

STICHTING ONDERZOEK WERELDVOEDSELVOORZIENING

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THE CONCENTRATION OF MACRO-NUTRIENTS IN (SUB)TROPICAL CROPS
OF MINOR IMPORTANCE

by

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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 macronutrients N, P and K in the economic product of a crop and in its residues and the dry matter distribution. Initially, these data were established for maize only, as QUEFTS was originally developed for this crop. However, QUEFTS can be adapted to any crop if the ranges in N, P and K concentrations in residues and economic products and the Harvest Index are known. Such data have recently been collected by the Centre for World Food Studies for the major (sub)tropical crops (Nijhof, 1987). Data for crops of minor importance are still lacking however.

In this study data are collected on the ranges in N, P and K concentrations as well as Harvest Indices for the "minor" (sub)tropical crops, particularly fruit and vegetable crops. These data are used for the calculation of yield-nutrient uptake relations.

METHODS

A large number of articles with data on the N, P and K concentrations and the dry matter distribution and concentration in different crops is reviewed (Appendices 1 and 2). These data are used to establish the minimum and maximum nutrient concentrations. They are derived for mature (i.e. to be harvested), complete plants (excluding roots) and the corresponding concentrations in economic products and residues are determined afterwards (see Table 1.) Extreme high or low concentrations are often found in one part of the crop, but are only used as minimum or maximum concentrations if they are accompanied by high or low concentrations in the other crop

parts. The established ranges cover 90% of the values found, i.e. the upper and lower extremes are excluded. Correlations between the N and P concentrations in a plant part as well as between the concentrations in economic product and residue are computed for all crops. Both types of correlations, if they proved to be strong, are used to determine the range of concentrations of the least documented nutrient and in the least documented plant part respectively.

Harvest Indices are calculated as the means of the values found. These indices are used to establish yield-nutrient uptake relations at minimum and maximum nutrient concentrations.

The Harvest Indices and nutrient ranges of pineapple and banana are determined for the mother plants only, i.e. ignoring the daughter plants and/or young shoots. The data collected for castor beans refer to annual varieties, although this crop can be grown as perennial too.

RESULTS

The values for the minimum and maximum N, P and K concentrations in the crops and their mean Harvest Indices are presented in the Tables 1 and 2.

Information on the nutrient concentrations in the residues of chillies and castor is rare. These values are estimated using data of the residues of other Capsicum species and cassava tops, respectively.

Reliable yield-nutrient uptake relations should include the Table 1. Nutrient concentration in economic products and crop residues of (sub)tropical crops, as fraction of N, P and K on dry matter basis.

crop	N	P	K
organ	min-max	min-max	min-max
	%	%	%
Banana/Plantain			
bunch	0.60-1.50	0.08-0.18	2.10-4.00
fruits	0.60-1.50	0.08-0.18	2.00-3.40
residues	0.70-1.40	0.07-0.17	1.50-8.60
Cabbage (white cabbage)			
heads + core's	1.80-4.20	0.19-0.70	1.50-4.50
residue	1.40-2.50	0.14-0.39	0.80-3.70
Carrot			
roots	0.50-2.30	0.10-0.60	0.70-4.30
tops	0.70-3.60	0.10-0.60	0.80-6.00
Castor (dwarf varieties)			
seeds	2.90-4.10	0.30-0.80	0.60-2.50
shell approximation	0.90-0.90	0.22-0.22	0.90-0.90
haulms *	0.50-1.80	0.08-0.50	0.45-1.80
straw	0.50-1.70	0.09-0.50	0.50-1.70
Chillies			
Pods (red ripe)	1.20-3.50	0.25-0.50	1.40-3.90
straw	1.00-3.50	0.11-0.40	1.20-4.40
Garlic			
bulbs	0.90-2.60	0.17-0.50	0.70-1.30
tops	1.40-3.50	0.16-0.32	1.40-4.70
Okra			
Pods	1.50-3.40	0.20-0.70	0.80-4.30
straw	0.50-2.40	0.07-0.26	0.90-3.60
Spinach: whole plants **			
Amaranthus spp.	2.50-5.50	0.60-0.80	3.70-7.80
flowering Amaranth	0.70-3.90	0.19-0.60	3.60-5.40
Indian Spinach ***	2.00-4.70	0.24-0.35	2.90-3.30
Kang Kong	3.20-6.30	0.23-0.60	3.10-6.60

