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FORECASTING OF GROUNDNUT YIELD USING METEOROLOGICAL VARIABLES

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ABSTRACT

Agriculture is one of the most significant economic sectors in India, which is strongly dependent on climatic conditions. Groundnut is one of the major oilseed crops of Gujarat and Junagadh has highest production of groundnut in Gujarat. For effective, forward-looking, and current planning, especially in agriculture, which is fraught with uncertainty, reliable and timely forecasts are essential. Therefore, effective yield forecast of such important oilseed crop is necessary for future planning and policy making. In the present investigation, the time series data of groundnut yield and weather parameters of 29 years Junagadh (1991-92 to 2019-20) were used. The week wise weather indices were generated using correlation between de-trend yield and weekly weather variables. Multiple Linear Regression (MLR) and Discriminant Function Analysis were used to develop yield forecasting model using weather indices before three week and one week before harvest, respectively. These models were compared using Coefficient of multiple determination (Adj. R^2), Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE). The study found that model-1A, developed using MLR technique have high value of adj. R^2 (78.8%) and low RMSE value (671.72). Multiple linear regression (MLR) was found to be more accurate than the discriminant function analysis approach.

Keywords: *yield forecasting, MLR, discriminant function*

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an annual legume mainly cultivated for the high-quality oil (36 – 54 %) and easily assimilated protein (12 - 36%) in its seeds. It is main oilseed crop in Gujarat, which is grown on an area of 1678.8 thousand hectares and has a productivity of 2422 kg ha^{-1} (Anonymous, 2020). In Gujarat, Junagadh has the highest area under groundnut production (238.50 thousand hectare) with productivity of 1771.72 kg/ha. Groundnut is best cultivated in the tropical climate and requires 20-30°C temperature and 50-75 cm rainfall.

Agriculture is one of the most significant economic sectors in India, which is strongly dependent on climatic conditions (Manjusha *et al.,* 2019; Vinaya *et al.,* 2017). Weather has a significant impact on a crop's growth, development, and yields as well as the prevalence of pests and diseases. For effective, forward-looking, and current planning, especially in agriculture, which is fraught with uncertainty, reliable and timely forecasts are essential. Therefore, effective yield forecast of such important oilseed crop is necessary for future planning and policy making. Realizing the impact of weather parameters on crop growth and yield an attempt has been made to develop the statistical model to forecast yield of groundnut using weather parameters in Junagadh district of Gujarat.

OBJECTIVES

(1) To develop weather based forecast models for yield forecasting of groundnut

(2) To compare two different model developing methods *viz*., Multiple Linear Regression (MLR) and Discriminant Function Analysis

METHODOLOGY

Data collection

The time series data of groundnut yield of 29 years (1991-92 to 2019-20) was obtained from the records of the Directorate of Agriculture, Gujarat. Weather data for the same period of time was collected from department of Agricultural meteorology, Junagadh Agricultural University. Data of first 24 years (1991-92 to 2014-15) were used to train model and remaining data of five years (2015-16 to 2019-20) were used for validation purpose. Five different weather parameters were included in the study *viz*., Maximum Temperature (X1), Minimum Temperature (X2), Total Rainfall (X3), Morning

Relative Humidity (X4) and Evening Relative Humidity (X5).

Pre harvest forecast models based on weather indices

For generating weighted and unweighted weather indices weekly data on weather variables of 13 and 15 weeks have been used. For weighted indices correlation coefficient between yearly crop yield (detrended) and weather parameters for respective weeks was used as weight. The forms of weather indices are given below (Agrawal *et al.,* 2007; Garde *et al*., 2015):

$$Z_{i,j} = \sum_{w=1}^{m} r_{ij}^{j} X_{iw}$$

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

Where,

i, i' = 1, 2, …, p

p = No. of weather variables under study

j = 0, 1 (where, '0' = un-weighed indices and '1' = weighed indices)

m = The week up to forecast (m < n)

w = The week number

r_{iw} = Correlation coefficient between yield (detrended) and i^{th} weather variable in w^{th} week

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

Multiple linear regression

The forecasting models were developed using stepwise multiple linear regression approach by taking weighted and un-weighted weather indices as predictors to forecast the groundnut yield well in advanced. The developed weather indices-based statistical forecast model is given below (Draper and Smith, 1981) :

Model - 1

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

Where,

Y = Observed groundnut yield

A_0 = Intercept

$Z_{ij'} Z_{ii'j}$ = Weather indices

$a_{ij'} a_{ii'j}$ = Regression coefficient of and weather indices

p = No of weather variables

e = Error term

c = Regression coefficients of trend variable

T = Trend variable (Year)

Two models were developed by using Model – 1 for weather data of 13 weeks (1A) and 15 weeks (1B).

