

Investment in Coconut Fertilizer —National Potential*

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INTRODUCTION

Compared to tea or rubber, the coconut Industry of Sri Lanka lags far behind from the point of view of fertilizer usage. The irony of it all is the fact that gauged from experimental evidence the coconut palm relative to other crops has shown the highest yield responses to fertilizer application (Constable *et al* 1963).

1. History of Fertilizer Usage in Coconut

Table 1. Fertilizer usage and coconut production

Period	Rate of Fertilizer Application	Quantity of Fert. used/annum	Estimated Acreage Fertilized per annum		Estimated Total Production (mean) nuts in millions
	lb/palm/annum	Tons	Acreage*	% of total acreage	
1939—1947	3½	1,000	10,000	1%	1657
1948—1956	3½	14,400	144,000	14.4%	2230
1957—1961	7	38,200	191,000	19.1%	2319
1962—1967	7	49,400	247,000	24.7%	2726
1968—1971	9	61,400	238,000	23.8%	2623
1972—1976	9	27,300	106,000	10.8%	2494

* Rounded Figures

Fertilizer usage on coconut in Sri Lanka and the production levels recorded during the period 1939 to 1976 (Table 1) reveal an important feature that is of immediate interest to those thinking in terms of rehabilitating the Industry.

During the period 1939 - 1947, the rate of application was a mere 3½ lbs. per palm per annum and the acreage fertilized was 10,000 acres, constituting just 1% of the total acreage.

During the period 1948 - 1956, coconut growers (especially the estate sector) became more conscious of the importance of fertilizer and the acreage fertilized rose to 14.4% of the total acreage, while the rate of application remained at 3½ lbs. This increase in the acreage fertilized gave rise to an increase in the Island's Production of 34.6% over the previous period.

During the period 1957 - 1961, with the introduction of the fertilizer subsidy scheme, the total consumption of coconut fertilizer nearly trebled. This increased consumption was more the result of the dosage being doubled to 7 lbs. per palm per annum than the increase in the

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acreage fertilized which was only 4.7%. The resultant increase in the production was only about 5% over the previous period. This failure for production to increase *pari passu* with the increased fertilizer input did create certain amount of doubts in Government circles as to the real benefits of fertilizer. While the recommendation to apply a higher dosage was not incorrect so far as the grower was concerned, the Government which has committed itself to a subsidy scheme did not benefit proportionately with the investment. This is only to be expected in a "diminishing returns" frame work. The Government would have reaped the full benefit of the investment only if an increased acreage took to fertilizer application even at the earlier lower dosage of 3½ lbs. per palm.

During the period 1962-1967, the dosage remained at 7 lbs. as before, but a further extra acreage of 5.6% took up to applying fertilizer. The substantial increase in production by 17.5% over the previous period confirms the validity of the earlier argument that from the national viewpoint, encouraging more growers to apply fertilizer pays higher dividends than trying to encourage a higher dosage.

During the period 1968-1971, the average fertilizer consumption increased to a record 61,400 tons. This increased consumption was again due to an increase in the dosage applied from 7 lbs to 9 lbs, but the acreage fertilized decreased by about 10,000 acres (*i.e.*, 1%). The Island's production dropped by about 4%. This was the time, policy makers quite rightly frowned at any suggestion to invest more on coconut fertilizer. Of course the CRI succeeded in convincing the C.D.A. that the coconut palm does respond remarkably to fertilizer and even recommended the application of a lower dosage over a wider acreage in order to reap the full benefits of the investment. This recommendation however did not receive serious notice.

However during the period 1972-1976, for well known reasons, people gave up fertilizing and the acreage fertilized dropped to a mere 10%. This in turn was reflected by a drop in production by 5%. This drop in production does not appear so alarming compared to what one would have expected from this steep decline in fertilizer consumption. This is because of the residual effects of past fertilizer applications. Plantations that had received fertilizer over a long period would have certain amount of fertilizer residues in the soil and further even the palms themselves would have built up a certain amount of growth potential which would enable them to withstand, at least for some time, the ill effects of fertilizer withdrawal. The years to come will, however, show a substantial decline if immediate steps are not taken to encourage fertilizer application on coconut.

