

Water movement in the active root zone of arecanut under drip irrigation

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Abstract

Three dimensional movement of water from a point source within the root zone of arecanut in sandy loam soil was studied at four discharge rates of 2, 4, 6 and 8 litres per hour (LPH) by applying ten litres of water per dripper per day. The horizontal movement of water was greater at higher discharge rates of 6 and 8 LPH. The wetting front reached the root zone depth by the 24th day. The volume of wetted soil at that time was 0.143, 0.223, 0.288 and 0.285 m³ for 2, 4, 6 and 8 LPH discharge rates respectively. The studies indicated that about 18 percent of the active root zone of arecanut could be wetted by the application of 20 litres of water per palm per day through two dripping points at a discharge rate of 6 and 8 LPH.

Key words: Wetting front, Root zone, Drip irrigation, Soil moisture

Introduction

In order to achieve maximum water use efficiency, the objective of a good drip irrigation system would be to provide maximum wetted soil, for a given discharge within the root zone of the plant. This can be achieved by increasing the discharge rate of individual dripper, increasing the number of dripper and increasing the amount of water applied. Amount of water applied remains the same depending on crop water requirement. Increasing the number of dripping points would increase the installation cost. Selecting a suitable discharge rate would be the most appropriate method to achieve the objective of getting maximum wetted area. While selecting the discharge rate care should be taken to consider the infiltration rate of the soil. Discharge rate should be set in such a way that the soil should be able to infiltrate the applied water with out any surface ponding and runoff.

A point delivery system causes three dimensional infiltration pattern and the shape of the wetted region of soil depends mainly on capillary force and gravity. These patterns will be influenced by soil texture, horizontal and vertical permeability, capillary suction, presence or absence of impermeable layer, volume of water applied per irrigation, rate of application and initial moisture content of the soil. The effect of discharge rate and

intermittent water application by point source irrigation on soil moisture distribution pattern was studied by Levin *et al.* (1979). In fine textured soils such as clay and clay loam, where the capillary force is stronger and gravity can almost be neglected, lateral movement could be more than vertical penetration (Vermeiren and Jobling, 1984). In deep sandy soils, the capillary force is smaller and gravity has relatively more influence, resulting in greater vertical flow (Brandt *et al.*, 1971). By examining the wetting pattern from an emission point, the distance to which water moves laterally in a particular soil type can be measured. This will help to determine the spacing of emitters (Scott Landgraf, 1985).

Laterite and sandy loam are the important arecanut growing soils in the west coast of India. Earlier workers had studied the water movement under drip irrigation in the active rootzone of coconut in laterite (Dhanapal *et al.*, 1995) and littoral sandy (Maheswarappa *et al.*, 1997) and sandy loam (Mathew *et al.*, 1999) soils. In this article, the results of a field study on water movement and wetting front under four discharge rates from a single dripping point in the active root zone of arecanut are presented.

Materials and Methods

The study was conducted at Central Plantation Crops Research Institute, Regional Station, Vittal. The

soil characteristics of the experimental field are summarized in Table 1.

Table 1. Physical and chemical properties of soil

Details	Soil depth (cm)	
	0-30	30-60
Sand, %	50.80	48.40
Silt, %	14.6	14.20
Clay, %	34.60	37.40
Soil type-Sandy clay loam		
pH	5.24	5.16
Bulk density, g/cm ³	1.63	1.68
Water holding capacity, %	33.2	31.3
Permanent wilting point, %	9	9.4
Field capacity, %	18.1	20.0

Experimental set up

Water movement from a single dripping point was studied to determine the amount of soil wetted within the arecanut root zone. The study was conducted in an arecanut garden that was irrigated using drip irrigation during non rainy period of May 2000.

A P.V.C. tank of 1000 litres capacity was connected to a water source through a float valve to provide water at a constant pressure head of four m water column, which in turn ensured a uniform emitter discharge. Water from the tank was conveyed to the palms through 16 mm LLDP laterals. The arecanut palms were irrigated using two dripping points, micro tubes, connected to the lateral.

Four rows of arecanut palms, each row containing ten palms were selected for the study. Each row was irrigated from a separate lateral, which was directly connected to the water tank. Each lateral was provided with a half inch gate valve to control the discharge through the micro tubes.

