

CONSUMPTIVE USE OF WATER IN RELATION TO CUMULATIVE PAN EVAPORATION (CPE) WITH AND WITHOUT MULCHING IN ARECANUT*

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ABSTRACT

Mulching reduced the consumptive use of water during dry months with increase in yield. Optimum water requirement and frequency of irrigation were worked out based on evapotranspiration and open pan evaporation rates. Irrigation at IW/CPE ratio of 1 to a cumulative pan evaporation of 30 mm gave maximum yield followed by irrigating at the same ratio to a cumulative pan evaporation of 60mm. Both organic mulch and polythene cover were equally effective; but the latter is prohibitively expensive for wider adoption.

INTRODUCTION

Arecanut (*Areca catechu* L.) is an extensively cultivated tropical palm. In coastal Karnataka it requires irrigation during summer months from December to May. Though the annual rainfall is high, the major portion is received during June to October and water scarcity during the dry months is a common phenomenon. Hence, there is a need to optimise irrigation needs of the crop to make the best use of available water. Results of an experiment carried out to study the possibility of reducing the consumptive use of water by the use of mulches and to determine the optimum quantity and frequency of irrigation based on IW/CPE ratio are reported in this paper.

MATERIALS AND METHODS

The experiment was conducted in a 16 year old areca garden adopting split plot design with five replications and four levels

of irrigation viz., irrigation of 30 mm of water with a CPE of 30 mm (I₁), irrigation of 30 mm of water with a CPE of 60 mm (I₂), irrigation of 60 mm of water with a CPE of 60 mm (I₃) and irrigation of 60 mm of water with a CPE of 120 mm (I₄) as main treatments and mulching with dried arecanut husk @ 6 kg per palm (M₁), mulching with white polythene sheet of 600 gauge thickness (M₂) and unmulched control (M₀) as sub plots.

The soil of the experimental field is lateritic clay loam, with 48% sand, 14% silt and 34% clay and bulk density varying from 1.4 g to 1.59 g/cc, moderately deep, well drained, and slightly acidic with a pH of 5.24. The field capacity of the soil is 20.6 per cent with a permanent wilting point of 9 per cent. The meteorological data recorded during the experimental period with their decennial mean are presented in the Figures 1, 2 and 3.

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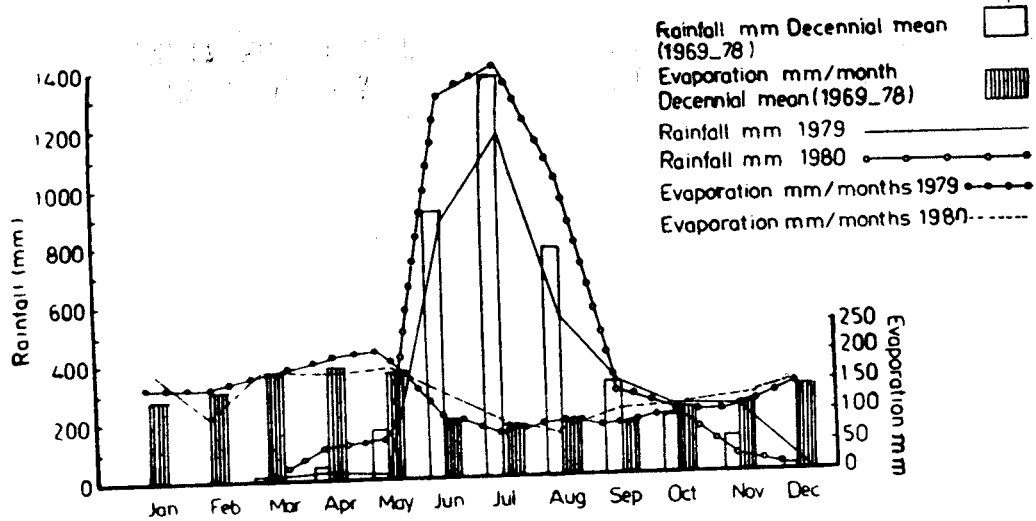


