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Evaluation of different approaches to study the effect of rainfall on groundnut in dry farming area of Gujarat

J. S. PATEL and M. R. VAISHNAV

Department of Agricultural Statistics, B A College of Agriculture, GAU, Anand-388 110

ABSTRACT

Different statistical approaches to study the effect of rainfall on groundnut yield in dry farming areas of Gujarat involving seasonal rainfall, monthly, standard weekly, crop physiological stage-wise total, shorter interval total rainfall at critical stages and different categories of rainy days in crop physiological stages as independent variables were evaluated. The yield data of long term experiment on crop rotations conducted during 1967 to 1979 at the Dry Farming Research Station, Targhadia (Rajkot) were utilised for this purpose.

The association between yield and season rainfall, monthly and standard weekly total were not significant in the crop rotations (viz. groundnut-cottan, groundnut-bajara, groundnut-groundnut). Rainfall at pegging stage (35-50 Das) had significant influence on yield. Further split to in smaller periods, showed that rainfall during a period of 7 days consisting 36-42 and 43-49 days after sowing is significant associated with yield.

Key words: Multiple regression, Transformation, Rainfall, Groundnut

Groundnut, mustard, linseed, sesamum and castor are the major oil seed crops of India. Groundnut (*Arachis hypogeae* L.) occupies about 47 per cent area and contributes about 67 per cent of total production of major oil seed crops in India (Sankara Reddi, 1982). Gujarat state shares 30.5 per cent area and 28 per cent production of groundnut in the country. In Gujarat, Saurashtra region alone occupies 87 per cent area and contributes 85 per cent production of the state (Anon., 1985). Groundnut is grown as a rainfed crop in the state. The rainfall distribution of the Saurashtra region is erratic and hence the yield of groundnut is highly affected year to year. In view of this, influence of rainfall on productivity groundnut was evaluated.

MATERIALS AND METHODS

The data obtained from a long term experiment conducted at Dry Farming Research Station, Targhadia (Rajkot) were utilised to quantify the effect of rainfall during different periods of growth and to suggest suitable approach for predicting the groundnut yield of bunch variety under dry farming conditions of the region. The average yield data of groundnut obtained from different rotations viz., groundnut-pearl millet, groundnut-cotton and groundnut - groundnut collected during the years 1967 to1979 were used in this study. The data of this experiment showed absence of

cumulative effects of fertilizer application (Anon. 1986). The bunch type variety J-11 was grown in the experiment. The daily rainfall data recorded at the station during the corresponding years were used as independent variable sets. Different approaches through simple linear, quadratic, cubic and multiple regression technique alongwith corralation coefficients were studied. Rainy days, considerning different quantities of rainfall, alongwith the approach suggested by Wang (1963) were also tried as independent variables. Transformations of data were also applied to study the effectiveness of transformed scale on predictability.

RESULTS AND DISCUSSION

Seasonal rainfall

Yean wise average groundnut yiled under three different rotations are presented in Table 1. Seasonal rainfall (sowing to harvesting) was considered as the independent variable, and linear, quadratic and cubic regressions were fitted to the groundnut yield of three different rotations viz. groundnut-pearl millet, groundnut-cotton and groundnut- groundnut and with its average. The same technique was repeated by taking the logarithmic and squre root transformations of the variables. The results (Table 2) indicated that maximum variation (about 34%) was accounted for by cubic curve fitting. However none of the models had given significant regression coefficient. Also there was no improvement in the model due to transformation of the independent variable. Thus, seasonal rainfall does not seem to be the important variable for pod yield and hence monthly rainfall was tried.

Monthly rainfall

Individual monthly rainfall amounts from June to September were used as four independent variables and multiple regression was fitted with original and transformed data. All the partial regression coefficients were non significant in all cases. It was also observed that maximum variation was accounnted for by original variables only. As the transformation could not provide favourable results, the rainfall was considered as such for the other approaches.

Standard weekly rainfall

Rainfall received in standard weeks 23 to 39 (as defined by the India Meteorological Department) were correlated with groundnut yield. All the correlation coefficients were observed to be non-significant. This may be due to sowing in different weeks in different years.

Crop physiological stagewise rainfall

The bunch variety J-11 has five different physiological stages i.e. preflowering (1-21 DAS, X_2), flowering (22-40 DAS, X_3), pegging (35-50 DAS,X_4), pod development(51-80 DAS,X_5) and maturity (81-120 DAS,X_6) (Joshi and Kabaria, 1972). Total rainfall received during different periods were correlated with groundnut yield.

