

Original Research Article

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Pre-Harvest Forecasting of Rice Yield for Effective Crop Planning Decision in Surat District of South Gujarat, India

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ABSTRACT

In the Gujarat State, rice occupies about 7 to 8 per cent of the gross cropped area and accounts for about 14.00 per cent of the total food grain production. Pre harvest forecast may provide useful information to agriculturalists, administration offices and merchants. In the current study statistical crop modeling was engaged to provide forecast in advance harvesting for taking timely pronouncements. In this paper Multiple Linear Regression (MLR) Technique and Discriminant function analysis were derived for estimating average rice production for the district of Surat in south Gujarat. The weather indices were developed using correlation coefficient as weight to weekly weather parameters for the years from 1975 to 2009. The cross authentication of the developed forecast model were confirmed using data of the years 2010 to 2012. It was observed that value of Adj. R^2 varied from 0.64 to 0.80 in different models. The study discovered that high value of Adj. R^2 was obtained in the model and which indicated that it was appropriate forecast model than other models. Based on the outcomes in Surat district, MLR techniques found to be better than Discriminant function analysis for pre harvest forecasting of rice crop yield.

Keywords

Weather indices; MLR techniques; Discriminant function analysis; Forecast

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Introduction

Rice (*Oryza sativa* L.) is regarded as a first cultivated crop of Asia. More than 90 per cent of the world's rice is grown and consumed in Asia, where 60 per cent of the world's population lives. Agriculture is the mainstay of Indian economy. Agriculture and allied

sciences contributes nearly 22 percent of Gross Domestic Products (GDP) of India, while about 65-70 per cent of the population is dependent on agriculture for their livelihood. About 60 percent of sown area is dependent on rainfall as a main source of irrigation. India is an important rice growing countries in the world which has the largest area (44.8 million

hectares) followed by China and Bangladesh. In respect of production, India ranks second with 154.6 million tonnes of paddy (103.6 million tones, milled basis) next to China (206.4 million tonnes of paddy, 144.4million tones on milled basis), (FAO, 2015). In the Gujarat state, rice is grown on an average about 6.50 to 7.25 lakh hectares of land comprising nearly 55 to 60 per cent of low land (transplanted) and 40 to 45 per cent of upland (drilled) rice. The prediction of weather conditions can have significant impacts on various sectors of society in different parts of the country. Forecasts are used by the government & industry to protect life and property. It helps in improve the efficiency of operations by planning. The weather and climatic information plays a major role before and during the cropping season and if provided in advance it can be helpful in stirring the farmer to form and use their own resources in order to gather the benefits. The advance knowledge of weather parameters in a particular region is advantageous in effective planning.

The crop weather relationship has been studied by Fisher (1924) and Hendricks and Scholl (1943) have done pioneering work at Indian Agricultural Statistic Research Institute, New Delhi. They developed models which required small number of parameters to be estimated while taking care of distribution pattern of weather over the crop season. Agrawal *et al.*, (1980) and Jain *et al.*, (1980) modified this model by expressing effects of changes in weather parameters on yield in the particular week as second degree polynomial in respective correlation coefficients between yield and weather parameters. This model was further modified (Agrawal *et al.*, 1986, 2011) by explaining the effects of changes in weather parameters on yield in particular week using linear function. Garde *et al.*, (2012) studied correlation and multiple regression analysis for pre harvest forecasting of rice

yield in the Pantnagar. The study proposed that modified model with incorporating technical and statistical indicators were effectively used for early pre-harvest forecasting of crop. Dhekale *et al.*, (2014) developed the pre harvest forecast models using multiple linear regression (MLR) technique and found that the 18th SMW forecast model accounts for 89 per cent of variation in yield with RMSE 107. Sisodia *et al.*, (2014) applied discriminant function analysis on meteorological parameters for developing suitable statistical models for forecasting rice yield in Faizabad, U.P. Garde *et al.*, (2015) studied different approaches on pre harvest forecasting of wheat yield using MLR and discriminant function techniques in Varanasi district and found MLR technique more suitable than discriminant function techniques. Kumar *et al.*, (2016) studied crop yield forecasting of paddy and sugarcane through modified Hendrick and Scholl technique for south Gujarat using weather parameters. Pisal *et al.*, (2017) determined the long term changes in rainfall using Mann-Kendall rank statistics and linear trend analysis.