Fig. 1. Rainfall and evaporation

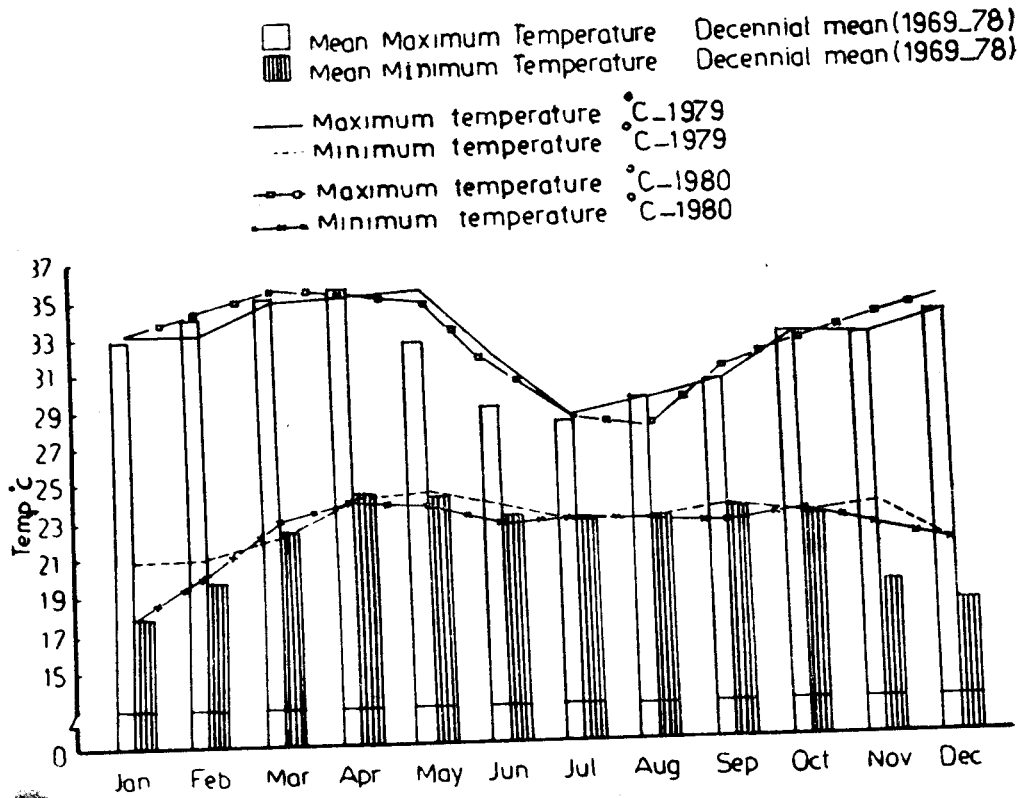


Fig. 2. Maximum and minimum temperature

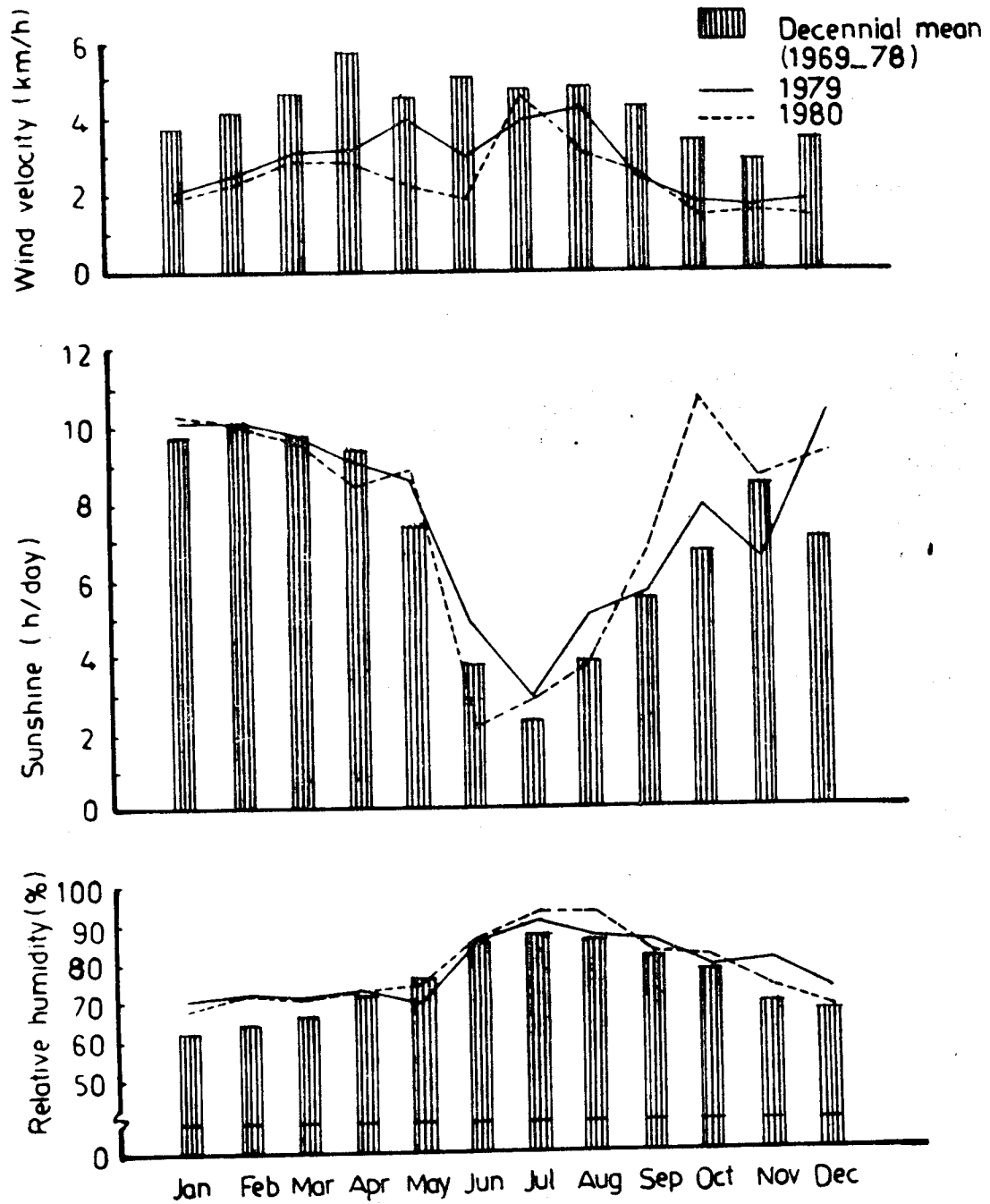


Fig. 3. Wind velocity, sunshine hours and relative humidity

The areca palms were irrigated from January to May as per the treatment schedule. Measured quantity of water was applied to each plot by using a 'U' shaped syphon and the quantity of water was adjusted to the quantity evaporated from the USWB Open Pan evaporimeter installed in the centralised meteorological observatory of the Station.

Soil moisture content was determined upto a depth of 50 cm by gravimetric method (Dastane, 1972) and converted to volume basis using the method described by Israelsen and Hansen (1962) and the stored moisture in the root zone was determined. The open pan evaporation was recorded daily. The frequency of irrigation, consumptive use of water and the relationship between ET/E pan were determined and different parameters have been worked out.

RESULTS AND DISCUSSION

United States Weather Bureaux (USWB) Open Pan Evaporation

The mean data on monthly evaporation from USWB Open Pan evaporation are presented in the Table I. The lowest rate of evaporation was recorded during January, with a mean of 4.88 mm/day and the highest was during May (6.48 mm/day). The rate

Table I. Mean monthly evaporation from USWB Open Pan

| Months | Mean monthly evaporation | | |
|----------|--------------------------|----------------|------|
| | 1979 | 1980 mm/day | Mean |
| January | 4.12 | 4.64 | 4.88 |
| February | 5.31 | 5.79 | 5.55 |
| March | 5.71 | 5.82 | 5.76 |
| April | 6.48 | 5.96 | 6.22 |
| May | 6.86 | 6.10 | 6.48 |

of evaporation is dependent on climatic factors such as temperature, humidity and wind velocity (Ritchie 1971). In the present investigation the temperature of the experimental site gradually increased as summer advanced (Fig. 2) which had resulted in a corresponding increase in the rate of evaporation from the open pan.

