(*ii*) *Intermediate:*

This is a period for which rainfall is more than PET/2 but does not exeed PET, there being two such periods *viz.* one at the beginning of the rainy season and another at the end of the rainy season. Thus, in this case

$$PET/2 < \text{Rainfall} \leqslant PET$$

(*iii*) *Humid:*

This is a period for which rainfall exceeds PET or equival

$$\text{Rainfall} > PET$$

Here it is to be noted that intermediate periods and th period constitute the 'moist' period.

Some studies utilising the data on the number 'humid' days have been carried out for the preparatio indices by George and Alda (1969). However, no st apprears to have been carried out earlier to in characteristics of 'moist' and 'humid' periods or their crop production. Such a study forms the subject matte present paper in which an attempt has been made to stu influence of these periods on the yield of Jowar crop and further assess the expected loss in normal yield due to the deviation of the date of cessation of 'humid' period from mean cessation date. The present paper, incidentally, also demonstrates the application of statistical methodology for studying some problems connected with agricultural meteorology.

2. Material and Methods

The data for the studies dealt with in this paper relating to daily rainfall for 26 years (1946-71) and on U.S. Pan evaporimeter records for 11 years (1961-71) for Jalgaon district (Maharashtra) were secured from the Indian Meteorological Department, Pune. The data on crop yields of Jowar, the main crop of this tract were collected from the Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, New Delhi. The season considered for the study was '1st May to 31st October'. The choice of this period was made in view of the fact that it coincides with the crop season of Jowar and also about 90 per cent of the total annual rainfall is received in this period. The available data on U.S. Pan evaporimeter readings were converted to PET by a method given by Ramdas [6] according to which PET can be estimated by the relation:

(1) PET=(Constant)×(U.S. Pan evaporimeter reading), the constant being 0.845 for monsoon season and 0.60 for other seasons.

However, for our studies, we have adjusted the multiplying constant by using instead the relation:

(2) PET=(0.65) × (U.S. Pan evaporimeter reading). This adjustment is supposed to provide estimates of PET at the ground level rather than a certain height above the ground level at which the measuring instrument is usually exposed from an extensive open body of water.

A limitation of data was a gap in the availability of Pan evaporimeter records for the period (1946-60). To circumvent this, the classification of days prior to 1961 in terms of the three aforementioned categories *viz.* 'preparatory', 'intermediate' and 'humid' was effected by using the average values of PET computed for each day of the season studied (namely May to October) on the basis of U.S. Pan evaporimeter data for the available period (1961-71). This was done under the assumption that the variation in PET would be small compared to that in rainfall and this, as such, would not vitiate the accuracy of the results. In this context, the coefficient of variation of Pan evaporimeter data was found to range between 12 to 37 per cent for different months from May to October as against 47 to 172 per cent in case of rainfall.

After having built up the basic data for each day, the entire period was classified into the three categories mentioned above. For each of these classifications, the total number of days of each year were worked out and an attempt was made to fit a suitable mathematical distribution.

Different mathematical functions were tried to examine the influence of moist and humid days on crop yield. The function which was found to have the maximum multiple correlation coefficient and a significant regression coefficient was considered for detailed examination of the relationship between the yield and type of period.

In order to determine the minimum number of moist days necessary for obtaining the normal crop yield, the data on the number of moist days for the respective years were plotted against crop yield. Before plotting, the observations on moist days and crop yield, were statistically examined against trend by fitting orthogonal polynomials. The results showed that R^2 for both first and second degree terms could explain only about 20 per cent of the variation and this, as such, did not provide any evidence of the existence of trends. On the plotted graph, the two lines drawn parallel to the coordinate axes corresponding to the normal number

of moist days and the normal yield generated four quadrants (Fig.). Criteria for obtaining the normal yield with minimum number of moist/humid days were then fixed by taking into account the number of observations falling in each quadrant.

