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# Onset of monsoon over Delhi

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(*Received* 20 *April* 1951)

ABSTRACT. A study of the onset of monsoon over Delhi and neighbourhood extending for a period of fifty years is attempted in this paper. Widespread rain over the districts around the station has been chosen as the criterion for fixing the date of onset of the monsoon. The rainfall data of the provincial raingauge stations have been examined. From the examination of the data of the past 50 years, the mean date of onset of monsoon over Delhi has been found and the standard deviation worked out. The frequency diagram shows approximately normal distribution about the mean date. Synoptic situations on these dates have also been examined and the onsets are roughly classified under different synoptic situations that brought in the monsoon during the last 50 years.

## 1. Introduction

The oppressive heat from which the people of northwest India suffer becomes truly fearful by the end of June and everyone pines for rains. Naturally, the public become exremely anxious about the date of arrival of the monsoon which, with violent storms and heavy rain showers, gives the much needed relief from the oppresive heat. The arrival of the monsoon in these tracts is a meteorological event of considerable importance and a study of this event over Delhi and neighbourhood extending for a period of fifty years is attempted in this paper.

Because of the difficulties of defining what the monsoon is, in unequivocal terms, in many cases it becomes difficult to declare definitely the date of onset of the monsoon over a station in northwest India, even after the event has taken place. Different criteria can be employed to determine this date, depending upon the particular aspect a party is interested in. The synoptic meteorologist may prefer an air-mass characteristic or a particular wind system ; a farmer would prefer the widespread nature of the associated rainfall, while a member of the general public may be satisfied with a comfortable drop in the day temperature. On occasions when all these criteria are simultaneously satisfied and in an abrupt manner, the date of onset gets uniquely defined. On other occasions it becomes necessary to specify a criterion for fixing the date of the onset. In this study the farmers' aspect of widespread rain over the district in which the station is situated and neighbouring districts has been chosen as the deciding factor.

## 2. Method of analysis

With this criterion for the onset of the monsoon, the rainfall data of the State raingauge stations round about Delhi for the last fifty years have been examined. The districts, *viz.*, (1) Gurgaon (2) Rohtak (3) Meerut (4) Muzaffarnagar (5) Bulandshahr were selected and the rainfall records of these districts for the period 15 June to 20 July were considered. For each year, a day was selected when most of the raingauge stations in all these district had reported rainfall. Then for ten days on either side of this date, the number of raingauge stations in each district which had rain was tabulated. From these tables, for each year, the date of onset of monsoon over Delhi was fixed as the day when the first burst of rains occurred. In most of the cases there was no difficulty in fixing a date uniquely. As would be clear from Table 1, the date of onset in the year 1926 can be easily fixed as 12 July.

But in certain cases the decision had to be subjective.

In some years a western disturbance gives a rain spell and the monsoon is established a few days thereafter. Example of such a case is shown in Table 2.

TABLE 1

**Number of raingauge stations which reported rainfall on different dates in July 1926**

| Date (July 1926) | Name of district with number of raingauge stations in the district within brackets | | | | |
|---|---|---|---|---|---|
| | Gurgaon (14) | Rohtak (7) | Meerut (7) | Muzaffarnagar (6) | Bulandshahr (6) |
| | Number of stations which had rainfall | | | | |
| 2 .. | 1 | — | — | 1 | 2 |
| 3 .. | 1 | — | — | — | 1 |
| 4 .. | — | — | — | — | — |
| 5 .. | — | — | — | — | — |
| 6 .. | — | — | — | — | — |
| 7 .. | — | — | — | — | — |
| 8 .. | — | — | — | — | — |
| 9 .. | — | — | — | — | — |
| 10 .. | — | — | — | — | — |
| 11 .. | — | 1 | — | — | — |
| 12 .. | 14 | 6 | 7 | 6 | 5 |
| 13 .. | 11 | 2 | 7 | 6 | 5 |
| 14 .. | 12 | 1 | 7 | 3 | 6 |
| 15 .. | 12 | 4 | 7 | 5 | 5 |
| 16 .. | 4 | 4 | 4 | 2 | 1 |
| 17 .. | 4 | — | — | — | 2 |
| 18 .. | 2 | — | — | — | — |
| 19 .. | 6 | 6 | 7 | 6 | 4 |
| 20 .. | 5 | 6 | 6 | 4 | 2 |
| 21 .. | 12 | 6 | 2 | — | 1 |
| 22 .. | 4 | 1 | 1 | 1 | — |

