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Effect of NPK Fertilizer Levels on Mineral Nutrition and Yield of Hybrid (Tall x Dwarf) Coconut

S. Mohandas*
Coconut Research Station,
Veppankulam – 614 906, Tamil Nadu, India

A field experiment was conducted at Coconut Research Station, Veppankulam during 2006-09 to asses the nutritional requirement of hybrid coconut (T x D) with 50 per cent nitrogen (N) substitution through organic manure. The experiment was conducted in 35 years old hybrid (T x D) palms (VHC 2). The experimental results proved that in hybrid coconut, a fertilizer level of 1000:250:2000 g NPK / Palm / year along with 50 kg of organic manure (Composted Coir Pith/ Vermi Compost) achieved economically higher mean annual nut yield, besides sustaining the soil fertility. While, the soil available NPK and index leaf NPK content was the highest at 1000:500:2000 g NPK/Palm / year. Considering consistent nut yield and sustainable soil health, 50 per cent of recommended N may be supplied through organic manure viz., vermicompost or composted coir pith and remaining 50 per cent N may be supplied through fertilizers. The organic manure that carries 50 per cent nitrogen can add organic matter to some extent in organically poor coastal coconut soils.

Keywords: Hybrid coconut, waste recycling, nutrients renewal, N substitution.

Coconut (*Cocos nucifera* Lin.) is an important plantation crop mainly cultivated in coastal belts of India. In general, coconuts survive for more than 60 years and continue to yield under ideal management conditions throughout the year and hence, require a continuous and balanced supply of nutrients for higher productivity (Upadhyay *et al*., 1998). Coconut palm absorbs large quantities of nutrients from the soil. A high proportion of mineral nutrients are removed from the soil by the coconut along with the harvested produce and debris. Application of fertilizers containing NPK and Mg at recommended rates partially compensates the depletion (Nadheesha and Tennakoon, 2008). Fertilizer requirement in coconut is generally assessed through computing the annual harvest of the nutrients by the palm or by studying the yield response to graded levels of applied fertilizers (Wahid, 1984). The annual nutrient removal by the coconut palms through nuts, fronds, trunk, bunch, spathe etc., varied from 20 to 174 kg N, 2.5 to 20.0 kg P_2O_5 and 35 to 49 kg K_2O ha^{-1}(Ouverier and Ochs, 1978). The removed nutrients are to be replenished by one way or other for the sustainable coconut production. Hence, nutrient management plays a key role in determining the productivity of palms.

Either under nourishment or negligence of fertilizer organics to coconut or total dependence on chemical fertilizer often leads to poor productivity and leads to soil health deterioration. Hence, for sustaining the palm productivity and health of coconut soil, a judicious combination of organic manure and fertilizer nutrients are essential. Coconut based cropping system offers enormous scope for nitrogen substitution through organic manure by way of *in-situ* waste recycling through vermicomposting. The present experiment is contemplated mainly to supplement the chemical fertilizers with organic manures through vermicomposting / composted coir pith in coconut gardens. This may paves way for the gradual replacement of chemical fertilizers in coconut based cropping system in long run.

Materials and Methods

A field experiment was laidout at Coconut Research Station, Veppankulam in order to assess the nutrient requirement of hybrid coconut (VHC 2) with 50 per cent nitrogen (N) substitution through organic manures. The experimental site is located at 20m above MSL with average mean annual rainfall of 1,125 mm. The experimental soil was sandy loam in texture with a pH 7.1, EC 0.16 and organic carbon content of 0.20 per cent. The available NPK content of the experimental soil was low in N, medium in P and K ie., 118, 11.5 and 136 kg ha^{-1}, respectively. The palms were 35 years old and treatments consisted of each three levels of N (0, 500 and 1000 g / palm / year), P (0, 250 and 500 g / palm /year) and K (0, 1000 and 2000 g / palm /year) and totally there were 27 treatment combinations. Three palms were selected for each treatment and the experiment was conducted in a 3^3 non-replicated

