

Rainfall probability analysis for crop planning in selected locations of Tamil Nadu

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Abstract: Rainfall data (>30 years) of two locations (Bhavanisagar and Madurai) in Tamil Nadu were subjected to probability and variability analysis. The results revealed that on an average Bhavanisagar and Madurai receive 636 and 845 mm of rainfall annually with a Coefficient of Variation of 35 and 21%. The average seasonal rainfall of South West Monsoon is 181 and 313 mm with a Co-efficient of Variation of 59 and 28 per cent. Both the locations are dominated by North East Monsoon season (302 and 376 mm) rainfall with more than 40% variability. North East Monsoon accounts for 48 and 45 per cent of total annual rainfall at Bhavanisagar and Madurai, respectively. The highest mean rainfall of 144 and 150 mm was recorded during the month October at Bhavanisagar and Madurai, respectively. The standard weeks 38th- 40th and 42nd - 47th have >50% chance to get 25 mm of rainfall in Bhavanisagar. At Madurai, standard weeks from 36th to 47th had more than 50% chance to get 25 mm of rainfall. At both the locations the chance of getting sowing rain seldom exceeds the threshold level of 67%, indicating risk of dry seeding under dryland condition. However, the analysis indicated that dry seeding could be taken up under dryland condition with substantial risk both at Bhavanisagar and Madurai. At Bhavanisagar region there is more chance for intermittent dry spell and hence drought resistant short duration grain legumes and groundnut may be suggested.

Key words: Rainfall, Madurai, Bhavanisagar, Variability, Probability

Introduction

Agricultural production is controlled by monsoon rainfall, which is the primary source for soil moisture for dryland crops in Tamilnadu. Critical analysis of rainfall over a place assumes greater importance for micro level planning. In agricultural planning, rainfall variability analysis aids to take farm decisions on times of sowing, inter culture operations, fertilizer application etc. Many studies have reported the advantages of working out weekly rainfall probabilities for a station or for an agroclimatic region (Ray *et al.* 1980; Agnihotri *et al.* 1986; Blanford, 1986). Gupta *et al.* (1975) suggested that the rainfall at 80 percent probability can safely be taken as assured rainfall, while that of 50

per cent probability is the medium limit for taking dry risk. In the selected locations of the study (Bhavanisagar and Madurai), the rainfall is concentrated in a short period during rainy months interspersed with intra-seasonal dry spells. These locations are severely affected by greater inter-annual rainfall variability causing degradation of natural resources in the crop production systems. Considering the problems associated with rainfall distribution, simple analysis of rainfall data are required for optimal crop planning. The overall aim of this paper is to understand the nature of rainfall variability on weekly, monthly and seasonal scale in the selected locations. The specific objectives of the paper are i) to quantify the expected rainfall in a given period at selected probability levels ii) to workout

Table 1. Annual and seasonal initial probability Analysis for Bhavanisagar and Madurai

Parameter	Winter (Jan-Feb)	Summer (Mar-May)	SWM (June-Sep)	NEM (Oct-Dec)	Annual
<i>Bhavanisagar</i>					
Mean RF (mm)	17.6	135.1	181.4	302.3	636.4
%of contribution	2.8	21.2	28.5	47.5	100.0
SD	27.2	69.5	106.4	176.3	223.5
CV (%)	154.6	51.4	58.7	58.3	35.1
Initial probability					
50%	0.0	139.8	163.0	289.1	635.6
75%	0.0	85.0	110.8	175.0	507.9
<i>Madurai</i>					
Mean RF (mm)	26.2	130.0	312.5	376.1	845.0
%of contribution	3.1	15.4	37.0	44.5	100.0
SD	35.7	71.4	86.7	151.0	177.2
CV (%)	136.3	54.9	27.7	40.1	21.0
Initial probability					
50%	10.5	97.4	301.0	350.0	840.2
75%	0.2	65.8	224.2	255.4	725.4

the chance of receiving a specific quantity of rainfall in a given period of time. The above objectives are the first step towards any climate analysis for crop planning. The results will be suitably integrated to identify the crop production risks.

Materials and Methods

Daily rainfall data were collected for the rain gauge stations of Bhavanisagar and Madurai for the past 33 and 30 years, respectively. The daily rainfall data were aggregated to weekly, monthly, seasonal and annual totals. The initial probability analysis was taken up to find out the amount of rainfall anticipated at 50% and 75% probability level for various categories of cumulative rainfall (weekly, monthly, seasonal and annual). Conditional probability of rainfall was also worked out for the study area for the data set taken for analysis.