In the current situation of India faces increasing population and industrial development which are adversely distressing the crop yield in India. Keeping in mind early crop yield forecast will help farmer to formulate the cropping pattern, agricultural practices which will results in to the increase yield of the farmers. Therefore main objective of the present study was to develop a simple approach for forecasting the rice yield before harvesting with help of weather parameters.

Materials and Methods

The present study was carried out in the Surat, district of South Gujarat. Surat is a one of the leading districts with respect to area, production and productivity of *kharif* rice.

Considering the specific objectives of the study, *kharif* rice yield data were collected from the Directorate of Economics and Statistics, Government of Gujarat, Gandhinagar, Gujarat from 1975 to 2012. The distribution of crop yield over the year is shown in Figure 1. The study utilised weekly weather data which were collected from the Indian Meteorological Department (IMD), Pune for period of thirty four years (1975-2012). The maximum temperature (X1), minimum temperature (X2), relative humidity (X3), wind speed (X4), and total rain fall (X5) considered for studying the effect on *kharif* rice grain yield. The weekly weather data related to *Kharif* crop season starting from a first fortnight before sowing to last of reproductive stage were utilized for the development of statistical models. Therefore for the each year weather data, from May-June (22nd standard meteorological week, SMW) to October (41st standard meteorological week, SMW) were utilized for *kharif* crop. The details of the yearly average of weather parameters for *kharif* season is given in Table 1

Statistical methodology

Multiple Linear Regression models (MLR)

The MLR models were developed using weather indices (Agrawal *et al.*, 1986, 2011), in this method, weekly data on weather variables of 20 weeks have been utilized for constructing weather indices (weighted & un-weighted along with their interactions). The forms of indices are given as below:

$$Z_{i,j} = \sum_{w=1}^m r_{iw}^j X_{iw} \quad \text{and} \quad Z_{i,i',j} = \sum_{w=1}^m r_{ii'w}^j X_{i'w}$$

Where,

$j = 0, 1$ (where, '0' represents un-weighted indices and '1' represents weighted indices)

$m =$ Week up to forecast ($m=20^{th}$)

$w =$ week number (1, 2, ..., m)

$r_{iw} =$ Correlation coefficient between adjusted crop yield and i^{th} weather variable in w^{th} week

$r_{ii'w} =$ Correlation coefficient between adjusted crop yield and the product of i and i'^{th} weather variable in w^{th} week

X_{iw} and $X_{i'w}$ are the i and i'^{th} weather variable in w^{th} week respectively

The pre-harvest forecast models were obtained by applying the MLR techniques by taking predictors as appropriate un-weighted and weighted weather indices. Stepwise regression analysis was used for selecting significant variables (Draper and Smith 1981; Gomez and Gomez 1984). The regression model was as follows:

Model-1

$$Y = A_0 + \sum_{i=1}^p \sum_{j=0}^1 a_{i,j} Z_{i,j} + \sum_{i \neq i'=1}^p \sum_{j=0}^1 a_{i,i',j} Z_{i,i',j} + cT + e$$

Where,

$Z_{i,j}$ and $Z_{i,i',j}$ are the weather indices
 $i, i' = 1, 2, \dots, p$

$p =$ Number of weather variables under study

$Y =$ District total crop yield (q/ha)

$T =$ Year number (trend parameter)

A_0 is the intercept

$a_{ij}, a_{ii'j}, c$ are the regression coefficient

e is error term normally distributed with mean zero and constant variance

Discriminant function analysis

Discriminant function analysis is a multivariate technique discussed by Anderson (1984), Hair *et al.*, (1995), Johnson and Wichern (2006) etc. Discriminant analysis is an appropriate statistical technique when the dependent parameter is categorical and the independent parameters are metric. It involves deriving a variate, a linear combination of two or more independent parameters that will discriminate best between prior defined groups. In present study crop years has been divided into three groups namely congenial, normal and adverse on the basis of crop yield adjusted for trend effect. Data on weather parameters in these three groups were used to develop linear or quadratic discriminant functions and the discriminant scores were obtained for each year. These scores were used along with year as regressors in developing the forecast models (Garde *et al.*, 2015).

