

## Research Articles

# MOISTURE MOVEMENT STUDIES UNDER DRIP IRRIGATION IN COCONUT BASINS

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### ABSTRACT

Field studies were conducted to determine wetting fronts and volume of active root zone in coconut basin (manuring -circular area around the bole) wetted with three quantities of water application, I<sub>1</sub>-33% of E<sub>0</sub>, I<sub>2</sub>-66% of E<sub>0</sub> and I<sub>3</sub>-100% of E<sub>0</sub> at a fixed emitter (dripper) discharge rate of 2 litres/hr. The efficiency of placing emitters on surface and sub-surface, on water movement and volume of basin wetted was also studied with irrigation equal to 100% of E<sub>0</sub>.

Vertical and horizontal movement of water and volume of active root-zone in coconut basin wetted were directly related to the quantity of water applied. The vertical and horizontal wetting fronts were 90 and 51 cm at I<sub>1</sub>, 100 and 60 cm at I<sub>2</sub> after 30 days of regular irrigation, and 120 and 65 cm at I<sub>3</sub> after 5 days irrigation. The percentage volume of active root zone wetted was 19.1, 21.5 and 28.6 at I<sub>1</sub>, I<sub>2</sub> and I<sub>3</sub> rates of water application during the periods. The vertical and horizontal fronts under surface and sub-surface placed emitters were 64 and 44 cm and 90 and 52 cm, respectively after a week's irrigation. The percentage volume of active root zone wetted was 13.6 and 18.2 respectively under surface and sub-surface placed emitters. The sub-surface placement wetted 35% more volume than the surface placed emitter.

### INTRODUCTION

Besides water, labour and energy saving features of drip irrigation, its favourable effect on yield has generated enormous interest among the coconut growers. One of the important considerations in the design of the drip irrigation system is to decide the minimum area or soil volume required to be wetted compared to the whole area or potential root zone of the coconut palm. The pattern of wetting front will be different for different soils due to variation in soil texture, permeability, presence or absence of impermeable layers, quantity of water applied per irrigation, discharge rate of the emitter and the initial moisture content of the soil. As the active roots of coconut palm are below 25 cm of soil surface, further economy is possible by allowing water to drip 25 cm below the soil surface.

Therefore, a short term field study was conducted in laterite soil to determine wetting

fronts with different quantities of water at a fixed discharge rate of the emitters and also the efficiency of surface and sub-surface placed emitters.

### MATERIALS AND METHODS

Field studies on wetting front under drip irrigation were conducted at Central Plantation Crops Research Institute, Kasaragod during non-rainy periods of January to March 1986 in coconut garden cultivated to hybrid palms Chandrasankara (COD × WCT). The palms were planted in 1972 and had reasonable growth. The soil of the experimental field was classified as laterite soil with gravelly-clay texture containing on an average 56 per cent gravels. Top 0-12 cm layer contains equal amount of sand and clay but clay fraction dominated in lower layers (Table I). As different soil layers differ in their physical composition, water is expected to move differently as influenced by soil

texture, the horizontal and vertical permeability and presence of impermeable layer (Vermeiren and Jobling, 1984).

For uniform emitter discharge rate, constant water head was maintained in the water storage tank by providing a float. The emitter discharge rate was checked daily. The wetting front measurements were done under three quantities of irrigation water, namely  $I_1$ -33 per cent of daily Open Pan Evaporation (33% of  $E_0$ ),  $I_2$ -66 per cent of the  $E_0$  and  $I_3$ -100 per cent of the  $E_0$ . Though, water requirement of coconut palms under Kasaragod conditions was reported to be equal to daily evaporation rate (Nelliath and Padmaja, 1978) during the period of water scarcity, reduced quantity of water is applied depending upon water availability. For computation,  $E_0$  was taken as 5 mm/day throughout the study period. The basin area was calculated considering 1.8 m radius from the bole. Thus, 16, 32, and 50 litres of water was applied per palm daily in  $I_1$ ,  $I_2$  &  $I_3$  respectively through four dripping points maintaining a discharge rate of 2 litres/hr. Four PVC conduit pipes of 30 cm length and 16 mm diameter were fixed opposite to each other at a distance of 1 metre from the bole in a slanting position leaving 5 cm above ground. Emitters were attached to PVC micro-tubes (4 mm I. D.) and placed inside the conduit pipes to allow water to drip at about 25 cm below the surface. Only two dripping points, opposite to each other were used for water-front studies. As water was allowed to drip about 25 cm below the soil surface, top 25 cm soil was scraped around

