Journal of Plantation Crops 28 (2): 117-122, August 2000

ROOT DISTRIBUTION AS INFLUENCED BY DIFFERENT METHODS OF IRRIGATION IN YOUNG ARECANUT (*ARECA CATECHU* L.) PALMS*

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(Manuscript received: 26-10-98; revised: 2-3-99; accepted: 1-6-2000)

ABSTRACT

A two year study (1997 and 1998) on root distribution pattern in young arecanut palms as influenced by different methods of irrigation indicated that highest root dry weight and root/shoot ratio were observed in ferti-drip method with two fold increase in number of feeder roots over drip method and more than four fold increase in number of feeder roots over basin method. Higher concentration of root dry mass was observed within 40 cm radius from the bole in ferti-drip (79%), drip (76%) and basin (82%) irrigation methods with lower proportion of root mass in subsequent layers. This suggests that all methods of irrigation have resulted in shallow root development. It was observed that horizontal spread of roots was influenced by nutrient and moisture availability pattern. Horizontal root spread was more in case of ferti-drip (75 cm) and drip methods (71 cm) than in basin method. Vertical spread of the root system was more or less same with all methods of irrigation (43-58 cm). There was a shift in the rooting pattern of arecanut palms with different methods of irrigation. Root mass per unit area was higher along dripping point plane than between dripping points both in case of ferti-drip and drip irrigation.

Key words: Ferti-drip irrigation, basin irrigation, feeder roots

INTRODUCTION

Knowledge of root distribution is essential in explaining the crop response to irrigation and in managing the irrigation system. This aspect assumes significance with drip irrigation as it is believed that drip irrigation may limit the volume of wetted soil and thus the root system development. Knowledge of root growth pattern is also necessary for formulating a rational method of fertilizer application. Although, some information on root distribution of arecanut (Bavappa and Murthy, 1961 and Bhat and Leela, 1969) was available, no studies were done with regard to the effect of irrigation on root system development. Hence, this study was conducted to obtain information on root spread and development under ferti-drip, drip and basin irrigation methods so that it would be useful in irrigation and fertilizer management.

MATERIALS AND METHODS

A long term experiment on ferti-drip irrigation at Central Plantation Crops Research Institute, Regional Station, Vittal was initiated in 1996 in a 2-yr old arecanut garden planted with cv. Mohitnagar at a spacing of 2.7 m x 2.7 m. The present study, which was a part of long term experiment, was carried out for two years in April, 1997 and 1998. The experimental soil is a sandy clay loam

* *CPCRI Contribution No. 1013*

with acidic pH (5.6) and high organic carbon status (2%).

Drip irrigation was given from November to May every year through three microtubes of 8 l/hr discharge rate. The microtubes were placed at 10 cm depth and 40 cm away from the base of the palm. Around 12-16 litres of water per palm, which was equivalent to 100% ET at that particular period, was given daily to both drip and fertigated palms. In case of ferti-drip method, fertilizers (Urea, DAP and Potassium chloride) were injected into the drip system through a ventury at 10 days internal. The recommended fertilizer dose of 100 g N: 40g P_2O_5 : 140 g K_2O per palm was fertigated in 21 splits throughout the post-monsoon season. Fertilizers were not applied to drip irrigated palms to observe the effect of irrigation alone. In case of basin irrigated palms, a fertiliser dose of 100g N:40g P_2O_5:140g K_2O per palm per year was applied in two splits (1/3rd in June and 2/3rd in October). Irrigation was given once in 6-7 days during November to February and once in 4-5 days during March to May @ 175-200 l/palm (IW/CPE ratio of one) for basin irrigated treatments.

In each system, two palms each in 1997 and 1998 were selected and excavated for root studies. In this technique, a trench of 90 cm width and 60 cm depth was cut. Every time, the soil mass of 30 cm width from the trench towards the base of the palm was washed down into the trench by gentle spraying of water, exposing the roots. Maximum horizontal and vertical length of roots was measured with palm intact in the trench. Exposed roots were cut and collected separately for different distances and depths. The same procedure was adopted by Mathavan *et al.*, (1984) in Tea and clove mixed system. Bohm (1979) and Vepraskas and Hoyt (1988) also stated that trench profile method is an accurate and faster method for root study.

Number of active main roots and feeder roots of less than 1 mm size were counted immediately after excavation. Root samples were thoroughly washed and dried in the oven. Dry weight of roots and shoots was recorded. Soil moisture samples were collected 24 hours after irrigation in case of drip and fertigated palms and 48 hours after irrigation in case of basin irrigation palms before root excavation process. Soil moisture per cent was estimated by gravimetric method. Soil moisture was same both in ferti-drip and drip methods because of same discharge rate and hence represented in the same bar in Fig. 4.