Conditional probability is worked out from the following formula

Percent probability = $(x - \bar{x}) / SD$; the \bar{x} represents the mean rainfall (mm) and x is the required threshold rainfall amount (mm) and the SD is the standard deviation. We considered weekly 25, 15 and 10 mm of rainfall as thresholds, as they have some relevance for taking up sowing, fertilizer application and weeding operation under rainfed condition respectively. Similarly 25, 50 & 100 mm for monthly 200, 300 and 400 mm for seasonal rainfall were worked out. The resultant values of the conditional probability computation were referred to 'Z' table to meet the criteria of normality. If the resultant value of the formula given above was positive, the corresponding value referred to 'Z' table and multiplied by 100 to arrive conditional probability in percentage. If the resultant value was negative, the corresponding 'Z' table value was deducted from 1 and multiplied by 100 for arriving probability.

Table 2. Monthly initial probability Analysis for Bhavanisagar and Madurai

Parameter	Month												Total		
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec			
<i>Bhavanisagar</i>															
Average	5.0	12.7	23.7	39.0	72.4	25.8	20.2	36.1	99.2	143.7	128.6	30.0	636.4		
% of contribution	0.8	2.0	3.7	6.1	11.4	4.1	3.2	5.7	15.6	22.6	20.2	4.7	100.0		
SD	10.4	24.5	45.1	30.0	41.7	24.78	27.1	50.8	76.8	101.3	128.7	38.4	599.7		
CV	211.1	193.6	190.8	76.8	57.5	96.11	134.1	140.7	77.1	70.4	100.1	128.1	1476.9		
Initial Probability	0.0	0.0	8.2	32.4	67.9	18.8	10.2	14.7	75.8	125.8	92.6	9.9	456.3		
	0.0	0.0	0.0	10.6	38.0	5.6	6.0	5.4	42.6	79.7	47.6	0.0	235.5		
<i>Madurai</i>															
Average	13.5	12.7	13.4	44.7	72.0	41.5	58.1	81.4	131.6	169.1	151.1	55.9	844.9		
% of contribution	1.6	1.5	1.6	5.3	8.5	4.9	6.9	9.6	15.6	20.0	17.9	6.6	100.0		
SD	29.0	24.0	27.1	50.0	56.3	33.9	43.7	58.9	69.6	98.0	119.6	56.6	666.7		
CV	214.7	189.8	202.4	112.0	78.2	81.6	75.3	72.3	52.9	58.0	79.1	101.2	1317.4		
Initial Probability	2.6	0	2.4	25.0	53.6	37.4	49.4	80.0	120.3	149.6	114.4	36.0	670.7		
	0	0	0	2.0	27.4	8.6	22.8	26.1	75.0	90.8	72.1	10.2	335.0		

Initial probability was worked out by using the simple model

$$IP = \frac{NXP}{100}$$

Where IP = Initial Probability,
N = Sample size,
P = Probability required

For computing initial probability, each data set were arranged in descending order. To understand the variability of rainfall, Coefficient of Variation (CV = (SD/mean) x 100) was calculated and expressed in percentage.

All the results were presented from Table 1 to 6.

Result and Discussion

Rainfall Variability

The mean annual rainfall of Bhavanisagar and Madurai are 636 and 845 mm with the annual co-efficient of variation (CV) of 35 and 21 per cent, respectively. The result indicated that the annual rainfall variability is relatively greater at Bhavanisagar than at Madurai. The seasonal rainfall analysis indicated that the highest mean rainfall of 302 and 376 mm were received during North East Monsoon (NEM) and 181 and 313 mm of rainfall during South West Monsoon (SWM) at Bhavanisagar and Madurai, respectively.

