International Journal of Agricultural Engineering, Vol. 4 No. 2 (October, 2011) : 160 -164

Research Paper :

Probability analysis of monthly and seasonal rainfall at Solapur, Maharashtra

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Received : May, 2011; Revised : July, 2011; Accepted : August, 2011

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ABSTRACT

The awareness of rainfall pattern, in terms of probability, helps in the planning of crops, different irrigation schemes and watershed management. Keeping it in view, the rainfall data of 22 years, from 1987 to 2008, were collected from the Dry Farming Research Station; Solapur were analyzed and discussed in this paper. Average annual rainfall was found to be 732.4 mm. Normal, surplus and drought months as well as seasons and years have been presented which may be useful for planning of agriculture and irrigation schemes. The per cent probability of *Zaid* and *Kharif* seasons to be normal is 81.82 % and 77.27 %, respectively. The probability for *Kharif* season to be drought is 4.55 % while that of *Zaid* season is 9.09 %. Total amount of rainwater available during the*Kharif*, *Rabi* and *Zaid* seasons was found to be in the range of 280.7 – 1100.3 mm, 0.0 – 128.7 mm and 63.7 – 452.5 mm, respectively. Thus the surplus amount of water during *Kharif* season may be stored in water harvesting structures, in order to provide supplemental irrigation for growing of wheat crop in *Rabi* season or in order to help in recharge of ground water.

Pradeep, C.M., Yasmin and Bhakar, S.R. (2011). Probability analysis of monthly and seasonal rainfall at Solapur, Maharashtra. *Internat. J. Agric. Engg.*, **4**(2) : 160-164.

Key words : Drought, Normal, Surplus seasons

Rainfall analysis is not only important for agricultural production but also for other administrative purposes. The distribution pattern of rainfall rather than the total rainfall during the entire period of time is more important for studying the pattern of rainfall occurrence. Of all the facts, water is the most precious and limiting natural resource in the world. Economic developments of any country depend on the factors in which water is one of the outstanding factor. Rainfall which is the main source of available water, play an important role in designing soil conservation structures, water harvesting structures, crop planning as well as watershed management strategies made by state government time to time. The probability distribution analysis of normal and surplus rainfall values, and drought events (months, seasons and years) were carried out for Solapur district of Maharashtra. The rainfall data of 22 years, from 1987 to 2008, were collected from Dry Farming Research Station; Solapur. Not only the farmer but also the policy makers and funding agencies have to depend on the seasonal rainfall. For seasonal analysis, therefore, the whole year was divided into three seasons *i.e. Kharif* (July to October), *Rabi* (November to February) and zaid (March to June). These were also classified as wettest and driest seasons on the basis of seasonal rainfall above and below the average annual rainfall of this district.

Pimpale *et al.* (2000) analyzed the rainfall data of 29 years (1970 - 1998) for finding out drought, normality and abnormality probability for Akola, Maharashtra. Ali (2002) tested the most important drought indices in different agro-ecological region for monitoring and analysis of drought conditions in the country. Thokal *et al.* (2003) studied the rainfall data of 31 years (1972 – 2002) of Dapoli located in Konakan region of Maharashtra state, was statistically analyzed weekly data of rainfall was found to be more useful for crop planning as water management practices than monthly, seasonal and annual data.

As rainwater utilization technology has to be site specific, it is necessary to use frequency analysis methodology for working out a strategy. Use of data analysis for crop management in irrigated and rainfed agriculture has been reported by several researchers for different regions (Druvanarayana *et al.,* 1978; Sharma *et al.,* 1979; Patil and Patil, 1989). In view of these objectives, analyses of rainfall on all these aspects have been undertaken for Solapur region of Maharashtra.

METHODOLOGY

The daily rainfall data were collected from Dry

Farming Research Station, Solapur. Solapur (17°42' N latitude and 75°48'E longitude and 457 m above mean sea level altitude) located on the south east edge of the state and lies entirely in Bhima and Seena basins. The entire district is drained by the Bhima River. The average rainfall of the station is about 732.4 mm. but the rainfall is highly erratic and irregular. The daily rainfall data for a period of 22 years (1987-2008) were converted into monthly, seasonal and annual rainfall. The daily rainfall was grouped as month, seasonal and annual, and the statistical parameters like average ($\overline{x}$), standard deviation (σ) and coefficient of variation (C_v) for all groups were worked out. Following the standard definitions, the years and months were classified as surplus, normal and drought.