3. Results and Discussion

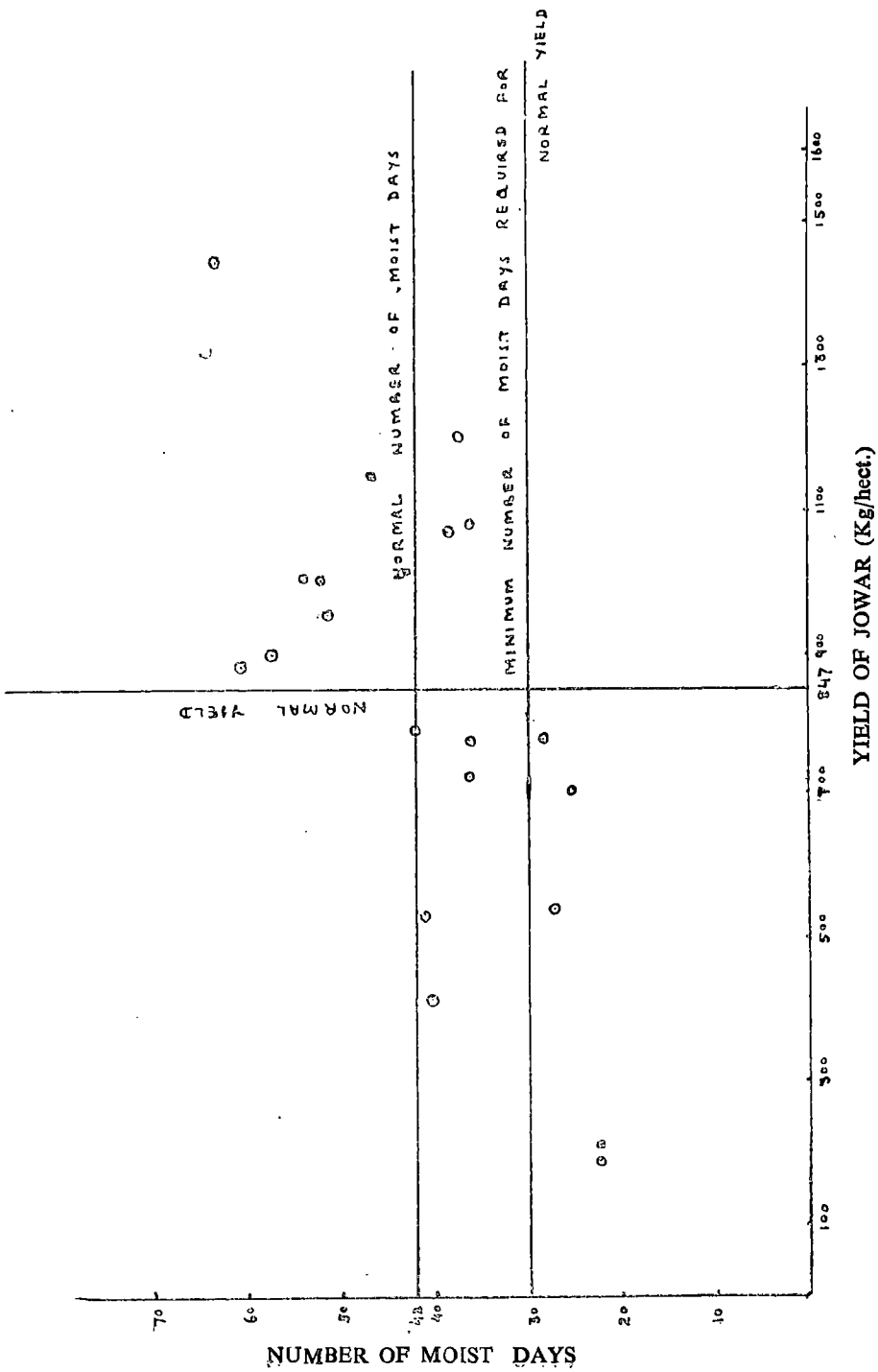
3.1. Fitting of Distributions

The data on moist and humid days (along with that on yield of Jowar) for Jalgaon district pertaining to 1950-71 are given in the following table:

TABLE 1

Moist/humid periods and yield of Jowar for District Jalgaon (1950-71)

Year	*Beginning of humid period*	*End of humid period*	*No. of days humid*	*moist*	*Yield of Jowar (kg/hect.)*
1	*2*	*3*	*4*	*5*	*6*
1950	8 July	17 Sept.	22	28	780
1951	26 June	5 Sept.	15	25	702
1952	16 June	4 Aug.	13	22	180
1953	20 June	3 Oct.	22	36	775
1954	27 June	6 Sept.	24	37	1198
1955	27 June	12 Sept.	20	27	536
1956	20 June	26 Sept.	26	44	1040
1957	22 June	13 Sept.	25	36	1083
1958	23 June	14 Sept.	35	42	788
1959	20 June	1 Oct.	46	51	948
1960	16 June	24 Sept.	36	46	1138
1961	20 May	27 Sept.	60	60	876
1962	28 May	26 Sept.	63	63	1445
1963	5 June	18 Sept.	52	54	997
1964	20 June	1 Oct.	64	64	1320
1965	9 July	3 Sept.	18	22	202
1966	9 July	7 Sept.	29	36	723
1967	17 June	12 Sept.	44	52	1000
1968	27 June	17 Sept.	29	38	1064
1969	21 June	13 Sept.	48	57	894
1970	2 June	7 Sept.	33	40	414
1971	26 June	6 Sept.	33	41	531


NORMAL NUMBER OF MOIST DAYS
MINIMUM NUMBER OF MOIST DAYS REQUIRED FOR NORMAL YIELD
NORMAL YIELD
847 900
100
300
500
700
1100
1300
1500
1600
70
60
50
40
30
20
10
NUMBER OF MOIST DAYS
YIELD OF JOWAR (Kg/hect.)

