*Mausam*, (1984), 35, 3, 397-402

551.577.38 : 633

# Extreme probability analysis of drought periods in monsoon in relation to water need of crop stages

G. RAMAKRISHNA RAO and D. G. PHULARI

*Department of Bio-meteorology,*
*Marathwada Agricultural University, Parbhani*

**सार** — पानी की आवश्यकता के अनुसार फसल की विभिन्न अवस्थाओं के समायोजन की दृष्टि से 1944 से 1976 तक 7, 10, 15, 20 और 25 दिन की बारम्बारताओं के अनुसार दैनिक वर्षा पर अनावृष्टि-कालावधि का अत्यान्तिक प्रायिकता विश्लेषण किया गया। इससे संकेत मिला कि जून का पहला पखवाड़ा, जुलाई का दूसरा पखवाड़ा, अगस्त का पहला पखवाड़ा तथा सितम्बर का दूसरा पखवाड़ा, बवाई, फूल आने व फली लगने, पुष्प गुच्छों की शुरुआत, कल्लों के फूटने तथा खरीफ की फसल में दाने पड़ने के लिये उपयुक्त नहीं है। वर्षा की उपलब्ध गहराई के अनुसार पानी की आवश्यकता को देखते हुए, यदि फसल की अवस्थाओं को समायोजित कर लिया जाय, तो किन्हीं दस वर्ष के समय में तीन वर्षों तक भरपूर फसल, पांच वर्षों तक अच्छी फसल और दो वर्षों तक आर्द्रता प्रतिबल की आशा की जा सकती है। आगे इस अध्ययन से पता चलता है कि यदि उपयुक्त समयक्रम का चुनाव किया जाय तो फसल की पैदावार अच्छी होगी, विशेषकर वहां, जहां मृदा की गहराई एक मीटर से अधिक है।

ABSTRACT. Extreme probability analysis of drought periods were conducted on daily rainfall from 1944 to 1976 for the frequencies 7, 10, 15, 20 and 25 days to adjust crop phases according to their water need. The study indicated that the first fortnight of June, second fortnight of July, first fortnight of August and second fortnight of September are not suitable for sowing, flowering and pod formation, panicle initiation, earhead emergence and grain filling of kharif crops respectively. If the crop phases are adjusted as per their water need with the available depth of rainfall three years of very successful cropping, five years with success and the crops may undergo severe moisture stress in two year period. Further, the study reveals that if proper crop sequence is chosen the crops would have good harvest in a year particularly where the soil depth exceeds a metre.

## 1. Introduction

The low and fluctuating rainfall during crop growing season constraints the cultivation of rainfed crops. Projection of future rainfall through probabilities making use of past rainfall records, would be of immense use in crop planning. Selection of more drought resistant varieties or hybrids could improve the performance on dryland provided the minimum amount of rainfall expected and the rainfall distribution in time is taken into consideration during crop growth period. Experimental evidences on the effect of rainfall on yield are reported by Burton *et al.* (1952), Lomas and Shashoua (1973) and Devanathan (1975). Non-significant correlation between yield and rainfall during 30 days before harvesting was discussed by Hadjichristoulou (1977). Therefore, the present analysis is aimed in studying the lowest depth of rainfall and its distribution in time during monsoon season at Parbhani to suggest better cropping pattern.

## 2. Data and analysis

Daily rainfall data of the southwest monsoon season for the period 1944 to 1976 was collected from the records of Crop Weather Observation Scheme of M.A.U. Parbhani. Rainfall duration frequencies for 7, 10, 15, 20 and 25 days in June, July, August, September and October months were analysed. Rainfall values over consecutive days of each frequency were found by moving totals of rainfall during 1-15 August, 2-16 August, ...... 17-31 August. This way, 17 values of 15 days' total of rainfall for August were obtained. Out of these values, the lowest rainfall on 15 consecutive days in August was found out. The same procedure was repeated for all the years. The lowest rainfall totals (items) were tabulated with corresponding years as given in Table 1. All the lowest rainfall totals were arranged in order of magnitude and a rank number '$m$' representing the serial number of the totals when arranged in decreasing magnitude is given for each item, making $m = 1$ as the largest and $m = 32$ as the lowest of the rainfall totals. The plotting position '$F_a$' of each item was computed by Weilbull formula given by Doorenbos and Pruitt (1975) :

$$F_a = \frac{100\,m}{N+1}$$

where $N$ represents the total number of items.

