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An examination of the crop yields at Crop-Weather stations with special reference to rainfall

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Under the all India "Co-ordinated Crop Weather Scheme", systematic quantitative observations are being recorded on a uniform basis at a network of selected experimental farms in India regarding the growth and yield of paddy, wheat, jowar, cotton and sugarcane crops, as well as the weather factors experienced by the crops during their life-cycle. The object of the scheme is to formulate, in quantitative terms, the effects of the different weather factors on the growth and yield of these crops. However, quantitative study of the data can be undertaken only after these have been collected for a sufficiently long period. Nevertheless, even the few years' data collected so far, provide some interesting information, though of a qualitative nature, regarding the effects of different weather factors on the growth and yield of the crops under observation. In this article, some outstanding examples of the effect of rainfall on the yield of paddy, wheat, jowar and cotton crops, over large contiguous areas, as seen from the crop-weather data collected so far, are presented and discussed. The sugarcane crop has not been included because, being an irrigated crop, it is not directly affected by the rainfall as much as the other four crops.

Under the crop-weather scheme, there should be two varieties of the crop under observation at each station. However, these two varieties at each station are not common for all the stations except in the case of wheat. In the case of wheat one of the two varieties under observation at each station is N.P. 4 which variety is, therefore, common for all the stations recording crop weather observations on the wheat crop. The yield values for paddy, jowar and cotton crops presented here are the averages of the yields of the two varieties, at each station, in each year. (In the case of cotton at Hagari, only one variety is under observation and the yield is of that variety only). In the case of wheat, as N.P. 4 is a common variety at all the stations, the yield values given in this article are those for the variety N.P. 4 only.

The average yields, *i.e.*, the average of the yields in different years, for each crop, at each

TABLE 1

Average yield of grain/kapas (cotton) in lbs per acre

States and Stations	Paddy	Wheat	Jowar	Cotton
West Bengal				
Chinsurah	2217 (10)			
Madhya Pradesh				
Labhandi	1648 (6)	520 (6)		
Nagpur		801 (7)	1454 (7)	888 (6)
Akola			1183 (9)	819 (6)
Powerkhera		343 (8)		
Bombay				
Niphad		385 (9)		
Jalgaon		483 (9)	872 (9)	566 (6)
Viramgam				648 (5)
Surat				274 (6)
Karjat	1903 (10)			
Sholapur			315 (9)	
Dharwar		708 (9)	1958 (9)	596 (6)
Hyderabad				
Parbhani		628 (9)	1112 (9)	332 (8)
Raichur			849 (9)	
Mysore				
Hagari			376 (7)	282 (7)
Madras				
Aduthurai	2887 (6)			
Koilpatti				419 (7)
Coimbatore	3289 (7)		366 (7)	291 (7)
Pattambi	1985 (7)			
Andhra				
Samalkota	3469 (7)			

station are given in Table 1, the figures within brackets indicating the number of years on which the average is based. Tables 2, 3, 4 and 5 give the yield values of paddy, wheat, jowar and cotton crops respectively, at each station and in each year. These yields have been classified under 3 categories, markedly good, markedly bad and normal. For this purpose, wherever the difference between the yield for a year and the average yield for the crop at the station is 25 per cent or more of the average yield, the year is considered to be abnormal, the yield being considered markedly good or markedly bad depending upon whether it is 125 per cent or more or 75 per cent or less respectively of the average yield. The above procedure was adopted because, as will be seen from Tables 2, 3, 4 and 5, only 7 to 10 years' data for each station are available and this makes it difficult to apply standard statistical methods like using the standard deviation as an index for judging the abnormalities in the data. In Tables 2, 3, 4 and 5 the values for markedly good yields are shown in bold figures and those for markedly bad yields in italics.

The number of years with abnormal (markedly good + markedly bad) yield, expressed as a percentage of the total number of station-years (number of stations × number of years), for each crop, as judged on the criterion explained above, are 15 per cent for paddy, 54 per cent for wheat, 53 per cent for jowar and 47 per cent for cotton. It appears that the yield of paddy has been much less variable than that of the other crops under study, possibly because the stations where paddy is under observation are situated in areas with more or less assured rainfall or irrigation facilities.