These trends discussed above introduces the main theme of this paper—namely that the problem of increasing production *via* fertilizer use hinges not so much on increasing the fertilizer dosage but getting a bigger acreage to apply fertilizer even at a reduced rate.

2. Comparative Influence of Zones, Weather and Fertilizer Use on Coconut Yields

The major factors (excluding soil differences) responsible for fluctuations in coconut yields are :—

- (a) Zonal differences (*i.e.*, district to district variations)
- (b) Weather (mainly rainfall) changes (*i.e.*, year to year variations within a given area)
- (c) Fertilizer Use.

Excluding areas marginal for coconut such as (1) the Northern and Eastern provinces which get a unimodal rainfall distribution (*viz.* only the North-East monsoonal rains), (2) Areas in higher altitudes which have low temperature and (3) Hambantota district which has very low rainfall, the gap in yield in the rest of the region (where coconut can be considered an economic crop) as conditioned by each of the above three factors at average levels of the other two factors has been estimated to be as follows:

Table 2. *Relative influence of zones, weather and fertilizer use on yield variations*

	<i>Gap in yield Nuts/Acre</i>	<i>Relative Contribution</i>
Zones	820	25%
Weather	980	30%
Fertilizer	1500	45%

From the above it is apparent that if the influence on yield variations of each factor is considered at average levels of the other two factors, the influence of fertilizer is the highest, second comes the weather and lastly the Zonal differences.

Table 3 shows the yields to be expected at different combinations of the three factors. The yields range from 1180 nuts/acre/annum under worst conditions to 4480 nuts/acre/annum under best conditions. The average yield per acre over the Island is estimated to be 2080 nuts.

Table 3. *Potential yields in every possible combination of the above three factors*

<i>Fertilizer</i>	<i>Climate</i>	<i>Weather</i>	<i>Yield nuts/acre/ annum</i>
Without	Poor	Poor	1180
Without	Poor	Good	1670
Without	Good	Poor	1590
Without	Good	Good	2980
With	Poor	Poor	2680
With	Poor	Good	3170
With	Good	Poor	3690
With	Good	Good	4480

This gap in yield would of course be wider if we take the soil complex into consideration and also the interaction between the three factors mentioned.

3. *The masking effect of weather on response to fertilizer*

It is sometimes difficult to convince the average coconut grower and economists who come to conclusions on survey data and also administrators of fertilizer policy that it pays to fertilize the coconut palm in spite of the universal acceptance that fertilizer is the shortest cut to increased agricultural production. This is on account of the wide fluctuations of yearly coconut yields arising from changes of weather—particularly rainfall. Such yield variations can at times mask the response to fertilizer application.