Ten liters of water per dripping point was applied every day. This was equivalent to applying 20 liters of water per palm per day through two dripping points. The required amount of water was applied to palms of each

row at different rates of 2 LPH, 4 LPH 6 LPH and 8 LPH respectively. The emitters were manually adjusted daily before starting irrigation.

Drippers having 2,4,6 and 8 LPH were operated for 5 hr, 2 ½ hr, 1 hr 40 min and 1 hr 15 min respectively to keep the volume of water applied per dripper constant at 10 litres per day. Irrigation was given daily till the completion of the experiment.

For studying the water movement and the wetting front, the methodology adopted by earlier workers (Dhanapal *et al.*, 1995, Maheswarappa *et al.*, 1997 and Mathew *et al.*, 1999) was followed. This was done 24 hrs after irrigation on the 1st, 4th, 8th, 12th, 16th, 20th and 24th days. By 24th day the waterfront crossed the maximum root zone depth (1 m) and hence the study was terminated.

For determining the wetting front, topsoil was removed around the dripping point and the horizontal movement of water was measured. A rectangular trench of required size was made along the east west direction keeping the dripping point at one corner of the trench. Vertical movement of water from the point source and waterfront in the horizontal direction along north south was then marked on a transparent sheet.

The trench was then extended in the same direction keeping the dripping point at the middle of one side of the trench. This way the wetting front for a full diameter, along east west direction was obtained.

The study was repeated on another palm as a replication and mean values of horizontal and vertical movements were recorded. Volume of the wetted front was worked out from the tracings of the waterfront. Soil moisture content at different depths (0-25, 25-50, 50-75 and 75-100 cm) and horizontal distances (10, 20, 30, 40 and 50 cm away from the dripping point) was measured simultaneously by gravimetric method. A new trench was opened each time through out the experiment.

Table 2 Moisture distribution pattern of emitters operating at different discharge rates

Elapsed time, days	Emitter discharge rate, LPH											
	2			4			6			8		
	Width cm	Depth cm	Volume m ³	Width cm	Depth cm	Volume m ³	Width cm	Depth cm	Volume m ³	Width cm	Depth cm	Volume m ³
1	19	54	0.052	25	52	0.052	33	49	0.077	38	53	0.080
4	23	58	0.084	34	57	0.084	46	54	0.108	48	54	0.094
8	25	65	0.109	40	63	0.109	53	60	0.142	52	60	0.127
12	28	75	0.123	43	68	0.123	60	64	0.176	61	66	0.160
16	36	88	0.123	45	80	0.123	65	70	0.197	67	72	0.192
20	35	99	0.136	48	96	0.136	76	82	0.231	74	86	0.223
24	36	112	0.143	50	108	0.143	78	98	0.288	80	101	0.285

Results and Discussion

Movement of waterfront

Lateral and vertical movement of water as a result of application of ten litres of water per day per dripping

