

Effect of graded levels of NPK on the reproductive characters and yield of hybrid coconut COD x WCT

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A field experiment was conducted at Coconut Research Station, Aliyarnagar, Tamil Nadu, to study the effect of graded levels of NPK fertilisation on the reproductive characters and yield of coconut hybrid Chandra Sankara (COD x WCT). The three levels of treatments of N (0, 500, 1000 g palm⁻¹ year⁻¹), P (0, 108,216 g palm⁻¹ year⁻¹) and K (0, 830,1660 g palm⁻¹ year⁻¹) comprised of 27 combinations, formed the treatment structure. The experiment was laid out in 3³ confounded design with two replications. Application of graded doses of nitrogen and potassium increased bunches harvested, female flowers produced per inflorescence and nut yield of palms and the differences among the treatments were significant. In addition, application of graded levels of N also increased the number of functional leaves. Application of graded levels of P did not influence these characters. Application of NPK at 1000:216:1660 g palm⁻¹ year⁻¹ recorded a mean yield of 146 nuts and at 50 percent of the above rates a mean yield of 142 nuts palm⁻¹ year⁻¹ was recorded. When N was the major limiting nutrient under the framework of the experiment, the influence of other nutrients such as P and K was not much expressed, however important is their role in nutrition of palms. The data also indicated a decrease in yield of palms at 1660 g of K application during 1996-97 and 1999-2000. Trivariate extension of the quadratic model without higher order interaction terms fitted to the yield accounts for 98.3 % of the variation. The physical optimum rate of fertiliser requirement works out to 818, 130 and 1362 g palm⁻¹ year⁻¹ of N, P and K respectively with a yield of 159 nuts palm⁻¹ year⁻¹. The available N, P and K varied between 49 and 62 ppm, 69 and 139 ppm and 68 and 268 ppm respectively and their reflect on the plant nutrition of N, P and K indicated sufficiency levels in the palm. Application of graded levels of NPK fertilisers influenced the copra content and copra yield. Application of NPK at 500:108:830 g palm⁻¹ year⁻¹ recorded 178 g copra nut⁻¹ and 26.0 kg copra palm⁻¹. The CB ratio was 1.91 for the above treatment with a net income of Rs 35,509/- ha⁻¹, while in the control treatment the net income was negative.

Keywords: Coconut hybrid, NPK levels, yield, reproductive characters, and BCR

Coconut is grown in an area of 1.946 million ha in India with an annual production of 14811 million nuts and a productivity of 7608 nuts/ha⁻¹ (2005-06). Tamil Nadu is one of the premier coconut producing states with a share of 19.03 % in area and 32.86 % in production. To sustain and enhance productivity it has become essential to plant superior varieties and hybrids both in replanting and area expansion programmes. For the existing tall cultivars a quantity of 560:138: 996 g NPK is recommended for adult tall coconut palms under Tamil Nadu conditions (Anon, 1999). Chandra Sankara, a hybrid (COD x WCT) was released for general cultivation in Kerala, Tamil Nadu and Karnataka during 1985. It is known that different varieties of coconut give varying yield responses to fertilizer application (Vernon et al., 1976 and Khan *et*

al., 1986). Growth curves are useful for modeling the response to a particular variable. These curves, which describe the relationship of yield to fertilizer application, provide the basis for calculating optimum fertilizer application rates. Information on the response of this coconut hybrid to applied nutrients and a suitable fertilizer schedule is not available for specific regions. Results of an investigation on these aspects are presented in this study.

