WATER MANAGEMENT STUDIES ON COCONUT IN INDIA

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ABSTRACT

Variability of rainfall, coupled with inadequate irrigation resources and poor water management are the main causes of low productivity of palms even in traditional coconut growing states.

Studies based on climatological approach at Kasaragod revealed that water requirement (W.R.) of adult palm is equal to the potential evaporation (Eo). Lysimetric studies at CWRDM, Calicut have shown that evapotranspiration (ET) rate of a five-year old palm increases from 2.9 mm/day in December to 5.5 mm/day in April and falls to 2.3 mm/day in June. At Coimbatore, the transpiration rate of coconut leaves was measured to be 7.5 $\mu g/cm^2$/sec. and the estimated W.R. ranged from 55 l/day in December to 115 l/day/palm in June.

An annual increase of 31 nuts/palm/year at Nileshwar was due to basin irrigation with 300 l at five days interval in sandy loam soil. In littoral sand, flood irrigation with 5 cm depth increased yield by 85.4 nuts/palm/year over pre-irrigation yield. At Kasaragod, irrigation with 20 mm at Irrigation Water (IW): Cumulative Pan Evaporation (CPE) ratio of 1.00, recorded the highest cumulative yield of 918 nuts/palm after 16 years of planting. At Calicut, irrigation with 30 or 45 mm of water at IW : CPE ratio of 1.00 resulted in significant improvement in yield of West Coast Tall palms when practiced along with mulching. Studies at Kasaragod have shown that in heavy rainfall areas, sea water can be used for irrigating coconut palms without any adverse effect on productivity of palms and soil conditions.

Drip irrigation has been found most suitable for water scarcity areas. In littoral sandy soil at Kasaragod, 32 l/palm/day through drip, produced 38 per cent higher nuts than basin irrigation with 200 l per four days.

Considerable improvement in productivity of palms under rainfed conditions have been reported through practices controlling run off, increasing infiltration, conserving soil moisture etc.

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INTRODUCTION

Variation in soil moisture ranging from near saturation (June to August) to severe moisture stress (December to May) is one of the major causes of low productivity of palms even in the traditional coconut growing states like Kerala and Karnataka where the annual rainfall ranges from 2,500 to 3,500 mm.

Information on water requirement of coconut and location specific agro-techniques for run off control and soil moisture conservation is needed for designing water management practices for coconut. The paper describes the results of the work done on various aspects of water management on coconut in India.

Water Management for Coconut in Relation to Climate

Water management is location specific and depends upon climate, soil, topography, ground water table etc. Moisture stress period prevails for 14 to 15 weeks in the southern and 18 to 21 weeks in the northern parts of Kerala (Rao and Vamadevan, 1982). Yusuf *et al.* (1986) analysed rainfall patterns of Kasaragod for 65 years and found that of the 3,500 mm annual rainfall, 75 per cent occurred within a short period from June to August and the period from December to middle of May remains rainless. The coconut palms suffer due to poor insolation and excess moisture in the former and due to moisture stress in the later periods. Summer irrigation and drainage are needed in these periods for healthy growth and productivity of palms. In southern Kerala, the annual rainfall of about 2500 mm is better distributed and the palms never experience severe moisture stress and thus productivity is higher. Under Kerala conditions, the effective rainfall under coconut was up to 41 per cent of the total precipitation (Rao *et al.*, 1988).

