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On some characteristic features of daily rainfall over Madhya Maharashtra

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सार – कृषि, जल विज्ञान और पानी से संबंधित अन्य मानवीय कार्यलापों की माँग को पूरा करने के लिए प्रायः संसाधित रूप में ही सूचना की आवश्यकता पड़ती है। इस संदर्भ में दैनिक वर्षा के आँकड़ें हमेशा महत्वपूर्ण रहते हैं चूँकि संचित दैनिक वर्षा के आँकड़ों के आधार पर ही साप्ताहिक, मासिक अथवा मौसमी आँकड़ें तैयार किए जाते हैं। इस शोध पत्र में मध्य महाराष्ट्र के नौ चुने हुए केंन्द्रों के दैनिक वर्षा के कुछ विशेष लक्षणों का विवेचन किया गया है। यह अध्ययन 10 वर्षों (1991–2000) के जून से सितंबर तक के महीनों के दैनिक वर्षा के आँकड़ों पर आधारित है।

वर्षा की मात्रा (अथवा उसकी कम मात्रा) के आधार पर किसी दिन को वर्षा का दिन, हल्की बौछार का दिन अथवा शुष्क दिन के रूप में श्रेणीबद्ध किया गया है। वाष्पोत्सर्जन की अवधारणा का उपयोग करके वर्षा के दिन को इसके बाद फसल के लिए उपयुक्त वर्षा के दिन में विभाजित किया गया है। दिनों की इन विभिन्न श्रेणियों का वर्गीकरण, वर्षा के मासिक आँकड़ों के लिए उनका योगदान और उनमें परस्पर संबंध का पता लगाया गया और उसकी विवेचना की गई है। वर्षा के दिनों का उपयोग दैनिक वर्षा की तीव्रता के औसत का पता लगाने और मासिक वर्षा के साथ उसके संबंधों का पता लगाने के लिए किया गया तथा इन सबकी जाँच समाश्रयण समीकरणों की श्रृंखला के माध्यम से की गई है। भारी वर्षा की आवृत्ति अर्थात 25 मि.मी. से अधिक की दैनिक वर्षा के दिनों का पता लगाया गया और मासिक वर्षा में इसके योगदान का मूल्यांकन किया गया है।

हाल के वर्षों में वर्षा के दिनों और वर्षा की मात्रा की प्रवृत्ति सामान्य से कम रही है। इस क्षेत्र में जून के उत्तरार्ध के आस–पास और जुलाई के महीनों में बिल्कुल शुष्क मौसम रह सकता है। कुल मासिक वर्षा में भारी वर्षा का बड़ा योगदान रहता है। जून और सितंबर के दौरान वर्षा की औसत दैनिक तीव्रता का मासिक वर्षा के साथ क्षीण संबंध का पता चला है।

ABSTRACT. Information in processed form, is often needed to meet the demands in agriculture, hydrology and other water-related human activities. In this context, daily rainfall continue to be of prime importance since it is the daily rainfall which, when accumulated gives weekly, monthly or seasonal totals. This paper deals with some of the characteristic features of daily rainfall at nine selected stations in Madhya Maharashtra. The study is based on daily rainfall data of June to September months for 10 years (1991-2000).

Depending upon rainfall amounts (or lack of it), a day has been categorized as rainy day, drizzle day or dry day. Making use of the concept of evapotranspiration, rainy day has been further divided into crop rainy day. Distribution of these various classes of days, their contribution to monthly totals and relationship among them, have been obtained and discussed. The rainy days have been used to obtain mean daily rainfall intensity and its association with monthly rainfall, examined through a series of regression equations. Frequency of heavy falls *i.e*., rainfall exceeding 25 mm in a day have been determined and its contribution to monthly rainfall, evaluated.

There seems to be a tendency for the rainy days and the rainfall to be below normal in recent years. Perfectly dry weather could prevail nearly half of June and July months over the region. Heavy rainfall contributes substantially to the monthly total. During June and September mean daily rainfall intensity is perhaps weakly related with the monthly rainfall.

Key words – Rainy day, Crop rainy day, Drizzle day, Mean daily rainfall intensity.

1. Introduction

Over most parts of India, rainfall is generally confined to a brief period, the south-west monsoon season (June-September). This period accounts of nearly 90% of the annual rainfall in the large tract of the country. The main crop *i.e*., kharif is also cultivated during this season. In view of its importance, monsoon rainfall has been studied by a large number of research workers, both in India and abroad.

Among the time-intervals, the daily rainfall is perhaps the most important in the tropics. Its distribution in the crop-growing season determines the yield, whereas its amount is of considerable importance in hydrology. In India, where rainfall is seasonal and agriculture is mostly rainfall dependent, the daily rainfall is more useful in planning day-to-day agricultural operations (Adejuwon *et al*. 1990). Also, when different time-periods are considered, the daily rainfall is highly skewed with a few falls of higher intensity contributing to a substantial proportion of monthly, seasonal or even annual amounts. Recent examples of studies of short-period rainfall characteristics on a daily basis in India include those by Ananthakrishnan and Soman (1989), Swaminathan *et al.* (1991), Kumar (1993), Krishnan *et al.* (1995) etc.

