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CENTRE FOR WORLD FOOD STUDIES

THE CONCENTRATION OF MACRO-NUTRIENTS IN PLANT PARTS OF
TROPICAL PERENNIALS

by

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9

INTRODUCTION

In order to predict crop yields in situations that crop growth is limited by nutrient availability, a system for quantitative evaluation of the fertility of tropical soils (QUEFTS) has been developed by Janssen et al (1986 and 1987).

The inputs required for the application of the QUEFTS system are, apart from chemical soil data, the minimum and maximum concentrations of the macro nutrients N, P and K in the economic product of a crop and its residues. Initially, these data were collected for annual crops only, as QUEFTS was originally developed for these crops (Nijhof, 1987). However, QUEFTS can be adapted to perennials too, if the ranges in N, P and K concentrations in the plant parts and their dry matter distribution are known.

The QUEFTS system only distinguishes economic products and above ground residues for annual crops. This distinction appears to be too rough for perennial crops. The nutrients, which are annually lost by leaf shedding would be ignored. Moreover, the ranges in the nutrient concentrations in the residues would depend on the ratio between the weight of the leaves and that of the stems plus branches. The age of the crop and the season generally influence this ratio strongly. Therefore, data on the annual production of leaf dry weight and that of stems and branches are required, as well as Harvest Indices (annual economic production/annual dry matter production). If these data are available, yield-nutrient uptake relations of a given crop can be calculated on an annual basis.

Up to now, these data have not been collected by the Centre for World Food Studies. The object of this study was to provide such data from literature, i.e. on the dry matter distribution and ranges in N, P and K concentrations of tropical perennials.

METHODS

A large number of articles with relevant data of different perennials is reviewed (see Appendices 1 and 2). These data are used to establish the mean Harvest Index, the ratio between the annual increment of leaf dry weight and that of the stems plus branches as well as the ratio between the weight of the present leaves and that of the stems plus branches. The data were also used to establish the minimum and maximum nutrient concentrations of the economic products, mature leaves, stems plus branches and complete trees (leaves + stems + branches) The established ranges cover 90% of the values found, i.e. the upper and lower extremes are excluded. Information is also collected about the conversion of dry harvested products into fresh marketable products. The data are derived from crops already in full economic production, while not older than 25-30 years.

RESULTS

Data on the nutrient concentration of perennial crops are rare. Therefore, this study had to be confined to the major tropical perennials. The values for the minimum and maximum N, P and K concentrations and the dry matter distribution of the different crops are presented in Tables 1 and 2.

The nutrient concentrations in the stems and branches of orange trees are derived from data of orange as well as from data of other citrus species. The mean weight of coconut fruits is about 0.6 kg dry matter and oil palm fruits weigh approximately 65% of the bunches. The composition of latex and its yield of rubber are expressed as percentage of and in kg Total Solids (TS), respectively.

Table 1. Nutrient concentrations in economic products, leaves, stems plus branches and complete trees of tropical perennial crops, as fraction of N, P and K on dry matter basis.

crop, organ	N min-max %	P min-max %	K min-max %
Cocoa			
fruits	1.30-2.00	0.21-0.36	2.30-4.10
leaves	0.75-2.30	0.07-0.24	0.60-2.00
stem + branches	0.40-1.00	0.02-0.06	0.50-0.90
tree	0.65-1.20	0.04-0.10	0.50-1.10
Coffee			
fruits	1.10-2.30	0.10-0.18	1.50-3.30
leaves	1.50-3.80	0.05-0.32	0.50-3.20
stem + branches	0.40-1.70	0.05-0.19	0.40-2.20
tree	0.55-2.30	0.05-0.21	0.45-2.50
Orange			
fruits	0.80-2.20	0.08-0.16	0.65-1.70
leaves	1.50-3.60	0.05-0.36	0.23-2.40
stem + branches	0.45-1.50	0.02-0.08	0.13-0.50
tree	0.50-2.20	0.02-0.13	0.19-0.80
Palmtree's			
Coconut			
bunch	0.45-1.20	0.05-0.08	0.60-1.30
leaves	0.50-1.20	0.09-0.13	0.40-1.10
trunk	0.25-0.45	0.02-0.05	0.17-1.50
palm	0.40-0.80	0.05-0.10	0.30-1.30
Oil Palm			
bunch	0.35-0.60	0.04-0.11	0.40-1.20
male infl*	1.50-2.00	0.20-0.44	1.57-3.00
leaves	0.85-1.60	0.06-0.16	0.35-2.10
trunk	0.30-0.95	0.04-0.12	0.20-3.20
palm	0.50-1.00	0.05-0.12	0.30-3.00
Rubber			
latex (% on TS)**	0.60-0.85	0.11-0.21	0.40-0.65
leaves	1.80-3.90	0.14-0.31	0.65-2.50
stem + branches	0.30-0.60	0.03-0.09	0.11-0.50
tree	0.35-0.70	0.03-0.10	0.14-0.60
Tea			
flushes	3.20-5.60	0.17-0.50	0.40-2.00
leaves	2.00-4.30	0.08-0.40	0.27-2.00
stem + branches	0.60-1.30	0.05-0.25	0.40-0.80
shrub	0.90-1.90	0.06-0.28	0.40-1.00

* infl = inflorescences

** TS = Total Solids

Yield-nutrient uptake relations are calculated from the ranges in nutrient concentrations and the mean annual productions of economic products, leaves, stems and branches (Tables 1 and 2). The results are presented in table 3 and relate to the dry matter yield of the economic parts. For many crops, these harvested organs are cleaned and/or processed before being marketed. The yields of Table 3 are therefore converted into yields of fresh marketable products (Table 5) using the data of Table 4.

