**Original Research Article**

**PROBABILITY ANALYSIS OF CRITICAL DRY SPELLS OF BEED AND JALNA DISTRICTS OF MARATHWADA REGION**

**ABSTRACT**

Information on dry spell analysis plays an important role in proper utilization of available rainwater resources. In the present study, probability analysis of critical dry and wet spells along with onset and withdrawal of rainy season was estimated for Beed and Jalna districts of Marathwada region of Maharashtra. Results indicated that, the average date of OEM was 20 June and 11 June and its withdrawal was 14 Oct and 22 September were observed in Beed and Jalna respectively. Data on average number of first, second and third critical dry spell (CDS) were also estimated and is indicated that a greater number of CDS i.e. (04) were observed in Jalna. Similarly, data on wet spells indicated that, Jalna accounts 108 wet spells and 94 wet spells were observed in Beed district. Results on Fortnightly dry spell probability analysis showed that, Mean duration of critical dry spell for Beed and Jalna district was observed as 18.93 was highest during second fortnight and 13.96 days was highest during seventh fortnight. These findings are helpful to study area for understanding the events of occurrence of dry spell and wet spell for effective agricultural planning and to decrease the adverse effects of dry spell at sensitive crop development stages, for water resource management.

**Keywords-** Dry spell, Wet spell, Rainfall, Onset of monsoon, probability

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**INTRODUCTION**

Efficient utilization of water resources is essential for assured and increased agricultural production. Among major controlling factors in agricultural production, rainwater has a major role. The distribution of rainfall has a significant impact on agricultural success or failure in a subtropical nation like India, especially when crops are rainfed (Bal and Minhas, 2017). According to Chakraborty and Newton (2011), water stress occurs throughout some crucial plant growth phases as a result of reduced agricultural output caused by unpredictable rainfall patterns and declining rainfall. Crop planning is an important task on the part of the cultivator especially in dryland situation. In dryland areas, crop planning is entirely dependent on amount of rainfall and distribution pattern particularly during kharif season. Dryland agriculture has its distinct importance in the sphere of agriculture production. Agriculture in India is the primary source of livelihood for nearly 48% of population and contributes 15% to the country’s GDP. About 52% of net sown area in India falls under rainfed agriculture, contributing 46% of food grain production and supporting livelihood for 40% of the population in the country (NRAA, 2020). The dryland areas suffer due to frequent weather aberration resulting in crop failure. The important characteristics of rainfall influencing agricultural production from rainfed areas are the date of onset of effective monsoon, the duration of dry spells, the time of occurrence of dry spells, the duration of wet spells and number of rainy days (Anil et.al., 2021). The important rainfall characteristics influencing agricultural production are date of onset of monsoon, the duration of wet spell, occurrence & duration of intervening dry spells and number of rainy days. Rainfed agricultural

practices significantly impact the economy of developing countries; however, these practices are highly vulnerable to the effects of weather and climate (Rockstrom, 2002). India stands first among the countries that practice rain fed agriculture both in terms of extent (86 M ha) and value of production (Srinivasa, 2015). The rainfall and dry spell analysis on specific area basis could serve a better guide for planning of efficient rain water management. Uneven distribution of rainfall could lead crops to different degrees of dry spells without significant reductions in total rainfall (Barron et al., 2003). In most of the state the percentage of irrigation is very low. In Marathwada region this percentage of total irrigated to total cropped area is only 10.13 leaving about 90 per cent area at the whim of monsoon. Marathwada is generally known to be drought prone area in Maharashtra. Precipitation is very uncertain in this region and sometimes suffers from severe droughts.

In such conditions only the knowledge of average annual rainfall is not useful in deciding cropping pattern. With growing emphasis on profitable crop production in such rainfed areas, knowledge of distribution of dry spells during monsoon season assumes an important role, it is important to know the chance of occurrence of dry spell during the critical period of lifecycle of the crops for planning the sowing periods and deciding the varieties of different crops. This helps the farmer in judicious utilization of soil moisture by way of crop planning. Average precipitation in Marathwada region of Maharashtra state (807 mm) is sufficient to support the double cropping on medium and deep soils. Cotton and sorghum were conventional dominant crops of the region, whereas during recent years, cotton, soybean and pigeon pea have become major cash crops in dryland areas. The rainfall during the monsoon is very uncertain and its distribution within growing season is not uniform. Early onset of rains, relative to the mean date of onset for a given location, results in a longer growing season (Sivakumar, 1988) in most of the state the percentage of irrigation is very low. Delayed onset of monsoon, limiting magnitude at onset, breaks in rainfall and early cessation of rainfall are common phenomena. A break in rainfall continues from a few days to several weeks.

The important characteristics of rainfall influencing production from rainfed farming are the date of onset of monsoon, the duration of rainy spells, the dates of occurrence and duration of intervening dry spells and distribution of weekly minimum rainfall and the number of rainy days. Runs of wet and dry spell helps to identify the duration of stress period. (Biswas, 1981). The occurrence of certain amount of rainfall at crucial times can determine the success or failure of a crop. Drying of crops, germination of seeds, disease during its growing period applying irrigation, fertilizer pesticides are some important agricultural activities for which probability of various sequences of wet and dry days may be used to determine the possible economic gains and losses. It is estimated that and million hectares of agricultural land in our country is rendered water logged every year. A surface drainage of this land is considered as removal of excess surface water from the area to a natural or artificial. Wet and dry spell helps to identify the duration of surplus water and water stress period. Information on dry spell analysis plays an important role in proper utilization of available rainwater resources. Marathwada region of Maharashtra state, comprises districts Hingoli, Nanded, Latur, Parbhani, Jalna, Beed, Aurangabad and Osmanabad. The area in the region mostly falls under assured rainfall zone, though 15 to 20% falls under low and moderately high rainfall zone each. Under such climate change and aberrant weather situation, crop planning and management should be based on probability of rainfall occurrence, dryspell and available soil moisture analysis.

**Materials and Methods**

**Location**

The present study is confined to Marathwada region of Maharashtra state. Marathwada region is one of the four regions in the State. Cotton, sorghum, soybean and pigeon pea are the dominant crops, grown on large scale all over Marathwada region. There are 56 rain gauge station in Marathwada. Amongst them, 2 stations., Beed and Jalna were selected for detailed analysis. The names and locations of the rain guage stations selected for analysis are given in table 1.

**Table 1: Geographical information of rain gauge station in Marathwada region**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr.**  **No.** | **Rain gauge station** | **Latitude North** | **Longitude East** |
| 1. | Beed | 190 | 750 |
| 2. | Jalna | 190 | 750 |

**Data collection and processing**

The daily rainfall data for the 2 rainguage stations of Marathwada region were obtained for the period 1981 to 2010 from the India Meterological Department, pune. The data collected for 30 years.

**Onset of Effective Monsoon (OEM)**

Pre-monsoon rains cannot be considered as effective monsoon for agriculture operations, particularly because these rains are followed by long dry spells which may affect the germination of seeds resulting in crop failure if sowings are undertaken immediately after these showers, to identify 'effective monsoon' as 'commencement of sowing rains distinct from pre-monsoon showers'.

**Determination of dates of OEM**

The concept developed by Ashok Raj (1979) on onset of effective monsoon and dry spells was adopted in the present study. Effective monsoon is that monsoon which leaves enough moisture to supports agricultural operations. If the average daily evaporation is e mm and after a prolonged dry spell, if it rains on a particular day an amount of r mm of rain, it is assumed that only (r-e) mm of rain will be available for the soil that day. If it rains on the subsequent days, the evaporation loss will be less than e mm. In the light of this, the rainfall of seven-day evaporational demand, is designated as the effective monsoon.

Accordingly, the date of commencement of a 7 days spell satisfying the following criteria can be defined as the date of onset of effective monsoon.

1. The first day’s rain in the seven days spell should be more than the average daily evaporation (e) of the place.
2. The total rain during the seven days spell should not be less than (5e+10) mm.
3. At least four out of these seven days should be rainy days with not less than 2.5mm of rain each day. A day is called a rainy day if the rainfall of that day is more than or equal to 2.5mm.

The dates of onset of effective monsoon for every year for each station were determined by applying the above three criteria. After identifying the date of onset of effective monsoon xi (i=1,2,3……n) in the Ith year for a particular rain guage station, the mean date m is computed as follows:

m =∑xi/n (from i=1 to n)

where, n is the number of years.

