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Short communication

Maize yield estimation using agro-meteorological variables in Jaunpur district of Eastern Uttar Pradesh

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Maize (Zea Mays L.) is an important cereal crop of India next to rice and wheat.Many factors including genetic, environmental and agronomic as well as the interaction between them are responsible for maize yield.Hemalatha *et al.* (2013) found that irrespective of the cultivars, early sowing is utmost important for realizing better yields of maize probably due to higher accumulation of number of growing degree days or heat units. In Jaunpur district of eastern Uttar Pradesh maize is a dominant cereal crop which is mainly grown in unirrigated areas (rainfed crop).It is normally sown with the onset of SW monsoon in the region. As maize is very susceptible both to excess water and moisture stress, its productivity is highly dependent on weather behaviour.The weekly sequences of dry and wet spells in combination with other weather variables are very crucial for its growth and grain yield.

Thus, the vulnerability of crop production to climate variability especially in rainfed regions is a challenge to policy makers and planner. Therefore, present study has been undertaken to develop the techniques of estimating the productivity of maize crop,much before the harvesting, based on past weather and yield records of maize for Jaunpur district of Eastern Uttar Pradesh.

Yearly maize crop data including production and productivity qha^{-1} for Jaunpur district for the period 1972 to 2012 were obtained from Directorate of Agriculture, Lucknow, Uttar Pradesh. Long term weather records were not available for Jaunpur district and therefore weather data (comprising maiximum temperature, minimum temperature, relative humidity at morning and evening) recorded at Babatpur airport located in neighbouring Varanasi district was used to develop the model, however, daily rainfall data was extracted from gridded rainfall data base (at a resolution of 0.25^{0}Lat. x 0.25^{0}Long.) provided by IMD. Jaunpur is spread over an area from Latitude 24.24^{0}N to 26.12^{0}N and Longitude 82.70^{0}E To 83.50^{0}E (jaunpur.nic.in/ jaunpur_english/geog_e.html), and therefore four grid points viz. 25.50^{0}N 83.00^{0}E, 25.00^{0}N 82.75^{0}E, 25.00^{0}N 83.25^{0}E and 24.75^{0}N 83.00^{0}E were choosen and average rainfall over these points were utilized in the model. These grid points belong to different areas of Jaunpur and their mean value represents the mean rainfall over Jaunpur district.

The daily weather data was converted into weekly data according to Standard Meteorological Weeks (SMW) starting from 22nd week (28th May) to 39th week (end of September)of each year i.e. the period from sowing to harvest of maize.Stepwise linear regression method was used to develop best regression equation using a number of independent weather variables and combination of agroclimatic variables.The statistical analyses of variables werecarried out with probability level of 0.05 to enter and 0.1 to remove the variables.Standard Error (SE) of estimates and coefficients of determination (R^2) values were examined, on the basis of which,regression model has been developed.

The combination of meteorological and agrometeorological indices were selected as per method given by earlier researchers (Ghosh *et al.,* 2014, Singh *et al,* 2014 and Mahdi *et al.,* 2013) to develop agro-meteorological yield model for maize crop at Jaunpur. The performance of the yield forecast model was validated against the observed yield in 2009 and 2010, whereas; forecast was made at the F3 stage (atleast twoweeksbefore harvesting) in 2011 and 2012 and compared against observed yield. The corresponding error in prediction was calculated and analysed for their being in the permissible limit.

The best agrometeorological indices selected and incorporated in the agrometeorological yield model for maize yield forecast wereTmax (Z11), TmaxxRain(Z131), TmaxxRHII(Z151) and RHIxRHII(Z451). (where Tmax, Rain, RHI and RHII are maximum temperature, 24 hourly rainfall ending at 8:30 IST, relative humidity (%) at 8:30 IST and relative humidity (%) at 17:30 IST) respectively.The developed model equation, which govern the yield variations is as follows:

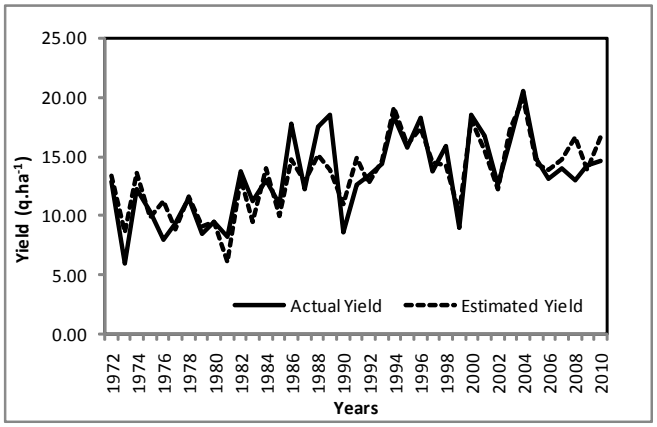

Fig. 1 : Comparison of actual yield and model estimated yield

Yield = -3.99431 + 0.16521x(time) + 1.32456x(Z11) + 0.00144x(Z131)+ 0.01190x(Z151) -0.00312x(Z451)

Where R^2=0.775 (at 5% probability level), Standard error of estimate= 1.82245, the percent MBE = 0and the percent RMSE = 12.38

The actual and estimated yield by this model is presented in Fig.1. In order to validate the model, the model predicted yields were compared with the corresponding actual yields using the relative deviations (RD) values for the years 2009, 2010 (Table 1). The actual and predicted yields for validation period showed average error of 5.56% (less than ±10% error), which were in the acceptable limit. Thus, the model was validated to forecast the yield of maize in Jaunpur district of East Uttar Pradesh.The results show that variations in different weather indices i.e. maximum temperature (weighted), combination of maximum temperature-rainfall (weighted), maximum temperature-relative humidity-17:30 IST (weighted) and relative humidity-8:30 IST- relative humidity-17:30 IST(weighted) incorporated in the model were affecting the yield of crop, at different stages of crop growth.The same model is used to forecast the productivity,two weeks in advance of the maturity stage, in years 2011 and 2012 with percentage error being 15.32 and 18.95 respectively and which is within the permissible limits. However, the forecast may be improved further by the use of observed weather data at Jaunpur station.

Table 1: Actual and model predicted yield (q ha^{-1}) for validation years 2009 and 2010 and forecast years 2011 and 2012 (forecast made at the end of 37th SMW)

	Year	Actual Yield	Predicted Yield	% error
Validation Years	2009	14.29	14.15	-0.98
	2010	14.61	16.62	12.10
Forecast Years	2011	14.54	17.17	15.32
	2012	14.54	17.94	18.95

It was found that weather indices generated with the help of past yield data and past weather records comprising of maximum temperature, minimum temperature, morning relative humidity, afternoon relative humidity and rainfall and their different combinations could forecast the yield of maize. The forecast model is found suitable to get advance estimates of production of maize crop.

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