The monthly co-efficient of variation was lowest for September (53 per cent) at Madurai and for May (58 per cent) at Bhavanisagar. The co-efficient of variation for seasonal rainfall at

Table 3. Initial probability analysis of Weekly Rainfall at Bhavnisagar and Madurai

Months. & Date	STD Week	Average		SD		CV(%)		Initial Probability			
		B. sagar	Madu rai	B. sagar	Madu rai	B. sagar	Madu rai	B. sagar	Madu rai	B. sagar	Madu rai
Jan (1-7)	1	1.6	2.8	6.7	8.3	411.5	291.2	0	0	0	0
Jan(8-14)	2	1.1	2.9	3.9	9.3	349.2	322.2	0	0	0	0
Jan(15-21)	3	2.0	6.4	8.0	26.9	401.8	419.2	0	0	0	0
Jan(22-28)	4	0.0	0.9	0.2	2.5	574.5	274.5	0	0	0	0
Jan(29-4)	5	0.3	3.0	1.5	8.2	574.5	268.4	0	0	0	0
Feb(5-11)	6	0.8	1.4	3.0	5.7	363.9	409.6	0	0	0	0
Feb(12-18)	7	4.0	2.2	12.9	7.6	318.3	337.2	0	0	0	0
Feb(19-25)	8	6.5	3.1	13.8	6.8	213.7	216.2	0	0	0	0
Feb(26-4)	9	2.7	3.9	6.5	13.5	235.2	345.5	0	0	0	0
Mar(5-11)	10	8.3	5.6	25.7	21.3	310.5	382.8	0	0	0	0
Mar(12-18)	11	9.3	2.0	37.6	5.1	406.0	257.3	0	0	0	0
Mar(19-25)	12	3.3	2.5	8.8	10.4	264.3	407.9	0	0	0	0
Mar(26-1)	13	1.3	2.8	3.9	7.7	300.8	280.1	0	0	0	0
Apr(2-8)	14	7.9	9.7	15.4	22.1	193.4	227.4	0	0	0	0
Apr(9-15)	15	10.1	6.4	20.2	26.7	201.0	414.4	2.0	0	0	0
Apr(16-22)	16	8.1	11.1	12.9	19.6	159.6	176.8	1.8	3.4	0	0
Apr(23-29)	17	11.8	13.4	18.2	24.2	153.5	180.1	3.8	2	0	0
Apr(30-6)	18	14.8	23.2	16.3	34.9	110.5	150.4	10.0	7	0	0
May(7-13)	19	18.7	19.5	26.7	32.8	143.0	168.1	8.0	5.6	0	0
May(14-20)	20	17.0	12.1	19.5	17.7	114.7	145.8	14.0	2.8	1.6	0
May(21-27)	21	17.1	15.4	18.8	19.4	110.0	126.6	12.8	6.6	1.0	0
May(28-3)	22	11.8	10.4	14.8	20.3	124.9	196.1	3.6	2.2	0	0
Jun(4-10)	23	10.5	10.0	13.4	13.1	127.6	131.8	2.6	3.1	0	0
Jun(11-17)	24	5.8	8.3	12.0	13.0	208.9	156.8	0	0	0	0
Jun(18-24)	25	2.2	11.8	5.7	20.0	262.7	169.6	0	0	0	0
Jun(25-1)	26	1.6	8.4	3.4	15.7	211.5	187.7	0	0.2	0	0
Jul(2-8)	27	3.7	5.8	8.1	11.2	219.7	190.9	0	0	0	0
Jul(9-15)	28	3.1	17.3	4.3	32.2	137.2	186.5	1.0	3.8	0	0
Jul(16-22)	29	3.1	17.0	5.7	21.2	184.2	124.8	0	9.8	0	0
Jul(23-29)	30	8.6	15.5	23.2	21.5	269.2	139.3	0	0.2	0	0
Jul(30-5)	31	8.2	6.9	22.5	13.3	275.7	192.0	0	0	0	0
Aug(6-12)	32	4.8	20.1	9.5	25.6	196.5	127.2	0	9.4	0	0
Aug(13-19)	33	7.8	21.4	16.7	40.4	215.2	188.5	0	3	0	0
Aug(20-26)	34	11.2	19.6	22.6	27.8	201.9	141.6	0	6.2	0	0
Aug(27-2)	35	7.5	23.2	13.4	26.1	177.5	112.5	0	18.8	0	0
Sep(3-9)	36	10.7	32.2	14.9	47.6	138.8	147.7	2.4	9	0	0
Sep(10-16)	37	21.1	26.9	26.1	30.6	123.9	113.7	9.4	18.6	0	1.8
Sep(17-23)	38	36.3	31.8	41.3	39.0	113.8	122.7	23.0	12.4	0.5	1.8