**Determination of dry spell and wet spell**

The dry spells were found out by applying the criteria stated by Ashok Raj (1979). The interval between the end of 7 days spell, beginning with the onset of effective monsoon and another rainy days with 5 e mm or more of rain or the commencement of another 7 day rainy spell satisfying the critiera with a total rainfall of 5e mm or more during this spell is called as the first dry spell. In similar manner dry spell during the season were worked out.

The interval between the OEM and the beginning of first critical dry spell is called the first wet spell. The subsequent wet spells were determined as the interval between two critical dry spells. Thus the wet spells are spells of prolonged rain with possible intervening critical dry spells.

**Critical dry spell (CDS)**

If the duration of the dry spell exceeds a certain period depending on the crop soil complex of the region the dry spell is called the critical dry spell. Duration of 10 days was considered to classify the dry spell as critical during every year. The critical dry spells were obtained for every year for each station. The mean dates of critical dry spells were determined by the same procedure as that of obtaining the mean dates of OEM. The critical dry spells were allotted to the eight fortnights of monsoon season. Though the length of dry spell exceeds 31 days. It was considered as spell with duration of 31 days that means maximum length of dry spell duration considered of 31 days. Allotment of these dry spells during eight fortnights was done by following criteria.

Each individual fortnight is given that length of dry spell which either start of lies in that fortnights with maximum duration of the dry spells. When the dry spell also extends in next fortnight but as starts in the previous fortnight was allotted to the fortnight in which it start duration of this dry spell includes length in next fortnight was given dry spell of that duration lying in that fortnight. The next fortnight was given dry spell of that duration lying in that fortnight starting from first day of the fortnight.

**Probability analysis of dry spells**

According to Chow (1964) mathematical or graphical methods are generally used for frequency or probability analysis. Mathematical methods is not justified when data are available for less than 30 years. Gumbels extreme value technique was applied for computation of probability values.

**Fortnightly Probability Analysis**

For graphical method of probability analysis, maximum values of dry spell duration in each fortnights were arranged in desending order of magnitude. Plotting positions were computed by using Gumbels extreme value distribution which were compared with the plotting position obtained by Weibuls method.

According to Gumble's extreme value distribution (Raghunath, 1985) probability (P) of occurrence of dry spell greater than or equal to 'd' days

P =  (1)  
 In which Y is known as reduced variable and is determined as,

(d – d) + 0.45 x σ

Y = (2)

0.7797 x σ

In Which σ = standard deviation

Σ (d – d)2

σ = (3)

n-1

d = length of dry spell of which probability was to be determined

n

d = mean = Σ di

i-1

n

The value of 'P' thus obtained is the plotting position to be plotted on probability scale against square root of dry spell on natural scale.

By Weibuls method plotting position was obtained by using

m

P = x 100

n+1

In which

P = plotting position percent chance

m = rank number when the data are arranged in descending order of magnitude with highest value marked as 1.

n = Total no. of years for which data are available.

The percent chance of occurrence of plotting position determined by these two methods were compared. Using probability by Gumbels method frequency curves for all fortnight were established for each location of the study. While locating the points on the probability paper, the square root of length of critical dry spell duration values were plotted, to reduce dispersion of data. After plotting, frequency curves was drawn to closer fit to active minimum dispersion of the points.

**RESULTS AND DISCUSSION**

**Analysis for Beed station**

**Onset and withdrawal of effective monsoon**

The criteria (Ashok Raj 1979) was used for determination of OEM and withdrawal of effective monsoon. The result have been presented in table.2.

**Table.2.: Dates of onset and withdrawal effective monsoon for Beed station**

|  |  |  |
| --- | --- | --- |
| **Year** | **Effective monsoon** | |
| **Onsets on** | **Ends on** |
| 1981 | 22 July | 30 Oct |
| 1982 | 15 June | 9 Nov |
| 1983 | 9 July | 3 Oct |
| 1984 | 12 July | 22 Oct |
| 1985 | 23 July | 6 Oct |
| 1986 | 3 June | 24 Sept |
| 1987 | 2 July | 18 Oct |
| 1988 | 16 June | 5 Oct |
| 1989 | 23 June | 27 Sept |
| 1990 | 21 May | 29 Oct |
| 1991 | 5 June | 21 Sept |
| 1992 | 18 June | 7 Sept |
| 1993 | 22 July | 20 Oct |
| 1994 | 3 June | 16 Nov |
| 1995 | 23 June | 19 Oct |
| 1996 | 4 July | 29 Oct |
| 1997 | 30 June | 29 Oct |
| 1998 | 14 June | 16 Oct |
| 1999 | 13 June | 13 Oct |
| 2000 | 1 June | 30 Sept |
| 2001 | 6 June | 16 Oct |
| 2002 | 24 June | 17 Oct |
| 2003 | 11 June | 4 Nov |
| 2004 | 26 June | 19 Oct |
| 2005 | 1 June | 10 Oct |
| 2006 | 15 June | 4 Sept |
| 2007 | 7 June | 19 Aug |
| 2008 | 11 June | 12 Oct |
| 2009 | 24 June | 20 Oct |
| 2010 | 29 June | 10 Oct |

**Critical dry spells**

When the duration of dry spell exceeds a certain value depending on crop soil complex of region, it is called as critical dry spell.

Critical dry spells at Beed range from 1 to 4 during each year. It was also observed that only one CDS occurred 1984,1985,1988,1993, 1998 and 2007 maximum four CDS occurred during 1986, 1990, 1994, 1999 and 2005.

Average dates of commencement of critical dry spells and their mean duration are shown in Table 3. This table indicates that the average date of OEM was 20 June and its withdrawal was 14 Oct with highest standard deviation of 29 days and lowest standard deviation 9 days total 74 dry spells observed and average number of CDS were 2.

**Table 3: Critical dry spell during year for Beed Station**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | 1CDS | Duration days | II CDS | Duration days | III CDS | Duration days | IV CDS | Duration days | Total No. CDS/  YR |
| 1981 | 10 Aug | 19 | 2 Oct | 22 | -- | -- | -- | -- | 2 |
| 1982 | 24 June | 10 | 2 July | 47 | 29 Sep | 27 | -- | -- | 3 |
| 1983 | 16 July | 23 | 17 Aug | 15 | -- | -- | -- | -- | 2 |
| 1984 | 20 July | 53 | -- | -- | -- | -- | -- | -- | 1 |
| 1985 | 28 July | 42 | -- | -- | -- | -- | -- | -- | 1 |
| 1986 | 18 June | 26 | 22 July | 18 | 12Aug | 33 | 24 Sept | 87 | 4 |
| 1987 | 9 July | 26 | 26 Aug | 26 | -- | -- | -- | -- | 2 |
| 1988 | 28 July | 21 | -- | -- | -- | -- | -- | -- | 1 |
| 1989 | 25 July | 11 | 1 Sept | 20 | -- | -- | -- | -- | 2 |
| 1990 | 27 June | 26 | 25 July | 13 | 8Sep | 15 | 14 Oct | 10 | 4 |
| 1991 | 11 June | 17 | 4 July | 74 | -- | -- | -- | -- | 2 |
| 1992 | 23 June | 19 | 19 July | 20 | 16Aug | 12 | -- | -- | 3 |
| 1993 | 29 July | 21 | -- | -- | -- | -- | -- | -- | 1 |
| 1994 | 14 June | 14 | 29 June | 55 | 6 Sep | 28 | 7 Oct | 38 | 4 |
| 1995 | 10 July | 10 | 4 Aug | 24 | 16Sep | 19 | -- | -- | 3 |
| 1996 | 12 July | 32 | 6 Oct | 15 | -- | -- | -- | -- | 2 |
| 1997 | 7 July | 44 | 23 Sept | 21 | 29Oct | 20 | -- | -- | 3 |
| 1998 | 2 July | 19 | -- | -- | -- | -- | -- | -- | 1 |
| 1999 | 24 June | 11 | 17 July | 14 | 2 Aug | 36 | 14 Sept | 15 | 4 |
| 2000 | 17 June | 14 | 14 July | 25 | 31Aug | 28 | -- | -- | 3 |
| 2001 | 20 June | 42 | 18 Aug | 28 | -- | -- | -- | -- | 2 |
| 2002 | 30 June | 17 | 10 Aug | 13 | 6Sep | 40 | -- | -- | 3 |
| 2003 | 27 June | 26 | 25 July | 100 | -- | -- | -- | -- | 2 |
| 2004 | 4 July | 19 | 27 Aug | 33 | 6 Oct | 12 | -- | -- | 3 |
| 2005 | 16 June | 12 | 15 July | 24 | 31Aug | 25 | 27 Sept | 11 | 4 |
| 2006 | 25 June | 17 | 16 July | 18 | 22Aug | 10 | -- | -- | 3 |
| 2007 | 19 June | 15 | -- | -- | -- | -- | -- | -- | 1 |
| 2008 | 16 June | 34 | 24 Aug | 38 | -- | -- | -- | -- | 2 |
| 2009 | 2 July | 15 | 6 Aug | 22 | 22Sep | 17 | -- | -- | 3 |
| 2010 | 11 June | 21 | 26 Aug | 22 | 18Sep | 14 | -- | -- | 3 |
| Average | 4 July | 21 | 9 Aug | 29 | 9 Sept | 22 | 29 Sept | 32 | 2 |
| SD (days) | **16** | **11** | **27** | **20** | **22** | **9** | **10** | **29** | **16** |

**Wet spell analysis**

The interval between OEM and beginning of first critical dry spell is called as first wet spell. The subsequent wet spells are interval between two critical dry spells, thus the wet spells are spells of prolonged rain with possible intervening dry spells of duration less than value depending on crop soil complex of region.