Instances of markedly good or markedly bad yields over large contiguous areas and the outstanding features of the associated rainfall are next examined, crop by crop.

(*A*) *Paddy* —It will be seen from Table 2 that over West Bengal and east Madhya Pradesh as represented by Chinsurah and Labhandi respectively, the year 1952-53 was a markedly bad year while in 1954-55 the yield at Labhandi was markedly good and the yield at Chinsurah, though falling short of markedly good yield as defined above, was definitely more than average (116%). Therefore, it would appear that over the area comprised of West Bengal and east Madhya

TABLE 2

Paddy

Yield of grain in lbs per acre

Year	Karjat	Pattambi	Coimbatore	Aduthurai	Samalkota	Chirsurah	Labhandi
1945-46	1849					2377	
1946-47	1973					2247	
1947-48	1746					1999	
1948-49	1720	1955	*2159*		2939	2064	
1949-50	1877	1968	3385	3573	*2408*	**2795**	1933
1950-51	2087	1770	3335	*2047*	3441	2277	1797
1951-52	2035	2007	3821	3149	4151	2206	1564
1952-53	2016	1939	3723	3085	**4593**	*1396*	*769*
1953-54	2217	1719	3481	2218	3307	2251	1571
1954-55	1508	2348	3120	3248	3446	2562	**2254**

TABLE 3

Wheat

Yield of grain in lbs per acre

Year	Dharwar	Parbhani	Jalgaon	Niphad	Powerkhera	Nagpur	Labhandi
1946-47	*0*	*135*	*0*	*47*			
1947-48	**907**	611	380	**597**	269		
1948-49	*32*	*462*	491	**649**	**620**	**1248**	
1949-50	**970**	**1249**	**1209**	332	*243*	629	*145*
1950-51	764	719	582	*258*	403	857	394
1951-52	873	766	*293*	**634**	368	729	**636**
1952-53	**929**	*319*	*247*	*84*	*142*	608	368
1953-54	655	*407*	470	**485**	413	909	**559**
1954-55	**1242**	**987**	**676**	380	284	627	430

Note : Bold figures indicate markedly good yields and figures in italics markedly bad yields

Pradesh, 1952-53 was a markedly bad year while 1954-55 was definitely a good year. The rainfall during the paddy seasons of 1952-53 and 1954-55 at these two stations, was next examined.

For this purpose, the crop season was divided into four periods, *viz.*, (*i*) Pre-sowing period, *i.e.*, a period of 8 weeks immediately before the sowing in nursery, (*ii*) Seedling period, *i.e.*, the period from sowing to transplantation, when the seedlings are growing in the nursery, (*iii*) Vegetative period, *i.e.*, from transplantation to panicle emergence, when practically all the vegetative growth takes place and (*iv*) Reproductive period, *i.e.*, from panicle emergence to harvest, when the grains form and develop. The total

TABLE 4

Jowar

Yield of grain in lbs per acre

Year	Dharwar	Parbhani	Jalgaon	Nagpur	Akola	Coimbatore	Hagari	Raichur	Sholapur
1946-47	1668	1270	668		1262			*573*	389
1947-48	**2711**	1355	**1333**		**2059**			718	*207*
1948-49	1796	*759*	879	*665*	*832*	*111*	329	711	*182*
1949-50	2203	1117	*645*	*642*	*749*	*90*	458	*507*	317
1950-51	*961*	*433*	953	1637	*64*	*251*	381	675	308
1951-52	1985	857	1001	**2117**	1014	*122*	*259*	647	*187*
1952-53	**2826**	**1988**	*461*	1774	**1509**	*28*	*196*	**1633**	**475**
1953-54	*1308*	*561*	894	**2169**	**1735**	**1561**	463	**1146**	289
1954-55	2164	**1664**	1017	1172	1425	399	**547**	1029	**479**