*Corresponding author email: smohanssac@yahoo.co.in

confounded factorial design. Based on the NPK content of vermicompost (1.4% N, 0.14% P and 0.29% K) and the composted coir pith (1.02: 0.60: 1.06 % and C: N ratio of 24.1), the required quantity of vermicompost or composted coir pith equivalent to 50 % N for each treatment along with P, K fertilizers (excluding the quantum of P, K supplied by the vermicompost - VC / composted coir pith - CCP) were applied as per treatments based on the avalilability of organic manure (CCP/VC). The above organic manure were applied in addition to the recommended Farm Yard Manure (FYM) ie., 50 kg/ palm/year. The fertilizers and organic manure (vermicompost / CCP) were applied in two equal splits, first during February and second during September of every year. The yield attributes viz., number of functional leaves, number of bunches produced, nut setting per cent, and nut yield for every treatment at the end of year were recorded. Besides, the soil available NPK and index leaf NPK content were estimated at the end of each year.

Results and Discussion

Effect of treatments on yield and yield attributes of coconut (Table 1 & 4)

The number of functional leaves recorded was significantly influenced by the NPK applied at graded levels. The number of functional leaves and bunches produced were in the range of 26 to 34 and 11 to 13 / palm, respectively among the NPK levels. Number of buttons produced was between 20.0 and 35.0 /

Table 1. Effect of NPK (50 per cent N through organics) on yield attributes and nut yield of hybrid (T x D) coconut

Treatment	No. functional leaves/palm			No. bunches/ palm /year			No. of buttons /Bunch			Mean annual nut yield / palm		
	2006 -07	2007 -08	2008 -09	2006 -07	2007 -08	2008 -09	2006 -07	2007 -08	2008 -09	2006 -07	2007 -08	2008 -09
T_{1} N P K $_{0\ 0\ 0}$	26.0	25.0	24.2	12	12	11	20.0	19.0	18.0	116	106	102
T_{2} N P K $_{0\ 0\ 1000}$	31.6	31.3	30.8	11	12	12	22.0	21.0	23.0	130	148	152
T_{3} N P K $_{0\ 0\ 2000}$	32.0	35.0	33.1	12	14	13	21.6	21.6	24.0	142	156	159
I_{4} N P $_{0\ 250}$ K $_{0}$	32.5	30.0	30.5	11	15	12	23.0	32.0	24.2	138	145	141
T_{5} N P $_{0\ 250}$ K $_{1000}$	32.0	31.0	31.2	12	14	13	25.3	28.3	28.0	140	150	158
I_{6} N P $_{0\ 250}$ K $_{2000}$	30.6	26.0	33.5	12	13	12	25.0	25.5	26.0	142	150	152
T_{7} N P $_{0\ 500}$ K $_{0}$	30.8	31.0	31.5	11	12	12	25.6	25.6	24.0	132	140	140
I_{8} N P $_{0\ 500}$ K $_{1000}$	31.0	32.0	33.2	11	11	13	21.5	21.5	23.6	135	144	145
T_{9} N P $_{0\ 500}$ K $_{2000}$	32.0	34.0	34.2	13	12	13	20.8	20.0	24.2	133	154	158
T_{10} N $_{500}$ P K $_{0\ 0}$	28.1	24.0	31.0	10	13	12	20.0	20.0	23.0	132	131	132
T_{11} N $_{500}$ P K $_{0\ 1000}$	30.9	31.2	32.5	12	13	13	22.0	22.4	22.5	138	138	148
T_{12} N $_{500}$ P K $_{0\ 2000}$	32.0	30.6	33.2	12	12	12	22.0	20.0	23.6	145	146	156
I_{13} N $_{500}$ P $_{250}$ K $_{0}$	30.0	29.2	31.0	13	12	13	23.0	21.0	25.0	138	142	146
T_{14} N $_{500}$ P $_{250}$ K $_{1000}$	32.0	32.0	32.5	13	13	13	32.0	30.0	26.8	147	155	155
I_{15} N $_{500}$ P $_{250}$ K $_{2000}$	33.0	33.2	33.6	13	12	13	34.6	32.0	28.2	150	160	162
T_{16} N $_{500}$ P $_{500}$ K $_{0}$	30.0	33.0	31.8	12	14	12	24.6	24.6	28.0	130	141	142
T_{17} N $_{500}$ P $_{500}$ K $_{1000}$	33.0	34.4	34.2	12	13	13	20.0	21.0	28.0	135	156	158
T_{18} N $_{500}$ P $_{500}$ K $_{2000}$	33.5	33.8	35.0	13	13	13	21.0	21.0	31.0	139	164	166
T_{19} N $_{1000}$ P K $_{0\ 0}$	28.0	30.0	30.0	12	13	11	27.0	35.0	28.0	125	136	135
T_{20} N $_{1000}$ P K $_{0\ 1000}$	30.0	29.8	31.2	12	13	12	23.2	31.0	28.0	138	142	156
T_{21} N $_{1000}$ P K $_{0\ 2000}$	30.0	30.6	32.0	12	12	12	28.6	26.6	29.2	140	150	160
T_{22} N $_{1000}$ P $_{250}$ K $_{0}$	30.5	31.2	32.5	12	12	12	30.6	22.6	27.2	136	140	142
T_{23} N $_{1000}$ P $_{250}$ K $_{1000}$	32.0	32.1	33.2	12	14	13	34.6	31.0	31.0	150	158	160
T_{24} N $_{1000}$ P $_{250}$ K $_{2000}$	34.0	30.5	38.2	13	12	13	20.1	32.0	32.8	156	172	178
T_{25} N $_{1000}$ P $_{500}$ K $_{0}$	30.1	30.6	32.8	10	11	12	30.3	29.0	28.0	134	148	142
T_{26} N $_{1000}$ P $_{500}$ K $_{1000}$	33.0	31.2	33.2	11	12	12	20.6	27.6	30.0	146	164	168
T_{27} N $_{1000}$ P $_{500}$ K $_{2000}$	34.0	31.2	36.0	13	14	13	34.0	32.3	33.2	158	176	182
SE / Plot	0.93	0.90	0.96	0.3	0.39	0.4	1.78	1.81	1.86	12.0	13.5	15.4
Gen. Mean	32.7	31.7	33.0	12.2	12.3	14.3	36.0	38.0	38.8	148	153	156
CV (%)	2.2	2.2	2.4	2.9	3.0	3.4	4.9	5.4	5.7	9.5	8.8	11.2
CD for NPK	1.0	1.0	1.0	0.4	0.4	0.4	2.0	2.2	2.4	14	16	18

