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HEAVY RAINFALL PATTERN OVER NORTH WESTERN PARTS IN DRY FARMING REGION OF INDIA

1. Dry Farming Region (DFR) or tract of India is mainly characterized by annual average rainfall between 400 to 1000 mm. These areas have hardly any supplementary irrigation facilities and for agriculture purposes have to be entirely depending on the monsoon rains. High variability of rainfall is another distinguishing feature in this zone. The tract is juxta positioned between arid and dry sub-humid zones and hence also known as "semi-arid region". Because of erratic and low quantum of rainfall, the main crop in the region is one, which do not need high amount of water during its growth stages and which can tolerate prolonged frequent periods of stress. These constraints force the farmer to go for pearl millet, which hence is grown on large scale and is their staple food. Unlike other parts in the country, rainfall is never uniformly and evenly spread during the rainy season in this region (Soman and Kumar, 1990). Rao (1958) studied the trends of rainfall over Rajasthan and found the rainfall to be a random event. Trends and periodicities of rainfall were studied, at west coast stations of India by Koteswaram and Alvi (1969), in sub-divisions of Maharashtra by Raghavendra (1974), in Tamil Nadu by Dhar *et al*. (1982), and in sub-divisions of India by Subramanian *et al*. (1992). Observational evidence indicated that increase in extreme rainfall events have been observed over India (Rakhecha and Soman, 1994). The objective of the present study is to find out the distribution and trend in the frequency of heavy rainfall in selected locations in the DFR of northwest India and also to examine contribution of such falls to seasonal rainfall total. Presence of systematic trend, if any in the seasonal rainfall series and its association with similar tendency of heavy rainfall is being established.

2. The study utilizes daily rainfall data from 1941-90 of monsoon period (June - September) in respect of 18 stations of Northwest part of DFR of India (Fig. 1). In this study heavy rainfall is defined as daily rainfall greater than 50 mm. Attempt has been made to find whether the frequency of such heavy falls follow some regular pattern or not. Next, the seasonal rainfall over these stations was also subjected to statistical analysis to determine if the rainfall is showing any decreasing or increasing tendency. Percentage contribution of heavy rainfall to seasonal rainfall is also worked out and discussed. Regression lines are fitted with respect to time by the method of least square to study increasing or decreasing tendency of typical stations only for heavy rainfall, seasonal rainfall and percentage contribution of heavy rainfall to seasonal rainfall, which is depicted in (Figs. 2, 3 and 4). Positive or negative tendency is plotted on the map to demarcate areas where the seasonal rainfall (Fig. 5) and percentage contribution of heavy rainfall to seasonal rainfall (Fig. 6) is decreasing with years, increasing with years or remained stationary.

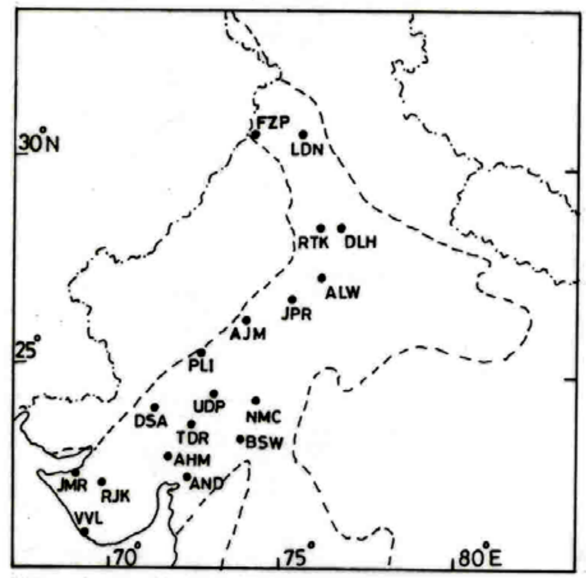

Fig. 1. Stations selected for trend analysis of N-W region of dry farming tract of India