Method-1

In this method the model was developed by considering five weighted weather indices

$Z_{i,j} = \sum_{w=1}^m r_{iw}^j X_{iw}$ []. The discriminant function analysis was carried out and two discriminant score have been obtained. For developing quantitative forecast, these two sets of discriminant scores along with trend parameter (year) were used as the regressors and crop yield as the regress and. The form of the developed model is as follows:

Model-2

$$Y = \beta_0 + \beta_1 ds_1 + \beta_2 ds_2 + \beta_3 T + \varepsilon$$

Where,

Y is un-trended crop yield,

β_i 's ($i = 0,1,2,3$) are model parameter, *T* is the trend parameter

ds_1 and ds_2 are discriminant scores and ε is error term assumed to follow $NID \sim (0, \sigma^2)$.

Method-2

In this method, 5 weighted and 5 un-weighted weather indices of five weather parameters were used as discriminating parameters in the discriminant function analysis. Two sets of scores were obtained (ds_1 and ds_2).

The forecasting model was fitted taking the yield as the regressand and the two sets of scores along with trend *T* as the regressors. The form of model considered is as follows:

Model-3

$$Y = \beta_0 + \beta_1 ds_1 + \beta_2 ds_2 + \beta_3 T + \varepsilon$$

Where, *Y* is un-trended crop yield,

β_i 's ($i = 0,1,2,3$) are model parameter, *T* is the trend parameter

ds_1 and ds_2 are discriminant scores and ε is error term assumed to follow $NID \sim (0, \sigma^2)$.

Method-3

The method utilized all thirty developed weather indices (weighted and un-weighted including interaction indices) as discriminating parameters in discriminant analysis. The two sets of discriminant scores were obtained (ds_1 and ds_2) and used as the regressors along with trend variable *T*. The form of model considered is as follows:

Model-4

$$Y = \beta_0 + \beta_1 ds_1 + \beta_2 ds_2 + \beta_3 T + \varepsilon$$

Where,

Y is un-trended crop yield,

β_i 's ($i = 0,1,2,3$) are model parameter, T is the trend parameter

ds_1 and ds_2 are discriminant scores and ε is error term assumed to follow $NID \sim (0, \sigma^2)$.

Method-4

In this method, discriminant function analysis was carried out using the average of un-weighted and weighted weather indices which were obtained for the first weather parameter i.e. maximum temperature, (X_1). The discriminant function analysis were carried out and got two sets of discriminant scores. Next these two sets of discriminant scores and averages of un-weighted & weighted indices of the second weather parameter i.e. minimum temperature (X_2) were used as discriminating parameters. The two sets of discriminant scores were obtained through discriminant function analysis. The procedure continues up to fifth weather parameter i.e. total rainfall (X_5). The forecasting model was fitted taking the yield as the regress and last two sets of scores (ds_1 and ds_2) along with trend T as the regressors. The form of model considered is as follows:

Model-5

$$Y = \beta_0 + \beta_1 ds_1 + \beta_2 ds_2 + \beta_3 T + \varepsilon$$

Where,

Y is un-trended crop yield,

β_i 's ($i = 0,1,2,3$) are model parameter, T is the trend parameter

ds_1 and ds_2 are discriminant scores and ε is error term assumed to follow $NID \sim (0, \sigma^2)$.

This model utilizes the complete data over 20 weeks and also considers relative importance of weather parameters in different weeks.

Comparison and validation of models

The comparisons and validation of models were done using following approaches

Forecast error (%)

The validation of the model using observed yield (O_i) and forecasted yield (E_i) was computed using below formula,

$$\text{Forecast Error} = \left[\frac{O_i - E_i}{O_i} \right] \times 100$$

Coefficient of multiple determination (Adjusted R^2)

The best fitted model among developed models were decided based on highest value of Adjusted R^2

$$R_{adj}^2 = 1 - \frac{SS_{res} / (n - p)}{SS_t / (n - 1)}$$

Where,

$SS_{res} / (n - p)$ is the residual mean square

$SS_t / (n - 1)$ is the total mean sum of square.