Materials and Methods

A field experiment was conducted at Coconut Research Station, Aliyarnagar under the All India Coordinated Research Project on Palms to study the effect of graded levels of NPK fertilizers on the reproductive characters and

yield of coconut hybrid Chandra Sankara (COD x WCT). The palms were planted during 1988 at a distance of 7.5 x 7.5 m in a square system. The soil of the experimental site is deep to very deep, has a sandy loam texture grading to a sandy clay loam with depth and analyzed available N (62 ppm), P₂O₅ (29.6 ppm) and K₂O (56.4 ppm). The soil had a neutral pH of 7.2 and EC of 0.14 dS m⁻¹. The three levels of treatments of N (0, 500, 1000 g palm⁻¹ year⁻¹), P (0,108,216 g palm⁻¹ year⁻¹) and K (0, 830, 1660 g palm⁻¹ year⁻¹) comprised of 27 combinations formed the treatment structure. The experiment was laid out in 3³ confounded design with two replications.

The seedlings received NPK nutrition as per treatment schedule and from fourth year onwards the adult palm dosages. Nitrogen was given as urea, P as single super phosphate and K as muriate of potash as per the requirements of individual treatments. The fertilizers were put on in two equal applications during June and December in circular basins, which were increased each year and from the fourth year onwards in circular basins of 1.8 m radius around the bole and incorporated. Ouvrier and Brunin (1974) have confirmed that the root distribution zone increases with the enlargement of the fertilizer placement around the stem. Observations on growth attributing characters and yield were recorded periodically and analyzed statistically. Trivariate extension of the quadratic model without higher order interaction terms was fitted to the yield (Black, 1993 and Colwell, 1994). Soil samples were collected 1 m away from the base of the palm from soil layers of 0-25 and 25-50 cm from four locations and pooled depth wise. The soil samples were shade dried and the 2 mm fraction was analyzed for pH, organic carbon, available N (Subbiah and Asija, 1956) P and K (Jackson, 1967). Leaf samples were collected from the 14th leaf (diagnostic leaf-Prevot and Bachy, 1962) during May 1999 and analyzed for N, P and K as per conventional procedures (Jackson, 1967). The data for the period 1996/1997 to 1999/2000 are presented and discussed.

Results and Discussion

Vegetative, reproductive characters and yield

N₁ and N₂ doses of nitrogen significantly (C.D.0.05) increased the functional leaves of palms compared to N₀ in all the years except during the year 1996 (Table 1). The number of functional leaves was not affected by graded levels of P and K. With N₁ and N₂ treatments the production of functional leaves increased progressively with the age of the palms and reached an optimum number over 30 during 1999, while in the N₀ treatment the palms maintained lower numbers consistently attaining under 27 in 1999. Reddy *et al.*, (2002) reported that response to fertilizer application in terms of number of leaves on the crown, leaflets per leaf, leaf length and petiole length was not observed on adult palms.

Table 1 Effect of NPK levels on number of functional leaves

Treatments	Functional leaves per palm on the crown			
	1996	1997	1998	1999
N 0	24.1	23.2	21.0	26.9
N 1	25.7	26.9	28.5	31.5
N 2	24.7	29.3	28.0	32.2
P 0	24.2	26.0	25.9	28.4
P 1	24.9	26.5	26.2	29.1
P 2	25.0	26.9	26.5	29.8
K 0	24.7	25.6	25.8	28.4
K 1	24.5	26.5	26.3	29.4
K 2	25.3	27.3	26.5	29.5
CD _{0.05} (N)	NS	1.5	1.7	2.4

Addition of incremental levels of N increased the number of bunches harvested per palm per year during all the four years (Table 2). The response with 500 g N was significantly higher than zero g N treatment, whereas at the higher level (1000 g N) little or no further increase resulted. Treatments with P did not influence the number of bunches harvested during different years. A slight increase compared to the number of bunches in the K₀ treatment was observed in palms receiving K at 830 g. Palms receiving K at 1660 g showed no further increase.

