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A study of Cyclonicity in relation to Rainfall over Indian region

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ABSTRACT. Based on examination of daily synoptic charts for the ten-year period, 1944—1953, a study has been made of days on which centre of a cyclonic system lay in each five degree square in the region covering India and neighbourhood. Monthly charts have been prepared, showing frequency of occurrence of cyclonicity over each such zone and also its progressive behaviour in regard to its persistence or future movement. A rainy day, defined as one having rainfall of 10 cents or more, is found to be related significantly to cyclonicity over a given area, except during hot weather period, March to May.

1. Introduction

Incidence of rain is perhaps the most important amongst weather elements, demanding attention of the weather forecaster. Despite various criteria as are used for the purpose, an accurate forecast of rain with due reference to space and time is yet not always possible. The possibilities of finding any new clue which would be of help to improve accuracy of the forecast would, therefore, deserve attention.

The condition preceding rain occurrence in an area is the development of a meteorological situation as may lead to a systematic rise of moist air mass. For this, the most important indication on synoptic charts, particularly over tropical areas, such as India, are convergence of air in lower layers, and associated mass divergence at certain higher levels. Due to inadequacy of data it often becomes difficult to locate precisely the zone of upper level divergence and study its influence on weather and rainfall over a given limited area, and forecasts have frequently to be based on the features of the low level convergence as shown by circulation pictures at and near surface layers. The rainfall over zones of 5-degree square in India and neighbourhood associated with cyclonic circulations in the lower troposphere has, therefore, been investigated for a ten-year period. The results are presented and discussed in this paper.

2. Data

The term 'cyclonicity' is used in the present study to denote a synoptic situation, in which at least one closed isobar exists over an area of 5-degree square with associated cyclonic circulation upto 1·5 km or more. On the basis of this definition and examination of daily synoptic charts and rainfall data for the period 1944—1953, monthly charts (Figs. 1 to 12) have been prepared, showing (*a*) total number of cyclonic systems which formed over or moved into each 5-degree square (figure within circle at the centre of each square), (*b*) number of those which moved in different directions as indicated by arrows, (*c*) total number of days on which cyclonic system lay over different squares (figure at the lower left-hand corner), (*d*) average monthly rainfall per station in inches (figure at upper right-hand corner), (*e*) average monthly number of rainy days (figure at lower right-hand corner) and (*f*) zone number (figure at upper left-hand corner). The number of stations and years for which rainfall data, for the period 1944—1953, were available for different five-degree squares, is given in Table 1.

3. Analysis of data

The cyclonicity of different zones in different months is shown in Figs. 1 to 12. One noticeable feature which is seen from these figures is that some of the cyclonic systems considered

TABLE 1

Zone	Rainfall data available			Zone	Rainfall data available		
	No. of stations	No. of years	Total No. of stations		No. of stations	No. of years	Total No. of stations
01	5	3	6	21	13	10	23
	1	2			3	9	
02	2	9	16		1	8	
	1	8			6	3	
	13	3		22	1	9	10
03	3	10	8		9	3	
	2	9		23	0	0	0
	1	8		24	0	0	0
	1	3		25	0	0	0
	1	2		26	7	10	9
04	2	3	2		1	8	
05	2	3	2		1	2	
06	6	3	7	27	9	10	14
	1	2			1	9	
07	4	3	5		3	8	
	1	2			1	6	
08	4	10	7	28	5	10	6
	1	9			1	9	
	2	3		29	1	10	1
09	11	10	12	30	0	0	0
	1	9		31	0	0	0
10	8	10	9	32	0	0	0
	1	8		33	0	0	0
11	10	10	11	34	1	10	1
	1	3		35	17	10	18
12	7	10	7		1	9	
13	0	0	0	36	1	10	1
14	0	0	0	37	0	0	0
15	1	2	1	38	1	6	1
16	0	0	0	39	0	0	0
17	2	10	4	40	0	0	0
	1	3		41	0	0	0
	1	2		42	0	0	0
18	10	10	12	43	5	10	6
	1	9			1	7	
	1	7		44	2	10	3
19	11	10	13		1	3	
	2	9		45	0	0	0
20	5	10	8	46	0	0	0
	3	9		47	0	0	0

here did not show systematic movement as expected. For example, in the month of January most of these systems in the northern parts of the country, were in association with western disturbances and should have moved east or northeastwards. But not a single one moved from square 2 and only 8 out of 19 moved from square 8. While examining the daily weather charts, the expected movement of these systems were

carefully looked into. In many cases, these systems showed the expected movement, but were found to be feeble after moving into the neighbouring zones (either no closed isobar or cyclonic circulation not upto 1·5 km) and according to the definition, they could not be taken into account for those zones. It is proposed to make a similar study, in due course, taking into consideration these feeble systems also.

