RESPONSE OF COCONUT PALMS (*Cocos nucifera* Linn.) TO N, P AND K FERTILIZER APPLICATION ON THE WEST COAST OF INDIA

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INTRODUCTION

Three fourth of the area under coconut in India lies in the West Coast, where mainly three types of soil viz. Sandy loam, Coastal sand and laterite are met with. Not much work has been done in the country on the manurial requirement of coconut under different types of soil. PATEL (1938) has reported in detail about the observational trials carried out on a deep red sandy loam soil of the Central Coconut Research Station (present Central Plantation Crops Research Institute), Kasaragod, India with different sets of arbitrarily selected manurial mixtures, but no comprehensive trial had been conducted on the requirement of N, P and K for coconut till 1953 in India.

The present study was initiated in the year 1953 and concluded in 1965 with the object of studying the response of bearing coconut palms growing in sandy loam soil, which forms the major soil type on which coconut is grown on the West Coast, to the application of N, P and K each at three levels with and without green manuring. PANDALAI and MARAR (1962) have reported the effect of NPK fertilizers on the yield and quality of nuts for the initial years of this experiment. In this paper an attempt has been made to give the abstract of results of the yield data of the individual years and also the combined analysis of yield as well as nut characters for the 10-year period 1955-1964.

EXPERIMENTAL

An NPK factorial experiment consisting of 54 treatments, laid out in $3^3 \times 2$ confounded design with 6 plot blocks and replicated twice was adopted. The experiment was conducted in the sandy loam soil at Central Plantation Crops Research Institute, Kasaragod. The results of chemical analysis of soil samples is given in Table I.

The three levels of nutrients adopted for investigation were 0, 0.34 kg and 0.68 kg each per palm per year. Nitrogen was applied as ammonium sulphate, phosphoric acid as super phosphate (ordinary) and potash as muriate of potash. *Crotolaria striata* was grown and incorporated as the green manure crop for the first 4 years and later green leaf manure was brought from outside and applied at 25.0 kg per palm per year since the growth of *Crotolaria striata* was not satisfactory.

Middle aged West Coast Tall palms were used for the experiment. Spacing of the palms was 25'. Fertilizer was applied in basins of 6' radius during the month of August each year. The normal cultural operation of ploughing thrice with iron plough were carried out.

Individual palm yield was recorded for every month for all the plots.

In studying the effect of manures on quality of nuts, samples of nuts (4 nuts per plot) harvested from

TABLE I

Mean percentages of plant nutrient contents of sandy loam soil in the experimental fields

(Expressed on oven dry basis)

Total Nitrogen (N) %	Total P_2O_5 %	Total K_2O %	Lime CaO %	Magnesia MgO %	Available P_2O_5 %	Available K_2O %	Available Nitrogen (N) %
0.045	0.070 4	0.323 3	0.153	0.12	0.002 85	0.001 93	0.010 2

TABLE II

Abstracts of Analysis of variance (Adjusted) showing significant effects

Source	Degrees of freedom	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	Combined analysis of 10-year data
Blocks	17	NS	NS	S**	S**	NS	S**	S*	S*	S**	NS	NS	S*
N	2	NS	S**	S**	S**	S**	S**	S*	S*	S**	S**	S**	S**
P	2	NS	NS	NS	NS	NS	S**	NS	NS	S*	S*	S**	S*
K	2	NS	NS	NS	S*	S**	S**	S*	S**	S**	S**	S**	S**
G	1	NS	NS	S*	NS	NS	NS	NS	NS	NS	NS	NS	NS
NP (J).....	2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
NK (J)	2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
PK (J)	2	NS	S*	S*	NS	NS	S*	S*	S*	S*	S*	S*	S*
NG	2	NS	NS	NS	NS	S*	NS	NS	NS	NS	NS	NS	NS
PG.....	2	NS	NS	NS	NS	NS	S*	NS	NS	NS	NS	NS	NS
KG	2	NS	NS	NS	NS	NS	NS	NS	NS	S**	NS	S*	NS
Other higher order interaction	20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Error.....	50	—	—	—	—	—	—	—	—	—	—	—	—

NS — Not significant P > 0.05
S* — Significant P < 0.05
S** — Significant P < 0.01

the experimental plots during the month of January each year were studied in detail for weight and volume of unhusked and husked nuts and copra content per nut. Oil content of the nuts under different treatment was estimated for the year 1958 and 1959 by Soxhlet extraction method.

To find out whether the fertilizer treatment has had any effect on foliar yellowing, palms showing this symptom in the different plots were counted for three consecutive seasons (1957-1959).

RESULTS

Yield.

