$	0.999
9	Nashpati	$Y= -10.71+(0.718_{X1})+(0.332_{X2})+(-0.94_{X3})+(0.254_{X4})$	0.998
10	Ramkela	$Y= -1.33+(0.636_{X1})+(0.361_{X2})+(-0.175_{X3})+(0.155_{X4})$	0.998
11	Gaurjeet	$Y= -6.15+(0.660_{X1})+(0.479_{X2})+(-0.152_{X3})+(0.276_{X4})$	0.998
12	Golajafrani	$Y= -12.15+(0.553_{X1})+(0.771_{X2})+(-0.067_{X3})+(0.018_{X4})$	0.993
13	Gulabkhas	$Y= 2.03+(0.558_{X1})+(0.391_{X2})+(-0.194_{X3})+(-0.249_{X4})$	0.997
14	Gorakh-purlangra	$Y= -5.83+(0.599_{X1})+(0.802_{X2})+(-0.162_{X3})+(0.181_{X4})$	0.998
15	Kalahafus	$Y= -7.34+(0.520_{X1})+(1.61_{X2})+(-0.170_{X3})+(0.277_{X4})$	0.997
16	Karela	$Y= -281.29+(12.05_{X1})+(-12.04_{X2})+(1.46_{X3})+(-0.362_{X4})$	0.727
17	Tamancha	$Y= -5.04+(0.936_{X1})+(0.524_{X2})+(-0.197_{X3})+(-0.129_{X4})$	0.994
18	Barahmasi	$Y= -4.58+(0.621_{X1})+(0.556_{X2})+(-0.149_{X3})+(0.079_{X4})$	0.998
19	Husnara	$Y= 1.88+(0.242_{X1})+(0.433_{X2})+(-0.109_{X3})+(-0.087_{X4})$	0.984
20	Chausa	$Y= -3.37+(0.348_{X1})+(0.707_{X2})+(-0.161_{X3})+(0.436_{X4})$	0.993

CONCLUSION

The research is very useful for the mango growers to predict and control malformation disease of mango caused by *Fusarium mangiferae*. Very little work has been conducted on Floral Malformation disease of Mango. Based on the results obtained in this study one can conclude that the multiple regression analysis for prediction of Floral Malformation 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 was maximum (up to 99.9%) in Langra and Minimum (72.7%) in Karela.

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