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Fiducial limits of monthly rainfall for Taliparamba

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ABSTRACT. A study of the fortyfour years' (1911 to 1954) rainfall data of the Agricultural Research Station, Taliparamba for the monsoon months June to October has been made in this paper. The fiducial limits of expected monthly rainfall are given and the pattern of rainfall discussed.

1. Introduction

Manning (1951) considers 90 per cent fiducial probability of rainfall as being of general interest to farmers. The fiducial limits, unlike the mere averages, enable the agriculturists to know with some degree of confidence, the expected minimum and maximum rainfall in different months. This will prove useful for him to adjust his cultural operations suitably and for planning for agricultural improvement.

The Agricultural Research Station, Taliparamba, is situated about eighteen miles north of Cannanore and seven to eight miles from the coast. This is in the typical pepper growing area of Malabar. The yield of pepper mainly depends on the rainfall received during the year. Any small change in weather conditions seems to affect the yield of this crop adversely, causing physiological shedding of spikes. For example, any temporary break in the monsoon for a short while followed by heavy showers especially during September–October, is believed to cause severe spike shedding.

2. Material and methods

The meteorological records were obtained from the officer-in-charge of the Agricultural Research Station, Taliparamba and the rainfall data for the period 1911 to 1954 (44 years) have been analysed.

Generally, frequency distributions of rainfall exhibit skewness with the mode lower than the mean. Hence means and standard deviations determined from such asymetrical distributions are not as useful as those derived from normal distribution. So the skewed distribution of rainfall has to be suitably transformed to give an approximately normal distribution for the estimation of "Fiducial limits", which can later be converted to the original units.

Many methods are available for transforming data exhibiting skewness. Of these, 'Kleczkowski's transformation' as indicated by Manning (1951) is convenient in that it is possible to adjust the transformation according to certain specific attributes of the population. The function $y = \log (x + C)$ was found to be satisfactory by Manning (1951) in correcting the skewness of the rainfall data. The constant C is derived from the equation $C = S/b - \overline{x}$, where S is the average standard deviation of monthly rainfall, b is the regression coefficient of standard deviation on mean monthly rainfall and $\overline{x}$ is the average of the mean monthly rainfall values. But Kleczkowski's transformation can be applied only when b, the regression coefficient of standard deviation on mean monthly rainfall, is statistically significant.

3. Analysis

The mean standard deviation and coefficient of variation were calculated for the months of June to October and b the regression coefficient was found to be statistically not significant (Table 1). This indicates that standard deviations and mean monthly rainfall are independent. Hence the application of Kleczkowski's transformation is inappropriate for the data.

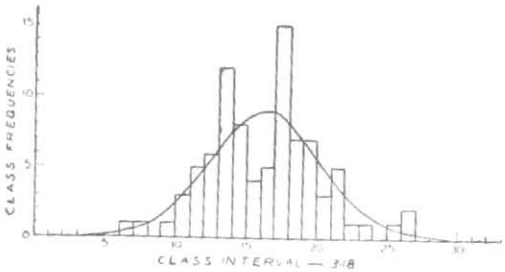

Fig. 1. Histogram and theoretical curve of rainfall for the months of June and July (44 years data)

Distribution of actual units : $N=88$; Mean $=42\cdot144$; S. D. $=12\cdot391$; $\beta_1=0\cdot049$; $\beta_2=3\cdot127$

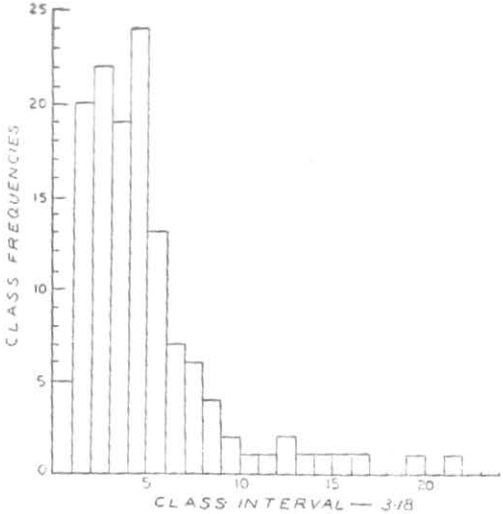

Fig. 2. Histogram of rainfall for the months, August—October (44 years data)