Root mean square error (RMSE)

The cross validation of the model were done using RMSE, for the year 2010 to 2012 using observed yield (O_i) and forecasted yield (E_i) was computed using below formula,

$$RMSE = \left[\frac{1}{n} \sum_{i=1}^n (O_i - E_i)^2 \right]^{1/2}$$

Results and Discussion

Association between Rice Yield and Weather Parameters

The associations between rice yield and week wise weather parameters were studied by using Karl Pearson correlation coefficient (Table 2). The main aim was to know strength between rice yield and weekly weather parameters.

The Positive significant correlation coefficient was observed between rice yields(Y) and some of the weekly weather parameters. It was found that 70 per cent weeks were positively significant correlation coefficient between yield and minimum temperature. The relative humidity (37th SMW) and rain fall (36th SMW) also found positively significant. The negatively significant correlation coefficient was observed between rice yield and maximum temperature (39th SMW). The remaining weeks found non-significant correlation coefficient between rice yields (Y) and the weekly weather parameters. The value of 'r' varies from -0.352 to 0.667 indicating that individual character does not explain more than 67 per cent variation in the yield. This suggests that simple regression using single weather parameter is not adequate to forecast the yield. It is necessary to utilize all weather parameters simultaneously. It is done by constructing un-weighted indices and weighted indices.

Statistical models

The models were developed for the SMW no from 32 to 37, keeping in the mind forecast of crop yield at least one month before harvest

Multiple Linear Regression models (MLR)

Based on strategies followed in model 1, the obtained forecast model equations are given in

Table 3. The Table 3 observed that the values of adjusted R^2 for different models were varied from 66.5 per cent (model A₁) to 80.2 per cent (model A₆). Based on highest value of adjusted R^2 model A₆ was selected as a best model among developed six models which found to be appropriate in the 37 SMW i.e. five weeks before the harvest of crop.

The model showed 80.2 per cent variation accounted due to weather indices Z_{21} , Z_{131} and Z_{451} and trend variable T .

Discriminant Function Analysis

The different methods were adopted using discriminant function analysis and detailed of the developed models below:

As discussed in method 1, the pre harvest rice yield forecast model 2 equations are given in Table 4. The Table 4 observed that the values of adjusted R^2 for different models were varied from 64.1 per cent (model B₁) to 66.5 per cent (model B₆). Based on highest value of adjusted R^2 model B₆ was selected as a best model among developed six models which found to be appropriate in the 37 SMW i.e. five weeks before the harvest of crop. The model showed 66.5 per cent variation accounted due to $tods_1$ and trend variable T .

As discussed in method 2, the pre harvest rice yield forecast model 3 equations are given in Table 5. The Table 5 observed that the values of adjusted R^2 for different models were varied from 64.1 per cent (model C₁) to 66.5 per cent (model C₆).

Based on highest value of adjusted R^2 model C₆ was selected as a best model among developed six models which found to be appropriate in the 37 SMW i.e. five weeks before the harvest of crop. The model showed 66.5 per cent variation accounted due to $tods_1$ and trend variable T .

Table.1 The average of weather variables for cropping season of Surat district of south Gujarat

