USE OF EYE ESTIMATE AND RAINFALL VARIABLES FOR PREHARVEST FORECASTING OF GROUNDNUT YIELD IN GUJARAT*

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(Received : April, 1981)

SUMMARY

In view of the economic importance of the groundnut crop in Gujarat and the wide fluctuation in prices of groundnut oil which demand socio-economic adjustment in advance, the preharvest forecasting of groundnut yield in Gujarat has been attempted by combing eye estimate and selected rainfall variables through regression analysis. Prediction models of groundnut yield for groundnut growing districts of Gujarat, obtained through stepwise regression analysis are discussed in the paper.

INTRODUCTION

Groundnut (*Arachis hypogaea Linn*) is one of the important oilseed crop in india. Among various states in India, Gujarat occupies the first position for groundnut both in respect of area as well as production. In view of the economic importance of the groundnut crop in Gujarat and wide fluctuations in prices of groundnut oils ,which demand socioeconomic adjustment in advance, the study has its own importancc.

The growing plant is a very efficient "integrator" of the many sequence of the contemporary wcather that it has experienced upto a particular stage of its growth (Ramdas[8]). Sanderson [9] used the condition reports (very-similar to eye estimate) and weather data in forecasting the yield of wheat in U.S.A. The regression technique was utilized by panse [7] to get improved estimate of cotton, using anna

* The article formed a part of the thesis, of senior author for the award of Ph,D. in Agricultural Statistics of Gujarat Agricultural University; 1980.

valuation (eye estimate) only. Bali [2] also used eye estimate to provide preharvest estimate of sugarcane yield in Utter Predesh.

Eye estimate figures on growing crop are normally available seven weeks in advance of the date of harvest of the crop from Table I. of the crop estimation surveys, conducted by the statistics branch of the Directorate of Agriculture, Gujarat State, Ahmedabad, The rainfall for the meteorological standard weeks during the groundnut growing season covering the period from 22nd week to 43rd week were also utilized as independent variables. An attempt has been made to apply regression analysis to the past historic data of the crop estimation surveys and the rainfall data to make the preharvest forecast more objective.

Materials and Methods

The actual crop cuttting yields (CCY) and the corresponding eye estimate (EEY) were collected for 29873 cutting experiments conducted in diffierent districts of Gujarat State, for the past 24 years from 1953-54 to 1977-78, under crop estimation survey. The daily rainfall data of 16 representative rain gauge stations for the corresponding 24 years were collected from the directorate of Agriculture, Gujarat State, Ahmedabad.

The data were processed to build up the estimates of average EEY at taluka and district level and to workout weekly totals of rainfall for the meteorological standard weeks during the groundnut growing season covering the period from 22 nd week to 43rd week. A comparative examination of EEY and the corresponding CCY was carried out to detect outliers using the procedure outlined by Anscombe [1]. The outliers were then replaced by the corresponding second forecast values. The correlation coefficient were worked out to examine the relationship between EEY and CCY in each district.

The analysis comprised of formulation of an appropriate model for forecasting groundnut yield for different districts of Gujarat State. Technological trend was examined in the time series data of yield per hectare of 24 years using graphical method. The time trend was absent and therefore time variable has not been taken as one of the independent variables. The presence of auto-correlation in regression analysis was examined using Durbin-watson statistic 'd' (Durbin and Watson [3] and indicated absence of auto-correlation. Stepwise regression analysis (Efroymson [4]) was carried out utilizing CCY as dependent and EEY with 22 rainfall variables

during the crop growing season as independent variables for the purpose of formulation of yield prediction model.