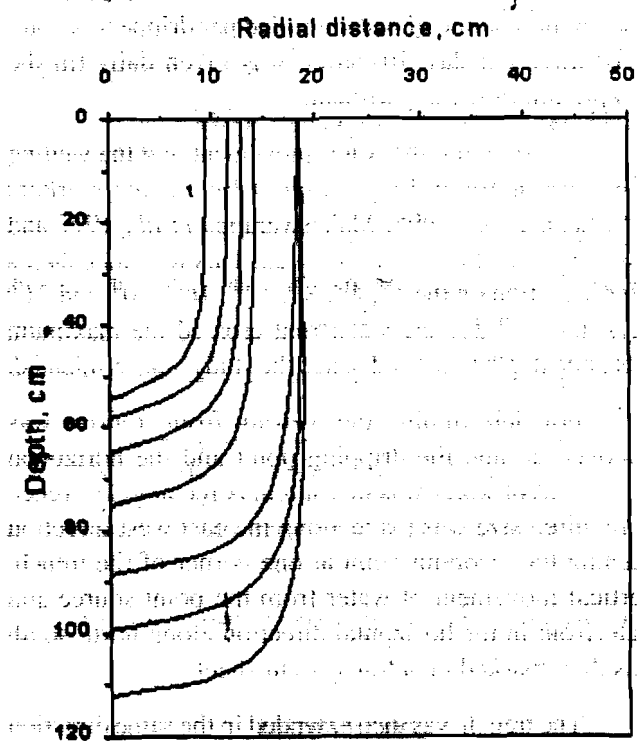


Fig. 1. Waterfront at 2 LPH

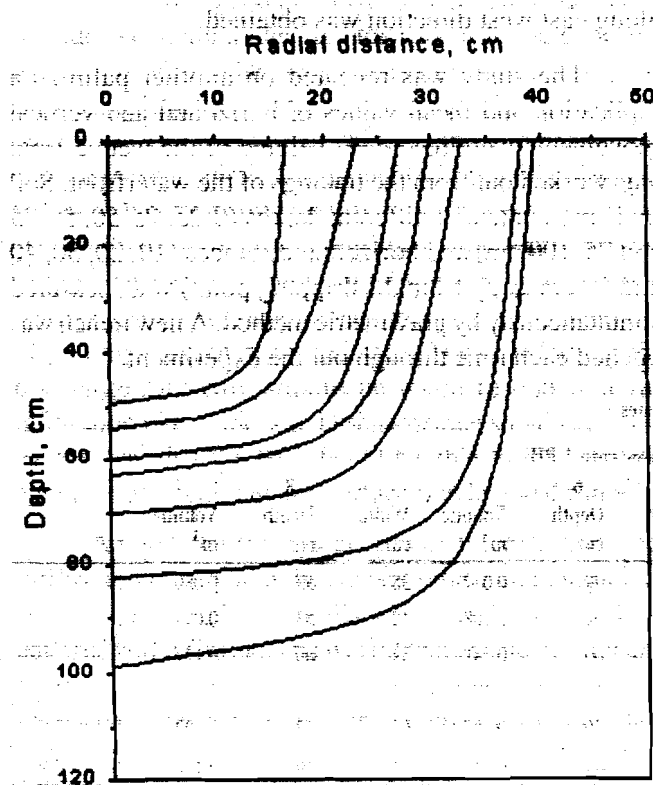


Fig. 3. Waterfront at 6 LPH

point @ 2 LPH, 4 LPH, 6 LPH and 8 LPH discharge rates recorded on different days during the study and are presented in Fig. 1, 2, 3 and 4, respectively. For all discharge rates the waterfront crossed the maximum root zone depth (1 m) by 24th day after starting the experiment.

