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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 Nelliat (1968). On an argumentative extension of the work of Copeland, Nelliat suggested application of 11.25 1 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)*

Month	*1981*	*1982*	*1983*	*1984*
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)*

Month	*1981*	*1982*	*1983*	*1984*
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)*

Month	1981		1982		1983		1984	
	Max	Min	Max	Min	Max	Min	Max	Min
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 M^3, 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,

T_1 – Control, no irrigation.

T_2 – Two earthenware pots buried on either side of the seedlings. Pots were filled twice a week.

T_3 – 20 litres applied once a week.

T_4 – 20 litres applied twice a week.

T_5 – 20 litres applied once in two weeks.

T_6 – 40 litres applied once a week.

T_7 – 40 litres applied twice a week.

T_8 – 40 litres applied once in two weeks.

T_9 – 60 litres applied once in two weeks.

In treatment 2, two earthenware pots of capacity 7.5 1. 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 1.

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 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) Months after planting*					*% 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 T_2, T_4 and T_7 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 T_2, T_4 and T_7 showed height increase of 60%, 42% and 65% over the control, respectively. The lowest height gain was observed in treatment T_5.

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 T_2, T_4 and T_7 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 T_5 which was only 7.3% over the control.

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

Treatment	*Girth (cm) Months after planting*					*% 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 T_2,T_4 and T_7 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 T_7 gave the highest crown width upto the 30th month while T_2 and T_4 gave the second and third highest crown widths.

At 30th month the % increase over the control for the treatments T_2, T_4 and T_7 were 84.3, 63.7 and 104.8 respectively. T_5 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 T_7, followed by T_2 and T_4. The lowest response was seen in T_5.

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*

Treatment	*No.of leaflets in the 3rd leaf*	*Tot.leaf area in the 3rd leaf (cm^2)*	*Leaf area per leaflet (cm^2)*
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 T_2, T_4 and T_7. 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), Nelliat (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 T_1, T_2, T_4, T_7 on height, girth, No. of leaves and crown width over the period are shown in fig.(1),(2),(3) and (4) respectively.

