Effect of Irrigation on Establishment and Early Growth of Coconut (VAR.CRIC 60) in the Dry Zone of Sri Lanka.

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ABSTRACT

The vigour and growth of seedlings of CRIC60 cultivar of coconut were studied in different irrigation treatments during the drought period, in a sandy soil in the dry zone. Nine irrigation treatments including a control with no watering were tested. Larger number of casualties were observed in the control while none in the irrigated plots. The best irrigation treatments in order of response were 40 litres applied twice a week, two earthenware pots buried on either side of the seedlings and filling them twice a week (27 litres per week) and 20 litres applied twice a week. However, the relative efficiency between 40 litres and 20 litres suggest that application of 20 litres twice a week could be preferred considering the savings on cost and the use of water. If finances are not limiting burying of two earthenware pots on either side of the plant and filling twice a week could be preferred.

INTRODUCTION

The coconut palm requires adequate and continuous supply of soil moisture for its proper growth and productivity. Soil moisture very often is the limiting factor in growth in areas subjected to long dry spells or where rainfall is low and poorly distributed. In the dry zone of Sri Lanka, March to September is the dry period. Inadequate soil moisture in these areas is the major constraint in the establishment of seedlings. Thus in the absence of rain, the newly transplanted seedlings need water regularly, until they are established. Further, it is necessary to continue irrigation during the dry months for the first two or three years, depending on the environmental conditions (Menon and Pandalai, 1958).

In the absence of irrigation, the newly planted seedlings are subjected to severe moisture stress during dry months resulting in a setback in growth and a high field mortality in the dry zone. Thus it became necessary to study the requirement of water and frequency of application when the seedlings are planted in a dry zone. A field experiment was conducted in the Eastern Province of Sri Lanka to study the establishment and early growth of coconut seedlings under different irrigation treatments.

Data available on the amount of water required by coconut seedlings during dry months are limited. Therefore the irrigation treatments identified here were based on observations of Copeland (1921) and Nelliatt (1968). On an argumentative extension of the work of Copeland, Nelliatt suggested application of 11.25 l of water per day to young palms. The treatments in this study are based on this work.

MATERIALS AND METHODS

1. Experimental area:

This study was conducted in the dry zone at the Research and Demonstration Farm of the Coconut Research Institute at Kalkudah in the Eastern Province of Sri Lanka. The site of the experiment was about 50 m from the sea coast.

Great soil group prevailing in the area is Regosols. Texture is sandy and the mechanical composition is 93.5%, sand, 2.0%, silt and 4.5% clay. The soil has a loose consistence and a very rapid infiltration and drainage.

2. Climate:

The mean monthly meteorological data for the station during the trial period are given in Tables 1 to 3.

Table 1. *Mean monthly rainfall (mm)*

<i>Month</i>	<i>1981</i>	<i>1982</i>	<i>1983</i>	<i>1984</i>
Jan	227.1	9.5	37.8	372.9
Feb	83.2	0.0	0.0	629.1
Mar	17.4	37.5	0.0	91.8
Apr	64.0	28.3	15.1	193.3
May	96.9	23.7	19.3	0.0
June	3.6	0.0	92.9	0.0
July	96.6	2.9	38.6	156.8
Aug	9.1	0.0	19.3	58.0
Sep	166.7	23.9	42.5	127.8
Oct	217.1	135.6	58.4	42.6
Nov	300.3	493.4	137.4	557.7
Dec	244.9	438.4	543.9	162.8
TOTAL	1526.9	1193.2	1005.2	2492.8

Table 2. *Mean Sunshine hours (h)*

<i>Month</i>	<i>1981</i>	<i>1982</i>	<i>1983</i>	<i>1984</i>
Jan	8.3	8.5	7.8	4.2
Feb	8.8	10.1	10.1	4.1
Mar	9.5	8.6	9.6	8.4
Apr	8.7	8.9	9.4	7.1
May	8.2	7.9	9.4	9.2
June	8.0	7.0	8.6	8.3
July	6.8	8.1	8.3	7.2
Aug	8.9	7.5	7.4	8.7
Sep	6.6	7.4	7.1	7.9
Oct	7.0	6.3	7.3	7.7
Nov	6.5	5.2	6.8	4.7
Dec	6.9	4.8	5.3	6.8