The abstract of the results of statistical analysis of the yield data of individual years from 1954-1964 and that of the combined 10-year period (1955-1964) are summarised in Table II to show at a glance the significance or otherwise of the main effects and two factor interactions.

The main effects of nitrogen showed significance for the first time in 1955, i.e. in the third year after the commencement of fertilizer application and have been showing similar effects consistently every subsequent year till the experiment was concluded. The results of analysis of the combined 10-year data confirmed the importance of nitrogen in coconut fertilization (Table III). The mean increase in yield for the 10-year period was 8.1 nuts (16. 9%) per palm per year. The difference in yield among the two levels in the combined analysis was not significant. As the inflexion point in the response function was found to be within the dosage range tried, the optimum dosage of nitrogen and the corresponding yield estimates were obtained, by fitting quadratic functions to the data. Response function for nitrogen for the combined 10-year data was found to be $Y = 47.80 + 37.50\ X - 40.23\ X^2$. Among the individual years, the optimum dose of nitrogen varied from 0.40 kg to 0.65 kg with a mean value of 0.48 kg and the yield estimates varied from 50.7 to 60.6 nuts, with a mean of 56.0 nuts per year. Both these values agree well with the corresponding estimates obtained from the combined 10-year data viz. 0.47 kg and 56.5 nuts. It is to be noted in this connection that a yield of 55.9 nuts had actually been obtained in the experiment for N_1 (0.34 kg).

TABLE III

Response in yield to the different levels of application of N, P and K based on the combined 10-year data

Levels of nutrient	N	P	K
0	47.8	50.9	50.0
1	55.9	53.5	54.0
2	54.7	53.9	54.4
Mean.....	52.8	52.8	52.8
L. S. D. (5 %) ..	2.3	2.3	2.2
Conclusion	$N_1\ N_2\ N_0$	$P_2\ P_1\ P_0$	$K_2\ K_1\ K_0$

Phosphorus failed to show any significant effects for the first nine years (1959 was an exception) but then for the next three years significant effects were seen. The combined analysis also revealed significant main effects for P, probably reflecting the trend

TABLE IV

Main effects of N, P and K on nut characters

Main effect	Mean value and percentage increase or decrease over no nutrient for different characters (10-year average)				
	Weight of unhusked nuts (gm)	Volume of unhusked nuts (cc)	Weight of husked nuts (gm)	Volume of husked nut (cc)	Copra weight per nut (gm)
N_0	987.1	2 619	535.3	583.1	179.2
N_1	928.6** (— 5.9)	2 502 (— 4.4)	482.1** (— 9.9)	530.9** (— 9.0)	164.8** (— 8.0)
N_2	890.6** (— 9.8)	2 404** (— 8.2)	467.0** (— 12.8)	516.6** (— 11.4)	162.1** (— 9.5)
P_0	934.4	2 517	489.8	537.5	168.9
P_1	932.2 (— 0.2)	2 513 (— 0.1)	499.1 (1.9)	550.9 (2.5)	169.5 (0.4)
P_2	939.7 (0.6)	2.496 (— 0.8)	495.5 (1.2)	542.2 (0.9)	167.7 (— 0.7)
K_0	895.0	2 331	476.9	530.4	163.3
K_1	953.6** (6.6)	2 562** (9.9)	503.3* (5.5)	550.2 (3.7)	171.0* (4.7)
K_2	957.7** (7.0)	2 632** (12.9)	504.1* (5.7)	550.1 (3.7)	171.8* (5.2)

* Significant at 5 % level ** Significant at 1 % level

( ) figures in the bracket denote percentage increase or decrease over no nutrient.

observed in the later years. The difference in yield between the two dosages, however, was not significant. As the linear component of the treatment variance alone was significant, the optimum dosage seems to lie beyond the higher dosage tried in the experiment.

Potash showed significant impact on yield for the first time in the fifth year (1957) and had been showing similar results for the subsequent years. Both the lower and higher doses of potash gave significantly higher yields than « no potash » treatment. Higher level of potash gave higher yield than lower level, though the difference was not significant (Table III). As in the case of phosphorus, the linear component alone was significant showing thereby that the optimum dosage may be beyond the higher dosage tried in the experiment.

The application of green manure did not make any significant impact on yield in any of the years.

Among the two factor interactions, only PK showed consistent effects. It turned out to be significant in eight out of eleven years and also for the combined 10-year data.