Table 2. The dry matter distribution of tropical perennials.

crop (economic product)	Harvest Index (%)	weight pr. leaves/weight st. + br. *	annual leaf growth/growth st. + br. *
Cocoa (fruits)	20	0.30	1.40
Coffee (fruits)	30	0.50	0.85
Orange (fruits)	40	0.30	1.70
Palmtrees			
Coconut (bunch)	58	1.30	2.90
Oil Palm (bunch)	40	0.55	3.50
(male infl)	3**		
Rubber (TS in latex)	9***	0.04	3.20
Tea (flushes)	17	0.25	0.80

* st. + br. = stem and branches, pr. = present.

** infl = inflorescence

*** TS = Total Solids

Berekening Cocoa:
(N_{min})

$$\frac{0.75 \times 1.40 + 0.4 \times 1.00}{2.40} = 0.604 \text{ (st. + br.) \% N}$$

$$0.2 \times 4.30 + 0.8 \times 0.604 = 2.074 \% N$$

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$$0.0130 + \frac{0.8}{0.2} \times 0.00604 = 0.0372 \rightarrow \frac{1}{0.0372} = 27$$

Janssen, B.H., F.C.T. Guiking, D. van der Eijk, E.M.A. Smaling and H. van Reuler (1986) A new approach to evaluate the chemical fertility of tropical soils. Proceedings ISSS Congress, Hamburg, Volume 3: 791-792.

gebruikt yield/uptake relaties in Tabel 3

Tabel 3 ↑

Janssen, B.H., F.C.T. Guiking, D. van der Eijk, E.M.A. Smaling, J. Wolf and H. van Reuler (in prep.) A system for quantitative evaluation of the fertility of tropical soils (QUEFTS).

Nijhof, K. (1987) The concentrations of macro-elements in the economic products and residues of (sub)tropical field crops. SOW-Staff Working Paper 87-08.

Table 3. Economic production-nutrient uptake relations for perennials at minimum and maximum N, P and K concentrations. (kg dry matter per kg nutrient uptake)

crop	N		P		K	
	max-min		max-min		max-min	
Cocoa (fruits)	12	- 3127	109	-279	11	- 25
Coffee (fruits)	12	- 32	131	-494	11	- 44
Orange (fruits)	15	- 41	174	-820	24	-123
Palmtree's						
Coconut (bunches)	54	-131	634	-988	47	-123
Oil Palm (bunches)	35	- 64	268	-705	20	- 98
Rubber (latex)*	2.9-	6.2	33-	75	4.5-	17
Tea (flushes)	5.6-	11	51-	218	12	- 49

* expressed as yield of total solids

Table 4. Conversion factors for dry harvested into dry marketable product and the dry matter content of the marketable products.

crop, marketable product	marketable product/ economic product (%)	dry matter content marketable product (%)
Cocoa (beans)	60	43
Coffee (beans)	62	59
Orange (fruits)	100	17
Coconut (nuts)	97	53
(dry copra)	34	6
Oil palm (bunches)	100	55
(oil)	31	0
Rubber (rubber)	92 % of TS	33 (DRC) *
Tea (fresh flushes)	100	22

* TS = total solids, DRC = dry rubber content.

gebruik of
kg/stem gewichtskend
en niet kg/stem
gewichtskend

Table 5. Fresh marketable production-nutrient uptake relations ^{for} some perennials at minimum and maximum N, P and K concentrations. (kg fresh product per kg nutrient uptake)

crop	N max-min	P max-min	K max-min
Cocoa (beans)	17 - 43	152- 389	15 - 35
Coffee (beans)	13 - 34	138- 519	12 - 46
Orange (fruits)	88 -241	1023-4824	141 -724
Palmtree's			
Coconut (kg nuts)	99 -240	1160-1808	86 -225
(number of nuts)	90 -212	1025-1597	76 -199
(dry copra)	19 - 47	228- 356	17 - 44
Oil Palm (bunches)	64 -116	487-1282	36 -178
(oil)	11 - 20	83- 219	6.2- 30
Rubber (dry rubber)	2.7- 5.7	30- 69	4.1- 16
(fresh latex)	8.2- 17	91- 209	12 - 48
Tea (fresh flushes)	25 - 50	232- 991	55 -223

Appendix 1. References.

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Appendix 2.