Rainfall data as seen from Table 1 and observations on the synoptic charts for the sea areas and also certain extra-Indian regions are too sparse for proper analysis, and any systematic study of features, such as possible relationship between cyclonicity and rainfall has necessarily to be limited to areas within the borders of India and Pakistan and certain parts of Bay of Bengal.

4. Cyclonicity and Rainfall

The results of this study are subject to the limitations imposed by uneven density of rainfall data from one zone to another, particularly over land zones relative to sea zones. However, with a view to finding out if any significant relationship could be traced between number of days with cyclonicity over a zone and incidence of rainfall there, areas with sufficient data, within the borders of India and Pakistan and certain parts of Bay of Bengal were considered. Scatter diagrams were prepared by plotting (*a*) average monthly rainfall and (*b*) average monthly number of rainy days, for each month in a season in each 5-degree square, against corresponding number of days with cyclonicity. While the diagrams pertaining to rainfall amounts have shown too much of scatter of plotted points to suggest any significant relationship between the two elements, those relating to number of rainy days have shown that, except during the hot season, March to May, number of rainy days is related positively to the number of days with cyclonicity (Figs. 13 to 16).

Absence of any clear relationship between the number of days with cyclonicity and amount of rainfall becomes understandable when we consider that total rainfall over an area depends on a number of other complex factors, such as upper air flow patterns, total moisture content, depth of cloud etc, besides the one factor considered in the present study, namely, convergence due to cyclonicity at lower levels.

The diagrams relating to number of rainy days also show a few points which are much more scattered than the rest. These are seen to relate to zones where rainfall is influenced largely by orography or waves in the easterlies, or to arid zone with little or no vegetation. Excluding these points, the correlation coefficients for the groupings of Figs. 13 to 16 are found to be 0·477 (n=45), 0·060 (n=45), 0·552 (n=56) and 0·786 (n=30) respectively. All these coefficients, except the second one, are significant at 1 per cent 'level of significance'. No significant relationship during the hot weather period is found due to the fact that rainfall during this period depends, besides cyclonicity, on the interaction of moist air and dry air along a line of wind discontinuity, temporary advance of monsoon over Malabar coast, instability in the atmosphere etc.

5. Conclusion

The monthly charts of cyclonicity of different zones over Indian region are seen to be of help in weather forecasting for this region. Number of rainy days is found to be related significantly to number of days with cyclonicity, except during hot weather period, March to May. Total rainfall over an area depends on a number of complex factors and is not related clearly to cyclonicity alone. Weather depends on a number of parameters, and a successful forecaster has to consider as many of these as possible and give proper valuation to each for different types of weather forecasts.

6. Acknowledgements

Very sincere thanks are expressed to Shri A. K. Roy for suggesting this investigation. Thanks are due to Shri K. N. Rao for going through the manuscript and giving valuable suggestions.

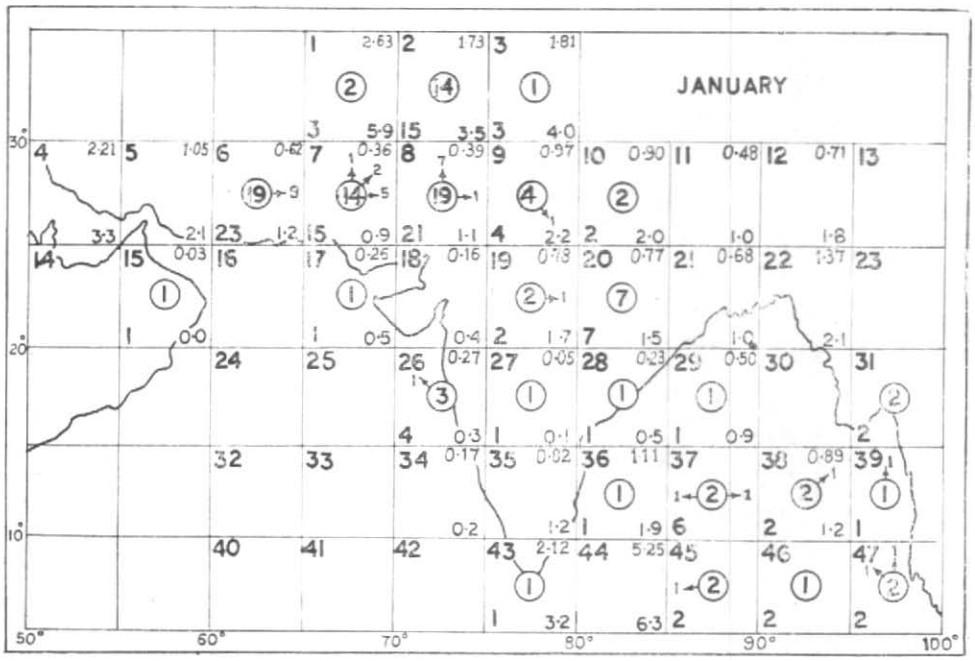
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Fig. 1