Frequency of irrigation

When the irrigation was based on IW/CPE ratio, for I₁ level of irrigation, the number of days required to have a cumulative total of 30 mm of evaporation from the open pan varied from 6.32 days (January) to 4 days (May), for I₂ and I₃ levels of irrigation the number of days required for a cumulative total of 60 mm was 12.65 days (January) to 10.68 days (May). Similarly for I₄ treatment, the number of days required to have a cumulative total of 120 mm it has taken 25.3 days (January) to 21.36 (May) (Table II).

The results reveal that as could be discussed later, it is reasonable to irrigate areca garden once in a week during January–February and with a shorter interval during April–May and it comes closer to weekly irrigation practised in the areca at present.

Soil moisture

Studies on soil moisture revealed that after 24 hours of irrigation, there was not much difference in soil moisture content of different irrigation treatments (Table III) while by the time of next irrigation in I₁ level of irrigation there was 16.78 per cent moisture and in I₄ level it was 8.91 per cent. In I₂ and I₃ treatments 13.64 and 15.50 per cent of moisture was observed, respectively.

In mulching treatments, there was 14.26 per cent moisture in plots mulched with arecanut husk while under polythene cover it was 14.31 and in unmulched control plot,

Table II. *Time in days taken for scheduling irrigation based on USWB Open Pan evaporation as per the treatment to different irrigation levels*

| Irrigation levels | Mean for 1979 and 1980 | | | | | |
|-------------------|------------------------|----------|-------|-------|-------|-------|
| | January | February | March | April | May | Mean |
| I ₁ | 6.32 | 5.30 | 5.16 | 4.91 | 4.00 | 5.33 |
| I ₂ | 12.65 | 10.60 | 10.33 | 9.83 | 10.00 | 10.68 |
| I ₃ | 12.65 | 10.60 | 10.33 | 9.83 | 10.00 | 10.68 |
| I ₄ | 25.30 | 21.20 | 20.66 | 19.66 | 20.00 | 21.36 |

I₁ = Irrigation of 30 mm with a CPE of 30 mm
 I₂ = Irrigation of 30 mm with a CPE of 60 mm
 I₃ = Irrigation of 60 mm with a CPE of 60 mm
 I₄ = Irrigation of 60 mm with a CPE of 120 mm
 M₀ = Unmulched control
 M₁ = Arecanut husk mulch
 M₂ = Polythene mulch

Table III. *Percentage of soil moisture before and after irrigations (Mean for 1979 and 1980)*

| Treatments | After 24 hrs of irrigation | | | | Just before the next irrigation | | | |
|----------------|----------------------------|----------------|----------------|-------|---------------------------------|----------------|----------------|-------|
| | M ₀ | M ₁ | M ₂ | Mean | M ₀ | M ₁ | M ₂ | Mean |
| I ₁ | 20.94 | 21.63 | 22.14 | 21.57 | 15.12 | 17.10 | 18.12 | 16.78 |
| I ₂ | 20.40 | 21.84 | 22.60 | 21.61 | 12.55 | 14.96 | 13.43 | 13.64 |
| I ₃ | 22.78 | 22.96 | 20.70 | 22.14 | 14.40 | 15.97 | 16.32 | 15.56 |
| I ₄ | 20.70 | 20.94 | 22.54 | 21.39 | 8.32 | 9.01 | 9.40 | 8.91 |
| Mean | 21.20 | 21.84 | 21.99 | 21.67 | 12.59 | 14.26 | 14.31 | 13.72 |

the moisture content observed was 12.59 per cent. The results indicated that the I₁ level of irrigation had received water much before the soil reached to 50 per cent of the available soil moisture while the I₄ treatment received irrigation only after the soil moisture depleted beyond permanent wilting point. Depletion of soil moisture was observed more in unmulched control plot as compared to mulched plots. Moisture conservation and reduction in the rate of surface evaporation from the mulched soils have been observed by Russel (1940), Pennman (1952), McCalla (1943), Gardener (1960), Benoit and Kirkham (1963) and Bond and Willies (1970).