bunch. The levels of fertilizers did not have much effect on the growth characters of adult palms as reported by Reddy *et al.* (2002). Among the various NPK combinations, NPK level of 1000: 500: 2000 g / palm /year registered the highest mean nut yield of 158, 176 and 182 nuts / palm / year during 2006-07, 2007-08 and 2008-09, respectively. However, it was comparable with NPK level of 1000:250:2000 g / palm / year (156, 172 and 178 nuts / palm / year). Here, out of 1000 g of N, 500 g was supplied through composted coir pith or vermicompost based on availability. With regard to N and K, for every incremental addition of each nutrient, there was a corresponding increase in nut yield, whereas in case of P, the increase in nut yield was observed only up to 250 g / palm / year. Incremental addition

Table 2. Effect of NPK (50 per cent N through organics) on soil fertility (kg ha^{-1})

Treatment	Available Nitrogen			Available Phosphorus			Available Potassium		
	2006-07	2007-08	2008-09	2006-07	2007-08	2008-09	2006-07	2007-08	2008-09
T_1 $N_0P_0K_0$	116	110	101	11.0	10.2	10.0	130	125	122
T_2 $N_0P_0K_{1000}$	118	112	111	12.0	11.1	11.6	170	176	178
T_3 $N_0P_0K_{2000}$	113	117	112	11.3	12.2	12.5	251	262	262
T_4 $N_0P_{250}K_0$	101	110	110	16.1	18.6	18.8	160	130	126
T_5 $N_0P_{250}K_{1000}$	105	118	102	17.1	19.0	19.1	252	180	176
T_6 $N_0P_{250}K_{2000}$	115	106	117	17.9	19.8	19.5	160	255	258
T_7 $N_0P_{500}K_0$	102	108	107	18.5	22.2	22.5	123	132	128
T_8 $N_0P_{500}K_{1000}$	123	101	108	20.0	22.0	23.0	175	178	178
T_9 $N_0P_{500}K_{2000}$	120	112	113	18.0	23.5	23.5	234	242	250
T_{10} $N_{500}P_0K_0$	143	148	148	20.1	11.0	11.0	126	136	130
T_{11} $N_{500}P_0K_{1000}$	152	155	152	13.0	11.6	11.5	210	181	182
T_{12} $N_{500}P_0K_{2000}$	154	161	150	11.3	12.0	12.0	226	248	256
T_{13} $N_{500}P_{250}K_0$	148	150	145	15.4	18.5	19.0	187	132	131
T_{14} $N_{500}P_{250}K_{1000}$	155	162	142	14.4	18.2	18.5	215	178	180
T_{15} $N_{500}P_{250}K_{2000}$	144	160	150	15.9	17.6	20.0	230	252	262
T_{16} $N_{500}P_{500}K_0$	150	154	152	17.2	22.1	23.6	172	130	136
T_{17} $N_{500}P_{500}K_{1000}$	143	162	146	19.2	21.5	22.5	187	182	182
T_{18} $N_{500}P_{500}K_{2000}$	148	168	142	19.9	20.5	23.0	244	261	263
T_{19} $N_{1000}P_0K_0$	160	178	178	13.0	11.0	11.8	168	138	132
T_{20} $N_{1000}P_0K_{1000}$	164	181	181	12.9	10.5	12.0	187	190	178
T_{21} $N_{1000}P_0K_{2000}$	167	175	192	13.0	11.2	12.4	250	258	266
T_{22} $N_{1000}P_{250}K_0$	167	192	199	16.6	18.0	18.0	168	130	130
T_{23} $N_{1000}P_{250}K_{1000}$	168	190	201	17.6	19.0	19.1	218	178	176
T_{24} $N_{1000}P_{250}K_{2000}$	162	188	211	18.1	19.8	19.2	255	252	256
T_{25} $N_{1000}P_{500}K_0$	175	190	201	19.1	21.5	21.2	192	132	132
T_{26} $N_{1000}P_{500}K_{1000}$	158	170	208	23.1	22.2	22.0	230	176	180
T_{27} $N_{1000}P_{500}K_{2000}$	165	188	206	22.2	21.6	22.6	243	246	258
