

ECONOMICS OF THE RESPONSE OF COCONUT TO FERTILIZER APPLICATION

V. ABEYWARDENA

Coconut Research Institute, Lunuwila, Sri Lanka

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The build up of the response to fertilizer application of an unfertilized coconut land is shown as a two-phased one. There is a substantial response after one year building up according to the law of diminishing returns and reaching a plateau by about the third year after manuring. This is followed by a second spurt at first showing "increasing returns" and then a "diminishing returns" phase ending up in an asymptote by about the 8th year from manuring. This two-phased pattern of response has been discussed and explained through the floral biology of a bunch of coconuts.

The economics of manuring based on this response over a period of ten years have been worked out (1) for the coconut grower based on local prices of coconut products and subsidised cost of fertilizer and (2) for the Government based on the imported cost of fertilizer and the export value of copra, fibre products and coconut shell charcoal (in terms of foreign exchange).

On the basis of this analysis it is argued that faced with the two alternatives – namely the first one of giving 50% subsidy as it is done now for the fertilizer to be applied at the rate of 4.08 kg (9 lbs) per palm and the second one of issuing free fertilizer to be applied at the rate of 2.50 kg (5.50 lbs) per palm – the Government will stand to benefit more from the second alternative in the sense that (1) the income per unit investment is very much higher and (2) on a practical basis the total production in Sri Lanka and also the nett foreign exchange earnings will increase considerably due to the fact that more growers will take to manuring. This however does not preclude those who can afford it applying the higher rate of 4.08 kg (9 lbs) per palm and getting higher nett profit.

INTRODUCTION

The coconut palm responds very satisfactorily and economically to fertilizer application perhaps much more so than tea or rubber. But it is sometimes difficult to convince the coconut grower and even administrators of fertilizer policy that it is so. This is because coconut yields are subject to variations as a result of variations in rainfall. Such yield variations can at times mask the response to fertilizer application.

Fig. 1 shows the production trends of an un-fertilized coconut holding in Chilaw District. These fluctuations in yield from year to year are mainly due to changes in weather conditions.

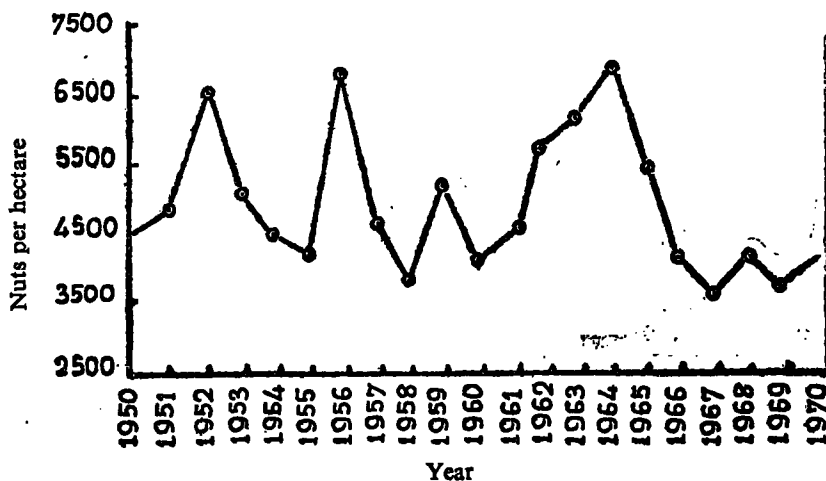


Fig. 1. Yields of a non-fertilized Coconut plantation.

Let us consider the extreme case of an individual who commences applying fertilizer to his land in 1964. From the very beginning, his crops will start falling. This fall is not due to any harmful effect of the fertilizer. As seen in the graph, his crops would have fallen anyway due to the adverse weather conditions that prevailed during the period. This person's failure to appreciate the beneficial effect of fertilizer is not surprising at all. No amount of explanation can convince him that fertilizer has a beneficial effect on crops and that if he had not applied fertilizer, his crops would have dropped even more.

The coconut research worker however can through controlled experiments see through this masking weather phenomenon by estimating the true response to fertilizer application as the difference between fertilized and un-fertilized plots side by side, probably aided by other statistical adjustments.

In this paper it is proposed to show the buildup of the response to fertilizer application of an un-fertilized coconut land over the years through such an approach and also to give the economics of the fertilizer input over the years.