Evapotranspiration (ET)

The rate of evapotranspiration was relatively reduced as the frequency of irrigation was lowered from 5.62 to 3.63 mm/day (Table IV). The maximum was observed in I₁ treatment and the minimum was in I₄ with no appreciable difference between I₂ and I₃. As the moisture level falls below the field capacity there will be an increase in soil water suction and the availability of water to the plant decreases correspondingly. In other words, as the soil dries up the evapotranspiration rate decreases. When the soil moisture decreases greater energy is required to

draw a given amount of water since the water is held in the soil pore space with greater force (Namken, Gerand and Brown 1968). Prashar and Singh (1963) have also observed an increase in evapotranspiration from 376 to 503 mm of water by increasing the number of irrigation from one to three.

Mulching with polythene sheet and with arecanut husk reduced the evapotranspiration (Table V). In unmulched plot the mean ET observed was 4.96 mm/day. In the plot mulched with arecanut husk and under the polythene cover the above figures were 4.40 mm/day and 3.79 mm/day respectively. Mulches act as a barrier for the diffusion of vapour from the soil resulting in minimisation of evaporation loss (Lal, 1974; Chandler, Boneta and Abruha, 1969 and Waggoner,

1960). Mulches also reduce the intensity of radiation and wind (Hanks, Bower and Bark, 1961 and Bond and Willes, 1970).

Crop coefficient (ET/E pan)

Among the different irrigation levels the widest ratio between consumptive use and USWB open pan evaporation was observed (0.94) in I₁ level of irrigation while the lowest ratio was noticed in I₄ treatment (0.58). In I₂ level of irrigation it was 0.68 and in I₃ level it was 0.79 (Table VI). The possible reason is that as the soil moisture suction increases, the potential gradient from the soil water to the leaves decreases and the effect being a reduction of evapotranspiration compared to the potential rate. When the soil moisture is not limiting the rate of evaporation is constant and dictated by the external

Table IV. *Evapotranspiration as affected by irrigation levels irrespective of mulches (mm/day) (Mean for 1979 and 1980)*

| Irrigation levels | Months | | | | | Mean |
|-------------------|---------|----------|-------|-------|------|------|
| | January | February | March | April | May | |
| I ₁ | 4.96 | 5.40 | 5.71 | 6.06 | 6.19 | 5.62 |
| I ₂ | 3.33 | 3.88 | 4.01 | 4.32 | 4.58 | 4.02 |
| I ₃ | 3.86 | 4.48 | 4.48 | 4.95 | 5.07 | 4.56 |
| I ₄ | 2.78 | 3.24 | 3.52 | 3.54 | 3.75 | 3.36 |
| Mean | 3.68 | 4.24 | 4.43 | 4.64 | 4.89 | 4.39 |

Table V. *Evapotranspiration as affected by mulches irrespective of irrigation levels (mm/day) (Mean for 1979 and 1980)*

| Treatments | Months | | | | | Mean |
|----------------|---------|----------|-------|-------|------|------|
| | January | February | March | April | May | |
| M ₀ | 4.15 | 4.76 | 4.76 | 5.29 | 5.68 | 4.96 |
| M ₁ | 3.71 | 4.27 | 4.40 | 4.79 | 4.86 | 4.40 |
| M ₂ | 3.20 | 3.64 | 3.84 | 4.06 | 4.15 | 3.79 |
| Mean | 3.68 | 4.24 | 4.38 | 4.79 | 5.06 | 4.38 |

evaporativity acting on the soil surface. If the evaporation persists and the soil surface dries, the ability of soil profile to transmit water to the surface falls below the evaporativity of the atmosphere and the actual evaporation rate falls below the optimum (Lemon 1956). The plant roots can absorb moisture at a certain rate for a given soil conditions. As the soil moisture content decreases and suction increases, a corresponding decrease in the absorption rate of water by plants results and leads to a lower evapotranspiration and reduced ratio of ET/E pan.

