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INFLUENCE OF WATERING ON THE YIELD OF COCONUT

V. ABEYWARDENA*

Coconut Research Institute, Lunuwila, Sri Lanka

ABSTRACT

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An experiment designed primarily to quantify the reduction in immature nutfall as a result of watering coconut palms during drought, showed that even at the sub-optimal dosage applied, irrigation gave rise to more bunches, more female flowers per bunch, less immature nutfall, more mature nuts and increased nut size – finally ending up with a 54.2% increase in total copra production.

Even in years in which the weather conditions were more favourable and only fifteen waterings were done, the yield increase was 25.9%.

It is argued that the traditional moisture conservation methods such as providing drains, mulching, harrowing and husk-burying hardly help to look after the moisture needs of the palm and that if an efficient system of getting water to the palms during dry periods is found, a two-fold increase in production is a possibility.

INTRODUCTION

The coconut palm, compared to other tropical perennial crops such as Tea or Rubber, shows a very wide tolerance of climatic and weather factors. Although its habitat is considered an essentially tropical one, it is found to yield economically even in very high latitudes ranging from 26°N (Assam) to 25°S (Madagascar). Even in tropical Sri Lanka where the latitude is almost optimal around 10°N, it does well within a wide range of rainfall conditions – ranging from 1016 mm (40 inches) to as much as 3810 mm (150 inches), provided the mean temperature is not below 21°C (70°F).

Although the coconut palm exhibits such wide tolerance as regards climate and weather, yet in the high yielding coconut belt of Sri Lanka, which constitutes the Intermediate Zone wtih annual rainfall ranging from 1270 mm (50 inches) to 2540 mm (100 inches) and part of the Dry Zone wherein the rainfall is less than 1270 mm (50 inches), it is known to be very sensitive to moisture stress. An examination of the year to year crop fluctuations in these areas reveals that crops in a given locality can fluctuate within a wide range of as much as – 40% of the mean yield purely as a result of the fluctuations in the incidence of rainfall.

* Present Address: Agroskills, Asoka Gardens, Colombo 4, Sri Lanka.

In this moisture limiting yet high-yielding Intermediate Zone of Sri Lanka, in a normally healthy palm a newly opened inflorescence carries on the average around sixteen female flowers each one of which is a potential nut. Within the first two months of the opening of the inflorescence, 20% of these fall either as unfertilized female flowers or as immature nuts. Within the second two months, about 40% more fall as immature nuts. Thereafter, immature nutfall is negligible. Thus even in healthy palms in this belt which is supposed to be good for coconut, nearly two-third of the potential crop is lost due to poor setting of nuts and/or immature nutfall and this can be largely attributed to moisture stress arising from inadequate rainfall (Abeywardene and Mathes, 1971).

The fact that moisture stress due to drought affects coconut yields adversely has been recognized for a long time. Ferguson (1923) reports of efforts by lay planters to supply water to the palms, by burying around the base of the palm porous earthenware pots which can conserve rainwater and release it gradually to the palm and also to which water can be poured during dry periods to alleviate moisture stress. Planters in Sri Lanka and in other countries are in the habit of adopting moisture conservation methods, such as providing drains to cut off surface runoff of rainwater and also "husk burying" and "mulching" to conserve moisture.

However, apart from these spasmodic attempts to conserve moisture collected from rainfall, there have not been reported any serious attempts by coconut research workers to study to what extent coconut yields can be improved by directly supplying water to the palm in times of moisture stress. Apparently the only work reprorted so far are the experiments of Nelliat in India. Nelliat (1968) reports that "the application of red-earth in planting pits in sandy soil helped the retention of soil moisture and thereby facilitated employing a longer interval between irrigations without adversely affecting the growth and vigour of the young palms to an appreciable extent. Irrigation with 45 litres of water once in four days combined with application of 0.15m^3 of red-earth in planting pits prior to planting resulted in quick and vigorous growth of the young coconut plams". Subsequently (Nelliat, 1977) it was reported that irrigating palms when the IW/CPW (Cumulative pan evaporation) ratio was around 0.75 to 1.0 resulted in significantly higher yields.

