Madras agric. J 68 (6) : 392-402, June 1981

Water Availability Periods for Crop Planning in Rajasthan

By

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The water availability periods are analysed on the basis of monthly rainfall (P), monthly potential evapotranspiration (P. E.) and monthly actual evapotranspiration (A.E.) using the modified Cocheme and Franquin (1967), and Krishnan (1971) for 14 stations of Rajasthan during the period 1901-1977. From these two techniques, it is seen that the duration of water availability periods are same in Western Rajasthan while it is more in extreme southeastern part viz, Alwar, Kota and Jhalawar since the soil moisture retention capacity is more which is utilized after cessation of the rainy period.

Since crops grown in any given region are adapted to the rain fall conditions, the commencement of humid period ($p \geq PE/2$) are also analysed for individual years during the study period based on the minimum availability of water. It can be seen that the commencement of humid period starts from June 20th in the extreme south and southeastern parts (around Banswara and Jhalawar) and is delayed upto July 2?th in the extreme northern parts of the state (around Ganganagar).

Since most of the area in Rajasthan is under rainfed agriculture, the availability of water in right time and in the right quantity is very important for agricultural operations. The growing season in Kharif of the state is never inhibited for want of temperature conditions, but is determined solely by rainfall distribution. Further, the management of the available water with suitable agronomic practices is essential for good plant growth and yield.

Though the rainfall is the main source for water supply of plants, the plant growth does not depend on rainfall alone since it should balance the water need of the crops. Based on this, Cocheme and Franquin (1967) proposed and classified the water availability periods in agrometeorological investigations of west African state.

An attempt has been made in this paper for assessing the water availability periods based on Cocheme and Franquin (1967) method for a scientific planning of agriculture and cropping pattern.

MATERIAL AND METHODS:

Cocheme and Franquin (1967) proposed the following classification in agrometeorological investigation of parts of west African states.

Preparatory:

This is the period when rainfall is more than ET/10 but does not exceed $E_T/2$ (where E_T stands for Evapotrans-, piration). There are two such periods one at the beginning and another at the end of the rainy season.

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Intermediate:

This is the period when rainfall is more than $E_T/2$ but does not exceed E_T. There are two such periods, one at the beginning of the rainy season and another at the end of the rainy season.

Humid:

This is the period when rainfall exceeds E_T, The two intermediate periods and the humid period form the moist period.

Since the above mentioned classification is not suitable for the agricultural operations of the state of Rajasthan the following criteria have been proposed for assessing the water availability period on the basis of the monthly rainfall (P) and monthly potential evapotranspiration (PE) (Thornthwaite's method is used for computing the potential evapotranspiration).

A simple graphical technique is used to determine the water availability periods viz., Moist ($PE/2 > P > PE/4$) and Humid ($P \geq PE/2$) period for all the stations of Rajasthan using climatological means (for the period 1901-1977). The area between the points of intersection of the lines of rainfall which is less than half and greater than one fourth of the value of potential evapotranspiration is known as the Moist period. Similarly the humid period is the period in which the rainfall is always in excess of half the potential evapotranspiration.

IMPORTANCE OF THE WATER AVAILABILITY PERIODS:

Humid Period ($P \geq PE/2$):

In the humid period water needs of crops are fully met and active crop growth development occurs and it is also the best time for crops to flower. It is, of course, during the humid period that surplus and runoff occur and in absence of actual drainage, might be an adverse climatic factor causing water logging.

Moist Period ($PE/2 > P > PE/4$):

This is the period during which rainfall is most variable and critical for sowing and vegetative growth in the first case and ripening of fruits in the second. The beginning of the first moist period appears to be the best time for sowing and traditionally it is the time when sowing most commonly takes place. The first moist and the humid periods taken together therefore represent approximately the time from sowing to heading of crops.

George *et al* (1969) and Raman, (1971) also attempted for assesing the water availability periods of different parts of India based on climatic as well as soil conditions of the region. Krishnan (1971) determined the water availability periods using the actual evapotranspiration which is a sum of the rainfall and soil moisture storage obtained from the Thornthwaite's water budgeting technique and balanced the same with potential evapotranspiration. The water availability periods were defined as follows:

Growth period with little water strees (Humid Period):

When the actual evaporation (AE) estimated by taking into account both rainfall, and stored moisture exceeds 50% of the potential evapotranspiration (PE) viz., AE≥ PE/2.