Table 2 Effect of NPK levels on number of bunches

Treatments	Bunches palm ⁻¹ year ⁻¹			
	1996-97	1997-98	1998-99	1999-2000
N 0	5.5	7.5	4.5	6.5
N 1	8.3	12.8	13.4	10.6
N 2	8.5	12.9	14.1	11.2
P 0	7.2	10.6	10.2	8.5
P 1	7.5	11.2	10.5	9.9
P 2	7.6	11.3	11.3	9.9
K 0	6.9	9.8	9.9	7.6
K 1	7.6	11.5	10.7	10.5
K 2	7.8	11.8	11.4	10.2
CD _{0.05}	0.8	1.2	1.3	2.3
	(N)	(N,K)	(N)	(N,K)

Table 3 Effect of NPK levels on the number female flowers

Treatments	Female flowers palm ⁻¹ year ⁻¹			
	1996-97	1997-98	1998-99	1999-2000
N 0	72	193	84	135
N 1	127	351	333	228
N 2	115	360	369	236
P 0	99	278	240	173
P 1	112	308	254	235
P 2	102	318	291	191
K 0	91	269	230	162
K 1	124	310	271	240
K 2	99	325	285	197
CD _{0.05}	14	28	36	64
	(N,K)	(N,P,K)	(N,P,K)	(N)

Table 4 Effect of NPK levels on the nut yield

Treatments	Nut yield (nuts palm ⁻¹ year ⁻¹)				Mean
	1996-97	1997-98	1998-99	1999-2000	
N 0	33	68	42	58	50
N 1	62	134	178	120	124
N 2	54	147	201	121	129
P 0	44	109	138	79	93
P 1	56	118	134	119	106
P 2	49	122	148	100	106
K 0	40	96	116	83	84
K 1	65	124	145	114	112
K 2	46	129	159	103	107
CD _{0.05}	5	15	18	21	13
	(N,P,K)	(N,K)	(N,K)	(N,P,K)	(N,P,K)
NPK Interaction					
NOPOK0	21	60	61	57	42
N1P1K1	86	154	180	146	142
N2P2K2	53	163	232	138	146

The number of female flowers produced per palm per year increased significantly at 500 g N during all the four years, with no further significant increase at 1000 g N; a trend similar to that of the number of bunches harvested (Table 3). The female flowers inflorescence¹ gradually increased from 13.1 to 15.2, 25.7 to 27.4, 20.8 to 24.8 and 20.7 to 21.5 during 1996-'97, 1997-'98, 1998-'99 and 1999-'00 respectively. Among the levels of P applied, the difference in female flower production was not significant. Nevertheless, female flower production is reported to be associated with P nutrition of palms. Addition of K increased the number of female flowers during different years except during 1996-97. The increase was significant at 830 g K with no further significant increase at 1660 g K. At higher levels of K application even a reduction in the number of female flowers was observed in particular years. These observations indicated that when N is the major limiting nutrient under the framework of the experiment and, the influence of other nutrients such as P and K was not much expressed; despite the importance of their role in plant nutrition.

The importance of N deficiency and response of palms to N nutrition has been well demonstrated in this experiment. Nitrogen application increased the nut yield during each of the four years. At 500 g N, the yield increase was 88%, 97%, 124% and 207 % nuts per palm year⁻¹ during 1996-'97, 1997-'98, 1998-'99 and 1999-'00 respectively over the zero g N treatment (Table 4). While this yield of palms at 500 g N level was significantly higher over that at the N₀ level, there were no significant differences between N₁ and N₂ levels. During 1996-'97 to 1999-'00, palms receiving no N nutrition but varying levels of P and K produced an average yield varying from 36-79 nuts. At the N 500 g level, the yield variance was between 101 and 150 and at N 1000 g it was between 100 and 154 nuts (Fig 1). Application of P did not consistently increase the nut yield significantly. However during 1996-'97 there was a yield of 56 nuts and in 1999-'00, a yield of 119 nuts was significant at application rates

of 108 g P. Pooled data indicated that P levels did not vary the nut yield among the treatments.