**Table 4: Wet spells during year for Beed station.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **I wet spell** | **duration days** | **II wet spell** | **duration days** | **III wet spell** | **duration days** | **IV wet spell** | **duration days** |
| 1981 | 22 July | 19 | 29 Aug | 34 | 24 Oct | 6 | -- | -- |
| 1982 | 15 June | 9 | 4 July | 17 | 6 Sept | 23 | 24 Oct | 16 |
| 1983 | 9 July | 7 | 8 Aug | 9 | 1 Sept | 22 | -- | -- |
| 1984 | 12 July | 8 | 11 Sept | 40 | -- | -- | -- | -- |
| 1985 | 23 July | 5 | 8 Sept | 28 | -- | -- | -- | -- |
| 1986 | 3 June | 15 | 14 July | 8 | 9 Aug | 3 | 12 Sept | 12 |
| 1987 | 2 July | 7 | 4 Aug | 22 | 21 Sept | 27 | -- | -- |
| 1988 | 16 June | 42 | 18 Aug | 48 | -- | -- | -- | -- |
| 1989 | 23 June | 32 | 5 Aug | 27 | 21 Sept | 6 | -- | -- |
| 1990 | 21 May | 37 | 23 July | 2 | 7 Aug | 32 | 23 Sept | 31 |
| 1991 | 5 June | 6 | 28 June | 6 | 16 Sept | 5 | -- | -- |
| 1992 | 18 June | 5 | 12 July | 7 | 8 Aug | 8 | 28 Aug | 10 |
| 1993 | 2 June | 2 | 3 July | 3 | -- | -- | -- | -- |
| 1994 | 3 June | 11 | 28 June | 1 | 23 Aug | 14 | 4 Oct | 3 |
| 1995 | 23 June | 17 | 20 July | 15 | 28Aug | 21 | 5 Oct | 14 |
| 1996 | 4 July | 8 | 13 Aug | 54 | 21 Oct | 8 | -- | -- |
| 1997 | 30 June | 7 | 20 Aug | 36 | 14 Oct | 15 | -- | -- |
| 1998 | 14 June | 18 | 21 July | 106 | -- | -- | -- | -- |
| 1999 | 13 June | 11 | 5 July | 12 | 31 July | 2 | 7 Sept | 7 |
| 2000 | 1 June | 16 | 1 July | 13 | 8 Aug | 23 | 28 Sept | 2 |
| 2001 | 6 June | 14 | 1 Aug | 17 | 15 Sept | 31 | -- | -- |
| 2002 | 24 June | 6 | 17 July | 24 | 23 Aug | 14 | 16 Oct | 1 |
| 2003 | 11 June | 16 | 23 July | 2 | 2 Nov | 2 | -- | -- |
| 2004 | 26 June | 8 | 23 July | 35 | 29 Sept | 7 | 18 Oct | 1 |
| 2005 | 1 June | 15 | 28 June | 17 | 8 Aug | 23 | 25 Sept | 2 |
| 2006 | 15 June | 10 | 12 July | 4 | 3 Aug | 18 | 1 Sept | 3 |
| 2007 | 7 June | 12 | 4 July | 77 | -- | -- | -- | -- |
| 2008 | 11 June | 5 | 20 July | 35 | 1 Oct | 11 | -- | -- |
| 2009 | 24 June | 8 | 17 July | 20 | 28 Aug | 25 | 11 Oct | 9 |
| 2010 | 29 June | 19 | 1 July | 11 | 17 Sept | 1 | 2 Oct | 2 |
| Avg. | 19June | 13.16 | 31Sept | 24.39 | 7Sept | 14.5 | 5Oct | 7.4 |
| SD(days) | 14.54 | 9.41 | 22.04 | 29.22 | 28.60 | 9.75 | 17.4 | 7.8 |

Table 4. shows wet spell duration. After observation of table it was observed that 29.22 was highest standard deviation and lowest standard deviation was 7.8. Total 98 wet spells were observed. Mean date of first wet spell was 20 June with mean duration , mean date of second wet spell was 14 July, 23 with mean duration 24 days and that of third wet spell 8 Sept with 15 days and 14 June with 8 days.

**Fortnightly dry spell probability analysis**

Monsoon period is divided into eight fortnight starting from 1 June. Allotment of dry spell during eight fortnights was done on the basis of commencement of dry spell in the criteria.

The allotment of critical dry spell duration during fortnight have been presented in table 5. After observation of table 5 it was observed that among all eight fortnights, maximum duration of dry spell was 31 days. Mean duration of critical dry spell was observed as 18.93 was highest during second fortnight and minimum mean duration was observed as is 9.4 days is observed during sixth fortnight. It was also observed that lowest standard deviation was in the third fortnight i.e. 9.74 and highest standard deviation is in the first fortnight i.e. 13.78. Order of fortnights to mean duration of critical dry spell was observed as

F6 < F8 < F7 <F5 <F4 <F3 <F2

**Table 5: Duration of critical dry spell during fortnight of the monsoon season for Beed station.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **June** | | **July** | | **August** | | **September** | |
| **1-15** | **16-30** | **1-15** | **16-30** | **1-15** | **16-30** | **1-15** | **16-30** |
| **F1** | **F2** | **F3** | **F4** | **F5** | **F6** | **F7** | **F8** |
| 1981 | 31 | 31 | 21 | 6 | 19 | 13 | 0 | 0 |
| 1982 | 14 | 10 | 3 | 31 | 20 | 0 | 0 | 27 |
| 1983 | 31 | 24 | 8 | 23 | 7 | 15 | 0 | 0 |
| 1984 | 31 | 27 | 11 | 31 | 19 | 0 | 31 | 0 |
| 1985 | 31 | 31 | 22 | 31 | 27 | 0 | 0 | 0 |
| 1986 | 2 | 26 | 13 | 18 | 31 | 29 | 13 | 31 |
| 1987 | 31 | 17 | 26 | 19 | 11 | 26 | 0 | 0 |
| 1988 | 15 | 0 | 0 | 21 | 17 | 0 | 0 | 0 |
| 1989 | 0 | 22 | 0 | 11 | 4 | 0 | 20 | 0 |
| 1990 | 31 | 26 | 22 | 13 | 6 | 0 | 15 | 7 |
| 1991 | 4 | 17 | 31 | 31 | 0 | 0 | 20 | 0 |
| 1992 | 17 | 19 | 11 | 20 | 7 | 12 | 0 | 0 |
| 1993 | 31 | 31 | 21 | 21 | 18 | 0 | 0 | 0 |
| 1994 | 2 | 31 | 31 | 31 | 22 | 7 | 28 | 18 |
| 1995 | 22 | 0 | 10 | 0 | 24 | 12 | 0 | 19 |
| 1996 | 31 | 29 | 3 | 31 | 28 | 0 | 0 | 0 |
| 1997 | 29 | 22 | 6 | 31 | 13 | 0 | 10 | 21 |
| 1998 | 13 | 17 | 19 | 5 | 0 | 0 | 9 | 0 |
| 1999 | 12 | 11 | 4 | 14 | 31 | 21 | 15 | 13 |
| 2000 | 0 | 14 | 25 | 23 | 7 | 14 | 0 | 0 |
| 2001 | 5 | 31 | 21 | 0 | 28 | 14 | 0 | 0 |
| 2002 | 23 | 17 | 16 | 0 | 13 | 7 | 31 | 25 |
| 2003 | 10 | 26 | 22 | 31 | 0 | 0 | 0 | 0 |
| 2004 | 25 | 0 | 19 | 7 | 0 | 31 | 10 | 3 |
| 2005 | 0 | 12 | 24 | 8 | 8 | 25 | 24 | 11 |
| 2006 | 14 | 17 | 11 | 18 | 2 | 10 | 13 | 31 |
| 2007 | 6 | 15 | 3 | 0 | 0 | 0 | 0 | 0 |
| 2008 | 10 | 31 | 19 | 4 | 0 | 31 | 30 | 15 |
| 2009 | 23 | 0 | 15 | 1 | 22 | 7 | 0 | 17 |
| 2010 | 28 | 14 | 31 | 31 | 7 | 22 | 15 | 14 |
| Avg. | 17.4 | 18.93 | 15.6 | 16.83 | 13.03 | 9.4 | 10.43 | 9.96 |
| SD(days) | 13.78 | 10.15 | 9.74 | 11.9 | 10.53 | 10.79 | 13.18 | 10.74 |

