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Short Comminucation

Development of the agro-climatic grape yield model for the Nashik district, India

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Grape is an important fruit crop due to its nutrient value. It helps the socio-economic growth of Indian farmers by exporting it to European and Arabian countries. Nashik district of Maharashtra is famous for growing horticultural crops (grape, pomegranate, onion etc.). About 40% agricultural land of the Nashik district is under the cultivation of the grape crop. Due to fluctuation in climatic parameters the yield of grapes has been adversely affected. The quantification of climatic parameters in the terms of grape yield will be helpful in developing model for prediction the grape yield. So it is needed to develop agro-climatic model for grape crop to forecast the yield to help planners/ farm managers to take appropriate measures for management of harvest (Kumar *et.al.,* 2014). This study aims to find out the relationship between the agro-climatic parameters and grape yield of Nashik district.

The climatic parameters such as temperature, relative humidity, sunshine hours, and precipitation were collected for the period of 1991-2014 from the Indian Metrological Department (IMD), Pune. The grape yield data of corresponding periods were collected from National Horticulture Board (NHB) Nasik. Fertilizer consumption data was collected from agriculture department of Nashik division, Maharashtra. Fertilizers consumptions has been considered for the month of September to March, because mostly fertilisers are being used after fruit pruning (Adsule,2013).

Selection of variables and statistical analysis

For the present model due care is taken to cover up maximum significant parameters. The model represents the entire phenomenon of the crop yield is therefore functionally given as;

$$Y = f(P, T, S_h, R_h, F,) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where, Y is grape yield (ton ha^{-1}), P is precipitation (mm), T is average temperature (^{0}C), S_h is sunshine (hours), and R_h is relative humidity (%).

The correlation analysis was done to find out the relationship between dependent and independent variables. If the correlation coefficient factor is greater than ± 0.3 then it would be considered for further analysis. The correlation analysis is given in the Table 1. Accordingly it shows correlation between i) yield and temperature (June and September), ii) yield and precipitation (August, September and November), iii) yield and relative humidity (August, September and November), iv) yield and sunshine hours (April, October, November, and January), v) yield and fertilisers use. Therefore these variables, which are highly correlated with the grape yield were considered for further analysis.

The variables considered for the model development were statistically checked for their significance (Popova and Kercheva, 2005). The P-test has been carried out to check the significance of parameters which are based on the variance factors. After the checking of significance, regression analysis was done for all the pairs of variables, to select the final form of the model. If P-value is less than 0.05, then parameters are statistically significant and only those were considered for present model. The parameters such as temperature, relative humidity and sunshine hours were not statistically significant as P-value is greater than 0.05 (Table 2). Among all other mentioned parameters precipitation of August and November, and use of fertilizers are statistically significant. Hence, the relationship between grape yield and precipitation in the month of August and November has been developed using regression analysis.

Model calibration and validation

The final form of the developed grape yield model is shown in the equation (2).

$$(Y) = 0.47 \times (42.8F - 0.019P_a - 0.21P_n - 7.026) \ldots\ldots\ldots(2)$$

For the calibration of grape yield model, observed data set of the period from 1991 to 2006 has been used. Where; (Y) is Grape yield (ha^{-1}), F is fertilisers use (ha^{-1}). P_n is precipitation of November (mm) and P_a is precipitation of August (mm).

For the validation of developed grape yield model, independent data set from the year 2007 to 2013 was considered and was is good agreement with the value of coefficient of determination (R^2) of 0.92.

Table 1: Correlation analysis between monthly climatic parameters and grape yield.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Average -Temperature (t °)	0.12	-0.07	0.30	0.18	0.20	0.30	0.12	-0.13	0.13	-0.01	-0.05	0.09
Precipitation (P)	-0.09	0.04	-0.20	-0.11	-0.30	0.32	0.12	-0.79	-0.22	0.14	-0.05	0.15
R. Humidity (Rh)	-0.18	-0.14	0.09	-0.06	-0.40	-0.34	0.05	-0.35	-0.22	0.01	0.06	-0.10
Sunshine hours (Sh)	0.53	-0.29	0.24	0.23	0.11	-0.07	0.45	-0.54	0.09	0.39	-0.02	0.09
fertilizers use	-	-	-	-	-	-	0.70	-	-	-	-	-

Table 2: The analysis of variance (P-value)

Parameters	Month	Coefficients	Standard Error	P-value
Average Temp (°C)	Jun	-0.047	1.575	0.976
	Sep	1.383	1.442	0.349
Precipitation	Aug	-0.022	0.009	0.023
	Sep	0.009	0.011	0.438
	Nov	-0.197	0.036	0.000
Relative Humidity	May	-1.318	2.169	0.586
	Jun	-0.517	1.106	0.672
	Aug	1.981	4.231	0.672
Sunshine hour	Apr	-0.632	1.236	0.631
	May	-0.025	0.692	0.973
	Jun	0.482	0.841	0.591
	Aug	-0.102	0.405	0.811
	Nov	-1.247	0.721	0.144
	Dec	-0.098	1.037	0.928
Fertilisers	F	39.910	3.909	0.000

To check the statistical fitness of developed model (Eq^n.2) various statistical tests such as discrepancy ratio (r), standard deviation of r, mean percentage error (MPE) and standard deviation of MPE are considered (Bharadiy and Manekar, 2015). The discrepancy ratio (r) is found 0.99, standard deviation (SD) of the discrepancy ratio (r) is found 0.20, whereas mean percentage error (MPE) is -0.00006, and standard deviation of MPE is found 0.20.

Further, the scatter plot of observed yield Vs simulated yield is shown in Fig. 1. The variation of the model reflects the actual yield of the scatter data points are within ± 10% bandwidth and 73% of results are found within this bandwidth.

Based on the present study, it is concluded that, the developed agro climatic grape yield model (Eq.2) can be used for the estimation of grape yield. This is also useful to determine the grape water requirement and irrigation scheduling based on the estimated grape yield model. The developed model can be used as the decision supporting tool for generating grape yield scenarios using future model inputs.

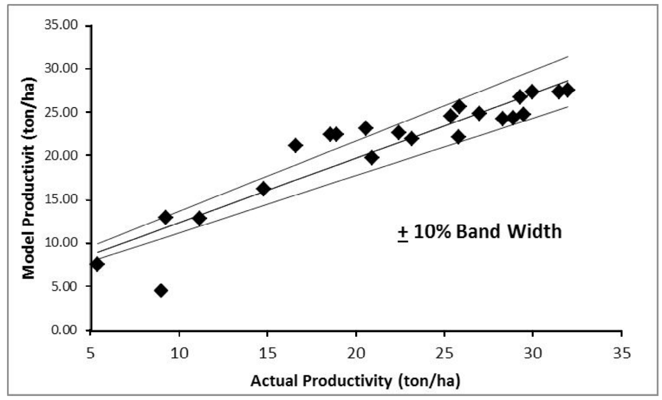

Fig. 1: The scatter plot of model and actual yield data points with ±10 % band width

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