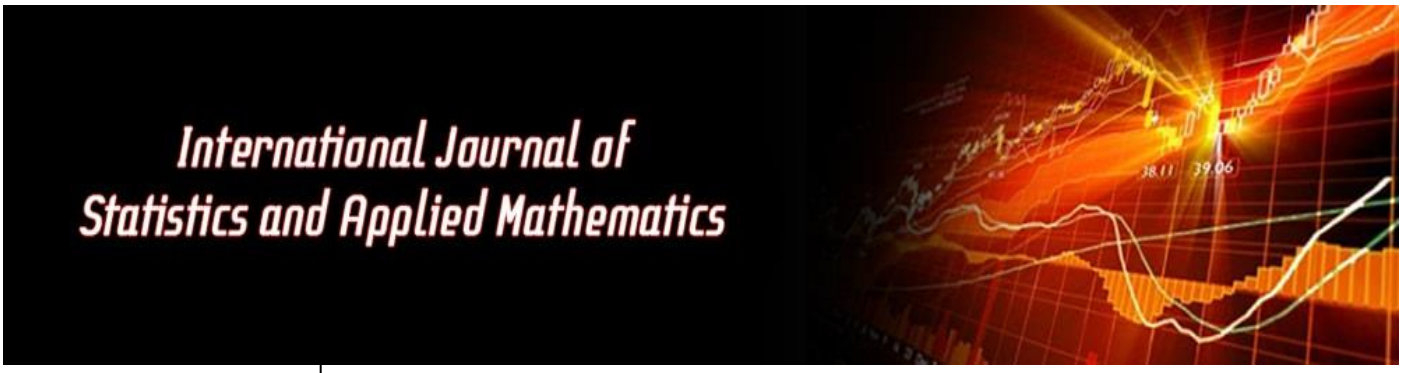
International Journal of Statistics and Applied Mathematics 2024; SP-9(1): 347-349



ISSN: 2456-1452
Maths 2024; SP-9(1): 347-349

https://www.mathsjournal.com
Received: 06-01-2024
Accepted: 07-02-2024

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Prediction of mango yield for Raipur District of Chhattisgarh

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Abstract
Mango yield and weather variable *viz*. minimum temperature, maximum temperature, relative humidity, sunshine, rainfall and wind velocity weekly weather data over a span of 18 years data period (2004-2021) for Raipur district of Chhattisgarh have been used in study. The model have been developed by (SRA) Stepwise Regression Analysis (forward method) and (MLR) Multiple Linear Regression on weather data. The stepwise regression model fitted on 14 generated weather variable along with T, i.e. 8 parameters have been used. The 8 generated weather variable long with this been used to fit the Multiple Linear Regression. In Unweight weather variables the significant and value of R2 found in Raipur district 0.02 and0.71 respectively. In Weighted variables the and significant value of R2 found in Raipur District 0.910 and 0.01 respectively. In Validation of Developed Model RMSE and R2 for Raipur i.e.1860.50 and 0.90 respectively.

Keywords: MLR, RMSE, SRA, Time trend (T) etc.

Introduction
A Mango is an edible stone fruit produced by the tropical tree Mangiferaindica. It is believed to have originated in southern Asia, particularly in eastern India, Bangladesh, and the Andaman Islands. M. indica has being cultivate in South and Southeast Asia since ancient times resulting in two types of modern mango cultivars: The "Indian type" and the "South east Asian type". Other species in the genus Mangiferaalso produce edible fruits that are also called "mangoes", the majority of which are found in the Malesianecoregion. The total global area under mango is 43.69 lakh ha and the global production is to the tune of 312.51 lakh tone. Arrow mango has 84% water, 15% carbohydrates, 1% protein, and has negligible fat (table). The energy value per 100 g (3.5 oz) serving of raw mango is250 kJ (60 calories). Fresh mango contains only vitamin C and folate in significant amounts of the daily value as 44% and 11%, respectively It is a rich source of vitamin A and C. Mango comes upon a wider an of soils from alluvial to laterite provided they are deep (minimum 6') and well drained. It prefers slightly acidic soils (pH 5.5 to 7.5). Mango is prone todamagesby a large member of pests, disease and disorders like Mango hopper, Mealy bug, Powdery mildew, Anthracnose, Fruit drop.