Minimum and Maximum N, P and K concentrations in plant parts of tropical perennials obtained from the literature.

Used abbreviations:

leaves/st + br p = present weight of leaves per present weight of stems and branches (g/g).

leaves/st + br i = annual weight increment leaves per annual weight increment of stems and branches (g/g).

HI = Harvest Index (%)

DRC = Dry Rubber Content

TS = Total solids

DM = Dry Matter

Reference Crop crop part	N min-max %	P min-max %	K min-max %
<hr/>			
Cocoa			
Aranguren et al (1982)			
leaves	1.77-1.77		
dead leaves	0.94-1.58		
stem + branches	1.03-1.03		
tree	1.14-1.14		
fruits	2.05-2.05		
leaves/st + br p	0.175		
Boyer (1973)			
leaves	1.06-1.06	0.06-0.06	0.49-0.49
stem + branches	0.30-0.30	0.01-0.01	0.42-0.42
tree	0.75-0.75	0.04-0.04	0.46-0.46
fruits	1.20-1.82	0.22-0.36	2.55-3.08
leaves/st + br i	1.43 (approximation)		
HI (fruits)	23.5		
beans/fruit %	65.0		
Corley et al (1983)			
HI (fruits)	20.0		
Haque et al (1980)			
lamina	0.84-2.26	0.06-0.25	0.61-1.83
Humphries (1939)			
fruits	1.64-1.64	0.28-0.28	2.28-2.28
ILACO (1981)			
bean DM %	42.5		
Khoo et al (1980)			
lamina	1.81-2.26	0.16-0.24	0.95-1.88
Ling (1984)			
lamina	2.26-2.96	0.17-0.21	1.89-2.63
Malavolta et al (1986)			
lamina	1.98-1.98	0.17-0.17	2.20-2.20
Nickols et al (1965)			
fruits		0.32-0.36	

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Omotoso (1975)			
fruits	1.47-1.66	0.20-0.29	2.85-3.67
beans/fruit %	62.2		
Omotoso (1975)			
lamina	0.70-?..?	0.08-?..?	1.30-?..?
Santana et al (1982)			
fruits	1.56-1.60		
Teoh (1980)			
lamina	1.83-2.87	0.14-0.28	1.34-2.55
Thong et al (1980) all approximations			
leaves + petioles	1.20-1.20	0.14-0.14	1.68-1.68
stem + branches	0.83-0.83	0.07-0.07	0.93-0.93
tree	0.93-0.93	0.09-0.09	1.13-1.13
fruits	1.58-1.58	0.26-0.26	2.73-2.73
leaves/st + br p	0.420		
beans/fruit %	51.3		
Uexhull (1978)			
fruits			4.20-5.50
Venema (1952)			
lamina		0.13-0.20	0.80-1.95
Wessel (1980)			
lamina		0.14-0.36	
Coffee			
Aduayi (1972)			
lamina		0.26-0.37	
Aduayi (1970)			
tree		0.05-0.13	
Anstead (1913)			
fruit	2.09-2.09	0.17-0.17	2.52-2.52
Anstead (1936)			
fruit	1.98-1.98	0.16-0.16	2.39-2.39
Aranguren et al (1982)			
leaves	1.51-1.51		
dead leaves	0.42-1.97		
stem + branches	0.51-0.51		
tree	0.54-0.54		
fruits	1.10-1.10		
leaves/st + br p	0.131		
Arzolla et al (1965)			
fruit	1.43-1.82	0.12-0.16	1.50-2.31
beans/fruit %	65.8		
bean DM %	42.8		
Bornemisza et al (1982)			
stem + branches	0.50-0.50		

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Cannell et al (1971)			
leaves	2.20-3.00	0.10-0.16	1.90-2.30
stem + branches	0.40-0.45	0.05-0.06	0.55-0.80
tree (extreme values)	1.22-1.67	0.07-0.12	0.87-1.60
fruits	1.53-1.53	0.11-0.11	1.93-1.93
HI (fruits)	53.8		
leaves/st + br p	0.81		
leaves/st + br i	0.84		
Canell et al (1971)			
HI (fruits)	40.6		
leaves/st + br p	0.577		
leaves/st + br i	0.964		
Catani et al (1958)			
tree	1.17-?..??	0.07-?..??	1.16-?..??
Cavallini (1978)			
lamina	1.59-4.06		0.36-3.63
Cooil (1958)			
lamina	2.50-3.90		
Dierendonck (1959)			
fruit	2.00-2.00	0.16-0.16	2.32-2.32
leaves	(1.90-4.00)	(0.04-0.20)	(0.25-3.32)
Haque et al (1980)			
lamina	1.30-3.40	0.08-0.16	0.75-2.16
Herndorfer (1933)			
tree	1.06-1.07		
fruits	1.64-1.65		
Hughes			
fruits	1.66-1.66	0.14-0.14	1.74-1.74
beans/fruit %	78.7		
bean DM %	86.7		
Jones et al (1966)			
fruits	1.18-1.18	0.12-0.12	1.93-1.93
beans/fruit %	52.3		
bean DM %	48.0		
Kimeu et al (1975)			
lamina	2.68-3.34	0.11-0.23	1.34-2.48
Kumar (1979)			
lamina	2.98-3.07		
Ledreux (1933)			
fruits	1.45-1.91	0.15-0.19	1.44-2.17
Lott et al (1962)			
lamina			0.75-3.40
Loue (1954)			
lamina		0.08-0.15	
Malavolta et al (1961)			
lamina		0.05-0.38	