The yield of palms at the 830 g K level increased by 62 %, 29 %, 25 % and 37 % during 1996-'97, 1997-'98, 1998-'99 and 1999-'00 respectively whereas the differences in yield between 830 and 1660 g levels during any of the four years were not significant.

The NPK interaction data revealed that application of N₁P₁K₁ at 500:108:830 g per palm per year recorded a mean yield of 142 nuts per palm per year and at N₂P₂K₂ at 1000:216:1660 g per palm per year the mean nut yield of palms was only 4 nuts higher.

Trivariate extension of the quadratic model without higher order interaction terms was fitted to the yield (Black 1993 and Colwell, 1994).

$$Y = a_0 + a_1N + a_2P + a_3K + a_4NP + a_5NK + a_6PK + a_7N^2 + a_8P^2 + a_9K^2 \quad (1)$$

Table 5 Parameter estimates from the model for the data

	<i>Coefficients</i>	<i>P-value</i>
Intercept	33.89977	9.3E-05
N	105.2326	1.1E-09
P	26.71667	0.007573
K	27.15347	0.006813
NP	-2.20417	0.425716
NK	8.25625	0.007132
PK	2.520833	0.363693
N ²	-35.4514	4.5E-08
P ²	-10.5806	0.013102
K ²	-13.3806	0.002725

Table 6 Effect of NPK levels on the soil pH and organic carbon content

Depth cm	pH		Organic carbon (%)	
	0-25	25-50	0-25	25-50
NPK Levels				
N 0	6.9	7.1	0.30	0.22
N 1	6.4	7.0	0.32	0.22
N 2	6.5	7.1	0.27	0.20
P 0	6.6	7.2	0.27	0.21
P 1	6.7	7.1	0.32	0.23
P 2	6.5	6.8	0.28	0.20
K 0	6.2	6.9	0.32	0.21
K 1	6.9	7.3	0.24	0.20
K 2	6.7	7.1	0.30	0.22
CD _{0.05}	NS	NS	NS	NS

Where a's are the coefficients to be estimated. These coefficients were estimated by Microsoft Excel regression function equation using data of Fig. 1. The fitted model accounts for 98.3% of the variation and gives a standard error of 9.35. Model parameters and their probability value are given in the Table 5. The model parameters probability value revealed that the interaction terms NP

and PK are non-significant, P square term significant at 5% level ($P \leq 0.05$) and all other terms are significant at 1% level ($P \leq 0.01$). This may be due to the reason that P is sufficiently available in the soil. The most limiting nutrient is N followed by K. The soil available nutrient values also showed the same trend (Table 7).