**Table I. Physical composition of soil (laterite soil, Hill block)**

Soil depth (cm)	Sand %	Silt %	Clay %	Gravel %	B.D. (core sample)
0-12	45.0	10.0	45.0	57.0	1.47
12-45	29.0	12.0	59.0	54.0	1.29
45-90	19.5	13.5	67.0	57.0	1.33

Source : Soil Science Section, CPCRI, Kasaragod (unpublished)

the dripping points to locate exact boundary of water-front at dripping points. Measurements were taken from the dripping points upto the fringe of moist soil at several places. To facilitate tracing of boundaries of lateral and vertical movement of water, trenches of convenient length, width and depth were opened parallel to the lateral lines (east-west). A piece of transparent plastic sheet was fixed on the wall of the trench and exact boundary was traced with sketch pen. Thereafter, from another dripping point of the same tree, another trench (north-south) was opened perpendicular to the first trench to trace the wetting front in other direction. For each observation, two dripping points were taken into account from one palm. From the mean values of the vertical and horizontal movement of moisture, approximate mean volume of the active root zone of coconut basin wetted by four emitters was computed. Such observations were recorded for three treatments with water separately. In case of irrigation equal to 100 per cent of  $E_0$ , wetting fronts were monitored after day-1, day-2, day-3, day-4 and day-5 following irrigation till it crossed the active root zone of 100 cm. Whereas in case of 66 per cent and 33 per cent of  $E_0$ , wetting fronts were monitored at an interval of 3 days beginning with day-1 after irrigation, till the wetting front either crossed the active root zone or got stabilized. Each time for every observation separate trenches were opened.

Wetting fronts were also measured under irrigation equal to 100 of  $E_0$  by placing emitters at 25cm below the surface, maintaining discharge rate at 2 litres/hr in the same garden. The wetting front was measured a week after regular irrigation. From the wetting front measurements, approximate volume of the active root zone of coconut palm basin wetted by four emitters was considered.

## RESULTS AND DISCUSSION

### Wetting fronts

The wetting fronts as a function of time and accumulated quantities of irrigation

