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Water requirements of young coconut palms in a humid tropical climate

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Summary. The evapotranspiration rates of five-year-old coconut palms (*Cocos nucifera* Linn. cv *West Coast Tall*) grown in an Oxisol on the West coast of India were quantified from soil moisture depletion studies and lysimetric measurements. The rates increased from 2.9 mm day^{-1} in December to 5.5 mm day^{-1} in April and reduced to 2.3 mm day^{-1} in June following the onset of monsoon rain. Ratios of evatranspiration to class A pan evaporation were 0.87–0.88 in the moderate rainfall period (September and October), 0.78–0.85 in the winter period (November–February), 0.87–0.96 in the summer period (March–May) and 0.60–0.68 in the rainy period (June–August).

Coconut (*Cocos nucifera* Linn.) palms in Kerala on the west coast of India (8°18′ to 12°48′N and 74°52′ to 77°25′E) cover 23% of the cropped area. The average annual rainfall of the area is 3,000 mm, but the palms are subjected to dry spells lasting 27–34 weeks. The major soils (covering 60% of the total area) are Oxisols which retain little soil moisture. Coconut palm does not reduce its leaf area to reduce water losses during moisture stress periods. During the dry season in Kerala, some farmers cut off the matured lower leaves of the canopy to increase transpiration and growth from younger leaves. Old palms withstand prolonged dry period without irrigation, but younger palms often wilt.

The coconut grows well in many tropical areas with a well distributed rainfall of 1,000 mm, but for profitable cultivation, evenly distributed rainfall of 1,000 to 2,250 mm y^{-1} is necessary (Menon and Pandalai 1960). When irrigated, coconut palms on the west coast of India improved the number of female flowers, arrested button shedding (Venkitesan 1973), and yielded 20 to 25 more nuts per palm than did an unirrigated stand (Vijayalakshmi and Marar 1969). Nelliat and Padmaja (1978) reported that the growth of young palms was retarded when the ratio of applied irrigation to pan evaporation fell to 0.50, while there was little response to irrigation when the ratio was between 0.75 and 1.00. Further to their studies, the evapo-

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transpiration from young coconut palms was measured and conclusions are presented in this paper.

Materials and methodology

Experimental site conditions

The experiment was located at Meleppalakkot (11°15'N; 75°52'E; altitude 70 m MSL) in a 0.8 ha plot from September, 1985 to August, 1986. Surrounding areas of the site were also under coconut. The plot contained 90 five-year-old palms (cv *West Coast Tall*) planted at 7 × 7 m spacing. The average height of the palms was 3 m and 6–7 functional leaves had developed to give a leaf area index of 0.35. Rooting depths were obtained by sampling two of the trees. The active root zone was confined to the depths of 30–80 cm and lateral distances of 50 cm from the trunk. Drainage of the site, which had a slope of less than 15%, was fairly good with depth to the water table ranging from 5 m in the rainy period to 12 m in summer period.

Soils in the area are Oxisols (*Isohyperthermic Kaolinitic* family of *Tropeptic Eutrorthox*) with a bulk density between 1.01 and 1.31. Coarse sand (> 2 mm) constitutes 31–86% and clay 35–52%. The initial infiltration rate was 20–25 cm h^{-1} and finally attained a rate of 12–13 cm h^{-1} after 5 h (Varadan and Raghunath 1985) as compared with the highest recorded rainfall of 5 cm h^{-1} in the area. The soil moisture content in the 0–150 cm layer ranged from 24.2% to 8% by weight (gravimetric) and the constant head permeability was 8.443 × 10^{-3} cm s^{-1}.

Weather observations

Net radiation and albedo were measured 1 m above the coconut canopy using sensors (CN 1 and CN 8 models) with programmable printing integrators supplied by Middleton Instruments (MDI-200 model). Rainfall intensity, soil temperatures at 2.5, 5.0, 15.0 and 30.0 cm depths, air temperature, humidity and class A pan evaporation were recorded at the site itself. Other weather variables were recorded 0.2 km from the experimental site.

Evapotranspiration

Evapotranspiration rates of the palms were determined from measurements of soil moisture depletion and from lysimetric observations.