Effect of Soil Moisture Deficit on Productivity of Coconut

Coconut is mostly grown on soils poor in water holding capacity. Severe stress conditions lead to drooping of leaves, breaking of leaf petioles and even death of palms. According to Coomans (1975) water stress results in lower leaf production and consequently less number of inflorescences. Female flower production is affected, flower and early fruit abscission is generally increased resulting in reduced fruit set. A period of drought occurring 15 to 16 months before the opening of spadices might lead to an abortion of spadices (Menon and Pandalai, 1960). This explains why the abortion of spadices occurs in the rainy season. Moisture stress during initiation of flower primordia which takes place about one year before the opening of spathe affects the nut yield two years later. Coomans (1975) observed a negative correlation between fruit set and accumulated water deficit over a period of five months prior to one year. He also observed maximum influence of water availability during the period between appearance of floral primordia and ovary differentiations. There are three stages in reproductive cycle of coconut, namely, initiation of flowers and fruit set, period of fruit enlargement and period of fruit ripening. The first stage determines the number of ripe fruits produced while the second stage determines the fruit size. The water availability at the second stage is most crucial for yield. Nambiar *et al.* (1969) identified three phases in development of nut, namely, slow progressive growth for about three months after fertilisation, rapid growth for about four months and finally decline in growth rate for about two months. Moisture stress at the second phase adversely affects the size of nut and copra content. Prasada Rao and Nair (1986) have reported that decrease in yield started from the eighth month with the maximum reduction in the thirteenth month after the drought was over.

Effect of Waterlogging on Productivity of Coconut

Under water logged conditions, palms suffer from stunted growth probably due to oxygen deficiency. Waterlogging also causes reduced nitrogen supply, decrease in nutrient content in the order of K, N, P, Ca and Mg, malfunctioning of roots, formation of toxic compounds and greater solubility of metal ions like manganese which are toxic. Prolonged anaerobic condition results in death of roots and palms. Under waterlogged conditions, palms are also susceptible to *Phytophthora* infection resulting in immature nut fall.

Water Requirement of Coconut

Climate is the major determinant of the water needed for optimum growth and yield of coconut palms. Crop water requirements are normally expressed by the rate of evapotranspiration (ET) in mm/day or mm/period. The evaporation (Eo) together with the crop coefficient (Kc) give the water requirement of crop. Since the growth and reproductive stages occur simultaneously after the juvenile period, coconut palm requires readily available moisture throughout its life cycle.

Shanthamalliah *et al.* (1978) reported that total water requirement of one year old coconut seedlings was 1591 and 1533 mm per year when irrigation was given at 80 to 100 per cent and 60 to 100 per cent respectively of available soil moisture. It was also reported that coir dust mulching with 15 cm thickness reduced water demand by 40 to 55 per cent. In water scarcity areas burying of pots with 20 l capacity up to the neck at a distance of 75 cm from the seedling on either side and filling them periodically with water is a common practice to supply sufficient moisture for establishment. The water requirement of young palms in the initial years (up to three years) is very low as the number and size of leaves are small.

The consumptive use of water for adult coconut palms varies with climate and soil and the irrigation requirement depends on the method of application. At CPCRI, Kasaragod, the optimum water requirement was found equal to potential evaporation rate. The IW/CPE ratio of 1.00 (IW = 20 mm) was found to be the best for irrigation scheduling. Jayakumar *et al.* (1988) have reported that the consumptive use of water for coconut palm of six years age ranges from 2.7 to 4.1 mm per day. They have also quantified the crop coefficient values for coconut for different months. Rao (1989) determined evapotranspiration of five year old coconut palm using lysimeter and reported that the ET increased from 2.9 mm per day in December to 5.5 mm per day in June. Joshi *et al.* (1988) recorded maximum ET of 6.6 mm per day when irrigation was scheduled with 20 mm of water at IW/CPE ratio of 1.00 during March. The ET rates were reduced to 4.0 and 2.3 mm per day when the IW/CPE ratios were 0.75 and 0.50, respectively. Vasu and Wahid (1990) using tritiated water have estimated transpiration of adult coconut palm to be 65 l per day. Mohandas *et al.* (1989) at Coimbatore (Tamil Nadu) measured the transpiration rate of coconut leaves to be 7.5 $\mu g/cm^2/sec.$ and estimated the total transpiration as 90 l per day. Varadan *et al.* (1990a) have estimated the irrigation depth and interval for coconut based on soil, crop and climatic approach for the various districts of Kerala. From the above review, it is clear that there is much variation with regard to consumptive use of coconut palm and the variations are mostly due to the soil, climate and method adopted for quantification.