Growth period with moderate water stress (Subhumid Period):

This is the period when actual evapotranspiration lies between 50% to 25% (i.e.,) PE/4<AE<PE/2. This should be fitted at the early or late stage of the crop growing season when its water requirements would be less.

Growth period with severe water stress (Semi Dry Period):

This is the period when AE is between one-fourth to one eighth PE i.e., PE/8<AE<PE/4. This period indicates the peripheral limits of the growing season of native vegetation and grasses. If the crop is to be grown during the period supplementary irrigation has to be given.

Dry Period:

This is the period when AE<PE/8 and even native grasses cannot be grown without supply of water.

For comparison, the above technique is also used for the state of Rajasthan to assess the water availability days. The actual evapotranspiration values were computed using Thornthwaite's (1955) book-keeping procedure taking into consideration of the field capacities of the soils.

COMMENCEMENT OF HUMID PERIODS:

It is very well known that the knowledge of the duration of water availability and the time of occurrence during the crop season is necessary for proper farm management with suitable agronomic practices. With a view to exploit the agricultural potential of the regions, crop planning and adaptation should be done such that growth phase of the crops approximately coincides with the duration of water availability, when water needs are fulfilled to the optimum. During normal conditions only rainfall is the main source for crop growth periods in most parts of the state of Rajasthan. Since crops grown in any given region are adapted to the rainfall conditions, the minimum water availability periods are worked out on the basis of the climatic normal rainfall values. Hence, based on the minimum availability of water which is rainfall amount alone in Rajasthan, the commencement of humid periods are analysed over the entire state for the period 1901-1977. The commencement of humid periods (P≥ PE/2) are estimated for each station in the state with the help of graphs for each year at each individual station. The date of commencement is taken as the point of intersection when the rainfall line exceeds PE/2 curve. The standard deviations of the commencement of humid periods are also worked out.

RESULTS AND DISCUSSION:

Table-1 shows the soil type, field capacity within the root zone and the mean monthly water balance parameters such as precipitation, potential evapotranspiration and actual evapotranspiration for each station of the State of Rajasthan.

Table-II gives the number of days under moist and humid periods according to the modified Cocheme and Franquin method. The total number of water availability days varies from 56 at Jaisalmer in the extreme west which are inadequate for growth of several crops to 126 days at Udaipur in the south of the state. Kota and Alwar have 119 and 121 days respectively over 123 days at Jhalawar in the southeastern part of the state. It can be seen that the total number of water availability days are less at Jaisalmer in extreme western part and more in south and southeastern part of the state.

Fig. 1a shows the duration and the time of occurrence of the water availability periods of the state of Rajasthan according to Cocheme and Franquin. It is seen that only moist period I is observed in the northwestern part viz., Jaisalmer, Phalodi, Bikaner and Ganganagar regions. And the duration of the water availability is also less in the northwestern part of the state. It is found that the humid period is of greater duration at the stations Udaipur (June 22nd to October 6th) and Jhalawar (June 19th to October Ist) and the humid period is less at Barmer (July 28th to September 5th). It is also noted that the beginning of the water availability periods are delayed by one month (that is from June 6th in the south to July 6th in the north) as we move from south to north of the state.

Table III gives the period and number of days under subhumid and humid periods in different parts of Rajasthan on the basis of Krishnan's classification. The same is shown in Fig. Ib.

From the above two techniques for assessing the number of water availability periods and duration the following conclusions can be drawn

In the western part of the state the total number of water availability days are same while in the extreme eastern part viz., Alwar, Kota and Jhalawar, the number of water availability days experienced are more than double. Since the capacity of soils to retain soil moisture is more, it is utilized after cessation of the rainy period. The duration of water availability is also more at the above three stations viz., Alwar, Kota and Jhalawar and a considerable increase at Udaipur also is noticed.