SE / Plot	17	19	21	0.3	0.3	0.3	18	19	17
Gen. Mean	161	171	178	14.2	13.2	15.2	201	208	211
CV (%)	14	16	18	12.1	12.8	13.6	10	10	10
CD for NPK	22	26	26	0.8	0.8	0.9	16	17	18

of nitrogen, from 0 to 1000 g / palm /year, the increase in nut yield was from 146 to 158 nuts / palm / year (2008-09). For P level from 0 to 250 g / palm / year, the yield increase was from 144 to 156 nuts / palm / year and for K level from 0 to 2000 g / palm / year, the increase was from 136 to 165 nuts / palm / year (2008-09). Though there was some numerical variation among the various NPK levels, the trend of observation was similar in all the years of experimentation with respect to yield and yield attributes of coconut. The overall performance of palm could be improved by the application of NPK fertilizers at recommended level (Sudhakara and Nambiar, 1991). Rethinam *et al*. (1991) reported that integrated nutrient management increased the nut yield from 28 to 51 nuts / palm / year within three years. Integrated nutrient management is a handy tool for productivity increase and its sustenance in coconut garden (Hameed Khan, 2004).

Effect of NPK on soil fertility (Table 2)

Soil available NPK was appreciably increased for every incremental addition of respective nutrients (Table 2&3). Among the different levels of NPK, the highest soil available NPK was registered at their highest level tried i.e. 1000: 500: 2000 g of NPK / palm / year, though the economic nut yield was obtained at 1000: 250: 2000 g NPK / palm / year. This fact was true throughout the period of experimentation. The results on soil available NPK revealed that all the treatments recorded low status of available nitrogen, however there was some numerical difference between the treatments. Treatment combinations *viz.,* T_1 to T_9 were found to have available nitrogen in the range of 101 to 117 kg ha^{-1} (2008-09) wherein, no nitrogen was applied. Among the treatments, from T_{10} to T_{18} that received 500 g N/palm / year registered the available N in the range of 142 to 152 kg ha^{-1} (2008-09). The higher available nitrogen was observed with the application of nitrogen at it's highest level i.e., 1000 g/palm/year (178 to 211 kg N ha^{-1} in 2008-09). Increasing the phosphorus level from 0 to 500 g/palm/year, progressively enhanced the P availability in soil. The available P content of 11.7, 19.0 and 22.7 kg ha^{-1} was recorded for P_0, P_{250} and P_{500} levels respectively (2008-09). Similar increase in K level from 1000 to 2000 g/palm/year, enhanced the soil available K content from medium to high level (130 to 259 kg ha^{-1} 2008-09). The effect of treatments on soil fertility status was almost similar in all the years of experimentation. Integrated nutrient management