Two simple parameters which also help in better understanding tropical rainfall conditions than monthly or seasonal total alone, are the number of rainy days and Mean Daily Intensity (MDI). They provide some indication of frequency of occurrence and an approximate measure of intensity of rains (Jackson, 1986).

The present study has been taken up with the following objectives in view :

(*i*) Contribution of daily rainfall to the monthly totals,

(*ii*) Frequency of rain-less or dry days, rainy days, crop-rainy days and days of heavy falls and

(*iii*) Identification of rainfall spells.

In addition to above, relationship between monthly rainfall with number of rainy days and mean daily intensity have also been determined.

2. Data and methodology

In this study, nine stations in Madhya Maharashtra *viz*., Jalgaon (21° 03′ N, 75° 34′ E), Malegaon (17° 40′ N, 75° 54′ E) and Dhulia (17° 40′ N, 75° 54′ E) situated in its northern parts; Pune (18° 32′ N, 73° 51′ E), Solapur (17° 40′ N, 75° 54′ E) and Ahmednagar (17° 40′ N, 75° 54′ E) in central parts and Kolhapur (17° 00′ N, 74° 00′ E), Satara (17° 40′ N, 75° 54′ E) and Sangli (17° 40′ N, 75° 54′ E) in its southern region, have been selected. The daily rainfall data for the monsoon months (June – September) for ten years (1991-2000) were collected from Meteorological Office, Pune. The daily falls were categorized as :

(*i*) Dry or rainless days *i.e*., days with no rainfall,

(*ii*) Drizzle days or the days receiving rainfall between 0.1 and 2.4 mm and

(*iii*) Rainy days (RD) when the rainfall recorded equalled or exceed 2.5 mm.

According to Jackson (1981), it may be mentioned that the question of suitable definition for wet or rainy day has always been a matter of debate. It varies according to problem at hand and objective in view.

The threshold amount of daily rainfall of 2.5 mm assumed to define a RD seems purely arbitrary. This amount wets hardly 1-2 mm of top soil surface. With the high rates of evaporation so common in tropics, this rain dries out within a few hours of its occurrence. Hence, for agricultural purposes, the RD seems to be of little practical importance. For healthy crop growth, the evapotranspirative demands of plants are nearly 5 mm. In this paper, the term Crop Rainy Day (CRD) has been introduced to define a day which receives a rainfall of 5 mm or more.

The mean daily rainfall intensity (MDI) has been calculated in this study by dividing the monthly rainfall amount (Y) by the number of rainy days, RD. A variety of forms of relationships between Y, RD and MDI were examined and discussed.

3. Results and discussion

3.1. *Intra-seasonal distribution of rainfall and rainy days*

The mean intra-seasonal changes in rainfall for the nine stations under study, is shown alongwith number of rainy days in Table 1 (a) and 1 (b) respectively.

A striking feature that emerges from Table 1 (a) is that monthly rainfall between July to September in a large number of cases, have been below normal. The rainfall during June has been observed to be above than their long time normal except over north Madhya Maharashtra barring Malegaon. The mean seasonal rainfall (June-September) have been positive in south Madhya Maharashtra. The picture in north and central Madhya Maharashtra is hazy with some stations recording significant negative departures like Jalgaon and Solapur while others (*e.g*., Malegaon and Pune) recording large positive departures.

Mean monthly distribution of RDs based on the 10 years data is given in Table 1 (b). As in the case of rainfall, by and large, there also seems to be a declining tendency in the number of RDs in different months at nearly all stations. For the season as a whole also there is a general fall in the number of RDs during the period under study.

TABLE 1 (a)

Mean rainfall (mm) & departure from normal (%)

Station	Month				
	June	July	August	September	Season
Northern portion					
Jalgaon	119.5	219.9	126.9	123.5	553.4
	(-16.2)	(3.1)	(-36.1)	(6.7)	(-17.4)
Malegaon	123.2	185.3	89.3	146.1	543.9
	(26.9)	(66.0)	(-20.6)	(56.1)	(31.1)
Dhulia	105.7	150.6	113.6	115.7	472.5
	(-20.0)	(-4.0)	(-16.5)	(-11.9)	(1.0)
Central portion					
Pune	203.3	185.8	108.5	163.1	609.0
	(75.1)	(-0.7)	(-11.3)	(35.8)	(11.6)
Solapur	129.9	105.9	111.6	172.5	508.8
	(16.5)	(-23.7)	(-18.7)	(-4.1)	(-10.3)
Ahmednagar	117.6	101.8	77.6	131.8	428.8
	(17.6)	(10.6)	(-20.4)	(-8.4)	(-1.1)
Southern portion					
Kolhapur	227.2	338.9	209.1	96.2	871.7
	(51.6)	(-5.8)	(-2.6)	(-21.8)	(2.8)
Satara	222.2	235.2	135.7	91.7	684.7
	(93.9)	(-8.3)	(-5.9)	(-23.5)	(7.7)
Sangli	167.6	144.0	76.0	80.0	467.7
	(93.8)	(45.6)	(4.4)	(-42.5)	(17.7)

Note : Figures in the parentheses are departures from normal as percentage.