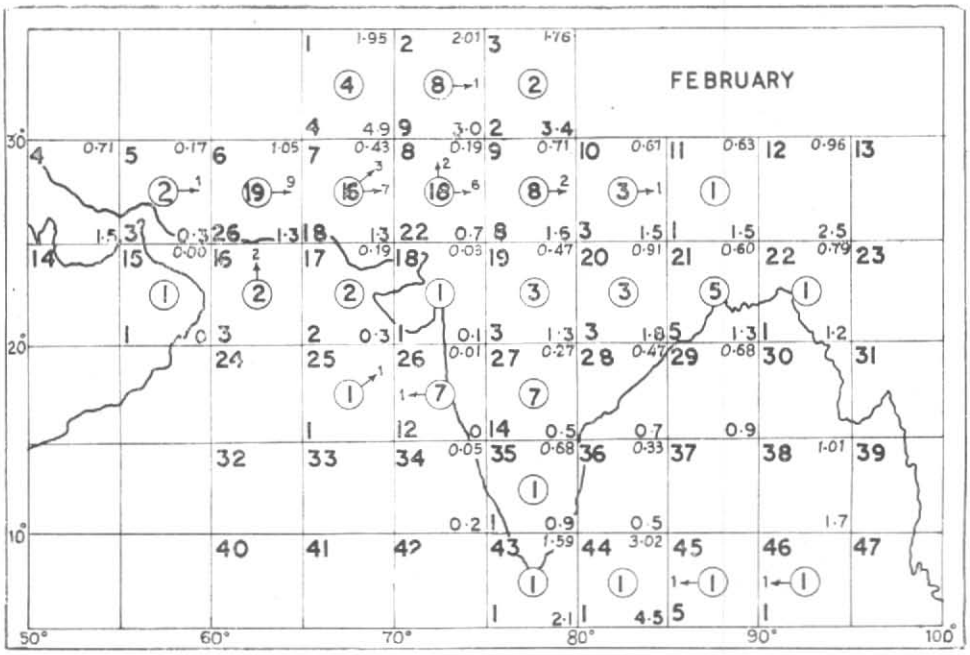
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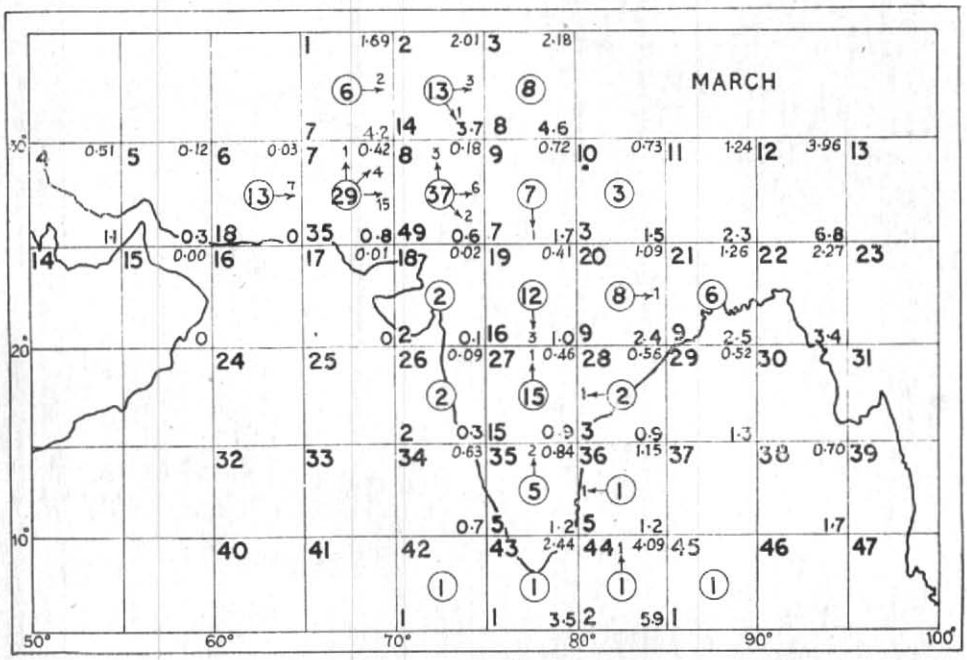
Fig. 2



