

Influence of drip irrigation on growth and yield of coconut (*Cocos nucifera* L.) in laterite soil

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Abstract

A field experiment on drip irrigation for West Coast Tall (WCT) coconut was conducted in laterite soil at Central Plantation Crops Research Institute, Kasaragod (Kerala, India) to study the drip irrigation requirement and its influence on growth and yield. The treatments included were three levels of drip irrigation (at 33, 66 and 100% E_0 daily), basin irrigation (100% E_0) and rainfed control. The experimental results revealed that annual leaf production and leaf nutrient status (N and K) of coconut palm was significantly higher in the irrigated treatments compared to the rainfed control. The female flower production and nut yield with 66 per cent of E_0 was on par with 100 per cent of E_0 through drip and 100 per cent of E_0 through basin irrigation. Drip irrigation equal to 66 per cent of open pan evaporation (E_0) proved to be economically efficient method of irrigation with water saving of 34 per cent compared to 100 per cent of E_0 through basin and drip methods.

Key words: Coconut, West Coast Tall, Drip irrigation, Growth, Female flower, Nut yield

Introduction

Coconut (*Cocos nucifera* L.) is a high value commercial crop grown in 92 countries with a total area coverage of 11.91 million ha producing 54,129 million nuts annually. India, Indonesia, Philippines and Sri Lanka are the four major countries, which together contribute 78 per cent of the world production. With an area of 1.91 million ha, India's share in the global coconut area is 15.92 per cent. India is now the leading coconut producing country in the world with a production of 15,000 million nuts and percentage share of 25.67 followed by Indonesia and Philippines. Of the total area of 1.91 million ha in India, the contribution of Kerala is 56.5 per cent (1.08 million ha). In production also, Kerala occupies the premier position with 6672 million nuts and a share of 44.7%. Though, Kerala falls under high rainfall zone, due to variability of rainfall, coupled with inadequate irrigation resources and poor water management, the palm invariably suffers from mild to severe stress between the months of December and May resulting in lower productivity. In northern Kerala, most

of the rainfall is received over a period of 4-5 months whereas in southern Kerala, it lasts for 8-9 months. Hence, there is good response for irrigation during the non-rainy period, especially under northern Kerala conditions.

The importance of irrigating coconut for sustained yield has been emphasised (Abeywardena, 1971; and Varadan and Madhava Chandran, 1991). Among the irrigation systems, drip irrigation is gaining importance as it maintains the soil moisture availability and air balance in the root zone of coconut near field capacity throughout the dry season and saves irrigation water (Vidhana Arachchi, 1998). Water requirement of coconut under littoral sandy soil for the non-rainy season (Dec. to May) was 5821 litres of water/palm supplied at the rate of 66% of E_0 through drip. This quantity was adequate to produce higher yield compared to higher level of irrigation (100% and 133% of E_0) (Dhanapal *et al.*, 2000). Dorota and Forrest (1996) reported that drip irrigation wets only a limited portion of the potential soil-root volume, which would be adequate for most plants

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to perform well, along with minimum evaporation loss of water. The cash flow analysis indicated that benefit cost ratio (B C R) in the drip irrigated coconut garden was 2.02 as compared to 1.68 under basin irrigation and 1.07 in rainfed gardens (Dhanapal *et al.* 2000). Keeping in view the above facts, a field trial was conducted at Central Plantation Crops Research Institute, Kasaragod in laterite soil to study the drip irrigation requirement and its influence on growth and yield of WCT coconut cultivar.

Materials and Methods

Experimental site

The experiment was conducted at Central Plantation Crops Research Institute (CPCRI), Kasaragod, Kerala, India, which is situated at 12° 30' N latitude and 75° 00' E longitude at an elevation of 10.7 m above mean sea level.

The average annual rainfall received in the area is 3400 mm, out of which, 86 per cent is received during the four monsoon months (June- September) and the period from December to mid-May remains rainless. The maximum temperature ranges between 28.8°C and 33.1°C and minimum temperature varies between 19.4°C and 24.4°C. The relative humidity ranges between 81 per cent and 94 per cent and the maximum open pan evaporation is recorded during the months of March to May (5.0 to 5.3 mm per day).