At the Coconut Research Institute of Sri Lanka studies have been going on for nearly two decades (Abeywardena, 1962, 1963, 1966 1968, 1971, 1972 and 1977) wherein we have attempted to establish quantitatively the infuence of moisture stress (arising from inadeaquate rainfall) on coconut yields. The success achieved through these studies is evidenced by the fact that crop forecasting based on rainfall is now being done successfully on an island-wide scale. As a logical extension of this work, an experiment was started in 1973 to ascertain to what extent the yield can be improved by providing water to the palm during dry periods. The preliminary results from this experiment are reported in this paper.

MATERALS AND METHODS

A block of tall palms (*Cocos nucifera* L) at Ratmalagara estate in Chilaw district was selected for the experiment. The soil type of the block is a sandy loam overlying lateritic gravels. The annual rainfall in the area ranges from 1354 mm (53.30 inches) to 2146 mm (84.50 inches) and is fairly well distributed with two peaks one during the South-West Monsoon in May and June, and the other during the heavy intermonsoonal rains during October and November.

The experiment which commenced in 1973 covered 20 trees each from high yielding palms, medium yielding palms and low yielding palms - thus providing for five replicates (in each group) of the following four treatments :

1. Control (No watering).
2. Watering with single dose weekly.
3. Watering with double dose fortnightly.
4. Watering with single dose fortnightly (a single dose consists of 82 gallons of water per palm)

Water was poured within a radius of 1.5 metres (5 feet) from the base of the palm – a circular earth bund being constructed to check the overflow of water beyond this area.

The dose of 373 litres (82 gallons) per palm was calculated in order hopefully to simulate 51 mm (2 inches) of rain within this 5-feet basin. However, it is now apprecaited that this dosage does not adequately simulate 51 mm (2 inches) of rain. When water is poured around the base of the palm, invariably a lateral moisture gradient is created from the base of the palm outward and thereby moisture actualy made available to the palm by the added water falls far short of what was intended. Moreover, as water was added during dry periods and during daytime, evaporation from the surface was considerable, thus effecting a further drain on the effective moisture availability. Due to these reasons, the dosage intended to simulate 51 mm (2 inches) of rain may not have simulated anything more than 25 mm (one inch) – perhaps much less.

However, the experiment did continue for about 4 years on these low rates. Very recently, we increased the rate to 836 litres (184 gallons) per palm. It should be appreciated that the results reported herein reflect only the responses to the earlier low dosage of watering, which was decidedly sub-optimal.

Watering was done only during dry periods when moisture deficits can occur. If (say) watering is due on a particular date, the rainfall is observed during the week prior to this date and if there is no rain, watering is done on the due date as per schedule. If however rain does occur, the next watering date is put off by some days depending on the quantum of rain received during the week. The basis of such postponement is shown in Table 1.

Table 1. *The basis of postponement of watering*

Rainfall during week(mm) preceding due date	*No. of days by which watering is put off*
— < 12.70 mm	*No. postponement*
12.70 mm — < 25.40 mm	1
25.40 mm — < 38.10 mm	3
38.10 mm — < 58.80 mm	5
50.80 mm — < 76.20 mm	7
76.20 mm — < 101.60 mm	10
101.60 mm — < 127.00 mm	12
127.00 mm — < 152.40 mm	14
152.40 mm — < 177.80 mm	16
177.80 mm — < 203.20 mm	18
203.20 mm and above	20

After any such postponement, the rainfall of the week immediately prior to the next scheduled date is observed and a further postponement would be made if the quantum of rain warrants it – the basis of postponement being the same as before.