For a correct assessment of yield response, a response function of the form $Y = 44.957 + 12.644\,N - 4.600\,N^2 + 1.961\,P - 1.117\,P^2 + 3.927\,K - 1.750\,K^2 + 1.767\,PK$ was fitted to the data. On testing the coefficients N and N^2 were found to be highly significant and that of K and PK at 5 per cent level. Attempts made to work out from the response surface function the optimum dosage values (per palm per year) of N, P and K gave the following results :

$N = 0.47$ kg ; $P_2O_5 = 1.00$ kg ; $K_2O = 0.89$ kg.

Nut characters.

The main effect of N, P and K on nut characters are summarised in Table IV. The effects of green manuring and first order interaction were negligible. Only nitrogen and potash have marked effect on the nut characters studied. P was totally ineffective. Nitrogen has affected all the nut characters adversely. The depressive effect tends to be more at higher level of application but the differences were not significant.

As opposed to nitrogen the effect of potash has been very beneficial and this effect tends to be enhanced at higher level though the differences were not significant.

Copra out-turn per tree.

This depends upon both the yield per palm and copra weight per nut and is worked out by multiplying the yield of nuts by copra weight per nut. The pattern of response for the period 1955 to 1964 as percentage over « no nutrient » is graphically represented in Figure 1.

It is seen that nitrogen had relatively little effect on the copra out-turn per palm. In the case of phosphorus there is evidence of some beneficial effect both at lower as well as higher level of application. Potash has very beneficial effect which tended to increase with passage of time.

Oil content.

There was not much difference in the oil content of nuts due to different treatments.

Foliar yellowing.

The results relating to the main effects of N, P and K are summarised in Table V. The data appear to show that within dosage ranges tried nitrogen seems to have increased and potash reduced the occurrence of foliar yellowing ; P did not have any marked effect either way.

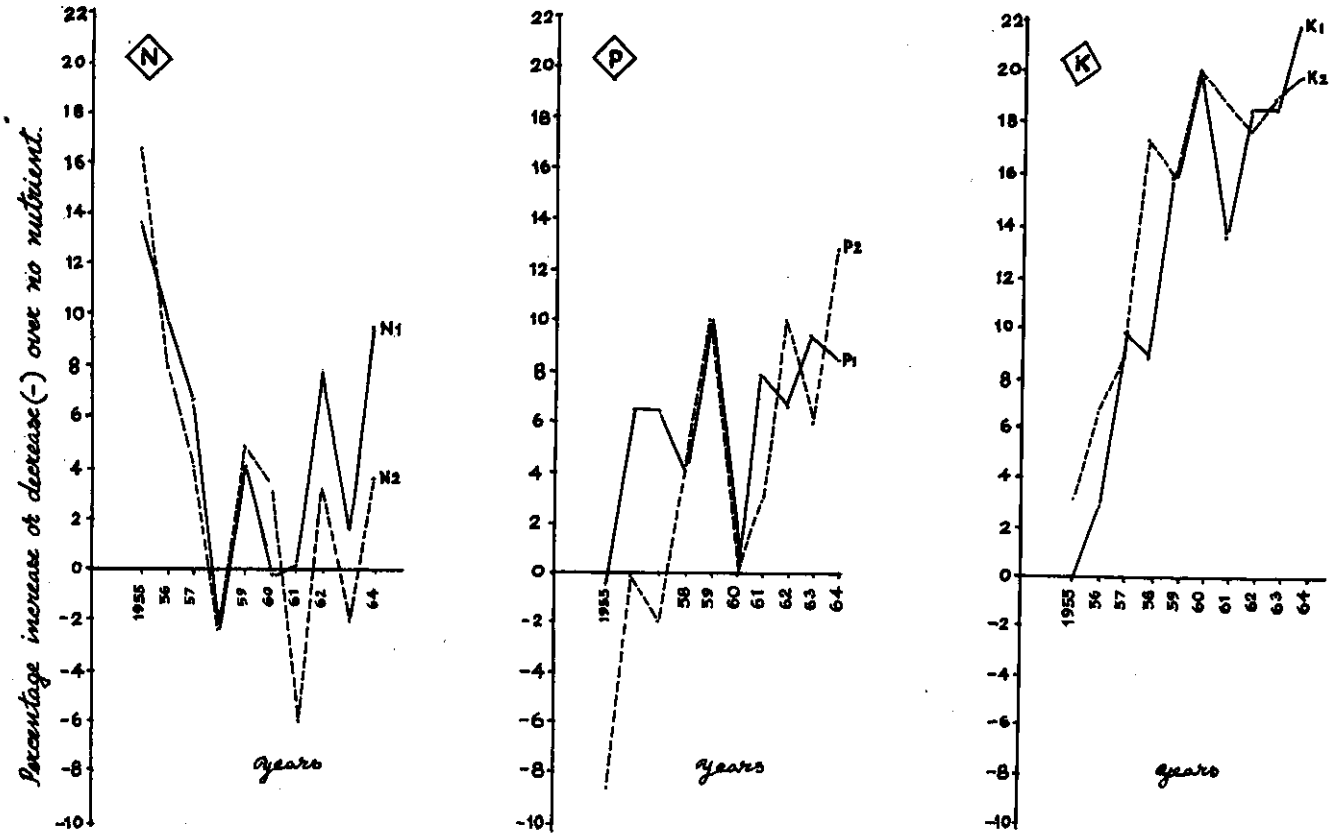

Fig. 1. — Main effect of N, P and K on copra out-turn per tree.