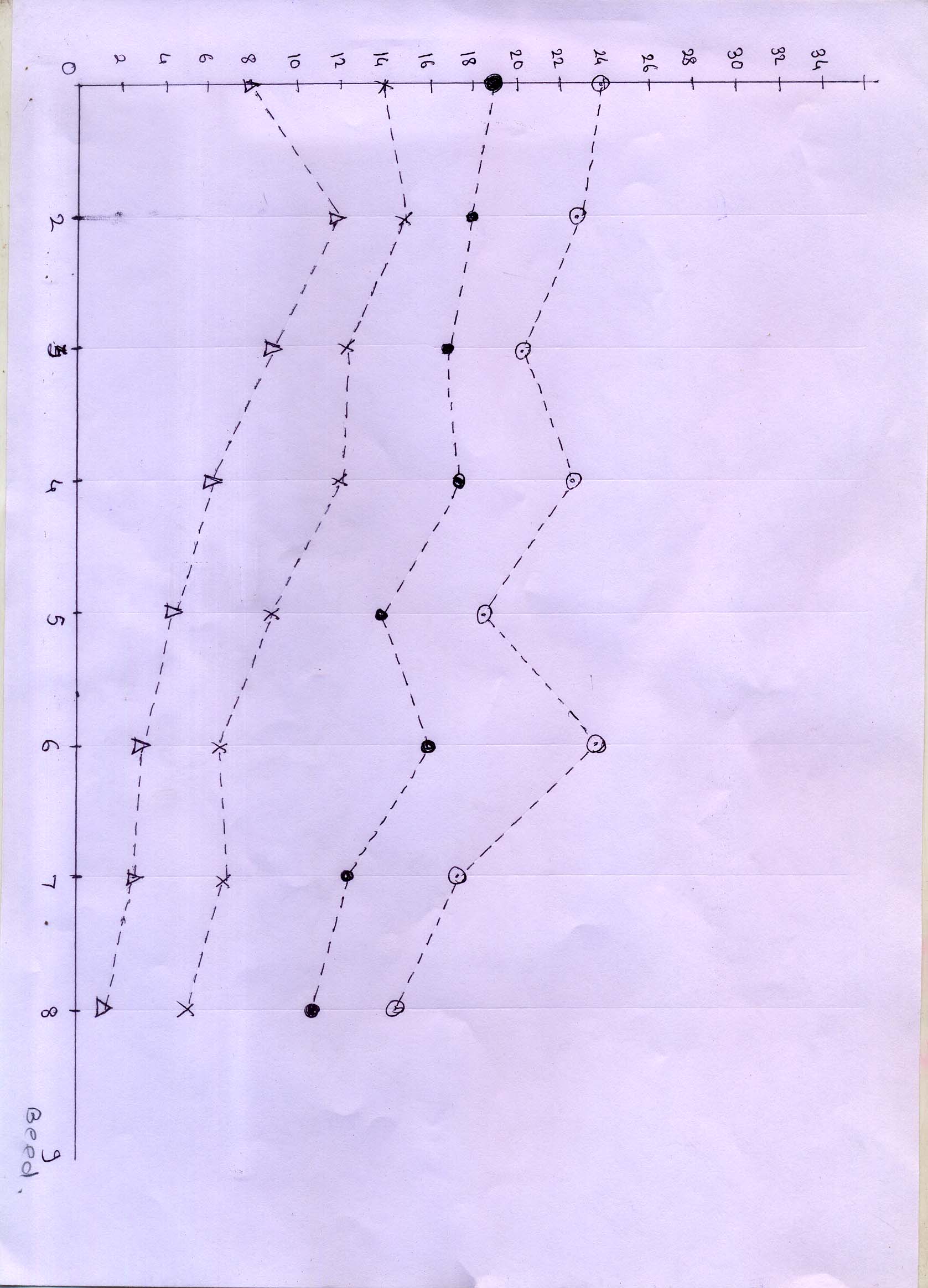
**Critical dry spells at different probability levels**

The critical dry spell durations at 25, 40, 60, 80 per cent probability level with respect to eight fortnight of the season have been presented in figure. 1. The established relationships for all fortnights for Beed station have been presented in Table 6.

From figure it was observed that trend of lines at all levels and through all fortnights was same except from first to second fortnight at 25 and 40 percent level. The trend of variation of critical dry spell duration was observed similar for first to second fortnight at all level and gradually increases from seven to right fortnight at all levels. The dry spell duration is highest at first & seventh during fortnight.

