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Evaporative index for scheduling irrigation in plantation crops

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सार — आर्द्र-कटिबन्धीय केरल भारत का जल संतुलन विश्लेषण बतलाता है कि एक वर्ष में पाँच से सात सतत महीनों के लिये वाष्पी मांग वर्षा से अधिक हो जाती है। लैट राइटों में उपलब्ध जल क्षमता के 20, 30, 40, 50, 60 तथा 70 प्रतिशत पर सिंचाई योजना बनाने के लिये नारियल, सुपारी, दालचीनी तथा केले के संचयी वाष्पन मान अभिकलित किए जा चुके हैं। दो दिन के भीतर एक मीटर की गहराई तक अध्ययन के अंतर्गत फसलों के लिये मृदा-आर्द्रता उपलब्ध जल क्षमता की 70 प्रतिशत तक पहुँच गई थी तथा 5 दिन के भीतर उपलब्ध जल क्षमता का 20 प्रतिशत तक। इन फसलों के लिये संचयी वाष्पन मान उपलब्ध जल क्षमता के 70 प्रतिशत पर 3 से 5 मि. मी. था तथा उपलब्ध जल क्षमता के 20 प्रतिशत पर 10 से 15 मि. मी. था।

ABSTRACT. Water balance analysis of the humid tropical Kerala, India shows that evaporative demand exceeds rainfall for five to seven consecutive months in a year. For scheduling of irrigation at 20, 30, 40, 50, 60 and 70 per cent of the available water capacity (AWC) in laterites, the cumulative evaporation values for coconut (*Cocos nucifera Linn.*), *arecanut* (*Areca catechu*), cinnamon (*Cinnamomum Zeylanica*) and banana (*Musa paradisiaca*) have been worked out. The soil moisture in one metre depth has reached 70 per cent of the AWC within two days and 20 per cent of the AWC within 5 days for the crops studied. The cumulative evaporation values for these crops were 3 to 5 mm at 70 per cent of the AWC and 10 to 15 mm at 20 per cent of the AWC.

1. Introduction

Under humid tropical conditions of Kerala, India (8° 18′–12° 48′ N, 74° 52′–77° 22′ E) an average annual rainfall of 3000 mm is received during May to November and there is a well defined dry spell for the remaining period of the year. This prolonged dry spell results in low productivity of crops like coconut (*Cocos nucifera Linn.*), arecanut (*Areca catechu*), cinnamon (*Cinnamomum Zeylanica*) and banana (*Musa Paradisiaca* cv Nendran).

The major soil group of this region is laterite with low moisture retentive capacity. There is a rolling topography with slopes upto 30 per cent. Nearly 84 per cent of cultivated area is under rainfed conditions. The yield of plantation crops can be increased by irrigation during prolonged dry periods (Menon and Pandalai 1960; Ochse *et al.* 1961; Paulo and Kozlowski 1977 and Nelliat 1968).

Scheduling of irrigation is generally practiced based on evaporation values, but evaporation records from class A pan are not available for many locations. A simple evaporimeter can be used for this purpose. Sharma and Dastane (1970) and Reddi and Reddy (1981) have reported that evaporation values measured with such simple evaporimeters give close correlations with data from the class A pan.

Irrigation scheduling at a desired level of the AWC for perennial crops in British Columbia was suggested by Sly and Wilcox (1976). Irrigation can be given to these tree crops at different levels of soil moisture between 20 and 70 per cent of the AWC depending upon the water requirement and water availability.

This paper attempts to establish a relationship between cumulative evaporation and soil moisture depletion under different plantation crops for scheduling irrigation.

2. Climatic demand and water balance of the region

The soil water balance for 11 selected stations in the region was computed based on mean potential evapotranspiration (Rao *et al.* 1971) and rainfall (1958-1975) data according to the book-keeping procedure of Thornthwaite and Mather (1957) and the course of monthly potential evapotranspiration, rainfall and actual evapotranspiration are shown in Fig. I. The stations are located from south to north in the region of Kerala, India.