Fig. 2a is a map of Rajasthan showing dates of commencement of humid periods ($P \geq PE/2$). It can be seen that the commencement of humid period starts from June 20th in the extreme southern parts (around Jhalawar and Bunsware) and is delayed upto July 20th in extreme northern parts of the State (around Ganganagar).

The standard deviation of the commencement of humid periods is shown in Fig. 2b. It is seen that the region around Alwar and Bharatpur have the least deviation <10 days and the region around Ganganagar has maximum deviation >20 days. Rest of the state experiences intermediary values.

According to this study the grand growth periods of the crops can be adjusted after the commencement of humid periods which will help better growth and development of crop. For a

better understanding and for application in the field climatic analysis on weekly or if possible on daily basis will perhaps give more useful information for the evaluation of crops in a particular region. Such information will pin point the exact periods for providing life saving irrigation to rescue crops from permanent damages.

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TABLE 1 Mauor Soil Types, Field Capacities and the Mean Monthly Water Balance Paraneteis of the Selected Stations in Rajasthan

Station	Major Soil type	Field Capacity within the root zone (mm)	Water balance para-meteres (mm) para-meter/ month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Jaisalmer	Desert soils	100	PE	17	26	103	169	207	206	203	187	167	154	58	26	1523
			P	2	2	3	2	7	17	65	61	25	1	2	2	189
			AE	2	2	3	2	7	17	65	61	25	1	2	2	189
Barmer	Grey and Brown	100	PE	22	43	129	183	210	207	198	180	165	156	79	33	1605
	(Desert) soils		P	3	4	5	2	7	27	85	105	35	3	1	1	278
			AE	3	4	5	2	7	27	85	105	35	3	1	1	278
Phalodi	Desert soils	100	PE	15	30	102	174	209	208	205	186	166	125	59	21	1500
			P	3	5	4	2	10	24	90	87	23	2	2	2	254
			AE	3	5	4	2	10	24	90	87	23	2	2	2	254
Jodhpur	Grey and Brown	150	PE	23	38	104	177	210	208	199	177	159	146	70	31	1542
	(Desert) soils		P	4	4	4	2	8	31	109	130	61	8	2	2	365
			AE	4	4	4	2	8	31	109	130	61	8	2	2	365
Bikaner	Desert soils	100	PE	12	25	89	172	213	213	211	190	172	141	51	16	1505
			P	7	7	6	5	13	29	83	90	45	9	2	4	300
			AE	7	7	6	5	13	29	83	90	45	9	2	4	300
Ganganagar	Desert and Grey	100	PE	14	20	68	162	208	215	217	201	173	136	46	14	1474
	and Brown		P	12	8	15	7	14	35	66	86	54	2	2	5	306
	(central part of district) Alluvial soils		AE	12	8	15	7	14	35	66	86	54	2	2	5	306
Pilani	Grey and Brown	200	PE	13	26	68	157	202	209	209	180	158	126	49	14	1402
	(Desert) soils		P	6	6	7	6	20	34	123	138	53	6	4	6	409
			AE	6	6	7	6	20	34	123	138	53	6	4	6	409

TABLE 1 Contd.

Station	Major Soil type	Field Capacity within the root zone (mm)	Water balance para-meteres (mm) parameter/ month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Sikar	Grey and Brown (Desert) soils	150	PE	15	28	85	157	202	206	193	173	154	115	46	19	1393
			P	7	5	5	2	21	39	179	187	66	8	4	6	479
			AE	7	5	5	2	21	39	179	187	66	8	4	6	479
Alwar	Alluvial soils	150	PE	16	30	78	173	209	212	199	178	158	122	52	21	1448
			P	13	8	9	6	29	53	236	283	150	29	5	8	829
			AE	14	15	24	23	35	54	199	178	158	92	25	12	829
Jaipur	Alluvial soils	150	PE	20	33	94	167	206	206	190	170	153	127	54	23	1443
			P	10	9	7	4	14	51	192	215	86	17	3	6	614
			AE	11	10	10	7	15	51	190	170	103	33	7	7	614
Ajmer	Red and Yellow soils	150	PE	15	32	94	164	206	203	187	163	151	124	49	25	1413
			P	7	6	5	2	14	58	167	163	77	14	3	5	521
			AE	7	6	5	2	14	58	167	163	77	14	3	5	551
Udaipur	Red and Yellow soils	150	PE	26	39	96	162	199	190	168	143	143	108	55	30	1959
			P	6	3	9	3	9	74	190	170	131	15	4	1	615
			AE	8	5	14	6	10	75	168	143	135	36	11	4	615
Kota	Medium and Block soils	250	PE	23	42	130	181	211	208	192	171	159	145	66	29	1557
			P	7	5	4	3	10	65	278	248	121	15	5	4	765
			AE	12	12	23	18	18	67	192	171	145	74	23	10	765
Jhalawar	Medium and Black soils	250	PE	26	44	114	175	209	203	178	160	147	128	58	30	1472
			P	9	3	3	3	5	90	312	295	152	21	9	5	907
			AE	17	20	37	34	22	95	178	160	147	108	39	18	875