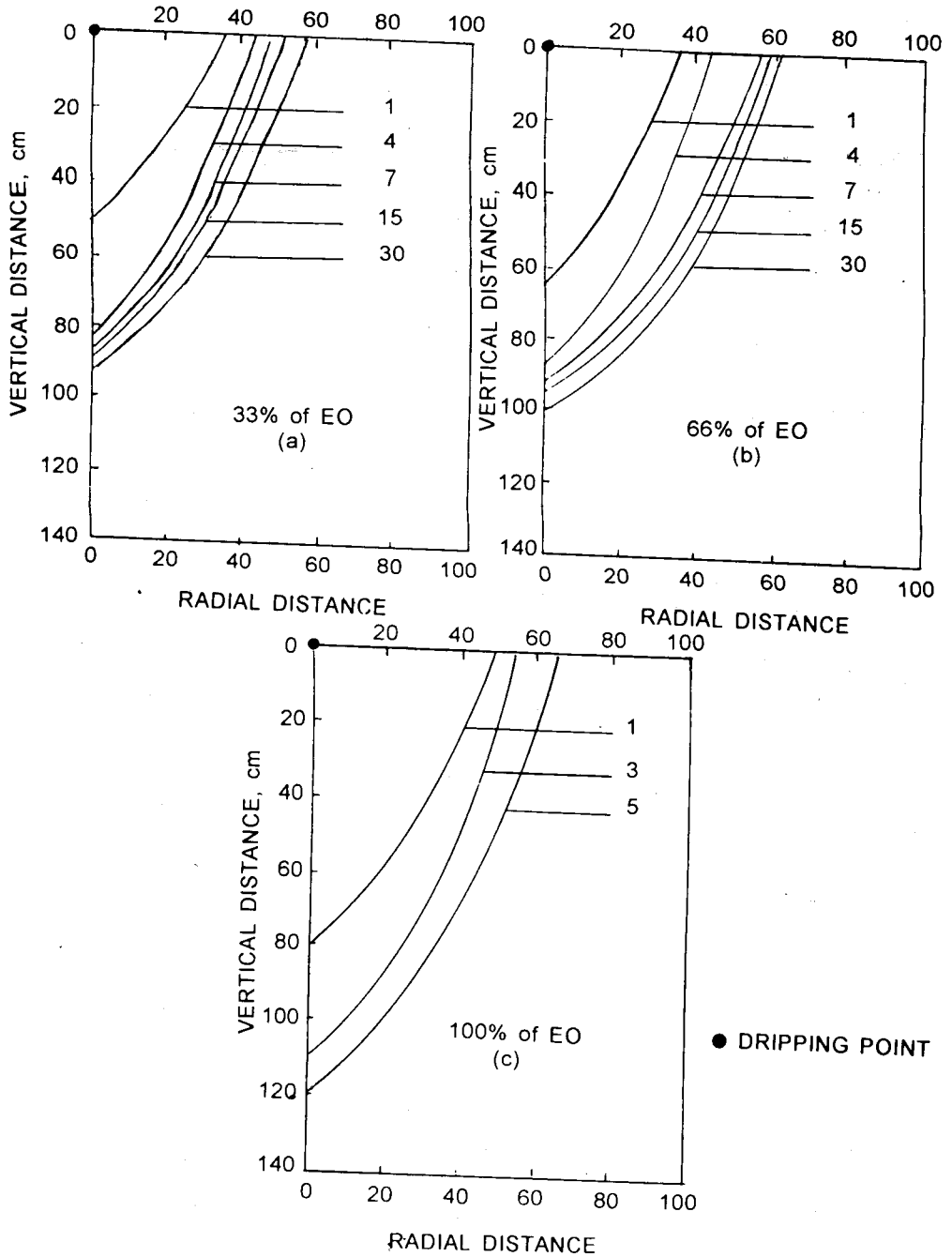


Fig. 1. Wetting fronts as influenced by quantity of irrigation water (number on the curves indicate days after regular irrigation)

water are presented in Fig. 1. Wider wetting patterns were recorded with the higher quantities of water and greater infiltration time. The maximum vertical and horizontal movement of water with irrigation equal to 33 per cent of  $E_o$  was 90 and 56 cm respectively after 30 days of irrigation. Whereas, with 66 per cent of  $E_o$ , the water moved 100 and 60 cm respectively in vertical and horizontal directions during the same period. However, with the irrigation equal to 100 per cent of  $E_o$ , the vertical front crossed the active root zone of one metre after 5 days of irrigation. The vertical and horizontal water movement was 120 and 65 cm respectively. Vermeiren and Jobling (1984) reported that in soils with finer texture such as clay or clay loams, the capillary forces are strong and gravity can be negligible; hence, the lateral wetting is sometimes greater than the vertical penetration. Contrast to this, the vertical movement in this study was greater than the lateral due to the highly gravelly nature of soil which aided the gravitational force more than the capillary forces. Brandt *et al.* (1971) reported that with the same quantity of water and infiltration time, the sand was wetted deeper than the loams.