Year	Max. Temp.	Min. Temp.	Relative Humidity	Wind Speed	Rain Fall
1975	32.1	25.6	87.8	10.2	78.6
1976	32.1	25.3	85.5	8.8	112.5
1977	32.5	24.6	84.6	8.7	56.2
1978	32.3	24.1	82.4	0.0	58.3
1979	32.9	23.4	82.5	8.9	66.5
1980	32.5	25.3	83.0	10.2	50.8
1981	32.6	25.4	82.8	10.4	58.4
1982	32.9	26	82.4	10.2	56.4
1983	32.4	25.4	87.5	0.2	96.2
1984	31.9	25	83.7	0.2	43.1
1985	32.6	25.4	81.2	0.4	15.7
1986	32.3	25.7	80.2	0.0	49.5
1987	34.0	26.0	75.6	0.0	25.4
1988	32.5	24.6	84.9	0.0	113.9
1989	32.5	26.1	78.7	0.0	16.0
1990	31.7	26.1	84.2	0.0	43.2
1991	32.6	25.7	79.9	0.4	32.1
1992	31.7	26.1	84.1	0.0	05.3
1995	33.8	26.4	77.3	0.1	30.3
1997	32.5	25.9	79.8	0.0	47.7
1998	33.9	26.7	79.9	0.0	75.9
1999	32.5	26.3	84.9	0	46.8
2000	32.4	26.4	83.3	8	36.1
2001	31.6	26	86.1	7.1	53.3
2002	31.9	25.8	84.5	5.4	52.3
2004	31.8	25.8	84.8	3.9	83.9
2005	32	26	83.7	5.6	100
2006	31.7	26.2	85.2	3.6	72.3
2007	32.2	26	86.7	4.3	82
2008	31.5	25.8	87.2	5.8	64.1
2009	32.5	26.5	84.4	6.5	66.3
2010	32.3	26.3	87.4	5	75.8
2011	31.9	26.5	85.2	7.5	60.8
2012	32	26.7	86.2	8.7	41.8

Table.2 Week wise correlation coefficient between rice yield and weekly weather parameters

SMW no.	Correlation coefficient between rice yield (Y) and weekly weather parameters (X _i)				
	Max. temp.	Min. temp.	Rel. Humidity	Wind Speed	Rainfall
w _i	X ₁	X ₂	X ₃	X ₄	X ₅
22	-0.186	0.386*	0.167	-0.125	0.149
23	0.113	0.486*	-0.145	-0.121	-0.312
24	-0.075	0.329	0.081	-0.16	0.003
25	0.191	0.481*	-0.141	0.029	-0.332
26	0.137	0.42	0.024	-0.061	-0.089
27	0.032	0.29	0.126	-0.203	0.215
28	-0.001	0.382*	0.018	-0.119	-0.189
29	-0.13	0.321	0.112	-0.172	0.196
30	-0.102	0.351*	0.179	-0.026	-0.034
31	0.026	0.469*	0.066	-0.019	-0.071
32	-0.004	0.525*	0.008	-0.01	-0.091
33	0.105	0.690*	0.049	-0.029	0.167
34	0.038	0.667*	0.052	-0.182	0.189
35	0.033	0.602*	0.228	-0.215	0.179
36	-0.127	0.68*	0.235	-0.041	0.424*
37	-0.186	0.593*	0.377*	-0.127	0.131
38	-0.153	0.605*	0.256	-0.079	0.003
39	-0.352*	0.412*	0.179	-0.141	0.132
40	-0.222	0.274	0.161	-0.089	-0.094
41	-0.263	0.19	0.295	-0.148	0.221

Table.3 Pre harvest rice yield forecast model 1 equations

Model1	SMW No.	Model Equations	Adj. R ²
A ₁	32	$Y = -216.759 + 25.520T + 2.423Z_{121}$	0.665
A ₂	33	$Y = -1258.536 + 27.521T + 1.828Z_{121} + 1.195Z_{131}$	0.715
A ₃	34	$Y = -1659.396 + 27.460T + 1.186Z_{131} + 1.758Z_{121}$	0.716
A ₄	35	$Y = -1887.861 + 21.368T + 261.445Z_{21} + 8.956Z_{20}$	0.738
A ₅	36	$Y = -859.329 + 29.360T + 157.551Z_{21} + 1.075Z_{131}$	0.747
A ₆	37	$Y = -1627.208 + 27.479T + 97.952Z_{21} + 1.009Z_{131} + 0.087Z_{451}$	0.802

Table.4 Pre harvest rice yield forecast model 2 equations

Model 2	SMW No.	Model Equations	Adj. R ²
B ₁	32	$Y = 1219.833 + 30.428T + 86.697ds_1$	0.641
B ₂	33	$Y = 1268.057 + 27.414T + 87.349ds_1$	0.651
B ₃	34	$Y = 1269.126 + 27.347T + 87.316ds_1$	0.652
B ₄	35	$Y = 1268.051 + 27.414T + 87.815ds_1$	0.654
B ₅	36	$Y = 1268.653 + 27.377T + 87.715ds_1$	0.653
B ₆	37	$Y = 1266.013 + 27.542T + 90.914ds_1$	0.665