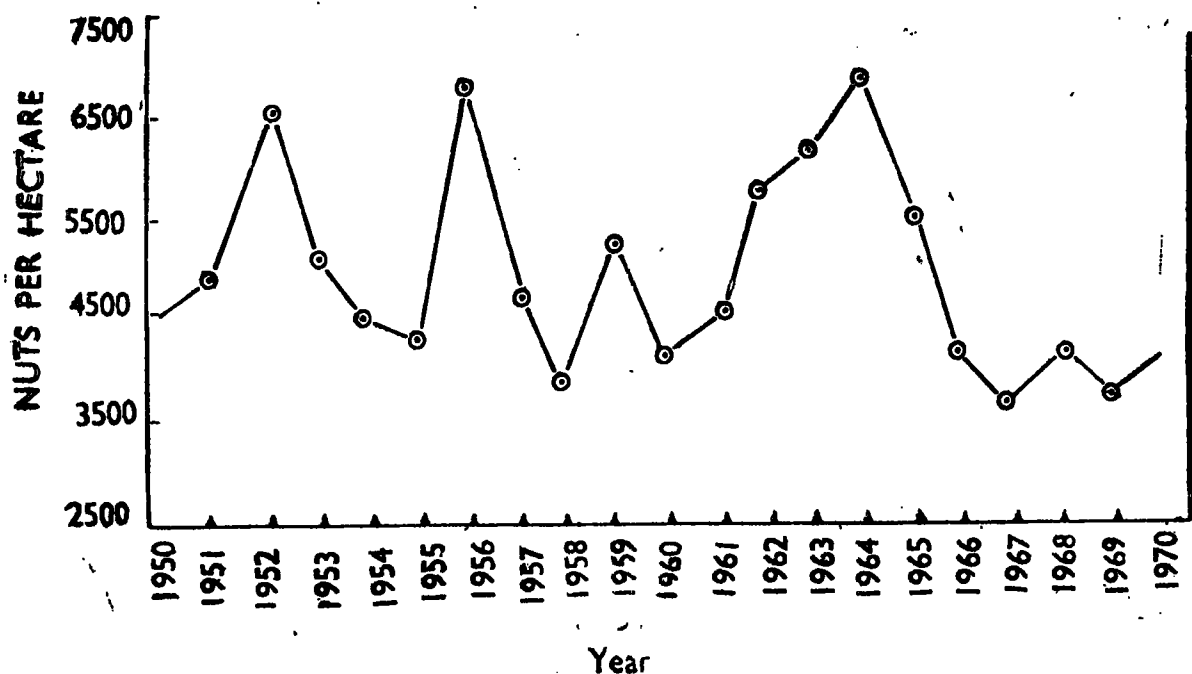


Fig 1. Yields of an unfertilized coconut plantation.

Fig. 1 shows the production trends of an unfertilized coconut land in Chilaw district. These fluctuations in yield are mainly due to changes in weather conditions.

Suppose we consider the case of an individual who commences applying fertilizer to his land in 1964 when his crops were at almost a peak. From the following year itself his crops will start falling down. This decline is not due to any harmful effect of the fertilizer but due to the adverse weather conditions that prevailed. However 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 been even less.

The coconut research worker can however through controlled experiments see through these masking weather fluctuations by estimating the true response to fertilizer application as the difference between fertilized and unfertilized plots side by side and probably made clearer by other statistical adjustments. This type of unequivocal clarifications cannot be obtained from survey data.

4. Response to Fertilizer

The response to fertilizer was measured as the difference between the plots given the treatment $N_0P_0K_0$ (*i.e.*, untreated) and the plots given the treatment $N_2P_1K_2$ which gave the best yield. This treatment $N_2P_1K_2$ 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_2O_5) and 0.57 kg. (1.25 lbs.) of Muriate of Potash (60.0% K_2O) calculated on a yearly basis.

One could obtain the progressive responses to fertilizer over time by deducting from each such difference the initial (*i.e.*, pre-manurial) difference between the two sets of plots. However these differences 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_{yx}) between the yields (x) of the unfertilized plots year by year and the corresponding absolute responses (y). The relationship was significant, r being equal to +0.64 ($P = < 0.05$).

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

Table 4. Response to fertilizer adjusted for weather differences

Year of Application	Response	
	Copra kg/ hectare	Nuts/ hectare
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 4.