Table 3. Mean maximum and minimum temperature (°C)

<i>Month</i>	<i>1981</i>		<i>1982</i>		<i>1983</i>		<i>1984</i>	
	<i>Max</i>	<i>Min</i>	<i>Max</i>	<i>Min</i>	<i>Max</i>	<i>Min</i>	<i>Max</i>	<i>Min</i>
Jan	27.8	22.9	28.0	22.9	28.4	22.8	27.8	23.6
Feb	28.6	23.4	28.8	21.9	29.8	22.3	28.0	23.8
Mar	30.5	25.7	30.2	23.6	31.1	23.5	29.9	24.1
Apr	31.7	25.6	32.2	25.2	32.4	24.9	31.2	25.0
May	33.5	26.1	32.7	25.0	33.4	25.6	32.5	26.1
June	34.5	25.4	34.1	25.1	33.7	25.3	34.6	25.5
July	32.5	24.6	33.7	24.8	33.7	25.2	32.1	24.5
Aug	34.3	24.7	33.8	24.9	32.7	25.0	32.9	25.0
Sep	31.6	24.2	33.4	24.3	32.3	24.2	31.0	24.2
Oct	31.2	24.0	30.7	23.5	29.5	23.8	28.2	23.8
Nov	29.8	23.4	28.9	23.2	29.5	23.4	28.2	23.8
Dec	28.4	22.7	28.2	23.3	28.5	23.8	28.2	23.4

3. Planting:

Nine-month old coconut seedlings (Var.CRIC 60) were used as the planting material. Five hundred and seventy six seedlings were planted on 27 October, 1982, in pits of size 0.75 M³, filled with two layers of husk, mixture of top soil and three baskets of cowdung, and spaced at 7.2 x 7.2m (24'x24'). A randomized block design with three replicates for each treatment was used. Each plot consisted of 12 plants.

4.Irrigation:

The following nine treatments were used,

T₁ – Control, no irrigation.

T₂ – Two earthenware pots buried on either side of the seedlings. Pots were filled twice a week.

T₃ – 20 litres applied once a week.

T₄ – 20 litres applied twice a week.

T₅ – 20 litres applied once in two weeks.

T₆ – 40 litres applied once a week.

T₇ – 40 litres applied twice a week.

T₈ – 40 litres applied once in two weeks.

T₉ – 60 litres applied once in two weeks.

In treatment 2, two earthenware pots of capacity 7.5 l. and made of clay-sand mixture were buried on either side of the seedling at a distance of 30 cm from the seedling. The quantity of water used per week was about 27 l.

The experiment was conducted for a period of 30 months from 27 October, 1982. Watering was done during the dry periods, March to September. The water was applied around the seedling at a radius of 1m from the bole of the seedling.

5. Parameters:

Growth characters, viz. the number of leaves, height of the seedling, girth at the collar, width of the crown, were recorded at six-monthly intervals. The total leaf area of the third leaf was measured at the end of the 30th month as this leaf could be used as a representative leaf to determine the growth Satheesan *et al* (1983) and Mathes *et al*. (1989). The vigour of the palm, patterned after Child (1974), was estimated using

$$V = \frac{C^2}{2\pi \sqrt{H^2 + \frac{L^2}{4}}}$$

Where C is circumference at the base, H is height of the seedling and L is width of the crown.

Height of the palm was measured from the ground level to the tip of the highest leaf when collected together. Width of the crown is defined as the furthest distance between the tip of two leaves in normal position.

RESULTS

Data on growth characters were subjected to analysis of variance.

1. Influence of irrigation on height:

The results and the analysis are given in Table 4.