Table 3. Effect of NPK (50 per cent N through organics) on leaf nutrient content (per cent)

Treatment	Nitrogen			Phosphorus			Potassium		
	2006 -07	2007 -08	2008-09	2006 -07	2007 -08	2008-09	2006 -07	2007 -08	2008-09
T_1 $N_0P_0K_0$	0.91	0.90	0.94	0.13	0.14	0.13	0.81	0.85	0.84
T_2 $N_0P_0K_{1000}$	1.20	1.21	1.26	0.12	0.11	0.12	0.91	0.94	0.92
T_3 $N_0P_0K_{2000}$	1.52	1.50	1.58	0.12	0.13	0.14	0.86	0.86	0.87
T_4 $N_0P_{250}K_0$	1.17	1.12	1.14	0.15	0.16	0.17	0.88	0.87	0.83
T_5 $N_0P_{250}K_{1000}$	1.23	1.21	1.31	0.16	0.18	0.18	0.91	0.96	0.95
T_6 $N_0P_{250}K_{2000}$	1.61	1.51	1.41	0.13	0.16	0.17	0.92	0.95	0.94
T_7 $N_0P_{500}K_0$	0.86	0.80	0.86	0.17	0.17	0.17	0.86	0.88	0.89
T_8 $N_0P_{500}K_{1000}$	1.21	1.11	1.14	0.18	0.19	0.18	0.90	0.94	0.96
T_9 $N_0P_{500}K_{2000}$	1.61	1.51	1.60	0.19	0.19	0.19	0.91	0.91	0.93
T_{10} $N_{500}P_0K_0$	0.28	0.29	0.29	0.15	0.17	0.18	0.92	0.96	0.95
T_{11} $N_{500}P_0K_{1000}$	1.26	1.16	1.19	0.13	0.14	0.15	0.96	0.96	0.97
T_{12} $N_{500}P_0K_{2000}$	1.58	1.52	1.42	0.12	0.10	0.13	0.92	0.90	0.89
T_{13} $N_{500}P_{250}K_0$	1.10	1..13	1.18	0.13	0.12	0.11	0.89	0.91	0.97
T_{14} $N_{500}P_{250}K_{1000}$	1.36	1.31	1.41	0.16	0.18	0.16	0.98	0.96	0.98
T_{15} $N_{500}P_{250}K_{2000}$	1.62	1.53	1.56	0.15	0.18	0.19	0.95	0.98	0.94
T_{16} $N_{500}P_{500}K_0$	1.03	1.01	1.13	1.16	0.19	1.19	0.91	0.94	0.93
T_{17} $N_{500}P_{500}K_{1000}$	1.20	1.01	1.21	0.19	0.18	0.16	0.98	0.96	0.97
T_{18} $N_{500}P_{500}K_{2000}$	1.56	1.46	1.45	0.21	0.24	0.23	0.97	0.98	0.87
T_{19} $N_{1000}P_0K_0$	0.98	0.94	0.98	0.12	0.13	0.15	0.99	0.91	0.92
T_{20} $N_{1000}P_0K_{1000}$	1.26	1.16	1.26	0.13	0.14	0.16	1.10	1.11	1.13
T_{21} $N_{1000}P_0K_{2000}$	1.48	1.38	1.39	0.15	0.16	0.18	1.16	1.12	1.15
T_{22} $N_{1000}P_{250}K_0$	1.16	1.18	1.28	0.16	0.17	0.17	1.18	1.16	1.19
T_{23} $N_{1000}P_{250}K_{1000}$	1.28	1.22	1.26	0.17	0.18	0.17	1.20	1.21	1.20
T_{24} $N_{1000}P_{250}K_{2000}$	1.60	1.56	1.66	0.19	0.17	0.18	1.20	1.24	1.25
T_{25} $N_{1000}P_{500}K_0$	1.00	1.06	1.07	0.18	0.17	0.19	1.18	1.06	1.08
T_{26} $N_{1000}P_{500}K_{1000}$	1.31	1.38	1.39	0.20	0.23	0.24	1.21	1.24	1.23
T_{27} $N_{1000}P_{500}K_{2000}$	1.63	1.62	1.65	0.19	0.18	0.19	1.20	1.24	1.22
SE / Plot	0.15	0.18	0.19	0.01	0.01	0.02	0.04	0.05	0.06
Gen. Mean	1.26	1.21	1.28	0.16	0.16	0.18	0.99	1.01	1.08
CV (%)	12.20	11.20	13.20	9.15	9.14	9.26	4.00	4.06	4.10
CD for NPK	0.18	0.17	0.19	0.02	0.02	0.03	0.05	0.06	0.08