The following definitions, suggested by Sharma *et al.* (1979) have been used in the analysis:

– Normal month: Any month receiving precipitation between 50 and 200 per cent of the monthly rainfall.

– Surplus month: Any month receiving precipitation greater than 200 per cent of the monthly rainfall.

– Drought month: Any month receiving precipitation less than 50 per cent of the monthly.

– Normal year: Any year receiving rainfall between ψ_1 and ψ_2. *i.e.* $\psi_1 < Y > \psi_2$

– Surplus year: Any year receiving rainfall greater than or equal to ψ_2. *i.e.* $Y \geq \psi_2$

– Drought year: Any year receiving rainfall less than or equal to ψ_1. *i.e.* $Y \leq \psi_1$

where, Y = annual rainfall (mm); $\psi_1 = \overline{X} - \sigma$; $\psi_2 = \overline{X} + \sigma$; $\overline{X}$ = mean annual rainfall (mm); and σ = standard deviation (mm).

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussion have been summarized under following heads:

Monthly and seasonal rainfall:

Mean, standard deviation (S.D.) and coefficient of variation (C.V.) for monthly, seasonally and annual rainfall over the study area, were calculated and are presented in Tables 1 and 2. Table 1 shows that September was the wettest month having average rainfall of about 175.9 mm with C.V. equal to 0.69 and February was the driest month receiving average rainfall just 2.3 mm with C.V. equal to 2.36. The wettest month next to September was August (average rainfall = 142.3 mm and C.V. = 0.67) and driest month next to February was January (average rainfall = 2.6 mm and C.V. = 3.09). Higher and longer values of coefficients of variation indicate the lesser and higher irregularity and randomness of nature, respectively. Out of total 264 months (22 years) normal, surplus and drought months were found to be 37.50, 14.77 and 47.73 % of the total months, respectively.

Table 2 shows that *Kharif* was the wettest season (average rainfall = 537.4 mm and C.V. = 0.41) whereas *Rabi* was the driest (average rainfall = 30.8 mm and C.V.=1.13). These wettest and driest seasons can be also clearly seen in Fig. 1. The per cent probability of *Zaid* season to be normal was 81.82 per cent, which was more and of *Kharif* season was 77.27 per cent. The probability

Table 2 : Seasonal rainfall statistics and distribution of normal, surplus and drought at Solapur

Seasons	*Kharif* season	*Rabi* season	*Zaid* season
Average Rainfall, mm	537.4	30.8	164.2
S.D.	222.3	34.8	85.9
C.V.	0.41	1.13	0.52
Normal season (%)	77.27	-	81.82
Surplus season (%)	18.18	13.64	9.09
Drought season (%)	4.55	-	9.09

Table 1 : Monthly rainfall (1987 – 2008) statistics at Solapur

Months	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Avg Rainfall (mm)	2.6	2.3	6.4	19.2	38.1	100.5	127.6	142.3	175.9	91.6	18.6	7.3
Ø $_1$–50 % of the monthly rainfall	1.3	1.2	3.2	9.6	19.1	50.2	63.8	71.1	88.0	45.8	9.3	3.7
Ø $_2$–200 % of the monthly rainfall	5.3	4.6	12.8	38.4	76.2	201.0	255.1	284.5	351.9	183.3	37.1	14.6
S.D. (σ)–standard deviation	8.1	5.5	12.1	17.5	39.4	75.2	72.8	94.6	121.3	78.5	31.6	14.5
C.V. – Coefficient of variation	3.09	2.36	1.90	0.91	1.03	0.75	0.57	0.67	0.69	0.86	1.70	1.99
NM– Normal month	5	1	4	9	7	16	16	13	13	10	4	1
SM– Surplus month	2	4	4	5	4	1	1	2	3	4	4	5
DM– Drought month	15	17	14	8	11	5	5	7	6	8	14	16