The soil of the experimental field was classified as laterite with gravely-clay texture containing on an average 56 per cent gravel. Top layer contains equal amount of sand and clay but clay fraction dominated in lower layer.

Experimental details

The experiment was conducted in randomised complete block design with four replications and three palms per treatment. The treatments comprised of:

- T1: Drip irrigation at 33 per cent E_0 (open pan evaporation) daily
- T2: Drip irrigation at 66 per cent E_0 daily
- T3: Drip irrigation at 100 per cent E_0 daily
- T4: Basin irrigation at 100 per cent of E_0 applied once in four days through hose pipe, and
- T5: Rainfed control.

The quantity of water applied in each treatment was calculated based on the effective root zone of coconut. The 1.8 m radius of coconut basin was taken

as the effective root zone as suggested by earlier workers (Kushwah *et al.* 1973; Maheswarappa *et al.*, 2000). The quantity of water applied was based on mean daily open pan evaporation (E_0) (Twenty years average) during December-January and February-May months (Table 1). The mean daily open pan evaporation values during the months of December-January was 4.2 mm and February-May was 5.0 mm.

Table 1. The quantity of water added in each treatment

Treatments	Quantity of water (litres)	
	Dec.-Jan.	Feb.-May
T1: Drip irrigation at 33 per cent E_0 daily	14 l day ⁻¹ palm ⁻¹	16 l day ⁻¹ palm ⁻¹
T2: Drip irrigation at 66 per cent E_0 daily	27 l day ⁻¹ palm ⁻¹	32 l day ⁻¹ palm ⁻¹
T3: Drip irrigation at 100 per cent E_0 daily	42 l day ⁻¹ palm ⁻¹	50 l day ⁻¹ palm ⁻¹
T4: Basin irrigation at 100 per cent of E_0 applied once in four days through hose pipe	168 l once in 4 days palm ⁻¹	200 l once in 4 days palm ⁻¹

The drip irrigation system consisted of an overhead water tank and the outlet was connected to a water filter along the main pipeline. From the main pipeline, the laterals (16 mm Low Density Poly Ethylene (LDPE) pipes) of convenient length were laid with end cap. At the base of each palm four emitters were placed one metre away from the bole at equidistance with the help of 4 mm LDPE micro tubes. The water from the emitters was allowed to drip at the rate of 2 litres per hour upto the 30 cm depth by putting the emitters in 30 cm x 30 cm x 30 cm pits with the help of conduit pipe.

Under basin irrigation, water was applied in basins of 1.8 m radius as per the treatments.

The coconut palms were planted during 1972 with the spacing of 7.5 m x 7.5 m. The adult palms were supplied with 500:320:1200 g NPK per palm per year in the form of urea, mussoorie rock phosphate, and muriate of potash applied in two splits, 1/3rd during April-May and 2/3rd during September-October. The irrigation treatments were imposed from 1993 during the non-rainy period of December to May up to 1999.

The annual leaf production per palm was recorded during the experimental period every year. Coconut leaf samples were collected from the index leaf (14th leaf) during 1999 and analysed for N, P and K content by adopting standard procedures (Jackson, 1973). Female flower production and nut yield from each palm was recorded separately during each harvest every year. The data recorded on various characters were subjected to Fisher's method of analysis of variance and interpretation of data was done as per the procedure given by Gomez and Gomez (1984).

Results and Discussion

Leaf production

The average annual leaf production ranged from 11 to 13 under different treatments (Table 2). The irrigated treatments irrespective of the method and quantity of water applied, produced similar results. All the irrigated treatments were on a par and varied significantly from the rainfed control (11.0). When there was adequate supply of water and nutrients, there was positive response in growth characters, which resulted in higher leaf production. Coconut palm in general produces one inflorescence/bunch in each leaf axil and thus higher leaf production will directly contribute towards increased nut yield. Under littoral sandy soil also Dhanapal *et al.* (2000) reported higher leaf production of WCT coconut variety due to irrigation. Abeyawardena (1979) and Venkitaswamy *et al.* (1997) also reported increase in leaf production under irrigated condition.