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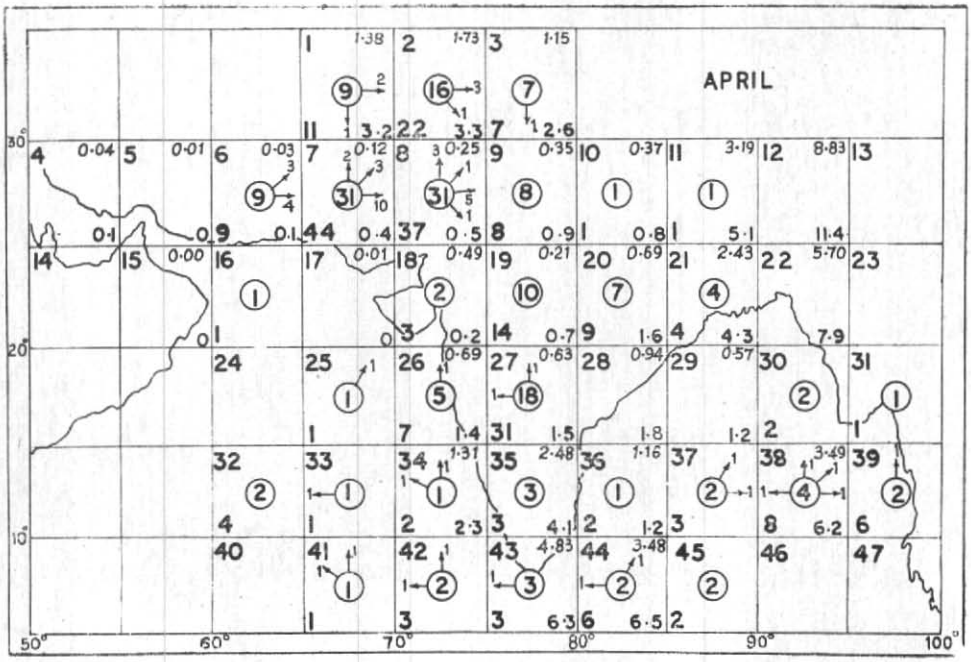

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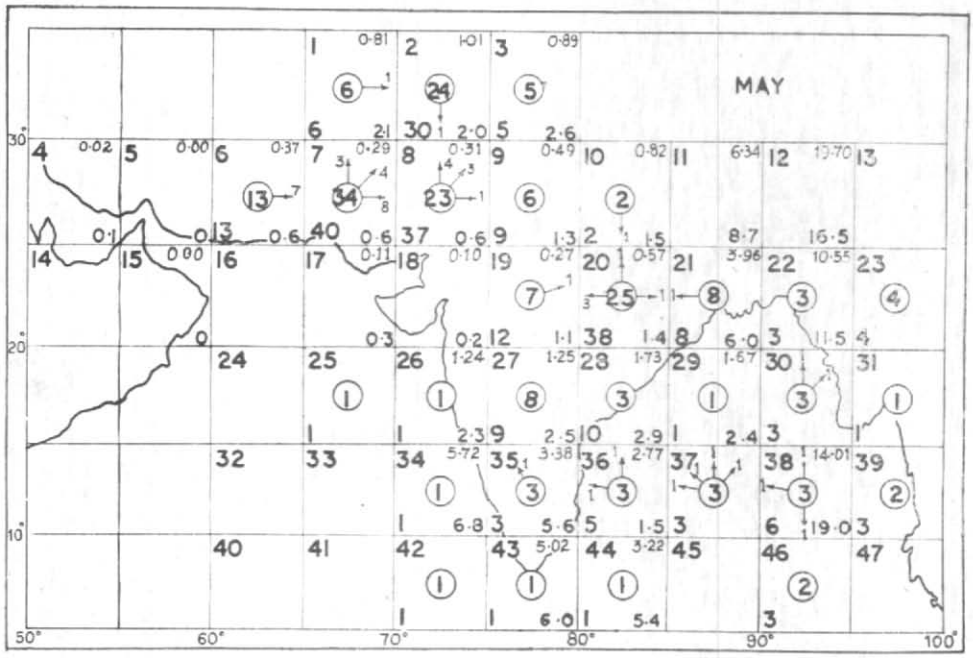

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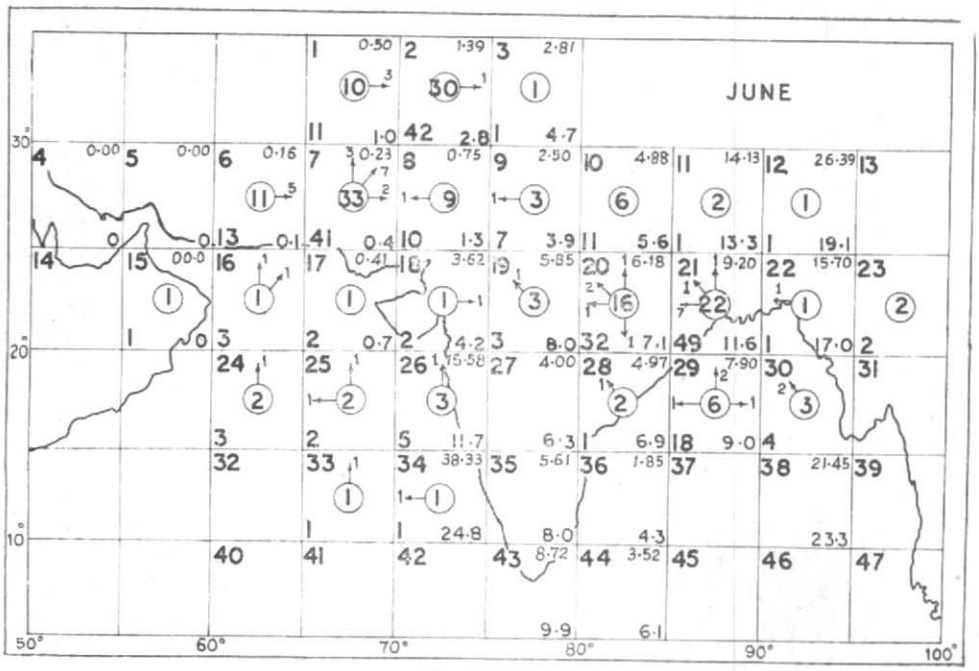