TABLE 5

Cotton

Yield of kapas in lbs per acre

Year	Koilpatti	Coimbatore	Hagari	Dharwar	Parbhani	Nagpur	Akola	Jalgaon	Surat	Viramgam
1947-48					**501**					
1948-49	405	*189*	279		333					
1949-50	**615**	300	**411**	567	*15*	*559*	*296*	*233*	329	
1950-51	391	350	*183*	619	412	925	813	**631**	**353**	747
1951-52	*286*	**459**	332	556	285	1053	**1330**	**907**	*119*	*350*
1952-53	*43*	*181*	246	451	411	941	1012	575	*171*	*225*
1953-54	467	356	284	551	*173*	**1113**	831	**779**	**409**	529
1954-55	**723**	*205*	239	**831**	**523**	737	639	*269*	265	**1389**

Note : Bold figures indicate markedly good yields and figures in italics markedly bad yields

rainfall and the number of rainy days for each of the above 4 periods at Chinsurah and Labhandi in the years 1952-53 and 1954-55 are given in Table 6.

It will be seen from Table 6 that at both Labhandi and Chinsurah, during the year 1952-53 when the yields were markedly poor, rainfall was lower during the pre-sowing period but higher during the seedling period as compared with the corresponding values during the good year, *i.e.*, 1954-55. During the vegetative period, at Chinsurah rainfall was not very different in the two years but at Labhandi there was a severe drought in 1952-53. During the reproductive period, at Labhandi, there was a little rain in both the years but at Chinsurah although there was some rain in 1954-55 there was no rain in 1952-53. It seems, therefore, that inadequate rain during pre-sowing period and excessive rain during seedling period both at

TABLE 6 (Paddy)

Rainfall and rainy days

Station	Year	Rainfall in inches and the number of rainy days				
		Pre-sowing period	Seed-ling period	Vege-tative period	Repro-ductive period	Total
Chinsurah	1952-53 (*b*)	7·32 (13)	17·65 (32)	17·81 (29)	0	42·78 (74)
	1954-55 (*g*)	19·52 (22)	10·55 (20)	18·27 (33)	1·54 (2)	49·88 (77)
Labhandi	1952-53 (*b*)	3·54 (10)	26·61 (30)	5·65 (8)	0·21 (1)	36·01 (49)
	1954-55 (*g*)	12·51 (11)	13·03 (23)	13·49 (12)	0·24 (1)	39·27 (47)

(1) Figures within brackets indicate the number of rainy days
2) (*g*) or (*b*) below the year indicate that the yield during the year was markedly good or bad respectively

Chinsurah and Labhandi, together with a severe drought during the vegetative period at Labhandi and absence of any rain during the reproductive period at Chinsurah, were responsible for the markedly poor yields at these stations in the year 1952-53.

(*B*) *Wheat*—In Table 3, the year 1946-47 stands out as a devastating one for the wheat crop in the Peninsula. In this year, the yield at each of the stations under study (all situated in Peninsular India) was the lowest so far recorded. In fact, at many of the stations even sufficient seed for the next sowing could not be harvested and seed material had to be obtained from north India for sowing the next crop. This complete failure of the wheat crop was due to a severe epiphytosis of rust brought about by prolonged spells of unseasonal wet weather during November 1946. These unseasonal rains were caused by three cyclonic storms which passed from the Bay of Bengal across Peninsular India, emerged into the Arabian Sea, recurved and entered into the Peninsula again, crossing the west coast. As a result of this, there was widespread rainfall throughout November 1946 in the areas which came under the influence of the three cyclones. The tracks of the three cyclones (reproduced from *Indian Weather Review*, 1946, Annual Summary, Part C) and the rainfall during November 1946 are shown in Fig. 1. The figures within brackets below the rainfall figures indicate the actual rainfall expressed as a percentage of normal. It will be seen from Fig. 1 that over a very large area of Peninsular India, November rainfall was greater than 300 per cent of the normal. It is clear, therefore, that the unusually wet weather during November 1946 created conditions favourable for the large scale severe epiphytosis of rust on wheat, thus causing a total failure of the wheat crop in Peninsular India during the 1946-47 season.

(*C*) *Jowar*—Out of the 9 stations for which data are available, at Coimbatore, Hagari, Raichur and Sholapur jowar is grown during the 'rabi' season when rainfall is not so important as during the 'kharif' season. Therefore, for the purpose of this review, further considerations are confined to the data from the other 5 stations only, *viz.*, Dharwar, Parbhani, Jalgaon, Nagpur and Akola where jowar is grown during the 'kharif' season.

