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Research Article

Production forecast of groundnut (*Arachis hypogaea* L.) using crop yield-weather model

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SUMMARY : Groundnut (*Arachis hypogaea* L.) is an annual legume primarily grown for high quality edible and easily digestible protein in its seeds. The paper focus on the identification the weather factors affecting groundnut yield and development of a statistical model for the pre-harvest prediction of groundnut yield based on weather parameters. Data on various weather parameters collected during the period from 1996 to 2009 were considered for the study. Linear correlation co-efficient worked out among yield with various weather factors observed during stage of 50 per cent flowering of the crop resulted in significant direct and indirect influence of different meteorological factors. Multiple linear regression model based on accumulated weather parameters were developed. In the fitted model, 75 per cent of variability in yield was explained by maximum temperature, minimum temperature and humidity. The model can be used by government as a basis for its policy decisions in regard to procurement, distribution, buffer-stocking, import-export, price fixation and marketing of groundnut and its substitutes. while agro-based industries, traders and the agriculturists need forecasts for planning their operations properly.

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KEY WORDS :
Groundnut, Multiple linear regression

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BACKGROUND AND OBJECTIVES

Groundnut (*Arachis hypogaea* L.) is an annual legume primarily grown for high quality edible oil (36 – 54% on dry matter basis) and easily digestible protein (12 – 36%) in its seeds. It is cultivated worldwide in tropical, sub-tropical and warm temperature areas located between 40^0N to 40^0S with a world production of 35.9 million tonnes at an area of 25.2 million ha. In India, it is spread over an area of 6.7 million ha with production of 7.3 million tonnes and productivity of 1155kg per hectare (FAO, 2009).

The crop can be grown successfully in places receiving a minimum rainfall of 500mm and a maximum of 1250 mm. The rainfall required for pre-sowing operations (preparatory cultivation) is 100 mm; for sowing it is 150 mm and for flowering and pod development an evenly distributed rainfall of 400-500 mm is required. The groundnut however, cannot stand frost, long and severe drought or water stagnation. Although groundnut is grown on a wide variety of soil types, the crop does best on sandy-loam and loamy soils and also in black soils with good drainage. Heavy and stiff clays are unsuitable for groundnut cultivation as pod development is hampered in those soils.

Reliable forecasts of crop production before the harvest constitute a problem of topical interest. Such forecasts are needed by the Government, policy makers, agro-based industries, traders and agriculturists alike. The Government needs these for use as a basis for its policy decisions in regard to procurement, distribution, buffer-stocking, import-export, price fixation and marketing of agricultural commodities while agro-based industries, traders and the agriculturists need forecasts for planning their operations properly. These forecasts are, however, of a subjective nature since these are based on eye-estimates and personal judgment of agricultural officials and the final crop production estimates, though based on objective crop-cutting experiments, are of limited utility as these become available quite later after the harvest.

In view of this, there is a need for an objective methodology for pre-harvest crop forecasting. This involves building up suitable forecast model(s) which has certain merits over the traditional forecasting method. These merits include the objectivity of the forecast and its ability to provide a measure of reliability which a traditional forecast method cannot provide. This, as such calls for the necessity of objective methods for pre-harvest forecast of crop yields.

Keeping in view of the above discussed concepts, the specific objectives of the study are framed as to identify the weather factors affecting groundnut yield and development of a statistical model for the pre-harvest prediction of groundnut yield based on weather parameters.

RESOURCES AND METHODS

Data for study were the collected from AICRP on Agrometeorology, UAS, Bangalore. Groundnut crop raised in Agrometeorology Division, GKVK campus during 1996 to 2009 was considered for the study. Recommended practices were followed during the cultivation. The following weather parameters were recorded at 50 per cent of the flowering stage of the crop.

X_1: Maximum temperature(^{0}C)
X_2: Minimum temperature(^{0}C)
X_3: Relative humidity(%),(morning hours)
X_4: Relative humidity(%),(afternoon hours)
X_5: Rainfall(mm)
X_6: Rainy days
X_7: Evaporation(mm)
X_8: Potentio evapo transpiration(mm)
X_9: Bright sunshine hours(hrs)
X_{10}: Growing degree days

Initially, correlation matrices are generated for weather parameters with yield to study the relationship among several factors.Simple linear correlation coefficients were computed among pod yield and the above described weather parameters (X_1toX_{10}). And intra-class correlation co-efficients among weather parameters were also obtained.

Multiple linear regression (M.L.R) models were employed for regressing Y on selected weather parameters. Model adequacy was also checked using normal probability plot and variance inflation factor method. The functional form relating Y to the explanatory variables weather parameters and biometrical characters is given as below:

$$\mathbf{Y = X\beta + \varepsilon},$$

where, Y-dependent variable vector, X-vector of weather parameters

$\beta' = (\beta_1,\beta_2,...,\beta_p)$, Vector of parameters,
$\varepsilon' = (\varepsilon_1,\varepsilon_2,\varepsilon_3...,\varepsilon_n)$, error vector

OBSERVATIONS AND ANALYSIS

Linear correlation co-efficient worked out among yield with various weather factors observed during stage of 50 per cent flowering of the crop resulted in significant direct and indirect influence of different meteorological factors (Table 1). Among them, rainy day, bright sunshine hours and growing degree days (r=0.63, 0.43, 0.65 and 0.37, respectively) were significantly and directly correlated. Significant inverse proportional correlation among yield to maximum temperature and afternoon relative humidity (r=-0.44 and -0.39) was observed.