Table.5 Pre harvest rice yield forecast model 3 equations

Model 3	SMW No.	Model Equations	Adj. R ²
C ₁	32	$Y = 1219.833 + 30.428T + 86.697ds_1$	0.641
C ₂	33	$Y = 1268.057 + 27.414T + 87.349ds_1$	0.651
C ₃	34	$Y = 1269.126 + 27.347T + 87.316ds_1$	0.652
C ₄	35	$Y = 1268.051 + 27.414T + 87.815ds_1$	0.654
C ₅	36	$Y = 1268.653 + 27.377T + 87.715ds_1$	0.653
C ₆	37	$Y = 1266.013 + 27.542T + 90.914ds_1$	0.665

Table.6 Pre harvest rice yield forecast model 4 equations

Model 4	SMW No.	Model Equations	Adj. R ²
D ₁	32	$Y = 1219.833 + 30.428T + 86.697ds_1$	0.641
D ₂	33	$Y = 1267.517 + 27.4484T + 87.824ds_1$	0.653
D ₃	34	$Y = 1268.407 + 27.392T + 87.724ds_1$	0.654
D ₄	35	$Y = 1267.234 + 27.465T + 88.265ds_1$	0.655
D ₅	36	$Y = 1204.214 + 31.404T + 107.210ds_1$	0.691
D ₆	37	$Y = 1265.762 + 27.557T + 90.634ds_1$	0.665

Table.7 Pre harvest rice yield forecast model 5 equations

Model 5	SMW No.	Model Equations	Adj. R ²
E ₁	32	$Y = 1219.833 + 30.428T + 86.697ds_1$	0.641
E ₂	33	$Y = 1268.057 + 27.414T + 87.349ds_1$	0.651
E ₃	34	$Y = 1269.126 + 27.347T + 87.316ds_1$	0.652
E ₄	35	$Y = 1268.051 + 27.414T + 87.815ds_1$	0.654
E ₅	36	$Y = 1268.653 + 27.377T + 87.715ds_1$	0.653
E ₆	37	$Y = 1266.013 + 27.542T + 90.914ds_1$	0.665

Table.8 Comparison of pre harvest rice yield forecast models

Model No.	Forecasting SMW no.	Year	Observed Yield	Forecast Yield	Forecast error (%)	Adj. R ²	RMSE
Model-1	37	2010	2445	2179	10.85	80.2	378.53
		2011	2750	2193	20.25		
		2012	2380	2159	9.27		
Model-2	37	2010	2445	1968	19.46	66.5	471.21
		2011	2750	2168	21.15		
		2012	2380	2064	13.26		
Model-3	37	2010	2445	1968	19.46	66.5	471.21
		2011	2750	2168	21.15		
		2012	2380	2064	13.26		
Model-4	36	2010	2445	2175	11.03	69.1	345.89
		2011	2750	2230	18.89		
		2012	2380	2255	5.26		
Model-5	37	2010	2445	1968	19.46	66.5	471.21
		2011	2750	2168	21.15		
		2012	2380	2064	13.26		