TABLE 1 (b)

Mean rainfall (mm) & departure from normal (%)

Station	Month				
	June	July	August	September	Season
Northern portion					
Jalgaon	7	14	9	8	38
	(1)	(1)	(-4)	(1)	(-1)
Malegaon	5	10	7	7	29
	(-1)	(3)	(0)	(2)	(4)
Dhulia	5	10	9	7	31
	(-2)	(0)	(1)	(1)	(0)
Central portion					
Pune	9	12	7	6	34
	(2)	(-1)	(-4)	(-1)	(-4)
Solapur	7	7	6	3	23
	(0)	(-2)	(-3)	(-6)	(-11)
Ahmednagar	5	7	6	7	25
	(-1)	(1)	(0)	(-1)	(-1)
Southern portion					
Kolhapur	12	18	17	8	55
	(2)	(-2)	(-1)	(-1)	(-2)
Satara	11	17	12	7	47
	(3)	(3)	(2)	(0)	(8)
Sangli	9	12	9	6	36
	(1)	(1)	(1)	(-2)	(1)

Note : Figures in the parentheses are departures from normal.

3.2. *Rainy days and seasonal rainfall*

High rainfall variability, undoubtedly, is a characteristic feature of tropical rainfall. But very few meteorological sub-divisions in India may have as heterogeneous a rainfall distribution as Madhya Maharashtra. The southern part (as represented by Kolhapur) normally receives highest rainfall of nearly 87 cm in 55 RDs [Table 1(b)]. This has also been observed by Chunale *et al*. (2003) recently.

As can be seen from Tables 1 (a) and 1 (b), in the southern portion of Madhya Maharashtra (as represented by Kolhapur, Satara and Sangli), the seasonal rainfall has been on the positive side of the normal with 87 cm in 55 RDs, 68 cm in 47 RDs and 47 cm in 36 RDs in these three stations respectively. The northern portion of Madhya Maharashtra (as represented by Jalgaon, Malegaon and Dhulia) receives nearly 55 cm of rainfall in 38 RDs at Jalgaon, 54 cm in 29 RDs at Malegaon and nearly 47 cm of rainfall in 31 RDs at Dhulia. The western portion of central Madhya Maharashtra (as represented by Pune) reflects opposite rainfall situation, where rainfall of 61 cm is recorded in 34 RDs. The eastern portion of central Madhya Maharashtra (as represented by Solapur and Ahmednagar) receives 51 cm and 43 cm rainfall respectively in nearly 25 RDs each. The districts of Solapur and Ahmednagar have been identified by Chowdhury *et al*. (1979) as the most drought prone area in whole of Maharashtra. Generally, there is a fall in seasonal number of RDs (exception being Malegaon and Satara), conspicuously so at Solapur. It is surmised that a lesser number of RDs have contributed to decrease in the mean rainfall during June to September over the area under study during the period 1991-2000.

For selected stations from north, central and south Madhya Maharashtra, cumulative monthly rainfall is