Soil moisture contents in the layers 0–15, 15–30, 30–60, 60–90 and 90–150 cm were determined gravimetrically by sampling at lateral distances of 50, 150 and 300 cm from the trunk of three trees during September, 1985 to August, 1986. Rates of soil moisture depletion were used to estimate evapotranspiration when soil moisture contents were between 60 and 100% of field capacity.

Evapotranspiration rates of the palms from March to August, 1986 were also measured using a pair of drainage lysimeters (Fig. 1) which had soil tanks 3.5 × 3.5 × 1.7 m deep. The lysimeters were centrally located in a field of 90 young coconut palms of uniform age spaced at 7 × 7 m. To collect surface runoff and deep percolation from the main soil tanks, two other collectors for each lysimeter were placed in subsurface masonry tanks. The lysimeter tanks were filled with soil layer by layer to match the bulk density in the undisturbed profile. Two palms were carefully excavated with minimum disturbance to the root system and were replanted in the lysimeters. Initially, the soil tanks were saturated with water by applying 325 mm before measurements of evapotranspiration began and thereafter daily irrigation at the rate of 25 mm day^{-1} was maintained. Percolation and runoff were measured 24 h after irrigation. The difference between the daily inflow (irrigation + rainfall) and the daily outflow (runoff + percolation) was taken as the evapotranspiration rate. Drainage from the soil tanks ceased within 24 h after irrigation, but there was a time lag of 24 h between irrigation and measurements of inflow and outflow. During this period evaporation occurred from the percolation and runoff water tanks and corrections were made for this.

The area of each lysimeter was 12.25 m^2 per tree compared with 49.00 m^2 per tree in the grove. Evaporation from soil in the interspaces were substantial, especially under irrigation. Such

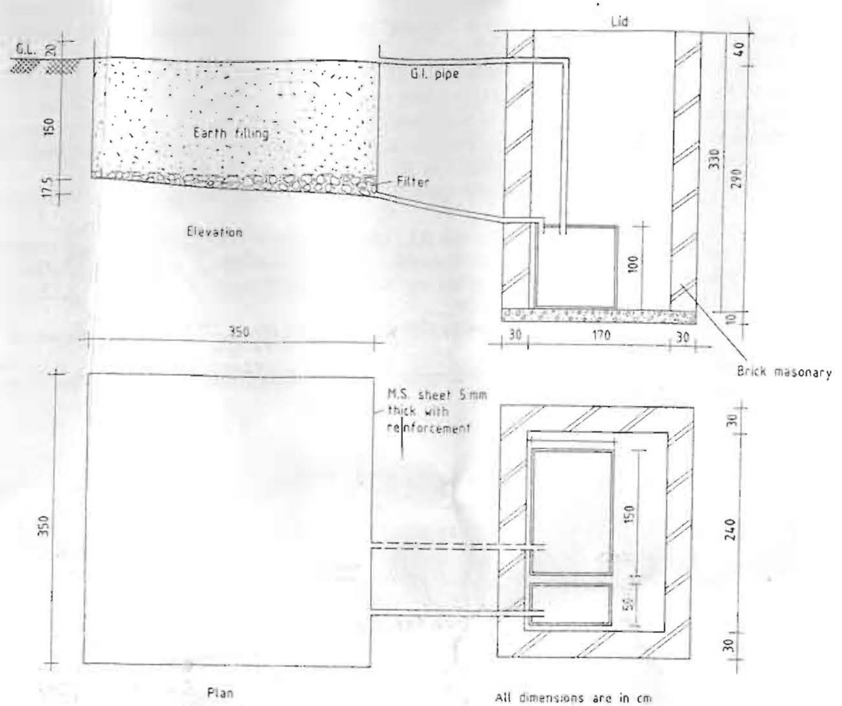

Fig. 1. Lysimeters for ET measurements of coconut palms

losses, obtained from changes in the soil moisture content to a depth of 150 cm depth, were between 2 mm day^{-1} (June) and 5 mm day^{-1} (May). The evapotranspiration losses from the coconut grove were thus estimated by combining the losses from a 12.25 m^2 lysimeter area and soil losses estimated for an area of 36.75 m^2. Irrigation rates per 49.00 m^2 coconut grove area were calculated from evapotranspiration after deduction of rainfall.

Results and discussion

Microclimate of the cropped area

Rainfall during the experimental period was 2,439 mm, 500 mm below the average. Class A pan evaporation was between 3.5 and 6.3 mm day^{-1} and daily average windspeeds were between 0.1 and 0.5 m s^{-1}.