* haulms: stem + leaves

straw: stem + leaves + shells

** Young plants if not otherwise indicated

*** Basella Alba

crop organ	N min-max %	P min-max %	K min-max %
Pigeon Pea			
seeds	2.80-4.30	0.20-0.50	0.70-1.20
shells	0.70-1.80	0.04-0.12	0.30-1.00
haulms *	0.70-2.00	0.07-0.20	0.30-1.10
straw	0.70-1.90	0.06-0.15	0.30-1.10
Pineapple			
fruits	0.45-2.00	0.04-0.18	0.70-2.70
fruit/crown/stalk	0.50-2.70	0.04-0.18	0.60-2.90
residue	0.70-3.60	0.07-0.16	0.60-3.70
Tomatoes			
fruits	1.70-3.50	0.15-0.90	1.50-6.00
straw	1.10-3.30	0.12-0.80	1.80-5.50

* haulms: stem + leaves

straw: stem + leaves + shells

** Young plants if not otherwise indicated

*** Basella Alba

nutrients taken up in the economic products and residues as well as the nutrients lost by leaf shedding. Therefore, Harvest Indices should also include the fallen leaves. Data on the amount of shedded leaves are lacking in the literature for a few crops and the Harvest Index has to be estimated from the data collected for the Harvest Index excluding the shedded leaves. This is done by taking 75-85 percent of the means of the collected Harvest Indices, depending on the stem/leaf ratio of the crop and its maturity at harvesting stage.

Table 3 presents the calculated yield-nutrient uptake relations. The data of Table 3 are converted into yields of fresh marketable products as presented in Table 4.

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Table 2. Harvest Indices (HI) of (sub)tropical crops, calculated for oven-dry crop organs and the dry matter (DM) concentration of their economic products.

crop economic product	HI excl. shed leaf %	HI incl. shed leaf %	DM % of econo- mic product. %
Banana/Plantain			
bunch	39	35	-
fruit	37	34	21
Cabbage (white cabbage)			
heads + core's	47	45	7
Carrot			
roots	70	51	10
Castor (dwarf varieties): approximations			
pods	29	39 *	-
seeds	19	15 *	86
oil	9	7 *	100
Chillies			
pods (red ripe)	48	36 *	87
Garlic			
bulbs	50	40 *	37
Okra			
pods	26	22	10
Pigeon Peas			
pods	28	22	-
seeds	17	14	84
Pineapple			
fruits	25	23	11
fruit/stalk/crown	36	33	-
Spinach: edible leaves + stems **			
Amaranthus spp	69	69	10
flowering Amaranth	21	17 *	17
Indian Spinach ***	100	100	7
Kang Kong	100	100	9
Tomato			
fruits	63	53	6

* estimation

** Young plants unless otherwise indicated.

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Table 3. Economic product-nutrient uptake relations of (sub)tropical crops at minimum and maximum N, P and K concentration (kg dry matter per kg nutrient uptake).

crop	N		P		K	
	max-min		max-min		max-min	
Banana/Plantains						
bunches	25	-53	204-481		5.1-21	
fruits	24	-52	198-467		4.9-20	
Cabbage (white cabbage)						
heads + core's	14	-28	85-227		11	-40
Carrot						
roots	17	-85	85-510		13	-68
Castor (dwarf varieties)						
pods	12	-27	43-195		13	-46
seeds	7.3-17		28-124		8.2-28	
Chillies						
pods (red ripe)	10	-34	83-224		8.5-28	
Garlic						
bulbs	13	-33	103-326		12	-35
Okra						
pods	8.4-31		62-223		5.9-25	
Pigeon Pea						
pods	10	-23	87-282		20	-63
seeds	6.3-14		54-175		13	-39
Pineapple						
fruit/stalk/crown	9.1-46		179-466		8.5-47	
fruits	7.1-36		140-365		6.6-37	
Spinach: edible leaves + stems						
Amaranth young	13	-29	86-115		8.9-19	
flowering Amaranth	4.4-24		28- 90		3.2- 4.7	
Indian Spinach young	21	-35	286-417		30	-35
Kang Kong young	16	-28	167-435		15	-32
Tomato						
fruits	16	-37	62-390		9.2-32	