PE: Potential Evapotranspiration, P: Precipitation, AE: Actual Evapotranspiration.

TABLE-2 Period and Number of Days Under Moist Period I, Humid Period and moist Period II in Different Stations in Rajasthan

(According To Modified Cocheme & Franquin Method)

Station	Moist period I (PE/2> P> PE/4)	Humid period P> PE/2	Moist period II (PE/2> P> PE/4)	Total No. of days
Jaisalmer	July 6th to Sept. 1st (56)	...	...	56
Barmer	June 28th to July 27th (30)	July 28th to Sept. 5th (38)	Sept. 6th to Sept. 14th (9)	77
Phalodi	July 3rd to Aug. 30th (58)	...	...	58
Jodhpur	June 25th to July 10th (16)	July 11th to Sept. 11th (61)	Sept. 12th to Sept 26th (15)	92
Bikaner	June 26th to Sept. 15th (80)	...	...	80
Ganganagar	July 3rd to Sept. 23rd (81)	...	...	81
Pilani	June 25th to July 9th (15)	July 10th to Sept. 9th (60)	Sept. 10th to Sept. 24th (15)	90
Sikar	June 19th to June 27th (9)	June 28th to Sept 8th (71)	Sept. 9th to Sept. 25th (17)	97
Alwar	June 15th to June 24th (10)	June 25th to Oct. 3rd (99)	Oct 4th to Oct. 12th (12)	121
Jaipur	June 13th to June 24th (12)	June 25th to Sept. 19th (85)	Sept. 20th to Oct. 5th (16)	113
Ajmer	June 12th to June 25th (14)	June 26th to Sept. 15th (80)	Sept. 16th to Oct. 2nd (17)	111
Udaipur	June 6th to June 21st (16)	June 22nd to Oct. 6th (105)	Oct. 7th to Oct. 11th (5)	126
Kota	June 10th to June 24th (15)	June 25 to Sept. 30th (96)	Oct. 1st to Oct. 8th (8)	119
Jhalawar	June 6th to June 18th (13)	June 19th to Oct 1st (103)	Oct. 2nd to Oct. 8th (7)	123

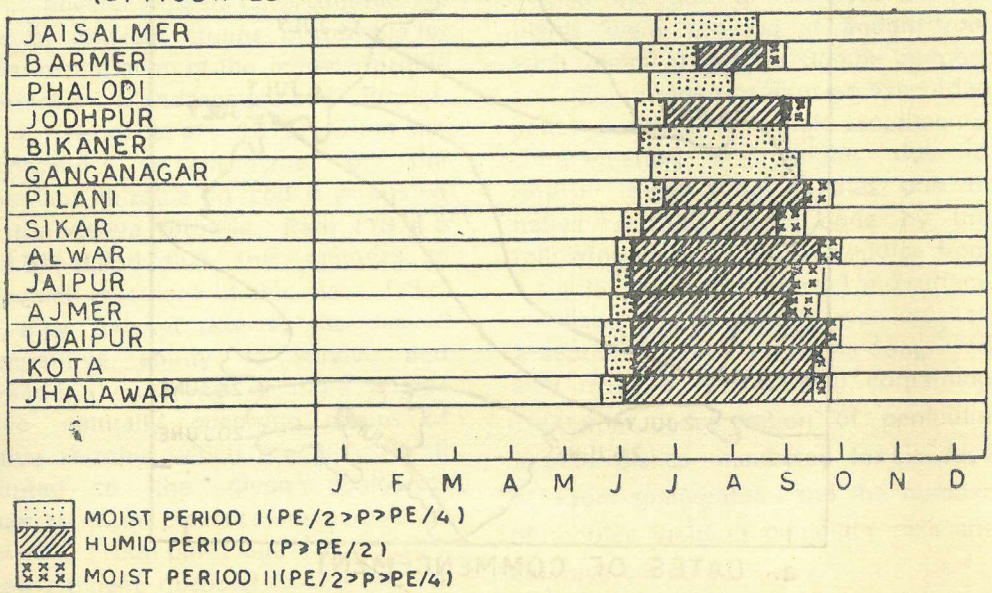
TABLE-3 Period and Number of Days Under Subhumid Period I, Humid Period and Subhumid Period II in Different Stations in Rajasthan