Discriminant function analysis

The discriminant function is a statistical method that classifies between different groups of objects based on characters which are considered to be relevant. The process begins with dividing crop years into three categories *viz*., congenial, normal, and adverse, based on crop yield adjusted for trend effect.

Two discriminant score have been generated utilizing categorical yield data and weighted weather indices which were described earlier. The forecast model was developed using two discriminant score along with trend variable through stepwise regression analysis (Agrawal et al., 2012; Garde et al., 2015). The form of the developed model is as follow:

$$Y = B_0 + B_1 ds_1 + B_2 ds_2 + B_3 T + \varepsilon$$

Where,

Y = Observed groundnut yield

Bi = Regression coefficient

ds_1 *and* ds_2 = Discriminant scores

T = Trend variable (Year)

ε = Error term

Two models were developed by using Model – 2 for weather data of 13 weeks (2A) and 15 weeks (2B).

RESULTS AND DISCUSSION

The pre-harvest forecast models were developed by using multiple linear regression and discriminant function analysis for 13 and 15 weeks and presented in Table 1. Among all the models, only model 1B, trend variable T was found significant. In model-1A, weather indices Z231 (Interaction of minimum temperature and total rainfall), Z21 (Minimum Temperature), Z141 (Interaction of Maximum Temperature and Morning Relative Humidity) and Z341 (Interaction of Total Rainfall and Morning Relative Humidity) were

Table 1: Pre-harvest yield forecasting models of groundnut.

Model No.	Forecast Model Equation	Adj. R^2
1A	$Y = 6522.59 + 1.84Z_{231} + 402.33Z_{21} + 1.45Z_{141} - 0.431Z_{341}$	78.80
1B	$Y = -4415.36 + 0.098Z_{351} + 1.78Z_{141} + 33.23T$	80.00
2A	$Y = 1566.53 + 389.24ds_1$	69.10
2B	$Y = 1566.53 + 326.51ds_1$	74.10

found significant. In model-1B, weather indices Z351 (Interaction of Total Rainfall and Evening Relative Humidity), Z141 (Interaction of Maximum Temperature and Morning Relative Humidity) were found significant. In model-2A and 2B, discriminant score ds1 was found significant.

The developed models were compared by using RMSE, forecast errors and MAPE are presented in Table 2.

Table 2: Observed and predicted yield of groundnut

Forecast Year	Observed yield	Forecast yield (kg/ha)			
		1A	**1B**	**2A**	**2B**
2015-16	1078.78	1826.12	12227.16	1901.28	2093.56
		(-6.87)	(-615.56)	(-11.27)	(-22.52)
2016-17	2382.55	1968.81	10926.68	1477.39	1638.15
		(17.37)	(-358.61)	(37.99)	(31.24)
2017-18	2218.52	1441.05	7725.91	708.65	186.67
		(35.04)	(-248.25)	(68.06)	(91.59)
2018-19	1933.16	787.73	11245.49	3007.50	3156.19
		(59.25)	(-481.72)	(-55.57)	(-63.27)
2019-20	2326.20	1932.95	17134.17	3381.95	3341.08
		(16.91)	(-636.57)	(-45.38)	(-43.63)
RMSE		**671.72**	**10197.70**	**1039.70**	**1212.96**
MAPE		**27.09**	**468.14**	**43.65**	**50.45**

*figures in parenthesis are forecast error

The RMSE, forecast error and MAPE were calculated for the year 2015-16 to 2019-20. The result from Table 1 and Table 2 revealed that the highest value of *Adj. R^2* was found in model 1B (80.00) which has highest RMSE value. Although model-1B has highest value of Adj. R2, it was not considered as best model. The Model-1A which was developed through MLR for 13 week has least value of RMSE so it was considered as suitable model for pre-harvest forecasting of groundnut yield. The similar results were found by Parmar *et al*. (2004) and Rajegowda *et al*. (2014) for groundnut yield forecasting and Biswas and Bhattacharya (2019) in sugarcane.