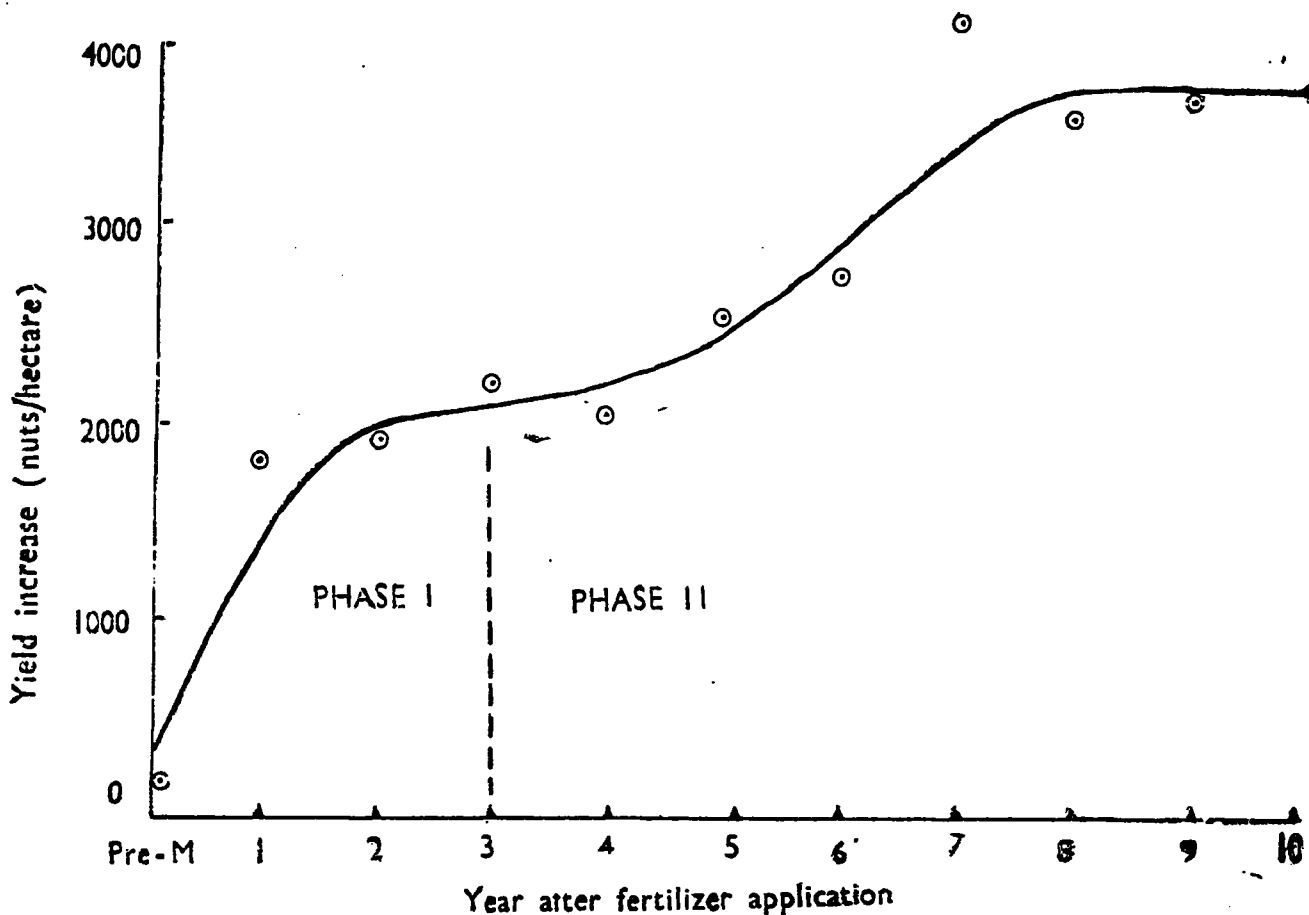


Fig 2. Response to fertilizer time.

Table 5. *Economics of fertilizer application on coconut*
(for the Government, i.e., in terms of Foreign Exchange Disbursements)

Year after appli- cation	YIELD INCREASE		INCOME FROM					Total income	Imported cost of fertilizer per Hectare	Profit per Hectare	% Profit per unit investment
	Nuts per Hectare	Kgs. copra per Hect.	Copra	Bristle Fibre	Mattress Fibre	Coir Yarn	Shell Charcoal				
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

There is a very clear progressive build up of the response (*i.e.*, yield increase) 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.

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

The econometric basis of a reduced dosage is clear from Fig. 3.