Response of Coconut to Irrigation

Coconut requires ample and frequent supply of water throughout its life and responds well to irrigation. The depth and frequency of irrigation however, varies with soil type, climate, yield potential, age and level of management. Vijayalakshmi and Marar (1959) reported that in deep sandy soil of Nileshwar, Kerala, irrigation increased the annual yield by 5 to 30 nuts/palm. Summer irrigation increased female flower production and arrested button shedding (Venkitesan, 1973) and improved yield by 20 nuts/palm/year compared to rainfed conditions (Marar, 1963).

Bhaskaran and Leela (1978) observed an increase of 39 and 31 nuts/palm/year respectively when the low and medium yield group palms were irrigated with 800 l of water once in seven days in basins of 2 m radius. In littoral sand, flood irrigation with 5 cm of water once in five days significantly increased the number of functional leaves and yield (96.6 nuts/palm/year) compared to basin irrigation with 800 l of water once in a week (33.4 nuts/palm/year).

Higher female flower production, setting percentage and yield of nuts were recorded when dwarf palms were irrigated (5 cm in one m radius basins) in alternate days compared to once in 15 days. The highest response was recorded in Malayan Yellow Dwarf palms (Louis *et al.*, 1980).

Systematic studies based on climatic approach on irrigation requirement of West Coast Tall (WCT) coconut palms (early bearing stage) were conducted at Kasaragod (Nelliat and Padmaja, 1978). The response to three depths of irrigation water (IW) namely, 20, 40 and 60 mm at three frequencies based on IW/CPE ratios of 1.00, 0.75 and 0.50 revealed that while growth characteristics did not differ significantly, frequencies of irrigation at IW/CPE of 1.00 and 0.75 significantly increased leaf number, female flower production and yield over IW/CPE ratio of 0.50. The seasonal water requirement with 20 mm IW at IW/CPE ratios of 1.00 and 0.75 was 930 and 680 mm respectively. The results of the above experiment after 16 years of planting revealed that cumulative yield since bearing was significantly influenced by quantity and frequency of irrigation. Influence of different levels and frequencies of irrigation are presented in Table 44.1. The mean yield of the palms under the above treatment namely, IW/CPE ratios of 1.00 and 0.75 with 20 mm IW were 123 and 121 nuts/palm/year, respectively.

Table 44.1: Cumulative yield of palms as influenced by depth and frequency of irrigation

Depth of water (mm)	*IW/CPE ratio*			*Mean*
	1.00	*0.75*	*0.50*	
20	918	872	637	809
40	834	783	776	798
60	769	698	741	736
Mean	841	784	718	

In another experiment at CPCRI, Kasaragod, COD × WCT hybrid produced 147 nuts/palm/year with 20 mm of IW at IW/CPE ratio of 0.75 compared to 122 nuts/year/palm under rainfed condition during 1986 to 1988. Similar trend was observed with WCT × COD hybrid and WCT also.

Varadan *et al.* (1990b) have reported that nut yield of coconut WCT palms increased significantly when IW was given at 30 to 45 mm with IW/CPE ratio of 1.00 along with mulching at 50 kg per palm.

Several workers have reported that coconut palms can withstand salt concentration ranging from 0.6 to 1.0 per cent (Shanmugam, 1973). Studies at CPCRI, Kasaragod revealed that irrigation with sea water at the rate of 90 l/palm in basins of 1.5 m radius twice a week was as good as irrigation with fresh water and increased yield by 41 per cent over rainfed palms in sandy soils. In sandy loam soil, irrigation with sea water combined with fresh water in the ratio of 1:2 recorded the highest yield (Table 44.2).