Table 4. Fresh marketable product-nutrient uptake relations of (sub)tropical crops at minimum and maximum N, P and K concentration (kg fresh product per kg nutrient uptake).

crop	N		P		K	
	max	-min	max	-min	max	-min
Banana/Plantains						
fruits	114	-246	943-2224		24	- 96
Cabbage (white cabbage)						
heads + core's	197	-407	1214-3957		159	-577
Carrot						
roots	174	-853	850-5100		127	-681
Castor (dwarf varieties)						
seeds	8.5-	20	32-	39	9.6-	34
oil	3.6-	8.5	13-	61	4.0-	14
Chillies						
Pods (red ripe)	12	- 39	95-	280	9.8-	33
Garlic						
bulbs	34	- 90	278-	638	32	- 96
Okra						
Pods	84	-306	617-2231		59	-251
Pigeon Pea						
seeds	7.4-	17	64-	208	15	- 46
Pineapple						
fruits	65	-325	1270-3314		60	-335
Spinach: edible leaves + stems *						
Amaranth	125	-288	863-1150		89	-192
flowering Amaranth	26	-143	167-	526	19	- 28
Indian Spinach	297	-510	4086-5957		433	-493
Kang Kong	177	-309	1856-4833		169	-227
Tomato						
fruits	259	-623	1036-6495		153	-538

* young plants unless indicated otherwise

Appendix 1. References table 1 and 2.

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Appendix 2.

Minimum and maximum N, P and K concentrations in economic products and crop residues of (sub)tropical crops obtained from the literature. Concentrations in the residues are between brackets if the concentrations in the residues and economic products are from different crops. Harvest Indices (HI) are expressed in dry matter and in percentages. Haulms are defined as stems and leaves. Shelling is the seed/pod percentage. D.M. % indicates the dry matter concentration.

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Banana and Plantains			
Awan (1978) fruits	0.91-0.91		
Baillon et al (1933) fruits	1.02-1.02	0.12-0.12	2.96-2.96
Bruennich (1911/12) bunch	0.88-1.00	0.12-0.14	2.53-3.49
residue	0.87-1.33	0.08-0.12	2.53-2.53
HI (bunch)	39.9		
Hye et al (1970) DM % fruits	30		
Irizarry et al (1981) bunch	0.66-0.66	0.08-0.08	1.72-1.72
residue	0.96-0.96	0.06-0.06	2.04-2.04
HI (bunch)	44.6		
Jauhari et al (1974) residue	2.78-?..?	0.55-?..?	6.72-?..?
Loesecke (1949) DM % fruits	20.1		
Marchal et al (1979) bunch	0.60-0.87	0.09-0.12	2.75-2.76
fruits	0.58-0.85	0.09-0.11	2.51-2.51
residue	0.74-1.18	0.07-0.11	4.74-8.96
HI (bunch)	51.5		
HI (fruits)	50.1		
Martin-Prevel et al (1968) bunch	1.26-1.26	0.18-0.18	3.65-3.65
fruits	1.26-1.26	0.17-0.17	3.31-3.31
residue	1.00-1.00	0.16-0.16	5.03-5.03
HI (bunch)	28.6		
HI (fruits)	27.7		
HI (fruits)	22.9 (incl shed leaves)		
DM % fruits	16.6 (approximation)		