RESULTS AND DISCUSSION

Main roots and feeder roots

More number of main roots, arising from the bole with ferti-drip and drip methods than with basin method both in 1997 and 1998 (Table 1). There was two fold increase in the number of feeder roots with ferti-drip method over drip method and more than four fold increase over basin method in 1998. This can be attributed to direct and efficient supply of nutrients, especially phosphorus, to the root system throughout the post-monsoon period in ferti-drip method. Application of phosphorus to a small surface area through drip increases the phosphorus concentration in soil preferably more than the P fixing capacity of the soil and enhances root development (Drew *et al.*, 1973; Bar-Tal *et al.*, 1990). While, Bar-Yosef *et al.*, (1989) stated that

Table 1. ***Effect of irrigation methods on number of main roots and feeder roots***

Irrigation methods	No. of main roots		No. of feeder roots							
	1997	1998	1997			1998				
			Horizontal	Vertical	Total	Horizontal (cm)		Vertical (cm)		Total
						0-40	40-80	0-40	40-80	
Ferti-drip	22	35	659	310	969	840	982	1071	299	3163
Drip	26	30	323	155	478	453	358	630	256	1697
Basin	17	20	98	327	425	118	-	763	523	1404

ferti-drip irrigation results in temporary high P concentration in the soil solution and enhances root growth. Similarly the number of feeder roots were higher in drip irrigated palms than in basin irrigated palms. This might be due to maintenance of optimum soil moisture regime constantly throughout post-monsoon season.

Mean root length

Data presented in Table-2, showed that there was not much difference between ferti-drip method and drip method with regard to mean horizontal and vertical root length. In contrast, horizontal length (20-21 cm) was comparatively very less in basin irrigated palms in both years. This might be due to minimal leaching losses of water and nutrients, favourable soil moisture conditions and control of nutrient concentration and movement in soil solution in drip and ferti-drip treatment. In case of basin irrigated palms, split application of fertilizers would have subjected to leaching losses due to poor retention capacity and low CEC of the soils of this particular site besides P adsorption. Thus, the main difference in root spread between different irrigation methods was associated with moisture availability and nutrient movement (Fig. 4). The soil water regime has been identified as a major factor affecting root distribution in sorghum (Garden, 1964). Hamblin *et al.*, (1990) also reported that the root growth was strongly influenced by moisture, nutrient availability and soil type.

Table 2. ***Maximum mean root length as affected by irrigation methods***

Irrigation methods	Horizontal (cm)		Vertical (cm)	
	1997	1998	1997	1998
Ferti-drip	45	75	41	45
Drip	41	71	40	43
Basin	20	21	42	58

Root dry weight at different distances and depths

Data presented in Table-3 revealed that spread of roots was more or less uniform all along the horizontal plane up to 80 cm distance both in ferti-drip and drip method. With regard to root dry weight, ferti drip, drip and basin methods have recorded 79, 76 and 82 per cent of the total root dry weight, respectively with in 40 cm radius from the bole. In earlier studies, in a eight year old arecanut palm, 61-67 per cent of all roots were found concentrated within 50 cm radius (Bhat add Leela, 1969). Bavappa and Murthy (1961) also reported maximum root concentration in first two or three feet depth in adult arecanut palms.

Root mass per unit area along and between dripping points

With regard to root mass per unit area (Fig. 1), ferti-drip irrigation has

Table 3. ***Dry weight of fine roots(g) at different depths and distances under different systems of irrigation***

Irrigation methods	1997			1998				
	Horizontal (cm)	Vertical (cm)	% of fine root wt to total wt	Horizontal (cm)		Vertical (cm)		% of fine root wt to total wt
	0-45	0-45		0-40	40-80	0-40	40-80	
Ferti-drip	12.9 (22.9)	6.1 (22.1)	42.0	15.1 (32.8)	20.2 (36.9)	33.8 (156.8)	4.0 (13.1)	30.5
Drip	8.8 (16.0)	5.0 (18.6)	40.0	11.2 (20.1)	8.5 (15.1)	12.4 (92.9)	8.7 (20.9)	27.0
Basin	0.6 (2.6)	4.1 (15.4)	26.0	1.8 (7.5)	-	16.5 (101.8)	12.5 (23.9)	23.0

Figures in parenthesis indicate total root dry weight in grams

resulted in more root mass per unit area at different distances both along dripping point plane (0.006 g/cm^2 - 0.08 g/cm^2) and between dripping points (0.004 g/cm^2 - 0.043 g/cm^2) than drip irrigation.However, the root mass concentration per unit area was considerably higher along dripping point plane than between dripping points in ferti-drip and drip irrigation methods indicating the need to shift dripping points every year to avoid root concentration.

