

IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON THE MINERAL NUTRITION AND YIELD OF WCT COCONUT IN LITTORAL SANDY SOIL AT KASARAGOD

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ABSTRACT

A field experiment was conducted in littoral sandy soil at Research Farm of Central Plantation Crops Research Institute, Kasaragod on WCT palms to study the response to 27 treatment combinations of three levels each of N (500, 1000, 1500), P_2O_5 (250, 500, 750) and K_2O (750, 1250, 1750) g/palm/year in combination with 20 kg organics/palm/year. Results revealed that despite sufficiency levels of N, P and K contents in the index leaf of palms and significant variations in N and K contents among different levels, the differential response in nut yield among the various combinations of fertilizer nutrients was not noticed. However, the mean nut yield in all the treatment combinations increased over 60% with the introduction of practice of application of 20 kg organics/palm/year and application of chemical fertilizers in three equal splits under various treatment combinations. This practice has even led to improvement in leaf P and K contents over earlier practice of chemical fertilizers alone. However, no appreciable build up was noticed for soil available N and K in the littoral sand. The soil available P was found in sufficiency level in all the treatment combinations.

INTRODUCTION

Coconut palm produces fronds and nuts throughout the year and hence, demands continuous supply of nutrients from the soil (Khan, 1993). An adult palm (West Coast Tall) producing 40 nuts and 12-13 fronds per year absorbed 321g N, 69g P (158 g P_2O_5) and 406g K (487 g K_2O) (Pillai and Davis, 1963). The general recommendation from Central Plantation Crops Research Institute for fertilizing the matured bearing palms is 500g N, 320g P_2O_5 and 1200g K_2O palm/year, to be applied in two split doses viz. one-third in May-June and two-third in September-October (Nelliatt, 1973).

Coconut is grown under highly heterogeneous soil conditions ranging from coastal sand to clay, from poorly drained uplands and hill slopes and strongly acidic to highly calcareous soils (Khan *et al.*, 1978). The productivity of coconut, though expected to be high in the coastal area, is low due to poor soil structure and nutritional status. The productivity is even lower in littoral sandy soils as consequences of high rainfall and heavy leaching of applied fertilizer nutrients. The coastal sandy soils occur extensively in Kerala, Karnataka and extended to Konkan region. They are sandy with less than 3% clay, very poor in organic matter, nutrients and water holding

capacity. The productivity could be increased through judicious nutritional management. The recommended blanket fertilizer dose for all soil types may not hold good in such situations. Earlier studies revealed that despite regular application of nitrogen fertilizers at the rate of 500, 1000, and 1500 g/palm/year in different treatment combinations no appreciable build up in soil was noticed in the littoral sandy soil (Srinivasa Reddy *et al.* 1999). This was mainly attributed to low nutrient retention power of the soil and suggested to improve the soil organic matter status, through application of organics, which in turn may act as site for nutrient retention thus, reducing the nutrient loss. The other aspects suggested were application of fertilizers in three splits and mulching in summer months to reduce the surface heating of littoral sand. Accordingly, application of organics at the rate of 20 kg/palm/year, fertilizer application in three equal splits during June, September and January months and dried coconut leaves mulching in the basin area during summer months were incorporated in the ongoing experiment from 1997 onwards. The results obtained there after are presented in this paper.

MATERIALS AND METHODS

The field experiment was laid out in the year 1972 in a 3³ factorial confounded design with

single replication in littoral sandy soil at Research Farm of Central Plantation Crops Research Institute, Kasaragod under All India Coordinated Research Project on Palms to study the response of WCT palms to graded levels of N, P and K in combination with organics. The experimental site is located at about sea level and receives an annual rainfall of 3500 mm. The soil is littoral sand having 98% sand, 0.2% silt and 0.7% clay and acidic soil pH (5.87). The palms were planted at a distance of 7.5m x 7.5m in a square system. The treatments include 27 combinations of three levels each of N (500, 1000, 1500 g), P₂O₅ (250, 500, 750 g) and K₂O (500, 1250, 1750 g)/palm/year. In addition absolute control (N₀P₀K₀), as side treatment for comparison was maintained. Each treatment consisted of a plot size of six palms (337.5 sq. meters). The response of the palms to various fertilizer levels was studied from 1975 to 1997 under recommended practice of two split application of treatment dose of fertilizers without organics addition and the results of which have been reported by Srinivasa Reddy *et al.* (1999). In 1997 the practice of application of organics 20 kg/palm/year in the form of FYM/vermicompost and fertilizers application in three equal splits @ one-third of treatment does each in June, September and January months was introduced and response studied. In addition, burnt lime @ 300g/palm/year, 20 days before second dose of fertilizer and MgSo₄ @ 500g/palm/year, along with the second dose of fertilizer were also applied to all the treatment palms uniformly from 2000 onwards. FYM/vermicompost prepared from the dry leaves of coconut in the same plot @ 20 kg/palm/year was applied uniformly to all the palms along with second doses of fertilizers i.e. in the month of September. All the palms were drip irrigated uniformly from November onwards till the onset of monsoon in June.