3. Rainfall in this zone is associated whenever the monsoon trough is south of its normal position and/or when the monsoon depressions from the Bay of Bengal traverse through central Madhya Pradesh to central Rajasthan. In such situations daily rainfall on many occasions become heavy to very heavy, leading to flood situations. Mean of total heavy rainfall, seasonal rainfall and percentage contribution of heavy to seasonal rainfall of all stations is shown in Table 1. It is quite obvious to note that the stations with highest frequency of number of occasions per year also concurrently show significant increase in heavy rainfall totals. Average seasonal rainfall of Banswara is seen to be highest *i.e*., about 990 mm and 50% of the seasonal total is contributed by heavy rainfall with a frequency of 5.1 per year. However lowest is observed at Pali *i.e*., 403.7 having 42.8% contribution of heavy falls with a frequency of only 2 per year clearly indicating most erratic distribution at this station. Range of frequency of heavy rainfall events is seen to be 1.8 to 5.1 and contribution of heavy falls to seasonal as 27% to 54.4 % and the average percentage contribution of all 18 stations is about 43%. In other words such a large magnitude is quite important in agricultural planning. The

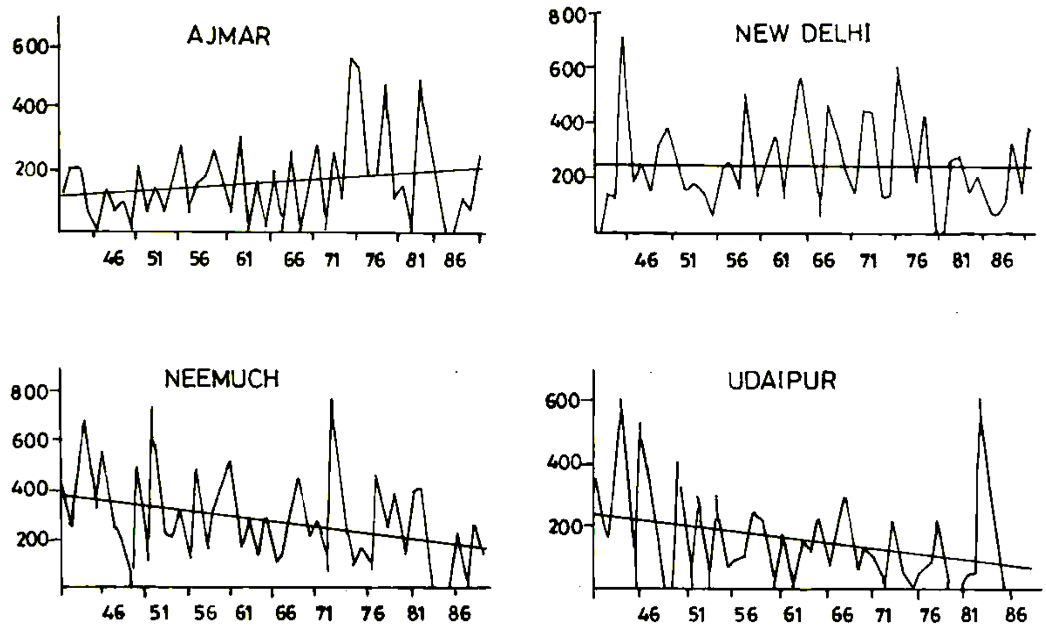

Fig. 2. Trend of heavy rainfall

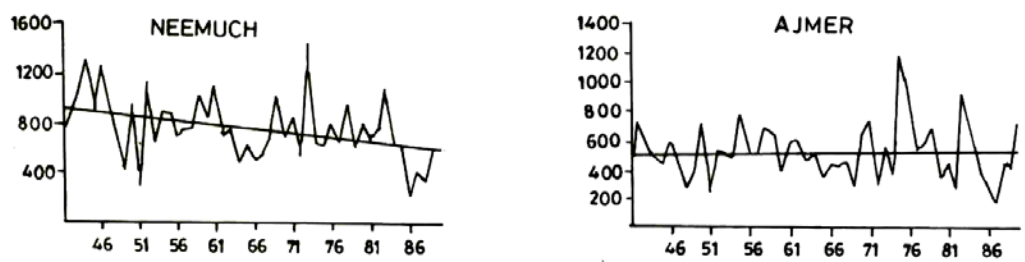

Fig. 3. Trend of seasonal rainfall

farmers must make use of such heavy falls and excess water should not be allowed to go unutilized as run off. Table 2 shows the direction of trend, coefficient of correlation and slope of regression line. It is seen that most of the stations shows negative tendency of percentage contribution of heavy rainfall to seasonal rainfall. However stations like Pali, Neemuch, Udaipur and Idar show significant negative correlation with time at 5% level however the other stations show non-significant negative correlation. It is seen from Fig. 2 that Neemuch and Udaipur shows sharp decrease in heavy rainfall with time with a rate of about 4 mm per year.Ajmer is the only station which shows positive trend with a rate of about 2 mm per year however Delhi shows no trend. Fig. 3 shows the trend of seasonal rainfall of two typical stations.Ajmer shows no trend line of 500 mm. However Neemuch shows sharp decrease in seasonal rainfall amount by about 8 mm per year due to the negative tendency of heavy rainfall. Fig. 4 shows the variation in percentage contribution of heavy rainfall to seasonal rainfall total for 4 stations *i.e.