It will be seen from Table 4 that in 1947-48, the yields were very good at Akola (Berar), Jalgaon, Dharwar (Deccan Desh) and Parbhani (Hyderabad North) while in 1950-51 the yields were very poor (lowest recorded so far) at Akola, Dharwar and Parbhani. At these stations, jowar is generally sown in the second half of July and vegetative growth of the crop is completed by about the middle of October when the earheads are put forth. As is well known, the crop requires an abundant supply of water during the vegetative growth period and, therefore, rainfall during this period, *i.e.*, August and September ought to be an important factor for the success of the crop.

The rainfall values for August and September of the 1947-48 and 1950-51 seasons for the rainfall sub-divisions of Berar, Deccan Desh and Hyderabad North, in which the stations under consideration are situated, are given in Table 7 which also gives the actual rainfall expressed as a percentage of the normal.

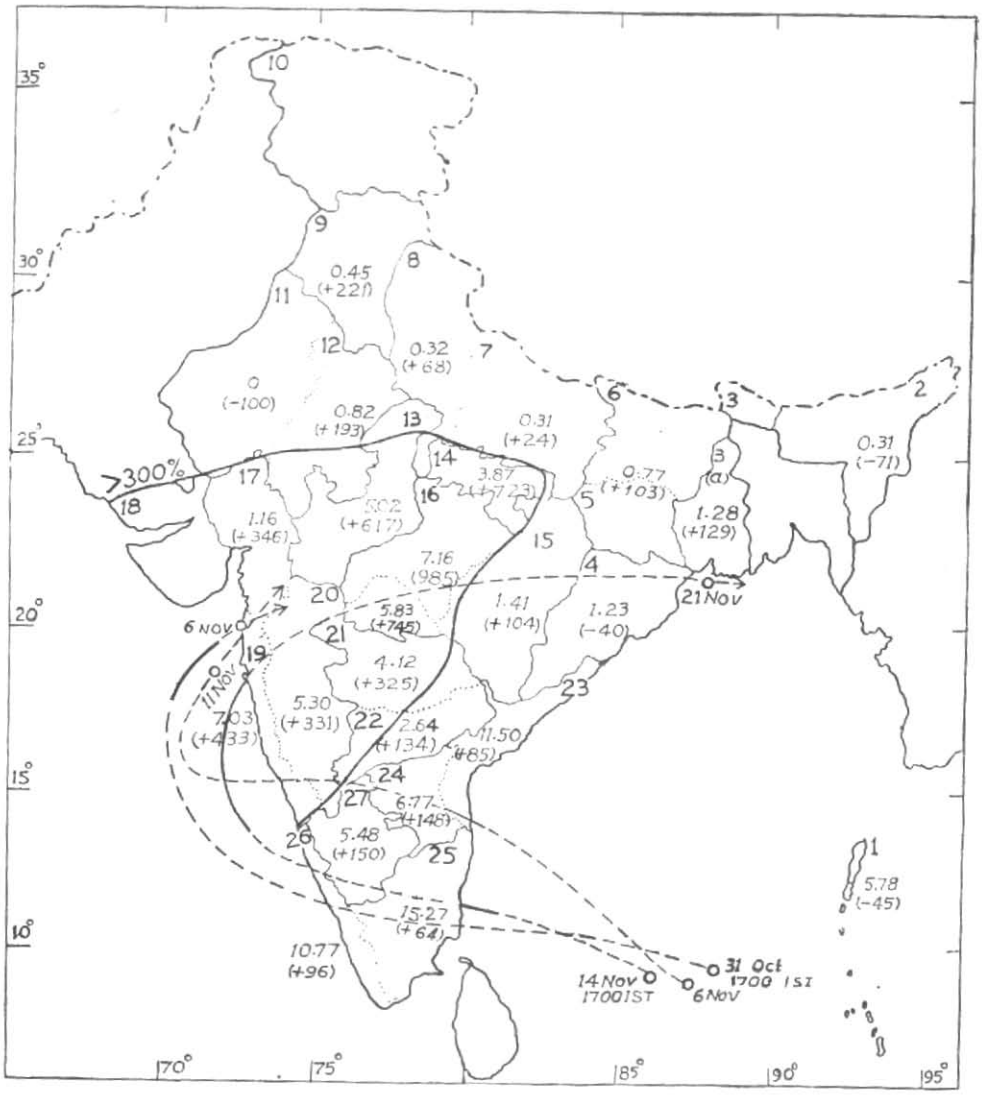

Fig. 1. Rainfall during November 1946

1. Bay Islands
2. Assam
3. Sub-Himalayan West Bengal
3(*a*) Gangetic West Bengal
4. Orissa
5. Chota Nagpur
6. Bihar
7. Uttar Pradesh East
8. Uttar Pradesh West
9. Punjab (India)
10. Jammu and Kashmir
11. Rajasthan West
12. Rajasthan East
13. Madhya Bharat
14. Vindhya Pradesh
15. Madhya Pradesh East
16. Madhya Pradesh West
17. Gujarat
18. Saurashtra and Kutch
19. Konkan
20. Deccan (Desh)
21. Hyderabad North
22. Hyderabad South
23. Coastal Andhra Desa
24. Rayalaseema
25. Tamilnad
26. Malabar and South Kanara
27. Mysore
28. Travancore–Cochin

TABLE 7 (Jowar)

Rainfall during August and September of 1947-48 and 1950-51

Rainfall Sub-division	Year	August		September	
		Rainfall (in.)	Percentage of normal	Rainfall (in.)	Percentage of normal
Berar	1947-48	9·27	145	11·33	191
	1950-51	3·57	56	4·07	69
Deccan Desh	1947-48	13·05	144	5·92	107
	1950-51	5·45	60	11·89	154
Hyderabad North	1947-48	11·79	178	9·46	118
	1950-51	4·67	70	9·89	123

It will be seen from Table 7 that—