The N, P and K were applied in the form of urea, Mussooriephos and muriate of potash respectively. Fertilizers were applied broadcast in circular basins of 1.8 m around the palm. The yield data was recorded every month from all the palms and annual yield/palm was computed. The yield from 1998-99 one year after introduction of organics application and fertilizers in three split doses has been included in this paper. The growth observations such as number of leaves on crown

and annual leaf production were recorded from three palms/plot in 2000 and 2001.

Soil and leaf samples were collected from two palms in each plot in May, 2000 prior to fertilizer application. Soil samples were taken from two opposite sides of the palm, from the circular basin at 1.0 m distance away from the bole, at two depths viz. 0-50 cm and 50-100 cm using a tube augur. The soil samples were air dried in shade, ground to pass through 2 mm sieve and analysed for available nitrogen, phosphorus and potassium status. Available nitrogen in soil was determined by alkaline permanganate method (Subbiah and Asija, 1956). The available phosphorus was estimated (Bray-1) following the procedure outlined by Bray and Kurtz (1945); Jackson (1973) and available potassium was determined in the 1N NH₄ OAC (Hanway and Heidel, 1952) flame photometrically. The leaf samples were collected from index leaf (14th leaf) of the palm with knife, by cutting 4-5 leaflets from the middle of the frond on both the sides (Chapman, 1964). The leaf samples were washed with distilled water, oven dried at 65 C for 72 hrs and powdered using a Tecator Cyclotec sample mill. The powdered fraction (0.5 mm) of leaf sample was digested in HNO₃: HClO₄ (3:1) diacid mixture and analysed for phosphorus and potassium content (Jackson, 1973). The nitrogen content in plant sample was estimated according to modified Kjeldahl procedure as described by Jackson (1973) using Tecator Kjeltac Auto Analyser.

RESULTS AND DISCUSSION

Growth parameters:

The number of leaves in the crown and annual leaf production/palm during the year 2000-01 did not differ significantly due to main effects of N,P,K and two factor interactions. The annual leaf production ranged from 12.8 to 13.0 leaves/palm in fertilizer treatments as compared to 11.7 leaves/palm in the unfertilized control (Table 1). This clearly shows that annual leaf production is normal in all the treatment combinations. However, the number of leaves in the crown at any given time ranged from 24 to 27 leaves in 2000 and 23 to 26 leaves in 2001. Thus, making the crown size small in all the palms under different treatment combinations. Earlier results,

with inorganic nutrition alone, the mean number of functional leaves in the crown under fertilizer treatments ranged from 20 to 22.4/crown (Srinivasa Reddy *et al.*, 1999). In the present study, the number of leaves in the crown increased to 24 to 27 under different integrated fertilizer treatments. This increase could be attributed to application of 20 kg organics/palm/year and application of inorganic in three splits every year.

Nut and copra yield:

The nut yield and female flower production/palm/year for three consecutive years (1998-99-2000-01) due to influence of integrated nutrition treatments did not differ significantly due to main effects of N, P, K and two factor interactions (Table 2). This trend remained similar to that of previous yield data (1995-97), where no organics was added and treatment fertilizers applied in two split doses as per the blanket recommendation (Srinivasa Reddy *et al.*, 1999). However, the mean yield under all the treatment combinations increased to 65 nuts in 1998-99, 58 nuts in 1999-00 and 65 nuts/palm/year in 2000-01 as compared