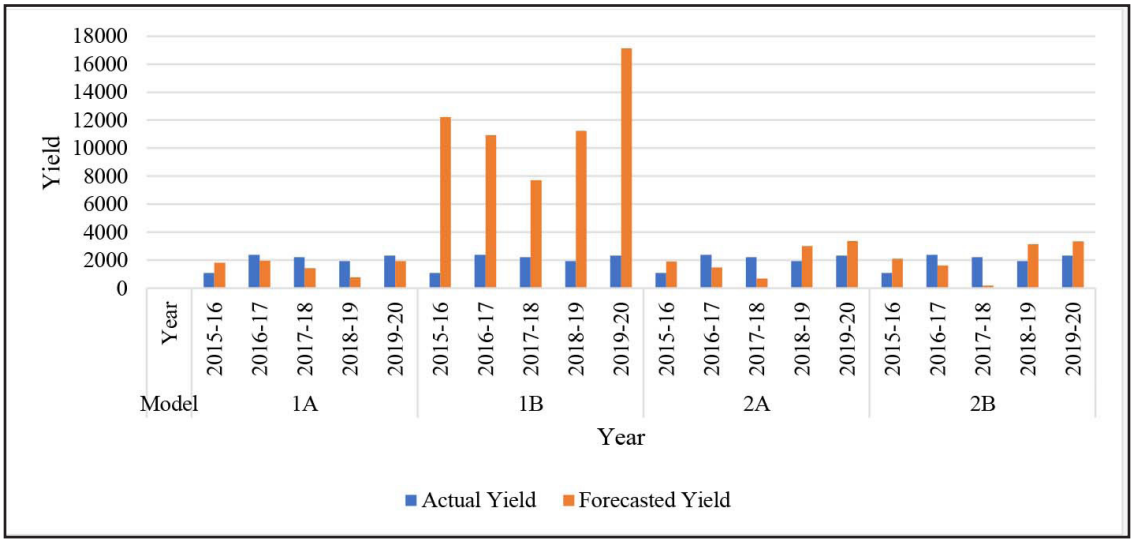

Fig 1: Graphical representation of actual yield and forecasted yield using MLR and discriminant function analysis

CONCLUSION

Pre-harvest forecasting is a statistical method that used to predict the crop yield in advance of harvesting. Weather factors plays an important role during whole cropping season. Forecasting of yield before harvest help farmers to take advance marketing judgement for the crop. Timely and reliable forecast of crops are also useful for researchers and policy makers for proper planning and evaluation of agricultural investments. The study concluded that multiple linear regression approach was found better than the discriminant analysis approach for pre-harvest forecasting of groundnut yield in Junagadh district.

CONFLICT OF INTEREST

No conflict of interest among researcher

REFERENCES

Agrawal, R.C. and Aditya, K. (2012). Use of discriminant function analysis for forecasting crop yield. *Mausam*, 63(3): 455-458.

Biswas, R. and Bhattacharya, B. (2019). Rice yield prediction in lower Gangetic Plain of India through multivariate approach and multiple linear regression analysis. *Journal of Agrometeorology*. 21(1):101-103.

Draper, N.R. and Smith, H. (1981). Applied Regression Analysis, Second edition, John Wiley and sons, New York.

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.

Manjusha K., Nitin P., Suvarna D. and Vinay Kumar H. M. (2019). Exposure, Perception and Advantages about Weather-based Agro-advisory Services by Selected Farmers of Anand District, India, *Int. J. Curr. Microbiol*. App. Sci. 8(5): 1934-1944.

Parmar, B. A., Sahu, D. D., Dixit, S. K., and Patoliya, B. M. (2004). Forecasting of groundnut yield using rainfall variables for Saurashtra region of Gujarat state. *Journal of Agrometeorology*, 6(1), 1-8.

Rajegowda, M. B., Soumya, D. V., Padmashri, H. S., Gowda, N. J., and Nagesha, L. (2014). Ragi and groundnut yield forecasting in Karnataka–statistical model. *Journal of Agrometeorology*, 16(2), 203-206.

Vinaya Kumar, H. M., Shivamurthy, M., and Lunagaria, M. M. (2017). Impact of rainfall variability and trend on rice yield in Coastal Karnataka. *Journal of Agrometeorology.* 19 (3): 286-287.

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