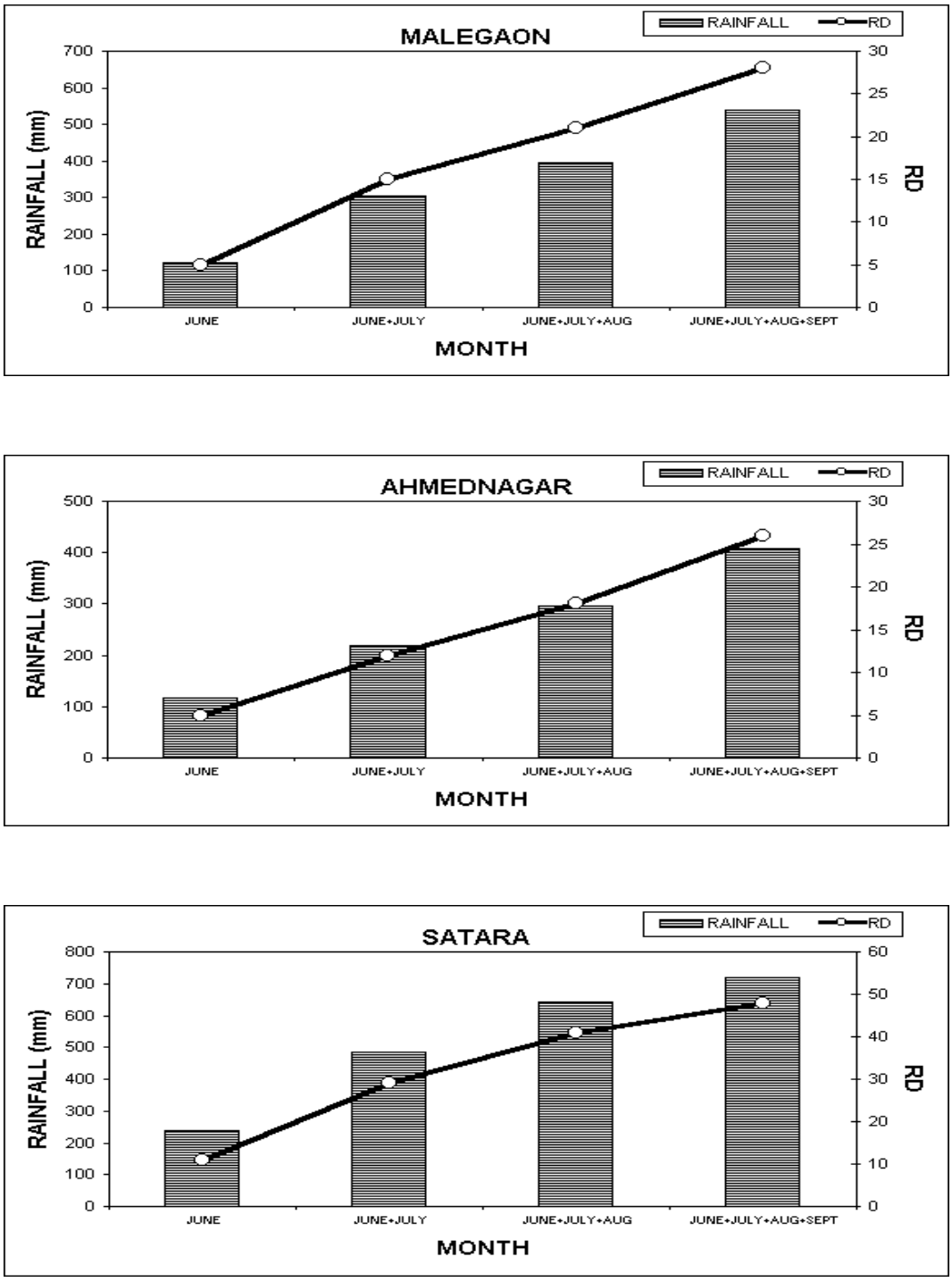


Fig. 1(a). Progressive increase in monthly rainfall (mm) and rainy days (RD)

shown [Fig. 1(a)] alongwith corresponding number of RDs. It is seen that the RDs keep pace with rainfall and seems evenly distributed - a pre-requisite for healthy crop growth and large yield.

The amount of rainfall contributed by the RDs, in the beginning is important for planning agricultural operations (sowing/transplanting, irrigation scheduling etc.), since the rainy season generally coincide with the kharif crop

season. Number of rainy days provides a rough indication of the extent to which crop water requirement is met. It is also important for hydrologic purposes if we consider RDs when the rainfall is mostly showery type towards the end of monsoon, since rainfall associated with these RDs are often heavy resulting in large surface runoff. Table 2 contains contribution by 10% and 25% of the RDs (both during the start and end of the monsoon) to the seasonal total. The table brings forth some interesting results.

The first 10% of the RDs generally contribute to 10-15% of the seasonal total except Kolhapur in south Madhya Maharashtra where the contribution is less than 10%. Similarly, the contribution of first 25% of RDs varies from $1/4^{th}$ to nearly $1/3^{rd}$ of the seasonal amount. Rainfall during the end of the season over the region appears much sub-dued with contribution of slightly more than 10% by last $1/10^{th}$ of the RDs, exception being Kolhapur and Satara in south Madhya Maharashtra where the contribution is significantly low. These pattern of the rainfall is also seen in last 25% of RDs where the contribution of the RDs is less than 20% at the above two stations (*viz*., Kolhapur and Satara); in the rest of the locations, it varies from 20 to 30%. This study thus brings out the uncertainty of the rainfall towards the end of monsoon season over Madhya Maharashtra, particularly its southern parts. Similar study for Kerala by Jayashree and Kumar (1997), however, found that the last 10% of RDs contributed significantly *i.e*., more than 25% of the seasonal total.

3.3. *Distribution of crop rainy days*

The threshold of 2.5 mm in defining RDs may not generally be of much help in ascertaining if the water demands of the plants has been met and to what degree. The concept of crop rainy days introduced in this paper takes into account the evapotranspirative demands. This demand according to several studies based on lysimetric data confirmed that maximum evapotranspiration rates in the tropical plants is approximately 5 mm per day. This observation has been used in this paper to define a crop rainy day (CRD), as the day which records a daily rainfall for at least 5 mm. Obviously, the number of CRDs would be less than the RDs; at the most the two can be equal if all RDs record significant falls. In this study, the largest number of CRDs occur in July while September records the lowest number of CRDs. Within the sub-division wide temporal and spatial differences, however, occur in crop rainy days. For example, in the northern portion the maximum number of CRDs is seen at Jalgaon followed by Dhulia and Malegaon; in the last named station except July, the number of CRDs are less than 5. In the central portion of the sub-division, Pune experiences the highest crop rainy days followed by Ahmednagar and Solapur. At both these two stations, the CRDs hardly exceed 5. Diverse pattern in distribution of CRDs is also seen in southern portion of Madhya Maharashtra. Kolhapur, for instance, records as large as 44 CRDs in a season:- the highest in the region followed by 34 at Satara. Surprisingly, within this small zone, Sangli barely experiences three weeks duration of crop rainy days.