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Medcalf et al (1956)			
lamina	2.78-3.52	0.08-0.13	1.00-2.30
Menard et al (1962)			
lamina			3.02-3.92
Mehlich (1966)			
leaves	1.90-2.80	0.13-0.24	1.73-2.64
stem + branches	0.82-0.96	0.10-0.14	1.19-1.48
tree	1.63-1.92	0.15-0.22	1.83-2.47
fruits	1.01-1.80	0.08-0.16	1.79-2.15
HI (fruits)	20.6		
leaves/st + br i	0.787		
Mehlich (1966)			
fruits			4.40-4.40
Omotoso (1974)			
lamina	2.24-3.20	0.08-0.14	2.59-3.02
Robinson (1968)			
lamina	1.80-3.00	0.06-0.13	1.00-3.00
Robinson (1965)			
fruits	1.26-1.32	0.13-0.15	2.36-2.39
Schnitzer (1974)			
lamina	2.20-3.40	0.10-0.21	1.40-2.60
Streng (1954)			
fruits	1.82-1.82	0.15-0.15	1.79-1.79
Tesha (1979)			
lamina	1.93-3.31		
Thomas (1958)			
lamina	2.96-2.96	0.18-0.18	1.94-1.94
Vasuseva (1977)			
fruits	2.45-2.92		
beans/fruit %	50.5		
Vicente-Chandler (1970)			
lamina	2.50-3.00	0.10-0.15	2.00-2.50
Welte et al (1971)			
lamina	2.60-2.90	0.13-0.18	2.15-2.43
Wilsson (1985)			
stem + branches	0.60-0.60	0.05-0.05	0.40-0.40
Citrus			
Akao (1978) mandarin			
leaves	2.80-2.80		
stem + branches	1.30-1.30		
tree	1.55-1.55		
Aldrich et al (1952) orange			
leaves		0.05-0.11	
Arnot (1947) orange			
leaves			0.19-0.25

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Bar-Akiva (1975) orange			
leaves	1.61-1.71	0.10-0.16	0.66-1.43
Barnette (1931) grapefruit			
leaves	2.41-2.41	0.14-0.14	2.46-2.46
stem + branches	0.44-0.44	0.05-0.05	0.45-0.45
tree	0.62-0.62	0.06-0.06	0.63-0.63
leaves/st + br p	0.099		
Bathurst (1958) orange			
leaves			0.40-2.25
Beverly et al (1984) orange			
leaves	2.25-2.80	0.12-0.18	0.38-1.15
Bingham et al (1958) orange			
leaves		0.06-0.44	
Bingham et al (1956) orange			
leaves		0.06-0.38	
Bouma (1965) orange			
leaves		0.09-0.16	
Cameron et al (1954) orange			
leaves	2.03-2.13	0.12-0.12	1.19-1.21
stem + branches	0.44-0.44	0.04-0.05	0.38-0.38
tree	0.79-0.80	0.06-0.06	0.55-0.57
leaves/st + br p	0.276		
Cameron et al (1936) orange			
fruits orange	1.34-1.42		
fruits grapefruit	1.29-1.29		
fruits lemon	1.28-1.28		
Cameron et al (1934) orange			
leaves	1.94-1.94		
stem + branches	0.53-0.53		
tree	0.92-0.92		
leaves/st + br p	0.396		
Cameron et al (1933) orange			
fruits	(1.17-1.17)		
leaves	1.94-2.53		
stem + branches	0.49-0.60		
tree	(0.91-1.03)		
leaves/st + br p	0.307		
Chapman (1960) orange			
leaves		0.07-0.30	
Chapman (1951) orange			
leaves		0.08-0.16	
Chapman (1950) orange			
leaves	2.00-3.50	0.08-0.30	0.35-2.00
Chapman (1949) orange			
leaves	2.00-3.16		0.35-2.00
Chapman (1941) orange			
leaves		0.06-0.25	0.30-2.00

