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INFLUENCE OF DRIP IRRIGATION ON GROWTH, NUT CHARACTERS AND YIELD OF COCONUT IN LITTORAL SANDY SOIL

By

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ABSTRACT

A field experiment was conducted at Central Plantation Crops Research Institute, Kasaragod, India for six years (1993-1999) to study the impact of drip irrigation levels and mulching on coconut in littoral sandy soil. The treatments consisted of three levels of drip irrigation (66, 100, and 133 % of open pan evaporation (E_0)) along with basin irrigation (100 % of E_0) and rainfed control as main plot treatments and mulching with coconut leaves and no mulching as sub plot treatments. The experimental results revealed that annual leaf production and leaf nutrient status of coconut was better in the irrigated treatments compared to the rainfed control. The drip irrigation at 66 per cent of E_0 (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) resulted in water saving and the nut yield was on par with 100 per cent and 133 per cent of E_0 through drip and 100 per cent of E_0 through basin irrigation and differed significantly compared to rainfed control. The nut characters like nut weight, husk weight, copra thickness, copra content and copra yield was

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superior under irrigated treatments compared to rainfed control. The copra yield was 499 kg per ha under rainfed condition, where as it was 2087 to 2202 kg per ha under irrigated treatments. Irrigation along with mulching with coconut leaves resulted in significantly higher nut yields.

***Key Words**: Coconut (Cocos nucifera L.), Drip irrigation, Growth, Littoral sandy soil, Nut characters and 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 54130 million nuts annually during the year 1999. India, Indonesia, Philippines and Sri Lanka are the four major global players, which together contribute 78 per cent of the world production. With an area of 1.91 million ha, India's share to the global coconut area is 16 per cent. India is now the leading coconut producing country in the world with a production of 15000 million nuts and percentage share of 27.6 followed by Indonesia and Philippines. In productivity too India ranks in the forefront with a productivity of 7821 nuts per ha whereas the world productivity is as low as 4294 nuts per ha (Rethinam, 2001).

In India, Andhra Pradesh stands in the forefront with the productivity of 19575 nuts per ha while in Kerala it is as low as 6188 nuts per ha (Rethinam, 2001) mainly because of the fact that, it is being grown as rain dependent crop and prevalence of root (wilt) disease. Though Kerala falls under heavy rainfall zone the variability of rainfall coupled with inadequate irrigation resources and poor

water management results in mild to severe stress on coconut palms between the months of December and May resulting in lower productivity. Coconut grown in drought-prone areas is often subjected to periodic moisture deficit during the dry season (Carr, 1992).

The littoral sandy soil, which occurs along the coastal length of Kerala, is the second largest soil type where coconut is predominantly grown. These coastal sandy soils are poor in fertility and water holding capacity, get heated up quickly and the heat remains during the full day time affecting water and nutrient uptake. Coconut palms which are grown in these littoral sandy soils experience stress during summer which makes the palms to yield much below their potential. Hence, it is imperative to provide irrigation during the non rainy season. Unlike other crops, coconut produces flower primordia round the year and hence adequate moisture should be available in the soil throughout the year. As the sandy soils contain mainly sand particles (99.1%), their infiltration rate is very high and hence the system of irrigation must be chosen very carefully. An ideal irrigation system will be the one in which water is supplied at the same rate at which it is absorbed by the palms and drip irrigation fits well to these conditions. The importance of irrigating coconut for a sustained yield has been emphasized (Abeywardena, 1971, Varadan and Madhava Chandran, 1991, Keller *et al.*,1992 and Dhanapal *et al.*, 2000b). 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). 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 to perform well along with minimum evaporation loss of water. The efficacy of irrigation can be increased by mulching the irrigated area and its favourable effect on soil temperature regulation (Varadan and Rao, 1983), soil moisture conservation and soil temperature reduction (Maheswarappa *et al.*, 1998) has been established.

Keeping in view the above facts, a field trial was initiated at Central Plantation Crops Research Institute, Kasaragod, Kerala (India) in littoral sandy soil with the objective to study the influence of drip irrigation levels combined with mulching with coconut leaves on growth, nut characters and yield of West Coast Tall coconut variety.

