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YIELD FORECAST OF RABI GROUNDNUT IN ORISSA STATE USING SOIL MOISTURE STORAGE MODEL

1. District level yield prediction of rabi groundnut is a major challenge, due to unavailability of irrigation data. One or several variables like meteorological factors and time trend representing technological advancement are related to crop yield for development of empirical statistical models (Agarwal *et al*. 1986). To meet the need of assured forecast, the requirement of truncated weather models has emerged as a tool, India Meteorological Department has developed meteorological yield models at state level using empirical statistical technique to forecast yield of principal crops like wheat and rice. The pioneering work in this direction has been done by Das *et al*. (1971), Chowdhury and Sarwade (1985). The scope of forecasting the yield of kharif groundnut in Rajkot district of Gujarat state was studied through multiple linear regression analysis with rainfall distribution (Chowdhury and Dandekar, 1991). Prediction model developed by retaining selected rainfall variables was helpful in forecasting the yield within a deviation of 5% from observed yield. Here we have developed district level yield model for rabi groundnut crop using book-keeping procedure of moisture storage developed by Thornthwaite and Mather, 1955. In this, actual evapo-transpiration is calculated fortnightly, GDD is also

calculated over the same periods, which are then related to the crop yield. This method has given a better forecast of the yield compared to only regression based agro-meteorological model.

Using these multiple linear models and current season data, yields were predicted. The forecast of rabi groundnut crop acreage was made at middle of March month using optical remote sensing (IRS) data. Groundnut production forecast at district level was provided by multiplying its acreage with the yield. The comparison of in-season trial forecasts provided by models with estimates released after harvest has shown small deviation at district level.

Developing district level yield prediction methodology for groundnut crop grown in rabi season was difficult because about 50% of the area is irrigated or grown near the river banks for which field level irrigation data was not available. This paper describes the methodology adopted and results of the yield prediction for major rabi groundnut growing districts of Orissa state in India which account for more than 90% of the state's acreage and production.

2. Orissa state has a geographic area of 15.54 m. ha extending from 17° 52' N to 22° 45' N and 81° 45' E and 87° 50' E. The state can be broadly bifurcated into four distinct regions (Sahu 1979): 1. Eastern Ghat. 2. Central tableland. 3. Northern plateau 4. Coastal delta. The Coastal delta region of Orissa state comprises more than 90% of rabi groundnut growing areas. The geographical location of the groundnut growing belt extends from 18° 46' N to 20° 95' N latitude and 83° 48' E to 87° 46' E longitude. Only five districts namely Cuttack, Jagatsinghpur, Jajpur, Kendrapara and Puri in this region account for more than 90% of the crop grown in the state. Therefore these five districts are chosen for yield prediction. Soil in this region comprises of mainly alluvial silty loam soil.

3. Meteorological data from 1987 to 1999 for the rabi season from September to March were taken from India Meteorological Department (IMD) Bhubaneswar, the meteorological data obtained are daily maximum & minimum temperature and rainfall of the region. Climatic PET data of Cuttack district was taken from published bulletin of India Meteorological Department, New Delhi (IMD 1991). District wise estimates of 'reported groundnut yields', were obtained from publication by Bureau of Economics and Statistics (BES), published by the department at Bhubaneswar.

4. Daily data of maximum temperature, minimum temperature were converted into average fortnight.

TABLE 1

Comparison of predicted yield to the reported yield by BES

District/yield	Predicted yield 1999-2000 (q/ha)	BES yield 1999-2000 (q/ha)	Relative Deviation (%)
Cuttack	9.70	9.44	2.75
Jagatsinghpur	12.6	12.53	0.56
Jajpur	9.8	11.93	-17.8
Kendrapara	10.38	9.23	12.5
Puri	11.8	9.32	23.4

