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CONSUMPTIVE USE AND IRRIGATION REQUIREMENT OF COCONUT PLANTATIONS IN KERALA

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ABSTRACT

An attempt was made to compute the water requirements of coconut plantations in the different months of the year, using different climatological methods. Efforts were also made to evaluate the mean effective rainfall in the state under coconut based land use, using mean rainfall and water requirement data and making use of the USDA, SCS method. Mean yearly water requirements of coconut plantations in the state was found to be of the order of 1126 mm (37 lit. per palm per day for a basin area of 12 m^2) .27 % of the total rainfall received in a year is found to be effective with respect to coconut based land use.

Mean annual irrigation requirements of coconut in the state was found to be of the order of 338 mm (4656 litres per palm for a basin area of 12 m^2), spread over the non monsoon months of January, February, March, April, May, November and December. The findings of the study will be helpful for the planning and design of irrigation projects and management of water resources in the state.

INTRODUCTION

Coconut plantations in Kerala State are largely dependent on rainfall. The dependence on rainfall for meeting the water requirements of these plantations necessitate informations on its water requirements for different months of the year and how far this need is met by rainfall (effective rainfall) of the locality.

Studies on effective rainfall in India is very few. Pharande and Dastane (1964) touched upon the subject of effective rainfall. Kushlani (1956) suggested that rainfall during the life cycle of the crop in a bad year should be considered as effective rainfall. Sastry (1956) suggested an empirical formula for evaluation of effective rainfall. Several studies on concepts of effective rainfall were reported (Hayes and Buell (1955), Ogrosky and Mockus (1964), Hershfield (1964), Miller and Thompson (1970), Chow (1964) and Stamm (1967). In the present study an attempt was made to compute the consumptive use and irrigation requirements of coconut plantations in the different months of the year using different climatological methods. An attempt also has been made to evaluate the effective rainfall in

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different parts of the state under coconut based land use.

MATERIALS AND METHODS

Data

Five climatological stations in Kerala State *viz.*, Calicut, Palghat, Cochin, Alleppey and Trivandrum for which normal values of climatological parameters for different months of the year are readily available (IMD, 1970) were made use of in the present study.

Estimation of reference crop evapotranspiration (ETo)

Many methods have been proposed for the estimation of ETo. In the present study the methods formulated by (1) Penman (1948) modified by Rao et al, (1971), (2) Thornthwaite (1948), (3) Khosla (1949) and (4) Leeper (1950) were used.

Method for the estimation of consumptive use and effective rainfall

The reference crop evapotranspiration and consumptive use (ET_{crop}) of crops is related by the equation:

$$ET_{crop} = ET_0 \times Kc$$

Where Kc is the crop coefficient for the particular crop. A crop coefficient of 0.65 has been made use of for coconut plantations based on a study conducted using volumetric lysimeters for coconut and is described in the next section.

Crop coefficient for coconut plantations

Crop coefficient for coconut crop has been worked out, based on a preliminary study conducted, making use of volumetric lysimeters. The lysimeters in duplicate for coconut crop (age of coconut = 6 years, variety = West Coast Tall) has been irrigated to field capacity once in five days. To determine Evapotranspiration (ET_{crop}), the following water balance equation has been made use of

$$ET_{crop} = P + I - D \pm \triangle W$$

P – precipitation, I – irrigation, D – deep percolation or drainage water, W – change of water content of the soil mass over a given period.

In the experiment conducted, the water budget was calculated over the period between two drainage occurrences. Directly after drainage is completed, the soil mass contains a well defined soil moisture content (field capacity). The soil is a laterite with loamy clay texture. The dry bulk density of the soil ranges from 1.2 to 1.37 gm / cm^3. The field measured field capacity of the soil is of the order of 28% (at 0.3 mb). After an adequate rain or irrigation, depleted water $\triangle$ W is again brought back to field capacity, after drainage capacity, after drainage ceases. $\triangle$ W then becomes negligible and ET_{crop} can be determined by $ET_{crop} = P+I-D$ b, ET_{ctop} values are calculated to be the average over the time periods between two drainage occurrences (5 days). The lysimetric observations were made during 28th November 1986 to 16th May 1987, at Kottamparamba (lat. 11° 15¹ N, long. 72° 52¹ E; altitude 70m above MSL). The crop coefficient (0.65) obtained for the pan evaporimeter was used in the present study for calculation of ET_{crop} throughout the year.

