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Leaf and soil nutrient status of mango (*Mangifera indica* L.) grown in peninsular India and their relationship with yield

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Abstract

In the mango orchards, surveyed in three states of peninsular India, year-wise and orchard to orchard variation in soil and leaf nutrients were observed. Leaf N varied significantly between the high and low yielding orchards. Leaf N, P and K contents were above the critical limits in both high and low yielding orchards. However, high yielding orchards were having higher leaf N, P and K contents. Fruit yield had significant correlation with leaf N before and during flowering, leaf P after harvest, leaf K before flowering, soil N at pea stage, and soil K before flowering, during flowering and at pea stage of fruits. The results indicated the importance of nitrogen and potassium nutrition in enhancing the productivity of mango orchards. Linear and multiple regression equations specified the yield variations accounted far by the leaf and soil nutrients. Leaf nutrient status explained the yield variations better than soil nutrient content.

Key words: Correlation, leaf nutrients, mango, *Mangifera indica* L., regression, soil nutrients, yield.

Introduction

Mango, grown in an area of over one million hectares with an annual production of nearly ten million tons, is the most important fruit crop of India. However, the productivity of mango in the country is low due to the neglect of orchards. Most of the mango growers in the southern states of Andhra Pradesh, Karnataka and Tamilnadu are not applying the recommended dose of fertilizers. The production efficiency of mango orchards varies, which can be attributed partially to variations in soil and leaf nutrients (Ray and Mukherjee, 1987; Ray and Mukherjee, 1988). Detailed studies of orchard efficiency in South Indian commercial varieties of mango have not been carried out. Therefore, the present investigations were conducted for important commercial mango varieties grown in peninsular India.

Materials and methods

Survey of twenty-five private mango orchards, comprising of three varieties namely Banganapally, Totapuri and Alphonso was done in Nuzuvid, Srinivaspur and Krishnagiri areas of Andhra Pradesh, Karnataka and Tamilnadu states, respectively. These included five orchards each of Banganapally and Alphonso and fifteen orchards of Totapuri. The age of the trees was in the range of 30 to 40 years in Andhra Pradesh and Karnataka and 20 years in Tamilnadu states. The data on fruit yield were collected from these orchards during the fruiting seasons of 1994 to 1997. The orchards were then classified as high and low yielding as per the procedure outlined by Ray and Mukherjee (1988). In each orchard, two trees were marked for detailed studies and sampling. The soil and leaf samples were collected at four stages namely after harvesting, before flowering, at flowering and at pea size of the fruits. Leaf samples were collected from 5 to 6 months old shoots from non-bearing branches. Soil samples were collected at 1.0 m from tree trunk and from three depths 0- 30, 30-60 and 60 -90 cm and mean values were calculated. The soil N, P and K were determined as per Jackson (1973) and leaf N, P and K contents according to procedures outlined in USDA (1954). The study was for four years with ten times sampling. Fruit yield was recorded during the fruiting season and the mean fruit yield was calculated. Statistical inferences were drawn as per Snedecor and Cochran (1967).

Results and discussion

Leaf nutrients: Orchard to orchard as well as year-wise variation was observed in leaf N, P and K contents (Table 1). Samra *et al.* (1978) have also noted similar findings of variation with intra and inter-varietal differences. Theses differences in leaf nutrient status were attributed to variations in available soil nutrient status, soil type and growing conditions. The mean fruit yield of high and low yielding trees irrespective of variety was highly significant (Table 2). Only leaf N was significantly different before flowering, during flowering and pea size of fruits. There was highly significant difference in mean leaf N content between high and low yielding trees; the former showing higher leaf N at all the stages. The differences between high and low yielding trees in leaf P and K contents were non-significant at all the stages. In the high yielding trees, the leaf N increased steadily after harvest till flowering and then decreased at flowering followed by another increase from flowering to pea size of fruits. Contrary to this, Pathak and Pandey (1978) reported decline in leaf N, P and K contents from flowering to harvest. In both, high and low yielding orchards, the leaf N, P and K contents were above the critical limits proposed by different workers (Table 3). However, the high yielding trees recorded higher levels for these nutrients than the low yielding ones. The leaf and soil nutrient status of mango orchards in Andhra Pradesh were higher than the other two states due to application of the recommended fertilizers by the growers. The higher leaf N, P and K status was due to higher availability of these nutrients in the soil, though