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Chaukan (1984) citrus			
leaves	1.50-2.90	0.08-0.12	0.76-1.81
Cutuli (1968)			
leaves orange	2.47-3.18		1.40-2.18
leaves lemon	2.18-3.79		0.65-1.81
Dasberg et al (1983) orange			
leaves		0.05-0.05	0.66-0.78
De Villiers et al (1961) orange			
leaves		0.08-0.12	0.30-1.50
Embleton et al (1956) orange			
leaves		0.08-0.14	
Embleton et al (1952) orange			
leaves		0.07-0.13	
Esdorn (1961)			
fruits orange	1.12-1.12		
fruits lemon	0.64-0.64		
leaves		0.07-0.13	
Esdorn (1961)			
fruits orange	1.12-1.12		
fruits lemon	0.64-0.64		
Forsee et al (1944) orange			
leaves		0.07-0.10	
Garcia Mari (1981) orange			
fruits			1.10-1.10
Gates et al (1966) orange cuttings			
leaves	2.42-?.	0.07-?.	
stem + branches	1.23-?.	0.08-?.	
tree	2.14-?.	0.07-?.	
HI	25.6		
leaves/st + br i	2.35		
Harding (1953) orange			
leaves		0.08-0.12	
Herschberg (1954) orange			
leaves		0.10-0.28	
Heymann-Herschberg (1952) orange			
leaves		0.10-0.30	
Hume et al (1985) sweet orange			
leaves	2.20-2.80	0.09-0.29	0.40-2.00
Jones et al (1955) orange			
leaves	2.20-2.70		
Koo et al (1973) orange			
leaves			0.34-2.05
Koo et al (1958) orange			
fruits	0.72-1.12	0.08-0.14	1.00-1.63
leaves	2.24-3.29	0.10-0.16	1.04-2.77
Koo et al (1956) orange			
fruits	0.83-1.14	0.12-0.14	1.15-1.56
leaves	2.34-3.03	0.14-0.25	1.23-2.40

Reference Crop crop part	N min-max %	P min-max %	K min-max %
<hr/>			
Kubota (1974) mandarin			
leaves	2.06-3.39		
stem + branches	0.89-1.42		
tree	0.99-2.77		
leaves/st + br p	0.702		
leaves/st + br i	0.854		
Kubota et al (1973) mandarin			
fruits	1.25-1.25	0.13-0.13	1.01-1.01
leaves	2.59-2.59	0.14-0.14	0.73-0.73
stem + branches	0.70-0.70	0.06-0.06	0.25-0.25
tree	0.91-0.91	0.07-0.07	0.33-0.33
leaves/st + br p	0.110		
leaves/st + br i	2.55 (approximation)		
HI	43.7 (approximation)		
Kubota et al (1972) mandarin			
leaves	2.44-2.70		
stem + branches	1.07-1.11		
tree	1.70-1.83		
Legaz et al (1982) calamondin			
fruits	1.68-1.68		
leaves	2.59-2.59		
stem + branches	0.93-0.93		
tree	1.48-1.48		
leaves/st + br p	0.445 or less		
Maquirieira et al (1984) orange			
fruits	2.10-2.91		
leaves	2.22-2.63		
Marchal et al (1958) mandarin			
fruits	1.00-1.11	0.08-0.09	1.05-1.34
leaves	1.97-2.07	0.05-0.08	0.34-0.77
stem + branches	0.74-0.98	0.02-0.04	0.18-0.32
tree	0.97-1.27	0.02-0.05	0.21-0.42
leaves/st + br p	0.331		
fruit DM %	17.3		
Mart Moreno et al (1975) orange			
leaves	2.73-?..?	0.17-?..?	2.44-?..?
stem + branches	1.01-?..?	0.18-?..?	0.64-?..?
Morris (1958) orange			
leaves			0.25-0.40
Nadir (1974) orange			
leaves	1.92-2.06	0.09-0.12	0.51-1.18
twigs	0.46-0.57	0.02-0.03	0.25-0.48
leaves + twigs	0.55-0.98	0.03-0.05	0.27-0.48
Nadir (1974) citrus			
fruits	0.94-1.44	0.09-0.16	0.61-1.76
Nadir (1971) orange			
fruits	0.88-1.18	0.08-0.11	0.76-1.43
Naude (1958) orange			
leaves			0.60-0.60

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Oppenheimer (1945) orange			
leaves	2.00-2.50	0.08-0.25	0.25-?..?
Reuther et al (1958) orange			
leaves	1.90-3.30	0.08-0.30	0.60-2.40
Reuther et al (1954) orange			
leaves	2.00-3.60		0.60-2.40
Reyneke et al (1958) orange			
leaves			0.50-1.20
Tellaria et al (1986) orange			
leaves	2.23-2.67	0.09-0.11	0.94-1.07
Ting (1980)			
fruits orange	0.82-0.82		
fruits grapefruit	0.72-0.72		
fruits tangarin	0.98-0.98		
Wallace (1954) orange			
leaves	1.74-3.92	0.10-0.34	0.17-0.31
stem + branches	1.09-1.16	0.12-0.12	0.11-0.14
Wallace et al (1951) orange			
fruits	0.94-1.11	0.15-0.15	1.11-1.62
shed leaves	1.52-1.60	0.05-0.05	0.45-0.51
Wallace et al (1951) and Cameron et al (1954) orange			
author's interpretation			
HI	53.8		
leaves/st + br i	0.918		
Williams et al (1956) orange			
leaves		0.10-0.10	
Coconut			
Chew (1978)			
crown	0.86-0.86	0.11-0.11	1.23-1.23
trunk	0.46-0.46	0.06-0.06	1.75-1.75
crown + trunk	0.71-0.71	0.09-0.09	1.42-1.42
bunch	0.53-0.53	0.10-0.10	1.03-1.03
crown/trunk p	1.68		
Copeland (1921)			
crown	0.38-?..?	0.13-?..?	0.75-?..?
Corley et al (1983)			
HI (nuts)	30.0		
Die (1974)			
nut	0.41-0.41	0.05-0.05	0.63-0.63
copra/nut %	29.3		
nutweight (KG DM)	0.55		
Furr et al (1979)			
nut			0.59-0.59