Similarly, cumulative fortnightly rainfall was calculated. First 15 days of a month were considered as first fortnight and 16th to end of a month was considered as second fortnight. A model is developed for yield prediction of rabi groundnut using the technique based on Thornthwaite and Mather (1955). In this approach, district level yields of rabi groundnut and meteorological data of maximum and minimum temperature and rainfall for last 12 years (1987-98) was taken into account for development of the model and 1999 meteorological data was used for prediction of yield. The residual soil moisture after monsoon season is taken into account for calculating AET based on soil water balance model published by Thornthwaite and Mather (1955). The fortnightly AET and Growing Degree Days (GDD) calculated are assumed to be linearly correlated with the yield. Although other simple methods have been developed (Dyer and Mack 1984, Lohmme and Katerji, 1991), this method requires least input data and it performs well in dryland and scarcity of rainfall areas. GDD is calculated as [{(Maximum temperature + Minimum temperature)/2} – base temperature]. Groundnut being a tropical crop, base temperature is taken as 10° C. The maximum soil moisture retention capacity (RC) for a particular type of soil and at particular PET level is obtained from the look-up table given in Thornthwaite and Mather (1955). Field capacity (FC) of the soil for this study area is taken as 200 mm. The model is run using data from September to take into account the effect of residual soil moisture available to the plant, as sowing of groundnut starts from November.

The selection of variables for the model was done using step-wise regression analysis. The goodness of fit of the regression equation is determined by coefficient of determination (r^2) and adjusted r^2. The adjusted r^2 is adjustment in r^2 based on the corresponding degrees of freedom (Draper and Smith 1981). Comparison of the predicted yield with that of the reported yield is done by computing the relative deviation index (RD) in

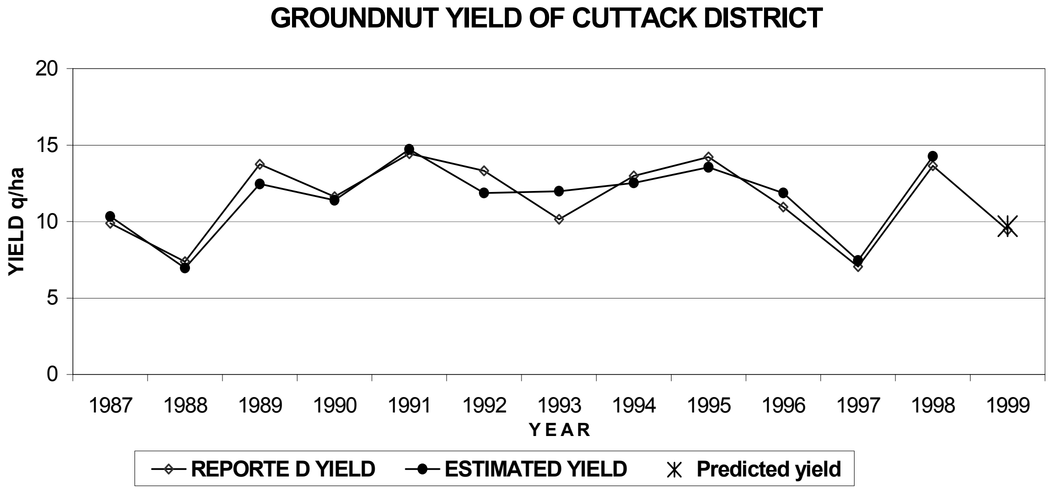

Fig. 1. Comparison of groundnut yield predicted to that of reported by DES of Cuttack district, Orissa

percentage. Lower the RD means better is the match between predicted and reported yield.

$$\mathrm{RD}(\%) = \frac{(\text{Predicted yield } - \text{Reported yield})}{\text{Reported yield}} \times 100$$

5. Groundnut crop is grown here during the rabi season (November/December – March). It is mainly dependant on the residual soil moisture after the rainy season. While the crop is sown in October-November, soil moisture storage is calculated from September to take into account available moisture in the soil one month before the crop is sown. Groundnut is mostly grown in coastal delta zone where rainfall in monsoon season is very high with high number of rainy days. Soil moisture uptake by previous crop (kharif rice) in September is neglected as rainfall is high during the monsoon in this region and soil moisture remains at field capacity during this month. AET1 … AET14 and GDD1… GDD14, representing fortnightly AET and GDD data was calculated from September 1st fortnight to 2nd fortnight of March respectively. AET 1 to 4 and GDD 1 to 4 have not been included in the selection of significant parameters, as they represent the previous crop grown before groundnut. The regression analysis of AET and GDD with the yield showed that out of 28 parameters used about 3 or 4 variables were found to be significant in the 5 districts analysed. These parameters were independently tested for prediction of 1999-2000 yield. The fitted yield values obtained from regression is referred to as 'estimated yield'. In most of the cases, technological improvement for the last one decade is taken into account by taking the trend of yield (linear regression of historical yields with the years) but was not found to be significantly affecting the yield.