the low yielding trees were having lower leaf K levels in spite of higher soil K contents. This can be attributed to available capacity, soil types and climatic conditions. Ray and Mukherjee (1987) also reported similar differences in leaf nutrients.

Soil nutrients: The mean available soil nutrients at 1.0m from trunk are presented in Table 4. Soil nutrient status varied widely with variety, year and orchard. The available soil N differed significantly only before flowering between the high and low

Table 1. Average yield and leaf nutrient at different stages of selected trees of mango orchards (Average of 1995 to 1997)

Location and state	Av. yield (kg/plant)	Variety	Status	Leaf nutrient status (%) dry weight											
				Nitrogen				Phosphorus				Potassium			
				AH	BF	F	P	AH	BF	F	P	AH	BF	F	P
Nuzuvid	223.3	Banganapally	High	1.84	1.76	1.79	1.99	0.23	0.05	0.08	0.11	0.84	0.91	0.84	0.84
(AP)	94.6	Banganapally	Low	1.72	1.68	1.39	1.85	0.19	0.07	0.07	0.08	0.87	0.86	0.74	0.76
	308.7	Totapuri	High	1.74	1.87	1.65	1.86	0.27	0.08	0.09	0.1	0.89	0.74	0.64	0.66
	172.0	Totapuri	Low	1.44	1.71	1.33	1.64	0.3	0.06	0.09	0.09	0.8	0.71	0.73	0.86
Srinivasapur	119.2	Alphonso	High	2.21	1.92	1.92	1.72	0.22	0.06	0.06	0.06	0.94	0.94	0.79	0.85
(KN)	60.1	Alphonso	Low	1.69	1.81	1.81	1.65	0.25	0.04	0.05	0.06	0.96	0.85	0.77	0.92
	187.5	Totapuri	High	1.14	1.82	1.82	1.97	0.29	0.07	0.06	0.08	1.08	0.89	0.71	0.94
	119.1	Totapuri	Low	1.06	1.87	1.87	1.72	0.24	0.06	0.06	0.06	0.94	0.76	0.69	0.64
Krishnagiri	130.0	Totapuri	High	1.50	1.69	1.69	1.91	0.06	0.08	0.07	0.032	1.03	0.62	0.58	0.69
(TN)	60.6	Totapuri	Low	1.49	1.5	1.5	1.46	0.1	0.09	0.13	0.13	0.87	0.73	0.69	0.62

Abbreviations: AH = After harvest; BF = Before Flowering; F = Flowering; P = Pea stage

Table 2. Comparison of mean leaf nutrients of high & low yielding trees form different orchards irrespective of variety (1995-1997)

Status	Average fruit yield (kg/plant)	Leaf Nutrients (%) dry weight basis)														
		Nitrogen					Phosphorus					Potassium				
		AH	BF	F	P	Mean	AH	BF	F	P	Mean	AH	BF	F	P	Mean
High	193.4	1.68	1.82	1.65	2.02	1.79	0.24	0.07	0.06	0.11	0.13	0.9	0.81	0.67	0.72	0.78
Low	101.2	1.48	1.72	1.44	1.75	1.6	0.22	0.07	0.06	0.07	0.11	0.85	0.78	0.68	0.67	0.75
Mean	147.3	1.58	1.77	1.54	1.88	1.69	0.23	0.07	0.06	0.09	0.12	0.87	0.79	0.67	0.69	0.76
SE	9.3	0.11	0.02	0.05	0.06	0.03	0.01	0.003	0.002	0.02	0.006	0.02	0.03	0.02	0.04	0.01
C.V.	19.9	23.68	4.92	11.86	11.62	6.49	21.68	13.07	13.28	77.90	16.30	8.31	14.44	12.1	19.81	8.22
C.D.(5%)	29.8	-	0.08	0.18	0.22	0.11	-	-	-	-	-	-	-	-	-	-
C.D. (1%)	42.8	-	-	-	-	0.16	-	-	-	-	-	-	-	-	-	-

