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Climatological factors in relation to dryland agriculture

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ABSTRACT. Detailed statistical studies were made on climatological data pertaining to important dry farming research stations in India, and certain aspects of climate investigated. Relationships among the climatological parameters were investigated. Rainfall distribution curves pertaining to long periods were examined for identifying regularities in the pattern of distribution, if any.

Number of rainy days and annual rainfall were closely correlated. Log monthly rainfall and log variability of rainfall were inversely correlated. Rainfall curve patterns indicated that the ascending and descending portions of the rainfall curve were very closely correlated. In the case of Kovilpatti, the magnitude of the ascending portion of the rainfall curve and the span of a sequence were very closely correlated. For Kovilpatti Centre wind velocity was established to be the best parameter for predicting Piche's evaporation. In the many relationship patterns studied it was interesting to note that a single relationship pattern held good for a number of different places or years, in spite of the fact that the ranges of values for the data studied were quite wide. Thus the study of these data was simplified as a very few relationship patterns were sufficient for prediction purposes.

1. Introduction

Drylands occupy a very large proportion of the cultivated area in the country, the figures being 75 per cent for the whole of India, and 60 per cent for Tamil Nadu. In dryland agriculture, the availability and conservation of moisture are prime factors. Unfortunately the vagaries of the weather, evaporation, run-off and percolation make it extremely difficult for the plant to obtain its required amount of moisture. In view of this it was thought that proper understanding of the patterns of variation of climatic parameters would go a long way in bringing dryland agriculture in tune with climate, thus obtaining the maximum benefit possible in the circumstances. Bearing this in mind, in the present study a detailed examination of climatological data available in the book, *Dry Farming in India*, (Kanitkar 1960) and data collected over a number of years by the Meteorology unit of the Regional Agricultural Research Station, Kovilpatti, Tamil Nadu (*see* Ref.) was made, and the results obtained are presented.

2. Methods

The data available were examined for possible relationships among pairs of parameters, making a preliminary plot of the data on graph paper to obtain the scatter diagram and to facilitate the understanding of the type of relationship involved. Data which were obviously discordant were omitted from the correlation study.

3. Results and Discussion

(i) *Number of rainy days and rainfall* — The correlation in this case was close ($r = 0.872$), suggesting the predictive value of number of rainy days in relation to annual rainfall.

(ii) *Monthly rainfall and its variability* — The 19-year (1921-1939) mean data for monthly rainfall and its variability percentage (coefficient of variation), were obtained for 23 stations situated in typical dryland regions, and including Kovilpatti, from the book "*Dry Farming in India*". An inverse log-log relationship ($r = -0.796$) was obtained in this case (Fig. 2) indicating that with a low annual rainfall the fluctuation of the rainfall about the mean would be considerable. But this is not entirely undesirable, because the variability implies fluctuations both above and below the mean value, so that there is a possibility of obtaining good rainfall also, when the fluctuation takes the figure considerably above the mean value. This has been quantitatively studied by Kanitkar (1960) where, for the five dry farming research stations studied the distribution of years representing rainfall above, almost equal to, and below the mean value was 34, 28 and 38 per cent respectively. This would indicate that under dryland conditions, with a low rainfall, the possibility of recording values below the mean is only about 40 per cent, the corresponding value for rainfall figures above or almost equal to the mean being about 60 per cent.

TABLE 1

Results of correlation studies

Relationship between: X	Relationship between: Y	No. of pairs of values	Correlation coefficient (R)	Regression equation
		Rainfall		
Number of rainy days	Annual rainfall, inches	41	0·872	$Y=4\cdot36+0\cdot528\,X$
Mean monthly rainfall, inches	Variability percentage	95	—0·796	$\text{Log } Y=2\cdot088-0\cdot455 \text{ Log } X$
Ascending portion of a sequence in rainfall curve, inches	Descending portion of same sequence in rainfall curve, inches	64	0·923	$Y=-0\cdot94+1\cdot05\,X$
Kovilpatti data (Do)	Span of same sequence, years	10	0·981	$Y=-0\cdot57+0\cdot320\,X$
		Evaporation		
		Kovilpatti data		
Mean monthly wind velocity km/hr (X_1)	Mean monthly Piche's evaporation, mm	60	0·783	$\text{Log } Y=0\cdot64+0\cdot0312X_1$
Mean maximum temperature °C (X_2)	Do.	60	0·660	$\text{Log } Y=-0\cdot985+0\cdot0545\,X_2$
Multiple regression of X_1 & X_2 above with	Do.	60	R=0·834	$\text{Log } Y=-0\cdot273+0\cdot024X_1+0\cdot028\,X_2$