Reference Crop crop part	N min-max %	P min-max %	K min-max %
<hr/>			
Nair (1979)			
crown	1.15-1.15	0.09-0.09	0.53-0.53
trunk	0.20-0.20	0.02-0.02	0.17-0.17
crown + trunk	0.51-0.51	0.05-0.05	0.29-0.29
nut	1.07-1.07	0.07-0.07	0.64-0.64
bunch	1.03-1.03	0.07-0.07	0.61-0.61
HI (bunch)	73.1 (approximation)		
fruit/bunch weight	98.7 (approximation)		
crown/trunk p	0.49 (approximation)		
crown/trunk i	2.52 (approximation)		
Nathanael (1964)			
bunch	0.52-0.52	0.08-0.08	0.56-0.56
Nelliati et al (1974)			
HI	66.7		
crown/trunk i	3.01		
nutweight (KG DM)	0.67		
Ouvrier (1984)			
crown/trunk p	1.75		
crown/trunk i	3.10 (approximation)		
HI (bunch)	63.1 (approximation)		
copra/nut %	30.9		
Ouvrier (1984)			
nut	0.53-0.62	0.08-0.10	0.65-1.19
copra/nut %	35.6		
Ouvrier (1982)			
nut	0.62-0.62	0.07-0.07	1.32-1.32
bunch	0.62-0.62		
copra/nut %	31.8		
Ouvrier et al (1980)			
nuts	0.57-0.57	0.08-0.08	0.91-1.08
bunch	0.57-0.57	0.08-0.08	1.02-1.02
nuts/bunch weight	0.955		
copra/nut %	35.3		
DM % nut	52.6		
nutweight (KG DM)	0.60		
Sampson (1923)			
crown approximation	1.06-1.06	0.09-0.09	0.35-0.35
trunk	0.40-0.40	0.02-0.02	0.17-0.17
crown + trunk appr	0.80-0.80	0.07-0.07	0.28-0.28
nut	1.06-1.24	0.07-0.08	0.67-0.92
Oil Palm			
Breure et al (1983)			
HI (bunch)	34		
Breure et al (1982)			
HI (bunch)	44.7		
fruits/bunch weight	65.1		
Corley et al (1972)			
HI (bunch)	48.1		

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Corley (1971)			
HI (bunch)	41.3		
crown/trunk p	0.89		
crown/trunk i	6.24		
male infl/bunch	0.054		
oil/bunch %	40.0		
Corley et al (1971)			
HI (bunch)	45.3		
Georgi (1931)			
crown	0.90-0.90	0.06-0.06	0.61-0.61
bunch	0.54-0.54	0.09-0.09	1.18-1.18
male inflorescence	2.05-2.05	0.27-0.27	1.82-1.82
male infl/bunch	0.179		
bunch DM %	51.2		
Ng et al (1967)			
crown	0.85-1.14	0.08-0.13	0.97-1.65
trunk	0.35-0.75	0.04-0.12	0.80-1.92
crown + trunk	0.47-0.82	0.05-0.12	0.97-1.92
bunch	0.32-0.62	0.03-0.11	0.36-1.01
male inflorescence	1.45-1.99	0.20-0.47	1.53-3.07
HI (bunch)	41.5		
crown/trunk p	0.412		
crown/trunk i	1.28		
male infl/bunch	0.021		
bunch DM %	56.3		
Sparnaaij (1969)			
oil/bunch %	21.7 (approximation)		
Rees et al (1963)			
HI (bunch)	28.4		
crown/trunk p	0.478		
crown/trunk i	3.16		
bunch DM %	58		
Tinker (1963)			
crown	0.85-0.89	0.07-0.11	0.28-0.88
trunk	0.34-0.64	0.05-0.08	0.16-0.54
crown + trunk	0.48-0.74	0.06-0.09	0.20-0.70
HI (bunch)	27.1		
crown/trunk p	0.371		
crown/trunk i	3.51		
Turner (1968)			
crown approximation	0.99-0.99	0.17-0.17	2.22-2.22
trunk	0.28-1.00	0.04-0.10	0.99-3.52
crown + trunk appr	0.98-0.98	0.12-0.12	3.18-3.18
Wilbaux (1937)			
male inflorescence	1.85-1.85	0.20-0.20	2.54-2.54
Zeller (1911)			
crown	1.69-1.69	0.08-0.08	0.61-0.61
trunk	0.61-0.61	0.11-0.11	0.27-0.27