Table 4. *Effect of irrigation on plant height*

Treatment	Height (cm)					% increase over the control at 30th month
	6	12	18	24	30	
T ₁ Control	127.5	135.1	138.7	165.1	241.8	
T ₂ Two pots either side	122.9	141.7	212.8	252.0	386.6	59.9
T ₃ 20 l once a week	123.9	137.2	175.5	206.2	293.1	21.2
T ₄ 20 l twice a week	122.2	136.6	209.3	230.4	343.4	42.0
T ₅ 20 l once in two weeks	123.9	132.1	145.5	174.5	261.8	8.3
T ₆ 40 l once a week	123.1	133.3	176.3	212.8	320.5	32.6
T ₇ 40 l twice a week	115.6	146.3	236.5	270.2	398.2	64.7
T ₈ 40 l once in two weeks	122.7	131.3	166.4	216.4	320.0	32.3
T ₉ 60 l once in two weeks	120.9	136.3	166.6	214.4	295.9	22.4
C V in %	5.5	5.8	12.4	16.1	14.2	
Significance	NS	NS	***	*	***	
C D (p - 0.05)	-	-	15.2	23.7	30.7	
S.E. of mean	3.9	4.6	12.9	20.1	26.0	

* p < 0.05 *** p < 0.001

The analysis of variance showed no significant response to irrigation during the first year of planting as seen from the results at six and 12 months after planting. Some height increase was observed during the second 6 monthly period, though there

was no significant difference between the treatments. However the response to irrigation was considerably high, thereafter. The analysis of variance for heights at 18, 24 and 30th month showed significant response between the treatments. The increase in height at 18 months for the treatments T₂, T₄ and T₇ outweighed the increase observed in the rest of the treatments and this difference was maintained throughout.

At the end of the 30th month, the treatments T₂, T₄ and T₇ showed height increase of 60%, 42% and 65% over the control, respectively. The lowest height gain was observed in treatment T₅.

2. Influence of irrigation on girth:

Significant difference in girth of seedlings was observed at 12 month with the control showing the least girth. The response to treatments T₂, T₄ and T₇ was marked, and the pattern was similar to the one observed in the increase in height. At the end of 30th month % increase observed in these treatments over the control was 76.6, 60.9 and 97.9 respectively. The lowest girth recorded was for the treatment T₅ which was only 7.3% over the control.

Table 5. *Effect of irrigation on girth at collar*

Treatment	Girth (cm)					% increase over the control at 30th month
	6	12	18	24	30	
T ₁ Control	13.5	16.0	20.1	27.4	48.8	
T ₂ Two pots either side	14.0	22.3	34.8	49.0	86.1	76.6
T ₃ 20 l once a week	14.2	18.8	26.2	36.6	65.5	34.4
T ₄ 20 l twice a week	12.9	20.6	31.0	43.2	78.5	60.9
T ₅ 20 l once in two weeks	12.9	17.0	22.1	27.7	52.3	7.3
T ₆ 40 l once a week	14.0	19.6	27.4	36.3	71.6	46.9
T ₇ 40 l twice a week	12.9	22.3	39.4	54.6	96.5	97.9
T ₈ 40 l once in two weeks	13.7	18.8	25.9	35.8	74.2	52.1
T ₉ 60 l once in two weeks	14.7	19.8	26.2	36.8	66.5	36.5
C V in %	7.1	9.6	11.9	19.6	9.0	
Significance	NS	**	***	**	***	
C D (p = 0.05)	—	1.3	2.3	5.2	4.4	
S.E. of mean	0.6	1.1	1.9	4.4	3.7	

** p < 0.01

*** p < 0.001

3. Influence of irrigation on leaf production.

The mean number of leaves in the different treatments is given in Table 6. As for the height no significant response was indicated between the treatments during the first year after planting. However, a rapid increase in the number of leaves per plant in some treatments was observed thereafter. As in the earlier parameters, the treatments T₂, T₄ and T₇ showed marked increases in leaf production, as in the case of girth and height. The % increase over the control for these three treatments were 71.9, 54.7, 78.1 respectively.