The results (Table 3) indicated that the correlation coefficient between groundnut yield and rainfall received during different stages of crop growth were positive but non-significant except for pegging stage. In pegging stage they were significant in all the cases except for the groundnut-cotton rotation. All sixty three possible combinations

Table 1: Yearwise average groundnut yield (kg ha^{-1}) under three different rotation.

Year	Groundnut Bajara	Groundnut Cotton	Groundnut Groundnut	Average
1967	2030	2031	2083	2048
1068	251	308	276	278
1969	874	855	896	875
1970	1575	1682	1424	1560
1971	944	683	549	725
1973	243	231	341	272
1975	2188	1870	2283	2114
1976	255	129	220	201
1977	735	613	665	671
1978	862	952	784	866
1979	577	559	540	559

Table 2: Percent variation (R^2) accounted for by different models

Independent variable	Model Type	Groundnut-Pearl millet	Groundnut-Cotton	Groundnut Groundnut	Average
Seasonal rainfall (x)					
X	Linear	1.2	1.5	0.3	0.9
	Quadratic	3.5	1.6	1.7	1.8
	Cubic	32.4	33.5	22.0	28.9
log (X)	Linear	6.4	2.5	2.2	3.6
	Quadratic	16.9	5.6	5.9	9.3
	Cubic	30.9	33.8	17.6	26.1
$\sqrt{X}$	Linear	3.0	2.2	1.1	2.1
	Quadratic	8.8	3.1	3.5	4.
	Cubic	31.1	33.8	17.6	26.1
Monthly rainfall (X)					
X	Linear	28.5	24.0	19.6	27.8
Log(X)	Linear	25.0	10.0	15.9	16.8
$\sqrt{X}$	Linear	25.8	17.4	18.7	20.6

Table 3: Correlation coefficients between rainfall received in different physiological stages and groundnut yield.

Stages	Groundnut Pearl millet	Groundnut Cotton	Groundnut Groundnut	Average
Presowing week	0.07	0.07	0.15	0.10
Preflowering	0.02	0.16	0.02	0.06
Flowering	0.16	0.16	0.15	0.16
Pegging	0.66*	0.59	0.68*	0.65*
Pod development	0.18	0.25	0.11	0.18
Maturity	0.49	0.39	0.52	0.47

* Significant at 5% level

Table 4: Maximum R^2 values observed under different combinations of variables

No. of Variables in combination	Variables Pearl millet	Groundnut Cotton	Groundnut	Groundnut Groundnut	Average
1	X_1	43.75*	34.86	46.61*	42.38*
2	X_2, X_4	47.12*	34.57	50.18*	47.16*
3	X_2, X_3, X_4	47.19*	41.83*	50.10*	47.0*
4	X_1, X_2, X_3, X_4	46.17*	40.51*	48.19*	45.70*
5	X_1, X_2, X_3, X_4, X_6	28.75	20.61	31.72	27.65
6	$X_1, X_2, X_3, X_4, X_5, X_6$	51.07	51.58	55.70	52.63
	X_2, X_3, X_4, X_5, X_6	50.50	51.45	55.13	50.59

X_1 = Presowing rainfall, X_2 = rainfall received during pre flowering stage (1-21) days, X_3 = rainfall received during flowering stage (22-40) days, X_4 = rainfall received during full pegging stage (35-50) days, X_5 = rainfall received during pod development stage (51-80) days, X_6 = rainfall received during maturity stage (81-105) days

of different growth stages were tried in multiple partial regression analysis with presowing rainfall (X_1). The combinations showing highest R^2 values are given in (Table 4.)

It was observed that pegging stage showed maximum R^2 (35 to 47 %) in all the three rotations and with average yield as single variable. These values improved to 51 to 55 % when all physiological stages were

Table 5: Correlation coefficients between rainfall received during different periods and groundnut yield