Fig.1 Trend of rice yield in Surat district

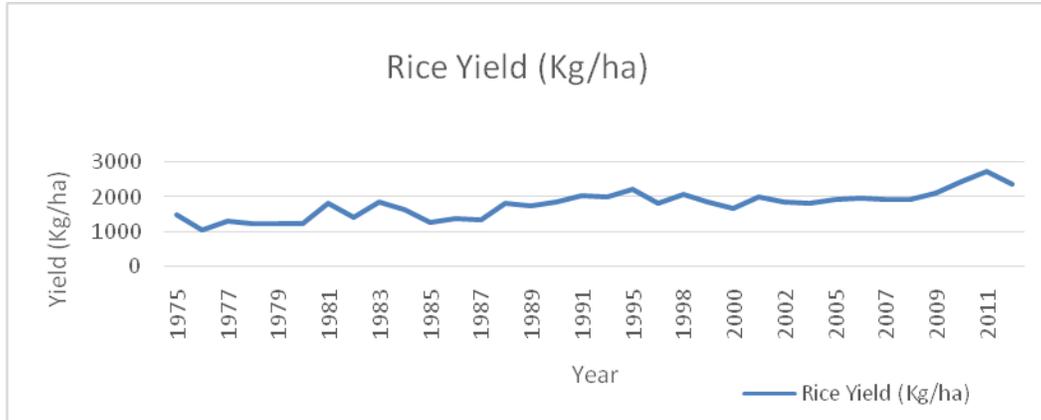
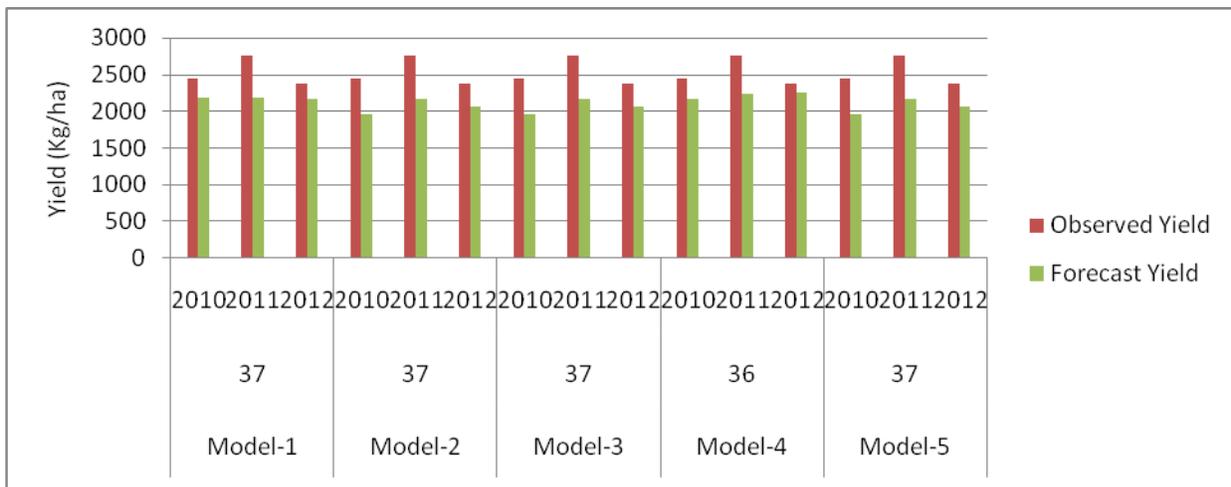


Fig.2 Graphical representation of observed yield and forecast yield



As discussed in method 3, the pre harvest rice yield forecast model 4 equations are given in Table 6. The Table 6 observed that the values of adjusted R^2 for different models were varied from 64.1 per cent (model D_1) to 66.5 per cent (model D_6). Based on highest value of adjusted R^2 model D_6 was selected as a best model among developed six models which found to be appropriate in the 37 SMW i.e. five weeks before the harvest of crop. The model showed 66.5 per cent variation accounted due to $tods_1$ and trend variable T .

As discussed in method 4, the pre harvest rice yield forecast model 5 equations are given in Table 7. The Table 7 observed that the values of adjusted R^2 for different models were varied from 64.1 per cent (model E_1) to 66.5 per cent (model E_6). Based on highest value

of adjusted R^2 model E_6 was selected as a best model among developed six models which found to be appropriate in the 37 SMW i.e. five weeks before the harvest of crop. The model showed 66.5 per cent variation accounted due to $tods_1$ and trend variable T .

Comparison between models

It was observed that different approaches of discriminant function analysis i.e. from model 2 to model 5 were more or less similar as coefficient of regression and values of adjusted R^2 . Comparison between models was carried out by using Adj. R^2 . The comparison of selected best fit models was done by forecast error and RMSE. The details of comparative study are given in Table 8 and the graphical representation is given in Figure

2.

It observed from Table 8 that, the value of adjusted R^2 varies from 66.5 to 80.2 and a value of RMSE varies from 345.89 to 471.21. The forecast error per cent varies from 9.27 to 20.25. The model 1 was selected as best fit model based on highest value R^2 and comparatively low value of RMSE and forecast error per cent. Therefore pre-harvest forecasting was done using model 1 in the 37th SMW i.e. five weeks before harvest of the rice crop.