The details of variables included in different stages of growth of groundnut crop season is presented in Table 1. The error of forecast was worked out using the formula :

Error of forecast $= \frac{\{\sigma_y^2 (1-R^2)\}^{\frac{1}{2}}}{\bar{y}} \times 100$ However the appropriate formula for the error of forecast of yield at X's of the

TABLE 1

Details of the variables included in different stages of growth of groundnut crop season

Standard week number	*Stage*	*Variable*
	Eye estimate	X_1
22	Presowing	X_2
23		X_3
24	Germination and vegetative	X_4
25	Development	X_5
26		X_6
27		X_7
28		X_8
29	Flowering and pegging	X_9
30	period	X_{10}
31		X_{11}
32		X_{12}
33		X_{13}
34	Full pegging to pod	X_{14}
35	development	X_{15}
36		X_{19}
37	Maturity	X_{17}
38		X_{18}
9		X_{19}
40		X_{20}
41		X_{21}
42		X_{22}
43		X_{23}
	Yield	Y

subsequent year not included in the forecast models, for the future forecast should be

$$S\ \hat{y}=\left[S^2\left\{1+\frac{1}{n}+\left(x_0-\bar{x}\right)'\left(x'\ x\right)^{-1}\left(x_0-\bar{x}\right)\right\}\right]^{\frac{1}{2}}$$

To select the appropriate models for each district the following different regression equations were worked out.

(*i*) with eye estimate alone.

(*ii*) eye estimate and rainfall variables upto 9th September by which time the estimate figures are normally available.

(*iii*) eye estimate and rainfall variable upto 23rd September

(*iv*) eye estimate and all selected rainfall variables.

(*v*) selected rainfall variables alone.

Finally, the prediction models were tested for its utility by predicting the district yield and comparing with CCY for the year not included in the development of the prediction model.

The state level estimate of average yield was obtained as

$$\bar{Y}=\frac{\sum_{i=1}^{d} A_i \hat{Y}_i}{\sum_{i=1}^{d} A_i}$$

where A_i and $\hat{Y}_i$ are the Area and Predicted yield of ith district.

Results and Discussion

The correlation coefficient between CCY and EEY in different districts, based on 21 to 24 years of data are presented in table 2. They varied from 0.6433 to 0.9078. At state level, the correlation coefficient is higher (0.9199) than those at district level. Sanderson [10] indicated that the crops which are subject to critical period of relatively short duration are more accurately predicted by condition report (EEY), than crops like cotton—where fruiting is continuous. In this respect, the groundnut crop has relatively short critical period of pegging to initial pod development stage. Therefore, it is expected that higher correlation should exist between eye estimate and crop cutting yield. The results obtained in the present study support this view.

TABLE 2

Correlation coefficient between CCY and EEY in different districts of Gujarat

Sr. No.	*District*	*Based on Years*	*Correlation Coefficicnt*
1.	Ahmedabad	24	0.9078**
2.	Banaskantha	24	0.8456**
3.	Baroda	24	0.7138**
4.	Broach	24	0.8271**
5.	Kaira	24	0.7269**
6.	Mehsana	24	0.8370**
7.	Panchmahal	24	0.8038**
8.	Sabarkantha	24	0.7655**
9.	Surat	24	0.6433**
10.	Amreli	24	0.8302**
11.	Bhavnagar	21	0.8570**
12.	Jamnagar	21	0.8592**
13.	Junagadh	21	0.8759**
14.	Kutch	21	0.7910**
15.	Rajkot	21	0.8807**
16.	Surendranagar	21	0.8577**
	Gujarat State	21	0.9199**

** denote Significance at 1% level.

The significant positive correlation, therefore, has been the basis for inclusion of EEY as one of the independent variables in the prediction equation in this study.

The appropriate models for all the 16 districts of Gujarat with time of forecast and R^2 are presented in table 3. The results revealed that the first variable (x_1) – EEY is highly significant in all the districts and eye estimate alone accounted for 41% to 82% of the total variation in yield in different districts. The prediction equation with eye estimate in combination with rainfall variables proved efficient in forecasting groundnut yield compared to regression equation with eye estimate or selected rainfall variables alone.