Materials and Methods
Study area: Raipur is located in Chhattisgarh (21°16' N, Latitude and 81°36' E Longitude and altitude 289.5 the average temperature in Raipur is 26.5 °C, Average rainfall around 1489 mm of the state.

Yield data: The yield data on Mango crop for 18 years (2004 to 2021) for Raipur have been procured from the published booklets and official website (http://agridept.cg.gov.in/index.htm) of the Directorate of Agriculture, Government of Chhattisgarh.

Weather data: Weekly meteorological data (2004 to 2021) procured from the department of Agro meteorology, Indira Gandhi Agriculture University, Raipur (CG.) and used for the different districts along with Chhattisgarh plain Zone for Mango crop.

The data of 8 weather variables have been collected up to the 26 weeks of the Mango crop cultivation which include 45th SMW from first year to 18th SMW from Next 2nd year. The meteorological variables are Maximum Temperature (Max temp) °C, Minimum Temperature (Min. temp) °C, Morning Relative Humidity (RH-I)%, Afternoon Relative Humidity (RH-II)%, Bright Sunshine (hours) (SS) hours/day, Rainfall (mm), Wind Velocity (WV), Evaporation respectively.

Statistical Methodology

Effect of individual weather parameters

Generated Unweighted weather variable			Generated weighted weather variable
Z	=	N Ξ ι (ι=1)	N ν ∑∑ρι ξι ι =1 ι =1 ∑ρι ι=1

The model the individual effect of weather effect of weather variable is.

$$\psi = \beta_0 + \beta 1 Z\iota_0 + \beta 2 Z\iota_1$$

Where,
Zio = Generated unweighted weather variable.
Zij = Generated weighted weather variable.
N = No. of weeks (45th SMW of the 1st year to 18th SMW of 2nd year)

R = Correlation coefficient between DE trend yield and weekly weather variable i = Weather parameter (I = 1…..8)
J = 0&1 (unweighted and weighted weather variable)

Model development through generates variables

Model development through multiple regression model on unweighted weather variable

$$\psi = \beta_0 + \beta_1 Z_{10} + \beta_2 Z_{20} + \beta_3 Z_{30} + \beta_4 + Z_{40} + \beta_5 Z_{50} + \beta_6 Z_{60} + \beta_7 Z_{70} + \beta 8 Z_{80} + T$$

Model development through multiple regression model on weighted weather variable

$$\psi = \beta_0 + \beta_1 Z_{11} + \beta_2 Z_{21} + \beta_3 Z_{31} + \beta_4 + Z_{41} + \beta_5 Z_{51} + \beta_6 Z\ 6_1 + \beta_7 Z\ 7_1 + \beta_8 Z_{81} + T$$

Model development through stepwise regression model on un-weighted weather variable

$$\psi = \beta_0 + \beta_1 Z_{10} + \beta_2 Z_{20} + - \ - - - - - - - + \beta_8 Z_{80} + \beta_9 T$$

Model development through stepwise regression model on weighted weather variable

$$\psi = \beta_0 + \beta 1 Z_{11} + \beta_2 Z_{21} + - - - - - - - - - - + \beta_8 Z_{81} + \beta_9 T$$

Measures for validation and of the models

Percent Deviation (PD): The formula for computation of Percent Deviation of forecast yield from actual yield is given by Md. Azfar *et al*. (2015) [11]. This measures the deviation (in percentage) of forecast from the actual yield data. The formula for calculating the percent deviation of forecast is given below.

Percent deviation

(Actual Yield - Forecasted Yield + (Actual yield) x 100

Root mean Square Error (RMSE)

$$PM\Sigma E = \left| \frac{\sum_{\iota=1} (\Phi_\iota - O_\iota)^{\prime}}{\Upsilon \quad \nu} \right|^{1/}$$

Where,
I =1, 2, 3.
N = Sample size
F_i = Actual yield
O_i = Predicted yield

Percent error (PE),
PE is defined as ratio of RMSE to mean observed value expressed as percentage this is another important tool of the model validation. The formula for calculating the Percent Error is given by Varshneya et al. (2010) [10] of forecast is given below.

$$PE = \frac{RMSE}{\overline{o}} \times 100$$

Where,
PE = Percent Error
RMSE = Root Mean Square Error
O = Mean of observed value
Coefficient of determination (R^2)
The models were validated on the basis of (R2) which can be computed from the formula given by Draper and Smith (1988) [3]. The R^2 statistic, a measure of the amount of variation about the mean explained by fitted equation, as

$$R^2 = 1 - \frac{RSS_{n-}}{CTSS}$$

Where, CTSS denotes the corrected total sum of squares. P is the total number of parameters in a fitted model (Including β_0) and RSSN - P is the corresponding residual sum of squares.