TABLE 2

**Number of raingauge stations which reported rainfall on different dates in June-July 1939**

| Date (June-July 1939) | Name of district with number of raingauge stations in the district within brackets | | | | |
|---|---|---|---|---|---|
| | Gurgaon (14) | Rohtak (7) | Meerut (7) | Muzaffarnagar (6) | Bulandshahr (6) |
| | Number of stations which had rainfall | | | | |
| 15 June .. | 8 | 3 | 1 | — | 1 |
| 16 .. | 7 | 4 | — | — | 1 |
| 17 .. | 9 | 4 | 2 | 5 | — |
| 18 .. | 9 | — | 6 | 4 | 6 |
| 19 .. | 4 | — | 1 | 1 | — |
| 20 .. | — | — | — | — | — |
| 21 .. | 2 | — | 2 | — | 2 |
| 22 .. | 1 | — | 3 | 4 | — |
| 23 .. | 6 | — | 1 | 3 | — |
| 24 .. | 10 | 2 | 5 | 5 | — |
| 25 .. | 9 | 2 | 4 | 3 | 4 |
| 26 .. | 9 | 1 | 2 | — | 4 |
| 27 .. | 11 | 2 | 7 | 6 | 6 |
| 28 .. | 1 | — | 5 | 6 | 5 |
| 29 .. | — | — | 5 | 4 | 1 |
| 30 .. | 1 | 1 | 3 | 3 | 2 |
| 1 July .. | 1 | — | 3 | 4 | 2 |
| 2 .. | 1 | — | 3 | 4 | 2 |
| 3 .. | 4 | — | — | — | — |
| 4 .. | 1 | — | — | — | — |
| 5 .. | 2 | — | — | — | 4 |

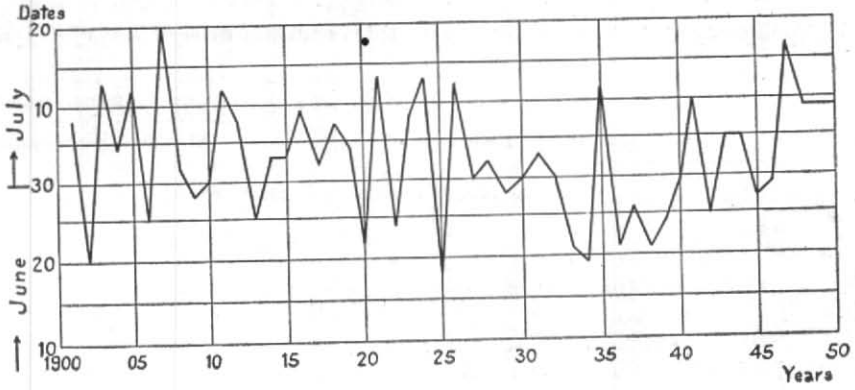


Fig. 1. Graph showing dates and years of onset of monsoon over Delhi

Scattered rain before the establishment of monsoon was due to a western disturbance. Monsoon established itself only on 24 June as has been verified from an examination of the synoptic situation. In such years the spurious dates have been eliminated by examining the weather charts.

### 3. Results

The dates of onset of monsoon over Delhi thus derived for the last 50 years are given in Table 3.

From the examination of these data, the arithmetic mean date has been found to be 2 July. Fig 1 shows the years and the dates of onset. The standard deviation $\sigma$ given by the square root of $\Sigma D^2/(n-1)$, where $D$ is the deviation from the mean date (2 July) and $n$ the number of years, works out to 7.8 days.

Fig 2 gives the frequency distribution of the dates of onset of monsoon over Delhi. It will be seen from the graph that the maximum number of occasions of onset of monsoon occur in the first week of July. The next lower frequencies appear in the second week of July and the last week of June. On 7 occasions out of 50, monsoon has burst in the third week of June and two isolated cases have been observed in the third week of July. The graph is approximately symmetrical about the mean date —2 July. It has been observed that 66% of the dates of onset actually lie between the interval M—$\sigma$ to M+$\sigma$ where M is the mean date and 98% of the dates fall within the interval M—2$\sigma$ to M + 2$\sigma$. Thus the curve which is approximately symmetrical about the mean value approximates to a normal curve. Hence there is a 68% chance that the monsoon will come over Delhi in the last week of June or the first week of July and it will rarely burst before the third week of June or be delayed beyond second week of July.

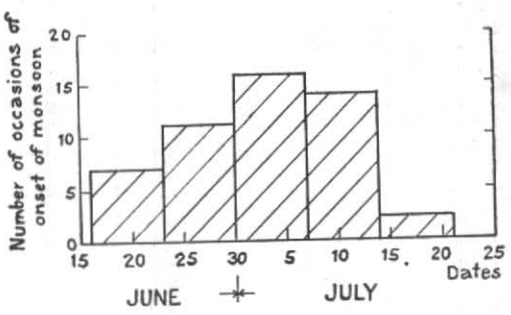


**Fig. 2. Graph showing frequency distribution of dates of onset of monsoon over Delhi**

### 4. Synoptic situations leading to the onset

The synoptic situations on the dates given in Table 3 were also examined and it has been observed that the situations that usher in the monsoon over Delhi can be classified broadly under the following types—

(*a*) Arrival of the Bay branch of the monsoon in association with a depression from the Bay of Bengal.