*, Ajmer, Ahmedabad, Neemuch and Pali. Ajmer shows increasing trend with slope (0.2), Ahmedabad shows almost no trend, Neemuch and Pali show negative trend. The highest negative slope (-0.77) is observed at Pali. It means that at this location the contribution of heavy rainfall to the seasonal rainfall is

TABLE 1

Avg. no. of occasions of heavy RF per year, total of heavy and seasonal RF, percentage contribution of heavy to seasonal RF of different stations

S. No.	Name of the stations	Average no. of occasions of heavy rainfall per year	Mean		
			Total of heavy rainfall (mm)	Seasonal rainfall total (mm)	Percentage contribution of heavy rainfall to seasonal rainfall
1.	Ahmedabad	3.7	325.0	747.4	43.5
2.	Anand	4.0	353.3	835.0	42.3
3.	Ajmer	2.0	159.3	501.8	31.7
4.	Alwar	2.0	158.8	564.2	28.1
5.	Banswara	5.1	496.5	992.6	50.0
6.	Deesa	2.6	231.0	536.2	43.1
7.	Delhi	3.0	240.0	632.0	38.0
8.	Ferozepur	1.8	152.7	366.1	41.7
9.	Idar	4.5	444.9	925.5	48.1
10.	Jaipur	2.4	175.0	570.0	31.0
11.	Jamnagar	2.5	245.2	501.9	48.9
12.	Ludhiana	2.8	233.0	560.0	42.0
13.	Neemuch	3.3	270.1	737.7	36.6
14.	Pali	2.0	172.8	403.7	42.8
15.	Rajkot	3.1	290.0	629.0	46.0
16.	Rohtak	2.3	161.4	487.2	33.1
17.	Udaipur	1.8	152.0	556.0	27.0
18.	Veraval	3.9	383.4	705.2	54.4

TABLE 2

Direction of trend, coefficient of correlation, slope of percentage contribution to seasonal rainfall of different stations of N-W part of DFR of India

S. No.	Name of the stations	Direction of trend	Correlation coefficient	Slope
1.	Ahmedabad	No Trend	0.02	0.03
2.	Ajmer	Increasing (+ ve)	0.14	0.18
3.	Alwar	Decreasing (- ve)	-0.12	-0.13
4.	Anand	Decreasing (- ve)	-0.12	-0.17
5.	Banswara	Increasing (+ ve)	0.10	0.10
6.	Deesa	Decreasing (- ve)	-0.26	-0.40
7.	Delhi	No Trend	0.03	0.04
8.	Ferozepur	Decreasing (- ve)	-0.25	-0.42
9.	Idar	Decreasing (- ve)	-0.29	-0.38
10.	Jaipur	No Trend	0.05	0.06
11.	Jamnagar	Decreasing (- ve)	-0.13	-0.21
12.	Ludhiana	No Trend	-0.07	-0.01
13.	Neemuch	Decreasing (- ve)	-0.30	-0.35
14.	Pali	Decreasing (- ve)	-0.44	-0.77
15.	Rajkot	Decreasing (- ve)	-0.20	-0.30
16.	Rohtak	Decreasing (- ve)	-0.10	-0.14
17.	Udaipur	Decreasing (- ve)	-0.30	-0.40
18.	Veraval	No Trend	-0.001	-0.002