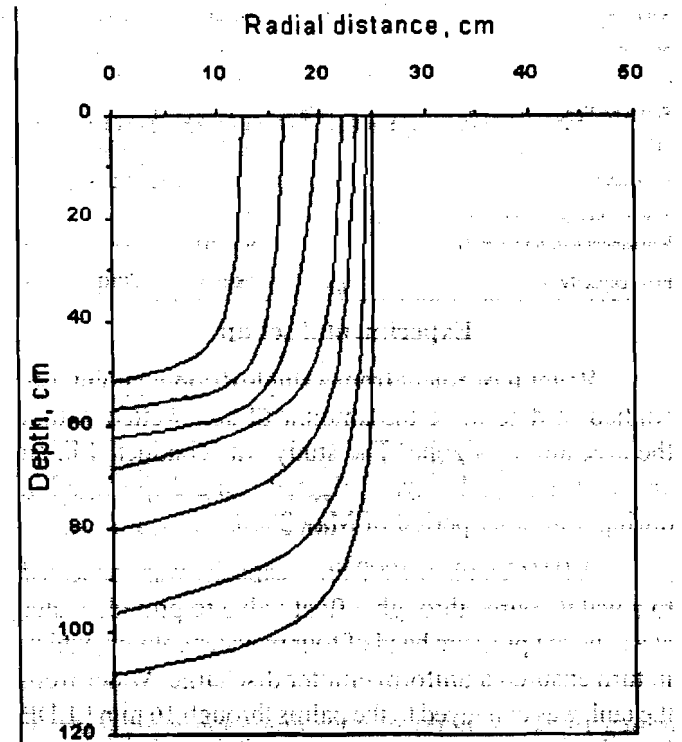


Fig. 2. Waterfront at 4 LPH

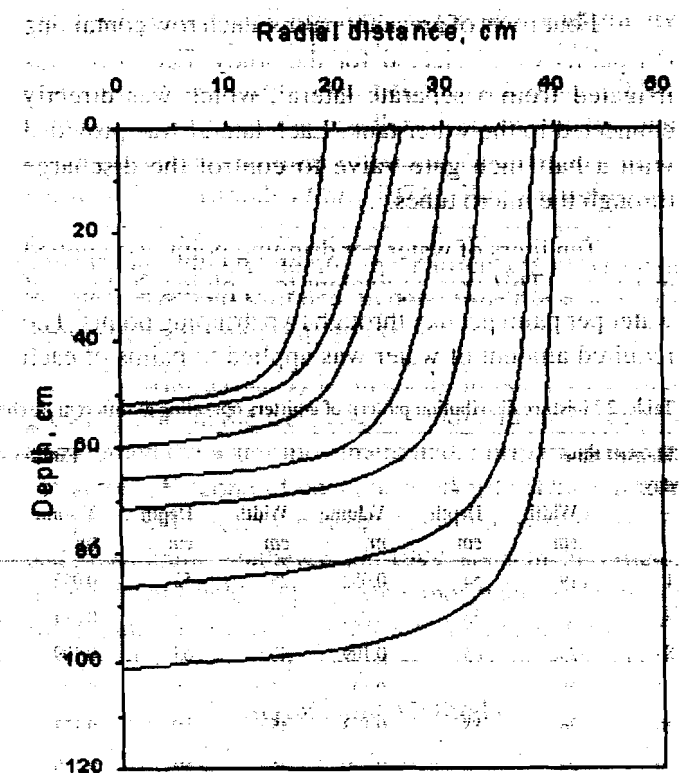


Fig. 4. Waterfront at 8 LPH

The horizontal movement of water front increased as the discharge rate increased even though the volume of water applied remains same. The data (Table. 2) also revealed that the lateral movement of wetting front was greater with 6 LPH and 8 LPH discharge rates compared to the lower discharge rates. The area of soil wetted from a point source is a function of the discharge rate and infiltration capacity of the soil. The higher discharge rate had therefore resulted in greater lateral movement of water and larger area wetted.

Percentage of wetted soil 'p' in the rootzone

The percentage of wetted soil 'p' was determined by dividing the wetted volume of the soil in the rootzone by the total volume of soil in the rootzone of the crop. The vertical and horizontal movement of water front decides the volume of the wetted soil. Only drip irrigation provides a complete control of water movement in a three dimensional space and helps to confine water within the active rootzone, while maximizing the percentage of root zone wetted. Volume of wetted soil and percentage of rootzone wetted for different discharge rates are given in Table 3.

Percentage of wetted soil was maximum for the dripping point having a discharge rate of 6 LPH and 8 LPH. However an increase in the discharge rate to 8 LPH did not increase the percentage of wetted soil over 6 LPH. Therefore it may be concluded that operating the drip irrigation system at a discharge rate of 6 LPH would be optimum for this soil. Soil moisture readings were taken at different depths and distances from the dripping point throughout the experiment. A three dimensional view of the soil moisture status around dripping points of 2 LPH, 4 LPH, 6 LPH and 8 LPH discharge rates on the 24th day is given in Fig.5, Fig.6, Fig.7 and Fig.8 respectively. It may be observed that as the discharge rate increased the wetting front also increased. Dhanapal *et al.*, (1995) reported that, at four litres per hour discharge rate, the wetted volume was larger compared to one, two and three litres per hour under laterite soil conditions in the active

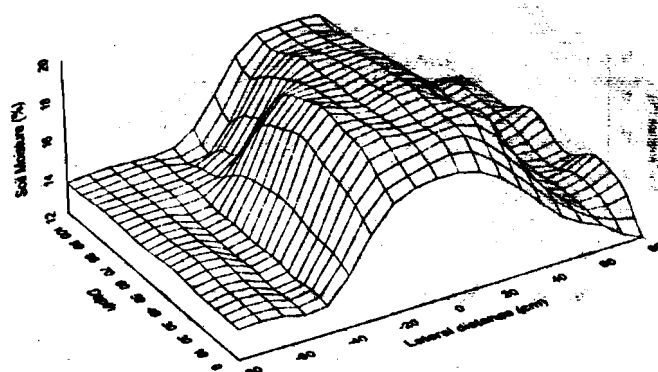


Fig. 5. Soil moisture (%w/w) status around dripping point on the 24th day at 2LPH discharge