TABLE 2

Contribution (%) by 10 and 25% RDs to the seasonal total

	Contribution			
	Cumulative RDs		Cumulative RDs	
Station	First 10%	First 25%	Last 10%	Last 25%
Northern portion				
Jalgaon	11.4	24.7	12.3	34.4
Malegaon	13.1	29.3	10.1	26.8
Dhulia	15.9	34.1	10.7	22.7
Central portion				
Pune	16.1	33.8	12.1	25.7
Solapur	11.2	27.5	10.6	25.6
Ahmednagar	9.9	34.0	16.1	29.5
Southern portion				
Kolhapur	9.5	28.5	8.4	17.8
Satara	14.4	33.4	6.7	17.0
Sangli	13.1	29.5	10.2	22.8

Analysis of ratio of CRDs to RDs in different months revealed that barring one or two exceptions, the ratio fluctuates between 0.7 to 0.9 in nearly all months and stations. Thus, 70% or more of RDs receive rainfall equal to or greater than 5 mm.

Progressive monthly rainfall is shown alongwith corresponding values of CRDs in Fig. 1(b) for representative stations. The pattern seems generally identical to that shown in Fig. 1(a) and perhaps does not need further elaboration.

3.4. *Contribution by drizzle days*

Rainfall less than 2.5 mm has been termed “Drizzle-day” in this paper. The amount apparently quantitatively small, is not without agricultural significance. Such rainfall episodes are sufficient to wet a few mm of the top soil profile and provide some relief to plants during the dry spells. Associated as they are with prolonged cloudiness and high humidity, the latter two factors help suppressing high rate of evapotranspiratory loss. Drizzle