Reference Crop crop part	N min-max %	P min-max %	K min-max %
<hr/>			
Martin-Prevel et al (1966)			
fruits	0.79-1.18	0.09-0.14	1.90-2.54
Martin-Prevel (1964)			
bunch	0.59-1.33	0.11-0.14	2.91-4.11
fruits	0.59-1.27	0.10-0.13	2.25-3.31
fruit wgt/bunch weight	0.953		
Martin-Prevel et al (1962)			
bunch	1.11-1.11	0.16-0.16	4.12-4.12
residue	1.37-1.37	0.10-0.10	6.22-6.22
HI (bunch)	46.9		
HI (bunch)	44.2 (incl shed leaves)		
DM % fruits	18.5		
Samuels et al (1978)			
fruits	0.64-0.64	0.08-0.08	2.22-2.22
residue	1.44-1.44	0.07-0.07	8.09-8.09
HI (fruits)	37.5		
Turner et al (1985)			
residue	1.76-?..?	0.22-?..?	3.40-?..?
Turner et al (1983) approximation			
bunch	1.33-1.33	0.18-0.18	2.58-2.58
fruits	1.49-1.49	0.16-0.16	2.79-2.79
residue	1.03-1.03	0.17-0.17	1.44-1.44
Turner et al (1982)			
fruits	0.89-1.83	0.14-0.18	2.39-3.29
Turner (1980)			
HI (bunch)	28.9		
HI (fruits)	28.3		
Twyford (1973)			
bunch	0.71-1.28	0.09-0.14	2.77-2.77
fruits	0.71-1.25	0.10-0.14	2.62-2.62
residue	0.75-0.88	0.12-0.17	1.57-2.65
HI (bunch)	28.9		
HI (fruits)	28.0		
HI (fruits)	26.7		
DM % fruits	16.3 (approximation)		
White Cabbage			
Abdulla et al (1963)			
straw		0.13-?..?	
Babish et al (1979)			
core + head	2.33-3.54	0.32-0.53	1.84-2.96
Beeson (1941)			
core + heads		0.13-0.77	
Furr (1976)			
core + heads			2.73-3.12
Geissler et al (1971)			
core + heads	2.64-2.82		

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Geissler et al (1953)			
core + heads			3.60-3.70
Hara et al (1981)			
core + heads	2.09-?.??		
straw	1.36-?.??		
HI (heads + core's)	32.7 or more (immature plants)		
Howard et al (1962)			
core + heads	2.40-2.40	0.43-0.43	2.75-2.75
Lorenz (1980)			
core + head		0.38-0.38	
Janes (1951)			
core + heads		0.50-0.70	2.20-3.70
Lukovinikova et al (1966)			
core + heads	2.52-2.52		
Maass et al (1976)			
core + heads	2.76-3.10	0.42-0.47	3.28-3.61
Nieuwhof (1969)			
core + heads	3.40-3.40	0.50-0.50	3.90-3.90
straw (approximation)	1.87-1.87	0.38-0.38	3.78-3.78
HI	47.9 (author's interpretation)		
DM % heads	7.1		
Peck (1981)			
core + heads	1.26-1.82		
straw	1.38-2.59		
HI	58.6		
HI (incl. shed leaves)	57.6 or less		
Peck (1978)			
core + heads (approximation)		0.31-0.44	1.60-4.05
straw		0.19-0.19	1.18-1.18
HI (approximation)	47.6		
Peck (1970)			
core + head		0.23-0.38	1.31-3.55
straw		0.17-0.47	0.66-3.43
HI	61.6		
HI (incl. shed leaves)	61.1		
DM % heads	6.4		
Pierre et al (1973)			
core + heads	2.86-3.93		
Remy (1916)			
core + heads	2.90-2.90	0.50-0.50	3.30-3.30
Rennie (1975)			
core + heads	2.22-2.82	0.29-0.36	
HI	33.4		
Schuphan et al (1985)			
core + heads	4.20-4.60	0.45-0.49	2.35-2.38
Vogel et al (1938)			
core + heads	2.90-3.70	0.30-0.50	4.10-5.10
Welch et al (1985)			
straw	1.89-?.??	0.52-?.??	3.25-?.??

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Carrot			
Anonymous (1986)			
root	0.67-1.12	0.27-0.34	2.37-2.68
Beeson (1941)			
root		0.14-0.65	
Bernstein et al (1974)			
top	2.00-?.	0.20-?.	1.88-?.
Bishop et al (1973)			
top	1.82-3.54	0.16-0.60	1.02-6.20
Furr (1976)			
root			2.53-2.94
Geyer (1978)			
root	1.85-1.85		
Greenwood et al (1980)			
root		0.32-0.36	
top		0.15-0.18	
HI	73.0		
Haag (1973)			
top	0.79-?.	0.09-?.	
Hamilton et al (1975)			
root	2.14-2.40	0.49-0.49	2.52-2.84
top	2.54-2.62	0.54-0.54	2.68-3.14
HI	57.6		
DM % roots	10.6		
Harrison (1986)			
root	1.21-1.81	0.27-0.40	1.56-2.85
Haworth (1966)			
root	1.30-1.82	0.20-0.29	0.93-3.22
top	2.15-2.82	0.16-0.34	1.12-4.32
Hipp (1970)			
top	2.46-?.		
Howard et al (1962)			
root	1.16-1.16	0.33-0.33	2.27-2.27
Howlett (1961)			
top		0.26-0.26	
ILACO (1981)			
DM % roots	11		
Krarup (1985)			
root	0.65-1.02	0.06-0.06	0.56-0.69
top	(1.68-1.99)	(0.05-0.05)	(0.45-0.63)
Kumar et al (1974)			
root	0.88-1.22		
DM % root	9.6		
Leh (1970)			
root	2.00-2.00		3.87-4.38
top	1.81-2.74		2.13-5.68

