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Rice yield forecasting for north central plateau zone of Odisha

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Abstract
Thirty seven years (1980-2016) of weather data and yield data of rice for 2 districts (Keonjhar and Mayurbhanj) of North Central plateau zone of Odisha was used to develop yield prediction equations. Models were validated with 2 years (2015 and 2016) data. Results indicated that models explained 79 and 56 percent variations for rice yield in Keonjhar and Mayurbhanj districts. The percent Mean Bias Error (MBE) was 2.87 and -1.03 and the percent Root Mean Square Error (RMSE) was 11.61 and 11.10 for Keonjhar and Mayurbhanj district respectively. This revealed that the models can be used to some extent for predicting the yield in different districts of North Central plateaue zone of Odisha. The outcomes are useful for taking decisions well in advance for transplanting of rice as well as for other input management and farm activities during different stages of the crop growing season.

Keywords: Rice, yield forecast, North central plateaue zone of Odisha, weather data and SMW

Introduction
Agriculture is always vulnerable to unfavorable weather events and climate conditions. Despite technological advances such as improved crop varieties and irrigation systems, weather and climate are important factors, which play a significant role in agricultural productivity (Agrawal and Mehta, 2007) [2].

The past two decades have witnessed globally a rapid increase in the awareness about climatic changes and triggered widespread apprehension amongst scientists and governments about their global implications (Cooper *et al.*, 2009; Byjesh *et al.*, 2010) [4, 3].

Crop growth simulation models provide the means to qualify the effects of climate, soil, and management on crop growth, productivity, and sustainability of agricultural production (Basak *et al.*, 2010) [8]. These tools can reduce the need for expensive and time-consuming field trials and could be used to analyze yield gaps in various crops including rice (Nain and Kersebaum, 2007) [1].

Crop acreage estimation and crop yield forecasting are two components, which are crucial for proper planning and policy making in the agriculture sector of the country. Regional level estimation of crop yield is the basis for planning crop production prospects at national level. Models based on weather parameters can provide reliable forecast of crop yield in advance of harvest and also forewarning of pests and diseases attack so that suitable plant protection measures could be taken up timely to protect the crops (Agrawal and Mehta, 2007) [2]. Under the FASAL project, IMD in collaboration with 46 Agromet Field Units (AMFU) located at different parts of the country develops intra-seasonal operational yield forecast at district and state level for 13 major crops of India during *kharif* and *rabi* seasons using statistical model (Ghosh *et al.* 2014) [5].

In view of futuristic changes in climate, it is imperative to assess their impact on crop productivity for a given region. Simulation techniques are easy, time-saving and economical for studying the influence of climatic variability on growth and yield of the crops. Several such attempts have been made for predicting productivity of different crops under changing climatic conditions (Tubiello *et al.*, 2002; Hundal and Kaur, 2007; Zacharias *et al.*, 2014) [9, 7, 10].

Long period crop yield data as well as weekly weather data as per meteorological standard week have been used for development of the district level yield forecast models. For developing the yield forecast, models using composite weather variables have been studied. Simple and weighted weather indices have been prepared for individual weather variables as well as for interaction of two at a time considering throughout the crop growing season.

Materials and methods

Rice and wheat crop yield data for the period of recent 37years (1980-2016) were used to develop yield forecasting models. The weather data was used in standard meteorological weeks (SMW) wise starting from 22nd to 41th SMW of each year i.e. the period from transplanting to harvest of rice. The variables used in this study were weekly of rainfall (mm), maximum and minimum temperature (0C), RH I i.e. morning relative humidity (%) and RH II i.e. afternoon relative humidity (%). For selecting the best regression equation among number of independent variables, stepwise regression procedure was adopted. Statistical Package for Social Science (SPSS) computer software was used for the analysis of data with probability level of 0.05 to enter and 0.1 to remove the variables. A regression model was fitted considering the entered variables obtained from individual stepwise regression analysis to predict the yield for the subsequent years. The multiple linear stepwise regression analysis has been developed on the basis of examination of coefficients of determination (R2), Standard Error (SE) of estimates values resulted from different weather variables. Two statistical tests, percent Mean Bias Error (MBE) and percent Root Mean Square Error (RMSE) are used to the degree of accuracy of each considered correlation to fit the measured data. MBE provide information on the long term performance and RMSE short term performance of the models. The best agro meteorological indices were selected to develop agro meteorological yield model for the each district as per methodology given by Ghosh *et al.* (2014) [5]. Yield forecast models have been developed and their performances have been validated against the observed.

Results and discussion

The yield variations explained by model together with standard error are shown in Table 1. Coefficient of determination (R2) has been significant at 5% probability level for rice in both the districts of North central plateau Zone of Odisha. The R2 was 79 (Keonjhar) and 56 (Mayurbhanj) percent. The percent MBE was was 2.87 and -1.03 and the percent Root Mean Square Error (RMSE) was 11.61 and 11.10 for Keonjhar and Mayurbhanj district respectively the best agrometeorological indices to incorporate in the agrometeorological yield model for rice was selected as Rain×RH II (Z351) and Rain (Z30) for Keonjhar district and Tmax (Z11) for Mayurbhanj district.

Table 1: Rice Yield forecast models for different districts of North Central plateau zone of Odisha

Districts	Keonjhar	Mayurbhanj
Regression equation	1954.82+Z351×0.0916+Z30×0.364	977.60+Z11×59.20
R^2	0.77	0.56
Standard Error	372	446
MBE (%)	2.87	-1.1
RMSE (%)	11.10	11.61

The validation of model for rice for year 2015 and 2016 are shown in Table 2. Results revealed that in 2015 the model overestimated the yield of rice in Keonjhar (7.7%) and Mayurbhanj (8.2%). Whereas, during 2016 in both the districts model underestimatedthe yield, Keonjhar (-8.8) and Mayurbhanj (-1.1). Models had less than ±10% error in rice yield prediction for both the districts during both the years. This has indicated that the model can be used for prediction of rice yield in the above districts. The result revealed that agro meteorological yield model explained the yield variability due to variations in temperatures, rainfall and relative humidity during the different stages (tillering, panicle initiation, booting and physiological maturity). Maximum and minimum temperatures were common agrometeorologial indices for most of the districts of this region. However, rainfall with relative humidity is also important agrometeorological indices for the districts of North Central plateau zone of Odisha

Table 2: Validation of model for forecast of rice in two districts of North Central plateau zone of Odisha

Rice Yield (Kgha^{-1})				
Districts	**Keonjhar**		**Mayurbhanj**	
Years	2015	2016	2015	2016
Forecasted	2178	2344	1979	1967
Observed	2007	2713	1965	1982
Error (%)	7.7	-8.8	8.2	-1.1

Conclusions

Yield forecast has been done for rice crop for two districts of North Central plateau zone of Odisha. The developed models have less MBE (below ±7%) and RMSE (below ±12%) and reasonably good R^2. The models are validated with ±10% error in both the districts. Therefore, it could be used for yield forecasting satisfactorily for rice crop and for both the districts of North Central plateau zone of Odisha Further, by and large, the maximum and minimum temperatures in combination with relative humidity have formed most important agro meteorological indices, which can be useful in forecasting of yield of rice crop in the region.

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