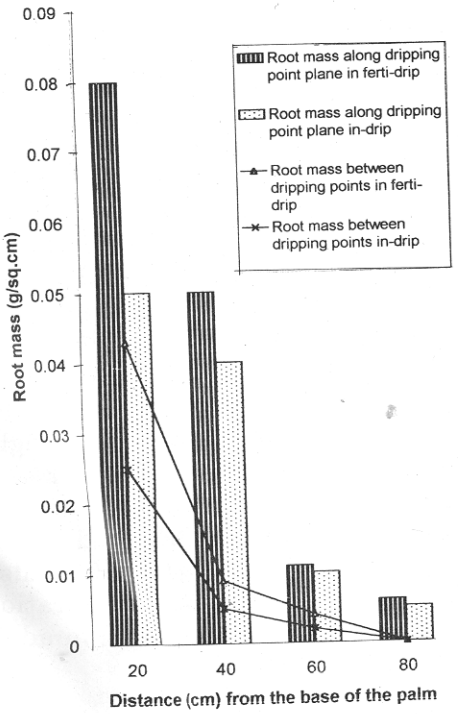

Fig. 1. Root mass per unit area at different distances as influenced by ferti-drip and drip in 1998.

Root growth particularly the development of a network of fine roots is important as it would result in more absorbing surface for water and nutrients. A more pronounced increase in feeder root mass to total root weight was observed with ferti-drip and drip methods over basin method both in 1997 and 1998. Dry weight of feeder roots amounted to 42%, 40% and 26% of toal root dry weight with ferti-drip, drip and basin methods, respectively in 1997. It followed the same trend in 1998. Feeder root mass concentration along the horizontal distance was 29% and 24% of total weight to roots with ferti-drip and drip, respectively. Whereas, it was only 5.6% in basin method. From Fig 2. and Fig. 3, it could be noticed that finer roots

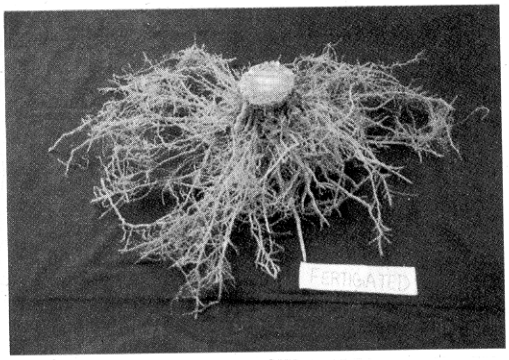

Fig. 2. Root distribution pattern as influenced by ferti-drip irrigation in three year old arecanut palm.

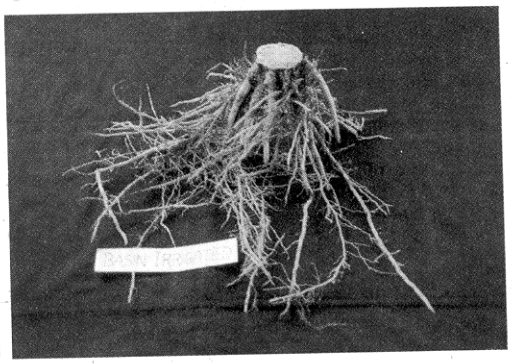

Fig. 3. Root distribution pattern as influenced by basin irrigation in three year old arecanut palm.

were more in ferti-drip irrigated palm than in basin irrigated palm.

Total root dry weight and root/shoot ratio

In 1997, dry weight of roots was higher with ferti-drip method (45 g) than with drip method (34.6 g) and basin method (18 g). In 1998 also, there was considerable increase in root dry weight (60-79%) with ferti-drip irrigation over other methods (Table 4). Root/shoot ratio followed the same trend as that of total root dry weight. Dry weight of roots and root/shoot ratio were higher with drip method, which was maintained as absolute fertiliser control, than with basin method in both years. The higher root/shoot ratio with drip method suggests that in arecanut this ratio is more influenced by frequency of irrigation than by the fertilizer nutrients. Klepper (1991) stated that water content and soil strength are the most critical factors for root growth under irrigation.