(*b*) Arrival of the Arabian sea current in association with a strengthening of the Arabian sea branch of the monsoon.

(*c*) Simultaneous strengthening of the Bay branch and the Arabian sea branch of the monsoon.

(*d*) Penetration of the Bay current or the Arabian sea current under the action of a western disturbance.

(*e*) In rare cases a simultaneous strengthening of the Arabian sea and Bay branches of the monsoon and a well placed western disturbance.

**TABLE 3**

**Dates of onset of monsoon over Delhi** (1901-1950)

| Year | Date | Year | Date |
|---|---|---|---|
| 1901 | 8 July | 1926 | 12 July |
| 1902 | 20 June | 1927 | 30 June |
| 1903 | 13 July | 1928 | 2 July |
| 1904 | 4 July | 1929 | 28 June |
| 1905 | 12 July | 1930 | 30 June |
| 1906 | 25 June | 1931 | 3 July |
| 1907 | 20 July | 1932 | 30 June |
| 1908 | 2 July | 1933 | 21 June |
| 1909 | 28 June | 1934 | 19 June |
| 1910 | 30 June | 1935 | 11 July |
| 1911 | 12 July | 1936 | 21 June |
| 1912 | 7 July | 1937 | 26 June |
| 1913 | 25 June | 1938 | 21 June |
| 1914 | 3 July | 1939 | 24 June |
| 1915 | 3 July | 1940 | 29 June |
| 1916 | 9 July | 1941 | 10 July |
| 1917 | 2 July | 1942 | 25 June |
| 1918 | 7 July | 1943 | 5 July |
| 1919 | 4 July | 1944 | 5 July |
| 1920 | 22 June | 1945 | 27 June |
| 1921 | 13 July | 1946 | 29 June |
| 1922 | 24 June | 1947 | 17 July |
| 1923 | 8 July | 1948 | 9 July |
| 1924 | 13 July | 1949 | 9 July |
| 1925 | 17 June | 1950 | 9 July |

Since 1901, on 17 occasions, a depression from the Bay of Bengal has been responsible for the setting in of the monsoon over Delhi. It has been observed that Delhi gets the first burst of monsoon rains when the depression after crossing the coast is centred frequently over the border of the Uttar Pradesh and Bihar or the adjoining parts of Madhya Pradesh. Skies are heavily clouded in the east Uttar Pradesh and moderately clouded in the west Uttar Pradesh and in Punjab (I). The depression usually gets filled up in the Uttar Pradesh itself without further westward travel. Fig. 3 shows a typical case of this kind. On the morning of 12 July 1926, the depression is centred near Satna with a low over Sind. The skies are moderately to heavily clouded in Uttar Pradesh and the Punjab (I) and Delhi gets its first burst of monsoon.

On 10 occasions out of these 50, the Arabian sea current has caused the onset of monsoon over Delhi. Strong southwesterlies usher in the moisture into the Punjab (I) after causing heavy rains over Gujarat and Rajasthan. Heavy clouding in Rajasthan caused by the inflow of humid winds usually give a prior indication of the penetration of monsoon over Delhi a day or two later. Fig. 4 illustrates such a case. On the morning of 29 June 1940 strong southwesterlies are blowing across north Bombay coast and Rajasthan and becoming southeasterlies in the east and central Punjab (I).

On 11 occasions, the combined effect of both the currents have been responsible for bringing about the monsoon rains. In such a case the convergence of the two currents cause fairly heavy rains. Fig. 5 depicting the synoptic situation on the morning of 8 July 1923 is an example. Delhi records six inches of rain on this morning.

On rest of the years the western disturbance has helped either of currents and thus caused arrival of the monsoon. In Fig. 6 for example, a depression is situated over the head of the Bay on 26 June 1937. Arabian sea current is moderate and a western disturbance is over Baluchistan. Under the combined effect of all these three situations, monsoon extends over Delhi. There are a few more cases when a western disturbance coupled with strong monsoon currents have ushered in the monsoon over Delhi.

Table 4 gives a summary of the situations that brought the monsoon current over the Delhi state and neighbourhood during the last 50 years.

