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Forecasting model for veneer grafting success in mango

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Abstract

Various models were developed to study the effect of weather variables on veneer grafting success of mango under Lucknow conditions. Models included various combinations of weather variables including their quadratic terms as independent and stepwise variable selection procedure was followed for improving the prediction values. The influence of weather parameters was described by the model as: $GS = 290.946 - 0.239MA^2 - 20.322MI - 0.305MI^2 - 3.58RH$ in which, GS= veneer grafting success, MA = maximum temperature, MI = minimum temperature, RH = relative humidity, and RF = rainfall. Study of forecast model revealed that the modelling data on MA, MI, and RH are appropriate for forecasting GS as it explained 83% variation in the data. The results indicated that maximum and minimum temperatures have curvilinear relationship with GS, and RH is better variable as compared to RF for forecasting the GS. Durbin-Watson value (2.82) indicated that there is not any serious autocorrelation in the residuals. The utility of the model is for the forecasting of grafting success based on environmental conditions.

Key words: Veneer grafting, success, environmental conditions, grafting success model

Introduction

Seasonal variation in the success of veneer grafting in mango is caused primarily owing to changes in the weather parameters. Extreme climatic conditions *i.e.* very high temperatures during summers and low temperatures in winters are responsible for poor success under north Indian conditions (Rajan and Sinha, 1993; Singh *et al.*, 1979). Rajan and Sinha (1993) reported that the success is significantly determined by the factors like maximum and minimum temperature, humidity and rainfall with interacting and interrelated components. Although data on grafting success and weather parameters are available, methods for explaining the relationship between weather conditions and grafting success have not been established. The objective of this study was to develop mathematical model using weather parameters for predicting grafting success.

Methods and materials

Healthy seedling rootstocks of about one year in age were used for veneer grafting, using 10 days prior defoliated, 5-6 months old scions of cv. Dashehari. Sprouted scions were counted for calculating grafting success after 60 days based on 20 grafts replicated thrice. Grafting was performed all the year round at monthly intervals starting from January to December.

Multiple regression models were fitted in the following forms:

$y = a + b_1x_1 + b_2x_2 + \ldots + b_kx_k$, where, y is dependent variable with k independent variables, $x_1, x_2, \ldots x_k$; a is constant and $b_1, b_2, \ldots b_k$ are the partial regression coefficients of independent variables.

Backward elimination procedure for the selection of variables was followed to build a model with less number of independent variables (Draper and Smith, 1976). Regression models were fitted with veneer grafting success (GS) as dependent variable and average monthly data of maximum temperature (MA), minimum temperature (MI), relative humidity (RH) and RF (rainfall) as independent variables. Quadratic terms of independent variables were also included in the models for improving the prediction values. Models were developed considering various combinations of weather variables.

Results and discussion

Seven models were developed to obtain suitable model for studying veneer grafting success-weather relationship. Various relationships of GS as dependent factor and MA, MI, RH and RF as independent factors are presented in Table 1. Following 7 models were fitted to predict GS and to determine the effect of independent factors on the grafting success:

Model	Equation
1	$GS = a + b_1MA + b_2MI + b_3RF + b_4RH$
2	$GS = a + b_1MA + b_2MI + b_3RH$
3	$GS = a + b_1MA + b_2MA^2 + b_3MI + b_4MI^2 + b_5RF + b_6RF^2 + b_7RH + b_8RH^2$
4	$GS = a + b_1MA + b_2MA^2 + b_3MI + b_4MI^2 + b_5RF + b_6RH + b_7RH^2$
5	$GS = a + b_1MA + b_2MA^2 + b_3MI + b_4MI^2 + b_5RH + b_6RH^2$
6	$GS = a + b_1MA^2 + b_2MI + b_3MI^2 + b_4RH + b_5RH^2$
7	$GS = a + b_1MA^2 + b_2MI + b_3MI^2 + b_4RH$

Table 1. Estimates of various parameters for the seven models developed to predict GS