Sep(24-30)	39	29.5	31.7	41.7	33.3	141.5	105.2	11.2	25	1.0	0
Oct(1-7)	40	27.6	31.7	35.1	33.7	127.1	106.5	15.0	16	3.8	1.2
Oct(8-14)	41	23.0	39.1	27.0	42.0	117.5	107.6	15.0	23.6	4.6	8
Oct(15-21)	42	38.5	37.7	46.7	44.6	121.4	118.2	25.8	17.4	5.7	0.2
Oct(22-28)	43	36.4	45.3	40.0	52.0	109.8	114.8	27.0	25	0.4	5.6
Oct(29-4)	44	34.3	35.3	41.1	39.0	119.7	110.4	20.2	24.6	1.4	5.4
Nov(5-11)	45	56.6	54.8	112.5	72.2	199.0	131.6	26.3	23	1.2	3.4
Nov(12-18)	46	24.6	32.8	40.7	37.9	165.5	115.6	4.0	13.8	0.0	2.6
Nov(19-25)	47	25.4	30.9	50.7	50.3	199.4	163.1	1.0	7.6	0.0	4
Nov(26-2)	48	8.2	15.1	22.0	23.8	267.2	158.1	0.0	2.3	0.0	0
Dec(3-9)	49	9.4	9.1	17.0	12.9	180.9	140.7	1.2	4.4	0.0	0
Dec(10-16)	50	9.6	14.3	24.7	26.1	257.5	182.2	0.0	1	0.0	0
Dec(17-23)	51	4.8	12.2	15.0	18.6	313.4	152.4	0.0	1.2	0.0	0
Dec(24-31)	52	3.9	17.7	9.5	42.2	241.6	238.1	0.0	0	0.0	0

Table 4. Conditional probability of annual and seasonal rainfall (%)

Season	Madurai			Bhavanisagar		
	200 mm	300 mm	400 mm	200 mm	300 mm	400 mm
Winter	0	0	0	0	0	0
Summer	16	1	0	18	1	0
SWM	90	56	6	43	13	2
NEM	88	69	44	72	50	29
Annual	100	100	99	60	52	40

Table 5. Conditional probability of monthly rainfall (%)

Months	Madurai			Bhavanisagar		
	25 mm	50 mm	100 mm	25 mm	50 mm	100 mm
Jan	34	10	0	3	0	0
Feb	31	6	0	31	6	0
Mar	33	9	0	49	28	5
Apr	65	46	13	68	36	2
May	80	65	31	87	71	25
June	69	30	4	51	16	1
July	78	57	17	43	14	0
Aug	83	70	37	59	39	10
Sep	94	88	68	83	74	50
Oct	93	89	76	88	82	67
Nov	85	80	66	89	73	59
Dec	71	54	22	55	30	3

Bhavanisagar is >50 per cent, indicating high variability compared to Madurai. The monthly co-efficient of variation was lesser (<100 %) from May to November at Madurai and during months of April, May, June, September and October at Bhavanisagar. Irrespective of the locations studied, the weekly co-efficient of variation was greater than 100 per cent in all the standard weeks. At Madurai the CV was <150 per cent between the standard weeks 34 and 46th coinciding with September and October months. At Bhavanisagar the weekly CV was less than 150 per cent between 36 and 44th standard weeks, quantitatively explaining shorter length of growing period at Bhavanisagar than at Madurai.

Initial probability

Annually 840 and 725 mm are expected with 50 per cent and 75 per cent chance, respectively at Madurai. Similarly, 636 mm and 508 mm of rainfall is expected with the corresponding probabilities at Bhavanisagar. It has also been noted that 50 per cent probable rainfall was more or less close to the mean annual rainfall at both the locations (Table 1).