MATERIALS AND METHODS

The data used for this analysis were obtained from the 3x3x3 N P K factorial experiment conducted at Bandirippuwa Estate beginning in 1935.

The response to fertilizer was measured as the difference between the plots given the treatment $N_0 P_0 K_0$ (ie. untreated) and the plots given the treatment $N_2 P_1 K_2$ which gave the best yield. This treatment $N_2 P_1 K_2$ consisted of a mixture containing 1.10 kg (2.43 lbs) of sulphate of ammonia (20.6% N), 0.83 kg (1.82 lbs) of saphos phosphate (27.5% $P_2 O_5$) and 0.57 kg (1.25 lbs.) of muriate of potash (60.0 % $K_2 O$) calculated on a yearly basis.

RESULTS

(a) Response to Fertilizer

The response to fertilizer is measured by the difference in yield between fertilized and un-fertilized plots deducting from each such difference the initial (ie, pre-manurial) difference between the two sets of plots. However this difference may not still reflect the true response to fertilizer for the simple reason that in a good weather year when yields are high, the absolute response is also high and vice versa in a poor weather year when yields are low, the absolute response is also low.

This phenomenon was verified by calculating the correlation coefficient (r_{xy}) between the yields (x) of the un-fertilized plots over the years and the absolute responses (y) over the years. The relationship was significant, r being equal to +0.64 ($P = < 0.05$).

Therefore for, a meaningful evaluation of the buildup of the response to fertilizer with time, adjustments have to be made for this dependence through a regression analysis.

Table 1. *Response to Fertilizer adjusted for weather differences.*

Year of Application	Response	
	Copra kg/hectare/year	Nuts/hectare/year
Pre-manurial	0	0
M ₁	368.8	1814
M ₂	389.0	1915
M ₃	446.1	2194
M ₄	415.9	2046
M ₅	516.7	2543
M ₆	553.7	2726
M ₇	817.1	4020
M ₈	719.6	3541
M ₉	748.8	3684
M ₁₀	753.2	3707

These adjusted responses both for the number of nuts per hectare and copra in kgs per hectare are shown in Table 1.

There is a very clear progressive buildup of the response ranging (1) in the case of nuts from 1814 per hectare per year in the first year after application to 3707 per hectare per year in about the 10th year and (2) in the case of copra from 369 kg/hectare per year in the first year to 753 kg/hectare per year in about the 10th year.

(b) Pattern of response to fertilizer

The pattern of response over time would also be an interesting study.

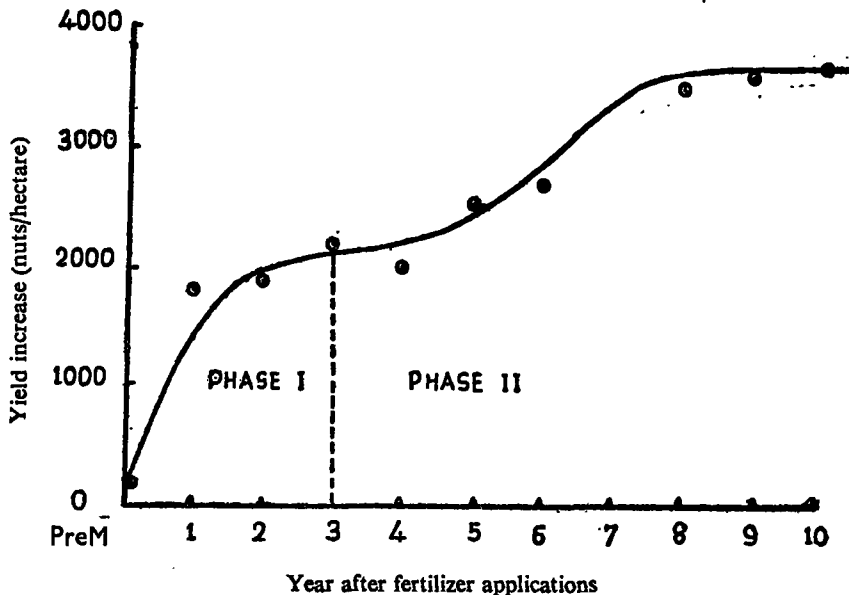


Fig. 2. Response to fertilizer with time.

