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Prediction of wheat yield for Raipur district through statistical model

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Abstract
The yield of wheat was predicted through regression model. The studies were conducted in Department of Agrometeorology, IGKV, Raipur (C.G.). Regression model was used to validate the forecasted yield for the year 2015-16 and 2016-17. The % of deviation were found-16.6% for 2015-16 & 14.7% for the year 2016-17, respectively. During validation period (2015-16 & 2016-17) the performance of model was quite satisfactory as the percentage error was less than 20%. Hence, these models can be used to forecast wheat yield for Raipur district.

Keywords: Regression model, prediction, wheat yield

Introduction
Crop yield forecasting is a valuable tool to evaluate the crop area and optimizing the crop yield. Forecasting of crop yield is a formidable challenge. No satisfactory model has universal validity existing till date. The aim of developing crop weather models is to ensure better utilization of resources and hence a more environment friendly and sustainable agriculture. Yield forecast in India are mainly based on judgment and final crop production estimates through crop cultivar surveys (Rai and Chandrahas, 2000) [4]. Weather and other agromet variables are used to anticipate the yield during crop growth period. Two forecasting methods are commonly used for evaluating crop yield forecasting i.e. Statistical and crop growth simulation model (Singh *et at*. 2017) [5]. Where regression techniques are basis of statistical model. Predictor's linear combination (both technological parameter and meteorological parameters) is required for Correlation and regression. It considers that the impact of weather and technological advance on yield based on parameters were taken from historical data, and find out the most probable outcomes for current year. Statistical models are comparatively simple and cost effective. The temperature effect on plant is studied by heat unit concept, to correlate phenological development in crop and to predict maturity dates (Gilmore and Rogers, 1958) [2]. Temperature is a major determinant of wheat growth and development. Yields decreased 3% to 5% by increasing temperature of 1°C above 15°C. Grain yield decrease when temperature is high before anthesis (Hunt *et al*. 1991) [3]. Pre-harvest forecast of the crop production at suitable stages of crop period before the harvest is vital for advance policy formulation in regards to crop procurement and distribution. For deciding future prospects and possible course of action in advance these models are useful for farmers. Thus, reliable and timely pre-harvest forecasting of crop yield is very important (Yadav *et al*. 2014) [6].

Materials and Methods
Description of Study Area
The field experiment was conducted at research and instructional farm of IGKV, Raipur situated in near center part of Chhattisgarh at latitude 21.16 °N, longitude 81.36 °E and altitude of 289.5 m and above mean sea level.

Weather Condition during Crop Period
During the crop growth period, the maximum temperature ranged from 27.4°C to 39.2ºC whereas minimum temperature ranged from 9.5ºC to 23. 4ºC. the total rainfall was recorded 57 mm, morning relative humidity varied from 54 to 89% whereas; in after noon, it varied from 15 to 41%.

Soil of Study Area
The soil of the experimental field was sandy loam with moderately course texture of Inceptisol group locally known as "Matasi." This soil contains low phosphorous, medium nitrogen & potassium and neutral in reaction.

Source of Data

Weather Data

Daily weather data of different district were collected from Department of Agrometeorology COA IGKV, Raipur during crop growth period (Nov. 2017 to Apr. 2018). Different weather parameters i.e. max. & min. Temperature (°C), rainfall (mm), solar radiation (per meter square) of daily weather data were used for DSSAT model.

Run Statistical Model

Yield forecast models at vegetative stage (F2) & pre-harvest stage (F3) have been worked out through step-wise regression method using SPSS software. Yield was regressed with 42 variables (weighted and un-weighted) to get best regression model. Two indices were worked out. To study the combined effect of weather variables, un-weighted and weighted indices were also computed. After getting best regression model, significant variables entered in the model and wheat yield for the subsequent year were predicted.

Fitting Regression Equation

Linear regression estimates the coefficients of the linear equation, involving one or more independent variables, which best predicts the value of the dependent variable. The model"s output has shown here in which the following abbreviations are used:

$Y = a + (b1)(x1) + (b2)(x2) + (b3)(x3) + (b4)(x4)$

Where-
Y = Predicted population
A = Intercept
b1, b2, b3, b4 = Regression coefficient
X1, x2, x3, x4 = Dependent variables

The value for R^2 (correlation coefficient) shows how strong is the correlation held between a predictor or independent variable and the dependent variable. The sign of "r" indicates the slope of the regression line. The model was selected as the suitable pre-harvest model based on these criteria viz. (1) High co-efficient of determination (R^2). (2) Standard error and low simulated forecast error.