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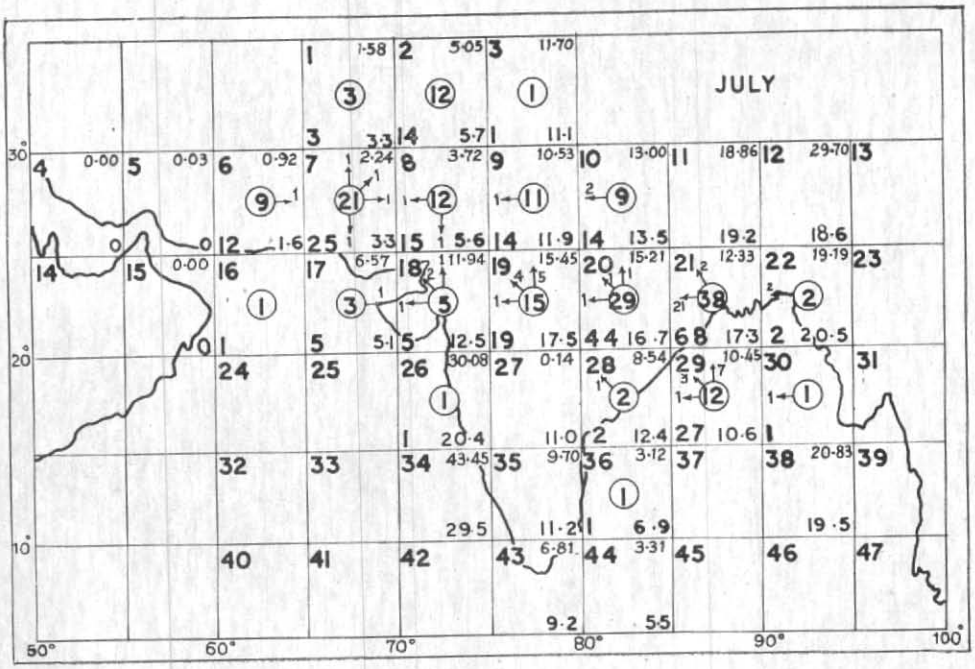

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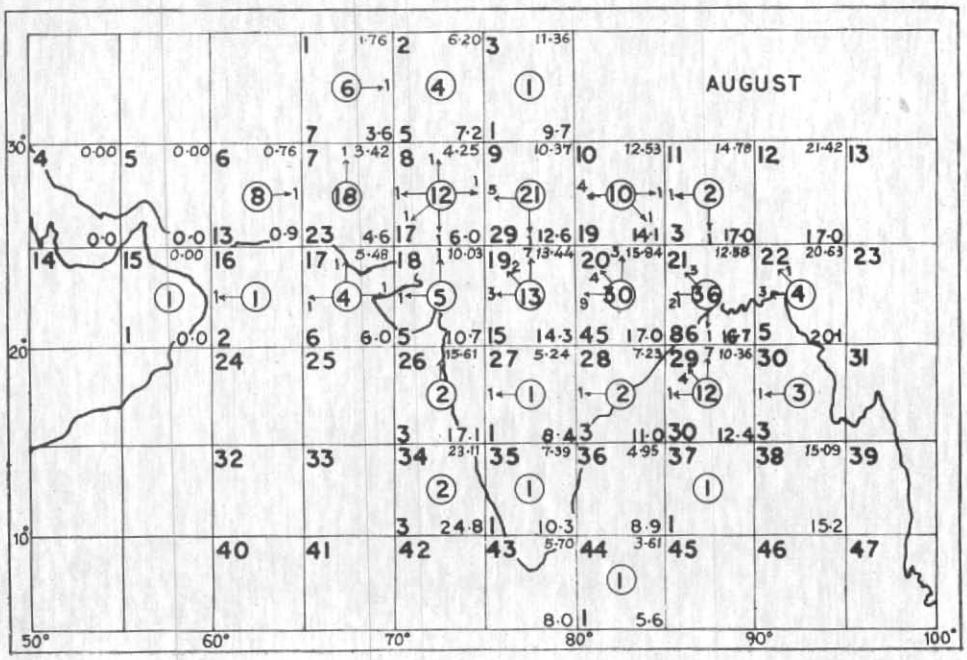