To fit a suitable distribution to the data on moist and humid days given in the preceding Table 1, g-statistics were computed and the results thereof are given in the following Table 2:

TABLE 2

Fitting of distribuions to data on moist and humid periods for Jalgaon District

Type of Period	*Mean*	*S.D.*	*C.V.%*	g_1	*S.E.* (g_1)	g_2	*S.E.* (g_2)	*Distribution fitted*
Moist	41.864	12.582	30	0.141	0.455	−0.964	0.853	Normal
Humid	34.409	15.108	44	0.596	0.455	−0.765	0.853	Normal

The value of both g_1 and g_2 denoting respectively the estimated coefficient of skewness and kurtosis were tested for their significance by using t-test when it was found that neither g_1 nor g_2 differed significantly from zero for both moist and humid days. As such, normal distribution was found to provide a good fit to both the sets of data.

3.2. Relationship between yield and moist/humid days

To study the relationship between the yield of jowar and the number of moist (humid) days, a time series graph of yield was superimposed on that of moist (humid) days. It was noted that the yield generally increased or decreased corresponding to an increase or decrease in the number of moist (humid) days. As per data given in Table 1, the correlation coefficient between yield rate and the number of moist days was 0.70 while that between yield rate and the number of humid days was 0.61, both being significant at 1 per cent level of significance. This suggested some linear relationships between yield and the number of moist (humid) days in the context of which regression of the yield Y on the number M of moist days and that of Y on the number H of humid days was studied, the relevant data on these aspects being those given earlier in Table 1. The regression equations in the two cases were found to be :

(3) $Y = 94.411 + 17.977^{**} M$ (for moist days)

and

(4) $Y = 400.765 + 12.968^{**} H$ (for humid days),

the regression coefficient being significant at 1 per cent level of significance in both of the cases.

Keeping in view that the period of the data utilised is small and only lesss than 50 per cent of variation in yield (for which coefficient of variation was found to be 40 per cent) has been explained

by the fitted regression lines, the predictive value of these regression equations is limited. All the same, however, the significant effect of two factors on yield cannot be overlooked.

3.3. Humid Period :

The 'humid' period was defined earlier as that receiving an excess of rainfall over PET. For Jalgaon district, the normal humid period was found to extend from the third week of June to the second week of September with September 15 at its mean cessation date The period '1st July to 15th September' also coincides with the entire growth period of the principal kharif crop of the tract *viz.* jowar including period of its seed formation. As such, this period is considered to be useful for crop production. An examination of the jowar crop yields revealed that the yields were low for the years 1952, 1965, 1970 and 1971 during which the humid period terminated earlier than the mean cessation date (*viz.* 15th September). Keeping this in view, it was considered desirable to study the influence on crop yield due to the deviation of the date of cessation of humid period from mean cessation date by fitting a regression line between the crop yield (Y) and the deviation (D) of the date of cessation of humid period from its mean cessation date, treating the yield (Y) as a dependent variable and the deviation (D) as an independent variable. The equation of the fitted regression line was found to be

$$(5)\quad Y = 853.923 + 16.929^{\bullet\bullet} D$$

It will be seen that the regression coefficient between the yield (Y) and deviation (D) is significant even at 1 per cent level of significance implying thereby that such deviation has a significant influence on crop yield. In the light of this, it is, thus, concluded that for obtaining good crop yield, the duration of the humid period should extend as far as the middle of September or even further.

SUMMARY

The paper studies some aspects of moisture availability periods and their influence on crop production which perhaps has not been done earlier. In addition, it also demonstrates the use of statistical methodology to some problems of interest in the field of agricultural meteorology. The data utilised for these studies pertained to daily rainfall and U.S. Pan evaporimeter records for district Jalgoan in Maharashtra which were secured from the Indian Meteorological Department, Pune while data on yield of Jowar the principal crop of the tract were secured from the Directorate of Economics and Statistics, New Delhi.

The Pan evaporimeter readings were converted to potential evapotranspiration (PET). Further, based on a comparison of rain-

fall with PET, the entire period of kharif season (*viz.* May to October) was classified into three categories of moisture availability periods depending on whether the moisture availability is surplus or deficient. The commencement and cessation of such periods (*viz.* moist and humid) were studied. It was found that the span of the humid period extended between the 3rd week of June to second week of September while that of the moist period extended between 2nd week of June to end of September. The mean cessation date of humid period was seen to be September 15 and it was found that the termination of humid period prior to September 15 appears quite likely to cause a depression in the crop yield.

Through a graphical technique adopted to determine the minimum number of moist/humid days needed for obtaining a normal crop yield, it was found that the requisite number of moist days was 30 while that of humid days was 25.

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