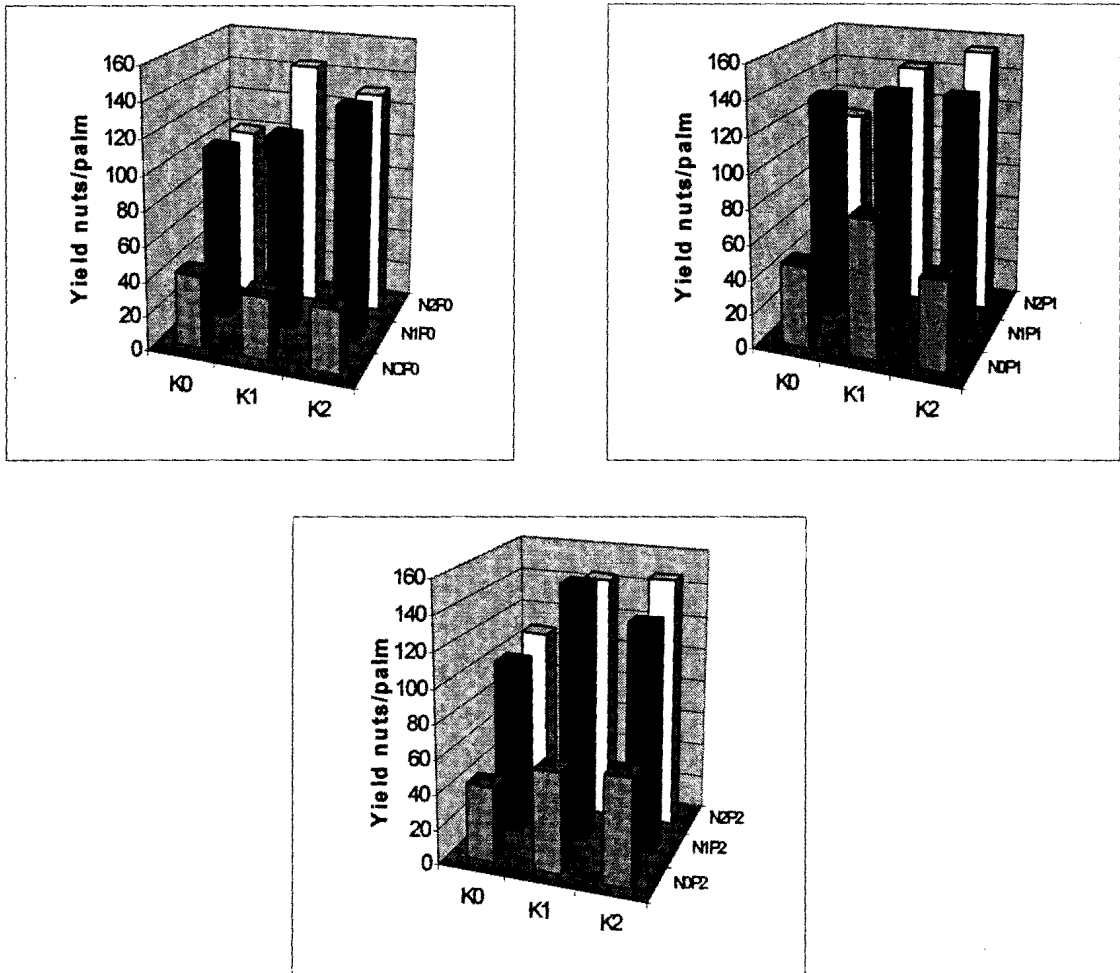


Figure 1 Effect of NPK nutrition on yield of nuts/palm

Table 7 Effect of NPK levels on the soil nutrient status

Depth cm	Soil available nutrients (ppm)					
	N		P		K	
	0-25	25-50	0-25	25-50	0-25	25-50
NPK Levels						
N 0	55	43	107	59	180	108
N 1	58	45	108	99	313	88
N 2	55	40	93	109	89	70
P 0	52	43	69	67	208	92
P 1	60	44	105	80	92	81
P 2	55	41	139	120	283	92
K 0	62	43	104	68	68	46
K 1	49	41	122	110	251	120
K 2	57	44	87	89	264	98
CD _{0.05}	NS	NS	NS	NS	119	45

The physical optimum of the response function is determined by partial differentiation of the model with respect to N, P and K. The resulting partial differential equations were equated to zero and solved for N, P and K. The physical optimum rate of application fertilizers works out to 818, 130 and 1362 g per palm per year of N, P and K respectively with nut yield of 159 nuts per palm per year.

Soil and leaf nutrient status

The pH of soil was between 6.2 and 6.9 in the 0-25 cm layer and 6.8 to 7.3 in the 25-50 cm layer in different treatments though an insignificant decrease was observed with increasing levels of N application (Table 6). In general the organic carbon status of the soil was also poor. The available soil nitrogen status was low and varied between 49 and 62 ppm and 41 and 45 ppm at 0-25 and 25-30 cm soil layers respectively around the bole (Table 7). Twelve years of inorganic fertilizer application with urea had not influenced a build up of soil available N status which is in conformity with an observation recorded by Khan et al (1986) in the red sandy loam soils cultivated to coconut elsewhere. This coupled with a poor organic carbon status of the soil indicated the need for organic supplementation in the regular fertilizer schedule or recycling of the organic wastes

generated within the system. While the soil N status was not indicative of the history of fertilizer application, it indicated a much more pronounced effect on the nutrition of the palms, as judged by the leaf analysis. This showed that foliar analysis was a more suitable method for judging the nutritional status of the palms. The foliar analysis values of N, P and K indicated sufficiency levels in the palm. There was a slight increase in the N content by both the addition of N and P, but a negligible reduction with K fertilizer application (Table 8).