Placement of emitters played a great role in water distribution as evident from Fig. 2. With surface placement, the water moved 64 cm vertically and 44 cm horizontally. But when the emitters were placed 25 cm below the soil surface, the water moved 90 cm vertically and 52 cm horizontally during the same period.

In the present study, the vertical movement of water was more than horizontal irrespective of whether the same quantity of water was applied on the surface or sub-surface. This was due, to pre-dominance of the gravitational force than others, owing to the gravelly nature of the soil.

#### *Wetted volume of active root zone in coconut palm basins*

The volume of coconut palm basin wetted by four emitters was related to the quantity of water applied, maximum (28.6 per cent) being in  $I_3$  and minimum (19.7 per cent) with  $I_1$  (Table II). The volume of active root zone wetted in  $I_1$  may be inadequate to supply water required by the palms. Though, irrigation equal to 100 per cent of  $E_o$  wetted about one-third of the active root zone (1.2m

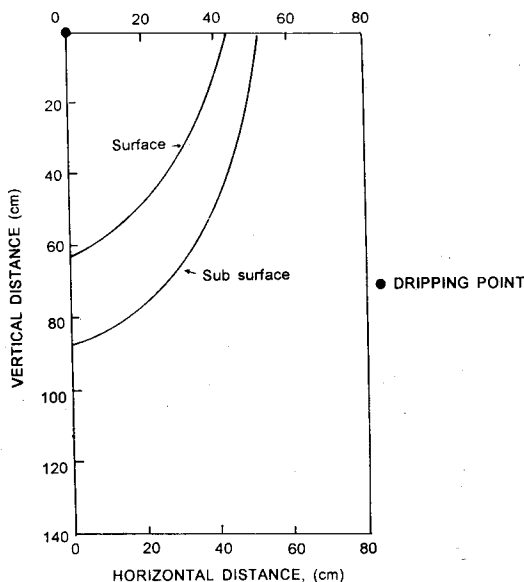


Fig. 2. Wetting fronts as a function of placement of emitters (after 7 days).

Table II. *Wetted volume of active root zone (wetted) in coconut palm basin as influenced by quantities of irrigation water*

Days after regular irrigation	I <sub>1</sub>		I <sub>2</sub>		I <sub>3</sub>	
	Wetted volume		Wetted volume		Wetted volume	
	Abso lute (m <sup>3</sup> )	% of active zone	Abso lute (m <sup>3</sup> )	% of active zone	Abso lute (m <sup>3</sup> )	% of active zone
1	0.32	3.1	0.64	6.3	1.34	13.1
3	-	-	-	-	2.22	21.9
4	1.11	11.0	1.25	12.3	-	-
5	-	-	-	-	2.91	28.6
7	1.37	13.5	1.39	13.7	-	-
15	1.70	16.7	1.89	18.6	-	-
30	1.91	19.1	2.19	21.5	-	-

\* Measurements were taken upto 5 days of regular irrigation

depth). It leads to the loss of water due to deep drainage, as the vertical front crossed 120 cm depth after 5 days of irrigation.

Interestingly, sub-surface placed emitter wetted 18.2 per cent of the active root zone which was about 35 per cent higher than the volume wetted under surface placed emitter (13.6%) (Table III).

*Soil moisture under different quantities and placement of irrigation water :*

The soil moisture content prior to the start of the experiment varied from 6.8 percent in 0-25 cm layer to 11.6 per cent in 75-100 cm soil depth (Table IV), indicating that except in lower layer, the moisture tension was less than 15 bars (10.5 per cent on undisturbed core basis).