Direction of trend, coefficient of correlation, slope of percentage contribution to seasonal rainfall of different stations of N-W part of DFR of India

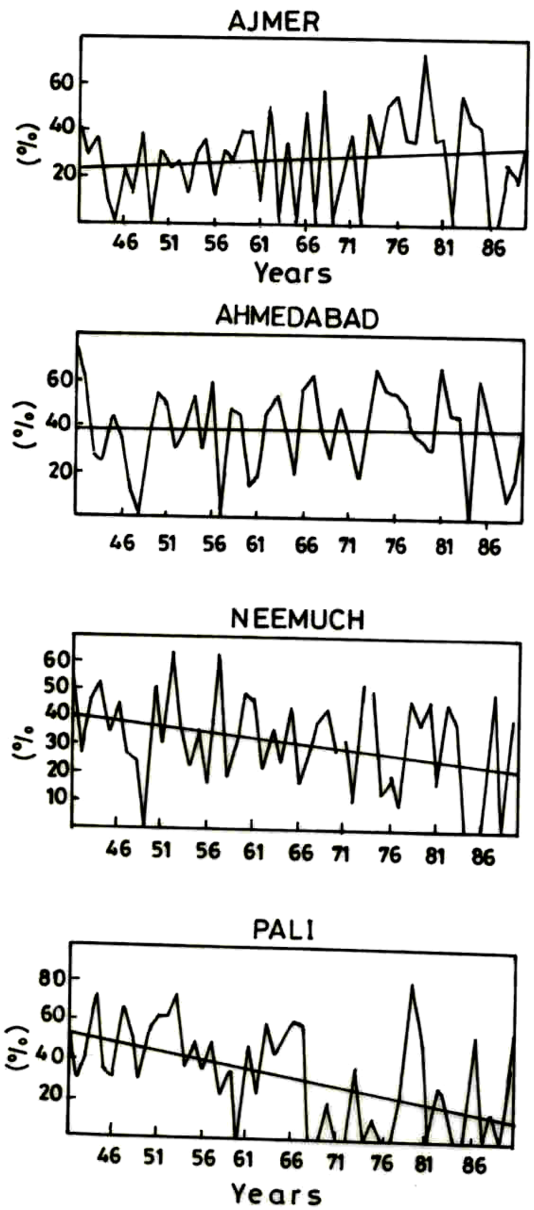

Fig. 4. Trend of percentage contribution of heavy rainfall to seasonal rainfall total