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Linser et al (1975)			
root	0.48-0.58		
top	0.52-0.60		
HI	72.8		
HI (incl. fallen leaves)	52.8		
Lorenz (1980)			
root		0.33-0.33	
top		(0.20-0.35)	
Mauer (1971)			
root	1.46-1.79	0.34-0.38	2.85-3.39
top	2.41-2.68	0.37-0.42	3.86-4.75
Maynard et al (1961)			
root			3.91-4.21
Nicolaisen, von et al (1964)			
root	0.86-1.81		
top	1.75-3.91		
HI	78.1		
Pankov (1978)			
top			1.70-?..?
Pankov (1977)			
top		0.25-?..?	
Rennie et al (1975)			
root	1.33-2.00	0.20-0.33	
top	2.54-2.58	0.25-0.26	
HI	60.6		
Schnetzer (1984)			
root	0.42-1.49		
top	1.41-2.39		
Southards et al (1962)			
top	1.39-3.95	0.18-0.66	0.98-6.52
Vereecken et al (1979)			
top	4.06-?..?	0.28-?..?	
Wunsch (1975)			
root	0.91-1.42		
top	2.27-2.54		
Zeid et al (1973)			
root	0.58-0.58		
top	0.68-0.68		
HI	76.8		
Castor (dwarf varieties)			
Allen et al (1985)			
straw	5.33-?..?	1.48-?..?	10.30-?..?
Daussant (1976)			
seeds	2.88-3.20		

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Hocking (1982)			
leaves	2.98-4.56	0.22-0.31	1.65-2.05
seeds	2.88-2.88	0.60-0.60	0.57-0.57
pods	2.10-2.10	0.35-0.35	2.42-2.42
shelling %	48.6		
DM % seeds	85.1		
Moshkin (1986)			
seeds	3.00-3.00		
pods approximation	2.07-2.07		
straw	2.36-?..?	0.18-?..?	1.93-?..?
HI (pods)	26		
HI (seeds)	21		
Nakagawa et al (1973)			
pods	2.39-2.39	0.28-0.28	0.43-0.43
straw	2.80-?..?	0.09-?..?	2.57-?..?
Nakagawa et al (1971)			
straw	2.28-?..?	0.07-?..?	2.45-?..?
Weiss (1971)			
shelling %	61		
oil % seeds	48		
Youssef et al (1970)			
seeds	3.98-4.28	0.79-0.83	
Zimmermann (1958)			
shelling %	65		
oil % seeds	50		
Chillies			
Bagyaraj et al (1982)			
straw		0.11-0.20	
HI (rough approximation)	34.7		
Beese et al (1982)			
HI	61.9		
Dadhich et al (1969)			
straw	2.00-3.03		
HI	32.1		
Ferrari (1972)			
fruits	2.90-3.33		
Govindarajan (1983)			
fruits	1.91-2.83	0.39-0.39	
DM % pods	90		
Hoskins (1976)			
fruits			2.73-4.02
Howard et al (1962)			
fruits	2.29-2.29	0.33-0.33	1.86-1.86
Kariman-Terani et al (1983)			
fruits			1.88-1.88
straw			1.59-2.08