MATERIALS AND METHODS

Experimental site

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

In a normal year the experimental area receives an annual rainfall for about five months from June to October and one or two summer showers. The average 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 middle 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 littoral sand (Quartzipsamments) with a mechanical composition of 95.8 per cent coarse sand, 3.3 per cent fine sand, 0.2 per cent silt and 0.7 per cent clay. The field capacity of the soil was 4.2 per cent and wilting point was 0.44 per cent with a bulk density of 1.66 kg m^{-3}.

Experimental details

The experiment was conducted during the non rainy seasons (December to May) of 1993 to 1999, in a coconut garden planted in 1972 with West Coast Tall variety. The split plot design involving irrigation treatments in the main plot and mulching treatments in sub-plots replicated four times was adopted for the study. The number of palms per main plot treatment were four and for sub-plot treatment there were two palms. The unit plot was laid out in rows and guard rows between treatments were maintained.

Treatment details

Main plot treatments

T_1: Drip irrigation at 66 per cent E_0 (open pan evaporation) daily

T_2: Drip irrigation at 100 per cent E_0 daily

T_3: Drip irrigation at 133 per cent E_0 daily

T_4: Basin irrigation at 100 per cent of E_0 applied once in four days through hose pipe, and

T_5 : Rainfed control.

Under drip irrigation, the quantity of water applied was based on mean monthly open pan evaporation (Twenty years average) during December-January and February–May months. The mean monthly open pan evaporation values during the months of December-January was 4.2 mm per day and February-May was 5.0 mm per day. The quantity of water added in each treatment is given in the Table 1.

Sub-plot treatments

M_0 : No mulch

M_1: Mulching with coconut leaves (Fifteen coconut leaves were used to cover the 1.8 m radius of the basin area).

The coconut palms were planted with the spacing of 7.5 m X 7.5 m and supplied with 500:320:1200 g N, P_2O_5 and K_2O per palm per year in the form of urea (46 % N), mussoorie phos (20 % P_2O_5) and muriate of potash (60 % K_2O) applied in two splits, 1/3rd during April-May and 2/3rd during September-October.

The drip irrigation system consisted of an overhead water tank and the outlet was connected with water filter along with main pipe line. From the main pipeline, the laterals of 16 mm OD LDPE (Low density poly ethylene) pipes of convenient length were laid with end cap. At the base of each palm six emitters were placed one meter away from the bole at equidistance with the help of 4 mm LDPE microtubes. The water from the emitters was allowed to drip at the rate of 2 litres per hour up to the 30 cm depth by putting the emitters in 30 cm^3 pits with the help of conduit pipe.

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 analyzed for N, P and K content by adopting standard procedures (Jackson, 1973). Nut yield from each palm was recorded separately during each harvest every year. Nut characters were studied from representative samples during three seasons of 1998 and 1999 and average was worked out.

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

INFLUENCE OF IRRIGATION

Growth characters

The mean annual leaf production ranged from 8 to 12 leaves per palm among the different treatments (Table 2). The irrigated treatments irrespective of the method and quantity of water applied, produced similar results (11.5 to 12 leaves) which varied significantly from the unirrigated control (8 leaves). Irrigating a palm results in production of more number of leaves which may be attributed to adequate supply of water and inturn, nutrients. Coconut palm in general produces one inflorescence/bunch in each leaf axils and thus higher leaf production will directly contribute towards increased nut yield. Abeywardena (1979) and Venkitaswamy *et al.* (1997) also reported increase in leaf production under irrigated condition.

Leaf nutrient status

The leaf analysis for the major nutrients viz., N, P and K indicated that N and K contents were influenced by the irrigation treatments, but P content was unaffected (Table 2). N and K contents were found to be significantly higher in the irrigated treatments compared to rainfed control. This clearly indicates that water is the key factor which affects nutrient uptake in littoral sandy soils. Nitrogen and potassium contents in 14th leaf were found to be significantly higher in irrigated treatments. Roots intercept more nutrient ions when grown in 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 become inactive by suberization and dehydration during dry weather, thus affecting the nutrient and water absorption process (Vidhana Arachchi, 1996). Better uptake of nutrients under irrigated condition might be because of more number of main and fine roots development compared to rainfed control (Dhanapal *et al.*, 2000a). Higher root activity in olive trees under drip irrigation also has been reported by Fernandez *et al.* (1991). In young arecanut palm also, higher number of main roots and feeder roots under drip irrigation method has been reported (Sujatha and Abdul Haris, 2000).