RESULTS

When one refers to yield responses in coconut, a number of yield components are of interest, because these components contribute, to some measure or other, to the final yield of copra. The components are :

i. Number of bunches produced.
ii. Number of female flowers per bunch
iii. Immature nutfall
iv. Number of mature nuts *and*
v. Nut size (copra outturn)

The data presented refer to the period 1975 to 1979. The years 1975, 1976 and 1978 were fairly good crop years and therefore reflected fairly good rainfall conditions whereas the years 1977 and 1979 reflected relatively poor rainfall condition. The data were therefore analysed separately for these two sub-periods in order to verify the differential responses to watering under favourable and unfavourable conditions. One would expect the responses to be relatively higher when rainfall conditions are less favourable. The data have been adjusted for pre-treatment differences by means of covariance analysis (regressing on the values of the corresponding character for the pre-treatment period 1971 – 1972). The variance ratios (F n_1, n_2) in the adjusted analysis of variance are given together with the mean of the smallest and largest critical differences suggested by Pearce (1953).

1. Influence of watering on production of bunches.

Table 2 *Mean number of bunches per annum*

Treatment	*Mean number of bunches per 100 palms per annum*		*% increase due to watering*	
	favourable conditions	*unfavourable conditions*	*favourable conditions*	*unfavourable conditions*
Control	1281	1287	—	—
Single dose weekly	1314	1319	2.6%	2.5%
Single dose fortnightly	1303	1346	1.7%	4.6%
Double dose fortnightly	1327	1369	3.6%	6.4%
Variance ($F_{3, 15}$) ratio	1.08	1.76		
L. S. D. (mean of smallest – largest)	56	81		

Although the analysis of variance of the character – number of bunches produced – does not show statistically significant differences between treatments, there are indications that watering increases bunch production – the more so when double dosage is put in fortnightly. The responses to watering, as expected, are higher when the weather conditions are unfavourable. The failure to show substantial responses in respect of bunch production is understandable, because there is a lag of nearly three and half years between the initiation of the bunch primordium and harvesting of the mature bunch. This experiment has not yet gone on for a sufficient period to show the full impact of watering on production of bunches.

2. Influence of watering on the number of female flowers per bunch

Table 3. *Mean number of female flowers per 100 bunches*

Treatment	*Mean number of female flowers per 100 bunches per annum*		*% increase due to watering*	
	Favourable conditions	*Unfavourable conditions*	*Favourable conditions*	*Unfvourable conditions*
Control ..	1636	1542	—	—
Single dose weekly ..	1664	1595	1.7%	3.4%
Single dose fortnightly ..	1789	1799	9.4%	16.7%
Double dose fortnightly ..	1632	1647	-0.2%	6.8%
Variance ($F_{3,15}$) ratio ..	1.13	2.43		
L. S. D. mean of smllest – largest)	232	212		

The number of female flowers in a bunch shows a fair increase due to watering although the variance ratios do not reach the significance level. The response is better in years when the weather conditions are less favourable. Here too, due to the long lag between the initiation of female flower primordia and their exhibition in the opened inflorescence, the responses shown in this preliminary stage are not what could be fully expected. One can confidently predict substantial increases in the years to come – especially with the recent increase in the dosage of water applied.

3. Influence of watering on total female flower production

Table 4. *Mean number of female flowers per palm per annum*

Treatment	*Mean number of female flowers per palm per annum*		*% increase due to watering*	
	Favourable conditions	*Unfavourable conditions*	*Favourable conditions*	*Unfavourable conditions*
Control ..	212	202	—	—
Single dose weekly ..	218	211	2.8%	4.5%
Single dose fortnightly ..	234	240	10.4%	18.8%
Double dose fortnightly ..	216	226	1.9%	11.9%
Variance ($F_{3,15}$) ratio ..	< 1.00	3.13		
L. S. D. (mean of smallest – largest) ..	36	29		

Although the production of bunches or the number of female flowers per bunch, taken severally, does not show appreciable increase due to watering, the response by way of total female flower production per palm is substantial. Irrespective of whether it is single dose or double dose, fortnightly applications seem to yield better results. The response is greater under unfavourable weather conditions.