TABLE 3

Prediction equation, time of forecast and R^2 for the appropriate model for predicting groundnut yield in different districts of Gujarat State

S. No.	*District*	*Prediction equation*	*Time of forecast*	R^2
1.	Ahmedabad	$Y=57.0239+1.0182X_1{**}-2.7252X_2{*}-0.3203X_3-0.9557X_5 -0.6116X_{11}+0.4674P_{15}-0.3722X_{16}$	middle of Sept.	0.9179**
2.	Banaskantha	$Y=200.53+1.2077X_1{**}+3.8684X_2+0.3531X_3-10.2000X_4 -2.1260X_5-0.2267X_7+2.0834X_8{**}+1.2569X_{15}+1.1353X_{16}$	middle of Sept.	0.9888**
3.	Baroda	$Y=71.6965+0.9947X_1{**}-0.8572X_{19}{*}+1.1874X_{19}$	end of Sept	0.6675**
4.	Baroach	$Y=258.06+0.6405X_1{**}-0.6366X_9{**}\times 1.1105X_{17}$	end of Sept.	0.8032**
5.	Kaira	$Y=209.14+0.6177X_1{**}+0.7216X_{15}+3.7207X_{21}$	middle of Oct.	0.6594**
6.	Mehsana	$Y=65.550+0.7913X_1{**}+4.2687X_8{**}-1.3439X_{12}{**}+0.9383X_{15}$	middle of Sept.	0.8951**
7.	Panchmahnl	$Y=56.6278+0.7711X_1{*}+0.5025X_8{*}+1.3439X_{12}{**}+1.1709X_{14}{**}$	middle of Sept.	0.8629**
8.	Sabarkantha	$Y=245.44+0.7249X_1{*}-2.4962X_2+0.8473X_6-1.1317X_7 -0.5663X_{11}{*}+0.9852X_{13}{*}$	middle of Sept.	0.8777**
9.	Surat	$Y=57.6959+0.9472X_1{*}+4171X_{13}+63.6845X_{23}{*}$	end of Oct.	0.6807**
10.	Amreli	$Y=121.56+0.7677X_1{**}+0.9798X_3+1.3722X_{15}$	middle of Sept.	0.7882**
11.	Bhavnagar	$Y=135.99+1.2646X_1{**}+0.6844X_8-2.3185X_{11}$	middle of Sept.	0.8156**
12.	Jamnagar	$Y=-100.27+1.0393X_1{**}+2.8973X_4+1.2913X_8+0.6349X_{15}$	middle of Sept.	0.7897**
13.	Junagadh	$Y=-254.86+1.2028X_1{**}+1.0322X_{11}+3.7054X_{16}{**}+1.0664X_{17}$	end of Sept.	0.8995**
14.	Kutch	$Y=111.90+0.7687X_1{**}-1.0143X_7+9.9396X_{19}$	end of Sept.	0.7493**
15.	Rajkot	$Y=33.9309+0.8884X_1{**}+2.6503X_{13}$	middle of Sept.	0.8271**
16.	Surendranagar	$Y=-61.6979+1.1055X_1{**}+2.6181X{*}_4-0.6846X_9{**}+0.4210X_{10} 1.4380X_{14}+1.1779X_{17}{*}$	end of Sept.	0.9026**

* and ** denotes significance at 5% and 1% levels.

Sanderson (Oct, and Dec, 1942) also observed similar results in his study on use of condition reports and weather data in forecasting the yield per acre of wheat. He reported that a combination of condition reports and weather factors proved highly successful in forecasting wheat yield in U.S.A. The prediction based on the combination of condition reports and weather factors are found to be considerably more reliable than that by condition report or weather factors alone.

The results for all the districts further revealed that the additional contribution of the rest of the rainfall variables included in the prediction equation is to the tune of 10 to 20 per cent only. The overall picture of the significant regression coefficient of rainfall variables indicated that the rains during the vegetative development stage and full pegging to pod development stage have positive effect on yield, while rains during pre-showing, germination and flowering to pegging period have negative effect on yield.