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Knott et al (1967) fruits	3.19-3.68	0.27-0.50	1.25-1.42
Lewis (1984) fruits	2.58-2.58		
Maistre (1964) fruits	2.75-2.75	0.46-0.46	3.01-3.01
Maurya et al (1984) fruits	3.19-3.68	0.24-0.27	1.25-1.42
Misra et al (1972) fruits	1.49-1.54		
Sarudi et al (1939) fruits		0.41-0.41	3.39-3.39
Viragh (1980) HI	62.5		
Westphal (1976) fruits	2.82-2.82		
Yamaguchi (1983) fruits	2.00-2.29	0.28-0.33	
Other Capsicum spp. (sweet and bell peppers)			
Albasel et al (1984) fruits	1.90-2.70		
straw	1.38-1.85		
El Sherbim (1980) fruits	3.34-3.34	0.46-0.46	3.46-3.46
straw	2.93-2.93	0.33-0.33	5.91-5.91
Kaufmann et al (1971) fruits	2.82-3.01	0.37-0.39	3.18-3.38
straw	(2.54-2.71)	(0.18-0.21)	(2.94-3.12)
Miller et al (1979) fruits	2.20-2.20	0.32-0.32	2.50-2.50
straw	2.30-2.30	0.35-0.35	2.80-2.80
Miller et al (1961) fruits	1.58-3.30	0.22-0.44	1.84-3.38
straw	1.09-4.93	0.12-0.40	1.00-4.64
Somos (1984) fruits	2.39-3.00	0.40-0.61	1.91-3.19
straw	(1.32-3.85)	(0.22-0.65)	(2.04-5.29)
Spaldon et al (1968) fruits	4.06-4.74	0.21-0.76	5.12-6.95
straw	3.13-3.19	0.11-0.32	3.95-3.98
Thomas et al (1967) fruits	2.25-2.47	0.34-0.46	
straw	2.24-2.24	0.18-0.18	

Reference Crop crop part	N min-max %	P min-max %	K min-max %
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Garlic			
Buwalda (1986)			
bulb	0.05-0.81		
top	0.26-1.20		
HI	52.1		
Fenwick (1985)			
DM % bulbs	37.5		
Lorenz (1980)			
bulbs		0.38-0.38	
Minard (1978)			
bulb	1.90-2.30	0.26-0.34	1.00-1.20
top	3.05-3.55	0.26-0.32	3.70-4.70
DM % bulbs	32		
Omar (1979)			
bulb	1.00-1.15		
top	2.08-3.10		
Pellet et al (1970)			
bulb	2.34-2.34		
Ramirez et al (1975)			
top		0.40-?..?	
Ruiz (1985)			
top	5.50-?..?	0.50-?..?	2.00-?..?
USDA (1976)			
bulb		0.38-0.38	
Watt (1963)			
bulb	2.56-2.56	0.52-0.52	1.37-1.37
Zink (1963)			
bulb	2.14-2.66	0.31-0.41	0.89-1.03
top	(1.95-?..?)	(0.28-?..?)	(2.20-?..?)
DM % bulbs	41.8		
Okra			
Ahmad et al (1968)			
Pods	2.10-3.49	0.53-0.71	2.10-2.80
Asif et al (1972)			
Pods	2.19-2.19	0.49-0.49	1.94-2.10
Costa et al (1972)			
Pods	3.15-3.15	0.54-0.55	1.90-4.40
straw	1.96-2.45	0.22-0.27	1.53-3.86
HI (Pods)	28.9		
Hipp et al (1972)			
straw		0.30-?..?	
Oyolu (1983)			
Pods	2.22-2.22	0.40-0.40	0.28-0.28
Paliwal et al (1972)			
Pods	1.16-2.16	0.26-0.46	1.80-4.18
straw	0.97-?..?	0.05-?..?	1.36-?..?