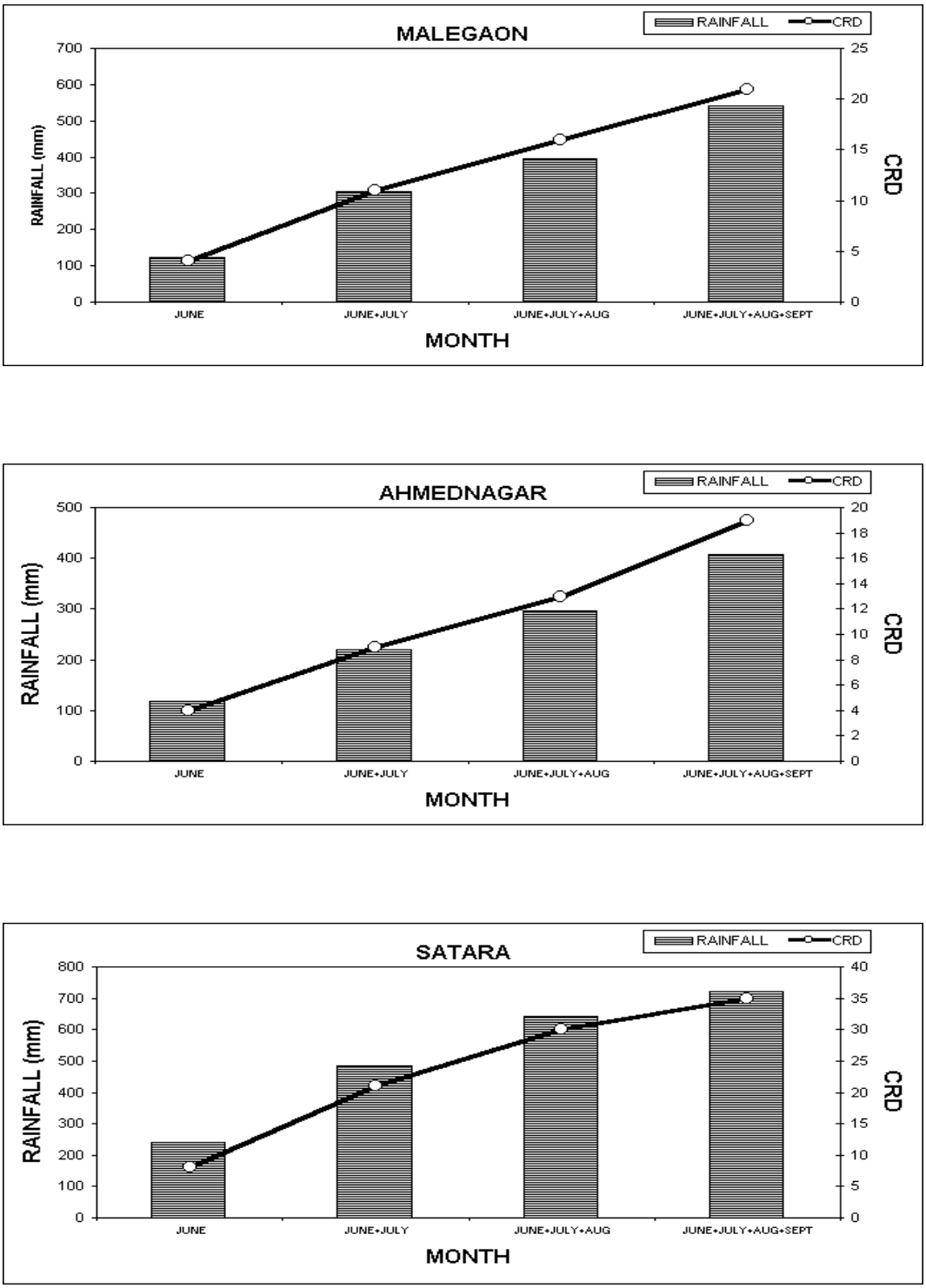


Fig. 1(b). Progressive increase in monthly rainfall (mm) and crop rainy days (CRD)

days are far less in number than RDs and CRDs and mostly occur in July and August.

In Ahmednagar, Dhulia and Malegaon drizzle days are found to be 5 or less in each month. They are more

TABLE 3

Contribution (%) of rainfall ≥ 25 mm/day in different months

Station	Month			
	June	July	August	September
Northern portion				
Jalgaon	57.3	46.5	33.2	53.6
Malegaon	57.0	57.4	14.3	58.3
Dhulia	34.9	37.3	21.0	39.2
Central portion				
Pune	51.4	37.0	18.4	43.2
Solapur	28.8	46.0	35.4	39.8
Ahmednagar	52.9	41.1	27.6	56.8
Southern portion				
Kolhapur	47.2	48.9	29.3	26.6
Satara	58.5	33.6	25.6	13.6
Sangli	36.9	24.2	8.2	27.7

TABLE 4

Mean daily rainfall intensity (mm/day)

Station	Month			
	June	July	August	September
Northern portion				
Jalgaon	19.4	15.9	15.2	22.8
Malegaon	23.7	17.9	13.5	19.8
Dhulia	20.6	16.1	13.0	17.3
Central portion				
Pune	21.9	15.5	17.3	19.3
Solapur	17.9	15.8	13.2	20.1
Ahmednagar	21.0	16.6	12.7	18.5
Southern portion				
Kolhapur	19.8	16.2	12.8	14.9
Satara	20.3	13.3	11.8	10.8
Sangli	17.4	11.3	8.0	13.3

numerous in Satara, Sangli and Pune particularly during August where the frequency exceed 10, occasionally even 15. In fact, such days contribute to nearly 1/4th of the total monthly rainfall.

3.5. *Analysis of rainless or dry days*

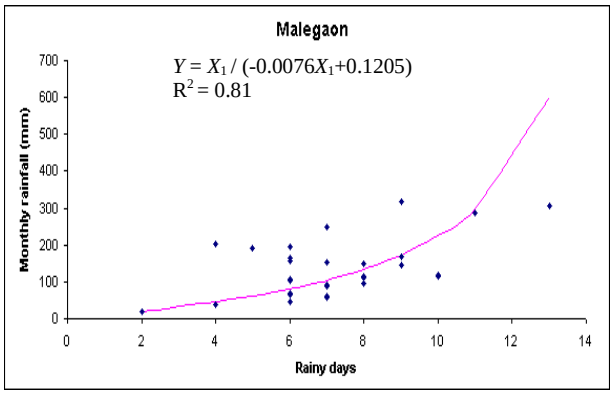
Absence of rainfall and availability of adequate sunshine help proper grain setting and grain filling. It also saves the crop from lodging and certain ruin if rainfall occurs during that stage.

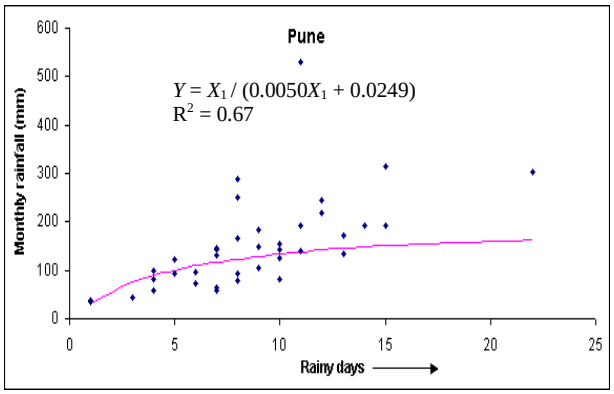
An attempt has also been made in this study to determine the spatial and intra-seasonal distribution of the dry days. Number of such days varied from month to month and location to location. In July and August, the lowest number (nearly 5 or less) of such days occurred at Pune, Kolhapur and Satara. At other stations and months, they generally exceed 15. This feature is seen prominently in the month of monsoon onset *i.e.*, June and its withdrawal *i.e.*, September in nearly all stations. In September particularly, the sun shines brilliantly over the Madhya Maharashtra for 20 days or more.