Added levels of P at 108 and 216 g increased the available P status in the profile, which varied from 69 to 139 ppm in the treatments. The high available P status of the soil in the control treatment is reflective of the history of P fertilizer application in the plot, which was subject to intensive cultivation with annuals prior to start of the coconut experiment.

Table 8 Effect of NPK levels on the leaf nutrient status (Frond 14)

Treatments	N (%)	P (%)	K (%)
N 0	1.88	0.12	0.89
N 1	2.03	0.12	0.81
N 2	2.06	0.11	0.70
P 0	1.85	0.11	0.82
P 1	2.33	0.11	0.84
P 2	2.03	0.12	0.74
K 0	2.06	0.12	0.79
K 1	1.98	0.11	0.79
K 2	1.94	0.11	0.82
CD _{0.05}	NS	NS	NS

Table 9 BC Ratio for different fertilizer treatments

Sl.No	Treatment	Gross income (Rs.)	Cost of cultivation (Rs.)	Net returns (Rs.)	BC Ratio
1	N ₀ P ₀ K ₀	22050	35300	-13250	-0.62
2	N ₁ P ₁ K ₁	74550	39041	35509	1.91
3	N ₂ P ₂ K ₂	76125	41120	35505	1.81

Though applied fertilizer significantly influenced available P content of the soil, the changes in foliar contents of P was not discernable being close to the critical levels proposed (0.12%) by Manciot et al (1979a, b). Khan et al (1992) reported similar relationship

between soil and plant P levels of palms in the west coast region of India. The available K status was 68 ppm (K_0) in 0-25 cm soil layer and increased to 251 and 264 ppm with K_1 and K_2 levels of application. The higher available P and K in the 0 – 25cm layer may be attributed to the mechanical incorporation in the soil following fertilizer application as a cultural practice (Khan *et al.*, 1985).

Interestingly the leaf K values were at the lower end of critical level (0.80 to 1.00 %) and were not influenced much by incremental K application. At higher levels of fertilizer application, the increase in yield might have led to dilution of nutrients in the sink resulting in lower plant levels. Nevertheless, the differences in N, P and K fertilizer application levels were not reflected in the nutrient status of the respective palms.

Copra yield and copra content

At N_0 level the copra content nut^{-1} was 130 g, whereas palms which received N at 500 g level produced an average copra content of 156 g nut^{-1} and 19.0 kg copra palm^{-1} . Higher levels of application of N reduced copra content. Earlier, Muliya and Nelliya (1971) reported a decrease in copra content with increasing N rates of application to palms. Further a decrease in copra content was also observed with increasing P application rates. Among the levels of K applied, 830 g per palm recorded a copra content of 147 g per nut and copra yield of 17.4 kg per palm. However the copra outturn decreased at higher levels of applied K. Among the NPK combinations, application rates of $N_{500} P_{108} K_{830}$ g palm yielded 178 g copra per nut and 26.0 kg per palm, which was commensurate with the values reported for COD X WCT. Comparatively, higher application rates at $N_{1000} P_{216} K_{1660}$ reduced the copra yield (23.9 kg per palm).