Model		β Coefficient				F statistics		R	R^2	Adjusted R^2	Std. Error of the estimate
		Estimate	Std. Error	t	p	F ratio	p				
1	a	385.830	176.308	2.188	0.065	2.774	0.113	0.78	0.61	0.39	18.910
	MA	-9.506	4.788	-1.986	0.087						
	MI	7.505	3.649	2.057	0.079						
	RF	0.019	0.128	0.151	0.884						
	RH	-2.501	1.306	-1.915	0.097						
2	a	394.906	155.321	2.543	0.035	4.204	0.046	0.78	0.61	0.46	17.717
	MA	-9.897	3.774	-2.623	0.031						
	MI	7.874	2.543	3.096	0.015						
	RH	-2.531	1.209	-2.093	0.070						
3	a	295.076	169.296	1.743	0.180	9.303	0.047	0.98	0.96	0.85	9.141
	MA	9.750	12.678	.769	0.498						
	MA^2	-0.335	.212	-1.578	0.213						
	MI	13.375	6.268	2.134	0.123						
	MI^2	-0.191	.206	-.929	0.421						
	RF	0.192	.704	.273	0.803						
	RF^2	-0.001	.002	-.262	0.811						
	RH	-8.425	3.981	-2.116	0.125						
	RH^2	0.040	.033	1.207	0.314						
4	a	306.207	143.517	2.134	0.100	13.848	0.012	0.98	0.96	0.89	8.00
	MA	10.413	10.880	.957	0.393						
	MA^2	-0.352	.176	-1.998	0.116						
	MI	13.064	5.390	2.424	0.072						
	MI^2	-0.162	.151	-1.074	0.343						
	RF	0.009	.065	.138	0.897						
	RH	-8.991	2.928	-3.071	0.037						
	RH^2	0.045	.024	1.867	0.135						
5	a	300.969	124.077	2.426	0.060	20.095	0.002	0.98	0.96	0.91	7.17
	MA	11.085	8.721	1.271	0.260						
	MA^2	-0.365	.133	-2.738	0.041						
	MI	12.867	4.658	2.762	0.040						
	MI^2	-0.151	.116	-1.302	0.250						
	RH	-9.031	2.612	-3.457	0.018						
	RH^2	0.045	.022	2.084	0.092						
6	a	419.147	86.272	4.858	0.003	21.578	0.001	0.97	0.95	0.90	7.53
	MA^2	-0.201	.036	-5.645	0.001						
	MI	17.181	3.350	5.129	0.002						
	MI^2	-0.265	.077	-3.427	0.014						
	RH	-8.225	2.661	-3.091	0.021						
	RH^2	0.039	.022	1.786	0.124						
7	a	290.946	54.815	5.308	0.001	19.940	0.001	0.96	0.92	0.83	8.64
	MA^2	-0.239	.033	-7.302	0.000						
	MI	20.322	3.267	6.221	0.000						
	MI^2	-0.305	.085	-3.596	0.009						
	RH	-3.580	.643	-5.569	0.001						

Stepwise variable selection resulted into Model-2 by the elimination of RF from the Model-1, which improved adjusted R^2 and F ratio values. In order to test whether inclusion of quadratic terms of independent variables can improve the model, MA^2, MI^2, RH^2 and RF^2 were also used as independent variables (Models 3-7). As a consequence, highly significant F values ($p < 0.001$), as compared to Models 1-2, were obtained. Similarly, R^2 values increased and standard error of the estimate decreased with the inclusion of the quadratic terms in the equations.

In the process of simplification of the models by using stepwise variable selection, Model 7 was obtained from the Model-6 by excluding RH^2 which had highest p value for the coefficient. Finally Model 7 was selected with the highest p value for MI^2 but less than 0.01, since the highest order term is statistically significant at 99% confidence level, further modification in the model was not attempted. The following model was found suitable for predicting GS and explained 83% variation in the data

$$GS = 290.946 - 0.239MA^2 - 20.322MI - 0.305MI^2 - 3.58RH$$

Predicted vs observed graph obtained by fitting the model has been depicted in Fig. 1, which clearly shows that grafting success can be efficiently predicted under certain sets of environmental conditions. Durbin-Watson statistics was calculated to test if there is any correlation based on order in which they occur in data. Since the Durbin-Watson value (2.82) is greater than 1.4, there is probably not any serious autocorrelation in the residuals.