These results are collaborated when number of hours of bright sunshine at these stations are compared (India Met. Deptt., 1991) with the dry days.

3.6. *Analysis of heavy rainfall*

The tropical rainfall total is generally made up of a large number of light to moderate falls and a few falls of heavy to very heavy precipitation. The latter category of rainfall is mostly due to the convective storms particularly observed during the onset and withdrawal phases of monsoon. Most parts of Madhya Maharashtra particularly central and southern portions, are traditionally rabi growing regions. Heavy falls towards the end of September help to build up adequate soil moisture, benefiting sowing and emergence in rabi crops. The small falls, undoubtedly, help agriculture but is of limited use in augmenting water storage in dams, reservoirs etc. On the other hand, the heavy to very heavy falls have large hydrological importance including power generation. A study is made to find out the frequency and distribution of heavy falls and its contribution to monthly totals. For this purpose a threshold of 25 mm of daily rainfall was assumed to define a heavy fall. Heavy falls in the monsoon season over Madhya Maharashtra appears less frequent. Hardly 1-2 such days are seen in each of monsoon months at all locations in Madhya Maharashtra. In July, the rainiest month, such occasions could be 3-4 days. A comparison of the number of days of heavy rainfall to that of RDs brings out some contrasting features within the sub-division. Whereas, in the northern parts of Madhya Maharashtra, *i.e.*, Jalgaon – Malegaon sector, nearly 20% of the RDs receive rainfall of 25 mm or more, in Dhulia, also situated in northern portion, heavy falls in the season hardly exceed 15% of the RDs. In this connection, Nene (1962) found that the rainfall of 25mm or more occurred on nearly 36% of the occasions at Jalgaon. This some-what large discrepancy may perhaps be due to different data sample size.





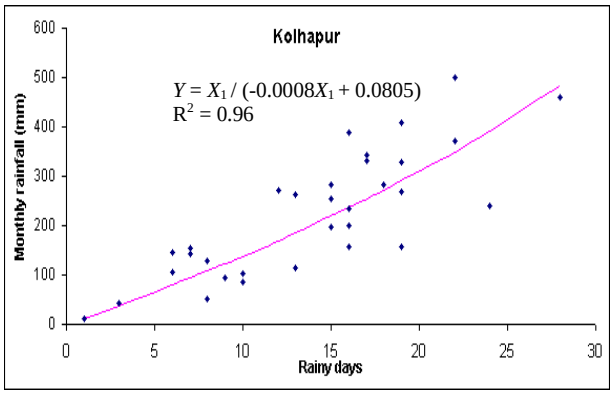
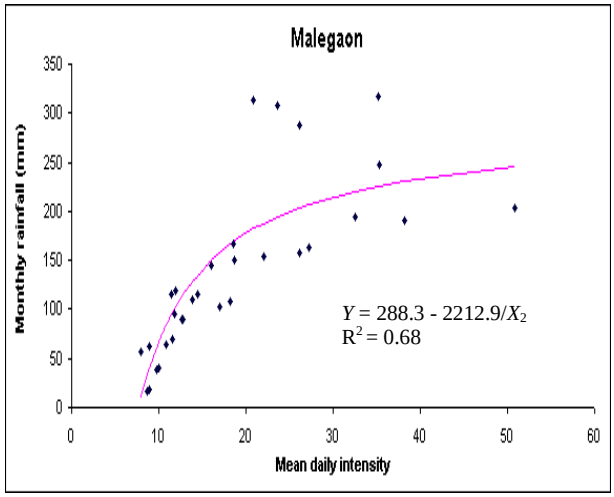
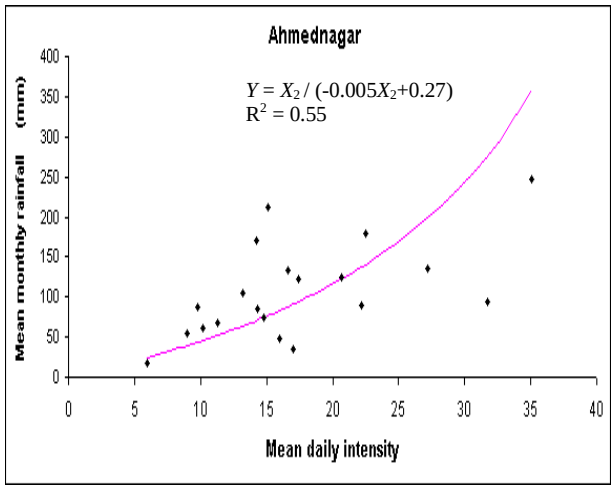


Fig. 2(a). Cumulative monthly rainfall (mm) against the cumulative monthly rainy days