The potential evapotranspiration values range between 3 and 6 mm/day. Rainfall is assured for 5 to 7 months in different locations. During the remaining period, the plants suffer from water deficiency due to

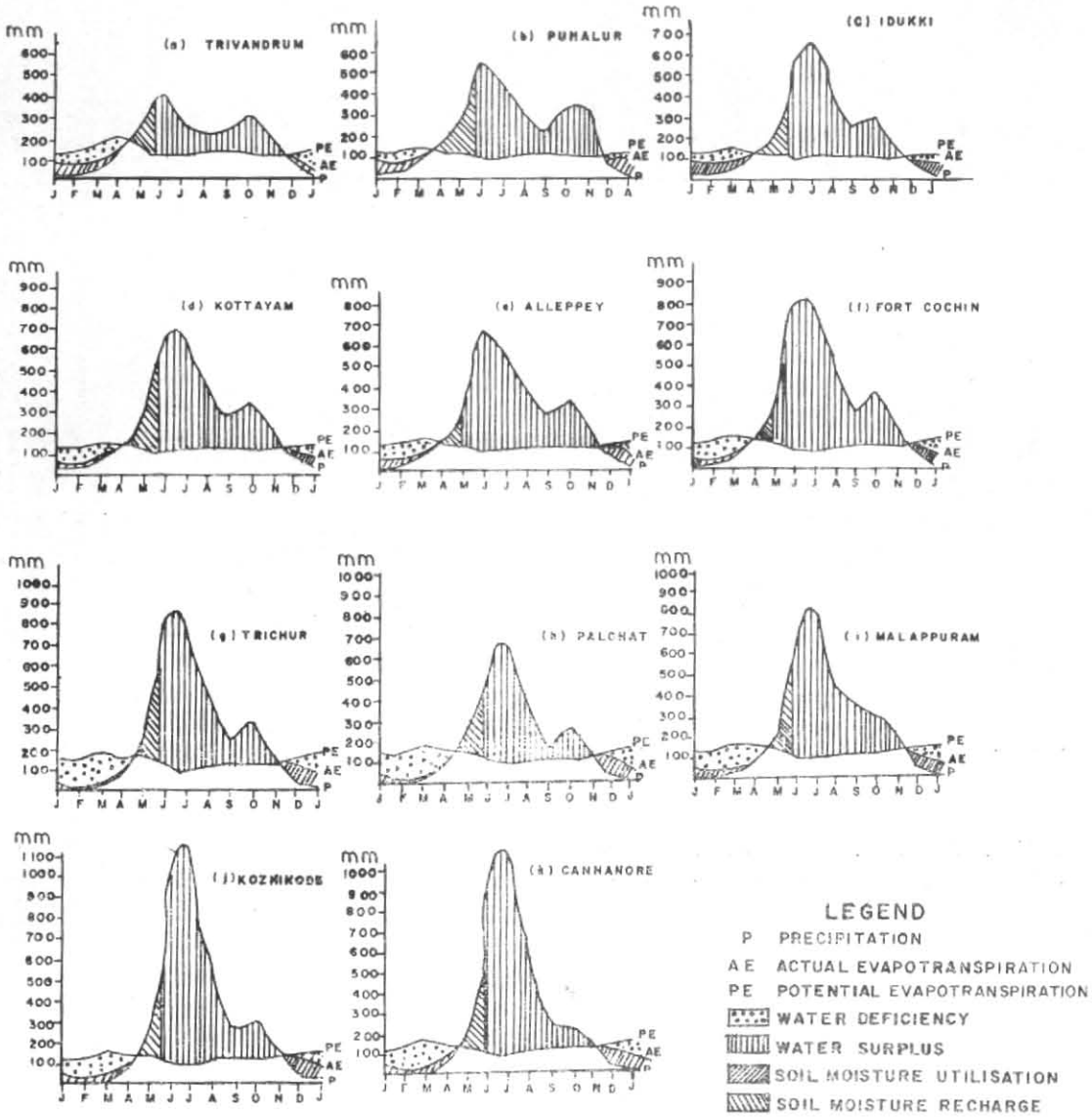

Fig. 1. Climatic water balance of Kerala

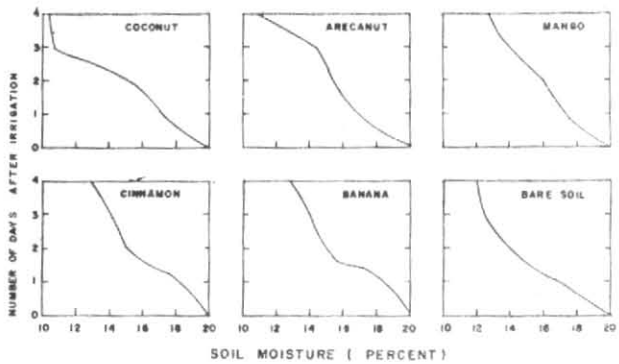

Fig. 2. Soil moisture depletion under plantation crops

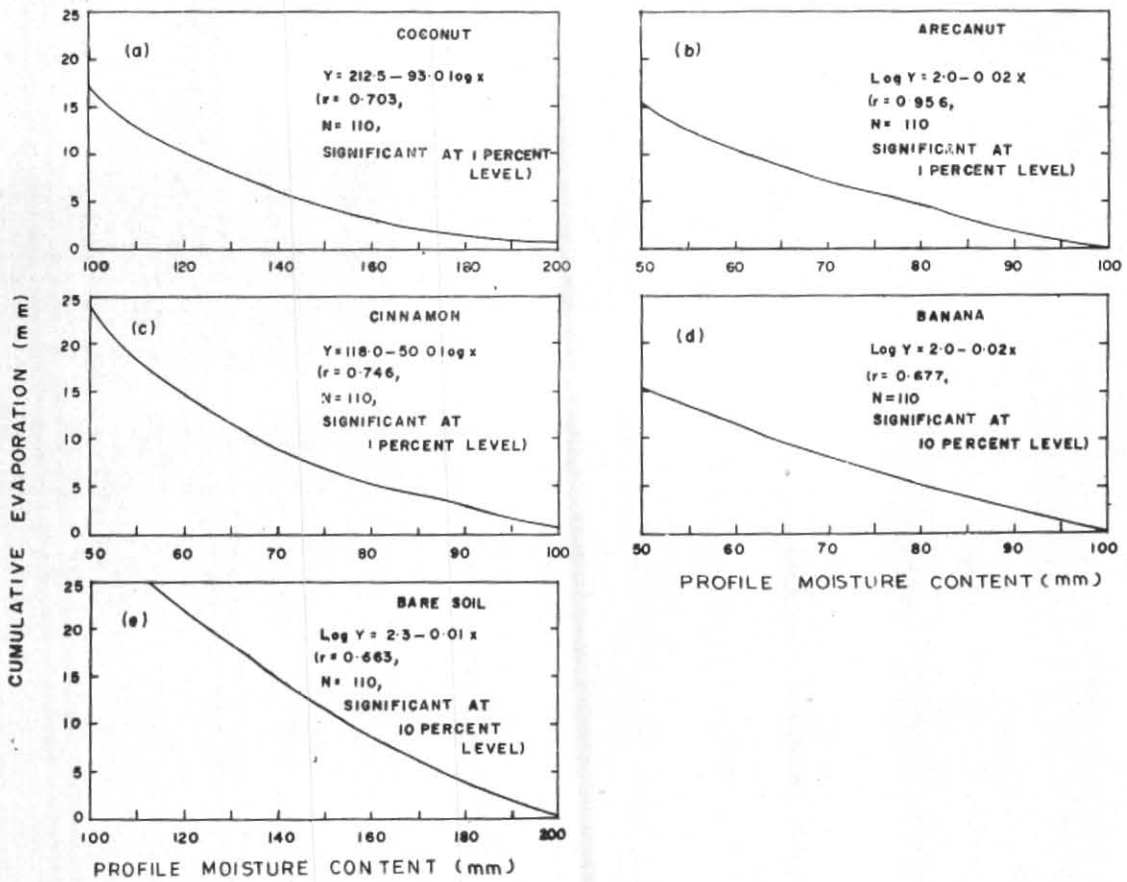

Fig. 3. Soil moisture depletion in relation to cumulative evaporation

TABLE 1

	AWC (per cent)					
	20	30	40	50	60	70
Coconut	9.9	7.7	6.0	4.7	3.7	2.9
Arecanut	11.1	9.4	7.7	6.2	4.8	3.5
Cinnamon	14.5	11.5	9.1	7.2	5.8	4.6
Banana	11.1	9.4	7.7	6.2	4.8	3.5
Bare soil	22.1	18.6	15.4	12.4	9.6	7.0

lack of rainfall. Hence, there is a need for irrigation during this period.

2.1. *Experimental details*

(a) *Location* — The field experiment under coconut, arecanut cinnamon and banana was conducted during 1981 summer in the campus of the Centre for Water Resources Development and Management, Kottamparamba longitude 11° 15′ N; longitude 75° 52′ E; height msl 80 m).

(b) *Weather (January to May* 1981) — The station has experienced normal weather conditions during the experimental period. The maximum air temperatures recorded at the nearest station Calicut (latitude 11° 15′ N; longitude 75° 47′ E & height msl 5 m) were between 30 deg. and 34 deg. C and minimum were between 20 deg. and 28 deg. C. The relative humidity (0830 IST) was from 70 to 90 per cent. The total rainfall during January to May 1981 at the experimental location was 450 mm out of the annual rainfall of 4,160 mm.