Abbreviations: AH = After harvest; BF = Before Flowering; F = Flowering; P = Pea stage

Table 3. Comparison of leaf nutrient status (%) of mango with existing critical limit (pooled data of 1995-1997)

Nutrient	Status	Range*	Mean*	Existing critical limits				
				Smith and Scudder (1951)	Young and Koo (1971)	Kumar and Nauriyal (1977)	Rameshwar and Sultan(1981)	Bhargava and Chadha (1988)
Nitrogen	High	1.65-2.02	1.79	0.67 (C)	1.20 (C)	1.00 (C)	1.00-1.25 (0)	0.70-0.99(C)
	Low	1.44-1.75	1.60					
Phosphorus	High	0.06-0.24	0.13	00.05(C)	0.10 (C)	0.10 (C)	0.07-0.10(0)	0.05-0.07(C)
	Low	0.06-0.22	0.11					
Potassium	High	0.67-0.90	0.78	0.25(C)	0.90(C)	0.50(C)	0.60-0.74(0)	0.25-0.39(C)
	Low	0.67-0.85	0.75					

* Values of 10 orchards

Table 4. Soil nutrient status at different stages of selected trees of mango orchards at 1.0m from trunk (Average of 1995 to 1997)

Location and state	Av. yield (kg/plant)	Variety	Status	Available soil nutrient (kg/ha)											
				Nitrogen				Phosphorus				Potassium			
				AH	BF	F	P	AH	BF	F	P	AH	BF	F	P
Nuzuvid	223.3	Banganapally	High	147.6	222.7	177.3	209.3	52.7	26.8	36.7	23.4	289.9	304.9	334.2	376.5
(AP)	94.6	Banganapally	Low	138.2	198.8	175.1	187.2	30.9	12.8	25.3	21.3	343.1	213.3	293.3	304.9
	308.7	Totapuri	High	165.9	148.2	160.2	167.6	65.0	25.9	27.3	23.6	402.5	298.2	313.8	317.5
	172.0	Totapuri	Low	185.3	160.6	163.9	155.1	21.5	14.1	27.3	24.4	338.3	280.5	298.9	252.2
Srinivasapur	119.2	Alphonso	High	149.7	192.6	231.6	254.2	32.8	11.6	11.9	15.7	409.1	395.5	390.6	442.2
(KN)	60.1	Alphonso	Low	166.6	197.2	208.7	191.4	40.3	9.4	13.0	19.4	448.3	385.8	376.7	446.6
	187.5	Totapuri	High	140.8	183.0	166.3	227.4	41.1	9.4	17.2	19.9	267.5	351.6	337.8	431.4
	119.1	Totapuri	Low	128.3	181.1	200.3	189.0	228.9	8.7	16.0	26.7	426.5	360.0	350.5	463.1
Krishnagiri	130.0	Totapuri	High	114.2	174.0	168	159.0	33.5	11.8	17.0	34.2	76.3	111.7	121.7	188.3
(TN)	60.6	Totapuri	Low	89.4	108.5	194.3	156.2	38.0	26.1	20.8	32.8	138.3	164.1	189.4	214.4

Abbreviations: AH = After harvest; BF = Before Flowering; F = Flowering; P = Pea stage

yielding orchards (Table 5). The differences in available soil P and K were not significant at different stages. However, high yielding orchards recorded higher soil N and P and lower soil K compared to low yielding orchards. The differences in soil nutrient status were attributed to nutrient availability, soil conditions and horticultural practices. The leaf K but not the soil K contents was higher for the high yielding trees. This could be due to the distribution and absorption capacity of the feeder roots.