**Table 6: Probabilities of dry spells in the fortnight for Beed station**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Order No.** | **Proba**  **bility by**  **weibuls method** | **June** | | | | **July** | | | | **Aug** | | | | **Sept** | | | |
| **1-15**  **F1** | | **16-30**  **F2** | | **1-15**  **F3** | | **16-30**  **F4** | | **1-15**  **F5** | | **16-30**  **F6** | | **1-15**  **F7** | | **16-30**  **F8** | |
| **Probability by Gumbels method, DS = days, % per cent** | | | | | | | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|  |  | **DS** | **%** | **DS** | **%** | **DS** | **%** | **DS** | **%** | **DS** | **%** | **DS** | **%** | **DS** | **%** | **DS** | **%** |
| 1 | 3.22 | 31 | 14.68 | 31 | 11.52 | 31 | 7.15 | 31 | 11.5 | 31 | 6.13 | 31 | 4.23 | 31 | 7.36 | 31 | 4.40 |
| 2 | 6.45 | 31 | 14.68 | 31 | 11.52 | 31 | 7.15 | 31 | 11.5 | 31 | 6.13 | 31 | 4.23 | 31 | 7.36 | 31 | 4.40 |
| 3 | 9.67 | 31 | 14.68 | 31 | 11.52 | 31 | 7.15 | 31 | 11.5 | 28 | 8.67 | 29 | 5.35 | 30 | 8.03 | 27 | 7.02 |
| 4 | 12.90 | 31 | 14.68 | 31 | 11.52 | 26 | 13.38 | 31 | 11.5 | 28 | 8.67 | 26 | 7.51 | 28 | 9.72 | 25 | 8.6 |
| 5 | 16.12 | 31 | 14.68 | 31 | 11.52 | 25 | 15.09 | 31 | 11.5 | 27 | 9.81 | 25 | 8.42 | 24 | 14.0 | 21 | 13.9 |
| 6 | 19.35 | 31 | 14.68 | 31 | 11.52 | 24 | 17.00 | 31 | 11.5 | 24 | 13.76 | 22 | 11.8 | 20 | 19.9 | 19 | 16.7 |
| 7 | 22.58 | 31 | 14.68 | 29 | 11.52 | 22 | 21.66 | 31 | 11.5 | 22 | 17.31 | 21 | 13.2 | 20 | 19.9 | 18 | 19.9 |
| 8 | 25.80 | 31 | 14.68 | 27 | 11.52 | 22 | 21.66 | 31 | 11.5 | 22 | 17.31 | 15 | 25.1 | 15 | 30.2 | 17 | 21.8 |
| 9 | 29.09 | 29 | 17.47 | 26 | 14.52 | 22 | 21.66 | 31 | 11.5 | 20 | 21.47 | 14 | 27.9 | 15 | 30.2 | 15 | 26.0 |
| 10 | 32.25 | 28 | 18.95 | 26 | 18.08 | 21 | 24.27 | 23 | 25.1 | 19 | 23.85 | 14 | 27.9 | 15 | 30.2 | 14 | 28.3 |
| 11 | 35.45 | 25 | 24.27 | 26 | 20.54 | 21 | 24.27 | 23 | 25.1 | 19 | 23.85 | 13 | 30.2 | 13 | 35.6 | 13 | 33.4 |
| 12 | 38.70 | 23 | 28.55 | 24 | 20.54 | 21 | 24.27 | 21 | 30.3 | 18 | 26.45 | 12 | 33.9 | 11 | 41.2 | 11 | 39.1 |
| 13 | 41.93 | 23 | 28.55 | 22 | 20.54 | 19 | 30.27 | 21 | 30.3 | 13 | 43.19 | 12 | 38.9 | 10 | 44.5 | 7 | 71.9 |
| 14 | 45.16 | 22 | 30.77 | 19 | 25.56 | 19 | 30.27 | 20 | 32.9 | 13 | 43.19 | 10 | 40.9 | 10 | 44.5 | 3 | 72.3 |
| 15 | 48.38 | 17 | 44.48 | 17 | 31.81 | 19 | 30.27 | 19 | 35.9 | 11 | 51.62 | 7 | 52.7 | 9 | 78.5 | 0 | 83.8 |
| 16 | 51.61 | 15 | 50.57 | 17 | 31.81 | 16 | 41.60 | 18 | 39.4 | 8 | 64.31 | 7 | 52.7 | 0 | 78.5 | 0 | 83.8 |
| 17 | 54.83 | 14 | 53.74 | 17 | 42.87 | 15 | 45.80 | 18 | 39.4 | 7 | 68.70 | 7 | 52.7 | 0 | 78.5 | 0 | 83.8 |
| 18 | 58.06 | 14 | 53.74 | 17 | 51.27 | 13 | 54.82 | 14 | 53.3 | 7 | 68.70 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |
| 19 | 61.29 | 13 | 51.35 | 17 | 51.27 | 11 | 63.94 | 13 | 57.3 | 7 | 68.70 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |
| 20 | 64.51 | 12 | 60.63 | 15 | 60.27 | 11 | 63.94 | 11 | 77.5 | 6 | 68.70 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |
| 21 | 67.74 | 10 | 67.25 | 14 | 78.17 | 11 | 63.94 | 8 | 76.5 | 4 | 73.01 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |
| 22 | 70.96 | 10 | 67.25 | 14 | 78.17 | 10 | 69.07 | 7 | 80.1 | 2 | 81.40 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |
| 23 | 74.19 | 6 | 80.13 | 12 | 78.11 | 8 | 70.17 | 6 | 83.8 | 0 | 93.40 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |
| 24 | 77.41 | 5 | 83.82 | 11 | 78.17 | 6 | 86.10 | 3 | 91.5 | 0 | 93.40 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |
| 25 | 80.64 | 4 | 86.65 | 11 | 78.12 | 3 | 94.73 | 1 | 95.3 | 0 | 93.40 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |
| 26 | 83.87 | 2 | 91.45 | 10 | 82.02 | 3 | 94.73 | 0 | 96.4 | 0 | 93.40 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |
| 27 | 87.09 | 2 | 91.45 | 0 | 99.77 | 3 | 94.73 | 0 | 96.4 | 0 | 93.40 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |
| 28 | 90.32 | 0 | 93.92 | 0 | 99.77 | 0 | 98.70 | 0 | 96.4 | 0 | 93.40 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |
| 29 | 93.54 | 0 | 93.92 | 0 | 99.77 | 0 | 98.70 | 0 | 96.4 | 0 | 93.40 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |
| 30 | 96.77 | 0 | 93.92 | 0 | 99.77 | 0 | 98.70 | 0 | 96.4 | 0 | 93.40 | 0 | 82.0 | 0 | 78.5 | 0 | 83.8 |

****

**° = 25%**

**• = 40%**

**× = 60%**

**Δ = 80%**

Fig 1: Dry spell duration at different probability level for Beed station

**Analysis for Jalna station**

**Onset and withdrawal of effective monsoon**

The criteria (Ashok Raj 1979) was used for determination of OEM and withdrawal of effective monsoon. The result have been presented in table.7.

**Table 7: Dates of onset and withdrawal effective monsoon for Jalna station**

|  |  |  |
| --- | --- | --- |
| **Year** | **Effective monsoon** | |
| **Onsets on** | **Ends on** |
| 1981 | 10 June | 31 Oct |
| 1982 | 20 June | 28 Oct |
| 1983 | 9 July | 14 Oct |
| 1984 | 13 July | 24 Oct |
| 1985 | 8 June | 9 Oct |
| 1986 | 11 June | 24 Sept |
| 1987 | 11 June | 18 Oct |
| 1988 | 12 June | 4 Oct |
| 1989 | 2 June | 2 Oct |
| 1990 | 8 June | 31 Oct |
| 1991 | 7 June | 16 Sept |
| 1992 | 15 June | 12 Oct |
| 1993 | 13 June | 22 Nov |
| 1994 | 24 Aug | 21 Oct |
| 1995 | 15 July | 15 Oct |
| 1996 | 5 July | 18 Oct |
| 1997 | 30 June | 29 Oct |
| 1998 | 11 June | 10 Nov |
| 1999 | 10 June | 9 Oct |
| 2000 | 3 July | 9 Oct |
| 2001 | 7 June | 13 Oct |
| 2002 | 23 June | 17 Oct |
| 2003 | 6 June | 22 Sept |
| 2004 | 22 July | 22 Sept |
| 2005 | 3 July | 13 Sept |
| 2006 | 30 May | 2 Sept |
| 2007 | 26 June | 2 Oct |
| 2008 | 1 June | 10 Oct |
| 2009 | 18 June | 8 Oct |
| 2010 | 11 June | 24 Oct |

* + 1. **Critical dry spells**

When the duration of dry spell exceeds a certain value depending on crop soil complex on region, it is called as critical dry spell. Critical dry spells at range from 1 to 4 during each year. It was also observed that only one CDS occurred 1983,2004 and maximum four CDS occurred during 1982, 1985, 2002, and 2008.

Average dates of commencement of critical dry spells and their mean duration are shown in Table 8. This table indicates that the average date of OEM was 11 June and its withdrawal was 22 Sept with highest standard deviation of 29 days and lowest standard deviation 13 days total 104 dry spells observed and average number of CDS were 3.

**Table 8: Critical dry spell during year for Jalna Station**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | 1CDS | Duration days | II CDS | Duration days | III CDS | Duration days | IV CDS | Duration days | Total No. CDS/  YR |
| 1981 | 11 July | 24 | 10 Aug | 19 | 7 Oct | 18 | -- | -- | 3 |
| 1982 | 21 July | 20 | 22 Aug | 16 | 11Sep | 13 | 28 Sep | 24 | 4 |
| 1983 | 28 Sept | 15 | -- | -- | -- | -- | -- | -- | 1 |
| 1984 | 3 Aug | 39 | 11 Oct | 11 | -- | -- | -- | -- | 2 |
| 1985 | 5 July | 11 | 26 July | 17 | 16Aug | 27 | 20 Sept | 12 | 4 |
| 1986 | 17 June | 26 | 23 July | 12 | 12Aug | 37 | -- | -- | 3 |
| 1987 | 24 July | 12 | 28 Aug | 35 | 6 Oct | 11 | -- | -- | 3 |
| 1988 | 24 June | 12 | 28 July | 22 | -- | -- | -- | -- | 2 |
| 1989 | 14 June | 20 | 25 July | 6 | 20Aug | 29 | -- | -- | 3 |
| 1990 | 20 June | 26 | 31 Aug | 22 | 13 Oct | 11 | -- | -- | 3 |
| 1991 | 12 June | 14 | 17 July | 49 | -- | -- | -- | -- | 2 |
| 1992 | 25 June | 16 | 14 July | 20 | 4Sep | 36 | -- | -- | 3 |
| 1993 | 19 June | 11 | 7 Aug | 13 | 4Sep | 12 | -- | -- | 3 |
| 1994 | 9 Sept | 27 | 7 Oct | 13 | -- | -- | -- | -- | 2 |
| 1995 | 29 July | 30 | 15 Sept | 26 | -- | -- | -- | -- | 2 |
| 1996 | 18 July | 21 | 11 Aug | 14 | 1 Sep | 11 | -- | -- | 3 |
| 1997 | 10 July | 36 | 29 Aug | 12 | 25Sep | 33 | -- | -- | 3 |
| 1998 | 30 June | 20 | 12 Aug | 11 | 27Aug | 15 | -- | -- | 3 |
| 1999 | 20 June | 17 | 20 July | 12 | 10Aug | 24 | -- | -- | 3 |
| 2000 | 14 July | 25 | 29 Aug | 19 | 25 Sep | 13 | -- | -- | 3 |
| 2001 | 20 June | 41 | 25 Aug | 30 | -- | -- | -- | -- | 2 |
| 2002 | 27 June | 19 | 20 July | 12 | 8Aug | 15 | 6 Sept | 40 | 4 |
| 2003 | 13 June | 13 | 5 July | 18 | 22Sep | 71 | -- | -- | 3 |
| 2004 | 15 Aug | 16 | -- | -- | -- | -- | -- | -- | 1 |
| 2005 | -- | -- | -- | -- | -- | -- | -- | -- | 0 |
| 2006 | 12 June | 17 | 15 July | 23 | -- | -- | -- | -- | 2 |
| 2007 | 1 July | 16 | 12 Sept | 16 | -- | -- | -- | -- | 2 |
| 2008 | 16 June | 12 | 15 July | 24 | 31Aug | 25 | 27 Sept | 11 | 4 |
| 2009 | 6 July | 23 | 10 Aug | 17 | -- | -- | -- | -- | 2 |
| 2010 | 18 June | 13 | 1 Aug | 12 | 21Sep | 30 | -- | -- | 3 |
| Average | 8 July | 20 days | 12 Aug | 19 days | 7 Aug | 24 days | 24 Sept | 19 days |  |
| SD (days) | **26** | **8** | **25** | **9** | **20** | **15** | **14** | **9** | **--** |