Reference Crop crop part	N min-max %	P min-max %	K min-max %
<hr/>			
Rubber			
N, P and K in latex as % on total solids.			
Amaral et al (1983)			
lamina	1.94-3.40	0.14-0.25	0.79-2.22
Anonymous (1974)			
lamina	3.40-3.55	0.31-0.32	1.26-1.44
Anonymous (1971)			
lamina	2.94-4.13	0.17-0.32	0.52-1.91
Bealing et al (1971)			
DRC/TS content	92.1		
TS content	34.6		
DRC %	32.6		
Bouychou (1974)			
lamina	2.75-3.52	0.18-0.25	0.81-1.08
Collier (1969)			
latex	0.59-0.82		
DRC/TS content	92.0		
TS content	37.2		
Deyin (1983)			
lamina	2.90-3.58	0.17-0.21	0.67-1.30
Dijkman (1951)			
tree	0.45-0.73	0.03-0.09	0.21-0.66
Dyck (1939)			
lamina	2.67-2.67	0.16-0.16	0.94-0.94
leaves + petioles	2.51-2.51	0.15-0.15	1.16-1.16
stem + branches	0.37-0.37	0.05-0.05	0.37-0.37
tree	0.42-0.42	0.05-0.05	0.39-0.39
leaves/st + br p	0.026		
Guha (1969)			
lamina	2.89-4.15	0.19-0.31	0.75-2.24
Haridas (1980)			
tree	1.57-?..?	0.07-?..?	0.76-?..?
Kalam et al (1979)			
lamina	3.01-3.51	0.16-0.22	0.86-1.29
Krishnakumari et al (1979)			
lamina	3.00-3.20	0.20-0.25	1.00-1.20
Lo et al (1985)			
lamina	3.20-3.40		0.60-1.00
Ng (1974)			
latex	0.63-0.74	0.10-0.12	0.40-0.45
Pakianathan (1982)			
latex	0.60-0.61	0.16-0.17	0.54-0.57
Plessix (1974)			
lamina	2.74-3.50	0.25-0.37	0.44-1.12
Pushpadas (1978)			
lamina	2.95-3.18	0.24-0.27	1.08-1.13
Pushparajah (1982)			
tree	0.56-?..?		0.27-?..?
lamina	1.62-1.97		0.45-1.81

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Pushparajah (1977) lamina		0.21-0.27	
Pushparajah (1975) latex	0.67-0.86	0.16-0.21	0.55-0.65
Pushparajah (1969) lamina	2.89-4.15	0.26-0.33	0.76-1.48
Pushparajah (1969) lamina	3.19-3.46	0.22-0.29	0.76-1.48
Pushparajah (1969) latex	0.60-0.68	0.15-0.21	0.42-0.52
Shorrocks (1965) latex	0.70-0.70	0.20-0.20	0.60-0.60
Shorrocks (1965) leaves	2.34-3.23	0.15-0.22	0.69-1.07
Shorrocks (1965) stem + branches	(0.28-0.65)	(0.03-0.09)	(0.08-0.46)
Shorrocks (1965) tree	0.33-0.65	0.04-0.09	0.12-0.37
Shorrocks (1965) leaves/st + br p	0.043		
Shorrocks (1965) leaves/st + br i	0.383		
Shorrocks (1965) HI (TS content)	9.1		
Silva (1971) lamina	3.08-3.29	0.22-0.22	0.59-1.22
Templeton (1969) HI (dry rubber)	7.0		
Templeton (1969) leaves/ st + br i	6.04		
Templeton (1969) HI (dry rubber)	10.1		
Teng et al (1975) lamina	3.26-3.78	0.18-0.24	0.99-1.33
Wycherley (1976) DRC %	35.5		
Yeang et al (1982) DRC/TS content	90.8		
Yeang et al (1982) DRC %	29.7		
Tea			
Aiyadura et al (1977) leaves	3.68-?..?		1.05-?..?
Aiyadura et al (1977) stem + branches	2.24-?..?		0.76-?..?
Antiya (1985) flush	4.60-5.50		
Burculadze (1971) leaves	1.17-1.20	0.11-0.16	0.26-0.30
Burculadze (1971) flush	4.50-4.90		
Child (1964) flush		0.40-0.40	2.00-2.00
Eden (1949) flush	4.02-4.02	0.37-0.37	1.33-1.33
Eden (1949) leaves	2.47-2.47	0.18-0.18	0.98-0.98
Eden (1949) stem + branches	0.94-0.94	0.12-0.12	0.62-0.62
Eden (1949) HI (flushes)	22.0 or less		
Eden (1949) leaves/st + br i	0.434 or less		