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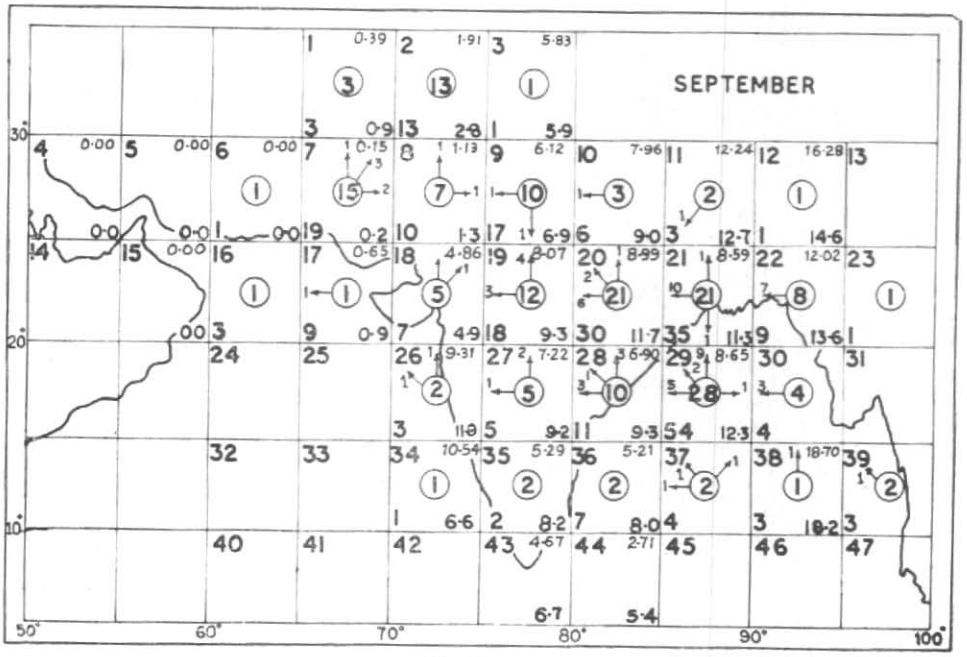
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Fig. 9

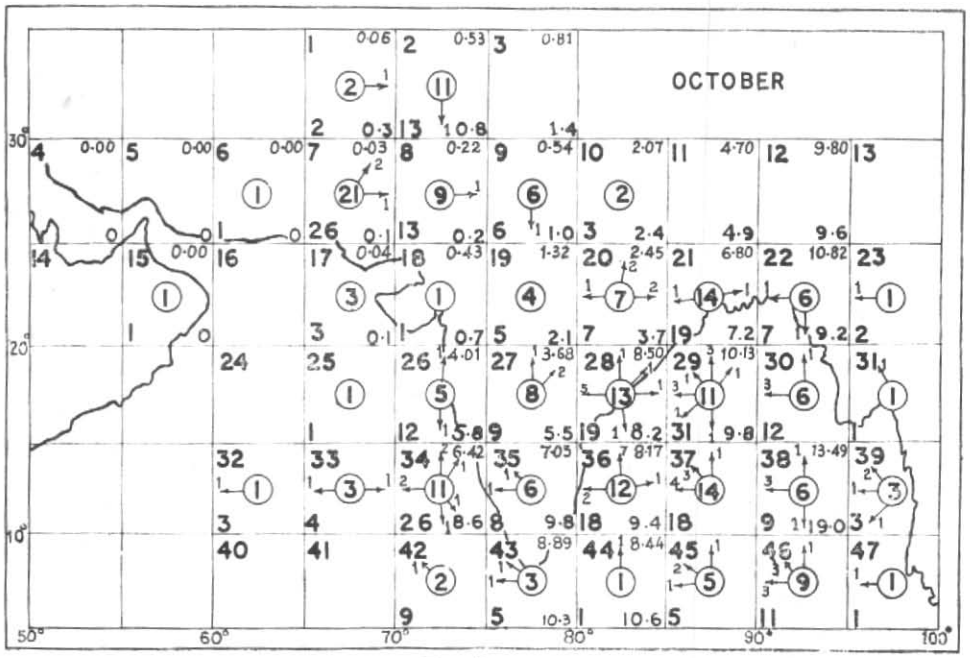
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Fig. 10