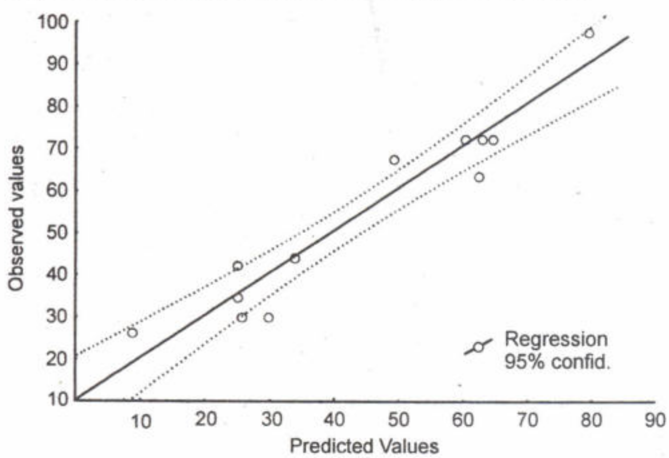

Fig. 1. Predicted vs. observed values, dependent variable: GS

Improvement in the prediction through models after inclusion of quadratic terms clearly indicates curvilinear relationship between GS and independent variables, temperature and RH. High coefficient value for MI is suggestive of important role of the parameter in grafting success. Minimum temperature plays an important role in limiting success under northern plains during November, December, and January and partially in October and February. Low temperature has pronounced effect on the production of callus tissue, which is a prerequisite for the graft union. Role of this parameter has been established long back in the successful graft union of temperate fruits (Shippy, 1930; Sitton, 1931). Mango being tropical species, requires rather higher temperature for graft union as compared to temperate species. The negative coefficient for RH might be due to the fairly high humidity in autumn and winter months with poor success. This also indicates that during summers when the MA and MI are high, low level of RH plays the limiting role whereas during winters low MA and MI reduce the success even under high RH conditions.

Negative and significant coefficient of MA^2 and MI^2 indicate their curvilinear relationships with GS. Rajan and Sinha (1987, 1993) reported that extreme maximum temperature with less RH become detrimental to veneer grafting success. Absence of RF in the final model indicates that monthly rainfall data has less importance in the model as compared to RH. Normally, grafting performed by detached methods during rainy season results in high success (Mukherjee and Majumder, 1964; Singh *et al.*, 1979; Rajan and Sinha, 1989) because of high ambient humidity along with congenial temperature. This favours rapid callus production and thereby formation of better graft union.

The model we developed represents an attempt to characterise the relationship among temperature, relative humidity, rainfall and grafting success and to account for the variation in the data. The utility of the model is for the prediction of grafting success based on certain environmental conditions. However, several other factors *viz.*, health and vigour of rootstock, condition of the buds on the scion, soil moisture regimes, grafter's skill may play role in determining the success. Nevertheless, these results can be used for future studies based on pooled data of several years.

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References

Draper, N.R. and H. Smith, 1966. Applied Regression Analysis. Wiley, New York.

Mukherjee, S.K. and P.K. Majumder, 1964. Effect of different factors on the success of veneer grafting. *Ind. J. Hort.*, 21:46-50.

Rajan, S. and G.C. Sinha, 1987. Use of Aluminium foil for increasing veneer grafting success under adverse conditions. *Prog. Hort.*, 19 (1-2),141-142.

Rajan S and G.C. Sinha, 1993. Explanation of varying grafting success in mango under different climatic conditions. Golden Jubilee Symp., Horticultural Research-Changing Scenario, Bangalore, India. (Abstr. 26.21)

Singh, N.P., R.P. Srivastava, H. Singh and M.S. Rajput, 1979. Seasonal effects on success in different methods of mango propagation. *Ind. J. Hort.*, 36:34-39

Shippy, W.B. 1930. Influence of environment on callusing of apple cuttings and grafts. *Amer. J. Bot.*, 17:290-327.

Sitton, B.G. 1931. Vegetative propagation of black walnut. *Mich. Agri. Exp. Sta. Tech. Bul.*, 9.