It is apparent that the response builds up in two well-defined phases. The first phase shows a large response after one year of manuring. This builds up according to the law of "diminishing returns" and reaches a plateau somewhere after 3 - 4 years. Then commences the second phase which constitutes at first an "increasing returns" phase followed by yet another "diminishing returns" phase, apparently ending up in an asymptote by about the 8th year of manuring.

(c) Economics of Fertilizer Application

The economics of fertilizer use as calculated based on the responses estimated from the smoothened curve in Fig. 2 are given in Table 2 and Table 3. Prices of coconut products and other conversion rates used are given in the appendix.

Table 2 shows the economics of the fertilizer input in the case of the local coconut grower based on the local prices of coconut products and subsidised cost of fertilizer. The grower could expect a return per unit investment in fertilizer of 107% after the first year of manuring building up progressively to 447% in about the 10th year.

Table 3 shows the economics in the case of the Government based on the export prices of coconut products and the full import cost of fertilizer - all in terms of foreign exchange disbursements. The Government can net in a return per unit investment in fertilizer of 174% after the first year of manuring building up progressively to 624% by about the 10th year - all in terms of foreign exchange.

DISCUSSION

Apart from experimental evidence reported time and again from the Coconut Research Institute of Sri Lanka indicating substantial responses to fertilizer application, the statistics reported herein regarding the second aspect of the buildup of the response to fertilizer application over the years should leave no misgivings whatsoever both in the minds of the coconut growers as well as the Government policy makers that investment in fertilizer for coconut is a very paying proposition. Such an investment would compare favourably with the best of alternative investments.

It would be pertinent to stress that the dosage of fertilizer for which this economic evaluation is made is only 2.50 kg (5.50 lbs) per palm and this is only slightly above half the current recommended dosage of 4.08 kg (9.0 lbs) per palm. Considering the fact that the Government now gives a subsidy of 50% on coconut fertilizer, it would appear to be a not unreasonable suggestion to think seriously in terms of offering to those coconut growers, who cannot afford even this subsidised rate, half the recommended dosage free of cost. Such an offer will costwise to the Government be the same as giving 50% subsidy at the rate of application of 4.08 kg (9.0 lbs) per palm. It will be a move that will pay good dividends both to the growers and to the Government - by way of increased production at no cost (except cost of application) to the grower and by way of foreign exchange earnings through increased exports to the Government - while still earning the appreciation of the large mass of the poor coconut growers for this generous gesture. If we consider the fact that even at the peak consumption of coconut fertilizer in 1968, the actual acreage fertilized was only about 21%, the potential for increased production via the suggested move is very vast indeed.

Further taking the two alternatives - namely the first one of offering 50% subsidy for application at the rate of 4.08 kg (9.0 lbs) per palm and the second one of offering 2.50 kg (5.50 lbs) per palm free of cost, the "returns" to "investment" ratio as far as the Government is concerned is far higher with the second alternative than with the first alternative. This is because of the fact that the response to increasing levels of fertilizer application follows the law of "diminishing returns" - at higher levels of application the ratio being much lower than at the lower levels subject of course to a minimum rate (Abeywardena, 1963).

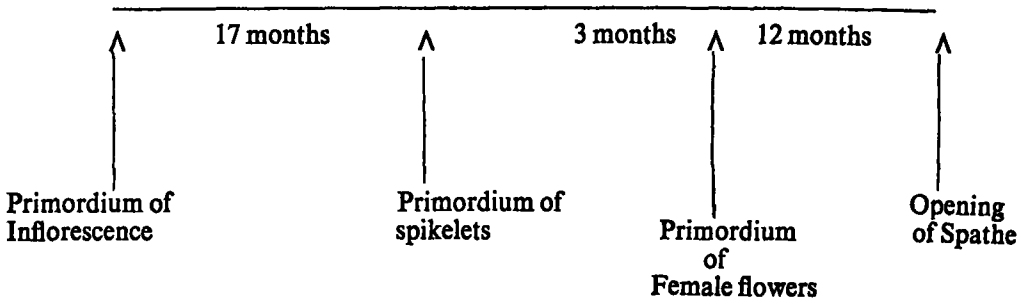
Quite apart from economics, another point of interest to coconut research workers that emanated from this study is the two-phased response to fertilizer application over the years. There is a substantial response after one year building up according to the law of "diminishing returns", then a plateau by about the third year. This is followed by a second spurt at first showing "increasing returns", and then "diminishing returns" phase ending up in an asymptote by about the 8th year. What is the biological explanation for this two phased pattern of response?