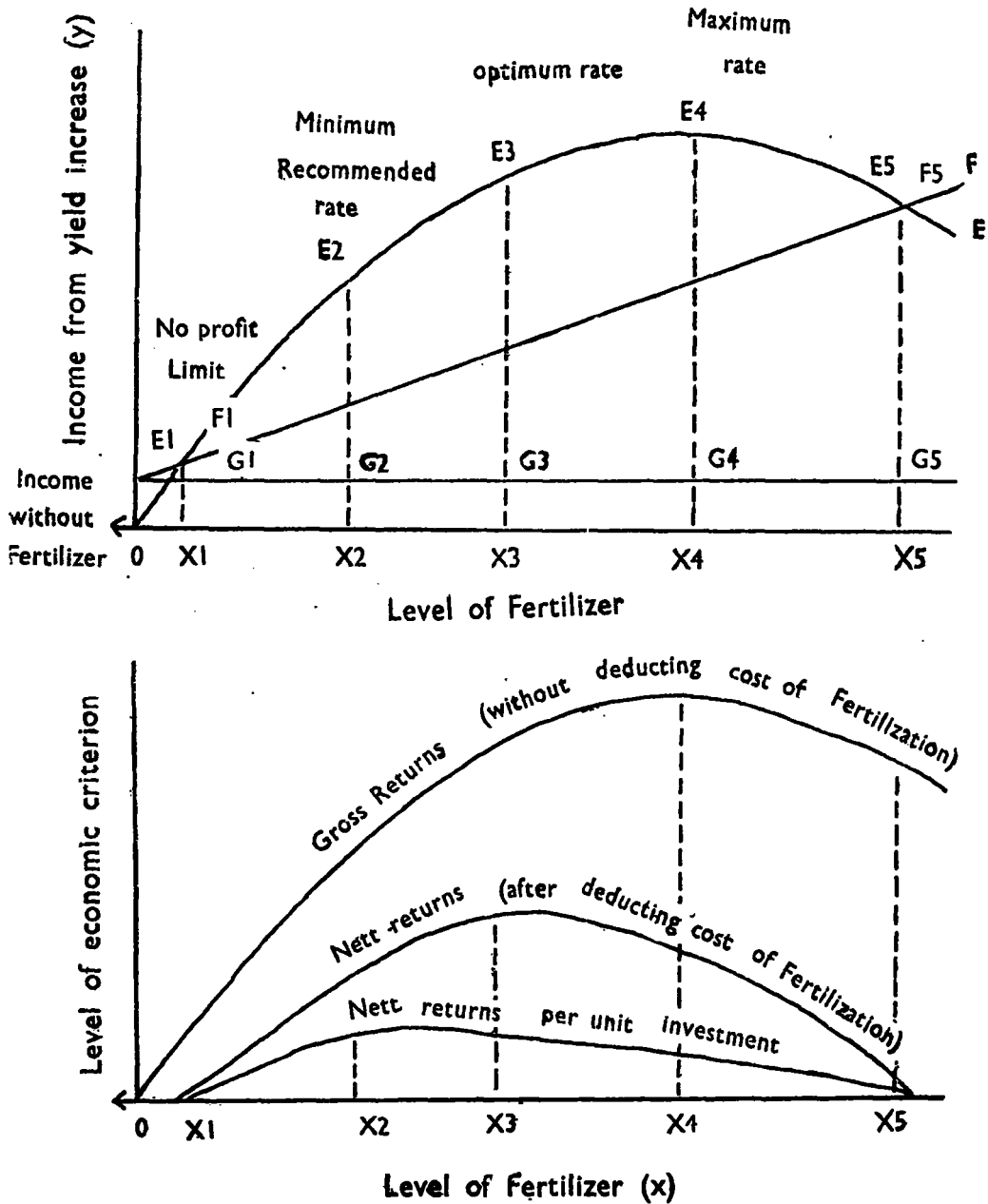


Fig 3. Critical levels of fertilizer application.

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. The explanation for this two-phased build up of the response has been discussed by Abeywardena (1978).