4. Influence of watering on percentage immature nutfall

Table 5. *Mean percentage immature nutfall*

Treatment	*Mean percentage nutfall*	
	Favourable conditions	*Unfavourable conditions*
Control ..	61.9%	65.1%
Single dose weekly ..	58.3%	57.7%
Single dose fortnightly ..	65.0%	66.2%
Double dose fortnightly ..	61.5%	64.1%
Variance ($F_{3,15}$ ratio) ..	1.79	3.63*
L. S. D.(mean of smallest – and largest) ..	5.4	6.1

The analysis of variance shows significant differences in the percentage immature nutfall. However, the only striking difference shown in Table 5 is the very large reduction in the percentage immature nutfall in the case of the treatment "single dose weekly". If the treatment "double dose fortnightly" showed a significant reduction in the % immature nutfall as well, one could have still reconciled these responses to fit into a reasonable pattern. Therefore caution is necessary in interpreting these observations.

An interesting phenomenon that has come to light in this analysis is that when the female flower production is high, the percentage immature nutfall too is high ($r=0.8847^{***}$) quite irrespective of treatments. Therefore in trying to understand the influence of watering (or any treatment for that matter) on immature nutfall using the criterion "percentage immature nutfall", one must take cognizance of this inherent positive relationship between female flower production and percentage immature nutfall. The percentage immature nutfall may be high or low purely because the female flower production is high or low and not necessarily due to the effect of any given treatment on immature nutfall. The results shown in Table 5 should therefore be viewed in the light of this finding in order to arrive at a more realistic interpretation.

Table 4 showed that the female flower production in the case of the "control" and "single dose weekly" are much lower than that in the case of the treatments "single dose fortnightly" and "double dose fortnightly". A reasonable adjustment should reveal a completely different and acceptable picture. For instance, if we take the traeatments "control" and "single dose weekly" (Table 4) the female flower production is 201 and 210 respectively. An adjustment for the positive correlation between % immature nutfall and female flower production should bring down the % immature nutfall in respect of the treatment "single dose weekly" still further from the already low value of 51.1%. Similarly the female flower production for the "single dose fortnightly" and "double dose fortnightly" being very much higher (239 and 227 respectively) than the control which is 201, an adjustment for the relationship would bring the % immature nutfall for these treatments too very much lower than the control. One can therefore confidently interpret that all three systems of watering have effected an *appreciable* reduction in the percentage immature nutfall, but this was masked by the variation in the production of female flowers which confused the picture.

5. Influence of watering on the production of mature nuts

Table 6. *Mean number of nuts per hectare per annum*

Treatment	*Mean number of nuts per hectare per annum*		*% increase due to watering*	
	Favourable conditions	*Unfavourable conditions*	*Favourable conditions*	*Unfavourable conditions*
Control ..	11,553	9,611	—	—
Single dose weekly ..	12,483	12,567	8.0	30.8
Single dose fortnightly ..	11,520	11,243	-0.3	17.0
Double dose fortnightly ..	11,959	11,463	3.5	19.3
Variance ($F_{3,\ 15}$) ratio ..	< 1.00n.s.	7.60**		
L. S. D. (mean of smallest – and largest) ..	1,660	1,362		

The total nut production has increased significantly due to watering. The best response (30.8%) is from an application of "single dose weekly" the second best response (19.3%) is from "double dose fortnightly" and the lowest response (17.0%) is from "single dose fortnightly". These responses are precisely in keeping with expectation.

While the relative responses compared with the corresponding controls are as expected, larger during drier conditions, the absolute levels of nut yields in watered palms are slightly higher under favourable conditions. This indicates that even during favourable conditions in the Intermediate Zone, a certain amount of moisture stress does exist and therefore judicious watering during dry periods even in good weather years can help.