The rainfall amount with 50 per cent initial probability at Madurai during SWM and NEM seasons were 301 and 350 mm, respectively. Likewise, 163 and 289 mm of rainfall is expected with 50 per cent chance during SWM and NEM seasons at Bhavanisagar. The monthly initial probability analysis also showed that one can expect mean monthly rainfall in every two years, irrespective of the locations studied. The weekly analysis revealed that probabilities of getting rainfall were absolutely zero (drought weeks) for the standard weeks from 1st to 15th, 24th to 27th and 30th to 31st at 50% level and 1st to 36th at 75% level at Madurai respectively. At Bhavanisagar, 1st to 14th, 24th to 27th and 29th to 35th standard week at 50% probability and 1st to 19th and 22nd to 37th std week at 75 per cent probability levels had zero amount of rainfall. The sowing weeks for Bhavanisagar was 38th std week and for Madurai was 36th

std week was expected. The rainfall amount of more than 25 mm was recorded during the standard weeks of 42nd, 43rd and 45th with 50 per cent probability at Bhavanisagar and 39th, 43rd and 44th standard weeks at Madurai. The analysis outlined a greater level of risk of getting below 25 mm of rainfall per week even during cropping season. Sarkar and Biswas (1988) reported that even 30 per cent probability rainfall can be taken as weekly assured rainfall if the annual rainfall is less than 400 mm. In current study locations 50 per cent probability was considered assured rainfall since the annual rainfall is >400 mm.

Conditional Probability

The conditional probability analysis showed that the chance of getting 200, 300 and 400 mm of rainfall during NEM season were 88, 69 and 44 per cent for Madurai. The results indicated that one can select a crop with a water requirement of approximately 200 to 300 mm (Table 3). The probability of receiving up 300 mm of rainfall is 69 per cent. Selection of crops, which requires more than 300 mm of rainfall, is considered risky. The weekly conditional probability analysis also indicated that the probability of receiving >25 mm of rainfall from 36th to 47th standard week is more than or equal to 50% at Madurai (Fig 3).

At Bhavanisagar, the probability of receiving 200 mm of rainfall during north east monsoon is 72 per cent and the chance got decline rapidly as the expected rainfall amount increased further. The standard weeks 38th - 40th and 42nd - 47th had >50% chance to get 25 mm of rainfall at this location. The results of the weekly analysis showed that the risk of intermittent dry spells at Bhavanisagar even after sowing a crop during North East Monsoon season. The monthly rainfall showed that there will be > 60 per cent chance to get 100 mm of rainfall during October and November months irrespective of the study locations (Table 2).

Table 6. Conditional probability analysis of weekly rainfall at Bhavanisagar and Madurai

Month & Date	5 mm		10 mm		15 mm		20 mm		25 mm		30 mm		
	Std Week	B sagar	Madu rai	B sagar	Madu rai	B sagar	Madu rai	B sagar	Madu rai	B sagar	Madu rai	B sagar	Madu rai
Jan(1-7)	1	31	40	11	19	2	7	0	2	0	0	0	0
Jan(8-14)	2	16	41	1	22	0	10	0	3	0	1	0	0
Jan(15-21)	3	35	52	16	45	5	37	1	31	0	25	0	19
Jan(22-28)	4	0	14	0	0	0	0	0	0	0	0	0	0
Jan(29-4)	5	0	41	0	20	0	7	0	2	0	0	0	0
Feb(5-11)	6	8	26	0	6	0	1	0	0	0	0	0	0
Feb(12-18)	7	47	36	32	15	20	5	11	0	5	0	2	0
Feb(19-25)	8	54	39	40	15	27	4	16	1	9	0	4	0
Feb(26-4)	9	36	47	13	33	3	21	3	12	0	6	0	3
Mar(5-11)	10	55	51	47	2	38	33	40	25	26	18	20	13
Mar(12-18)	11	54	28	49	6	44	1	44	0	34	0	29	0
Mar(19-25)	12	42	41	22	24	9	12	9	5	1	2	0	0
Mar(26-1)	13	17	39	1	18	0	6	0	1	0	0	0	0
Apr(2-8)	14	58	58	45	50	32	41	22	32	13	25	8	18
Apr(9-15)	15	60	52	50	45	41	37	31	31	23	25	16	19
Apr(16-22)	16	59	62	44	52	30	42	18	33	10	24	5	17
Apr(23-29)	17	65	64	54	56	43	48	33	39	24	32	16	25
Apr(30-6)	18	73	70	61	65	50	59	37	46	26	48	18	42
May(7-13)	19	70	67	63	61	56	56	48	50	41	43	34	37
May(14-20)	20	73	66	64	55	54	44	44	33	34	23	25	16
May(21-27)	21	74	70	65	61	54	51	44	41	34	31	25	23
May(28-3)	22	68	60	55	51	41	41	29	32	19	24	11	17
Jun(4-10)	23	66	65	52	50	37	35	24	22	14	13	7	6
Jun(11-17)	24	52	60	36	45	22	31	1	18	5	10	2	5
Jun(18-24)	25	31	63	9	54	1	44	38	34	0	25	0	18
Jun(25-1)	26	16	58	1	46	0	34	0	23	0	14	0	8
Jul(2-8)	27	44	53	22	36	8	21	2	10	0	4	0	2
Jul(9-15)	28	33	65	5	59	0	53	0	46	0	41	0	34
Jul(16-22)	29	37	72	11	63	2	54	0	44	0	35	0	27
Jul(23-29)	30	56	69	48	60	39	51	31	42	24	33	18	25
Jul(30-5)	31	56	56	47	41	38	27	30	16	23	9	17	4
Aug(6-12)	32	49	72	29	66	14	58	5	50	2	42	0	35
Aug(13-19)	33	57	66	45	61	33	56	23	52	17	46	9	42
Aug(20-26)	34	61	70	52	64	43	57	35	50	27	42	20	36
Aug(27-2)	35	58	76	43	70	29	62	29	55	10	47	5	40
Sep(3-9)	36	65	72	52	68	39	64	27	60	17	56	10	52
Sep(10-16)	37	73	76	66	71	59	65	52	59	44	52	37	46
Sep(17-23)	38	78	75	74	71	70	67	65	62	61	57	56	52
Sep(24-30)	39	72	79	68	74	64	69	59	64	54	58	50	52
Oct(1-7)	40	74	79	69	74	64	69	59	64	53	58	47	52
Oct(8-14)	41	75	79	68	75	62	72	54	67	47	63	40	59