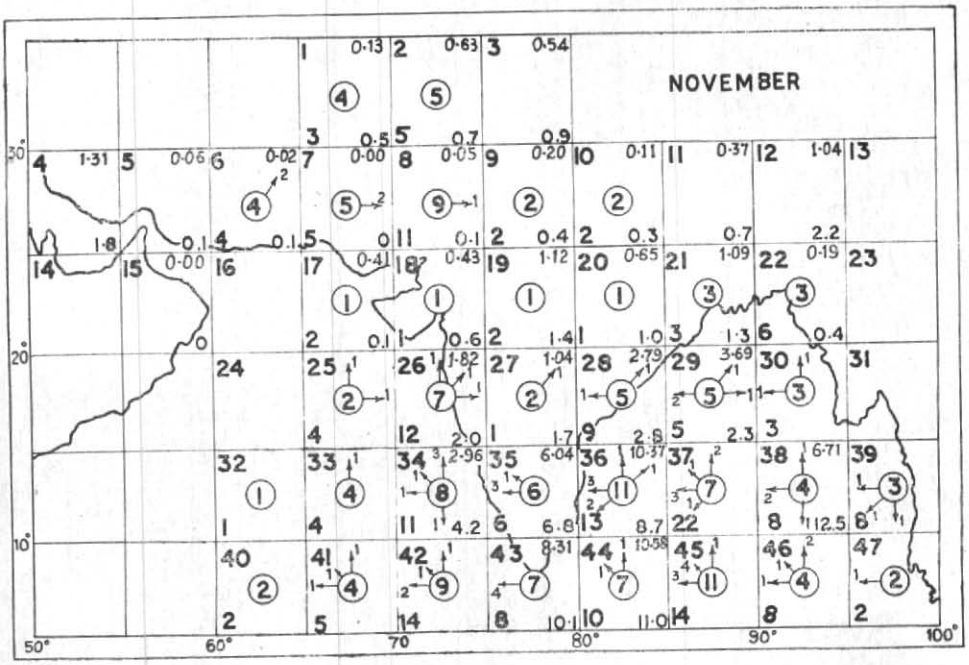
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Fig. 11

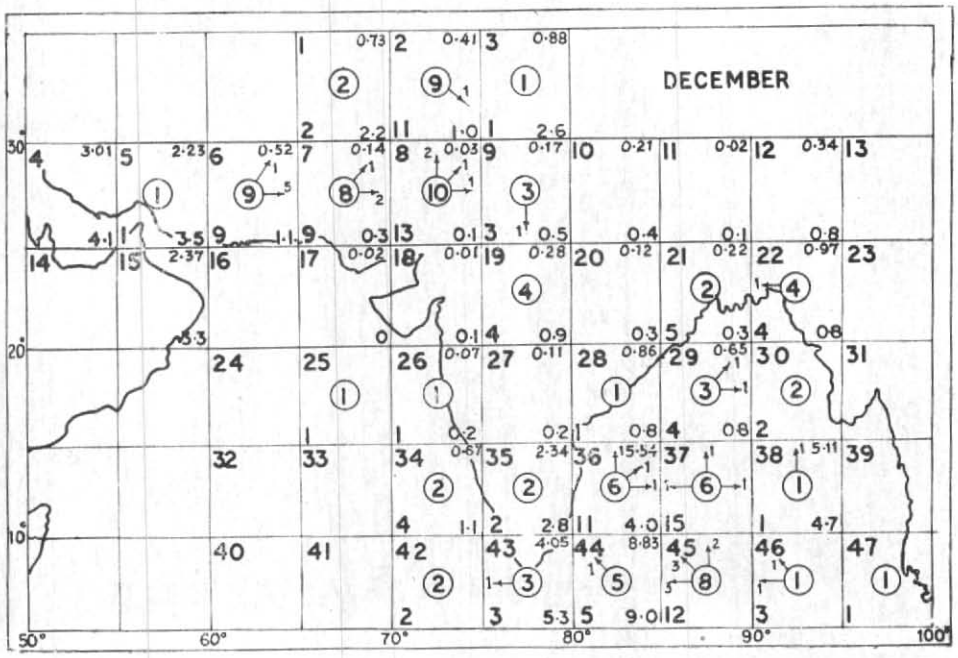
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Fig. 12