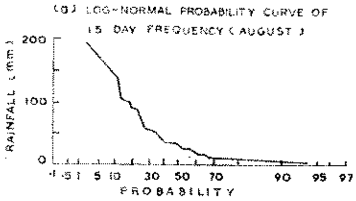



Fig. 1. Log-normal probability curves of 15 days frequency (August)

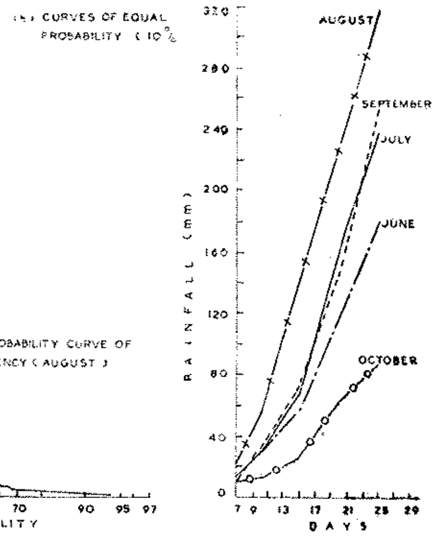
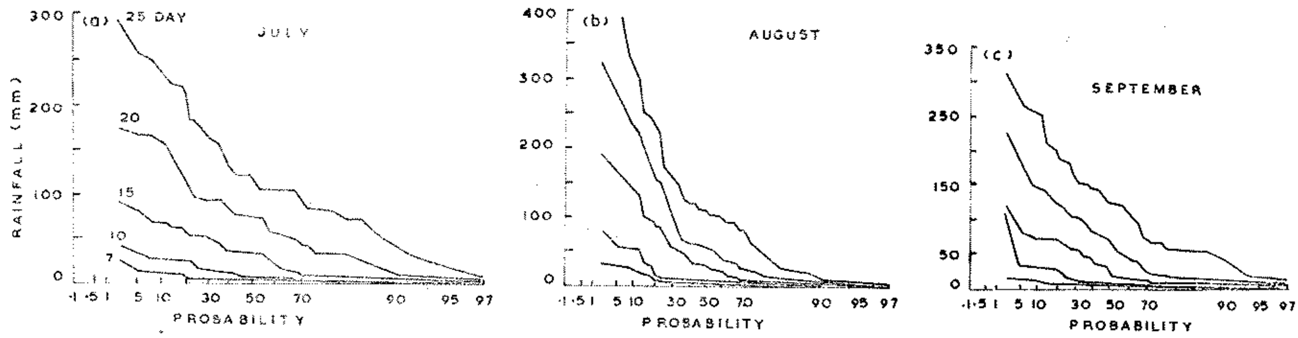
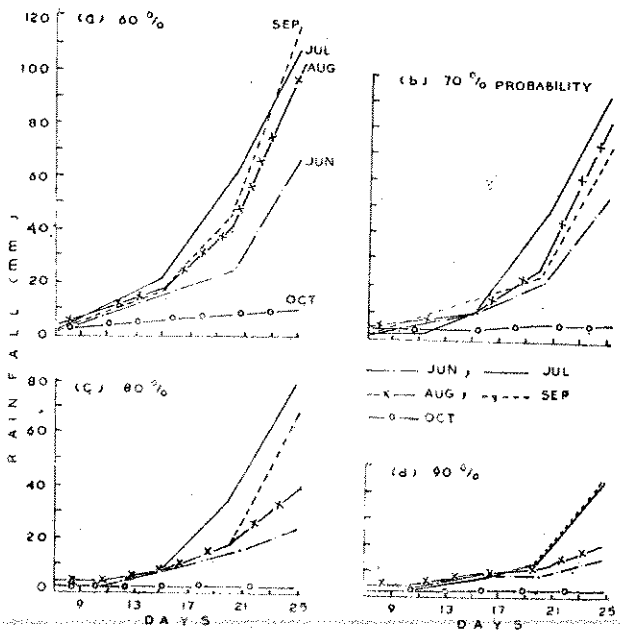