Seshadri [11] reported that the hair on the peg and pod of groundnut helps in taking up little moisture from soil thus preventing the pod from excessive drying up and helping in its proper development. The physiology of water absorption in groundnut indirectly justifies that the rains during full pegging to pod development stage have positive effect on yield. The drizzling rains during this stage help in proper development of pods and the higher yields are obtained.

Joshi and Kabaria [6] also reported negative correlation of yield with rainfall during flowering to pegging period and positive correlation of yield with rainfall during full pegging to pod development stage. The results of this study are in confirmation with the results obtained by Joshi and Kabaria [6]. The results obtained by Singh *et. al.* [12] at Hissar, Joshi and Raddar (5) at Dharwar also reflect the same views.

The results further revealed that the R^2 values of the prediction equation for all the districts are highly significant. They ranged from 0.6594 to 0.9888. The time at which the forecast is available varies from second week of September to end of October. Thus a satisfactory prediction of groundnut yield for Gujarat State can be given by end of October using eye estimate in combination with rainfall variables.

The validity of the prediction equation of different districts were judged by putting the value of the variables observed during the year

1978-79 (the year not included in the study). The prediction yield for the year 1978-79 and the actual crop cutting yields along with error of forecast for different districts and Gujarat state are presented in table 4. The estimated yield during the year 1978-79 for the Gujarat State was 839.7kg/ha, as against actual crop cutting yield 883.5kg/ha, with a difference of 4.9 per cent, which is well within the limit of the difference observed in the data under study.

Thus it is possible to provide forecast for the Gujarat State by the end of the October. The State Department of agriculture issues second forecast by 10th November and final forecast by 10th February. Therefore preharvest forecast with the help of prediction equation using eye estimate in combination with rainfall variables as

TABLE 4

Actual crop cutting yield (CCY) and Predicted yields of groundnut (kg/ha) for the year 1978-79 for different districts and Gujarat State

Sr. No.	*District*	*CCY*	*Predicted Yield Y*	*Error of forecast %*
1.	Ahmedabad	369.1	538.3	2.96
2.	Banaskantha	1320.6	1016.0	2.18
3.	Baroda	560.2	567.5	4.35
4.	Broach	589.8	571.7	3.22
5.	Kaira	547.5	696.6	3.38
6.	Mehsana	566.9	567.9	3.85
7.	Panchmahal	636.8	632.9	2.45
8.	Sabarkantha	458.5	675.7	2.47
9.	Surat	778.6	847.6	2.85
10.	Amreli	778.2	681.4	3.74
11.	Bhavnagar	738.4	507.0	4.72
12.	Jamnagar	856.8	1141.7	4.94
13.	Junagadh	1466.0	1179.5	2.44
14.	Kutch	782.8	807.4	6.52
15.	Rajkot	782.7	657.3	4.15
16.	Surendranagar	244.7	167.7	3.38
	Gujarat State	883.5	839.7	1.12

shown in table 3 can be given earliest by the end of October. This forecast will be about four months earlier to the final forecast issued by the State Department of Agriculture.

It is presumed that the weather conditions and the damage from insects, pest and diseases and other causes would be normal during the period after the forecast is made. In reality, this cannot be ruled out and to that extent it is a limitation.

ACKNOWLEDGEMENT

The authors are grateful to Dr. D. Singh former Director, IASRI New Delhi, Dr. P.D. Mistry, Head of the Department of the Agricultural Meteorology, B.A. College of Agriculture, Anand, and Dr. C.G. Khatri, Head of the Department of Statistics, Gujarat Univeristy, Ahmedabad, for their valuable guidence. My gratitude is also recorded to Shri S.P. Doshi at Computer Centre, I.A.S.R.I., New Delhi for his help in analysis and Department of Agriculture, Gujarat State, Ahmedabad for providing data on rainfall and crop estimation surveys.

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