Nut Yield

Pooled data on nut yield for six years (1993-1999) indicated that there was no significant difference among different levels of drip irrigation and between the drip and basin irrigation (Table 3). Nut yield under irrigated treatments (66 to 72 nuts palm^{-1} year^{-1}) were on par with each other but were significantly superior to the rainfed control (27.8 nuts palm^{-1} year^{-1}). Influence of irrigation on nut yield could be seen from second year after imposing treatments and nut yield starts stabilized from fourth year onwards (Fig. 1). During first two years the yields were on par among the treatments and the yields under rainfed palms started declining drastically from second year

onwards of treatment imposition. Nut yield under irrigated treatments were significantly higher compared to rainfed control, clearly indicating that there was good response for irrigation in littoral sandy soil. However, the response for the higher quantity of water applied was less conspicuous, the soil being porous and poor in organic matter. Therefore, the treatment where 66 per cent of E_0 was applied through drip could produce the same effect as that of 100 and 133 per cent E_0 through drip and 100 per cent of E_0 through hose irrigation in coconut basin. Increase in nut yield was mainly attributed to production of more leaves and better uptake of nutrients under irrigated treatments. Increase in growth characters and better availability of moisture resulted in increase in photosynthetic rate, stomatal conductance and transpiration rate under irrigated palms (Anon., 1997). Rajagopal *et al.* (1989) also reported greater stomatal resistance and epicuticular wax content and reduced transpiration rate, leaf water potential and ~productive dry matter under severely moisture stressed palms compared to well watered palms. According to Mahindapala (1987) in the dry zone of Sri Lanka, coconut requires 25 to 30 litres of water per day through drip method. Kulandaivelu (1990) has reported that, under Trichy condition of Tamil Nadu (India), water requirement for coconut palm through drip irrigation ranged from 55 litres per day in December months to 115 litres per day in June months. It was also reported that yield of nuts under drip method at 30 and 45 litres day^{-1} $palm^{-1}$ was on par with basin irrigation at 600 litre $palm^{-1}$ $week^{-1}$ (Varadan and Madhava Chandran, 1991) besides stabilised yield with minimum fluctuation under adequate irrigation (Jose Mathew *et al.*, 1996). Sivanappan and Kottiswaran (1985) reported that the quantity of water to be irrigated for coconut palms by drip irrigation varies from 0.005 to 0.07 m^3

palm^{-1} day^{-1}. Water saving in the 66 per cent of E_0 through drip treatment was due to the reason that the water was applied at reduced quantity and thus the deep percolation loss was avoided. Though more water was applied under 100 and 133 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. Maheswarappa *et al.* (1997), while studying the moisture movement under littoral sandy soil, have reported that the vertical movement of water crossed the active root zone of 120 cm on 3rd and 4th day after irrigation at 4 litres/h and 2 litres/h discharge rate, respectively. Subramanian *et al.* (1997) and Kapadiyal *et al.* (1998) also reported 40-50 per cent saving of water through drip irrigation system compared with surface irrigation. With the adoption of drip irrigation system there could be saving of labour requirement and thus economically it results in higher benefit cost ratio (Dhanapal *et al.*, 2000b). Coastal sandy soils have very low water holding capacity, hence the supply of water according to the daily requirement of the palms through drip system may prove ideal, since it maintains a uniform moisture level throughout the period and economizes the quantity of irrigation water compared with other surface irrigation methods.

Nut characters

The nut characters studied in irrigated palms were significantly higher compared to rainfed control (Table 4). The nut weight recorded under rainfed control was lesser by 49 per cent compared to basin irrigated palms. The copra thickness and copra content were significantly lower under rainfed control compared to

irrigated palms which finally resulted in lower copra yield. The copra yield was 399 kg per ha under rainfed condition, where as it was 2087 to 2202 kg per ha under irrigated treatments. It is evident from the table 4 that the nut weight, copra thickness, copra content was significantly higher in irrigated treatments. The copra yield was 499 kg per ha under rainfed condition, where as it was 2087 to 2202 kg per ha under irrigated treatments. Increase in nut characters under irrigated treatments was due to better growth, nutrient uptake by the palms. Abeywardena (1979) also reported increase in nut size and copra yield due to irrigation.