Economics of fertilizer application

Application of fertilizers at $N_1 P_1 K_1$ and $N_2 P_2 K_2$ and cost of cultural operations resulted in realization of a net income of

Indian Rs 35509- and 35505- per ha respectively (Table 9). The additional cost involved in the $N_2 P_2 K_2$ treatment viz Rs. 2079 per ha- had no extra benefit in net income, reducing the benefit cost ratio BCR to 1.81. For every rupee invested, the benefit gained was Rs 1.91 per ha under $N_1 P_1 K_1$ and Rs 1.81 per ha under $N_2 P_2 K_2$ respectively. Thus, the BCR was most favourable for fertilizer treatment $N_1 P_1 K_1$ indicating the economic advantage of fertilizing adult coconut palms with 500 g N, 108 g P and 830 g K.

Conclusion

Application of NPK fertilizers at 500:108:830 g $\text{palm}^{-1} \text{ year}^{-1}$ in two split applications during June and December was optimal for the Chandra Sankara hybrid with a mean yield of 142 nuts per palm per year, net income of Indian Rs.35509 per ha and BCR of 1.91. The above NPK level had positive influences on number of bunches, female flower production, copra content, copra yield and leaf N content.

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References

- Anonymous. (1999) *Crop Production Guide* 1999. Directorate of Agriculture, Chennai. pp.131.
- Black, C.A (1993) *Soil fertility evaluation and control*. Lewis Publ., Boca Raton, CRC Press, Florida, USA, 768 pp.

- Colwell, J.D. (1994) *Estimating fertilizer requirements: A quantitative approach*. CAB. International, Wallingford, U.K. 262 pp
- Jackson, M.L. (1967) *Soil Chemical Analysis*. Prentice Hall India (1st edn). New Delhi, 498 p.
- Khan Hameed, H., Sankaranarayanan, M.P., Narayana, K.B. and George, M.V. (1985) Comparative efficiency of selected phosphates as P-carriers for coconut (*Cocos nucifera* L) *Trop. Agric.(Trinidad)* **62** (1) 57-61
- Khan Hameed H., Gopalasundaram, P., Joshi, O.P. and Nelliath, E.V. (1986) Effect of NPK fertilization on the mineral nutrition and yield of coconut genotypes. *Fert. Res.*, **10** (2) 185-190
- Khan Hameed, H., Biddappa, C.C., Narayanan, M., George, V.T., Cecil, S.R. (1992) Residual Effect of long term phosphorus reserves in soil and plant nutrient contents, microbial association and yield of coconut. *J. Plantn. Crops* **20**(suppl.) 14-18.
- Manciot, R., Ollagnier, M and Ochs, R. (1979 a) Mineral nutrition and fertilization of coconut around the world. *Oleagineux* **34** (11) 499-510
- Manciot, R., Ollagnier, M and Ochs, R. (1979 b) Mineral nutrition and fertilization of coconut around the world II. Study of the different elements. *Oleagineux* **34** (12) 511-516
- Muliyar, M.K., and Nelliath, E.V. (1971) Response of coconut palms to N, P and K fertilizer application on West coast of India. *Oleagineux*, **26** 687-691
- Ouvrier, M and Brunin, G. (1974) Root densities in an industrial coconut plantation and fertilizer spreading techniques. *Oleagineux* **29**(1) 15-17.
- Prevot, P and Bachy, A. (1962) Leaf analysis of coconut palm. Influence of leaf rank and vegetative development on elemental contents. *Oleagineux*, **17** (5) 451-458.
- Reddy, D.V S., Upadhyay, A.K., Gopalasundaram, P and Hameed Khan, H. (2002) Response of high yielding coconut variety and hybrids to fertilization under rainfed and irrigated conditions. *Nutrient Cycling in Agroecosystem*, **62** 131-138.
- Subbiah and Asija. (1956) A rapid procedure for estimation of available nitrogen in soil. *Curr.Sci.* **25** (8) 259-260.
- Vernon, A.J., Emose, P.N. and Mudaliar, T. (1976) Coconut fertilizer yield trials in Fiji. *Fiji Agric.J.* **38** (2) 49-60.