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Sharma et al (1973)			
pods	2.23-2.77		
straw	0.38-?..?		
Siemonsma (1982)			
pods	2.93-3.04	0.38-0.40	2.35-2.63
straw	1.66-1.68	0.16-0.16	0.85-0.87
HI (pods)	22.2		
HI (pods)	19.2 (incl leaves shed)		
DM % pods	10		
Singh et al (1974)			
pods	2.27-2.27	0.17-0.17	
Pigeonpea			
Abrams (1975)			
seeds	3.30-3.49		
Ahlawat et al (1983)			
seeds	3.43-3.58	0.47-0.51	
straw	1.01-1.01	0.12-0.13	
HI (seeds)	27.4		
Ahlawat et al (1981)			
seeds	3.45-3.58	0.43-0.53	
straw	1.01-1.02	0.11-0.15	
HI (seeds)	24.6		
Bressani et al (1980)			
seeds	3.66-3.66		
Dahiya (1977)			
seeds	2.74-3.84		
Dahiya (1977)			
seeds	2.93-4.32		
Dahiya (1977)			
seeds	2.94-4.06		
Dalal (1980)			
seeds	3.17-3.17	0.33-0.33	1.05-1.05
shells	1.47-1.47	0.10-0.10	0.32-0.32
haulms	2.27-2.27	0.17-0.17	0.51-0.51
straw	1.92-1.92	0.14-0.14	0.42-0.42
HI (seeds)	29.9		
shelling %	49.3		
Dalal (1974)			
seeds	3.59-3.59	0.15-0.15	0.94-0.94
straw	1.61-1.61	0.11-0.11	0.60-0.60
HI (seeds)	36.5		
FAO (1977)			
seeds	2.96-4.21		
Hegde et al (1982)			
seeds	3.02-3.27	0.33-0.39	0.63-1.22
shells	0.89-0.89	0.09-0.11	0.35-0.35
haulms	1.10-1.31	0.09-0.14	0.21-0.31
straw	1.06-1.25	0.09-0.13	0.23-0.31

Reference Crop crop part	N min-max %	P min-max %	K min-max %
ICRISAT (1975)			
haulms	1.40-1.40		
Irizarry et al (1983)			
pods	3.14-3.14	0.09-0.09	1.68-1.68
haulms	1.38-1.38	0.09-0.09	1.23-1.23
HI (seeds)	18.1		
HI (incl. fallen leaves)	15.9		
shelling %	60.0		
Jambunathan et al (1982)			
seeds	2.48-4.58		
Kumar et al (1980)			
shells	1.45-1.45	0.09-0.09	
Manimekalai et al (1979)			
seeds	3.16-3.91		
Rao et al (1984)			
seeds	2.96-2.96		
shells	0.78-0.78		
haulms	0.74-0.74		
straw	0.74-0.74		
HI (seeds)	30.0		
HI (incl. fallen leaves)	25.2		
shelling %	68.5		
Rao (1983)			
seeds	3.03-3.09		
shells	0.67-0.70		
haulms	0.67-0.81		
straw	0.67-0.79		
HI (seeds)	27.9		
shelling %	65.1		
Rao et al (1981)			
seeds	3.12-3.12	0.50-0.50	
shells	0.78-0.78	0.06-0.06	
Rathaswamy et al (1973)			
seeds	2.88-3.42		
Salunkhe (1986)			
seeds	4.06-4.06	0.41-0.41	
DM % seeds	9.85		
Sheldrake et al (1979)			
seeds	3.38-3.45	0.28-0.29	
shells	0.68-0.68	0.03-0.03	
haulms	0.99-1.13	0.06-0.06	
straw	0.97-1.09	0.05-0.06	
HI (seeds)	22.4		
HI (incl. fallen leaves)	16.0		
shelling %	66.5		
Singh et al (1980)			
seeds	3.74-4.08		
shelling %	61.1		
Singh et al (1968)			
seeds	3.66-3.66	0.36-0.36	

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Singh et al (1982) seeds	3.28-3.28		
Singha (1982) HI (seeds)	30.7		
Tripathi et al (1982) seeds	3.18-3.44		
Tripathi et al (1981) seeds	2.85-3.41		
Tripathi et al (1977) seeds	3.19-4.08		
Wilson et al (1983) haulms	3.30-?..??	0.24-?..??	
Yadav (1983) seeds	4.42-4.42		
shells	1.14-1.14		
DM % seeds	21.4		
Pineapple			
Black et al (1969) fruit	1.12-1.12	0.17-0.17	1.62-1.62
fruit + crown	1.21-1.21	0.16-0.16	1.58-1.58
residue	1.02-1.02	0.09-0.09	1.53-1.53
HI (fruits)	13.2		
HI (fruit + crown)	20.1		
Boland et al (1979) fruits	0.39-1.23	0.03-0.13	0.38-2.16
Dull (1971) fruits (approximation)	0.28-0.71	0.04-0.16	0.08-2.46
Lacoeuilhe (1979) residue	1.42-?..??	0.11-?..??	2.87-?..??
HI	29.2		
Lacoeuilhe (1974) residue	1.12-?..??		2.14-?..??
Lacoeuilhe et al (1971) fruits	0.52-0.61	0.10-0.11	0.89-1.82
fruit + crown	0.68-0.96	0.12-0.12	0.76-2.07
residue	0.95-1.24	0.14-0.18	0.75-2.98
HI (fruits)	37.2		
HI (fruits + crown)	43.5		
DM % fruits	13.1		
Lodh (1972) fruits	0.54-0.54	0.01-0.01	2.08-2.08
DM % fruits	10.6		
Norman (1980) HI fruits	9.4		
HI fruit/crown/stalk	32.4		
DM % fruits	4.9		