Table 4. Effect of NPK levels (50% N through organics) on yield and yield attributes of coconut and soil fertility

Level of NPK (g/ palm/ year)	No. of functional leaves / palm	No. of bunches / palm/ year	No.of buttons/ bunch	Nut yield / palm / year	Available nutrients (kg ha^{-1})
		2006-07			
N_0	30.9	11.7	23.2	134	123
N_{500}	31.3	12.2	26.6	139	149
N_{1000}	31.3	12.9	27.7	143	165
P_0	29.8	11.7	22.9	134	13.0
P_{250}	31.8	12.3	27.5	144	16.6
P_{500}	31.9	11.8	26.9	137	19.7
K_0	29.6	11.4	24.9	131	158
K_{1000}	31.7	11.8	25.5	140	205
K_{2000}	32.3	12.6	26.9	145	243
		2007-08			
N_0	30.6	12.8	23.8	146	110
N_{500}	31.1	12.8	23.6	149	157
N_{1000}	31.8	12.6	25.9	155	184
P_0	29.7	12.7	23.5	142	11.2
P_{250}	30.6	13.0	28.2	153	18.6
P_{500}	32.2	12.4	25.7	153	21.9
K_0	29.3	12.7	24.9	136	132
K_{1000}	31.6	12.8	26.0	153	180
K_{2000}	31.6	12.7	25.7	161	253
		2008-09			
N_0	31.4	12.3	23.6	146	109
N_{500}	32.8	12.6	25.9	152	148
N_{1000}	32.9	12.2	29.4	158	198
P_0	30.9	12.0	24.0	144	11.7
P_{250}	32.6	12.7	27.3	156	19.0
P_{500}	33.5	12.6	27.4	156	22.7
K_0	30.6	11.9	24.4	136	130
K_{1000}	32.4	12.7	26.4	156	179
K_{2000}	34.0	12.7	28.0	165	259

lays emphasis on improving and maintaining soil fertility for sustained productivity in coconut (Hameed Khan *et al.,* 2000)

Index leaf nutrient content (Table 3)

The index leaf nutrient (NPK) content was significantly influenced due to added levels of NPK as observed in other parameters. Hereagain, the highest leaf NPK content was observed with the application of NPK at their highest level viz., 1000, 500, 2000 g NPK, respectively, per palm per year. Enhanced nutrient release at the highest level of NPK and its subsequent absorption by the palm ultimately resulted in higher NPK in the index leaf, which may help in better photosynthesis and leads to better palm productivity. At the highest level of NPK i.e., 1000, 500, 2000 g / palm / year, respectively, the index leaf NPK content were also the highest. This proved the beneficial effect of INM in enhancing the leaf nutrient content. Similar observation was earlier made by Ghosh and Bandopadhyay (2009)

Conclusion

For hybrid coconut, a fertilizer level of 1000:250:2000 g NPK/Palms/year along with 50 kg FYM was found to be economical for achieving higher nut yield and sustaining the soil fertility. Considering consistent nut yield and sustainable soil fertility, 50 per cent of recommended nitrogen may be supplied through organic manure of either vermicompost or

composted coir pith based on availability and remaining 50 per cent nitrogen may be applied as fertilizer. The soil available NPK and index leaf NPK content was highest at 1000:500:2000 g NPK/Palm/ year. This may pave way for the gradual replacement fertilizer in coconut based cropping system by way of *in-situ* waste recycling.

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