Distribution of actual units : $N=132$; Mean $=15\cdot06$; S.D. $=11\cdot55$; $\beta_1=4\cdot295$; $\beta_2=8\cdot321$

TABLE 1

Mean monthly rainfall (June to October), standard deviation and coefficient of variation

Month	Mean	Standard deviation	Coefficient of variation (%)
Jun	39·85	11·24	28·21
Jul	44·44	12·97	29·19
Aug	25·38	13·54	53·35
Sep	9·58	5·29	55·22
Oct	10·21	4·92	48·19

Regression coefficient $(b) = 0\cdot216$

$F = 7\cdot01$ (not significant)

TABLE 2

Fiducial limits (9 : 1) for monthly rainfall (June to October)

Month	Lower limit	Mean	Upper limit	Observed deviations from limit (values outside range) Below lower limit	Above upper limit
Jun	20·92	39·85	58·78	1	3
Jul	22·60	44·44	66·28	2	3
Aug	10·27	22·62	49·86	0	3
Sep	2·63	7·94	23·97	5	1
Oct	3·93	9·07	20·92	2	1
			Total	10	11

Total observed deviations from limits 21

*Expected deviations from limits 22

* (220 rainfall months—fiducial limits 9:1)

Manning (1951) further suggests that when the relationship between mean monthly rainfall and standard deviation is poor, a less powerful transformation may be attempted. So the data under study were transformed by Bartlett's square-root transformation, $\sqrt{(x + 0 \cdot 5)}$. But the transformed distribution of rainfall was found to be far from normal because $\beta_1 = 0 \cdot 369$; $\beta_2 = 2 \cdot 343$ and also it failed to provide a good fit to the theoretical normal curve by χ^2–test. Likewise, other methods of transformation like logarithmic method, inverse sine method etc were found to be not suitable for the data.

Then the data were split into two fairly homogeneous units based on the coefficients of variation of different months (Table 1). The months of June and July were taken as one unit and the months of August, September and October as another. These two units were analysed separately.

The distribution for June and July was continuous and was found to taper off gradually in both directions and hence Sheppard's correction for grouping was applied. The values of β_1 and β_2 for the distribution were $0 \cdot 049$ and $3 \cdot 127$ respectively. The distribution can, therefore, be assumed to be normal even without any transformation. The goodness of fit by χ^2–test indicated that the observed deviations could easily have occurred by chance. In Fig. 1 the histogram and theoretical curve of the distribution with the usual parameters are given.

The rainfall data for the months of August, September and October when grouped separately, showed a highly skew distribution about their means (Fig. 2) and gave $\beta_1 = 4 \cdot 295$ and $\beta_2 = 8 \cdot 321$.

Cochran (1938) has stated that when the ratio of the mean to the standard deviation is constant the logarithmic transformation ($y = \log x$) is more suitable than the square-root or inverse sine methods. Since the difference in coefficient of variation of the rainfall data for the months of August, September and October is not great, this

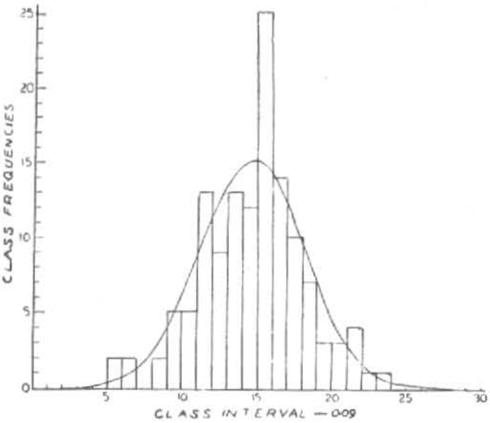

Fig. 3. Histogram and theoretical curve of rainfall for the months, August—October (44 years data)

Distribution of units transformed by $y = \log x$: $N = 132$; Mean$= 1 \cdot 071$; S. D.$= 0 \cdot 311$; $\beta_1 = 0 \cdot 028$; $\beta_2 = 3 \cdot 212$

logarithmic method of transformation was attempted. Sheppard's correction for grouping was applied as the transformed distribution was found to tail off gradually in both directions. Values of β_1 and β_2 ($\beta_1 = 0 \cdot 028$; $\beta_2 = 3 \cdot 212$) for the transformed data indicate that the distribution approximates closely to the normal distribution. The χ^2–test proved that the observed data satisfactorily fitted the normal distribution. Histogram and theoretical curve for the transformed data are given in Fig. 3.