Results and Discussion

The individual effect on weather variables have been find out for Raipur district. This result has been showing on the basis of different statistical parameters through regression given below.

Table 1: Individual weather variables for Raipur district

District	Model	R2	Sig.
Max. Temp.	Y = 10509 – 181.63Z10 + 127.88Z11	0.47	0.08
Min temp.	Y = 8190.88 + 22.56Z20- 39.79Z21	0.65	0.05
Rainfall	Y = 7495.81 - 110.84Z30- 125.29Z31	0.51	0.05
Relative humidity I	Y = 3987.70 + 11.68Z40+ 20.99Z41	0.64	0.05
Relative humidity II	Y = 5172.71 + 66.07Z50+ 9.21Z51	0.52*	0.04
Wind velocity	Y = 7584.24 - 74.36Z60- 164.16Z61	0.28	0.06
Evaporation	Y = 8136.30 - 567.40Z70- 488.53Z71	0.60*	0.01
Sun shine hours	Y = 4787.73 + 397.97Z80- 41.28Z81	0.49	0.05

***p<0.001, **p<0.01, *p<0.05

Develop the suitable yield forecasting models based on weather parameters through different statistical techniques.
This result for model development has been calculated in two sections (i) through unweighted (ii) through weighted variable by methods the Multiple Regression Model methods. The

Multiple Linear Regression method has been used to fitting of model.

Raipur District fitting of model through generated unweighted variable by Multiple Linear Regression. The two Generated variable (weighted and unweighted) through the technique described in this table only 8 unweighted (i.e. 8 for all weather variables) has been used to fitting of the model (Multiple Linear Regression) for Raipur districts.

Table 2: Through generated unweighted variable by multiple linear regression

Name of District	Developed Model with Unweighted Weather variable	R2	Sig.
Raipur	$Y=29603.34 - 411.023Z_{10} - 138.706Z_{20} + 63.74Z_{30} - 354.17Z_{40} -54.77Z_{50} - 51.92Z_{60} - 28.57Z_{70}+71.51T$	0.716*	0.027

***p<0.001, **p<0.01, *p<0.05

Raipur district fitting of model through Generated weighted variable by Multiple Linear Regression. The two Generated variable (weighted and unweighted) through the technique described in this table only 8 weighted (i.e.8 for all weather variables) has been used to fitting of the model Multiple Linear Regression for Raipur districts.

Table 3: Through generated weighted variable by multiple linear regression

S. No.	Name of District	Developed Model with Weighted Weather variable	R2	Sig.
1	Raipur	$Y = 1296.79+ 76.44Z_{11} + 19.79Z_{21} + 15.16Z_{31} + 0.24Z_{41} - 152.47Z_{51} -0.65Z_{61} + 344.39Z_{71}-11.70T$	0.910**	0.001

***p<0.001, **p<0.01, *p<0.05

Validation of Raipur district developed model: The validation of model has been also added in this table. The PE, PD, RMSE and R2 were the parameters to determination of best fit model for Raipur district. The value of PE (percent error) - 137.02, RMSE (Root mean square error) 1860.50 the value or R2 found i.e. 90% which is highly significant at 0.1% level of significance. The validation of model PD for 2019 is 35.60, 2020 is 39.86, 2021 is 35.97 the details result of validation in this table.

Table 4: Validation of Raipur district developed model

District	Year	Actual Yield	Predicted Yield	PE	RMSE	R2	PD	Sig.
RAI	2019	5001.95	1280.71	-137.02	1860.50	0.90*	35.60	0.01
	2020	5001.94	1493.69				39.86	
	2021	5001.94	1299.05				35.97	

***p<0.001, **p<0.01, *p<0.05

Conclusion

In this study Predicted yield is very well near to actual yield on the basis of above validation factors we can say model is very good fit for further forecasting for Raipur district on the same trend. The conclusion of the work can be drawn as the development models are summarized on monthly generated data for Raipur district for the models on the basis of percent error (PE), percent deviation (PD) and Coefficient of determination (R^2). The model is very good fitted for further and found best for Raipur district. The above techniques showing that all Mango crop for Raipur District of Chhattisgarh.

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