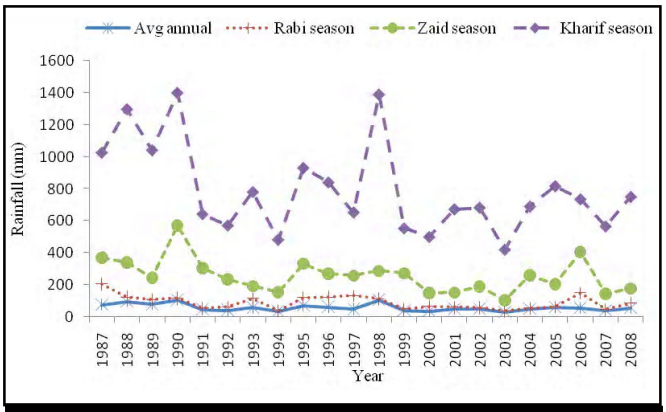

Fig. 1 : Variation in seasonal rainfall at Solapur

for *Zaid* season to be drought was 9.09 per cent which is higher in comparison to *Kharif* season 4.55 per cent while that of *Kharif*, *Rabi* and *Zaid* to be surplus is 18.18, 13.64 and 9.09 per cent, respectively. Standard deviation is very high so there was uncertainty of rainfall during *Rabi* season.

Drought, normal and surplus months:

It was obvious from Table 3 that occurrence of maximum number of droughts, normal and surplus months in a year was 8, 7 and 4, however, their probability of occurrence was merely 18.18 per cent, 18.18 per cent and 9.09 per cent of the total years. There was every possibility of occurrence of 3 drought months, 2 normal months with no surplus month in a year. Most of the drought occurred in the post and pre-monsoon period's *i.e.* October to May and highest frequency in February and normal rainfall occurred in the months between June to September and highest frequency in both June and July months. And for surplus rainfall, December and April months were the highest per cent probable months.

Month wise distribution of normal, drought and surplus rainfall confirms that the highest frequency of occurrence of normality was in both June and July months and percentage distribution of normal months varied from 1.01 to 16.16 (Table 4). It can also be seen that the percentage distribution of drought months varied from 3.97 to 13.49 indicating the assured rainfall during these months. During June to October, 61.82 per cent of the total months were normal, 28.18 per cent of drought and rest 10.0 per cent were surplus.

Table 3 : Probability distribution of normal month (NM), drought month (DM) and surplus month (SM) in a year and percentage of total years having the given number of NM, DM and SM

NM	Probability	% of total years having given number of NM	DM	Probability	% of total years having given number of DM	SM	Probability	% of total years having given number of SM
7	0.18	18.18	8	0.18	18.18	4	0.09	9.09
6	0.32	13.64	7	0.27	9.09	3	0.23	13.64
5	0.50	18.18	6	0.59	31.82	2	0.55	31.82
4	0.68	18.18	5	0.77	18.18	1	0.86	31.82
3	0.86	18.18	4	0.91	13.64	0	1.00	13.64
2	1.00	13.64	3	1.00	9.09			

Table 4 : Month wise distribution of normal, drought and surplus rainfall of Solapur

Month	% of total NM falling in given month	Normal rainfall % of total years having given month as NM	% of total DM falling in given month	Drought rainfall % of total years having given month as DM	% of total SM falling in given month	Surplus rainfall % of total years having given month as SM
Jan.	5.05	22.73	11.90	68.18	5.13	9.09
Feb.	1.01	4.55	13.49	77.27	10.26	18.18
Mar.	4.04	18.18	11.11	63.64	10.26	18.18
April	9.09	40.91	6.35	36.36	12.82	22.73
May	7.07	31.82	8.73	50.00	10.26	18.18
Jun.	16.16	72.73	3.97	22.73	2.56	4.55
Jul.	16.16	72.73	3.97	22.73	2.56	4.55
Aug.	13.13	59.09	5.56	31.82	5.13	9.09
Sept.	13.13	59.09	4.76	27.27	7.69	13.64
Oct.	10.10	45.45	6.35	36.36	10.26	18.18
Nov.	4.04	18.18	11.11	63.64	10.26	18.18
Dec.	1.01	4.55	12.70	72.73	12.82	22.73

During the *Rabi* season (October to February), out of total 126 months, the number of drought months worked out to be 70, which was accounted for 55.56 per cent of the total. This confirms the likelihood of failure of *Rabi* crops under rainfed conditions. The percentage distribution of drought months during *Rabi* season was from 36.36 to 72.27.