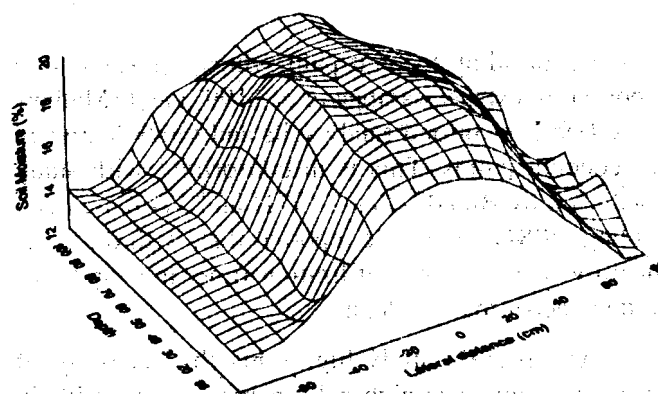


Fig. 6. Soil moisture (%w/w) status around dripping point on the 24th day at 4LPH discharge

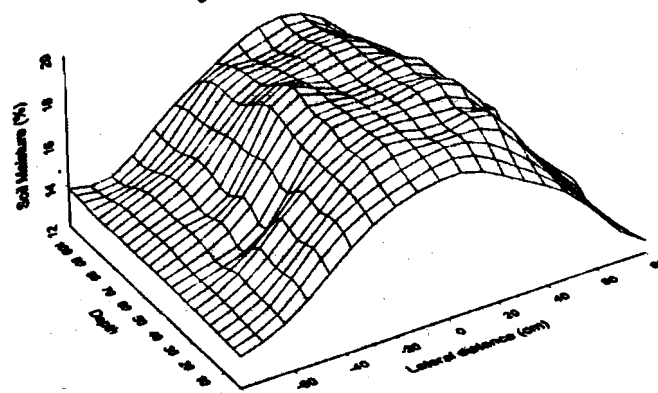


Fig. 7. Soil moisture (%w/w) status around dripping point on the 24th day at 6LPH discharge

Table 3. Volume of wetted soil and percentage of rootzone wetted for different discharge rates

Elapsed time (days)	Volume of wetted soil from a single dripping point (m ³)				% of root zone wetted from two dripping points			
	2 LPH	4 LPH	6 LPH	8 LPH	2 LPH	4 LPH	6 LPH	8 LPH
1	0.0525	0.0681	0.0766	0.0798	3.34	4.34	4.87	5.08
4	0.0840	0.0906	0.1076	0.0941	5.35	5.77	6.85	5.99
8	0.1088	0.1106	0.1416	0.1269	6.93	7.04	9.02	8.08
12	0.1232	0.1310	0.1759	0.1604	7.84	8.34	11.20	10.21
16	0.1226	0.1599	0.1968	0.1916	7.81	10.18	12.53	12.20
20	0.1363	0.1930	0.2314	0.2226	8.68	12.29	14.73	14.17
24	0.1432	0.2226	0.2883	0.2851	9.12	14.17	18.35	18.15

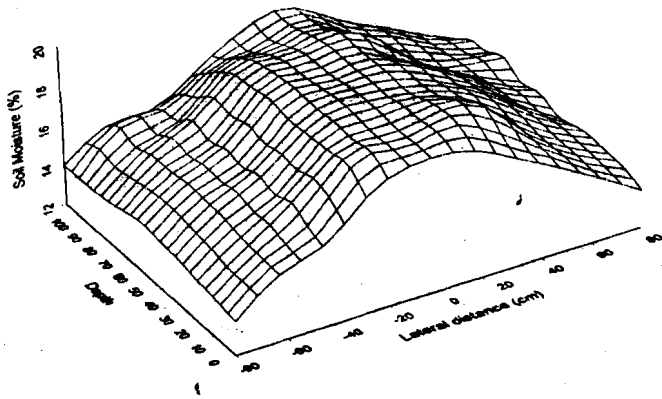


Fig. 8. Soil moisture (%w/w) status around dripping point on the 24th day at 8LPH discharge

rootzone of adult coconut palm. Similar results were reported by (Maheswarappa *et al.*, 1997) and (Mathew *et al.*, 1999) for littoral sandy soils and sandy loam soil for coconut palms. This is in conformity with study conducted by Brandt *et al.*, (1971) and Vermeiren and Jobling (1984), who have reported that, with the same quantity of water and infiltration time, the sand was wetted deeper than the loams.

The present study highlights the necessity of operating drippers at higher discharge rate of 6 LPH in order to get higher wetted soil with in the rootzone. This may also helps in reducing clogging of drippers

(Padmakumari and Sivanappan 1985). The study also revealed that providing two dripping points and operating the same even at a high discharge rate of 6 LPH or 8 LPH could wet only about 18 % of the active rootzone.

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