(*i*) During 1947-48, in all the three rainfall sub-divisions, rainfall was more than normal during both August and September. This would have induced good vegetative growth resulting in the markedly high yield of the jowar crop in these areas in 1947-48.

(*ii*) During 1950-51, on the other hand, rainfall during August was below normal over the whole area. However, rainfall during September was above normal in Deccan Desh and Hyderabad North, but was below normal again in Berar. Thus during 1950-51 Berar suffered from drought for the two successive months of August and September, during which practically all the vegetative growth of the crop takes place. No wonder, therefore, that the yield of jowar at Akola in 1950-51 was very poor indeed (64 lbs per acre), being only 5 per cent of the average yield.

In Deccan Desh and Hyderabad North, good rainfall during September helped to prevent the total failure of the jowar crop but the damage caused by deficient rainfall during the early vegetative growth in August could not be completely made good. Therefore, in 1950-51, the yield of the jowar crop at Dharwar and Parbhani was markedly poor though not as bad as at Akola.

(*D*) *Cotton*—Out of the 10 stations for which data are presented in Table 5, cotton is grown as a 'rabi' crop at Hagari, Coimbatore and Koilpatti. Therefore, for reasons explained under jowar, further considerations are confined to the other 7 stations only where cotton is grown as a dry crop during 'kharif' season.

It will be seen from Table 5 that in the year 1949-50 the yield was very poor at Parbhani, Nagpur, Akola and Jalgaon. At Surat and Viramgam the yield was markedly poor in 1951-52 and 1952-53. On the other hand, the yield was quite high at Akola, Jalgaon and Nagpur in 1951-52, at Parbhani in 1954-55 and at Surat and Viramgam in 1950-51. Therefore, the rainfall for the relevant periods for these years was examined. For this purpose the season was divided into (1) pre-sowing period, *i.e.*, 8 weeks immediately before sowing, (2) Vegetative period, *i.e.*, from sowing to beginning of flowering and (3) Flowering period, *i.e.*, from the beginning of flowering to the first picking. The rainfall and the number of rainy days during each of the above periods are given in Table 8.