The relationship between average monthly rainfall and coefficient of variation indicates that in general, rainfall has inverse relationship with coefficient of variation *i.e.* decrease in coefficient of variation resulted increase in wetness of the month (Fig. 2). Fig. 2 also reveals that the monsoon season (June to September) was the wettest having maximum average rainfall with minimum uncertainty *i.e.* lesser C.V.

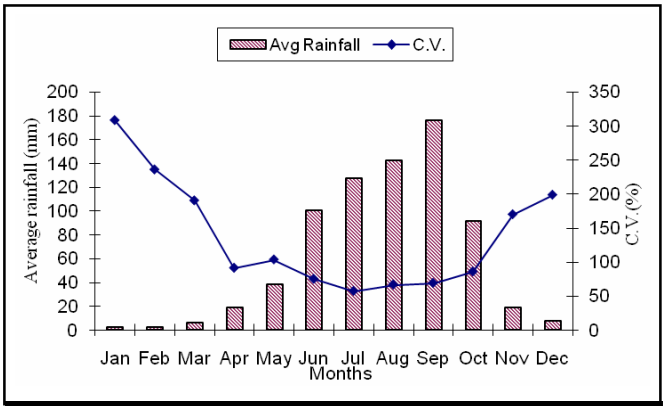

Fig. 2 : Variation of monthly rainfall at Solapur

Drought, normal and surplus years:

Average annual rainfall at Solapur is 732.4 mm with standard deviation of 261.01 mm. Distribution of annual rainfall is shown in Fig. 3. Any year receiving the rainfall less than or equal to 471.4 mm ($\bar{x}$ - σ) will be drought year and it accounted for 13.64 per cent. Any year receiving the rainfall equal to more than 993.4 mm ($\bar{x}$ + σ) will be the surplus year; therefore, 13.64 per cent of the years should be the surplus years for the study period. The year receiving rainfall between 471.4 mm to 993.4 mm will be the normal years (72.72 per cent).

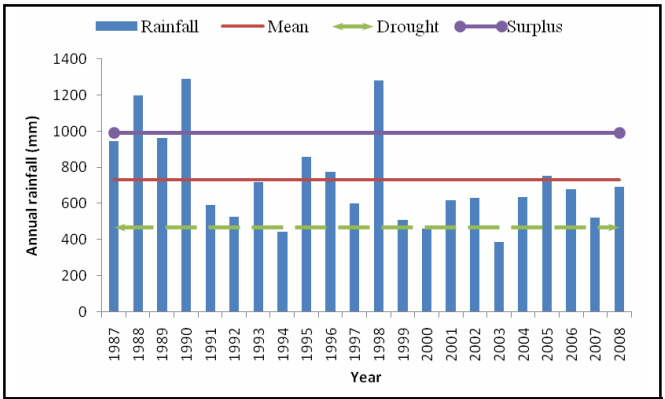

Fig. 3 : Distribution of annual rainfall at Solapur

Analysis reveals that the rainfall was mainly confined to *Kharif* season (July to October), which was found to be wettest season with average seasonal rainfall equal to 537.4 mm and average annual rainfall was found to be 732.4 mm. The excess water of *Kharif* season may be of great use in *Rabi* and *Zaid* seasons, if conserved in soil to maintain proper moisture level or stored in water harvesting structures to enhance ground water recharge and use for irrigation purpose. The stored water in water harvesting tank at suitable location could be utilized for irrigation of wheat crop of *Rabi* season or short-duration varieties of mulch crop like sun hemp.

It was found that September was the wettest month (average rainfall = 175.9 mm), February was the driest month (average rainfall = 2.3 mm). The probability of normal, surplus and drought months were found to be 37.50, 14.77 and 47.73 per cent of the total months, respectively. The surplus water of normal months may be useful in drought months if proper water management e.g. storing the water in water harvesting tank or below the ground surface, could be adopted.

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