(According To Krishnan Method)

Station	Subhumid period I (PE/2> AE> PE/4)	Humid period (AE> PE/2)	Subhumid period II (PE/2> P> PE/4)	Total No. of days
Jaisalmer	July 6th to Sept. Ist (56)	...	...	56
Barmer	June 28th to July 27th (30)	July 28th to Sept. 5th (38)	Sept. 6th to Sept. 14th (9)	77
Phalodi	July 3rd to Aug. 30th (58)	...	...	58
Jodhpur	June 25th to July 10th (16)	July 11th to Sept. 11th (61)	Sept. 12th to Sept 26th (15)	92
Bikaner	June 26th to Sept. 15th (80)	...	...	80
Ganganagar	July 3rd to Sept. 23rd (81)	...	...	81
Pilani	June 25th to July 9th (15)	July 10th to Sept. 9th (60)	Sept. 10th to Sept. 24th (15)	90
Sikar	June 19th to June 27th (9)	June 28th to Sept 8th (71)	Sept. 9th to Sept. 25th (17)	97
Alwar	June 15th to June 26th (12)	June 27th to Nov. 12th (136)	Nov 13th to March 20th (128)	174
Jaipur	June 15th to June 23rd (9)	June 24th to Sept. 27th (94)	Sept. 28th to Oct. 15th (18)	121
Ajmer	June 12th to June 25th (14)	June 26th to Sept. 15th (80)	Sept. 16th to Oct. 2nd (17)	111
Udaipur	June 5th to June 22nd (18)	June 23rd to Oct. 5th (103)	Oct. 6th to Nov. 1st (25)	146
Kota	June 9th to June 21st (13)	June 22nd to Oct. 15th (114)	Oct. 16th to Feb. 16th (121)	248
Jhalawar	May 30th to June 16th (17)	June 17th to Feb 4th (228)	Feb. 5th to March 30th (56)	300

FIG.1 DURATION OF WATER AVAILABILITY PERIODS IN RAJASTHAN.