Fig. 2. Curves of equal probability (10%)




Figs. 3(a-c). Log-normal probability curves of different frequencies (a) July, (b) August and (c) September




Figs. 4 (a-d). Rainfall duration curves (a) 60%, (b) 70%, (c) 80% and (d) 90%

TABLE 1

Month : August, Frequency : 15 days

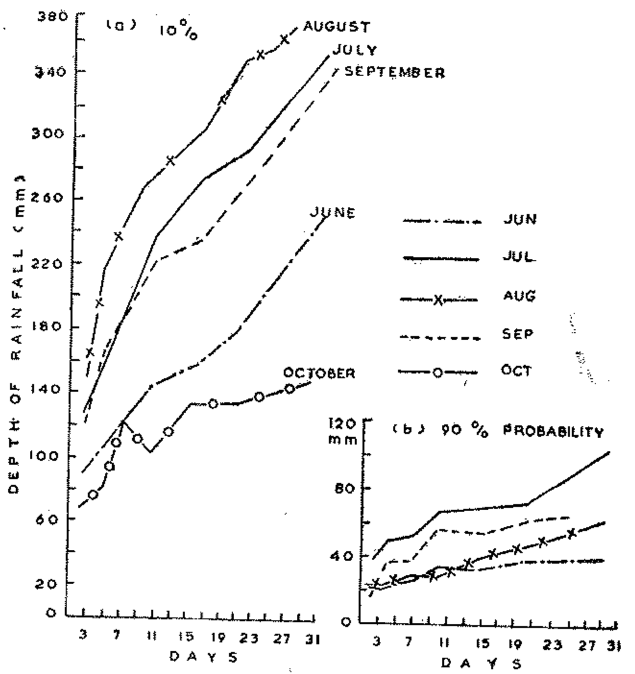
| Year | Total rainfall (mm) | Corres-ponding dates | Items arranged in dec-reasing order ($N$) | Rank No. ($m$) | Plotting position '$F_a$' |
|---|---|---|---|---|---|
| 1944 | 34.5 | 1-15 | 193.5 | 1 | 2.94 |
| 1945 | 24.6 | 17-31 | 167.8 | 2 | 5.83 |
| 1946 | 45.4 | 15-29 | 153.0 | 3 | 8.82 |
| 1947 | 15.6 | 1-15 | 131.4 | 4 | 11.17 |
| 1948 | 9.1 | 14-28 | 102.9 | 5 | 14.71 |
| 1949 | 24.1 | 15-29 | 99.5 | 6 | 17.65 |
| 1950 | 2.3 | 2-16 | 87.1 | 7 | 20.54 |
| 1951 | 53.1 | 3-17 | 86.5 | 8 | 23.53 |
| 1952 | 50.0 | 4-18 | 77.8 | 9 | 26.47 |
| 1953 | 8.2 | 17-31 | 56.6 | 10 | 29.41 |
| 1954 | 7.9 | 16-30 | 53.1 | 11 | 32.35 |
| 1955 | 153.0 | 15-29 | 50.0 | 12 | 35.29 |
| 1956 | 9.7 | 5-19 | 45.4 | 13 | 38.24 |
| 1957 | 167.8 | 2-16 | 39.4 | 14 | 41.18 |
| 1958 | 87.1 | 10-24 | 34.5 | 15 | 44.82 |
| 1959 | 6.6 | 7-21 | 32.4 | 16 | 47.66 |
| 1960 | 5.9 | 14-28 | 31.4 | 17 | 50.00 |
| 1961 | 86.5 | 1-15 | 86.4 | 18 | 52.94 |
| 1962 | 102.9 | 14-28 | 24.6 | 19 | 55.88 |
| 1963 | 193.5 | 1-15 | 21.1 | 20 | 58.82 |
| 1964 | 26.6 | 15-29 | 15.6 | 21 | 61.76 |
| 1965 | 56.6 | 1-15 | 15.4 | 22 | 67.65 |
| 1966 | 2.2 | 11-25 | 10.3 | 23 | 69.71 |
| 1967 | 15.4 | 4-18 | 9.7 | 24 | 70.39 |
| 1968 | 10.3 | 17-31 | 9.1 | 25 | 73.53 |
| 1969 | 31.4 | 2-16 | 9.0 | 26 | 76.47 |
| 1970 | 99.5 | 1-15 | 8.2 | 27 | 79.41 |
| 1971 | 32.4 | 1-15 | 7.9 | 28 | 82.35 |
| 1972 | 57.8 | 15-29 | 6.6 | 29 | 85.29 |
| 1973 | 131.4 | 1-15 | 5.9 | 30 | 88.24 |
| 1974 | 9.0 | 9-23 | 2.6 | 31 | 89.18 |
| 1975 | 39.4 | 10-24 | 2.3 | 32 | 94.12 |
| 1976 | 2.6 | 4-18 | 2.2 | 33 | 97.06 |