The magnitude of a coconut crop will depend on a number of critical crop components given below:

- (1) Kernel development (nut size)
- (2) Number of female flowers per bunch
- (3) % setting of female flowers
- (4) Button shed and immature nutfall
- (5) Number of inflorescences in a year

The progress of development of a bunch of coconuts is shown in Fig. 3 (menon & Pandalai 1956).

(a) NON-VISUAL PHASE (32 months)



(b) VISUAL PHASE (12 months)

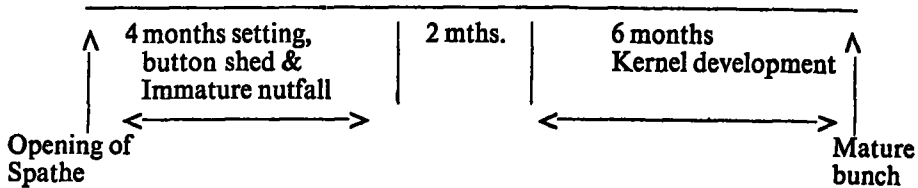


Fig. 3. Development cycle of a bunch of coconuts

The primordium of the spathe (unopened inflorescence) is formed about 32 months (ie, nearly 3 years) before the spathe opens, the primordium of the spikelets (which carry the female flowers) about 15 months before and the primordium of the female flowers about 12 months before. This constitutes the non-visual cycle. This is then followed by the 12-month visual cycle beginning with the opening of the spathe, the setting of female flowers within one month, button-shed followed by the immature nutfall mostly within the first four months and kernel development within the last six months.

From the above it is obvious that kernel development would be the first crop component to be influenced by fertilizer application. This could happen any time within six months. After a period of one year, the immature nutfall, button-shed and setting of female flowers would be affected in that order. It would take about 24 - 27 months before fertilizer application could affect the production of female flowers. This progressive influence of fertilizer application on these crop components mentioned explains clearly Phase I of the fertilizer response curve shown in Fig. 2.

With all the crop components in a bunch of coconuts now looked after, the plateau formed during the 3-4 year period is to be expected. What then induces the second spurt in Phase II of the response curve?

It is well known that a high yielding palm, whatever the stimulus be that gives rise to the high yield, produces a higher number of bunches. While a low yielding palm produces only about 8 - 10 bunches in a year, a high-yielding palm produces as much as 16-18 bunches (Abeywardena 1973). As explained earlier it takes anything over three years before fertilizer application or any other stimulus can affect bunch production. The second spurt in the response curve after the fourth year is therefore the direct result of the influence of fertilizer application on production of bunches.

The final "diminishing returns" and asymptotic feature of the response is typical of most biological responses.

ACKNOWLEDGEMENTS

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REFERENCES

- Abeywardena, V., (1963). Economics of fertilizer use. *Trop. Agric. (Cey.)*, 119. 183 - 202.
- Abeywardena, V., (1973). Annual Report of the Biometrician. *Ceylon Cocon. Q.*, 24, 46-48.
- Menon, K. E. V. and Pandalai, K. M. 1953. *The Coconut Palm A monograph* Indian Central Coconut Committee. Ernakulam, South India, 384 pp.

A P P E N D I X

Number of palms per hectare — 158
1250 nuts = 254.0104 kg (1 Candy or 560 lbs) of Copra

Rates of Fertilizer application

Sulphate of Ammonia	1.10 kg/palm
Saphos Phosphate	0.83 kg/palm
Muriate of Potash	0.57 kg/palm

Cost of fertilizer as at November 1976 (50% subsidy)

Sulphate of Ammonia	Rs. 778.00 per metric ton
Saphos Phosphate	Rs. 437.00 per metric ton
Muriate of Potash	Rs. 696.00 per metric ton

Total cost of above dosage per hectare is Rs. 255.21.

Cost of application of fertilizer @ cts. - /40 per palm is Rs. 63.20 per hectare.

- (1) Income from Copra based on the average market price of Copra (1973 - 1976) =
Rs. 182.81 per 100 kgs.
 - (2) Income from husks based on present (1977) average price of husks ex estate = Rs. 60.00
per 1000 husks (nuts).
 - (3) Income from shells based on current (1977) average value of coconut shells ex estate =
Rs. 40.00 per 1000 shells (nuts).
- (1) Income from Copra based on the average export price (1973 - 1976).....
Rs. 3.08 per kg.