* + 1. **Wet spell analysis**

The interval between OEM and beginning of first critical dry spell is called as first wet spell. The subsequent wet spells are interval between two critical dry spells, thus the wet spells are spells of prolonged rain with possible intervening dry spells of duration less than value depending on crop soil complex of region.

**Table 9 : Wet spells during year for Jalna station.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **I wet spell** | **duration days** | **II wet spell** | **duration days** | **III wet spell** | **duration days** | **IV wet spell** | **duration days** |
| 1981 | 10 June | 31 | 4 Aug | 6 | 29 Aug | 39 | 25 Oct | 6 |
| 1982 | 20 June | 31 | 10 Aug | 12 | 7 Sept | 4 | 24 Sept | 4 |
| 1983 | 9 July | 81 | 13 Oct | 1 | -- | -- | -- | -- |
| 1984 | 13 July | 21 | 11 Sept | 10 | 22 Oct | 2 | -- | -- |
| 1985 | 8 June | 27 | 16 July | 10 | 12 Aug | 4 | 12 Sept | 8 |
| 1986 | 11 June | 6 | 13 July | 10 | 4 Aug | 8 | 18 Sept | 6 |
| 1987 | 11 June | 43 | 5 Aug | 23 | 2 Oct | 4 | 17 Oct | 1 |
| 1988 | 12 June | 12 | 6 July | 22 | 19Aug | 46 | -- | -- |
| 1989 | 2 June | 12 | 4 July | 21 | 4Aug | 16 | 18 Sept | 32 |
| 1990 | 8 June | 12 | 16 July | 46 | 22 Sept | 21 | 24 Oct | 7 |
| 1991 | 7 June | 5 | 26 June | 21 | 4 Sept | 12 | -- | -- |
| 1992 | 15 June | 10 | 11 July | 3 | 4Aug | 31 | 10 Oct | 2 |
| 1993 | 13 June | 6 | 30 June | 38 | 20 Aug | 15 | 16 Oct | 67 |
| 1994 | 24 Aug | 16 | 6 Oct | 1 | 20 Oct | 1 | -- | -- |
| 1995 | 15 July | 14 | 28 Aug | 18 | 11 Oct | 4 | -- | -- |
| 1996 | 5 July | 13 | 8 Aug | 3 | 25 Aug | 7 | 12 Sept | 46 |
| 1997 | 30 June | 10 | 15 Aug | 14 | 10 Sept | 15 | 28 Oct | 1 |
| 1998 | 11 June | 19 | 20 July | 23 | 23 Aug | 4 | 11 Sept | 29 |
| 1999 | 10 June | 10 | 7 July | 13 | 1 Aug | 9 | 3 Sept | 30 |
| 2000 | 3 July | 11 | 10 Aug | 19 | 17 Sept | 8 | 8 Oct | 1 |
| 2001 | 7 June | 13 | 31 July | 25 | 24 Sept | 19 | -- | -- |
| 2002 | 23 June | 4 | 16 July | 4 | 1 Aug | 7 | 23 Aug | 14 |
| 2003 | 6 June | 7 | 26 June | 9 | 23 July | 30 | 1 Dec | 71 |
| 2004 | 22 July | 24 | 31 Aug | 22 | -- | -- | -- | -- |
| 2005 | 3 July | 1 | -- | -- | -- | -- | -- | -- |
| 2006 | 30 May | 13 | 29 June | 16 | 9 Aug | 24 | -- | -- |
| 2007 | 26 June | 5 | 17 July | 57 | 28 Sept | 4 | -- | -- |
| 2008 | 1 June | 15 | 28 June | 17 | 8 Aug | 23 | 23 Sept | 2 |
| 2009 | 18 June | 18 | 6 July | 12 | 27 Aug | 42 | -- | -- |
| 2010 | 11 June | 7 | 31 June | 32 | 13 Aug | 39 | 21 Oct | 3 |
| Avg. | 22June | 15.7 | 27July | 17.5 | 30Aug | 16.46 | 7Oct | 18.66 |
| SD(days) | 18.05 | 15.1 | 29.9 | 13.09 | 26.7 | 13.45 | 25.97 | 22.94 |

Table 9. shows wet spell duration. After observation of table it was observed that 29.9 was highest standard deviation and lowest standard deviation was 13.9. Total 104 wet spells were observed. Mean date of first wet spell was 22 June with mean duration, mean date of second 27 July, 18 days, third mean date 1 Sept with 16 days and fourth mean date 7 Oct with 8 days.

**Fortnightly dry spell probability analysis**

Monsoon period is divided into eight fortnight starting from 1 June. Allotment of dry spell during eight fortnights was done on the basis of commencement of dry spell in the criteria.

The allotment of critical dry spell duration during fortnight have been presented in table 10. After observation of table 10. It was observed that among all eight fortnights, maximum duration of dry spell was 31 days. Mean duration of critical dry spell was observed as 13.96 days was highest during seventh fortnight and minimum mean duration was observed as is 10.23 first fortnight. It was also observed that lowest standard deviation was in the 8.54 and highest standard deviation was in eight fortnight i.e. 12.27. Order of fortnights to mean duration of critical dry spell was observed as