Correlation studies: The correlation matrix of fruit yield with leaf nutrients is presented in Table 6. Fruit yield had significant positive correlation with leaf N before and during flowering, leaf P after harvest and leaf K before flowering, in the decreasing order. Therefore, nitrogen application is of great importance in enhancing the fruit yield by increasing the leaf N status. Ray and Mukherjee (1987) as well as Rameshwar and Sultan (1981) obtained similar results.

The correlation matrix of fruit yield with soil nutrients is presented in Table 7. Significant positive correlation of fruit yield was recorded with available soil N at pea stage and with available soil K before flowering, at flowering and at pea size of fruits. This indicated the relevance of nitrogen and potassium fertilizers rather than that of phosphorus in increasing the fruit yield of mango, especially in the low yielding orchards. Even in a long range nutritional field trial, mango yield response was noted only for N and K, but not for P (Reddy *et al.*, 1998), lending support to this contention.

Table.5 Comparison of available mean soil nutrients of high and low yielding trees from different orchards irrespective of variety at 1.0m from tree trunk (1995-1997)

Status	Average	Available soil nutrient (kg/ha)														
	fruit yield	Nitrogen					Phosphorus					Potassium				
	(kg/plant)	AH	BF	F	P	Mean	AH	BF	F	P	Mean	AH	BF	F	P	Mean
High	193.4	143.6	184.1	189.8	202.7	180.0	45.0	17.1	21.6	22.6	27.1	293.8	292.4	293.9	347.3	306.8
Low	101.2	141.6	155.5	201.9	180.0	169.6	31.9	14	20.1	24.3	22.6	338.9	290.0	301.2	333.8	316.0
Mean	147.3	142.6	169.8	195.8	191.0	174.8	28.4	15.5	20.8	23.4	24.8	316.3	291.0	297.5	340.5	311.0
SE	9.3	10.3	8.5	7.1	7.9	4.3	4.7	3.0	1.3	1.0	1.7	18.1	14.9.0	14.4	10.7	10.5
C.V.	19.9	22.9	16.5	11.5	13.1	7.8	39.2	62.7	19.7	13.3	22.0	18.1	16.2.0	15.3	9.9	10.7
C.D.(5%)	29.8	-	28.3	-	-	-	-	-	-	-	-	-	-	-	-	-
C.D. (1%)	42.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations: AH = After harvest; BF = Before Flowering; F = Flowering; P = Pea stage

Table.6 Correlation matrix of yield and leaf nutrients (NPK) of mango trees at 4 growth stages (Average 1995-1997)

	Yield	LNAH	LNBF	LNF	LNP	LPAH	LPBF	LPF	LPP	LKAH	LKBF	LKF
LNAH	-0.13											
LNBF	0.63**	-0.59**										
LNF	0.54**	0.17	0.11									
LNP	0.27	-0.45*	0.65**	-0.19								
LPAH	0.46*	-0.80**	0.80**	-0.02	0.67**							
LIPBF	-0.29	0.04	-0.14	-0.02	0.02	-0.02						
LPF	-0.27	0.14	-0.22	0.18	-0.12	-0.12	0.68					
LPP	-0.22	0.14	-0.43*	-0.01	-0.38	-0.35	0.28	0.36				
LKAH	0.027	-0.02	-0.17	0.63**	-0.25	-0.05	-0.34	-0.10	0.05			
LKBF	0.43*	-0.08	0.28	0.56**	0.16	0.29	-0.20	-0.01	-0.14	0.41		
LKF	-0.1	0.67**	-0.68**	0.26	-0.64**	-0.71**	-0.21	0.02	0.05	0.31	-0.03	
LKP	-0.15	0.71**	-0.75**	0.31	-0.62**	-0.77	-0.13	0.12	0.27	0.43	0.06	0.82**