- (2) From 1000 husks of coconut 90.72 kg of fibre are obtainable (W.R.N. Nathanael; CCQ. Vol. XIX No. 3 : 150-152) and as per average fibre exports of 1973-1976 (Custom Returns of Coconut Exports) the exports of fibre forms are in the following proportions.

Bristle Fibre	29.13%
Mattress Fibre	68.13%
Coir Yarn	2.74%

Therefore for 1000 husks (nuts) 26.43 kg of Bristle Fibre
 61.80 kg of Mattress Fibre
 and 2.49 kg of Coir Yarn are exported.

- (3) 20,000 whole shells produce (2240 lbs*) 1016.0416 kg of Coconut Shell Charcoal (*Coconut Palm Products by Brian E. Grimwood, FAO, Rome)

i.e., 1000 whole shells = 50.80 kg of Shell Charcoal

- (4) Income from Bristle Fibre is based on the average export price (1973-1976) Rs. 1.45 per kg of Bristle Fibre.
 (5) Income of Mattress Fibre is based on the average export price (1973-1976) Rs. 0.78 per kg of Mattress Fibre.
 (6) Income from Coir Yarn is based on the average export price (1973-1976) Rs.1.97 per kg of Coir Yarn.
 (7) Coconut Shell Charcoal price is based on the average export price (1973-1976) Rs. 0.63 per kg of Charcoal
 (8) **Imported cost of fertilizer**
 Assuming the imported cost of fertilizer as 25% less than the local unsubsidized price of fertilizer.
i.e., Rs. 382.82 per hectare at the dosage quoted above.

Conversion Table

1 lb = 0.45359 kg

1 acre = 0.40468 hectare.

1 Candy = 1250 coconuts = 560 lb = 254.01 kg Copra.

No. of palms/acre = 64

No. of palms/hectare = 158

2204.6 lb = 1000 kg = 1 Metric Ton

Table 2. *Economics of fertilizer application on coconut (for land owner)*

Year after commencement of fertilizer application	YIELD INCREASE		INCOME PER HECTARE			Total income per hectare	Subsidised cost of fertilizer per hectare & cost of application	Profit per hectare	% Profit per hectare
	Nuts per hectare	Kg copra per hectare	From copra 1 Rs.	From husk 2 Rs.	From shell 3 Rs.	Rs.	Rs.	Rs.	
1st	1400	284	519	84	56	659	318	341	107
2nd	1975	401	733	118	79	930	„	612	192
3rd	2110	429	784	127	84	995	„	677	213
4th	2200	547	817	132	88	1037	„	719	226
5th	2450	498	910	147	98	1155	„	837	263
6th	2890	587	1073	173	116	1362	„	1044	328
7th	3400	691	1263	204	136	1603	„	1285	404
8th	3660	744	1360	220	146	1726	„	1408	443
9th	3700	752	1375	222	148	1745	„	1427	449
10th	3700	752	1375	222	148	1745	„	1427	449

Table 3. *Economics of fertilizer application on coconut*
(For the Government, i.e., in terms of foreign exchange disbursements)

Year after application	YIELD INCREASE		INCOME FROM					Total income Rs.	Imported cost of fertilizer per hectare Rs.	Profit per hectare Rs.	% profit per unit investment
	nuts per Hectare	Kgs copra per hectare	Copra Rs.	Bristle fibre Rs.	Mattress fibre Rs.	Coir yarn Rs.	Shell charcoal Rs.				
1st	1400	284	875	54	67	7	45	1048	383	665	174
2nd	1975	401	1235	76	95	10	63	1479	„	1096	286
3rd	2110	429	1321	81	102	10	68	1582	„	1199	313
4th	2200	447	1377	84	106	11	70	1648	„	1265	330
5th	2450	498	1534	94	118	12	78	1836	„	1453	379
6th	2890	587	1808	111	139	14	92	2164	„	1781	465
7th	3400	691	2128	130	164	17	109	2548	„	2165	565
8th	3660	744	2292	140	176	18	117	2743	„	2360	616
9th	3700	752	2316	142	178	18	118	2772	„	2389	624
10th	3700	752	2316	142	178	18	118	2772	„	2389	624