5. Economics of Coconut fertilizer from the National Angle

The economics of fertilizer use based on the visually fitted curve in Fig. 2 have been worked out by Abeywardena (1978).

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—is shown in Table 5.

It is clear that the Government can net in a return per unit investment of 174% in the first year after manuring. This builds up progressively to 624% by about the 10th year after manuring.

6. Case for a reduced dosage from the National Angle

It would be pertinent to stress that the dosage of fertilizer on the basis of which the above economic evaluation was made is only 2.50 kg. (5.50 lbs.) per palm. This is only slightly above half the current recommended dosage of 4.08 kg. (9 lbs.) per palm.

Suppose we are prepared to accept that the current recommended dosage is the optimum or profit maximising dosage. Then it could be argued that in a situation as it is today when our foreign exchange resources are at a low ebb and also when these scarce foreign exchange earnings have other important avenues of investment; a reduced dosage (say) 6 lbs/palm over a wider area is a far more paying proposition to the Government. Moreover this would attract more growers to take up to fertilizer with substantial returns to themselves.

The response curve (in terms of income) is OE (Fig. 3). This is the income from yield in excess of what is obtainable without the addition of fertilizer, as indicated by the fact that the curve starts from the origin zero. Let G_0G be the line indicating fixed costs, *i.e.*, cost of application; F_0F the line representing cost of fertilization, *i.e.*, cost of fertilizer plus cost of application; and OX and OY are the fertilizer and income axes respectively.

With a response curve of this type it is possible to define as much as five critical economic criteria with regard to the level of fertilizer application. There are two points at which the cost curve F_0F cuts the income curve OE. These are E_1F_1 and E_5F_5 and may be termed "break-even" points. The corresponding rates of fertilizer application are X_1 and X_5 and therefore the range X_1 to X_5 constitutes the profitable range of fertilizer application. The third critical level is X_4 corresponding to the maximum production. The fourth critical level is the optimum level X_3 at which point the absolute nett profit (EF) is a maximum and therefore is the recommended level of fertilizer application provided capital is not limited.

However when capital is limited or when there are alternative investments, we are compelled to apply reduced rates. These reduced rates should not be lower than what econometricians term the "minimum recommended rate" (Pesek and Heady, 1958). What is this "minimum recommended rate"?

As the rate of application is reduced from the optimum level X_3 , the relative profit (*i.e.*, $\frac{EF}{FX}$) giving the average return per unit of investment in fertilizer) increases until we reach a point X_2 at which this criterion is a maximum. Therefore although the lowering of the rate of application below X_3 (the optimum dosage) brings about a lower absolute nett profit, the average return per unit of investment increases down to X_2 , thereby ensuring in fact a more efficient use of fertilizer resources per rupee invested. This critical point X_2 is what is termed the "minimum recommended rate". There is therefore economic sense in lowering the dosage upto the minimum recommended rate X_2 when capital is limited.

Table 6. Comparative economics of applying dosages of 6 lbs and 9 lbs per palm per year over the island

Rate of Application	Criterion	Year after commencement of manuring									
		1	2	3	4	5	6	7	8	9	10
9 lbs per palm per year	Quantity of fertilizer (Met. tons)	301097	301097	301097	301097	301097	301097	301097	301097	301097	301097
	Cost (Rs. in millions)	309.4	309.4	309.4	309.4	309.4	309.4	309.4	309.4	309.4	309.4
	Extra production (nuts in millions)	592.9	881.6	958.8	994.3	1103.3	1284.7	1537.7	1688.0	1712.6	1712.6
	Extra income (Rs. in millions)	370.2	550.9	608.8	622.8	691.5	804.1	962.5	1056.3	1071.6	1071.6
	Nett profit (Rs. in millions)	60.8	241.5	291.4	313.4	382.1	494.7	653.1	746.9	762.2	762.2
	% profit per unit investment	20	78	94	101	124	160	211	241	246	246
6 lbs per palm per Year	Quantity of fertilizer (met. tons)	200731	200731	200731	200731	200731	200731	200731	200731	200731	200731
	Cost (Rs. in millions)	206.3	206.3	206.3	206.3	206.3	206.3	206.3	206.3	206.3	206.3
	Extra production (nuts in millions)	539.1	801.4	871.6	903.9	1003.1	1167.1	1397.9	1534.6	1557.0	1557.0
	Extra income (Rs. in millions)	337.0	501.2	545.8	565.8	628.4	730.5	875.0	960.8	974.5	974.5
	Nett profit (Rs. in millions)	130.8	295.0	340.0	360.0	422.2	524.3	668.8	754.6	768.3	768.3
	% profit per unit investment	63	143	165	174	205	254	324	366	372	372