Estimation of effective rainfall

In view of the complex nature of the factors that govern the magnitude of effective rainfall, attempts made for its direct experimental measurement have not been able to offer a satisfactory solution. However, several empirical methods have been formulated which yield fairly good results. Based on extensive field data, the Soil Conservation Service of United States Department of Agriculture has published in 1969, a table of mean monthly effective rainfall and consumptive use. The present study makes use of these tables.

Monthly ET_{crop} values were calculated and tabulated for different months of the year and for all stations selected for the study. Mean monthly rainfall for different months were also tabulated. Using these two data, mean effective rainfall for different months of the year were estimated making use of the table (USDA, SCS, 1969).

RESULTS AND DISCUSSION

Crop coefficient (Kc)

Crop coefficient calculated for the open pan evaporimeter for the different months are presented in Table I.

The mean crop coefficient for the pan evaporimeter was found to be of the order of 0.65.

Consumptive use (ETcrop)

A comparison of the consumptive use values computed for different months of the year and for different stations are presented in Table III. Results of Penman's (modified) method was found to show maximum variations in predicted monthly consumptive use values in a year, having maximum in March, and minimum in June-July. Khoslas and Leeper's formulae gives least variations in monthly consumptive use values in a year. Thornthwaite formula is found to under-predict in the month of January, February and March and over-predict in the rest of the months in a year compared to Penman's (modified) method.

The predicted values of water requirements (consumptive use) of coconut by

Table I. *Crop coefficient for coconut*

Month	ET_{crop} lysimetric mm day^{-1}	ET pan evaporation	Crop coefficient ET_{crop} / ET_0
November	2.83	3.65	0.78
December	2.87	4.02	0.73
January	3.01	4.82	0.63
February	3·43	5.49	0.62
March	3.64	6.04	0.60
April	3.59	6.27	0.58
May	3.54	6.13	0.56
Mean	3.27	5·20	0.65

Table II. *Mean rainfall (MR), effective rainfall (ER), consumptive use (CU), irrigation requirement (IR) and drainage requirement (DR) under coconut based land use (mm)*

	January	February	March	April	May	June	July	August	September	October	November	December
						CALICUT						
MR	5	11	21	111	322	870	860	404	215	290	140	29
CU	104	106	126	115	104	74	69	76	83	84	86	95
ER	5	11	15	77	104	74	69	76	83	84	81	21
IR	98	95	111	38	0	0	0	0	0	0	4	74
DR	0	0	0	0	218	796	790	328	131	205	0	0
						PALGHAT						
MR	3	5	17	106	129	414	546	274	125	242	112	18
CU	124	121	144	121	113	81	75	83	92	86	91	111
ER	3	5	13	75	87	81	75	83	79	86	73	13
IR	120	116	130	46	26	0	0	0	12	0	18	98
DR	0	0	0	0	0	332	471	190	0	156	0	0
						COCHIN						
MR	9	34	50	139	364	755	571	885	234	332	183	36
CU	102	101	119	103	91	70	71	75	79	79	80	91
ER	9	25	36	90	91	70	71	75	79	79	80	26
IR	93	76	82	12	0	0	0	0	0	0	0	64
DR	0	0	0	0	272	685	500	310	155	253	103	0
						ALLEPPEY						
MR	18	27	74	158	456	781	521	313	271	395	209	36
CU	100	98	117	102	92	73	74	98	80	80	80	93
ER	13	19	53	95	92	73	74	98	80	80	80	26
IR	86	79	63	6	0	0	0	0	0	0	0	67
DR	0	0	0	0	364	707	446	215	191	314	129	0
						TRIVANDRUM						
MR	20	20	43	122	248	331	215	164	122	271	206	73
CU	99	100	117	105	97	77	80	90	93	84	79	89
ER	14	14	28	81	97	77	80	90	78	84	79	50
IR	84	86	89	23	0	0	0	0	14	0	0	39
DR	0	0	0	0	151	254	135	73	0	187	127	0