6. Influence of watering on copra out-turn (nuts/candy)

Table 7. *Mean copra out-turn (nuts/candy)*

Treatment	*Mean copra out-turn nuts/candy*		*% decrease in out-turn*	
	Favourable conditions	*Unfavourable conditions*	*Favourable conditions*	*Unfavourable conditions*
Control ..	1,317	1,608	—	—
Single dose weekly ..	1,148	1,337	12.8%	16.9%
Single dose fortnightly ..	1,217	1,421	7.6%	11.6%
Double dose fortnightly ..	1,155	1,300	12.3%	19.2%
Variance ($F_{3,\ 15}$) ratio ..	10.66***	16.66***		
L. S. D. (mean of smallest – and largest) ..	73	107		

Under favourable weather conditons, watering improved the copra out-turn significantly 12.3% for "double dose fortnightly", 12.8% for "single dose weelkly" and 7.6% for "single dose fortnightly". Under drier conditions, the improvements in copra out-turn are relatively higher, being 19.2% for "double dose fortnightly", 16.9% for "single dose weekly" and 11.6% for "single dose fortnightly". Even under favourable conditions prevailing in the Intermediate Zone, there is plenty of scope for improving nut size by watering.

7. Influence of watering on total copra yield

Table 8 *Mean copra yield – pounds per hectare*

Treatment	*Mean copra yield lb/hectare*		*% increase due to watering*	
	Favourable conditions	*Unfavourable conditions*	*Favourable conditions*	*Unfavourable conditions*
Control	5,011	3,488	—	—
Single dose weekly	6,311	5,377	25.9%	54.2%
Single dose fortnightly	5,252	4,371	4.8%	25.3%
Double dose fortnightly	5,958	5,096	18.9%	46.1%
Variance ($F_{5, 15}$) ratio	5.24*	22.97***		
L. S. D. (mean of smallest – and largest) ..	777	515		

Under relatively drier conditions, there is a considerable increase in copra yield due to watering. The highest response (54.2%) is for watering "single dose weekly", the second highest (46.1%) for double dose fortnightly" and the lowest (25.3%) for "single dose fortnightly. Even under favourable weather conditions, there are appreciable responses", being 25.9% for "single dose weekly", 18.9% for "double dose fortnightly and 4.8% for "single dose fortnightly".

8. Influence of watering on the seasonal pattern of crops

Coconuts are generally picked bi-monthly. Within the main coconut growing area of Sri Lanka, namely, the "coconut triangle " the relative dimensions of the six picks within the year follow a regular pattern, the best harvests being in the middle of the year and the poor harvests being at the beginning of the year and at the end of the year.

When palms are watered during dry periods, it is reasonable to expect this regular seasonal pattern obtaining under rainfed conditions to change to a more even level. This feature is amply demonstrated in Fig. 1.

It is evident that in the case of watered palms, the gaps in the relative dimensions of the six picks are tending to close up.

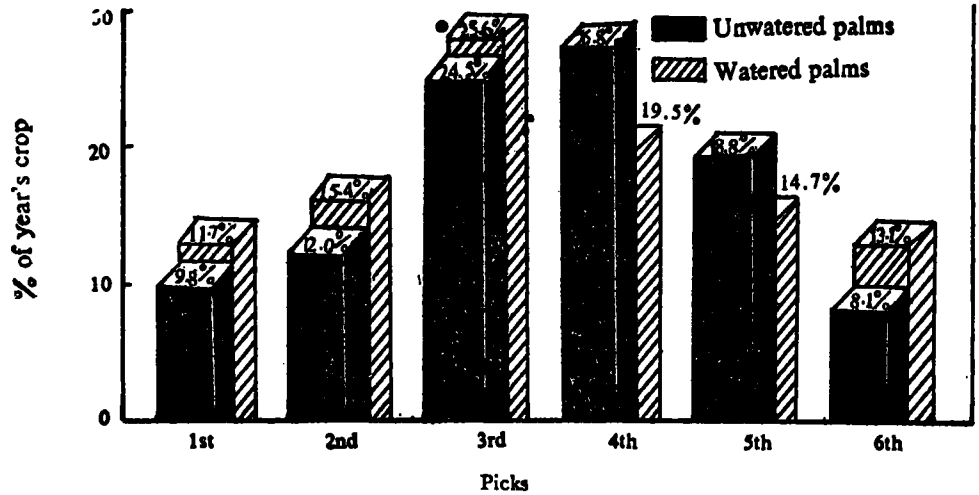

Fig. 1. Relative magnitudes of picks in watered and unwatered palms.