Moisture data (Fig. 4) and root distribution pattern indicated that the horizontal root distribution was strongly affected by wetting pattern of the irrigation system. In case of ferti-drip and drip methods, the moisture availability along the horizontal plane up to 90 cm distance and up to 60 cm depth (23-26%) was higher than field capacity level (18-22%) in arecanut basin. Favourable soil moisture levels and uniform water distribution region in ferti-drip and drip methods coincided with maximum number of root mass. Greater horizontal root length and uniform spread of fine roots along lateral plane were observed in drip and ferti-drip methods. In case of basin

Table 4. ***Total dry weight of roots and root/shoot ratio under ferti-drip, drip and basin irrigation methods in arecanut basins.***

Irrigation methods	Total dry wt (g)		Root/shoot ratio	
	1997	1998	1997	1998
Ferti-drip	45.0	239.6	0.40	0.34
Drip	34.6	149.4	0.37	0.31
Basin	18.0	133.2	0.36	0.25

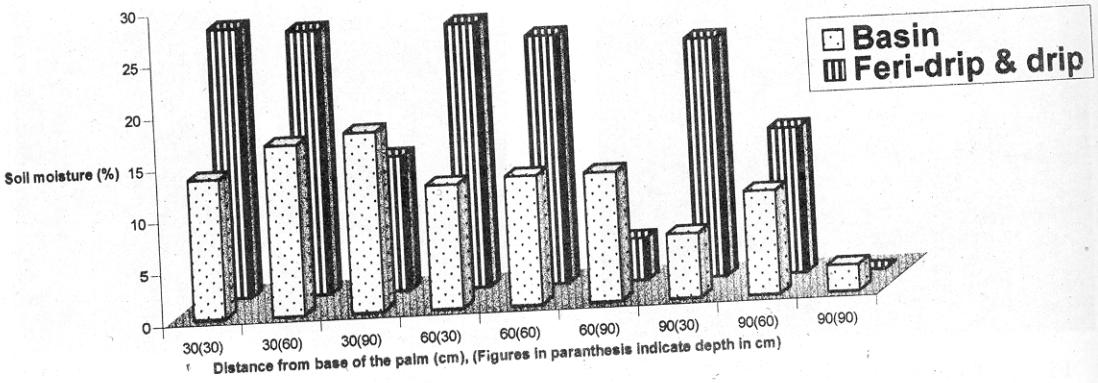

Fig. 4. Soil moisture (%) in arecanut basin at different distances and depths in 1998.

method, the soil moisture up to 30 cm depth in the root zone was never saturated and the surface soil layer dried faster *i.e.,* with in 48 hrs after irrigation. The infiltration rate and FC level in arecanut basin in laterite soils for this particular site were estimated as 5.36-16.2 cm/hr and 18-22 per cent. respectively (Veerappadevaru, 1990). The faster moisture depletion in basin method can be ascribed to surface evaporation losses, faster infiltration rate and less water holding capacity of these soils resulting in less irrigation efficiency and consequently, affecting the root distribution. This also suggests that the maintenance of favourable soil moisture conditions throughout the post-monsoonseasonwouldbebeneficial for better root spread and growth. The results of the present study indicated that there was a shift in rooting pattern of arecanut with different methods of irrigation.

REFERENCES

BAR-TAL, A., BAR-YOSEF, B. and KAFKAFI, V. 1990. *Agron. J.* **82**: 600-603.

BAR-YOSEF, B., SAGIV, B. and MARKOVITCH, T. 1989. *Agron. J.* **81**:443.

BAVAPPA, K.V.A. and MURTHY, K.N. 1961. *Arecanut J.* **12**: 65-71.

BHAT, K.S. and LEELA, M. 1969. *Trop. Agric.* **46**(1): 55-61.

BOHM, M.C., SAKAR, L.R. and ASHLEY, T.W. 1973. *J. Exp. Bot.* **24:** 1189.

GARDNER, W.R. 1964. *Agron. J.* **56**: 41-45.

HAMBLIN, A., TENNAT, D and PERRY, M.W. 1990. *Plant Soil* **122**:47-58.

KLEPPER, B. 1991. *Irrigation Sci.* **12**: 105-108.

MATHAVAN, R., BAVAPPA, K. V. A. and GUNASENA, H. P. M. 1984. *J. Plantn Crops* **12**(2) : 169-177.

VEERAPPADEVARU, G. 1990. *Drip irrigation studies in mixed cropping system of arecanut and cocoa.* M. Tech. Thesis submitted to KREC, Suratkal, Karnataka.

VEPRASKAS, M.J. and HOYT, G.D. 1988. *Agron. J.* **80**(2) : 166-172.