Table III. *Mean consumptive use (CU) values computed by different methods (mm)*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly
						CALICUT							
CU (K)	96	99	101	105	104	95	92	94	95	97	98	96	1178
CU (T)	104	98	118	122	126	108	94	99	104	107	104	102	1290
CU (P)	104	106	127	115	104	74	69	76	83	84	86	95	1126
CU (L)	87	91	98	102	101	86	81	82	85	88	89	86	1081
						PALGHAT							
CU (K)	100	105	111	110	104	95	91	93	96	97	98	97	1201
CU (T)	110	106	129	128	126	102	91	98	104	107	103	104	1316
CU (P)	124	121	144	121	113	81	75	83	92	86	91	111	1247
CU (L)	94	102	114	111	101	100	83	97	82	88	90	89	1156
						COCHIN							
CU (K)	96	99	102	103	101	95	93	93	95	95	97	96	1171
CU (T)	104	98	117	118	121	107	96	97	104	104	102	102	1170
CU (P)	102	101	119	103	91	70	71	75	79	79	80	91	1068
CU (L)	87	91	97	98	96	85	81	83	86	86	88	87	1070
						ALLEPPEY							
CU (K)	98	99	103	104	102	96	93	94	95	96	97	97	1179
CU (T)	106	99	118	120	122	108	99	99	104	105	102	104	1292
CU (P)	100	98	117	102	92	73	74	78	80	80	80	93	1072
CU (L)	89	92	99	101	97	86	82	83	85	86	87	88	1081
						TRIVANDRUM							
CU (K)	96	98	102	103	101	95	94	94	95	95	95	96	1170
CU (T)	103	97	116	118	121	107	101	103	104	104	99	101	1279
CU (P)	99	100	117	105	97	77	80	90	93	84	79	89	1113
CU K)	86	89	96	99	96	85	53	84	85	86	85	86	1067

(K) Khosla's, (T) Thornthwaite's, (P) Penman's and (L) Leeper's methods

the Penman's method show better agreement with the atmospheric demand for evapotranspiration loss of water with the changes of seasons. The results of Penman's method was hence used for computations of effective rainfall in this study.

Mean monthly rainfall, effective rainfall in coconut based land use and consumptive use of coconut for the different stations are presented in Table II.

Effective rainfall was found to vary from 42% (Trivandrum) to 22% (Calicut) of the mean annual rainfall. Mean seasonal rainfall, effective rainfall and effective rainfall as a percentage of the seasonal rainfall are presented in Table IV.

On an average for the state as a whole the effective rainfall with respect to coconut for different seasons are 22% for south west monsoon (June–September) 41% for north east monsoon season (Oct-Dec.) 85% for Jan. Feb. and 48% for hot weather period (March-May).

CONCLUSIONS

Consumptive use of coconut was quantified using different methods. Out of the four methods used, Penman's (modified) method is found to predict

Table IV. *Mean monthly rainfall, effective rainfall and effective rainfall as percentage of the seasonal rainfall for different locations in the state*