Table 2. Annual leaf production and leaf nutrient content of WCT as influenced by irrigation in laterite soil

Treatments	Annual leaf production (Mean of 1993-99)	Leaf nutrient content (During 1999)		
		N (%)	P (%)	K (%)
T1: Drip irrigation at 33 per cent E_0 daily	12.6	1.85	0.125	1.54
T2: Drip irrigation at 66 per cent E_0 daily	12.8	1.86	0.127	1.56
T3: Drip irrigation at 100 per cent E_0 daily	13.1	1.90	0.127	1.66
T4: Basin irrigation at 100 per cent of E_0 applied once in four days through hose pipe	12.9	1.94	0.129	1.54
T5: Rainfed control	11.0	1.70	0.115	1.32
CD (P=0.05)	0.90	0.11	NS	0.17

Leaf nutrient status

The leaf analysis for the major nutrients viz., N and K indicated that there was statistically significant difference among the irrigation treatments (Table 2). N and K contents were found to be statistically higher in the irrigated treatments compared to rainfed control whereas, the P content did not differ statistically among the treatments. This clearly indicates that water is the key factor, which affects nutrient uptake from the soil. Higher uptake of N and K by coconut in littoral sandy soil under irrigated condition compared to rainfed control was also reported by Dhanapal *et al.* (2000). Roots intercept more nutrient ions when grown in moist soil with adequate moisture than in dry soil, because root growth is more

extensive. Mass flow of soil water to supply the transpiration stream, transports most of the nitrates to the roots (Tisdale *et al.* 1985). Higher uptake of K under adequate soil moisture condition was due to the increased solubility and better availability of the nutrient. Under rainfed condition, the nutrient uptake was significantly lower and this might be due to the fact that cells of the absorption zone of coconut roots grown in gravelly soils become inactive by suberization and dehydration during dry weather, thus affecting the nutrient and water absorption process (Vidhana Arachchi, 1996).

Female flower production and Nut Yield

The pre experimental data on flower production and nut yield did not show any significant difference among the treatments and the average yield ranged from 25 to 32 nuts per palm per year. Pooled data on female flower production for six years (1993-1999) show statistically significant differences among the treatments (Table 3). Irrigation treatments recorded significantly higher number of female flowers (184.5 to 225.5) compared to rainfed control (157.4). Among irrigation treatments, drip irrigation @ 33% of E_0 recorded significantly less female flowers (184.5 no.) compared to other irrigation treatments. Abeyawardena (1979) and Venkitaswamy *et al.* (1997) also reported increase in female flower production under irrigated condition. Pooled data on nut yield for six years (1993-99) revealed that there were significant differences among irrigation treatments and rainfed control. Among the irrigation treatments, drip irrigation @ 33 % of E_0 recorded statistically lower nut yield (68.2 nuts/palm/year) compared to other irrigation treatments but recorded significantly higher yield compared with rainfed control (52.6 nuts/palm/year). Nut yield recorded at T2, T3 and T4 treatments were statistically on par with each other. This clearly indicated that drip irrigation @ 33 % of E_0 failed to produce significant increase in yield, which may be due to the fact that the water applied could not meet the water requirement of the palm as indicated by lower stomatal conductance, transpiration rate and lesser photosynthetic activity (Anon. 1995 and 1997) and lesser female flower production. At higher levels of irrigation, there was increase in stomatal conductance, photosynthetic rate and transpiration rate resulting in higher nut yield. Rajagopal *et al.* (1989) also reported greater stomatal resistance and epicuticular wax content and reduced transpiration rate, leaf water potential and reproductive dry matter under severely moisture stressed palms compared to well watered palms. Increase in nut yield was mainly attributed to production of more number of leaves and better uptake of nutrients under these