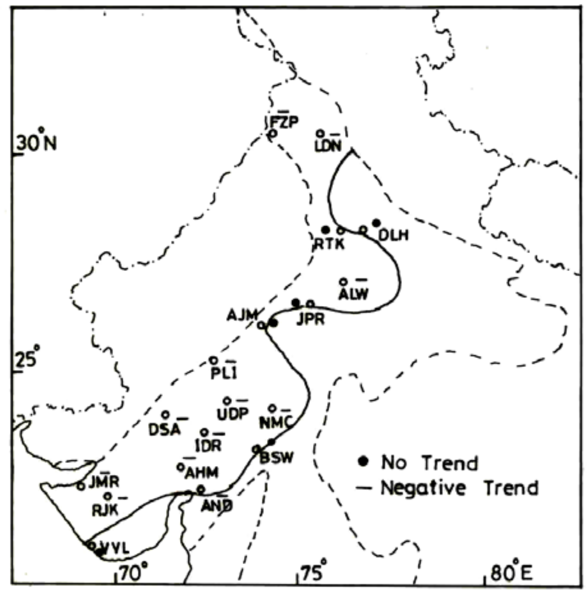

Fig. 5. Trend of seasonal rainfall total

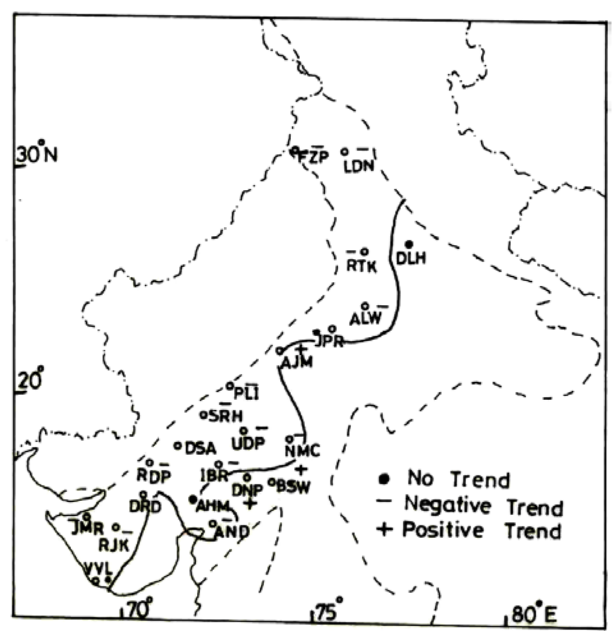

Fig. 6. Trend of percentage contribution of heavy rainfall to seasonal rainfall total

coming down at the rate of nearly 0.8% per year. Other locations of large slopes are Udaipur (0.40), Deesa (-0.40), Neemuch (-0.35) and Idar (-0.47). From Fig. 4 it is also revealed that there is a large variation in percentage contribution from year to year. For instance at Pali, in 1979 the percentage contribution was nearly 80%, contributed by 5 occasions of heavy falls. At Neemuch and Ahmedabad though variation is quite large on an average percentage contribution is 36.6% and 43.5% (Table 1). Next to Pali, Ajmer also shows about 70% contribution of heavy falls on 3 occasions in the year 1979 however the average percentage contribution of Ajmer is 31.7%.The area of demarcation of negative trends of 12 stations and 6 stations of no trend in seasonal rainfall are plotted on the map (Fig. 5) of N-W region of dry farming tract. Thar desert in N-W part of Rajasthan and some parts of Saurashtra in Gujarat reveal a negative tendency. Similar tendency is also seen over Haryana and Punjab. The study of behaviour of percentage contribution of heavy rainfall to seasonal rainfall and its time trends are already determined. Further these are plotted and analyzed on the map (Fig. 6) of dry farming tract of N-W region. It is clearly seen that both the maps *i.e.*, trend of seasonal rainfall and trend of percentage contribution of heavy rainfall to seasonal rainfall generally coincides with each other. It means that in the area where there is systematic decline in the percentage contribution of heavy rainfall, the seasonal rainfall also has been decreasing.

4. The concept of percentage contribution studied in the paper is primarily of great use in agriculture. At locations where the percentage contribution exceeds 40, evidently the rainfall during the crop season is not evenly distributed, but is positively skewed. In such cases once rainfall has occurred, during the beginning of the crop season, chance of the crop experiencing water stress during subsequent growth phases is quite high. So a proper water harvesting technique to store water for use in subsequent period is a must. Heavy falls during the flowering and anthesis period is again harmful, as it will lead to destruction of flowers and lodging of plants. During maturity period, this type of heavy falls will destroy the crops to a great extent. The results have another implication in hydrology, whenever there are occasions of heavy rainfall; significantly large amount of water goes as run off (both surface and deep drainage). If it goes as deep drainage, the rainfall is likely to recharge the underground aquifers and is beneficial in future. But as we know the rate of infiltration in such cases is extremely low compared to the intensity of rainfall, a large amount goes waste as surface runoff. A judicious water harvesting and water conservation devices can prevent such wastage.

5. It is seen that the majority of stations in N-W part of dry farming region of India show negative inclination with time of heavy rainfall, seasonal rainfall, and percentage contribution of heavy rainfall to seasonal rainfall total. The average of percentage contribution of heavy rainfall to seasonal rainfall of all 18 stations is about 43%. The minimum contribution is 27% and maximum is 54%. In exceptional cases it is, as high as 80% in a particular year.

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