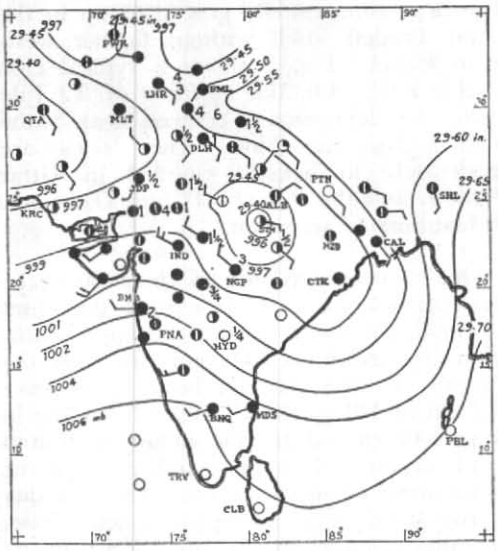


Fig. 3. Weather Chart at 0800 IST on 12 July 1926

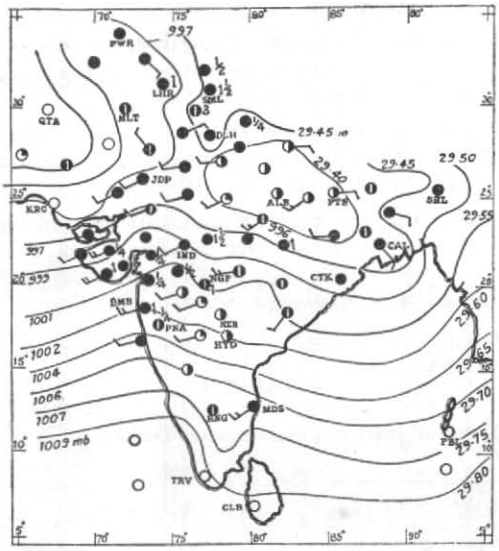


Fig. 4. Weather Chart at 0800 IST on 29 June 1940

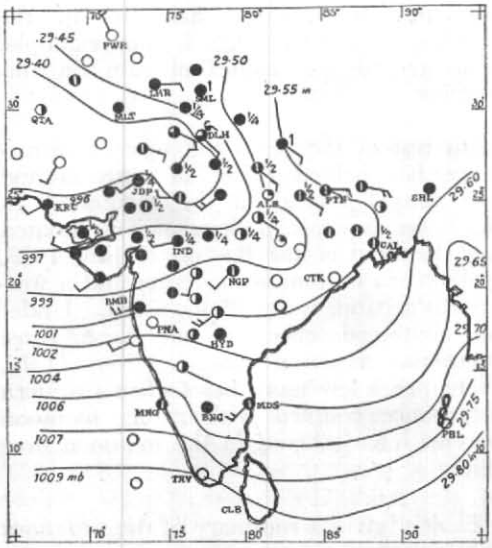


Fig. 5. Weather Chart at 0800 IST on 8 July 1923

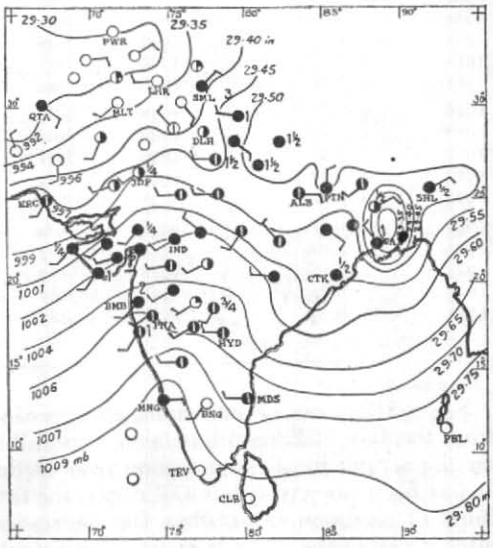


Fig. 6. Weather Chart at 0800 IST on 26 June 1937

TABLE 4

| Synoptic situations that brought monsoon current over Delhi | Years |
|---|---|
| Arrival of the Bay current in association with a depression from the Bay | 1901,1911,1912,1913,1914,1915, 1916,1918,1919, 1920,1924,1925 1926,1928,1931,1939,1947 |
| Arrival of the Arabian Sea current as a result of its strengthening | 1904,1905,1906,1910,1921,1927, 1933,1940,1946,1949 |
| Simultaneous arrival of the Bay and the Arabian Sea branches consequent on a strengthening of both | 1907,1908 1909,1923,1929,1930, 1934,1938,1941,1944,1948 |
| Arabian sea branch or Bay branch penetrating under the influence of an active western disturbance | 1903,1917,1922,1932,1936,1942, 1945,1950 |
| Simultaneous strengthening of both the branches and an active western disturbance | 1902,1935,1937,1943 |

**5. Acknowledgement**

I am extremely indebted to Mr. P.R. Pisharoty, Meteorologist who suggested to me this subject for study and under whose expert guidance this work has been done.

My thanks are also due to Mr. A.K. Roy, Director, Regional Meteorological Centre, New Delhi, for pointing out certain improvements in the method of fixing the date of onset of monsoon.