Oct(15-21)	42	76	77	73	73	69	70	66	66	61	61	57	57
Oct(22-28)	43	79	78	75	75	71	72	66	69	61	65	56	61
Oct(29-4)	44	76	78	72	74	68	70	64	65	59	61	54	56
Nov(5-11)	45	68	75	68	73	64	71	63	68	61	66	59	63
Nov(12-18)	46	68	77	64	73	59	68	54	63	50	58	45	53
Nov(19-25)	47	66	70	62	66	58	63	54	59	50	55	46	51
Nov(26-2)	48	56	66	47	58	38	50	29	42	22	34	16	27
Dec(3-9)	49	60	63	48	47	37	33	26	20	18	11	11	5
Dec(10-16)	50	58	64	49	57	41	49	34	41	26	34	20	27
Dec(17-23)	51	50	65	36	65	25	44	16	34	9	25	5	17
Dec(24-31)	52	46	62	26	62	12	52	5	48	1	43	0	39

From the above analysis of rainfall data it has been noted that the annual and seasonal rainfall at Madurai has relatively variability than at Bhavanisagar. Irrespective of the locations, the major cropping period under dryland condition is only during North East Monsoon season. But with in the cropping season, dry spells are expected at Bhavanisagar limiting the crop production. Early season dry spell especially in first two to three weeks may decide the over all yield variability, as the early season dry spells are capable of deciding the plant establishment, plant stand and subsequently the plant population. Looking for dryland crops during South West Monsoon is highly risky both at Madurai and Bhavanisagar. Even during north east monsoon season, supplemental irrigations during early stages of the crop growth and during maturity stages can alleviate the problem of shortening length of growing period due to early and terminal droughts. Generally, the crop water requirement with mild soil moisture stress could be met from October 3rd week to November 2nd week in these study locations. In remaining weeks with in the cropping period, possibility

of moisture stress is greater. The analysis revealed that the drought resistant short duration crops like grain legumes and sorghum, maize may be grown to avoid the risk of crop failure.

Reference

- Agnihotri, Y., Madukar, R.M. and Singh, P. (1986). Weekly rainfall analysis and agricultural droughts at Chandigarh. *Vayimandal*, 16: 54-56
- Blanford, H.F. (1886). Mem. India Met. Dept, pp.3, 658.
- Gupta, R.K., Rambabu and JeJwani, K.G. (1975). Weekly rainfall of India for crop planning programme. *Soil Conservation Digest*, 3: 31-39
- Ray, C.R., Senapati, P.C. and Lai, R. (1980). Rainfall analysis for crop planning, Copalpur (Orissa). *Journal of Agricultural Engineering*, 17: 1-8.

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