Table 6. *Effect of irrigation on leaf production*

Treatment	No. of leaves Months after planting					% increase over the control at 30th month
	6	12	18	24	30	
T ₁ Control	5.1	5.2	5.9	6.0	6.4	
T ₂ Two pots either side	5.0	6.9	7.5	8.9	11.0	71.9
T ₃ 20 l once a week	5.0	6.1	6.6	7.1	8.6	34.4
T ₄ 20 l twice a week	4.9	6.6	7.1	8.0	9.9	54.7
T ₅ 20 l once in two weeks	4.6	5.9	6.1	6.4	7.5	17.2
T ₆ 40 l once a week	5.0	6.4	6.5	7.3	8.8	37.5
T ₇ 40 l twice a week	4.7	7.2	8.4	9.3	11.4	78.1
T ₈ 40 l once in two weeks	4.9	6.3	6.4	7.1	8.9	39.1
T ₉ 60 l once in two weeks	5.1	6.2	6.4	7.5	9.1	42.2
C V in %	7.65	10.1	4.9	10.9	12.2	
Significance	NS	NS	***	***	***	
C D (p = 0.05)	—	—	0.6	1.4	1.9	
S.E. of mean	0.2	0.4	0.2	0.5	0.6	

*** p < 0.001

4. Influence of irrigation on crown size.

The mean crown size for different irrigation treatments are given in Table 7. Variance analysis showed significant response to the treatments from the 18th month onwards. Treatment T₇ gave the highest crown width upto the 30th month while T₂ and T₄ gave the second and third highest crown widths.

At 30th month the % increase over the control for the treatments T₂, T₄ and T₇ were 84.3, 63.7 and 104.8 respectively. T₅ showed the lowest increase of 15.0 %

Table 7. *Effect of irrigation on crown size*

Treatment	Width of crown(cm) Months after planting					% increase over the control at 30th month
	6	12	18	24	30	
T ₁ Control	90.9	106.4	112.8	152.1	199.6	
T ₂ Two pots either side	91.9	123.2	208.0	290.8	368.0	84.3
T ₃ 20 l once a week	94.7	118.9	153.9	208.8	265.6	33.1
T ₄ 20 l twice a week	86.9	122.7	190.0	240.5	326.9	63.7
T ₅ 20 l once in two weeks	89.7	113.8	129.8	180.3	229.6	15.0
T ₆ 40 l once a week	97.3	116.8	157.5	220.5	282.9	41.7
T ₇ 40 l twice a week	83.0	122.1	220.5	319.3	408.9	104.8
T ₈ 40 l once in two weeks	90.2	112.0	151.6	207.5	234.4	17.4
T ₉ 60 l once in two weeks	95.2	118.6	155.4	216.7	256.5	28.5
C V in %	9.1	5.6	12.2	15.4	13.0	
Significance	NS	NS	***	***	***	
C D (p = 0.05)	—	—	13.7	23.8	25.3	
S.E. of mean	4.8	3.8	11.6	20.2	21.4	

*** p < 0.001

5. Influence of irrigation on the vigour of the palm.

As described elsewhere the vigour of the palm was evaluated using the function

$$V = \frac{C^2}{2\pi\sqrt{H^2 + \frac{L^2}{4}}}$$

The vigour thus evaluated was weighted so as to yield a value of 100 for the control and rest of the values for the other treatments adjusted accordingly.

The average values obtained for the respective treatments are shown in Table 8.

Vigorous growth was observed in all treatments, from 12th month onwards. Most vigorous growth was observed in T₇, followed by T₂ and T₄. The lowest response was seen in T₅.