The expected percentage of time of consecutive days lowest values of rainfall was also found by noting the corresponding dates when the lowest depth of rainfall was received in each frequency. All values computed for 15 days frequency of August are given in Table 1. A vertical scale was given for rainfall and plotted according to '$F_a$' position on a log-normal probability paper (Fig. 1). From the log-normal probability plots the depth of rainfall was read for probabilities 10, 20, 30, ......... 90 per cent (Table 2). Rainfall duration curves were obtained by plotting, for a given frequency of rainfall occurrence, the number of days against the depth of rainfall. Finally, the curves of equal probability were drawn through the plotted points (Fig. 2). The same procedure was adopted for different frequencies of all the months.

### 3. Results and discussion

From log-normal probability curves given in Fig. 3, it is observed that, in general, there is steep fall in rainfall amount at lower probabilities. At frequencies 7, 10 and 15 days, the rainfall above 70 per cent and 7 and 10 days frequencies the rainfall above 20 per cent is much less. At lower probabilities the difference in rainfall amount decreases sharply after 50 per cent probability in all the months. This indicates that 7-10 days lowest rainfall frequencies are quite common and they occur at least in alternate years. In all the months except in October, the rainfall increases more above 10-day frequency indicating that the possibilities of higher rainfall, in general, are after 10 days of minimum rainfall. At all the frequencies rainfall in June is less than the rainfall in July, August and September. The October is the lowest rainfall month. From the behaviour of August rainfall it appears that though August is the mid month of southwest monsoon with higher amount of rainfall, its dependability is less at higher probabilities and rainfall failures are more in August when compared with July and September.

It is noticed from the rainfall duration curves (Fig. 4) that in August the rate of increase in rainfall amounts with increase in frequency is more at probabilities 10, 20 and 30 per cent when compared to that of other months. All the months are lagging behind August in attaining same depths of rainfall up to 30 per cent probability. The time lag is 4 days and 6 days in the case of July and September respectively. The time lag is still more with June and October. This indicates that the dependability and intensity of August rainfall is more at lower probabilities. At higher probabilities, July and September rainfall is more dependable than that of August. Similar type of variation of




Figs. 5 (a & b). Rainfall duration curves (a) 10% and (b) 90% (*from* Rao *et al.* 1979)

August rainfall was reported by Ramakrishna Rao *et al.* (1979) in the log-normal probability analysis of maximum rainfall. In general, it is observed that at all probabilities, the amount and rate of rainfall increase is more after 10-day frequency, revealing that the lowest rainfall periods occur quite often and they possibly break after 10 days of their onset. The possibilities of early withdrawal of lower depths of rainfall periods are still higher at 15-day frequency.