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Filippova (1980)			
flush	4.80-5.60	0.31-0.43	1.66-1.66
Hadfield (1974)			
HI (flushes)	14.7 (approximation)		
Hoshina (1982)			
leaves	2.76-2.76		
stem + branches	0.70-0.70		
Ikegaya (1971)			
leaves		0.19-?..?	
stem + branches		0.06-?..?	
Jayman et al (1980)			
leaves		0.17-0.21	
Kathiravetpillai et al (1981)			
leaves	2.87-?..?	0.16-?..?	0.85-?..?
stem + branches	1.19-?..?	0.16-?..?	0.70-?..?
shrub		0.16-?..?	
Kularatne et al (1971)			
leaves	2.79-?..?	0.43-?..?	1.95-?..?
stem + branches	1.20-?..?	0.26-?..?	0.73-?..?
Kulasegaram et al (1983)			
flush	3.43-5.60	0.16-0.39	1.46-2.03
leaves	2.24-3.15	0.08-0.13	0.66-1.38
stem + branches	0.77-?..?	0.05-?..?	0.41-?..?
Lee (1981)			
leaves	3.65-?..?		
Magambo (1985)			
HI (flushes)	19.1		
leaves/st + br p	0.263		
leaves/st + br i	0.985		
Magambo (1981)			
HI (flushes)	11.0		
leaves/st + br i	0.527		
Magambo (1978/79)			
leaves	2.88-3.02	0.16-0.21	1.63-1.95
stem + branches	0.79-?..?	0.06-?..?	0.83-?..?
shrub	1.53-?..?	0.10-?..?	1.14-?..?
Menon et al (1981)			
leaves		0.24-0.27	
Nakayama (1971)			
leaves	2.31-3.33		
stem + branches	0.69-0.85		
Othieno (1983)			
leaves	3.37-3.64	0.17-0.20	1.42-1.65
Othieno (1980)			
leaves		0.11-0.32	
Portsmouth (1953)			
leaves			0.48-1.25
Putkaradze (1966)			
flush		0.32-0.52	

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Ranganathan (1975)			
flush	3.00-3.00	0.50-0.50	1.83-1.83
leaves	3.50-3.50	0.42-0.42	1.00-1.00
stem + branches	1.32-1.32	0.29-0.29	0.36-0.36
shrub	1.96-?..?	0.33-?..?	0.54-?..?
HI (flushes)	17.4		
leaves/st + br i	1.37		
Sarishvuili (1978)			
flush	4.50-5.00	0.35-0.43	1.49-1.74
Selvendran et al (1973)			
leaves	3.05-?..?		
stem + branches	0.51-?..?		
Sivasubramaniam (1971)			
leaves			0.56-2.00
Tanton (1979)			
HI (flushes)	21.2		
Watson et al (1982)			
leaves	3.23-3.63	0.10-0.16	0.72-1.08
Wettasinghe (1980)			
leaves	3.12-3.67	0.09-0.18	0.28-1.05
Willson (1974)			
flush	3.30-4.04	0.18-0.28	1.44-1.69
Willson (1969)			
flush	5.00-5.00	0.35-0.35	1.78-1.78
leaves	5.00-5.00	0.35-0.35	1.63-1.63
shrub	3.50-?..?	0.26-?..?	2.11-?..?
Wood et al (1964)			
flush	4.00-4.99	0.38-0.46	1.63-2.49
flush DM %	22.6		
Zurbicky et al (1964)			
flush	4.00-4.70		1.49-1.66

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Kirby (1967) straw	1.75-?..?		3.60-?..?
Lorenz (1980) fruits		0.55-0.55	
Maher (1976) fruits	3.00-3.00	0.50-0.50	4.50-4.50
straw	3.12-3.12	0.50-0.50	5.13-5.13
HI (incl shed leaves)	43.0		
Mayr (1969) fruits		0.35-0.35	
Orphanos et al (1980) fruits	1.83-3.31		
O'Sullivan et al (1974) straw	0.74-?..?		
Oswiecinski (1982) straw	0.30-?..?	0.17-?..?	2.91-?..?
Pill et al (1980) fruits			3.07-4.57
Pill et al (1979) fruits		0.54-0.62	4.72-5.35
Pill et al (1978) fruits		0.85-0.93	3.02-4.83
Roorda et al (1981) fruits	1.68-3.50	0.28-0.80	2.74-5.87
Souci (1962) fruits	1.90-2.76	0.30-0.44	4.48-5.34
Tanaka et al (1974) fruits	2.78-2.78	0.41-0.41	2.99-2.99
straw	(2.24-2.24)	(0.22-0.22)	(4.01-4.01)
HI	53.6		
HI (incl shed leaves)	48.8		
DM % fruits	6.7		
Uexhull et al (1978) fruits	1.93-1.93	0.41-0.41	3.77-3.77
straw	2.34-2.34	0.51-0.51	5.39-5.39
HI	70		
Ward (1967) fruits	1.81-1.81	0.42-0.42	3.40-3.40
straw	2.61-2.61	0.80-0.80	3.25-3.25
HI (approximation)	81.0		
Watt (1963) fruits	2.71-2.71	0.42-0.42	3.75-3.75
Widders et al (1982) fruits			3.67-4.09
straw			2.38-2.38
straw (extreme values)			1.98-2.55
HI	57.0		
Widders et al (1979) fruits			3.94-4.09
straw			1.68-3.50
HI	55.5		