The daily insolation ranged from 0.70 kWh m^{-2} on a cloudy day in June to 7.15 kWh m^{-2} in March on a cloudless day. The hourly maximum values for the corresponding periods were 165 W m^{-2} and 1,050 W m^{-2} respectively.

The disposition of solar radiation by the coconut canopies on a clear summer day is shown in Fig. 2. About two thirds of the incident radiation was transmitted. The intensity of solar radiation reaches a maximum of 895 W m^{-2} at 1,300 h with a net radiation of 546 W m^{-2}. The mean reflection coefficient of the canopy for shortwave radiation was 0.26 compared to the value of 0.20 for bare Oxisols.

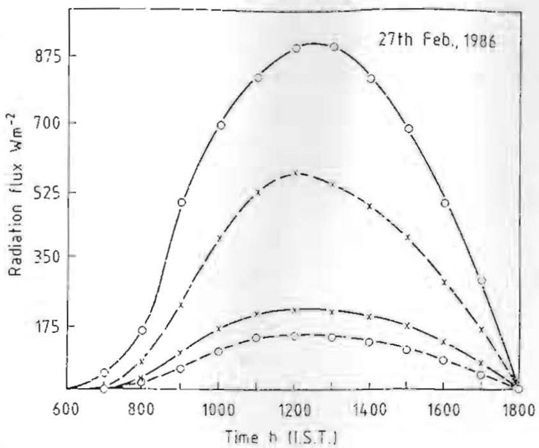

Fig. 2. Incident (o——o) and reflected (×——×) solar radiation 1 m above a coconut grove (4 m from ground level) with the intercepted (o---o) and transmitted (×---×) radiation from the canopy-grove area

Table 1. Evapotranspiration from coconut palms at Meleppalakkot (Kottamparamba)

Month	Evapo-transpiration from 3.5 × 3.5 m lysimeter area (mm day^{-1})	Evapotranspiration from 40.9 m^2 coconut grove (ET) (mm day^{-1})	Class A pan evaporation (Epan)	Crop coefficient (ET/Epan)	Rainfall (mm)
September, 1985	5.1	3.6	4.1	0.88	98
Ocotober	4.9	3.4	3.9	0.87	260
November	4.4	3.1	3.8	0.82	175
December	4.2	2.9	3.6	0.81	13
January, 1986	4.8	3.4	4.0	0.85	3
February	6.0	4.2	5.4	0.78	0
March	7.2	5.0	5.6	0.89	9
April	7.8	5.5	6.3	0.87	56
May	6.4	4.5	4.7	0.96	50
June	3.3	2.3	3.5	0.66	1,007
July	3.6	2.5	4.2	0.60	348
August	3.9	2.7	4.0	0.68	420
Mean	5.1	3.6	4.4	0.82	2,439

Evapotranspiration rates

Rates of daily evapotranspiration from the coconut palm grove ranged between 2.3 and 5.5 mm day^{-1} (Table 1). The records for March to May show that the peak grove rates reached 7.00 mm day^{-1}. During the dry summer period, there was a gradual increase from 2.9 mm day^{-1} in December to 5.5 mm day^{-1} in April. With the onset of monsoon rains in June, both radiation and saturation deficit decreased and the evapotranspiration rate also decreased from 4.5 mm day^{-1} in May to 2.3 mm day^{-1} in June. Taking into account, the losses from the lysimeter area only, evapotranspiration ranged from 3.3 to 7.8 mm day^{-1}.

During the monsoon (July–October), evapotranspiration measured by the soil moisture depletion method and lysimetric methods were comparable. Soil moisture depletion could not be measured in June because of frequent rainfall.

Crop coefficients

The ratio of evapotranspiration from the grove to class A pan evaporation ranged between 0.60 in July to 0.96 in May with an annual mean value of 0.82 (Table 1).

Conclusions

The evapotranspiration rates of young coconut palms grown on an Oxisol in a humid tropical area ranged from 2.3 to 5.5 mm day^{-1} and from 0.60 to 0.96 of open pan evaporation. These rates imply that the irrigation needed in the 7 × 7 m coconut grove was 122, 161, 207, 231, 172 and 142 litres per palm in the months from December to May.

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