7. *Alternative Proposals for Promotion of Fertilizer Application to Coconut*

(i) Application of reduced dosage over the whole Island.

The comparative economics of applying a reduced dosage of 6 lbs/palm over the whole Island as opposed to a dosage of 9 lbs per palm is shown in Table 6.

In the first year, an initial outlay of Rs. 206 million is needed when application is at the rate of 6 lbs/palm as compared to Rs. 309 million when the rate of application is 9 lbs/palm. The extra production to be expected is 539 million nuts when the rate of application is 6 lbs/palm and 593 million when the rate is 9 lbs/palm. However the nett profit as well as the percentage profit per unit investment is higher at the reduced dosage. The economics upto the 10th year is shown in Table 6.

(ii) *Zone-wise application of Fertilizer*

If a reduced dosage over the whole Island is considered to be still beyond our capacity, one can think in terms of a phased programme of fertilizer application commencing with a zone or two to begin with.

The island can be divided into five zones in descending order of their coconut potential.

Such a zonal grouping is shown in Table 7.

Table 7. *Zonal Grouping, of districts and their Potential*

Zone	Classification	Districts	Area hect ares	Yield nuts/ hectare *	Total production (nuts in millions)
I	Intermediate	Matara, Kurunegala, Chilaw, Monaragala	210,989	5273	1113
II	Wet	Colombo, Kalutara, Kandy, Matale, Galle, Kegalla, Ratnapura	176,150	4349	766
III	Dry	Hambantota, Mannar, Vavuniya, Puttalam, Anuradhapura, Polonnaruwa]	54,460	2921	159
IV	Unimodal Rainfall	Jaffna, Batticaloa, Amparai, Trincomalee	23,668	1873	44
V	Low Temperature	N'eliya, Badulla	1,095	2567	3

*Census of Agriculture 1952 — Coconuts

The yearly yield increases to be expected over a ten-year period of application of fertilizer at the reduced rate by Zones is shown in Table 8 (a).

The economics of such a zone-wise application is shown in Table 8 (b).

Table 8(a). Yield increase from applying reduced dosage of 6 lbs/palm/year—Zone-wise

Zone	Area (Hectares)	Fertilizer input per annum		Total produc- tion with- out fer- tilizer (nuts in millions)	Yield increase (beginning 1st year after manuring) (nuts in millions)									
		Quantity (M.tons)	Cost (Rs. in millions)											
					1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
I	210989	90814	93.3	1112.6	295.4	416.7	445.2	464.2	516.9	609.8	717.4	772.3	780.7	780.7
II	176150	75818	77.9	766.1	176.2	280.1	308.3	317.1	352.3	405.1	493.2	546.1	554.9	554.9
III	54460	23440	24.1	159.1	49.0	75.2	83.9	87.1	95.3	108.9	133.4	152.5	156.3	156.3
IV	23668	10187	10.5	44.3	17.8	28.4	33.1	34.3	37.3	42.6	52.1	61.5	62.7	62.7
V	1095	472	0.5	2.8	0.7	1.0	1.1	1.2	1.3	1.5	1.8	2.2	2.4	2.4