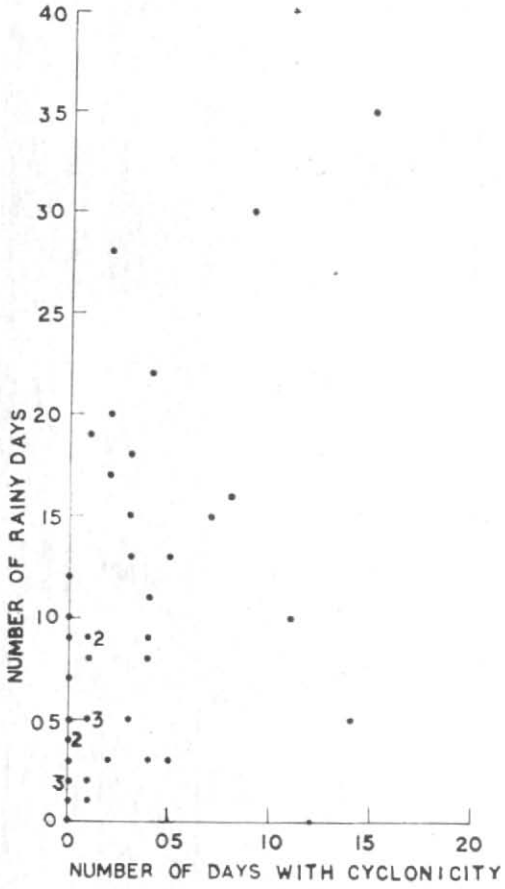

Fig. 13. Winter season

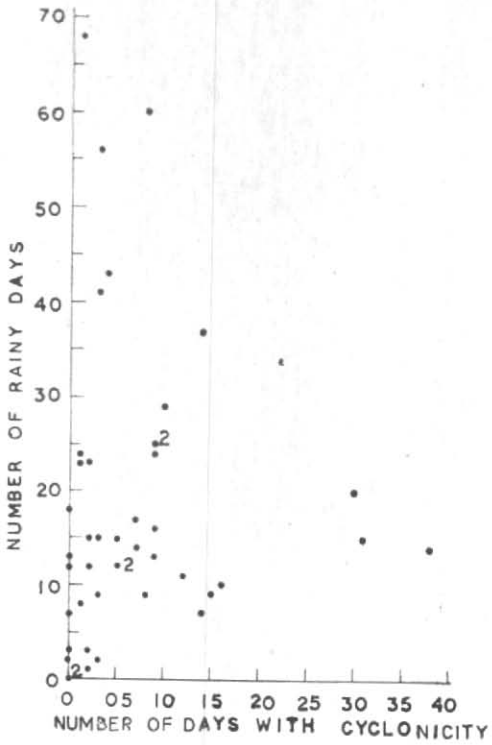

Fig. 14. Hot weather period

The numbers by the side of the points give their coincident values

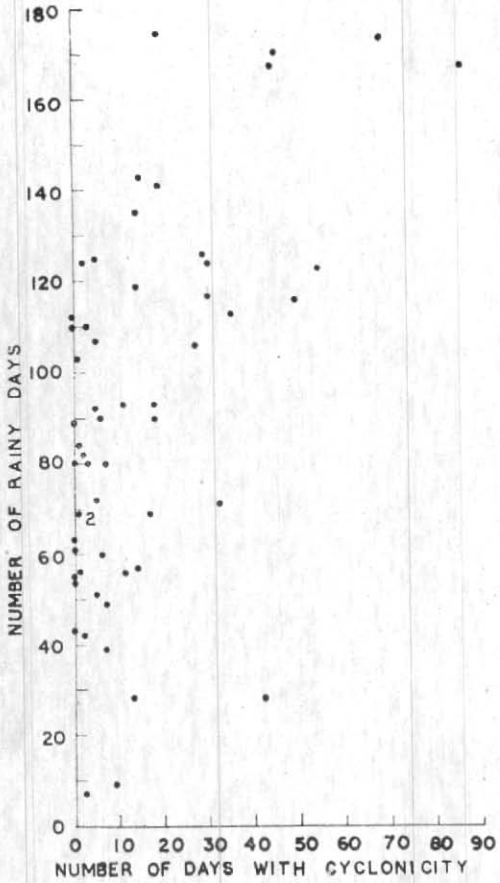

Fig. 15. Southwest monsoon season

The number by the side of the point gives its coincident value

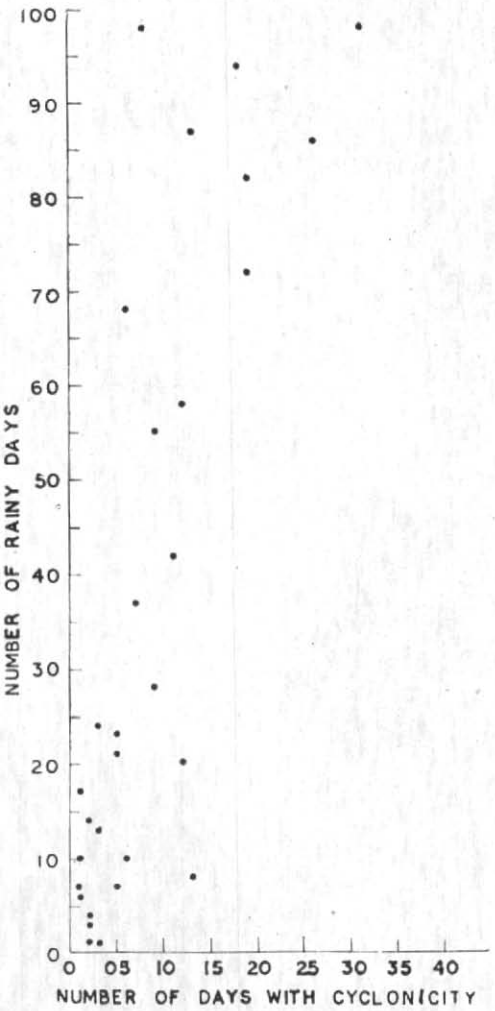

Fig. 16. Post-monsoon season