The distribution of rainfall in October at higher probabilities reveals that the lowest rainfall frequencies of 20 days or even higher are more. Therefore, the rainfall depth below 40 per cent probability of October and stored soil water due to September rainfall may be taken into consideration for rabi (post rainy) season crop planning.

It can be seen from Table 3 that the lowest rainfall occurrence time percentage is higher during first fortnight of June, August and October and second fortnight of July and September. The lower percentages correspond to second fortnight of June, August and October and first fortnight of July and September. Therefore, the crop yields will be severely damaged if the critical periods like emergence, flowering, pod formation, panicle initiation and grain filling coincides with the higher percentage time of lowest rainfall periods. To diminish the adverse effect of lower depths of rainfall on kharif (rainy season) crops, the critical periods of these crops which need more water should not coincide with the minimum rainfall depths. From the results it appears that first fortnight of June, second fortnight of July, first fortnight of August and second fortnight of September are not favourable for sowing, flowering and pod formation, panicle initiation, earhead emergence and grain filling of kharif crops respectively.

The percentages of lowest rainfall occurrence time are in opposite to that reported for maximum rainfall in Table 4. At 10 per cent and 90 per cent probabilities, there is an agreement in the variation of rainfall duration curves between highest and lowest amounts as shown in Fig. 5. This confirms the validity of the present results. The depths of rainfall received at 7, 15 and 20 days frequencies are given in Table 5. The depth of rainfall received at 7-day frequency is very much less when compared to that of 15 days and 20 days frequencies and this depth may not be significant for the discussion on crop production. While the depth of rainfall at 15 days frequency at 30 and 50 per cent probabilities is 214 mm and 128 mm respectively. These depths are nearly one fourth and one eighth of

**TABLE 2**

**Depth of rainfall (mm) as a function of time**
(Month : August)

| Probability (%) | Frequency (Days) 7 | 10 | 15 | 20 | 25 |
|---|---|---|---|---|---|
| 10 | 22 | 25 | 140 | 235 | 318 |
| 20 | 8 | 18 | 88 | 155 | 230 |
| 30 | 8 | 10 | 56 | 116 | 160 |
| 40 | 6 | 8 | 45 | 68 | 126 |
| 50 | 4 | 8 | 32 | 58 | 112 |
| 60 | 4 | 8 | 18 | 40 | 100 |
| 70 | 4 | 6 | 10 | 28 | 82 |
| 80 | 4 | 4 | 8 | 18 | 40 |
| 90 | 4 | 4 | 8 | 10 | 20 |

**TABLE 3**

**Percentage of time**

| Frequency (Days) | Dates | Month Jun | Jul | Aug | Sep | Oct |
|---|---|---|---|---|---|---|
| 7 | 1-12 | 27 | 19 | 27 | 9 | 30 |
| | 7-19 | 36 | 19 | 12 | 48 | 33 |
| | 14-25 | 24 | 27 | 21 | 24 | 36 |
| | 20-30 or 31 | 12 | 36 | 39 | 18 | 30 |
| 10 | 1-10 | 39 | 27 | 42 | 18 | 36 |
| | 11-20 | 48 | 33 | 21 | 52 | 30 |
| | 21-30 or 31 | 12 | 39 | 36 | 30 | 33 |
| 15 | 1-15 | 70 | 46 | 52 | 49 | 52 |
| | 16-30 or 31 | 30 | 55 | 48 | 52 | 48 |
| 20 | 1-15 | 76 | 52 | 54 | 46 | 33 |
| | 16-30 or 31 | 24 | 48 | 46 | 55 | 67 |
| 25 | 1-28 | 73 | 61 | 55 | 55 | 36 |
| | 5-30 or 31 | 27 | 39 | 46 | 46 | 64 |