Table III. *Wetted fronts and volume of active root zone (wetted) as influenced by placement of emitters*

	Wetted fronts		Wetted volume*	
	Vertical (cm)	Horizontal (cm)	Absolute (m <sup>3</sup> )	% of active root zone
Surface	64	44	1.382	13.6
Sub-surface	90	52	1.846	18.2

\* by four emitters

Table IV. *Soil moisture content (%) as influenced by surface versus sub-surface placement of emitters*

Soil depth (cm)	Horizontal distance from emitters (cm)						Initial soil moisture %
	Just below emitter		25		50		
	Sur-face	Sub-surface	Sur-face	Sub-surface	Sur-face	Sub-surface	
0 - 25	16.9	-	14.7	-	12.9	-	6.8
25 - 50	12.5	18.4	11.6	16.8	11.3	14.8	8.6
50 - 75	11.8	16.7	10.8	14.2	9.8	13.3	9.8
75 - 100	11.5	13.5	11.6	12.4	11.8	12.2	11.6

Table V. Soil moisture content (%) as influenced by quantities of water applied

Soil depth	Horizontal distance from emitters (cm)			
	0	25	50	65
<b>(a) <math>I_1</math> (33% of <math>E_0</math>), 30 days after irrigation</b>				
0 - 25	*	14.4	12.2	9.6
25 - 50	16.6	15.5	14.4	10.4
50 - 75	14.9	12.5	12.1	11.0
75 - 100	13.2	11.8	10.9	11.2
<b>(b) <math>I_2</math> (66% of <math>E_0</math>), 30 days after irrigation</b>				
0 - 25	*	16.3	14.4	12.1
25 - 50	20.6	18.8	16.3	10.8
50 - 75	18.5	16.4	15.2	11.2
75 - 100	16.3	14.5	12.2	12.0
<b>(c) <math>I_3</math> (100% of <math>E_0</math>), 5 days after irrigation</b>				
0 - 25	*	18.6	17.3	12.2
25 - 50	23.4	20.6	15.8	10.7
50 - 75	19.7	15.5	13.6	11.3
75 - 100	16.6	14.8	12.4	11.6

N.B. \* Emitters were placed below 25 cm.

The data presented in Table V (a), (b) and (c) for three quantities of water applied, indicated that soil moisture content was higher in different depths of soil as well as at different horizontal distances with increase in quantity of water application. With irrigation equal to 100 per cent of  $E_0$ , the moisture content even at a distance of 65 cm (lateral) from the emitter, was well above the moisture held at 15 bars. This shows that higher rate of water application maintained favourable soil moisture in larger area than lower rate of water application.

Placement of emitter below 25 cm soil surface maintained higher moisture below the emitters (Table IV), possibly due to the reduced evaporation rate from the sub-surface. Thus, for enhanced available water, it is essential to put emitters 25 cm below the soil surface.

The above studies indicated that the vertical and horizontal movement of water was

directly related to the quantity of water applied and the same was true for volume of root zone wetted in the coconut palm basin. Soil moisture content in various layers too was directly proportional to the rate of water application.

Sub-surface placement of emitters covered more volume of the basin and maintained higher moisture than the surface placed emitter.

Thus, the rate of water application may be decided depending upon the availability of water. Though, there is some deep percolation loss with irrigation equal to 100 percent of  $E_0$  (50 litres), the treatment maintained favourable soil moisture and covered larger volume of the active root zone of the coconut palm basin. This study highlights the discharge rate at which the water has to be applied and also the quantity of water to be applied to the laterite soil under coconut through drip irrigation.

## REFERENCES

- BRANDT, A., BRESLER, E., DINER, N., BEN-ASHER, I., HELLER, J and GOLDBERG, D. 1971. Infiltration from a trickle source. 1. Mathematical models. *Soil Sci. Soc. Am. Proc.* **35**(5) : 675-682.
- NELLIAT, E. V. and PADMAJA, P. K. 1978. Irrigation requirement of coconut and response to levels of fertilizer under irrigated condition during the early bearing stage. pp. 186-199. In: *Proc. PLACROSYMI* (Ed.-in-Chief E. V. Nelliat) Indian Society for Plantation Crops, Kasaragod, Kerala.
- VERMEIREN, L. and JOBLING, G. A. 1984. *Localized irrigation*. F. A. O., Rome, 18p.