Table 44.2: Effect of sea water and fresh water irrigation on the yield of coconut (1967 and 1968)

Treatment	*Mean yield (nuts/palm/year)*
a) Sandy Soil	
1. Irrigation with sea water	42.2
2. Irrigation with fresh water	43.0
3. Unirrigated	30.0
b) Sandy loam soil	
1. Unirrigated	52.6
2. Sea water + fresh water (2:1)	60.8
3. Sea water + fresh water (1:2)	80.5
4. Sea water alone	67.1
5. Fresh water alone	53.6

Experiments conducted during 1977 to 1979 at CPCRI, Kasaragod on sea water irrigation of coconut in littoral sand revealed that EC of the soil increased during summer months but after the monsoon there was no significant difference in EC of soil which were irrigated either with sea water or fresh water. These results show that in high rainfall areas sea water could also be used for irrigation in sandy soils without any effect on the coconut palm or soil characteristics.

Irrigation Methods for Coconut

The surface irrigation methods commonly adopted for irrigation of coconut are flooding, basin irrigation, sprinkler or perfosprays and drip irrigation.

Though higher yield of coconut is realised under flood irrigation than basin irrigation (Bhaskaran and Leela, 1978), there is considerable wastage of irrigation water under flood irrigation, as practiced in certain areas of Tamil Nadu and East and West Godavari districts of Andhra Pradesh.

In basin irrigation, water is applied in the basins of 1.8 to 2.0 m radius around the palm and there is partial wetting of root zones. Irrigation channels are provided in the centre of the two rows and each basin is connected with this channel. In this method also there is loss due to deep percolation and surface evaporation. Application of water in the basin through use of hose pipe is being advocated to reduce water loss in transit. This is being done in the Kallada Tree Irrigation Project in Kerala (Anonymous, 1982).

Sprinkler irrigation or perfosprays is most suited for intercropping or mixed cropping systems in coconut gardens where the entire surface is required to be wetted. Irrigation efficiency is high in this method compared to basin and flood irrigation.

Drip irrigation is ideally suited for widely spaced crop like coconut and it saves water, energy, labour and the efficiency is high. Based on the study during 1985–87 at CWRDM, Calicut it was concluded that the yield of coconut with drip irrigation at the rate of 30 l/palm/day during January to May was comparable to basin irrigation at the rate of 600 l/palm/week (Table 44.3). The benefit cost ratio for drip and basin methods were worked out to be 4.8 and 1.2 respectively (Anonymous, 1988).

Table 44.3: Mean yield of coconut under different irrigation methods

Treatments	*Yield of nuts/palm/year*			*Mean*
	1985	*1986*	*1987*	
1. Basin irrigation @ 600 l/palm/week	59.3	58.3	72.3	63.3
2. Ring irrigation @ 300 l/palm/week	50.8	50.3	46.8	49.3
3. Sprinkler irrigation @ 60 l/palm/day	48.7	56.3	60.3	55.1
4. Drip irrigation @ 30 l/palm/day	59.3	67.5	51.2	59.3
5. No irrigation	51.5	68.0	36.7	52.1

Drip irrigation demonstration for coconut at the rate of 30 l/palm/day in various districts of Kerala by CWRDM during 1985 to 1988 has shown that the yield of nuts improved significantly from the third year after starting of the irrigation (Anonymous, 1988).

In littoral sandy soils at Kasaragod, drip irrigation at the rate of 32 l/palm/day recorded 32.9 nuts/palm/year which was 38 per cent higher than the yield under basin irrigation with 200 l/palm at four days interval and 57 per cent higher than rainfed condition (Anonymous, 1989).

Water Management Practices for Coconut Under Rainfed Conditions

Despite the efforts for development of water resources and providing subsidy for installing irrigation systems, vast areas under coconut will remain under rainfed condition especially in Kerala. Coconut palms on the west coast suffer from severe moisture stress during November to May (Yusuf and Dhanapal, 1988). *In situ* soil water conservation and reduction of surface evaporation are the two approaches which will alleviate moisture stress under rainfed condition. Conservation practices such as contour bunding and terracing (Vijayalakshmi and Marar, 1959) and opening short linear trenches across the slope in a staggered manner (Rethinam, 1987) were suggested for intercepting run off water.