There was significant relation with sunshine hours which directly helps for photosynthesis. Similarly, it showed negative relation with afternoon relative humidity as it encourages incidence of pest and diseases. Similarly it shows

Table 1 : Correlation analysis- weather parameters

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Y	1.00										
X_1	-0.44*	1.00									
X_2	-0.34	0.44*	1.00								
X_3	0.63*	-0.57**	-0.04	1.00							
X_4	-0.39*	-0.65**	-0.53**	0.43*	1.00						
X_5	0.31	0.08	0.34	0.03	-0.16	1.00					
X_6	0.43*	0.04	0.25	0.10	-0.18	0.80**	1.00				
X_7	0.15	0.46*	0.29	-0.72**	-0.50**	0.14	0.08	1.00			
X_8	0.44*	0.39*	0.33	-0.64**	-0.49**	0.23	0.16	0.65**	1.00		
X_9	0.65*	0.13	0.17	-0.44*	-0.32	0.29	0.27	0.78**	0.75**	1.00	
X_{10}	0.37*	0.11	0.31	-0.50	-0.24	0.52**	0.59**	0.56**	0.67**	0.78**	1.00

X_1=Maximum temperature, X_2= Minimum temperature, X_3=Relative humidity (morning hrs), X_4= Relative humidity(afternoon hrs), X_5= Rainfall, X_6= Rainy days, X_7= Evaporation, X_8= Potentio evapo transpiration, X_9=Bright sunshine hours, X_{10}= Growing degree days
* and ** Indicate significance of value at P=0.05 and 0.01, respectively

the correlation among the weather variables reveal that, most of the weather parameters are highly related.

Multiple linear regression model based on accumulated weather parameters were developed. Table 2 shows the fitted model with R^2 value, indicates that 75 per cent of variability in yield can be explained by maximum temperature, minimum temperature and humidity. The standard errors of regression coefficients along with t-statistic values are presented. As maximum temperature increases one unit, yield will be increased by 57.5 units whereas yield decreases with increase in minimum temperature and humidity. As the minimum temperature increases by one unit, yield will be reduced by 5.10 units and decrease in yield will be 11.8 units by the increase of one unit of humidity.

Measures of model adequacy were also employed to check for multicollinearity. Model adequacy check was carried out (Table 3) for the fitted models. As variance inflation factors computed were less than 10, gives an indication of no multicollinearity among the regressors. Normality assumptions were checked with normal probability plot (Fig.1), indicated that pod yield follows a normal distribution with respect to weather parameters.

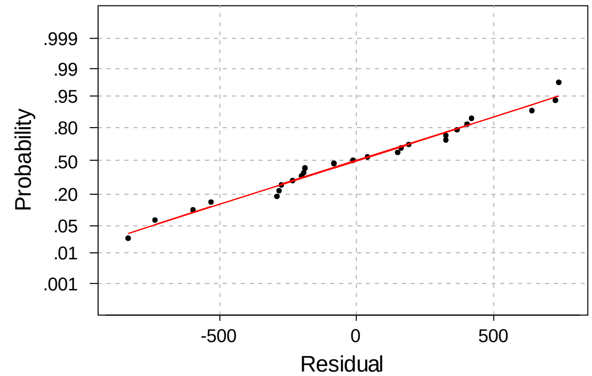

Fig. 1: Normal probability plot of selected model based on weather

The predicted yield by using the model is presented in Table 4 along the observed yield. It was found that from the table, one can predict yield before harvest to an extent of 83 per cent of realization by using model. The weather factors affecting the yield of the groundnut crop can be modelled into a prediction model, so as to perform the forecasting of the crop before the

Table 2 : Regression

Weather parameters	Co-efficients	S.E.	t values	R^2
Intercept	767	2.1	4.9*	
Max. temp	57.5	(8.4)	6.9**	75.9
Min. temp	- 5.10	(2.0)	2.5*	
Relative humidity	- 11.8	(2.2)	5.3**	

* and ** Indicate significance of value at P=0.05 and 0.01

Table 3 : Variance inflation factor

	variables		
	X_1	X_2	X_3
VIF	2.15	2.43	2.70

Table 4 : Comparison of yield with fitted models

Observed	Expected	Observed	Expected
1350	1250	2284	2022
740	1003	1442	1423
754	1097	1352	1453
754	410	1452	1578
720	768	1115	1006
525	595	1450	1529
656	798	1338	1288
969	986	1520	1227
1513	1345	901	600
1517	1318	1127	1367
1645	1562	853	1123
1867	1741	Per cent of realization	83

harvest up to the extent of 80-90 per cent accuracy. The model will help in taking policy decisions relating to the food procurement, distribution, price, import and export policies and for exercising several administrative measures for storage and marketing of groundnut and its substitutes.

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