Table 8. Effect of irrigation on the vigour of palm

Treatment	Months after planting					% increase over the control at 30th month
	6	12	18	24	30	
T ₁ Control	100.0	100.0	100.0	100.0	100.0	
T ₂ Two pots either side	112.4	187.0	196.0	213.6	189.4	89.4
T ₃ 20 l once a week	115.4	134.0	138.5	146.1	149.7	49.7
T ₄ 20 l twice a week	97.9	161.3	157.9	182.3	178.4	78.4
T ₅ 20 l once in two weeks	94.7	112.9	114.7	110.2	105.3	5.3
T ₆ 40 l once a week	114.1	150.2	146.2	142.6	161.5	61.5
T ₇ 40 l twice a week	104.5	180.0	226.4	232.6	229.3	129.3
T ₈ 40 l once in two weeks	108.2	141.0	138.8	131.6	172.0	72.0
T ₉ 60 l once in two weeks	125.2	148.1	137.7	133.0	156.5	56.5
C V in %	12.4	20.1	16.6	26.8	14.9	
Significance	NS	***	***	**	***	
C D (p= 0.05)	—	50.8	43.4	71.1	41.5	
S.E. of mean	7.73	16.93	14.46	23.71	13.83	
** p < 0.01 *** p < 0.001						

6. Influence of irrigation on leaflet production and total leaf area of the 3rd leaf.

The leaf area of a leaflet was calculated by measuring the length and the breadth at the broadest position and using the function developed by Mathes *et al.* (1989). Since the evaluation of leaf area was very tedious and time-consuming the recording was done only at the end of the 30th month and only for the 3rd leaf. The 3rd leaf was counted from the unfold leaf taken as number 1.

The mean number of leaflets and the average total leaf area on the 3rd leaf are shown in Table 9. Variance analysis showed highly significant difference between the treatments for these two characters.

Table 9. *Effect of irrigation on leaflet production and the leaf area of the third leaf*

<i>Treatment</i>	<i>No. of leaflets in the 3rd leaf</i>	<i>Tot. leaf area in the 3rd leaf (cm²)</i>	<i>Leaf area per leaflet (cm²)</i>
T ₁ Control	70.7	5016.6	70.6
T ₂ Two pots either side	166.0	30192.5	182.1
T ₃ 20 l once a week	112.3	19416.1	172.8
T ₄ 20 l twice a week	155.3	28427.4	183.0
T ₅ 20 l once in two weeks	132.7	22203.1	167.2
T ₆ 40 l once a week	126.0	20995.4	166.3
T ₇ 40 l twice a week	180.0	35673.6	197.9
T ₈ 40 l once in two weeks	110.0	17929.7	162.6
T ₉ 60 l once in two weeks	176.7	28334.5	160.7
C V in %	19.4	30.1	
Significance	***	***	
C D (p=0.05)	45.6	12.5	
S.E. of mean	15.2	3873.9	
p < 0.001			

As for all the previous characters discussed, the number of leaflets and the leaf area were higher in treatments T₂, T₄ and T₇. This is a clear indication the influence of irrigation on the growth of the palm.

Leaf area per leaflet (Table 9) for all the irrigation treatments was more than 200% that of the control.

DISCUSSION

The main objective of this trial was to highlight the effect of irrigation on the performance of coconut seedlings and to ascertain the best dosage and frequency of irrigation in sandy soil of the dry zone.

At the commencement it was the intention to conduct this trial until bearing. However, due to reasons beyond our control the experiment had to be abandoned at the end of the 3rd year; nevertheless the data available were more than adequate to establish the main objective of this trial.

The results showed that the coconut seedlings respond well to irrigation. Although no seedlings died in the irrigated plots, 48% of the seedlings died in the non-irrigated plots. The results show the need for supplementary irrigation during establishment of seedlings. Also in non-irrigated plots, the seedlings which survived showed retarded growth, further suggesting the need for irrigation, particularly during dry periods in order to achieve satisfactory growth. The mortality rate in a dry zone could be as high as 70% (Perera *et al.* 1986). The comparatively low casualty rate (48%) observed in this experiment may be due to the scattered showers experienced during the trial period and the high water table in the area.

As could be expected, the seedlings showed very slow growth during the first year of planting. Except for the girth, other characters did not show significant difference between the applied treatments. Growth in all irrigation treatments was better than the control, although statistical significance could not be established.