Table VI. *Crop coefficient (ET/E pan)*

| Treatments | Mean for 1979 & 1980 | | | |
|----------------|----------------------|----------------|----------------|------|
| | M ₀ | M ₁ | M ₂ | Mean |
| I ₁ | 1.06 | 0.92 | 0.83 | 0.94 |
| I ₂ | 0.75 | 0.70 | 0.59 | 0.68 |
| I ₃ | 0.90 | 0.80 | 0.67 | 0.79 |
| I ₄ | 0.61 | 0.59 | 0.53 | 0.58 |
| Mean | 0.83 | 0.76 | 0.66 | 0.75 |

Among the different mulching treatments, unmulched control plot had shown the highest ratio between the consumptive use and open pan evaporation (0.83) and when organic mulch was applied, the ratio was reduced to 0.76 and the use of polythene sheet as a mulch it had further reduced to 0.66 (Table VI). Mulches act as a vapour movement barrier and minimise the evaporation loss from the soil (Lal, 1974, Chandler et al., 1969 and Waggoner, 1960) resulting in a lower ratio of ET/E pan.

The seasonal water requirement of arecanut was found to be 105.0 cm for I₁, 75.8 cm for I₂, 82.2 cm for I₃ and 63.4 cm for I₄ treatments respectively. In the case of mulching treatments, the seasonal water requirement under unmulched control was 93.6 cm;

under arecanut husk it was 83.0 cm and under polythene cover mulch it was 71.4 cm respectively.

Yield

The results on the yield of arecanut (Table VII) revealed that irrigation of 30 mm of water with a CPE of 30 mm gives significantly more yield. The treatment I₁ had resulted in a production of 10672 kg of ripe nuts/ha as against 8521 and 8891 kg/ha respectively in the treatment that received irrigation of 30 mm and 60 mm with a CPE of 60 mm (I₂ and I₃). The treatment irrigated with 60 mm with a 120 mm of CPE (I₄) had only 4973 kg of nuts per hectare. Similarly in the plots mulched with arecanut husk and polythene sheet, the yield increased significantly (8795 and 8878 kg per ha respectively) compared to unmulched control (7110 kg/ha).

The maximum expected crop coefficient, ET/E pan ratio, is 1. However, in the present investigation, with 30 mm of irrigation with a cumulative pan evaporation of 30 mm

Table VII. *Effect of irrigation levels and mulches on weight of ripe arecanut (kg/ha)*

| Treatments | Mean for 1979 and 1980 | | | |
|----------------|------------------------|----------------|----------------|-------|
| | M ₀ | M ₁ | M ₂ | Mean |
| I ₁ | 9604 | 11357 | 11070 | 10672 |
| I ₂ | 7247 | 8946 | 9371 | 8521 |
| I ₃ | 7453 | 9535 | 9700 | 8891 |
| I ₄ | 4166 | 5370 | 5370 | 4073 |
| Mean | 7110 | 8795 | 8878 | 8261 |
| | I | M | I x M | |
| 'F' test | S** | S** | NS | |
| CD (P=0.05) | 881 | 391 | — | |

S** = Significant at 1%

NS = Not significant

the ratio observed was 0.94 and for the practical purposes, this may be taken as nearer to 1 which was also found to be the optimum ratio for irrigating areca garden. It is possible to reduce the above ratio by the application of mulches.

The results suggested that though the potential ET observed was 0.94 whenever flood irrigation is given to arecanut, water will have to be applied with slightly in excess quantities providing sufficient allowances for compensating the percolation and run-off losses. The results also indicated that by the use of organic mulches it is possible to bring down the water requirement of arecanut from IW/CPE ratio of 1 to 0.76 with a cumulative pan evaporation of 30 mm. Though by the use of polythene mulch it is possible to bring down the above ratio to 0.66, the high cost of polythene sheets makes it prohibitive and uneconomical for adoption in arecanut gardens.

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