It is seen from Table 8 that at all the stations except Surat and Viramgam, the total rainfall and the number of rainy days during the flowering period was much greater during the year when the yield was markedly poor. It is obvious, therefore, that excessive rain and longer spells of wet weather during the flowering season ruined the cotton prospects at these stations in 1949-50 and very poor yields were obtained. This is in agreement with the findings of Kalamkar and Satakopan (1940) that excessive rainfall during flowering decreases the yield of cotton. In the case of Nagpur in 1949-50 the yield was further depressed by the unfavourable distribution of the rainfall as is seen from the excessive rainfall during pre-sowing period and deficient rains during the vegetative period.

During the year 1949-50, the damage would have been widespread as will be seen from the

TABLE 8 (Cotton)

Rainfall and rainy days

Station	Year	Rainfall (inches) and number of rainy days			
		Pre-sowing period	Vegetative period	Flowering period	Total
Parbhani	1949-50(*b*)	11·30 (14)	15·61 (23)	14·18 (17)	41·09 (54)
	1954-55(*g*)	6·06 (7)	25·18 (34)	0·45 (2)	31·69 (43)
Jalgaon	1949-50(*b*)	9·55 (10)	17·59 (25)	17·38 (14)	44·52 (49)
	1951-52(*g*)	3·62 (7)	11·49 (18)	5·03 (2)	20·14 (27)
Nagpur	1949-50(*b*)	15·53 (19)	17·20 (27)	11·92 (15)	44·65 (61)
	1951-52(*g*)	5·79 (16)	24·62 (30)	5·81 (7)	36·22 (53)
Akola	1949-50(*b*)	10·98 (20)	15·60 (21)	15·78 (23)	42·36 (64)
	1951-52(*g*)	6·97 (9)	10·70 (18)	4·65 (11)	22·32 (38)
Surat	1950-51(*g*)	19·94 (17)	9·46 (27)	0	29·40 (44)
	1951-52(*b*)	0·34 (2)	22·70 (22)	0·18 (1)	23·22 (25)
	1952-53(*b*)	0·55 (5)	13·43 (28)	0·06 (0)	20·04 (33)
Viramgam	1950-51(*g*)	5·92 (7)	18·45 (20)	0	24·37 (27)
	1951-52(*b*)	7·60 (9)	2·11 (3)	0·09 (0)	9·80 (12)
	1952-53(*b*)	3·18 (7)	10·37 (16)	0·84 (2)	14·39 (25)

(1) Figures within brackets indicate the number of rainy days

(2) (*g*) or (*b*) after the year indicate that the yield during the year was markedly good or bad respectively

values of rainfall of the rainfall sub-divisions (in which the stations are situated) as a whole, given in Table 9.

It will be seen from Table 9 that during 1949, over a wide area comprised of north Hyderabad, west Madhya Pradesh, Berar and Bombay-Deccan, the total rainfall during September and October, which is the flowering season for the cotton crop in this area, was much above normal and this would have reduced the yield of the 1949-50 crop considerably. Considering the extent of the area, the magnitude of the total loss must have been really great.

TABLE 9 (Cotton)

Rainfall

Rainfall Sub-division	Rainfall (inches) during					
	September 1949		October 1949		Total for September and October	
	Actual	Dep. from normal	Actual	Dep. from normal	Actual	Dep. from normal
North Hyderabad	16·00	7·95	2·50	0·48	18·50	8·43
West Madhya Pradesh	13·76	5·95	5·79	4·11	19·55	10·06
Berar	15·07	9·15	6·09	4·22	21·16	13·37
Bombay-Deccan	14·29	6·11	2·62	−0·76	16·81	5·35

In the case of Surat and Viramgam as will be seen from Table 8, the poor yields appear to have been due to the cumulative deficiency of rainfall during the pre-sowing and vegetative periods in 1952-53 and excessive rain at Surat and a severe drought at Viramgam during the vegetative period in 1951-52.

In conclusion, it may be stated that the broad effects of rainfall on the yield of crops presented in this review may be of some help in the assessment of crop outlooks, though qualitatively, if and when in future, features of rainfall similar to the occasions described above, happen to occur.

REFERENCE

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