TABLE V

Main effects of N, P and K on foliar yellowing

Level of nutrient	Percentage of tree showing foliar yellowing (Mean of 3 years)		
	N	P	K
0	2.4	5.6	9.8
1	5.4	4.9	3.4
2	7.6	4.9	2.2

DISCUSSION

From the results it is clear that nitrogen at lower level increases the yield, the mean increase being 8.1 nuts (16.9 per cent) per palm per year, whereas the higher level of nitrogen depressed the yield. Yield increase by the application of nitrogen was also reported from Coconut Research Institute, Ceylon by analysing the data for 26 years of a 3^3 factorial experiment [Eden *et al.* 1964]. The application of nitrogen had relatively only a little effect on the copra out-turn, due to its adverse effects on the copra weight per nut which is in conformity of the findings of Frémond and Villemain (1964), Frémond and Gros (1958) and Eden *et al.* (1964). By fitting the response function the optimum dose of nitrogen was found to be 0.47 kg per palm per year under the conditions prevailing at Central Plantation Crops Research Institute, Kasaragod.

Phosphorus did not have any effect on yield in the initial years but during the last 3 years as well as the combined 10-year data show significant effect in yield probably due to accumulation and slow release of fixed phosphorus from the soil. It has been shown [Eden, *Loc. cit.*] that in Ceylon phosphorus had little effect on yield but in another trial in the same country phosphorus has given significant response in yield. Anon, (1955). Smith (1969) and Frémond and Gros (*Loc. cit.*) showed that the application of phosphorus had little effect on yield. Increased yield can be expected much earlier by the application of high dosage of phosphorus by satisfying the fixing capacity of the soil. The response function was linear in shape, showing thereby that the optimum dosage lies beyond the higher dosage tried in the experiment. Application of phosphorus did not affect any of the nut characters studied whereas it has increased the copra out-turn per nut both at lower as well as higher level of appli-

cation. SMITH (*Loc. cit.*) reported increase in size of the nut by the application of phosphorus.

Compared to nitrogen, there was more time lag before getting significant response to potash (Table I). It has increased not only yield and copra out-turn but also all the nut characters studied. The beneficial effect was more pronounced at higher level of application which tended to increase with passage of time. FRÉMOND and GROS (1956), EDEN *et al.* (*Loc. cit.*), VILLEMAIN (1964) and CHARLES (1965) showed the beneficial effect of potash application on copra production and yield of nuts. Though the mean increase in copra out-turn over the 10-year period was only 13.9 per cent it was 21.8 per cent during the last year of the experiment. This increase is more due to the increased number of nuts than to the increased copra weight per nut.

In sandy loam soil at Kasaragod, application of organic matter was not found necessary in addition to NPK fertilizer application. Similar result was reported from Ceylon [ANON, 1963].

Among the two factor interactions only PK showed beneficial effects. The presence of one of these nutrients only, in the absence of the other did not make any appreciable impact on yield while the application of both these nutrients together had a very beneficial effect. EDEN *et al.* (*Loc. cit.*) showed an interaction between nitrogen and potash. Considering the individual treatments $N_1P_1K_2$ gave the maximum average yield of 62.0 nuts.

The results of seven year data (1958-1964) showed that the quantum of response in yield and the percentage increase over the pre-treatment period steadily decreased with increase in the initial bearing capacity of the palms. Under the conditions of the experiment there has been practically no benefit due to fertilizer application on palms yielding 50 nuts or more per year during the pre-treatment period.

A most interesting observation in this experiment was the occurrence of foliar yellowing which increased with the increase in the dosage of nitrogen and decreased with the increase in the dosage of potash, phosphorus having no effect. It has been shown [OSBORNE and HEWITT 1963] that in Banana also similar yellowing occurred due to the excess of nitrogen and deficiency of potash. SIMMONDS (1959) reported that potash deficiency is the main causative factor for premature yellowing of Banana.

From the above it is clear that the balanced application of fertilizer to coconut is not only beneficial but also necessary for increasing the production of coconuts.

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