to only 36 nuts/palm/year (mean of 1995-97) before the introduction of organics and increased split application of treatment dose of fertilizers. The nut yield increase was 80% in 1998-99, 60% in 1999-00 and 80% in 2000-01 due to combined application of 20 kg organics/palm/year and fertilizers in three split doses as compared to chemical fertilizers alone in two split applications (1995-97). This clearly shows that in soils like littoral sand, it is very important to improve the nutrient holding capacity of soil and ample care to reduce the nutrient leaching losses in high rain fall zones rather than attempting for higher dose of chemical fertilizers alone. The additive influence of blending inorganics with bulky organic manures in establishment of coconut seedlings and precocity in flowering of palms in littoral sandy soil was reported earlier by Nambiar *et al.* (1983). Even in the absolute fertilizer control ($N_0P_0K_0$) barring the year 1999-00, the nut yield increased to 12 nuts in 1998-99 and 18 nuts/palm/year in 2000-01 due to application of organics @ 20 kg/palm/year as compared to only 9 nuts/palm/year before the introduction of organics (1995-97). This increase in nut yield could be attributed to

Table 1: Number of leaves in WCT coconut as influenced by different levels of NPK fertilizers in combination with organics in littoral sandy soil

Treatments	No. of leaves on crown			Annual leaf production/palm 2000
	Pre-exptl.	2000	2001	
Nitrogen Levels				
N1	22.4	27.2	26.2	13.0
N2	20.2	25.7	23.8	12.8
N3	21.1	24.1	22.8	12.8
Phosphorous Levels				
P1	21.0	25.5	24.2	12.9
P2	21.6	26.2	24.3	13.0
P3	21.2	25.3	24.3	12.8
Potassium Levels				
K1	22.4	26.5	25.0	12.9
K2	20.0	24.4	23.3	13.0
K3	21.3	26.1	24.5	12.8
SE/plot	3.01	2.29	2.93	0.69
CD at 5%				
Main effects	NS	NS	NS	NS
Interactions	NS	NS	NS	NS
$N_0P_0K_0$	14.0	24.0	23.0	11.7

only application of 20 kg organics/palm/year. When combined the organics application (20 kg/palm/year) with different treatment combinations, the yield increase was enormous. The mean of all fertilizer treatment combinations were 65, 58 and 65 nuts/palm/year as compared to 12, 9, 18 nuts/palm/year with absolute fertilizer control treatment in 1998-99, 1999-00 and 2000-01 respectively. This indicates the improved response of palms to chemical fertilizers in combination with organics. But, the differential response to levels of N, P and K fertilizers was not noticed. Probably with the build up of organic matter in the soil over the years, palms may show differential response to levels of chemical fertilizers.

Dry copra yield/nut and copra yield/palm for the year 2000-01 also revealed that none of the main effects of N, P, K and two factor interactions were found significantly influenced. Dry copra weight/nut did not vary much due to fertilizer treatments and unfertilized control treatment.

However, the copra yield/palm/year ranged from 8.09 to 9.37 kg/palm in the fertilized treatments as compared to only 1.94 kg/palm/year in the unfertilized control. This was mainly due to higher number of nuts production in the fertilized treatments.

Soil nutrient status:

The soil available N, P and K at 0-50 cm and 50-100 cm soil depths is given table 3. The soil available N did not differ significantly due to main effects of N, P and K (27.5 to 52.4 ppm) and also their interactions. This again shows that no appreciable build up of N in soil was noticed even at higher levels of N application (500 to 1500 g N/palm/year) in combination with 20 kg organics/palm/year. Studies at Kasaragod indicate that about 80-100 ppm alkaline permanganate oxidisable-N as per Subbiah and Asija (1956) in soil is sufficient to maintain optimum N status in the palms. In coastal sandy soils of the Konkan

Table 2: Coconuts, copra yield and female flower production as influenced by different levels of NPK fertilizers in combination with organics in littoral sandy soil

Treatments	Nut yield/palm/year			Female flower production/palm/year (1999-01)	Dry copra yield		
	Mean of two years (1995-97)	1998-99	1999-00		2000-01	(g/nut)	(kg/palm/year)
N Levels							
N1	37	66	59	71	130	144.4	9.37
N2	31	63	57	62	128	135.8	8.09
N3	35	65	60	61	123	142.4	8.68
P Levels							
P1	36	69	60	64	124	147.5	9.13
P2	34	65	63	64	129	129.6	8.27
P3	32	61	53	67	127	145.5	8.74
K Levels							
K1	35	69	62	65	129	142.8	9.10
K2	32	63	60	63	129	135.8	8.52
K3	36	63	53	66	123	143.9	8.53
Mean	36	65	58	65			
SE/plot	10.30	24.4	11.3	10.66	10.44	21.57	2.13
CD at 5%							
Main effects	NS	NS	NS	NS	NS	NS	NS
Interactions	NS	NS	NS	NS	NS	NS	NS
N₀P₀K₀	9	12	9	18	30	143.8	1.94

region of Maharashtra importance of N on coconut yield, palm height and number of leaves was well established from the results of long term experiment. A higher order interaction between N and K for nut production was observed (ACCAIP, 1983).