Based on the results discussed it was found that MLR techniques gave better forecast results than Discriminant function analysis for pre harvest forecasting of rice crop yield.

This study reveals that stepwise Multiple Linear Regression techniques (MLR) can be successfully used for pre-harvest crop yield forecasting. This model was most consistent and can be apply on zone or state level. The study also shows that use of de-trended yield data in model development gets most appropriate pre-harvest forecast models. The technique of discriminant function is found useful in classifying the crop year in to congenial, normal and adverse year with respect to crop yield. It can be concluded from the results that there is a wide scope for using alternative approaches to develop predictors that could be used in forecasting models for reliable and dependable forecast. Therefore, it is important to continue research on these aspects for various other crops also on a continuous basis. This methodology can be applicable in many crops viz. rice, pulses, oil seeds, sugarcane etc. to develop pre-harvest forecasting models and these forecasts have significant value in agricultural planning and policy making.

References

- Agrawal, R. Jain, R.C. and Mehta, S.C., (2001). Yield forecast based on weather variables and agricultural inputs on agro-climatic zone basis. *Ind. J. Agri. Sci.*, 71 (7), 487-490.
- Agrawal, R.; Chandrahas and Kaustav A, (2011). Use of discriminant function analysis for forecasting crop yield. *MAUSAM*, 63(3): 455-458.
- Agrawal, R.; Jain, R. C. and Jha, M. P. (1980). Modes for studying rice-weather relationship. *MAUSAM*, 37(1): 67-70.
- Anderson, T. W.; (1984). *An Introduction to Applied Multivariate Statistical Analysis*. John Wiley & Sons, New York.
- Dhekale, B. S; Sawant P. K. and Upadhye, T. P. (2014). Weather based pre-harvest forecasting of rice at Kolhapur (Maharashtra). *Trends in Biosciences*, 7(1): 39-41.
- Draper, N.R. and Smith, H. (1981). *Applied regression analysis*, second edition, John Wiley and sons, New York
- Fisher, R. A., (1924). The influence of rainfall on yield of wheat at Rothamsted. *Philosophical Transaction of Royal Society of London*, Series B, 213: 89-142.
- Food and Agriculture Organization, (2015). Rice market monitor, report 18(2): 2-6.
- Garde, Y. A., Dhekale, B. S. and Singh, S., (2015). Different approaches on pre harvest forecasting of wheat yield. *Journal of Applied and Natural Science*, 7 (2): 839 – 843.
- Garde, Y. A.; Shukla, A. K.; Singh, S. (2012). Pre-harvest forecasting of rice yield using weather indices in Pantnagar. *International Journal of Agricultural Statistical Science*, 8(1): 233-241.
- Gomez, K.A. and Gomez, A.A. (1984). *Statistical Procedures in Agricultural Research*. 2nd edition, New

- York, Chichester, etc.: Wiley paperback, pp. 680
- Hair; Joseph, F.; Anderson; Rolph, E.; Tatham; Ronald L. and Black, W. C.; (1995). *Multivariate Data Analysis with Readings*, Prentice Hall, Inc. New Jersey.
- Hendricks, W. A. and Scholl, J. C. (1943). Technique in measuring joint relationship. The joint effect of temperature and precipitation on corn yield. N. C. Staff Agricultural Experimental Techniques Bulletin, 74.
- Jain, R. C.; Agrawal, R. and Jha, M. P. (1980). Effect of climatic variables on rice yield and its forecast, *MAUSAM*, 31(3): 591-596.
- Johnson; Richard, A. and Wichern, D. W. (2006). *Applied Multivariate Statistical Analysis*, Pearson Education.
- Kumar, N.; Pisal, R. R.; Shukla, S. P. and Pandey, K. K., (2016). Crop yield forecasting of paddy and sugarcane through modified Hendrick and Scholl technique for south Gujarat. *MAUSAM*, 67(2): 405-410.
- Pisal, R.R., Kumar Neeraj and Shukla, S.P., (2017). Long term trend analysis of rainfall at heavy rainfall zone of South Gujarat, India. *Ind. J. Soil Cons.*, 45(2): 168-175.

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