(c) *Soils* — The soils are latosols (Oxisols, Kaolinitic isohyperthermic family of Tropeptic, Eutroothox in USDA system of classification. These are highly porous clay loam soils with a more or less uniform profile. The gravel (>2 mm) content varies from 22 to 45 per cent of the total volume in differentl ayers. The organic matter content is low and it ranges from 0.5 to 1.2 per cent. The surface soils upto 30 cm depth retains about 20 to 22 per cent moisture at 0.3 bar and 10 to 12 per cent at 15 bar. The hydraulic conductivity is of the order of $3 \times 10^{-5} cm^{-1}$ sec^{-1}. The observed depth to water table is 6 to 7 m during the dry periods. The slopes of the location are varying from 5 to 10 per cent.

Nearly 44 per cent of the cultivated area is under plantation crops and hence forms a major aspect of state of economy. These crops are grown in the slopes mostly under rainfed conditions except banana which is either irrigated or grown in lowland with high water table. The crops taken for observation are well established and their age group ranges from 30-35 years except banana which is 6 to 8 months old.

3. Methodology

The evaporation was measured in the open field using a simple evaporimeter of one litre capacity. It

was coated with metallic zinc white paint and had a screen cover of 6/20 wiremesh with a gauging point to facilitate recording of water levels.

The observations on cumulative evaporation (mm) and soil moisture (percent on oven dry basis) were started 24 hours after saturating the soil in the active rootzone of the crop. Saturation of the soil was carried out upto one metre depth for coconut and bare soil and upto 0.5 metre depth for arecanut, cinnamon and banana. The lateral area covered for soil moisture observation was 2 sq. m. for all the crops. When the soil moisture was depleted to 20 per cent or less of the AWC, plants were irrigated and observations repeated.

The soil samples were taken for moisture determination at 30, 60 and 90 cm, both lateral and depthwise for coconut and bare soil and at 15, 30 and 45 cm depths for other crops. The observations for each tree were replicated 3 times with 3 trees at each time.

The cumulative moisture content in the active rootzone of each crop was computed. The values measured from simple evaporimeter were corrected with a coefficient of 0.809 (significant at 0.01 level) obtained at Pattambi for class A pan and simple evaporimeter data.

The cumulative evaporation values were related to the moisture depletion under different crops and bare soil by regression analysis.

4. Result and discussion

The potential evaporation values at the experimental site during the summer period were between 3 and 8 mm/day. The variation in moisture content in the profile under different crops and bare soil after irrigation are given in Fig. 2. The moisture content was ranging between 10 and 13 per cent on fourth day after irrigation and it was almost stagnant at 10 per cent thereafter. The small variations in the moisture on the fourth day under different crops may be due to soil type and topographic conditions of the experimental area. Under unirrigated and non-rainy day conditions the soil moisture was 10 per cent under crops and bare soil throughout the experimental period.

The relationship between the cumulative evaporation and the profile moisture content for different crops and bare soil are shown in Fig. 3. The moisture depletion was high for coconut, arecanut, cinnamon and banana as compared to the bare soil (Table 1). The equations given in Fig. 3 may be conveniently used for scheduling irrigation based on cumulative evaporation values for a given crop under different levels of moisture requirement and water availability. However, the physiological stage of the crop and the water requirement has to be taken into consideration for irrigation. The present paper is confined to illustrate the usefulness of simple evaporimeter for scheduling of irrigation in plantation crops.

From Table 1 it can be seen that the cumulative evaporation values at 70 and 20 per cent of the AWC for the crops studied were 3-5 and 10-15 mm respectively. Since, the evaporation rates in the area were 3-8 mm/day, 70 and 20 per cent of the AWC can be attained within two and five days respectively. The cumulative evaporation values at 70 and 20 per cent of the AWC for bare soil were higher than the crops. This shows that the evaporation from bare sail was less than the evapotranspiration of the plantation crops.

5. Summary and conclusions

The humid tropical region of Kerala, India experiences prolonged dry spells during December to April and hence irrigation is essential. The plantation crops like coconut, arecanut, cinnamon and banana cover larger cultivated area of this region. The soils are mostly laterites and they have low moisture retentive capacity. To suggest scheduling of irrigation based on the cumulative evaporation and soil moisture, an experiment was conducted at Kottamparamba Campus of the Centre with different crops and the relationship between cumulative evaporation and available soil profile moisture content were established. The results have shown that the cumulative evaporation values at 70, 60, 50, 40, 30 and 20 per cent available profile moisture content in the one metre depth for the crops studied were 3-5, 4-6, 5-7, 6-9, 8-11, and 10-15 mm respectively. The cumulative evaporation values thus obtained can be utilized for scheduling irrigation at any desired level of profile moisture content.

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