**TABLE 4**

**Percentage of time**

| Frequency (Days) | Dates | Month Jun | Jul | Aug | Sep | Oct |
|---|---|---|---|---|---|---|
| 2 | 1-10 | 23 | 36 | 26 | 44 | 43 |
| | 11-20 | 33 | 13 | 33 | 23 | 26 |
| | 21-30 or 31 | 44 | 51 | 41 | 33 | 17 |
| 4 | 1-10 | 23 | 23 | 33 | 50 | 51 |
| | 11-20 | 33 | 23 | 33 | 26 | 30 |
| | 21-30 or 31 | 47 | 54 | 34 | 24 | 12 |
| 7 | 1-10 | 30 | 26 | 26 | 46 | 56 |
| | 11-20 | 26 | 30 | 40 | 21 | 23 |
| | 21-30 or 31 | 44 | 44 | 34 | 33 | 21 |
| 10 | 1-10 | 16 | 26 | 26 | 33 | 57 |
| | 11-20 | 30 | 30 | 26 | 41 | 21 |
| | 21-30 or 31 | 54 | 44 | 48 | 26 | 14 |
| 15 | 1-15 | 36 | 50 | 58 | 58 | 70 |
| | 16-30 or 31 | 64 | 50 | 42 | 42 | 30 |
| 20 | 1-15 | 40 | 55 | 63 | 66 | 79 |
| | 16-30 or 31 | 60 | 45 | 37 | 34 | 21 |

From : Rao *et al.* (1979)

**TABLE 5**

**Rainfall depths (mm) of 7 day, 15 day and 20 day frequencies at selected percentage**

| Month | 30% 7 days | 15 days | 20 days | 50% 7 days | 15 days | 20 days | 70% 7 days | 15 days | 20 days |
|---|---|---|---|---|---|---|---|---|---|
| Jun | 7 | 30 | 91 | 5 | 24 | 38 | 4 | 10 | 22 |
| Jul | 4 | 50 | 105 | 2 | 32 | 77 | 2 | 10 | 44 |
| Aug | 8 | 56 | 116 | 4 | 32 | 58 | 4 | 10 | 28 |
| Sep | 5 | 68 | 104 | 4 | 32 | 73 | 2 | 14 | 26 |
| Oct | 6 | 10 | 20 | 4 | 8 | 8 | 2 | 4 | 6 |
| Total | 30 | 214 | 436 | 19 | 128 | 254 | 14 | 48 | 126 |

the normal rainfall (857.4 mm). At 20-day frequency, the depth of rainfall is almost double to that of 15 days frequency.

As the soils of the region are moderate to deep black with maximum water holding capacity of 250 mm upto one metre depth, it is envisaged from the above discussion that if the crop phases are adjusted as per their water need with available depths of rainfall obtained in the study, three years of very successful cropping, five years with success and the crops may undergo severe moisture stress in two years in a given ten years period. Further, it appears that if proper crop sequence is chosen with optimum soil management two crops a year is possible particularly when soil depth exceeds a metre as the stored water at the end of kharif season is enough to sustain second crop.

## References

Burton, G.W., Parham, S.A., Southwell, B.L. and Stephens, J. L., 1952, *Georgia Exp. sta. Bull.*, 47, Revised.

Devanathan, M.A.V., 1975, *Expl. Agric.*, **II**, 183.

Doorenbos, J. and Pruitt, W.O., 1975, Crop water requirements, Irrigation and drainage, Paper 24, pp. 111-23, FAO, Rome.

Hadjichristoulou, A., 1977, *Expl. Agric.*, **13.**, pp. 217-223.

Lomas, J. and Shashoua, Y., 1973, In plant response to climatic factors (Ed. UNESCO), Proc. Uppsala Symp. 1970.

Ramakrishna Rao, G., Kadam, D.M., Shinde, J.S. and Varade, S.B., 1979, *Indian J. agric. Sci.*, **49** (4), 284-90.