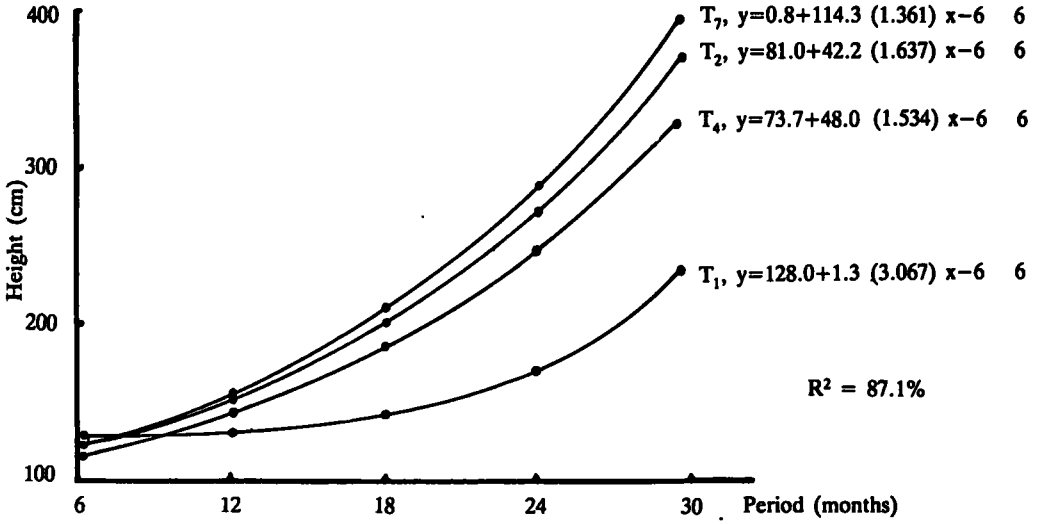

Fig. 1 Relation of height and period

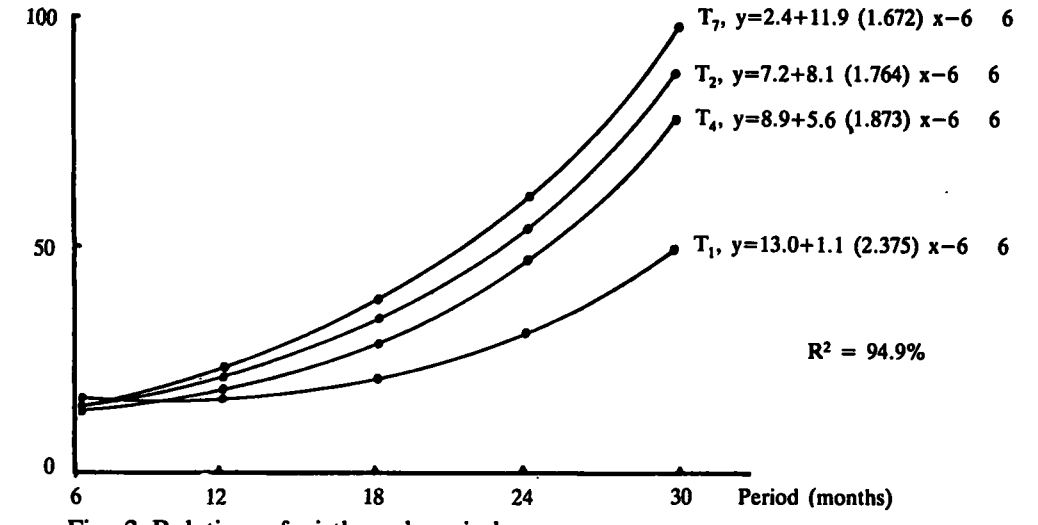

Fig. 2 Relation of girth and period

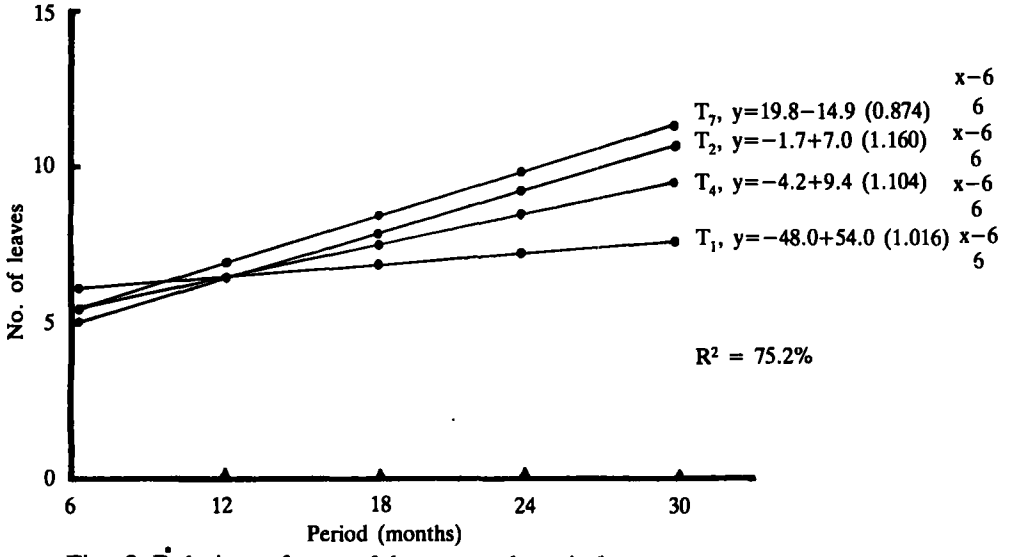

Fig. 3 Relation of no. of leaves and period

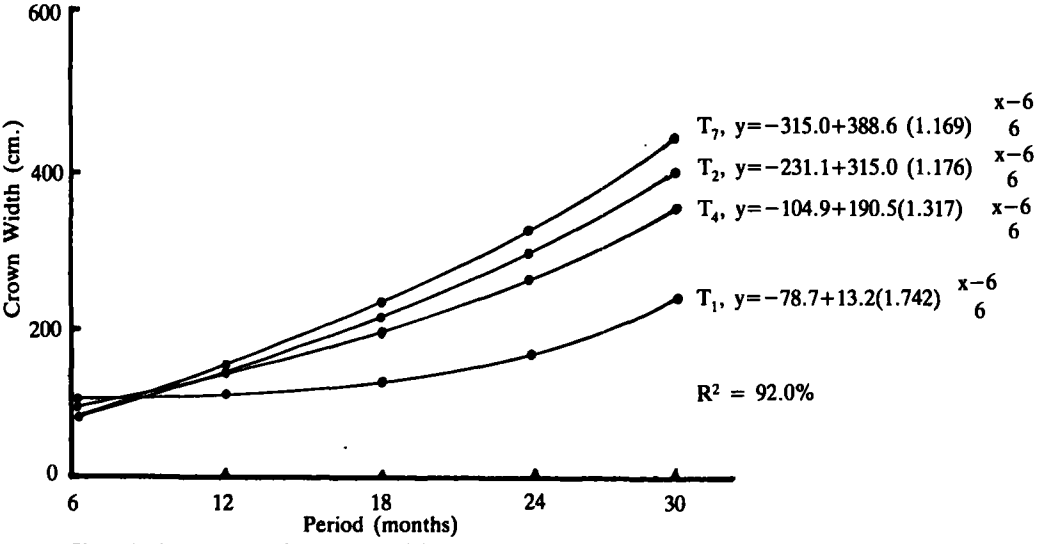

Fig. 4 Relation of crown width and period

T_1 – no irrigation

T_2 – two earthenware pots either side

T_4 – 201. applied twice a week

T_7 – 401. 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

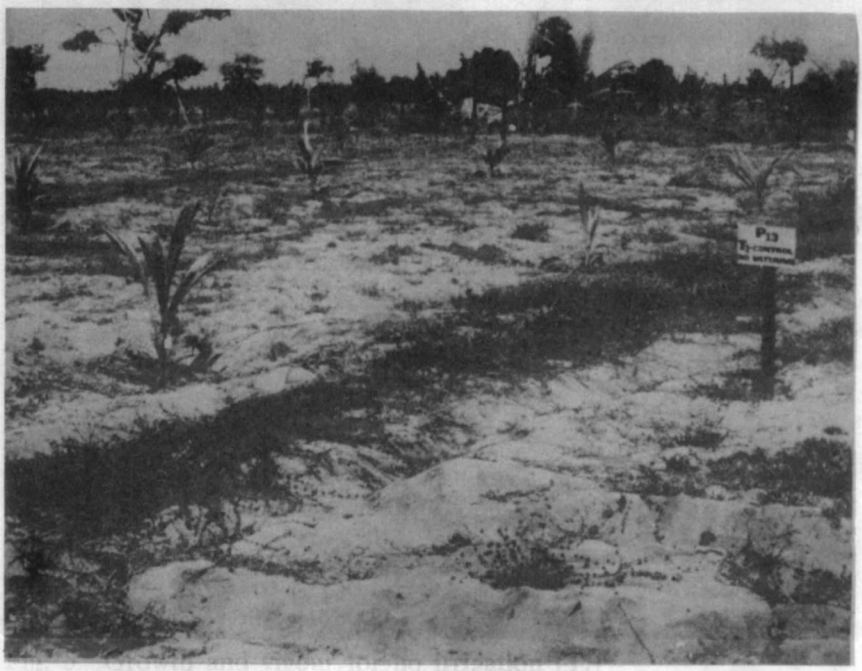

Fig. 5 Growth and vigour for no irrigation (T_1)

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 201. twice a week (T_4)

Fig. 8 Growth of vigour for water applied 401. 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 eathenware 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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An Alternative Approach for Analysis of Data from a Long-Term Experiment

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ABSTRACT

Long term experiments are commonly analysed at the end of the experiment using all the data collected over the entire duration of the experiment. Various methods are adopted to analyse such data but, in general, little consideration is given to the effect of climatic factors during this period. Consequently, information gathered from such an analysis is often incomplete.

An alternative approach for data analysis is proposed where the successive years of the experiment are classified into two states, namely, "Good year" and "Bad year" depending on the weather conditions. As a result, four different possible situations namely, "good year followed by a bad year", "good year followed by a good year", "bad year followed by a good year" and "bad year followed by a bad year" are considered. The method is illustrated using a data set from a trial carried out at the Coconut Research Institute and has demonstrated the feasibility of obtaining precise information on the treatment effect.

INTRODUCTION

A long-term experiment is one which is continued on the same set of plots over a number of years with a pre-planned sequence of treatments. Because of the cumulative character of the treatment effect and the cost involved in such experiments, more emphasis has to be given on analysing data from these experiments to obtain as much information as possible. The data collected over the life of the experiment are commonly analysed at the end of the experiment. Of the various methods available to analyse such data, only very few methods consider the time effect as a random variable.

One method used for some perennial crops is to divide the time taken by the experiment into two periods on the assumption that the perennials are biennial in cropping (Pearce, 1953). Another approach is to consider successive years as a separate variable and to include the "year effect" in the linear model used. Neither of these methods consider the direct effect of weather during the period of the experiment.