(a) MODIFIED FRANQUIN & COCHEME METHOD



(b) USING KRISHNAN'S METHOD

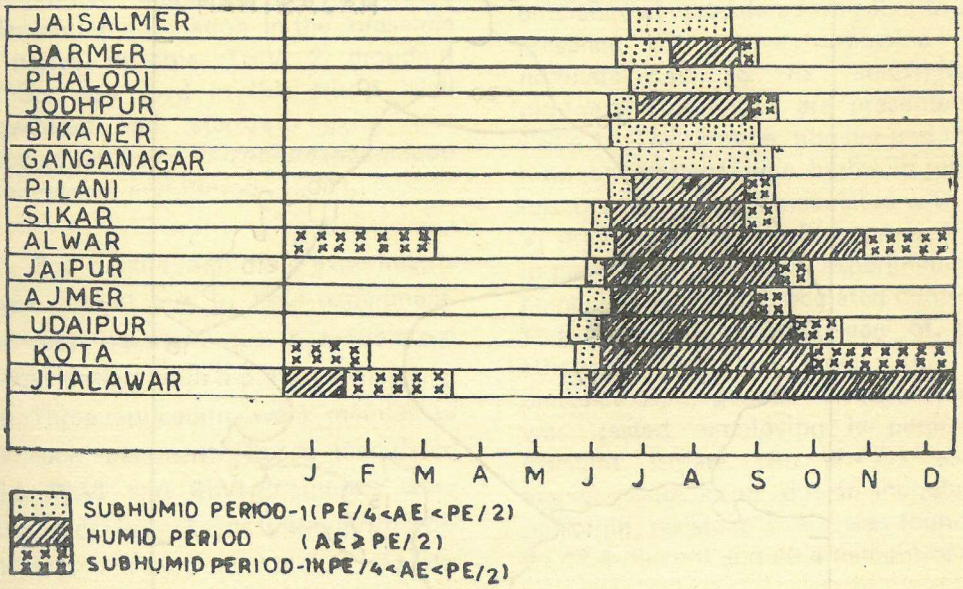
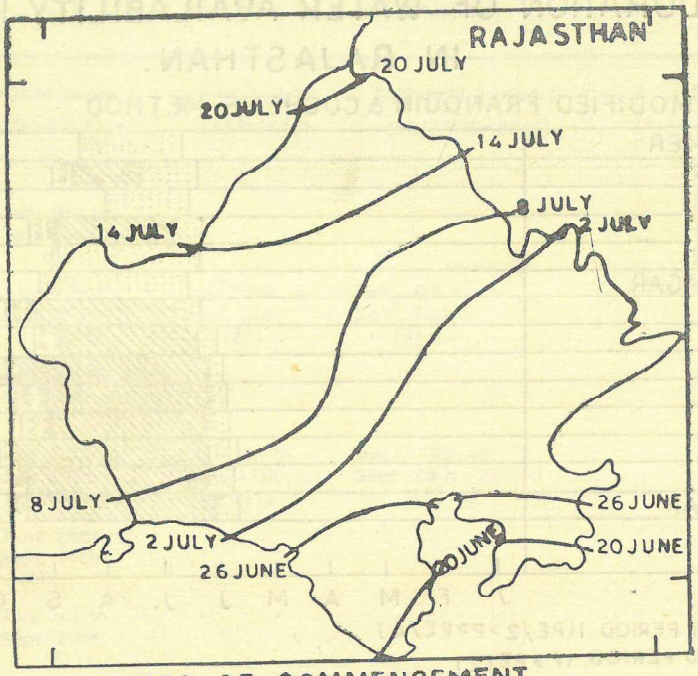
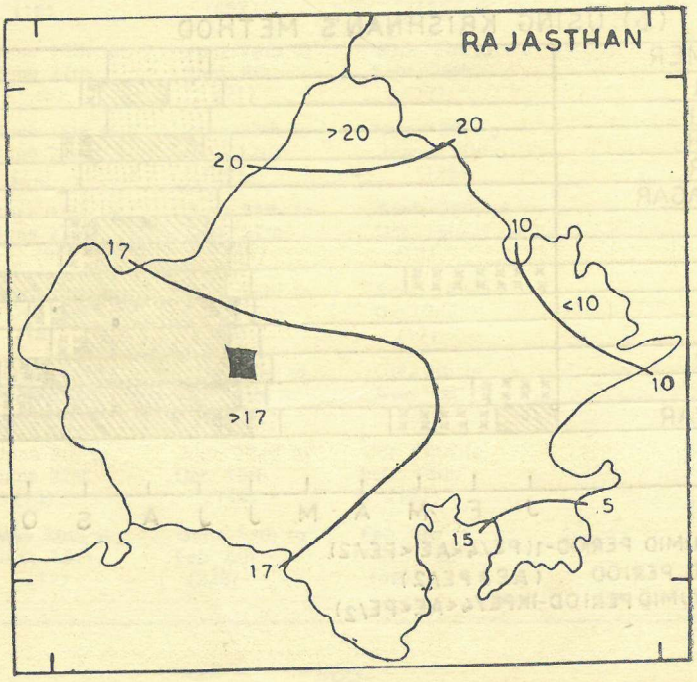


FIG.2 HUMID PERIODS ($P > PE/2$) IN RAJASTHAN



a. DATES OF COMMENCEMENT



b. STANDARD DEVIATION OF COMMENCEMENT