Soil available P was significantly higher at P3 (750 g P₂O₅/palm/year) level (99.8 ppm and 85.1 ppm at 50 and 100 cm soil depths, respectively) compared to P1 (250 g P₂O₅/palm/year) level (48.9 and 39.5 ppm). Among the interactions, NK was found significant for available P in soil (Table 4). At N1 level, the availability of P was significantly higher at K3 level (114.5 ppm) when compared to N1K1 (64.0 ppm) and N1K2 (62.3 ppm). Even the lower levels recorded in the present study were well above the critical limits proposed for soil available P (10-12 ppm of available P-Bray and Kurtz-P1) to maintain the optimum P content in the palms (Khan *et al.*, 1990).

Soil available K was significantly higher at K2 (1250 g K₂O/palm/year) (47.8 ppm and 33.0 ppm at 50 and 100 cm soil depths, respectively)

and K3 (1750 g K₂O/palm/year) (56.8 ppm and 32.2 ppm at 50 and 100 cm soil depths, respectively) levels compared to K1 (750 g K₂O/palm/year) level (28.2 ppm). At 100cm soil depth, all the two factor interactions were found significant in respect of available soil K (Table 5). From N x P interaction, N1P2 and N1P3 were found to record significantly higher values than all other NP combinations except N3P1. In respect of N x K interactions, N1K2 was significantly superior over all other combinations except N1K3 and N3K3. From P x K interactions, it was found that P3K2 was significantly superior over other PK combinations except P2K2, P2K3 and P3K3. Soil available K of 55 ppm in the top 1 m of a red sandy loam soil was found sufficient to maintain sufficiency levels of 1.0-1.1% K in fronds (Khan *et al.*, 1986). In the present investigations in none of the treatment combinations the available soil K reached 55 ppm level.

Leaf nutrient status:

Studies at Kasaragod have indicated that foliar nutrient content in the range of 1.7-1.8%N,

Table 3: Soil available nutrients as influenced by different levels of NPK fertilizers in combination with organics in littoral sandy soil

Treatments	N (ppm)		P (ppm)		K (ppm)	
	50 cm	100 cm	50 cm	100 cm	50 cm	100 cm
<i>N Levels</i>						
N1	52.4	34.1	80.3	83.7	53.3	33.1
N2	49.0	27.5	73.9	61.1	40.4	23.3
N3	42.0	33.0	70.2	50.9	39.1	30.0
<i>P Levels</i>						
P1	50.5	30.7	48.9	39.5	44.7	27.2
P2	41.9	32.2	75.8	71.0	35.0	29.4
P3	51.5	31.6	99.8	85.1	53.1	29.8
<i>K Levels</i>						
K1	50.4	29.3	69.6	55.9	28.2	21.3
K2	47.8	34.4	71.9	69.7	47.8	33.0
K3	45.7	30.9	82.9	70.1	56.8	32.2
CD at 5%						
Main effects	NS	NS	17.42	28.89	16.17	4.20
Interactions	NS	NS	NK Sig.	NS	NS	Sig.
N ₀ P ₀ K ₀	53.5	26.2	20.8	18.3	13.3	6.7

0.8-1.0%K and 0.11-0.12%P is required for optimum production (Cecil and Khan, 1993). The leaf N content due to main effects of N, P and K were found significantly different (Table 6). N3 (1500g N/palm/year) level was found to record significantly higher leaf N % (2.11) than N1 level (1.79%). Under P levels, P2 (500g P₂O₅) recorded higher leaf N % (2.05) than P3 (750g P₂O₅) level (1.88%). Among K levels, K2 (1250g K₂O) recorded higher leaf N % (2.04) than K1 (750g K₂O) level (1.90%). Increased levels of K increased the leaf N content indicating increased N uptake. Steineck (1974) suggested that K application influences efficient utilization of nitrogen, thereby suggesting that plant absorbs only the quantity of K required for full utilization of absorbed N.