Result and Discussions

Wheat yield forecast for Raipur district was worked out. The regression equation along with R^2 is given below:

$Y = 62.6652x + 703.76$

Where Y = predicted yield
X = Time

Table 1 revealed that the predicted mean value of grain yield was 1871.8 kg/ha while observed value was 1716 kg/ha and this showed 9% error for the year 2011-2012. In 2012-13, predicted yield was 1806.4 kg/ha against the actual yield was 1936 kg/ha with % deviation of-4.4%. Deviation % was found 1.1% for actual yield 1786 kg/ha and predicted yield 1806.4 kg/ha for the year 2013-14. In 2014-15, actual yield was 1580 kg/ha while predicted yield was 2198.4 kg/ha and % of error 39.1%. This % of error was above the acceptable limit (± 20%) for yield forecast, but remaining years were within the acceptable error limit. It varied from 1.1 to 39.1% for the year 2011 to 2015.

This model was further used to validate the forecasted yield for the year 2015-16 and 2016-17. The % of deviations were found-16.6% for 2015-16 & 14.7% for the year 2016-17, respectively. During validation period (2015-16 & 2016-17) the performance of model was quite satisfactory as the percentage error was less than 20%. Hence, these models can be used to forecast wheat yield for Raipur district.

Similar finding was also reported by Singh *et al.* (2017) [5]. They found that simulated yield was maximum (3869 ±373 kg ha-1) at Pusa (NWAPZ) and lowest 3208 ±269kg ha-1) at Sabour, while the forecasted yield was maximum at Sabour (2095 ±572 kg ha-1) and lowest at Pusa (1517 ±373kg ha-1). It is also seen that the forecasted yield was very close to observed yield during 2007-08 to 2011-12 with per cent error of only ±4.

Table 1: Actual and predicted grain yield of wheat crop along with % error.

Years	Actual Yield	Predicted Yield	Error %
2011-12	1716	1871.8	9.0
2012-13	1936	1806.4	-4.4
2013-14	1786	1806.4	1.1
2014-15	1580	2198.4	39.1
Validated yield (kg/ha)			
2015-16	2042	1701.4	-16.6
2016-17	1770	2031.1	14.7

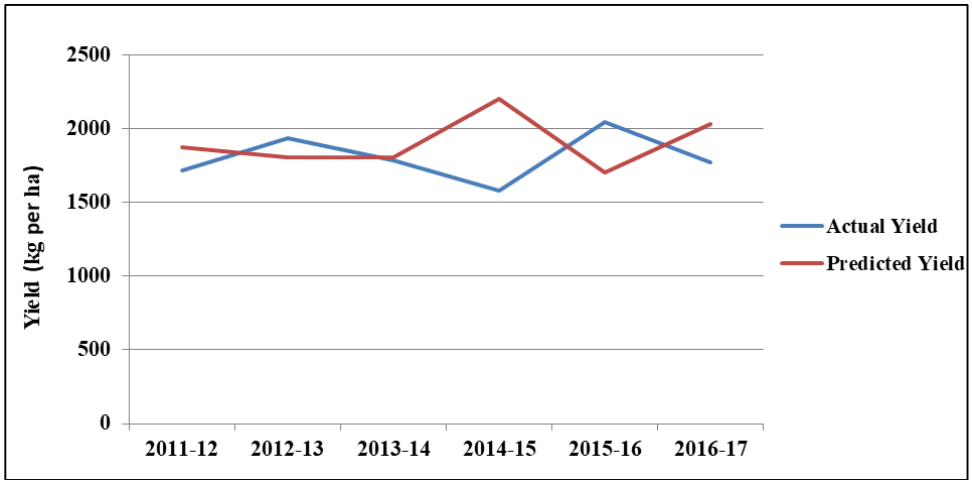

Fig 1: Actual and predicted grain yield of wheat crop along with % error.

Conclusion

The statistical model can be utilized to predict development, growth, yield & yield attributes of wheat crop for different districts of Chhattisgarh.

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