	SW Monsoon (June – Sept.) mm	NE Monsoon (Oct. – Dec.) mm	(Jan. – Feb.) mm	Hot weather (March–May) mm
		CALICUT		
Rainfall (R)	2351	460	17	455
Effective rainfall (ER)	304	267	17	197
ER as % of R	13%	58%	100%	43%
		PALGHAT		
Rainfall (R)	1360	373	93	253
Effective rainfall (ER)	320	173	93	177
ER as % of R	24%	46%	100%	70%
		COCHIN		
Rainfall (R)	1948	553	44	554
Effective rainfall (ER)	298	187	35	219
ER as % R	15%	34%	79%	40%
		ALLEPPEY		
Rainfall (R)	1887	641	46	690
Effective rainfall (ER)	327	187	33	242
ER as % R	17%	29%	72%	35%
		TRIVANDRUM		
Rainfall (R)	834	551	40	414
Effective rainfall (ER)	326	214	29	206
ER as % of R	39%	39%	72%	50%

crop water requirements most agreeable with the climatological demands of the place. Mean yearly consumptive use of coconut was found to be of the order of 1126 mm (37 litres per palm per day for a basin area of 12 m^2). The yearly irrigation requirement of coconut was also estimated to be of the order of 338 mm (4,656 litres per palm for a basin area of 12 m^2).

Mean effective rainfall (mean of the five stations considered) for the state as a whole unit under coconut based land use was found to be of the order of 22%, 41%, 85% and 48% during the south-west monsoon, north east monsoon, January–February months and hot weather seasons respectively. Effective rainfall during south west monsoon season is maximum (39% of the seasonal total) at Trivandrum and minimum at Calicut (13% of the seasonal total). 27% of the annual rainfall is found to be effective under coconut based land use in the state.

REFERENCES

CHOW, V. T. 1964. Hydrology of agricultural lands. *Handbook of Applied Hydrology*, Sec. 21–83, Mc Graw Hill Book Co., New York.

HAYES, C. I. and BUELL, J. H. 1955. Water and forests; trees also need water at the right time and place. In *Water Year Book*, USDA, 219–228.

HERSHFIELD, D. M. 1964. Effective rainfall and irrigation water requirements. *J. Irrig. and Dr. Div.* ASCE 90: IRZ: 3920, 33–47.

INDIA METEOROLOGICAL DEPARTMENT (IMD), (1961–1970) Climatological tables of observatories in India, *IMD Publication.*

KHOSLA, A. N. 1949. Analysis and utilisation of water resources. *Irrigation Journal*, Central, Board of Irrigation and Power, India 6 (1)

KUSHLANI, K. B. 1956. Irrigation practices and design, 1. New Delhi Central Water and Power Commission, Govt. of India.

LEEPER, G. W. 1950. Thornthwaite climatic formulae. *Journal of Aust. Inst. Agri. Sci.*, **16.**

MILLER, A. and THOMPSON, J. C. 1970. *Elements of Meteorology.* Chic. Merril Pub. Co.

OGROSKY, H. O. and MOCKUS, V. 1964. Hydrology of agricultural lands. *Sec. 21* In *Book of Hydrology* by V. T. Chow, NewYork,

PENMAN, H.L. 1948. Natural evaporation from open water, bare soil and grass. *Proc. Roy. Soc. London.* **193:** 120-145.

PHARANDE, K. S. and DASTANE, N. G. 1964. Effective rainfall. *New Delhi, Post Graduate School Journal.*, Indian Agricultural Research Institute.

RAO, K. N., GEORGE, C. J. and RAMSASTRI, K. S. 1971. Potential evapotranspiration over India. Scientific report, No. 136, *India Meteorological Department Publication.*

SASTRY, A. S. R. 1956. Utilisable rainfall by the crops. *Ann. Rep.* Cent. Board of Irri. and Power. India. 315–324

STAMM, G. G. 1967. Problems and procedures in determining water supply requirements for irrigation projects. In *Irrigation of Agricultural Lands* by Hagen et al. Wisconsin, Amer. Soc. Agron., Agronomy-II.

THORNTHWAITE, C. W. 1948. An approach towards rational classification of climate, *Geographical Review*, **38:** 65–94.

U. S. DEPT. OF AGRI. (SOIL CONS. SERVICES). 1969. *Engineering Field Manual for Conservation Practices.*