Interestingly, the first response of fast growth and establishing a significant difference was shown for the girth. However, after the first year of planting all the characters showed marked response to irrigation treatments. The lowest response was shown to the application of 20 l once in two weeks, thus clearly establishing the need for higher dosage for a satisfactory growth. The rest of the treatments showed satisfactory response to all the characters recorded.

The three treatments (in order of performance) viz. 40 l applied twice a week, two earthenware pots buried either side of the plant and 20 l applied twice a week, gave better performance than the rest of the treatments. On a reasonable extension of the finding of Copeland (1921), Nelliatt (1968) had suggested the water requirement by a young palm as 11.25 litres per day. In our trial, the best treatment appear to be the application of 40 l of water twice a week. The response to treatments T₁, T₂, T₄, T₇ on height, girth, No. of leaves and crown width over the period are shown in fig.(1),(2),(3) and (4) respectively.

Fig. 1 Relation of height and period

Fig. 2 Relation of girth and period

Fig. 3 Relation of no. of leaves and period

Fig. 4 Relation of crown width and period

T₁ - no irrigation

T₄ - 20 l. applied twice a week

T₂ - two earthenware pots either side

T₇ - 40 l. applied twice a week

Although application of 40 l twice a week gave the best response the difference between that and the performance of 20 l applied twice a week was not large. This is indicative when ratio of performance of 20 l twice a week to 40 l twice a week was compared for height, girth, number of leaves, crown, width, vigour and leaf area at the end of 30th month, namely, 1:1.16; 1:1.23; 1:1.15; 1:1.25; 1:1.28; 1:1.25 respectively.

Water is generally scarce in the dry zone and more so during the drier periods. Considering these constraints, application of 20 l of water twice a week is suggested instead of application of 40 l twice a week. If earthenware pots are to be used, an initial high cost of outlay has to be incurred. However, if finances are available then

Fig. 5 Growth and vigour for no irrigation (T_1)

Fig. 6 Growth and vigour for two earthenware pots buried either side of the palm (T_2)

Fig. 7 Growth and vigour for water applied 20l. twice a week (T_4)

Fig. 8 Growth of vigour for water applied 40l. twice a week (T_7)

burying of two pots either side could be suggested in preference to 20 l or 40 l applied twice a week, for the reason that the water requirement is about 27 litres per week whereby saving considerable amount of water. Further the growth performance is little different to 40 l application.

Thus in conclusion, irrigation with 20 l applied twice a week or two earthenware pots buried on either side of the plant and filling them twice a week would result in quick and vigorous growth of the young seedlings. Plates 1,2,3 and 4 show the difference in growth and vigour for the four treatments; control, two earthenware pots buried either side of the palm, 20 l applied twice a week and 40 l applied twice a week at the end of the experimental period.

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REFERENCES

- Child, R. (1974). Nutritional requirements and fertilizer practice in coconuts. Coconut 2nd ed. Longman, London 130 – 156.
- Copeland, E.B. (1921) The Coconut (Second revised edition) Macmillan & Co. London P 12.
- Mathes, D.T., Liyanage, L.V.K. and Randeni, G. (1989). A Method for Determining Leaf Area of One, Two and Three Year Old Coconut Seedlings (Tallx Tall – Var CRIC 60). *Cocos*. 7.00
- Mathew, C.(1972) Summer Irrigation to Coconut Palm. Coconut Bulletin Vol III No.1 P 2.
- Menon, K.P.V. and Pandalai, K.U. (1958). The Coconut Palm Indian Central Coconut Committee.
- Nelliat, E.V. (1968). Effect of frequency of irrigation on newly planted young coconut palms in sandy soil. Indian J. Agric. Sci. 38: 737-746.
- Perera, U.V.H., Ranbanda, L. and De Silva, Sumith (1986). Contribution to Productivity From Coconut Subsidies Puttalam District. Publication of Ministry of Coconut Industries, Sri Lanka.
- Satheesan, K.V., Narasimhayya, G. and Ramadasan, A. 1983). A rapid method for estimation of leaf area of one year old seedlings of tall variety of coconut palms. Journal of Plan. Crops 11(1): 47-49.