DISCUSSION

The necessity to carry out this watering trial arose from our earlier observations that even in healthy palms growing under relatively favourable conditions, as much as two-third of the potential crop is lost by way of poor nut set as well as immature nutfall and also our belief that moisture stress arising from droughts is mainly responsible for this.

Our main expectation from this experiment was therefore to highlight a reduction in immature nutfall as a result of watering – leading to higher yields. But the results of this experiment clearly show that watering improved all crop components and not merely a reduction in immature nutfall. Palms watered even at these sub-optimal rates adopted by us showed more bunches, more female flowers per bunch, less immature nutfall, more mature nuts, and increased nut size – finally ending up with a 54.2% increase in total copra production.

As expected, the yield responses to watering were higher in relatively drier years. Even in years in which the weather conditions were relatively more favourable, watering showed a 25.9% yield increase with only about fifteen waterings done during such years.

It is also clearly established that a single dose applied weekly is superior to a double dose applied fortnightly.

This experiment was conducted in a locality which cannot be considered a rainfall deficient area in the strict sense of the phrase, and the rates of watering adopted by us were very inadequate. Therefore the observed increase of 54.2% in copra production – with only about 24 waterings during relatively dry years and an increase of 25.9% with only about 15 waterings during better years is very encouraging indeed. With the recent increase in the dosage of watering in this experiment, a very substantial increase in yield within the next few years can be predicted.

Coconut is essentially a rainfed crop, with the few more progressive planters adopting moisture conservation methods in order to derive additional benefit from the rains received. With this system persisting from time immemorial in this "lazy man's crop," any suggestion to shift emphasis from *conservation* of moisture derived from rain to supplying of moisture through channels other than rain, may perhaps sound a revolutionary one. We do not for once underestimate the beneficial effects of moisture conservation measures such as supplying drains, mulching, harrowing and husk-burying. But the moot question is whether all such measures adequately look after the moisture needs of the palm. Even estates that regularly adopt all these practices show wide fluctuations in crops from year to year as a result of fluctuations in rainfall. A good rainfall year is followed by a good crop year and a poor rainfall year is followed by a poor crop year – and this in spite of the best efforts at moisture conservation including that of burying all the husks which at present prices of fibre) could have fetched a tidy additional income, if converted into fibre products. This clearly argues that all our moisture conservation measures hardly touch the fringe of the problem and consequently the full potential of the palm remains pathetically untapped.

While on this question of limited moisture availability, one may consider alternative approaches to increased coconut production. Why not concentrate on intensive coconut cultivation in the sprawling Wet Zone? Why not employ experts to seed clouds to bring in more rain? Or even cynically why not pray for rains? The answer is "more and more rain" whether it occurs naturally or whether it is induced, is not necessarily conducive to high coconut production for the simple reason that more rains necessarily implies more cloudy skies and reduced hours of sunshine and these are decidedly detrimental to higher production. An assured supply of soil moisture without unduly reducing the hours of sunshine is the answer to increased production. And that can be achieved only in the drier area of the Intermediate and Dry Zones and that provided water can be supplied to the palms.

One could confidently state that provided water is available and some economic and efficient system of getting this water to the palms is found, prospects of a two-fold, (even higher) increase in coconut production in the Intermediate and Dry Zone belt including a part of the Wet Zone are very bright. Further, the Dry Zone areas in the North Central Province, Northern Province and part of the Southern Province, which hitherto did not go in for coconut planting seriously, can do so with confidence.

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