Fiducial limits (for $p = 0 \cdot 1$) of rainfall for the months of June and July were calculated from their respective means and standard deviations together with the appropriate value of t. From the transformed data of rainfall for the months of August, September and October, means and standard deviations were calculated and fiducial limits (for $p = 0 \cdot 1$) were determined as before. Actual units were obtained by reconversion. The data are given in Table 2.

On reconversion to the original units, these limits were found to provide quite a good fit to the actual data. For example, the freaks of rainfall (*i.e.*, departures from

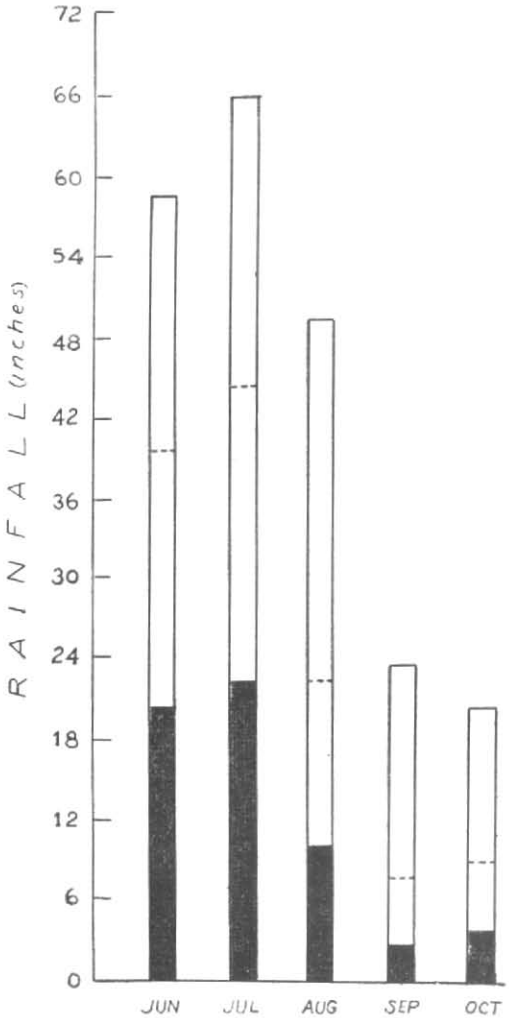

Fig. 4. Fiducial limits (9 : 1) for monthly rainfall (June—October)

Minimum expected rainfall shown by blocking
Dotted lines indicate the mean

limits) for the Taliparamba data (June to October) would normally be expected on 22 occasions, but, in fact, the total observed deviations from limits were on 21 occasions (Table 2). This proves that there is a satisfactory agreement between the expected and observed data and indicates that if suitable methods of transformation are adopted, the fiducial limits for monthly rainfall can be determined precisely.

4. Discussion

A rainfall pattern of the Agricultural Research Station, Taliparamba, with the upper and lower limits of expected monthly rainfall (June to October) is presented in a form free from the bias imposed by skewness on actual mean monthly rainfall values (Fig. 4). Minimum expected rainfall for individual months is shown by blocking and mean by dotted lines. The height of the column denotes the maximum rainfall expected.

In September, even though the lower limit of rainfall is less than in October, the upper limit is definitely more than that of October. This indicates that heavy rains are possible even during the end of southwest monsoon (*i.e.*, in September), which is supposed to adversely affect the pepper crop and cause shedding of spikes. But from Table 2 it is seen that the rainfall freaks during the month of September are confined mostly below the lower limit and hence chances of occurrence of very high rainfall above the upper limit are rather remote. During the month of August the rainfall freaks are entirely confined above the upper limits. The distribution of freaks of rainfall during the other months is shown in Table 2. Such an accurate representation of rainfall pattern is considered as a very valuable guide for successful crop production.

5. Acknowledgement

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