In case of Cuttack (Table 2), AET of 1st fortnight of February (pod development stage) was positively correlated with the groundnut yield while GDD at 1st fortnight of December *i.e.*, at early growth stage was negatively correlated with yield. This can be explained by the fact that in 1st fortnight of February one irrigation is required for better groundnut yield which in turn causes more evapo-transpiration. At early growth stage the crop has shown negative correlation with temperature and yield. In case of Jagatsinghpur, AET at 1st fortnight of February (pod development stage) and GDD at 2nd fortnight of March (ripening stage) are found to be positively correlated with yield. At pod development stage one irrigation is required causing more evapo-transpiration and also higher temperature with sunny days at pod ripening stage is conducive for good yield of groundnut. GDD at 2nd fortnight of October was negatively correlated as the crop is at seedling stage. Similarly in the case of Jajpur, Kendrapara and Puri, AET at 1st fortnight of November (seedling stage) or 2nd fortnight of March (ripening stage) is positively correlated. GDD at 1st fortnight of December or January *i.e.*, at early growth stage or flowering stage is negatively correlated because severe lower temperature hampers growth at this stage and affects yield. AETs are positively correlated which shows enough moisture content is necessary for good evapo-transpiration and in return for good pod formation. The combination of estimated and reported yield by BES is depicted in the graph (Fig. 1), which shows good fit between estimated and reported

TABLE 2

District wise models developed for predicting yield of 1999-2000

District	Equations	r^2	Adj. r^2
Cuttack	Y = 34.955 + 0.18 × AET11 – 2.12 × GDD7	0.86	0.83
Jagatsinghpur	Y = 20.667 + 0.158 × AET11 + 1.184 × GDD14 – 1.92 × GDD4	0.75	0.65
Jajpur	Y = 30.149 + 0.22 × AET5 – 2.118 × GDD7	0.79	0.75
Kendrapara	Y = 13.513 + 0.068 × AET14 – 0.816 × GDD10 + 1.089 × GDD11 – 0.662 × GDD7	0.78	0.66
Puri	Y = –30.952 + 1.973 × GDD14 + 0.042 × AET14 + 0.09 × AET5	0.80	0.73

yield. The predicted yield is marked by asterisk (*) in Fig. 1. The Table 1 shows the comparison of the predicted yield and the reported yield. Comparison of predicted *v/s* reported yield showed maximum relative deviation of 23% in Puri district. This may be attributed to the fact that the climatic PET of Cuttack district is taken as input for calculation of all the districts. Puri being nearer to coast does not conform to the climatic PET of Cuttack. Other four districts are bifurcation of the old Cuttack district, represent similar agro-climatic condition, which can be taken as representative climatic PET in the absence of any other data. In Jajpur the predicted yield showed far lower yield than the reported yield. The possible solution would be to calculate PET for every district using modified Penman-Monieth method, which would give a better result. The models developed are presented in Table 2. As an illustration the fit of reported and estimated yields of a district is depicted in Fig. 1.

6. Comparison of the reported BES yield to the predicted yield as depicted by relative deviation (Table 1) shows that yield forecast of rabi groundnut using the yield model developed by book keeping procedure of soil moisture storage along with GDD has performed well in rainfed areas without irrigation facility except in Jajpur and Kendrapara where irrigated areas are more. District level yield forecast in rainfed areas can be attempted using this procedure especially for groundnut grown during the rabi season when rainfall is very scanty and other water balance models does not hold good in rainfed conditions.

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