INFLUENCE OF SOIL MULCH ON GROWTH AND YIELD

The dried coconut leaves which are available in the garden could be used for mulching purpose in coconut garden. The mulching treatment did not bring about any significant difference in annual leaf production, leaf nutrient content and nut characters. However, application of dried coconut leaves as mulch resulted in a significant improvement in yield at the rate of 14 nuts palm^{-1} year^{-1} over the 'no mulch' treatment (Table 3). The data on the interaction (Table 3) reveal that there was no yield improvement with mulching compared to no mulching in unirrigated treatment indicating that unless there was enough moisture in the soil, the effect of mulch was negligible on nut production. The yield increase over control in the irrigated treatments under 'no mulch' was only 76 to 121 per cent while in the mulched treatments the difference was 167 to 230 per cent (Fig. 2). This clearly shows the advantages of mulching with irrigation in increasing the nut yield.

Mulching with dried coconut leaves was found to have positive response to yield parameter, though growth characters were not significantly affected. Uthaiah *et al.* (1993) have reported that the growth of coconut seedlings was better under drip irrigation coupled with coir pith mulching treatment. It is a proven fact that mulching influences soil moisture and soil temperature to a greater extent. Under "irrigation with mulch" conditions, soil moisture availability increases and soil temperature reduces (Varadan and Rao, 1983 and Maheswarappa *et al.*, 1998) which are the two most important physical factors which influence various processes such as evapotranspiration, growth, development and biological activity (Lal, 1974). However, mulching under rainfed condition did not produce any significant impact because the sandy soils have low water holding capacity and perhaps could not retain the moisture during non-rainy season.

CONCLUSIONS

The investigations have clearly shown the importance of irrigation and mulching in coconut cultivation in littoral sandy soil under humid tropical conditions. Irrigation through drip method at all the rates result in better nut yield and copra yield compared to rainfed control treatment, the most economic one being drip irrigation at 66 per cent of E_0 in terms of water saving with six emitters placed at equidistance (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). Mulching with coconut leaves also resulted in better growth, increase in nut yield and copra yield showing a positive interaction with irrigation.

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Table 1. Quantity of water applied in different treatments.

Treatments	Quantity of water (litres)	
	December-January	February-May
T_1: Drip irrigation at 66 per cent E_0 daily	27 L day^{-1} $palm^{-1}$	32 L day^{-1} $palm^{-1}$
T_2: Drip irrigation at 100 per cent E_0 daily	42 L day^{-1} $palm^{-1}$	50 L day^{-1} $palm^{-1}$
T_3: Drip irrigation at 133 per cent E_0 daily	56 L day^{-1} $palm^{-1}$	64 L day^{-1} $palm^{-1}$
T_4: Basin irrigation at 100 per cent of E_0 applied once in four days through hose pipe	168 L once in four days $palm^{-1}$	200 L once in four days $palm^{-1}$

Table 2. Annual leaf production and leaf nutrient status of coconut as influenced by irrigation and mulching in littoral sandy soil.

Treatments	Annual leaf production	Leaf nutrient content (% d.m in leaf 14) during 1999		
	Av. of 1993-99	N	P	K
Main Plot : Irrigation				
T_1: Drip irrigation at 66 % of E_0 daily	11.5	1. 81	0.11	1.68
T_2: Drip irrigation at 100% of E_0 daily	12.0	1.79	0.12	1.70
T_3: Drip irrigation at 133 % of E_0 daily	11.6	1.80	0.10	1.65
T_4:Basin irrigation at 100 % of E_0 once in four days	11.8	1.78	0.11	1.61
T_5: Rain fed control	8.0	1.31	0.11	1.12
CD (P=0.05)	0.8	0.33	NS	0.27
Sub Plot : Mulching				
M_0 : No Mulch	10.8	1.698	0.11	1.52
M_1 : Mulch	11.1	1.775	0.11	1.552
CD (P=0.05)	NS	NS	NS	NS

Table 3. Influence of irrigation and mulching and their interaction on coconut nut yield (Pooled data for 6 years)