For reducing surface evaporation and improving soil water retention, the following methods were suggested:

i) Mulching with coconut husks, coir dust and dried coconut leaves.
ii) Cover cropping to reduce evaporation loss.
iii) Intercultivation.
iv) Application of common salt at the rate of 2 kg/palm in the basin.

Studies on the response to husk burial in coconut gardens (1937 to 1943) at Kasaragod in red sandy soil (Marar and Kunhiraman, 1957) indicated beneficial effect on productivity after three years which continued up to six years. Trenches with 0.3 to 0.45 m depth and 1.8 m length dug up in between rows of coconut trees were filled up at the rate of 1000 husks per trench. The treated plots yielded 22 nuts/palm more than the control. The experiment was repeated during 1948 to 1950 and the results were similar. At Pilicode, Kerala, husk burial at 37.5 cm depth was found to be economically viable. Results of husk burial at the rate of 1000 coconut husks in trenches of 150 cm length and 40 cm depth between rows recorded maximum available moisture at Veppankulam (Balasubramaniam *et al.*, 1985). Husk burial in the basin of the coconut palm in 2 m radius also improved the yield. The total yield per palm for four years was 235 and 265 nuts/palm for trench burial and mulching basins, respectively compared to 177 nuts/palm under control.

Available water capacity of littoral sandy soil has increased from 0.7 to 1.94 per cent by the incorporation of coir dust at the rate of 50 kg/palm as mulch material (Joshi *et al.*, 1982) and mulching with 50 kg green leaves/palm reduced the soil temperature by 6°C at a depth of 0 to 20 cm in laterite soil (Varadan and Rao, 1983).

Water Management Practices for Coconut under High Rainfall Conditions

In high rainfall regions like Kerala and coastal Karnataka, coconut palms in certain places suffer due to waterlogging especially during rainy season. Paddy fields converted to coconut gardens also experience waterlogging problem in rainy season. Shallow channels (relief drains) are opened to remove surplus water and are connected to main drains to lower the water table. But no systematic studies have been reported on drainage requirement and design for coconut since this crop is normally grown in upland conditions.

Surface drains to a depth of 1.5 m in between rows of coconut palms, to remove excess water from the root zone during rainy season as well as during irrigation, had increased the yield of nuts from 35.7 to 66.1/palm/year, at the Agricultural Research Station, Nileshwar.

Future Thrust Areas

The following areas of work are suggested:

1) Since the major cropped area under coconut is under rainfed condition, agro-techniques are to be developed for *in situ* soil water conservation for individual holdings and groups of holdings on watershed basis.

2) As drip irrigation has been found to be effective for coconut especially in rolling topography, refinement of quantity of irrigation for drip method under different agro-climatic conditions is needed.

3) The water demand or consumptive use of water of coconut has to be quantified for different stages of growth based on soil-crop-climate method.

4) Drainage requirement for coconut has to be quantified and suitable techniques including design to be developed for adoption at individual and group levels.

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DISCUSSION

K.S. Jayasekara: 1) Out of 4.6 mm/day ET, how much is accounted for surface evaporation? 2) Have you studied water uptake pattern in deep soil layers in coconut?

Mohd. Yusuf: 1) It is not possible to separate evaporation components from the evapotranspiration for tall trees like coconut. 2) Water extraction has been studied up to 120 cm soil depth.

Mwinjaka: Is one year data enough to conclude that sea water does not affect the productivity of palms and soil conditions?

Mohd. Yusuf: The experiment on the use of sea water for irrigation purpose was started in 1958 and continued till 1968. The data presented pertains to latter part of two years.