(*iii*) *Rainfall distribution patterns*

(a) *Ascending and descending portions of rainfall curves* — Graphical representations of rainfall distribution patterns for the five dry farming research stations of Sholapur, Bijapur, Raichur, Bellary and Rohtak presented by Kanitkar (1960) and also for Kovilpatti were examined in detail for possible regular patterns. It was interesting to observe (Fig. 2) that the correlation between the vertical magnitudes of the ascending and descending portions of the rainfall curve was very close ($r=0\cdot923$) (Fig. 3). Through this relationship it will be possible to predict, in a fairly dependable manner, the lowest figure that the rainfall will touch, if the highest figure for the sequence is known. It also leads to the useful conclusion that in a sequence the higher the maximum rainfall reached, the lower the minimum rainfall would be, and *vice versa* (Fig. 1). It was significant that the same regression pattern held good for a large number (64) pairs of values obtained from six stations, indicating the uniformity of the relationship for all these stations. It was also interesting to observe that the regression coefficient for this correlation (1·05) was almost equal to unity, indicating a simple relationship).

(b) *Ascending portion of rainfall curve and corresponding span of sequence* — In the case of Kovilpatti station only the span of a sequence in the rainfall curve (consisting of a maximum and a minimum portion) was observed to be related to the vertical magnitude of the ascending portion of the curve. With the ten pairs of values available for the station a very high correlation was obtained ($r=0\cdot981$) indicating the possibility of predicting in a dependable manner, the duration of a sequence from a knowledge of the magnitude of the ascending portion of the rainfall curve. In spite of the fact that the correlation was calculated with only a small number of values, usually considered inadequate for correlation studies, the underlying relationship was plain. Curiously this relationship held good only for Kovilpatti and not for the other five experiment stations studied.

The information regarding the duration of the sequence in a cycle, and the minimum rainfall that might be touched in a drought year, that can be obtained through predictions made as indicated above, will be useful in dryland agriculture, as the farmer can get prepared in advance to meet a drought year and provide alternative sources of water, such as those from farm ponds, to give a few light irrigations at the critical time to save the crop.

(*iv*) *Evaporation*

The data regarding wind velocity, maximum temperature and Piche's evaporation for 5 years (1954, 1957, 1964, 1965 and 1968) taken at random during the period 1949 to 1969 for Kovilpatti were utilised for the study. The correlation between wind velocity and Piche's evaporation for all the months in the five years studied recorded a highly significant correlation coefficient of 0·783 (Fig. 4). It was interesting to note that evaporation rate was primarily determined by the wind velocity and not appreciably by maximum temperature ($r=0.660$).

To determine if the relationship between wind velocity and evaporation could be improved upon by including maximum temperature as an additional independent variable, a multiple regression analysis was performed with wind velocity, and maximum temperature as independent variables, and Piche's evaporation as dependent variable. The multiple correlation coefficient came to 0·834, only slightly higher than the one (0·783) for the correlation with wind velocity alone, indicating thereby that wind velocity alone could serve as a satisfactory parameter for depicting evaporation, and that maximum temperature was not so useful in this regard. Wind velocity and maximum temperature were themselves correlated to a certain extent ($r=0·534$), and this may account partly for the observed lack of improvement in the degree of correlation by including maximum temperature as the second independent variable. It is also known that evaporation is determined by the effective temperature rather than the maximum temperature, and this may serve partly to explain the present observation. Thus in a given situation, the maximum temperature might have been high, but have lasted only for a short span of time.

4. Summary and Conclusions

Detailed statistical studies were made on climatological data pertaining to important dry farming research stations in India, and important aspects of climate like temperature, rainfall and evaporation touched upon. Relationships among the climatological parameters were studied in detail. Rainfall distribution curves pertaining to periods of over 60 years were examined in detail to spot regularities, and significant ones identified and quantitatively established.

There were considerable regularities in the variation of climatological parameters. Number of rainy days and total annual rainfall were correlated. In the study of rainfall and its variability log monthly rainfall and log variability were closely and inversely correlated. Rainfall curves for important dry farming research stations indicated several important regularities : (*a*) The magnitudes of the ascending and descending portions of the rainfall curve were closely related; (*b*) in the case of Kovilpatti data the magnitudes of the ascending portion of the curve and the span of a sequence were closely correlated. These relationships established in the present study made it possible to predict the pattern of rainfall and also the low rainfall to be expected in drought years, from a knowledge of the previous rainfall data.

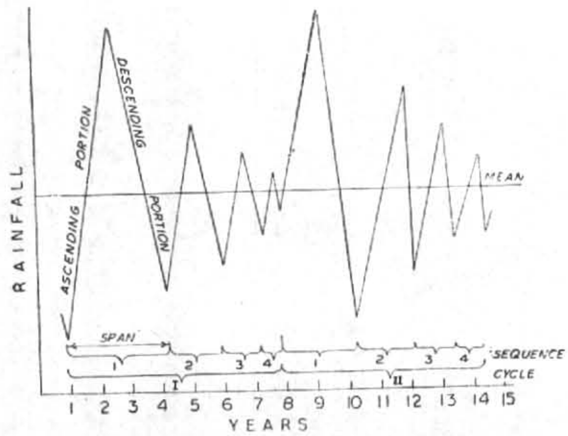

Fig. 1

Rainfall distribution curve (schematic)