F4 < F3 < F8 <F5 <F6 <F7 <F1<F2

**Table 10: Duration of dry spell during fortnight of the monsoon season for Jalna station.**

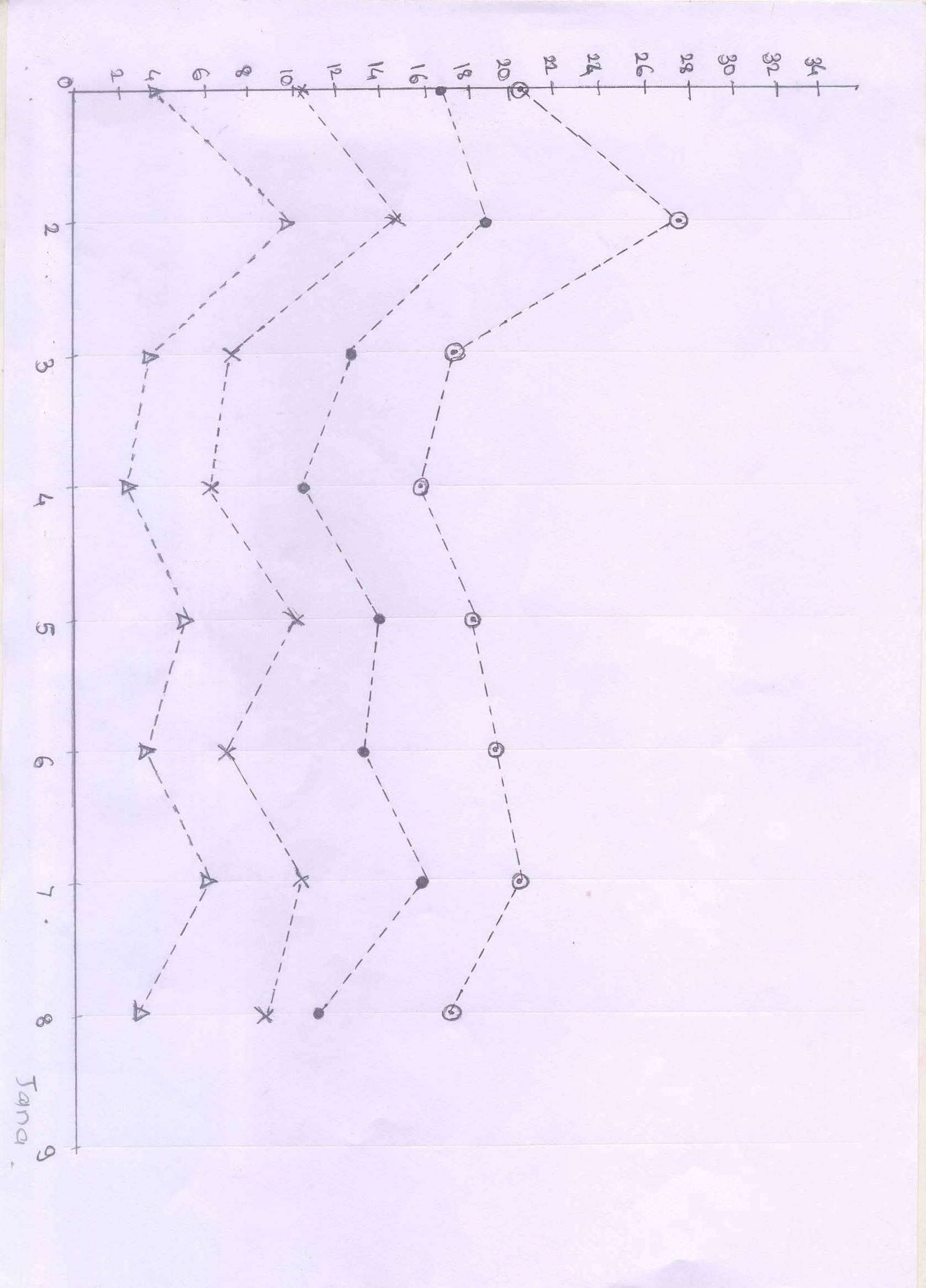
|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **June** | | **July** | | **August** | | **September** | |
| **1-15** | **16-30** | **1-15** | **16-30** | **1-15** | **16-30** | **1-15** | **16-30** |
| **F1** | **F2** | **F3** | **F4** | **F5** | **F6** | **F7** | **F8** |
| 1981 | 9 | 26 | 24 | 19 | 19 | 13 | 0 | 24 |
| 1982 | 19 | 31 | 0 | 20 | 10 | 10 | 13 | 15 |
| 1983 | 31 | 24 | 8 | 0 | 0 | 0 | 30 | 0 |
| 1984 | 31 | 28 | 12 | 0 | 31 | 26 | 0 | 12 |
| 1985 | 7 | 0 | 11 | 17 | 11 | 27 | 9 | 0 |
| 1986 | 10 | 26 | 11 | 12 | 31 | 31 | 6 | 0 |
| 1987 | 10 | 31 | 0 | 12 | 4 | 31 | 31 | 0 |
| 1988 | 11 | 12 | 5 | 22 | 18 | 0 | 0 | 0 |
| 1989 | 1 | 20 | 0 | 10 | 4 | 29 | 0 | 0 |
| 1990 | 7 | 26 | 15 | 0 | 0 | 22 | 31 | 0 |
| 1991 | 6 | 14 | 0 | 31 | 18 | 0 | 10 | 0 |
| 1992 | 14 | 16 | 20 | 18 | 31 | 24 | 0 | 0 |
| 1993 | 12 | 11 | 0 | 0 | 13 | 4 | 12 | 0 |
| 1994 | 31 | 31 | 0 | 0 | 23 | 0 | 27 | 20 |
| 1995 | 31 | 30 | 14 | 30 | 27 | 0 | 26 | 0 |
| 1996 | 31 | 25 | 4 | 21 | 14 | 9 | 11 | 0 |
| 1997 | 29 | 20 | 31 | 5 | 0 | 12 | 8 | 31 |
| 1998 | 10 | 17 | 19 | 0 | 11 | 15 | 10 | 0 |
| 1999 | 9 | 18 | 2 | 12 | 24 | 18 | 20 | 0 |
| 2000 | 31 | 31 | 2 | 25 | 8 | 19 | 16 | 13 |
| 2001 | 6 | 13 | 31 | 0 | 0 | 30 | 23 | 0 |
| 2002 | 22 | 19 | 15 | 12 | 15 | 8 | 31 | 30 |
| 2003 | 5 | 13 | 18 | 7 | 0 | 0 | 0 | 31 |
| 2004 | 31 | 31 | 21 | 0 | 16 | 15 | 31 | 0 |
| 2005 | 31 | 18 | 2 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 0 | 17 | 23 | 22 | 8 | 0 | 0 | 0 |
| 2007 | 25 | 16 | 16 | 0 | 0 | 0 | 16 | 12 |
| 2008 | 0 | 12 | 24 | 0 | 9 | 25 | 24 | 11 |
| 2009 | 17 | 0 | 23 | 13 | 17 | 11 | 0 | 0 |
| 2010 | 10 | 13 | 0 | 0 | 12 | 0 | 30 | 30 |
| Avg. | 10.23 | 19.86 | 11.7 | 10.26 | 12.46 | 12.83 | 19.78 | 20.81 |
| SD(days) | 11.74 | 8.54 | 10.31 | 9.26 | 9.8 | 11.44 | 10.67 | 12.27 |

* + 1. **Critical dry spells at different probability levels**

The critical dry spell durations at 25, 40, 60, 80 per cent probability level with respect to eight fortnight of the season have been presented in figure.2. The established relationships for all fortnights for Jalna station have been presented in Table 11.