Periods (DAS)	Groundnut-Pearl millet	Groundnut-Cotton	Groundnut-Groundnut	Average
7 Days period				
22-28	-0.32	-0.35	-0.31	-0.33
29-35	-0.14	-0.12	-0.12	-0.12
36-42	0.65*	0.64*	0.59@	0.63*
43-49	0.53@	0.45	0.56@	0.52@
50-56	0.30	0.39	0.25	0.31
57-63	0.30	0.37	0.20	0.29
64-70	-0.28	-0.28	-0.29	-0.29
71-77	-0.35	-0.43	-0.31	-0.37
8 Days period				
22-29	-0.34	-0.37	-0.33	-0.35
30-37	-0.10	-0.08	-0.09	-0.09
38-45	0.32	0.26	0.31	0.30
46-53	0.43	0.49	0.40	0.44
54-61	0.31	0.40	0.24	0.32
62-69	-0.31	-0.34	-0.37	-0.35
70-77	-0.26	-0.31	-0.21	-0.26
9 Days period				
22-30	-0.32	-0.35	-0.31	-0.33
31-39	-0.07	-0.06	-0.06	-0.06
40-48	0.46	0.39	0.47	0.44
49-57	0.37	0.45	0.32	0.38
58-66	0.12	0.16	0.03	0.10
67-75	-0.19	-0.16	-0.16	-0.17
10 Days period				
22-31	-0.31	-0.33	-0.30	-0.32
32-41	-0.08	-0.05	-0.06	-0.06
42-51	0.45	0.50	0.41	0.46
52-61	0.30	0.39	0.23	0.31
62-71	-0.28	-0.32	-0.35	-0.33
72-81	-0.37	-0.43	-0.30	-0.37

*Significant at 5% level
@ significant at 10% level

Table 6: Regression constant and coefficients for selected model

Particulars	Groundnut Pearl millet	Groundnut Cotton	Groundnut Groundnut	Average
Regression constant	181.1	197.1	145.8	215.2
Regression coefficient				
$b_{1.2}$	36.6 **	34.5 **	34.7 **	32.2 **
b_2	6.9 **	5.8 **	7.3 **	6.7 **
R^2	78.7	68.2	74.0	74.1

** significant at 1% level of significance

Table 7: Per cent variation (R^2) accounted by different rainy days

Rainy day with rainfall	Groundnut Pearl millet	Groundnut Cotton	Groundnut Groundnut	Average
>10 mm	51.7	50.4	51.7	51.2
>7.5 mm	54.0	55.0	52.2	53.5
>5.0 mm	43.8	33.9	50.6	43.0
>2.5 mm	38.3	27.2	41.2	35.4
As defind by Wang	25.5	27.0	44.0	36.4

incorporated in the model. Inclusion of presowing rainfall with physiological stages could not improve the values of R^2. Thus all stages together accounted for about 50 to 55% of variation in yield out of which pegging stage contributed for about 35 to 46% variation in pod yield.

Shorter duration rainfall

Sarker (1977) identified critical periods by taking correlations between wheat yield and weather factors during successive overlapping periods. Accordingly an attempt was made to consider correlations with different periods of 7, 8, 9 and 10 days interval starting from flowering period up to pod development stage (22-80 DAS).

Correlation coefficients (Table 5) of the period 36-42 DAS (X_1) and 43-49 DAS (X_2) were found to have significant influence on pod yield and these two periods were selected for regression study. Both the partial regression coefficients were significant (Table 6) under all rotations and for the average yield. Rainfall distribution of 50-100

mm during 5 to 8 weeks after sowing resulted in higher dry matter accumulation and pod yield in spreading groundnut (Anon. 1995). Thus, the results are in partial confirmation to present investigation where bunch variety was used.

The results indicated that the magnitude of the corresponding partial regression coefficients($b_{1,2}$) for the period 36-42 DAS and (b_2) for the period 43-49 DAS was nearly the same in all rotations as well as in case of average yield. Both these periods accounted for about 74 per cent of total variation in groundnut yield. The higher rate of change was observed for the period of 36-42 DAS as compared to 43-49 DAS. These findings are in confirmation with those reported by Joshi and Gajipara (1971), Joshi and Kabaria (1972) and Patil *et al.*(1984).

Rainy days

Different amounts of rainfall received in a day i.e. 10, 7.5, 5 and 2.5 mm or more, were considered as rainy days alongwith the rainy days defined by Wang (1963) and used as independent variables in multiple regression analysis (Table 7).

This could account for a maximum 55 per cent variation in groundnut yield which is as good as the physiological stage wise rainfall. None of the regression coefficients in any model were significant. Thus in this type of analyis rainy day approach was not found to have any influence on pod yield at any stage.

Thus, the overall results revealed that rainfall received during 36-42 DAS and 43-49 DAS has significant influence on pod yield in bunch variety under dry farming situation. Under scarcity of rainfall in *kharif* season one or two irrigations at about 36 and 43DAS is likely to save the crop from severe loss in yield. Based on this, the following model is proposed which can be used to predict groundnut yield of bunch varieties (kg ha^{-1}) grown in dry farming areas of Saurashtra.

$$Y = 215.2 + 32.20\ X_1 + 6.69\ X_2\ (R^2 = 0.74)$$

where X_1 = rainfall recevied during 36 to 42 DAS and X_2 = rainfall recevied during 43 to 49 DAS

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