Nutrients applied to soil are reflected early in the plant (Dwivedi *et al.*, 1979), but large dilution of absorbed nutrient in the palm poses difficulties in interpreting the soil analysis data. In the present results, even the lower level of N (500g) recorded

Table 4. Soil available P (ppm) at 0-50 cm soil depth as influenced by interaction of N, P and K levels of fertilizers in WCT coconut in littoral sandy soil

	N1	N2	N3	Mean
K1	64.0	74.4	70.4	69.6
K2	62.3	87.9	65.5	71.9
K3	114.5	59.6	74.8	82.9
CD (5%) for NK interaction	30.17			

Table 5. Soil available K (ppm) at 50-100 cm soil depth as influenced by interaction of N, P and K levels of fertilizers in WCT coconut in littoral sandy soil

	N1	N2	N3	K1	K2	K3
P1	22.8	26.6	32.2	28.9	28.9	23.9
P2	38.3	17.7	32.2	19.4	32.2	36.7
P3	38.3	25.6	25.6	15.6	37.8	36.1
K1	21.1	22.2	20.6			
K2	42.8	26.1	30.0			
K3	35.6	21.6	39.4			
CD (5%) for NP, NK, PK interactions						7.28

the leaf N% within the range of critical limits prescribed inspite of low build up of N in the soil (Table 3). This could be due to dilution effect of nutrient in the plant system as none of the palms showed over 27 leaves in the crown (Table 1).

Leaf P content did not vary significantly due to main effects of N, P and K (0.160-0.163%). However, in all the fertilizer treatment combinations the leaf P content maintained was above the critical limits prescribed (0.12%) as in soil also the available P was well above the sufficiency level under all treatment combinations.

The leaf K contents varied significantly due to main effects of N and K. In general all treatment combinations showed leaf K content above the critical limit proposed for K (0.8-1.0%) inspite of low soil available K noticed. This could be possibly due to dilution effect in the plant system. Application of nitrogen at N1 (500g N) level was found to record significantly higher leaf K % (1.91%) compared to N2 (1000g) level (1.68%) and N3 (1500g) levels (1.49%). This is also very well

Table 6. Leaf nutrient contents in WCT coconut as influenced by different levels of NPK fertilizers in combination with organics in littoral sandy soil

Treatments	N %	P %	K %
N Levels			
N1	1.79	0.161	1.91
N2	2.03	0.163	1.68
N3	2.11	0.163	1.49
P Levels			
P1	1.99	0.160	1.69
P2	2.05	0.166	1.76
P3	1.88	0.160	1.63
K Levels			
K1	1.90	0.160	1.46
K2	2.04	0.163	1.71
K3	1.99	0.164	1.91
CD at 5%	0.095	NS	NS
Main effects			
Interactions	NS	0.23	NS
N ₀ P ₀ K ₀	1.46	0.130	0.85

reflective of the main effect of N, where at higher N levels, the leaf K content decreased which can be very well explained by the observation of Steineck (1974). Increased levels of K application (K2-1250g K₂O and K3-1750g K₂O levels) significantly increased the leaf K contents (1.71% and 1.91%) over K1 (750g) level (1.46%). Phosphorous application at different levels did not induce much variation in leaf K contents.

In comparison with the results of 1997 (prior to introduction of organics and increased split application of fertilizers), the present results showed improvement in leaf P and K contents in all the treatments. Earlier, the P content ranged from 0.11-0.12% and K content ranged from 0.97-1.32% under various treatment combinations (Srinivasa Reddy *et al.*, 1999). The results in the current investigation ranged from 0.160-0.163% for P and 1.46-1.91% for K in the index leaf of coconut palm (Table 6). Though, even in the earlier period the leaf P and K contents were above the critical limits owing to higher concentration of absorbed nutrients in lesser number of leaves in the crown, the further increase in leaf P and K contents could be attributed to application of 20 kg organics/palm/year and increased number of splits of chemical fertilizer application.

CONCLUSIONS

The results of this study revealed that inspite of application of 20 kg organics/palm/year and application of treatment dose of fertilizers in three equal splits, no appreciable build up was noticed for soil available N and K in the littoral sand. The soil available P was found in sufficiency level in all the treatment combinations. Despite sufficiency levels of N, P and K contents in the index leaf of palms and significant variations in N and K contents among different levels, the differential response in nut yield among the various combinations of fertilizer nutrients was not noticed. However, the mean nut yield in all the treatment combinations increased over 60% with the combined application of 20 kg organics/palm/year and application of chemical fertilizers in three equal splits under various treatment combinations. This practice has even led to improvement in leaf P and K contents over earlier practice of chemical fertilizers alone.

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