treatments. Coconut palm in general produces one inflorescence/bunch in each leaf axil and thus higher leaf production will directly contribute towards increased nut yield. Since difference in the nut yield obtained under 66 and 100 per cent of E_0 is non significant, it clearly indicated that irrigation @ 66 % of E_0 might be sufficient to produce maximum yield in laterite soil. Similar type of results have been reported by many workers for Kerala conditions (Dhanapal *et al.*, 2000, Varadan and Madhava Chandran, 1991; Jose Mathew *et al.*, 1996; Saseendran and Jayakumar, 1988). According to Mahindapala (1987) in the dry zone of Sri Lanka, coconut requires 25 to 30 litres of water per day through drip method. Under Trichy condition of Tamil Nadu (India), water requirement for coconut palm through drip irrigation ranged from 55 litres per day in December to 115 litres per day in June (Kulandaivelu, 1990). The main reason for 34 per cent of water saving in the 66 per cent of E_0 through drip treatment compared to 100 per cent of E_0 through drip or basin irrigation, was due to the fact that the water was applied at reduced quantity at the correct depth and thus the deep percolation loss was avoided. Subramanian *et al.*, (1997) and Kapadiyal *et al.*, (1998) also reported saving of irrigation water to the tune of 40 to 50 per cent over surface irrigation by adopting drip irrigation. Though more water applied under 100 per cent E_0 under drip and basin irrigation, it did not contribute towards higher yield, probably because the excess water might have moved beyond the root zone and was not used by the palms.

Table 3. Nut yield and female flower production (number /palm) in WCT as influenced by irrigation under laterite soil.

Treatments	Pre-experimental (During 1991-93)		Average of 1993-99	
	Female flowers	Nut yield	Female flowers	Nut yield
T1: Drip irrigation at 33 per cent E_0 daily	79.9	28.2	184.5	68.2
T2: Drip irrigation at 33 per cent E_0 daily	73.2	30.1	214.7	96.5
T3: Drip irrigation at 33 per cent E_0 daily	66.0	24.9	200.8	89.8
T4: Basin irrigation at 100 per cent of E_0 applied once in four days through hose pipe	78.6	31.6	225.5	98.2
T5: Rainfed control	79.5	30.8	157.4	52.6
CD (P=0.05)	NS	NS	25.6	9.5

Economics of drip system (Rs./ha)

Based on the treatment effect on yield (Table 3), economic analysis was performed and the results are furnished in the following table.

Table 4. Economics of drip system in laterite soil (Rs./ha)

Treatments	Gross Cost	Gross Return	Net return	% increase of Net Return over T5
T1	27000	49600	22600	
T2	27000	65200	42200	
T3	27000	64300	37300	
T4	28200	68600	40400	
T5	21400	36400	15000	

It could be inferred from the above table that the percentage increase of net return over T-5 (Rainfed condition) was maximum in T-2 consisting of Drip irrigation at 66 % E_0 (excluding investment cost) daily followed by T-4 (basin irrigation at 100 % E_0 applied once in four days through hose pipe. The relative economic returns from the drip system are higher than other treatments, which clearly indicate the economic worthiness of investing in drip irrigation system in coconut gardens with laterite soil.

To further confirm the above results, the cash flow analysis was performed using 10 % as discount rate. Three basic investment parameters viz., Benefit-Cost Ratio (BCR), Net Present Worth (NPW) and Pay Back Period (PBP) were used (Table 5). The results indicated that all the three parameters were highly positive and favoured the economic worthiness of investment in drip irrigation system.

Table 5. Investment analysis of drip system in laterite soil

Treatments	BCR	NPW	PBP
T1	1.62	116140	02
T2	2.25	236574	01
T3	2.09	206465	01
T4	2.43	248241	-
T5	1.70	92168	-

Discount rate assumed as 10%

Though the BCR was at par as well as NPW is higher in case of T-2 as compared to T-4. Moreover drip system is recommended for those areas in which water resources are scarce and it could be well managed with the own family labour. Hence in the laterite belt of Northern Kerala, where labour and water resources are scarce, it is economic viable to invest in drip irrigation system

Conclusions

It is evident from the result that irrigation at higher levels improved growth, development, nutrient uptake and nut yield of the palms. As evident from the results the most economic irrigation level being the drip

irrigation at 66 per cent of E_0 in terms of nut yield and water saving (Dhanapal *et al.*, 2000). Under Northern Kerala condition of India, irrigate coconut palms through drip irrigation at the rate of 27 litres of water per palm per day during December-January months and 32 litres of water per palm per day during February-May months for higher yields.

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