Treatments	Nut yield palm^{-1} Year^{-1}		
Irrigation/Mulching	No Mulch	Mulch	Mean
T_1: Drip irrigation at 66 % of E_0 daily	59.3	75.9	67.6
T_2: Drip irrigation at 100% of E_0 daily	65.1	79.7	72.4
T_3: Drip irrigation at 133 % of E_0 daily	56.2	78.3	67.2
T_4: Basin irrigation at 100 % of E_0 once in four days	58.3	74.4	66.3
T_5: Rain fed control	28.1	27.6	27.8
Mean	53.4	67.2	
CD for Main plots (P=0.05) =12.3			
CD for Sub plots (P=0.05) =4.5			
CD for Sub plot at the same level of main plot =12.1			
CD for Main plot at the same or different levels of subplot =19.2			

Table 4. Influence of irrigation and mulching on nut characters of coconut in littoral sandy soil (Pooled data of two years).

Treatments	Nut weight (g/nut)	Husk weight (g/nut)	Copra thickness (mm)	Copra content (g/ nut)	Copra yield (kg/ha)
Main Plot : Irrigation					
T_1:Drip irrigation at 66 % of E_0 daily	503.8	380.0	13.9	175.6	2093
T_2: Drip irrigation at 100% of E_0 daily	509.0	371.7	13.8	175.1	2202
T_3: Drip irrigation at 133 % of E_0 daily	506.5	383.9	13.6	173.9	2087
T_4: Basin irrigation at 100 % of E_0 once in four days	521.9	368.5	13.9	179.1	2115
T_5: Rain fed control	256.9	179.5	11.2	101.6	499
CD (P=0.05)	35.2	19.0	0.2	7.5	481
Sub Plot : Mulching					
M_0 : No Mulch	463.2	349.6	13.6	162.4	1741
M_1 : Mulch	456.0	357.0	13.7	159.7	1859
CD (P=0.05)	NS	NS	NS	NS	NS

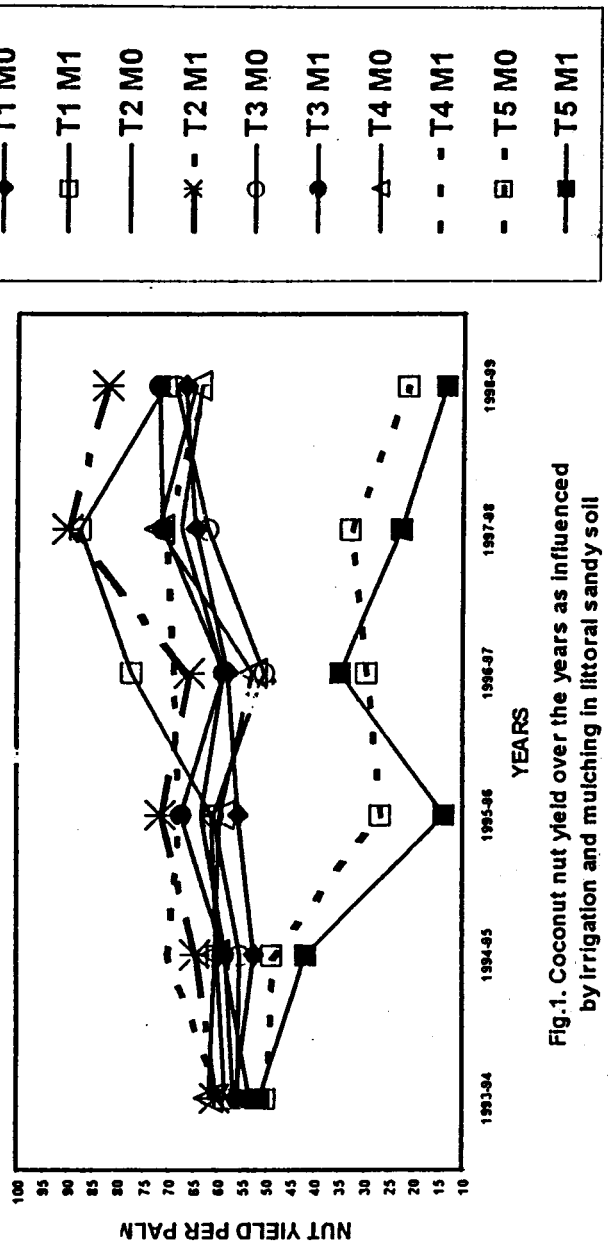

Fig.1. Coconut nut yield over the years as influenced by irrigation and mulching in littoral sandy soil