Table 8(b). Economics of applying reduced dosage of 6 lbs/palm/year—Zone-wise

Zone	Area (Hectares)	Fertilizer input per annum		% Profit per unit investment (beginning 1st year after manuring)									
		Quantity (M.tons)	Cost (Rs. in millions)										
				1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
I	210989	90814	93.3	98	179	199	211	247	309	381	418	424	424
II	176150	75818	77.9	41	125	148	155	184	225	296	339	346	346
III	54460	23440	24.1	27	95	118	126	148	183	247	297	306	306
IV	23668	10187	10.5	6	70	99	105	123	155	211	269	275	275
V	1095	472	0.5	2	22	43	63	63	84	124	186	206	206

Table 9(a). *Yield increase from applying reduced dosage of 6 lbs/palm/year over different proportions of the total acreage*

Proportion of area fertilized	Area (hectares)	Fertilizer/input/annum		Total production without fertilizer (nuts in millions)	Yield increase (beginning 1st year after manuring) (Nuts in millions)									
		Quantity (M.Tons)	Cost (Rs in millions)		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
					100%	466362	200731	206.3	1112.6	539.1	801.4	871.6	903.9	1003.1
75%	349771	150549	154.7	766.1	404.3	601.1	653.7	677.9	752.3	875.3	1048.4	1151.0	1167.8	1167.8
50%	233181	54959	103.1	159.1	269.6	400.7	435.8	452.0	501.6	583.6	699.0	767.3	778.5	778.5
25%	116591	50183	51.6	44.3	134.8	200.4	217.9	226.0	250.8	291.8	349.5	383.7	389.3	389.3
12.5%	58296	25092	25.8	2.8	67.4	100.2	109.0	113.0	125.4	145.9	174.7	191.8	194.6	194.6

Table 9(b). *Economics of applying reduced dosage of 6 lbs/palm/year over different proportions of the total acreage*

Proportion of area fertilized	Area (Hectares)	Fertilizer/input/annum		% profit per unit investment (beginning 1st year after manuring)									
		Quantity (M.Tons)	Cost (Rs. in millions)	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
				100%	466362	200731	206.3	63	143	165	174	205	254
75%	349771	150549	154.7	63	143	165	174	205	254	324	366	372	372
50%	233181	54959	103.1	63	143	165	174	205	254	324	366	372	372
25%	116591	50183	51.6	63	143	165	174	205	254	324	366	372	372
12.5%	58296	25092	25.8	63	143	165	174	205	254	324	366	372	372

(iii) *Fertilizer application over different proportions of the total acreage*

An alternative to a zone by zone promotion of fertilizer application is to commence a phased programme commencing with a fraction of the area at a time—applications for fertilizer to be considered on a “First come first served basis.”

The yield increase to be expected over a 10-year period with the application of fertilizer at the reduced dosage over different proportions of the total acreage is shown in Table 9 (a).

The economics of such a scheme is shown in Table 9 (b).

(iv) *Fertilizer application in holdings below a certain size*

Another alternative to promote extensive fertilizer use is to offer more generous subsidies to the relatively smaller sized holdings, while the bigger holdings will continue to enjoy the present subsidy.

The economics of such a scheme cannot be worked out as the statistics available on coconut acreage under different holding sizes are not up to date.

8. *Discussion and Summary*

From the facts presented in this paper, there can be no argument that every effort has to be made to promote fertilizer use for coconut, if we are to save the industry and put off if not avoid the grim prospect of having to import coconut for domestic consumption, quite apart from earning valuable foreign exchange.

In the context of scarce foreign exchange resources and the Government saddled with the problem of alternative avenues of investment of this scarce foreign exchange, one has to think seriously in terms of a reduced dosage over a wider acreage which ensures a higher return per unit investment.

Even at such a reduced dosage, an attempt to get island-wide coverage may present problems. If so, a phased programme either covering selected zones at a time or a fraction of the area at a time, or giving higher subsidies for the smaller holdings or evolving an optimum combination of these approaches is recommended.

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