**Table 11: Probabilities of dry spells in the fortnight for Jalna station**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Order No.** | **Proba-**  **bility by**  **weibuls method** | **June** | | | | **July** | | | | **Aug** | | | | **Sept** | | | |
| **1-15**  **F1** | | **16-30**  **F2** | | **1-15**  **F3** | | **16-30**  **F4** | | **1-15**  **F5** | | **16-30**  **F6** | | **1-15**  **F7** | | **16-30**  **F8** | |
| **Probability by Gumbels method, DS = days, % per cent** | | | | | | | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|  |  | **DS** | **%** | **DS** | **%** | **DS** | **%** | **DS** | **%** | **DS** | **%** | **DS** | **%** | **DS** | **%** | **DS** | **%** |
| 1 | 3.22 | 31 | 9.53 | 31 | 10.0 | 31 | 5.00 | 31 | 3.15 | 31 | 4.85 | 31 | 7.08 | 31 | 7.02 | 31 | 7.15 |
| 2 | 6.45 | 31 | 9.53 | 31 | 10.0 | 31 | 5.00 | 30 | 3.15 | 31 | 4.85 | 31 | 7.08 | 31 | 7.02 | 31 | 7.15 |
| 3 | 9.67 | 31 | 9.53 | 31 | 10.0 | 24 | 11.52 | 25 | 7.08 | 31 | 4.85 | 30 | 7.08 | 31 | 7.02 | 31 | 7.15 |
| 4 | 12.90 | 31 | 9.53 | 31 | 10.0 | 24 | 11.52 | 22 | 10.5 | 27 | 8.03 | 29 | 7.08 | 31 | 7.02 | 30 | 7.43 |
| 5 | 16.12 | 31 | 9.53 | 31 | 10.0 | 23 | 12.89 | 22 | 10.5 | 24 | 11.74 | 27 | 10.5 | 31 | 7.02 | 30 | 7.43 |
| 6 | 19.35 | 31 | 9.53 | 30 | 11.63 | 23 | 12.89 | 21 | 11.9 | 23 | 13.26 | 26 | 12.0 | 31 | 7.02 | 30 | 7.43 |
| 7 | 22.58 | 31 | 9.53 | 28 | 15.37 | 21 | 16.24 | 20 | 13.6 | 19 | 21.28 | 25 | 13.4 | 31 | 7.02 | 30 | 7.43 |
| 8 | 25.80 | 31 | 9.53 | 26 | 20.17 | 20 | 18.28 | 19 | 15.5 | 18 | 23.85 | 24 | 14.8 | 27 | 11.0 | 24 | 13.5 |
| 9 | 29.09 | 29 | 12.19 | 26 | 20.17 | 19 | 20.35 | 18 | 17.6 | 18 | 23.85 | 22 | 18.8 | 26 | 12.4 | 20 | 22.2 |
| 10 | 32.25 | 25 | 18.61 | 26 | 20.17 | 18 | 22.63 | 17 | 19.8 | 17 | 26.68 | 19 | 24.4 | 24 | 15.5 | 15 | 31.0 |
| 11 | 35.45 | 22 | 25.12 | 25 | 23.03 | 16 | 28.07 | 13 | 32.1 | 16 | 29.77 | 18 | 27.1 | 23 | 17.3 | 13 | 36.7 |
| 12 | 38.70 | 19 | 33.67 | 24 | 26.23 | 15 | 31.29 | 12 | 35.9 | 15 | 33.40 | 16 | 32.7 | 16 | 35.7 | 12 | 39.7 |
| 13 | 41.93 | 17 | 40.36 | 20 | 59.81 | 15 | 31.29 | 12 | 35.9 | 14 | 37.06 | 15 | 24.9 | 16 | 35.7 | 12 | 39.7 |
| 14 | 45.16 | 14 | 51.62 | 20 | 59.81 | 14 | 34.56 | 12 | 35.9 | 13 | 40.97 | 15 | 24.9 | 13 | 46.8 | 11 | 43.1 |
| 15 | 48.38 | 12 | 59.90 | 20 | 59.81 | 12 | 41.92 | 12 | 35.9 | 12 | 45.14 | 13 | 42.5 | 12 | 50.9 | 10 | 46.4 |
| 16 | 51.61 | 11 | 63.94 | 19 | 47.14 | 11 | 45.80 | 10 | 44.1 | 11 | 49.53 | 12 | 46.1 | 11 | 55.2 | 0 | 82.9 |
| 17 | 54.83 | 10 | 68.34 | 18 | 52.68 | 11 | 45.80 | 7 | 58.1 | 11 | 49.53 | 11 | 49.8 | 10 | 59.5 | 0 | 82.9 |
| 18 | 58.06 | 10 | 68.34 | 18 | 52.68 | 8 | 59.17 | 5 | 68.7 | 10 | 54.10 | 9 | 58.0 | 9 | 63.5 | 0 | 82.9 |
| 19 | 61.29 | 10 | 68.34 | 17 | 52.68 | 5 | 72.30 | 0 | 90.1 | 9 | 58.80 | 8 | 62.1 | 8 | 58.4 | 0 | 82.9 |
| 20 | 64.51 | 10 | 68.34 | 17 | 52.68 | 4 | 78.82 | 0 | 90.1 | 8 | 63.45 | 4 | 77.8 | 0 | 94.8 | 0 | 82.9 |
| 21 | 67.74 | 9 | 72.30 | 16 | 63.30 | 2 | 41.60 | 0 | 90.1 | 8 | 63.45 | 0 | 90.5 | 0 | 94.8 | 0 | 82.9 |
| 22 | 70.96 | 9 | 72.30 | 16 | 63.30 | 2 | 41.60 | 0 | 90.1 | 4 | 81.71 | 0 | 90.5 | 0 | 94.8 | 0 | 82.9 |
| 23 | 74.19 | 7 | 46.14 | 14 | 74.07 | 2 | 41.60 | 0 | 90.1 | 0 | 94.25 | 0 | 90.5 | 0 | 94.8 | 0 | 82.9 |
| 24 | 77.41 | 7 | 46.14 | 13 | 79.16 | 0 | 90.80 | 0 | 90.1 | 0 | 94.25 | 0 | 90.5 | 0 | 94.8 | 0 | 82.9 |
| 25 | 80.64 | 6 | 83.83 | 13 | 79.16 | 0 | 90.80 | 0 | 90.1 | 0 | 94.25 | 0 | 90.5 | 0 | 94.8 | 0 | 82.9 |
| 26 | 83.87 | 6 | 83.83 | 12 | 83.83 | 0 | 90.80 | 0 | 90.1 | 0 | 94.25 | 0 | 90.5 | 0 | 94.8 | 0 | 82.9 |
| 27 | 87.09 | 5 | 38.83 | 12 | 83.83 | 0 | 90.80 | 0 | 90.1 | 0 | 94.25 | 0 | 90.5 | 0 | 94.8 | 0 | 82.9 |
| 28 | 90.32 | 1 | 96.01 | 11 | 81.96 | 0 | 90.80 | 0 | 90.1 | 0 | 94.25 | 0 | 90.5 | 0 | 94.8 | 0 | 82.9 |
| 29 | 93.54 | 0 | 97.35 | 0 | 99.9 | 0 | 90.80 | 0 | 90.1 | 0 | 94.25 | 0 | 90.5 | 0 | 94.8 | 0 | 82.9 |
| 30 | 96.77 | 0 | 97.35 | 0 | 99.9 | 0 | 90.80 | 0 | 90.1 | 0 | 94.25 | 0 | 90.5 | 0 | 94.8 | 0 | 82.9 |

****

**° = 25%**

**• = 40%**

**× = 60%**

**Δ = 80%**

Fig.2: Dry spell duration at different probability levels for Jalana station.

**SUMMARY AND CONCLUSION**

The records of daily rainfall data for important 2 rain gauge station, one in each district of Marathwada region were obtained from Indian Meteorological Department, Pune. The period for which data were available range from 1981 to 2010 years.

Mean dates of OEM for Beed is 20 June with standard deviation 16 days total 75 dry spells were observed during period of 30 years. Average number of CDS is 2 and mean date of first CDS was 4 July with 21 days and that of second CDS was 9 Aug with 29 days. Mean duration of dry spell was highest during 2 nd fortnight and lowest during 6 th fortnight.

Mean dates of OEM for Jalna is 21 June with standard deviation 18 days. Total 78 dry spells were observed during period by 30 years. Average number of CDS is 2 and mean date of first CDS was 8 July with 20 days and that of for second CDS was 12 Aug with 19 days. Mean duration of dry spell was highest during 2 nd fortnight and lowest during 4 th fortnight.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

**Option 1:**

**AUTHORS DISCLAMER/DECLARATION**

NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

**ACKNOWLEDGEMENT**

Daily rainfall data of 30 years from (1981 to 2010) were collected from India Meteorological Department, Pune, Maharashtra**.**

**REFERENCES**

Anil D, Shivakumar A, Hindhudhar KR3 and Pallavi CH.2017. Rainfall and dry Spell analysis for Mahabubnagar district. Bulletin of Environment, Pharmacology and Life Sciences. 6(9): 30-39.

Ashok Raj, P.C. (1979): Onset of effective monsoon and critical dry spells. A computer-based forecasting technique: IARI Bulletin No.2, WTC, IARI, New Delhi.

Bal SK and Minhas PS. 2017. Atmospheric Stressors: challenges and Coping Strategies. Abiotic Stress Management For Resilient Agriculture. 9–50.

Barron J, Rockstrom J, Gichuki F, Hatibu N 2003. Dry spell analysis and maize Based forecasting technique: IARI Bulletin No.2, WTC, IARI,New Delhi.

Biswas, B.G &amp; Maske S.D. (1981): Rainfall analysis for use in Dryland Agriculture. Indian J. soil Conservation,9 (2) :8-19.

Chakraborty S. and Newton AC. 2011. Climate change, plant diseases and food security: an overview. Plant Pathol. 60, 2–14.

NRAA, 2020. Prioritization of Districts for Development Planning in India: A Composite Index Approach. National Rainfed Area Authority, New Delhi, p. 85.

Rockstrom, J. &amp; Barron, J. (2002). Rainwater management for increased productivity among small-holder farmers in drought prone environments. Journal of. Physics and Chemistry of the Earth, Parts. 27, 949-959.

Sivakumar, M.V.K. (1988). Predicting rainy season potential from the onset of rains in southern sahe-lian and sudanian climatic zones of West Africa. Agriculture and Forest Meteorology. (42), 295–305

Srinivasa, R., Lal, R., Singh, R., Jakkula, V., Sahrawat, K., Venkateshwarlu, B., Sikka, A. &amp; Virmani S. (2015). Advances In Agronomy. 113-181. yields for two semi-arid locations in east Africa. Agric. For. Meteorol. 117:23-37.