Abbreviations: AH = After harvest; BF = Before Flowering; F = Flowering; P = Pea stage; L=Leaf; N=Nitrogen; P=Phosphorus; K=Potassium

Table.7 Correlation matrix of yield & leaf nutrients at 1.0m from tree trunk of mango trees at four growth stages (Average 1995-97)

	Yield	SNAH	SNBF	SNF	SNP	SPAH	SPBF	SPF	SPP	SKAH	SKBF	SKF
SNAH	0.30											
SNBF	0.21	0.12										
SNF	0.37	0.08	0.06									
SNP	0.47*	0.14	-0.05	-0.01								
SPAH	0.14	-0.15	-0.01	-0.03	-0.01							
SPBF	0.23	-0.17	-0.01	0.14	-0.20	0.21						
SPF	-0.18	-0.10	-0.35	-0.53*	-0.07	0.28	0.29					
SPP	-0.30	-0.10	-0.4	-0.12	-0.32	-0.16	0.20	0.16				
SKAH	0.24	0.35	0.08	0.22	0.30	0.08	-0.19	-0.13	0.43*			
SKBF	0.74**	0.30	-0.01	0.41	0.51*	-0.08	0.04	-0.17	-0.27	0.69**		
SKF	0.46*	0.53*	0.43*	0.46*	0.44*	-0.07	-0.12	-0.23	-0.54**	0.79**	0.69**	
SKP	0.50*	0.26	0.31	0.42	0.57**	0.08	-0.33	-0.40	-0.36	0.73**	0.75**	0.82**

Abbreviations: AH = After harvest; BF = Before Flowering; F = Flowering; P = Pea stage; S=Soil; N=Nitrogen; P=Phosphorus; K=Potassium

Regression analysis: The linear regression equations of variables having significant correlation with leaf and soil nutrient contents for average samplings of 1995 to 1997 are given below:

	Equation	Variance explained(%)
1.	Y = - 68.36 + 21.57 LNBF	40.17
2.	Y = -38.65 + 120.35 LNF	29.50
3.	Y = 99.35 + 205.02 LPAH	21.67
4.	Y = -0.81 + 1.50 SKBF	51.53
5.	Y = 17.23 + 0.38 SKP	25.28
6.	Y = - 48.67 + 1.02 SNP	22.49

Thus, leaf N could account for only 40.17% and 29.50% variability in yield at two samplings of before and during flowering, respectively, although the simple correlation of these were significant with fruit yield. The leaf P after harvest accounts for the lowest yield variation. With respect to soil nutrients at 1.0m radial distance from the trunk, maximum yield variability was attributable to soil K before flowering and least was accounted by soil N during pea stage. Leaf and soil P had no substantial relationship with mango yield.

The multiple regression of yields with leaf and soil nutrients, having significant correlation with yield, for average sampling of 1995 to1997 are given below

$Y = -208.65 + 107.37\ LNBF + 107.26\ LNF + 11.38\ LPAH^{**} - 3.99\ LKBF^{**}$ ($r = 0.79^{**}$; $R^2 = 0.63$)

$Y = -39.71 + 0.39\ SNP^{*} + 0.53\ SKBF + 0.01\ SKF^{**} - 0.13 SKP^{*}$ ($r = 0.73^{**}$; $R^2 = 0.54$)

Figures in parentheses indicate multiple determination values and * and ** indicate statistical significance at 5% and 1% levels respectively. The leaf N, P and K together could explain the variation in yield to an extent of 63%.

The partial regression coefficients of P and K were significant. The soil N, P and K together influence yield variation to an extent of 54%. The influence of leaf nutrients was more than that of soil nutrients on fruit yield. Appropriate nutrient management to improve the leaf nutrient status, therefore, can enhance the productivity of mango considerably.

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