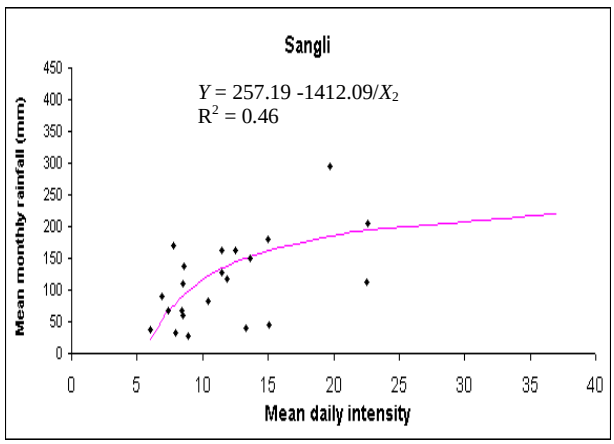


Fig. 2(b). Cumulative monthly rainfall (mm) against mean daily rainfall intensity

In the central Madhya Maharashtra, nearly 20% of RDs get heavy rainfall. Surprisingly, in the southern portion, the heavy falls appear to be less frequent in whole of the season, the number of heavy falls ranging between 10 to 15%. Another interesting feature brought out by the analysis is that the heavy falls are numerically more in numbers in July and August in the region. However, compared to RDs, in June and September, generally the ratio of heavy rainfall to RDs record the maximum percentage compared to other months; sometimes the ratio exceed even 1/3rd.

Contribution of heavy falls to monthly total is given in Table 3. On very few occasions in the individual months, during the monsoon season, the heavy falls are not observed. In northern parts of the region, practically in every month, the heavy falls contribute from 1/3rd to slightly more than ½ of the monthly total. This trend is also seen in the central region of the sub-division. Further south, however, the contribution of heavy rainfall to monthly total, though remaining significantly large, decreases particularly during August when they contribute nearly 1/4th of monthly totals at Kolhapur and Satara. The contribution is lowest *i.e*., less than 10% at Sangli.

It is evident from Table 3 that the onset and retreating phases of the monsoon, the rainfall which is contributed more by thunderstorms, leads to significantly large monthly rainfall.

3.7. *Rainy days, mean daily rainfall intensity and monthly rainfall relationships*

The two relatively simple parameters which assist in providing a better picture of tropical conditions than does the monthly rainfall total alone, are the number of rainy days and the mean daily rainfall intensity, MDI (Jackson, 1986). The MDI is obtained as

$$\text{MDI} = \frac{\text{Total monthly rainfall}}{\text{No. of RDs in the month}}$$

Mean monthly distribution of MDI for different stations is presented in Table 4.

Except for Sangli in August, the mean daily intensity (MDI) is invariably above 10 mm per rainy day. In fact, for every month this station records the lowest intensity among the locations selected. The lowest value of MDI is observed in August, in all stations; incidently this is typically the month with frequent "breaks" in monsoon. The crops during the month, particularly in its later half, are mostly in anthesis and reproductive stages and vitally need intermittent short dry spells for proper development and grain setting. The MDI in June is generally found to be largest (except for Jalgaon and Solapur).

An attempt is also made in this paper to evaluate dependence of monthly rainfall (Y), separately, on RDs (X_1) and MDI (X_2). For this purpose, a number of equations were fitted to the data. Those equations which gave maximum and significant correlation are selected. The equations within the three regions were almost identical and shown below.:

The equation

$$Y = X_1 / (AX_1 + B) \quad (1)$$

was found to represent all locations in Madhya Maharashtra.

When the MDI was considered, some diverse result emerged. In the northern and southern parts of the sub-division, the MDI could be represented by

$$Y = A + B / X_2 \quad (2)$$

However, for the central parts, the curve

$$Y = X_2 / (AX_2 + B) \quad (3)$$

gave the best fit.

For selected stations from each part of the region, these are shown in Fig. 2 alongwith the scatter plots.

A glance at the Fig. 2 (a) clearly brings out the dependence of monthly rainfall on RDs, though the coefficients varied from location to location. As far as the monthly rainfall and MDI is concerned [Fig. 2(b)], it can be noticed that the latter does not exert as much influence on the rainfall as RDs. The correlations are lower compared to that with RDs. Only in the lower rainfall areas of Sangli and Ahmednagar, relationship of rainfall and MDI were found more pronounced than that between rainfall and RDs.

4. Conclusions

(*i*) During the period under study, monthly rainfall and number of rainy days seems to have decreased at a large number of stations.

(*ii*) First 10 and 25% of rainy days contribute 10-15% and 25-35% of the total seasonal rainfall.

(*iii*) Rainfall in the form of 'drizzle' is common in August and add substantially to the monthly total.

(*iv*) Heavy rainfall is a characteristic feature during June-onset phase and September – the retreating phase of monsoon and contribute to 1/3rd to slightly more than half of the monthly total particularly in north and central parts of Madhya Maharashtra.

(*v*) Association between monthly rainfall and mean daily rainfall intensity seems rather weak.

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