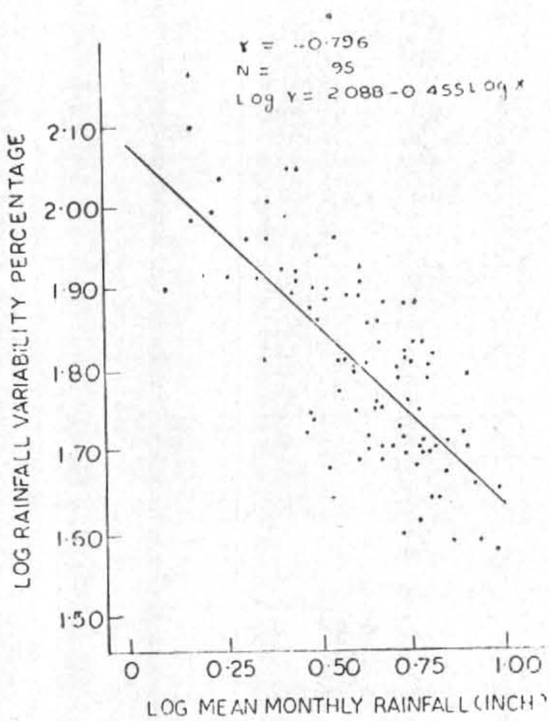

Fig. 2

Mean monthly rainfall-variability relationship

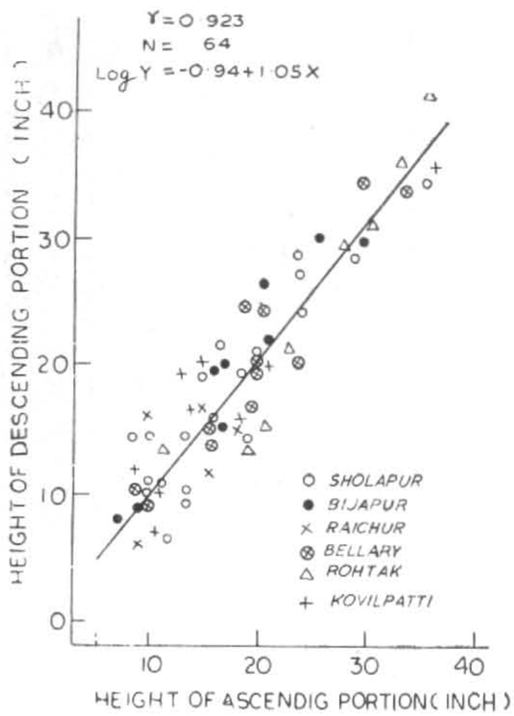

Fig. 3

Rainfall curve characteristics : Ascending and descending portion relationship

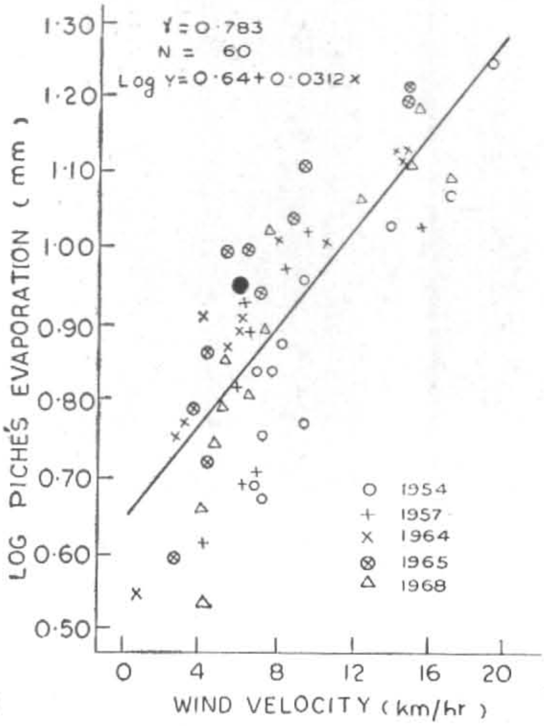

Fig. 4

Wind velocity — Pichers evaporation

In the study of evaporation with Kovilpatti data, wind velocity was established to be the best parameter for predicting Piche's evaporation. Although maximum temperature was also found to influence evaporation, its contribution was less in extent. Inclusion of maximum temperature in a multiple regression with wind velocity *versus* evaporation did not appreciably improve the degree of relationship.

In the many relationship patterns studied, it was interesting to note that a single relationship pattern held good for a number of different places or years, thus simplifying the task of studying these data, as a single relationship pattern could be used for prediction purposes, instead of having to change the pattern for each place or year. It was also significant that high correlations were obtained in these cases, in spite of the fact that ranges of the values for the data studied were wide. Similar observations have also been made previously in soil studies (Raj 1968-1969).

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