Reference Crop crop part	N min-max %	P min-max %	K min-max %
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Onaha et al (1986)			
HI fruits	24.9		
HI fruit/crown/stalk	29.8		
HI fruits	22.8 incl fallen leaves		
HI fruit/crown/stalk	27.8 incl fallen leaves		
Page (1971)			
residue	0.87-5.30		
Page (1971)			
residue			1.53-4.29
Sale (1938)			
fruits		0.04-0.04	1.04-1.04
Sideris et al (1946)			
residue		0.13-?..?	3.19-?..?
Sideris et al (1945)			
residue		0.07-?..?	1.75-?..?
Teisson et al (1982)			
HI (fruits)	38.5		
HI fruit/crown/stalk	50.4		
DM % fruits	16.5		
Spinach, nutrient concentrations of whole plants			
Cornelis et al (1985) Ipomoea aquatica			
young plant	3.43-6.37	0.04-0.56	4.75-5.21
HI	100		
DM %	9.8		
Grubben (1975) Amaranthus spp.			
young plant	3.51-3.51	0.61-0.61	7.88-7.88
HI	67		
DM % young plant	9.6		
flowering plant	1.63-1.63	0.31-0.31	3.75-3.75
HI	22		
Hill et al (1982) Amaranthus spp.			
flowering plant	3.38-4.29	0.33-0.52	5.43-5.63
Linneman et al (1986) Ipomoea aquatica			3.01-5.68
Olufolaji et al (1980) Amaranthus cruentus			
young plants	2.12-3.45	0.68-0.77	6.05-7.44
flowering plants	0.56-0.93	0.50-0.59	3.58-4.35
HI (approximation)	20		
Purushothanman et al (1980)			
young Kang Kong	4.86-4.86	0.62-0.62	6.76-6.76
HI	100		
DM %	7.6		
Young Amaranth	3.94-3.94	0.68-0.68	5.89-5.89

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Schmidt (1971)			
young Amar. tricolor	4.57-5.28		2.92-4.20
HI (approximation)	50		
DM %	14		
young Basella alba	4.01-4.80		2.92-3.24
HI	100		
DM %	7.1		
young Ipomoea aquatica	5.10-5.70		3.26-4.07
HI	100		
DM %	11.8		
Taylor (1982/83) Amaranthus caudatus flowering plant		0.16-?..??	4.43-?..??
Vuurmans (1977)			
Indian Spinach young	1.74-3.43		
Kang Kong young	3.08-4.78		
Wills et al (1984)			
young Amaranthus spp.	5.59-5.59		7.59-7.59
HI	89		
DM %	8.3		
DM % Kang Kong	7.8		
Spinach, nutrients in leaves.			
Donald (1986)			
Basella alba	2.63-2.63	0.36-0.36	3.55-3.55
Faboya (1983)			
Amaranthus caudatus		0.30-0.33	0.64-0.77
Basella alba		0.23-0.25	0.50-0.52
Grubben (1975)			
DM %	15.6		
Ifon et al (1979)			
Amaranthus hybridus	0.66-0.68	4.20-4.38	
Johnson (1973)			
Amaranthus spp. leaves + stemtops	5.77-5.77	0.61-0.61	8.72-8.72
Katiyar et al (1985)			
Amaranthus polygamus	4.70-4.70	0.72-0.72	
Norman (1972)			
Amaranthus hybridus	5.33-5.33		
Oliveira et al (1975)			
Amaranthus candatus edible leaves	4.28-4.28	0.31-0.31	0.26-0.26
DM % leaves	18.8		
Sheeramuku (1982)			
Amaranthus spp.	3.22-4.59		
Basella alba	4.24-4.24		
Ipomoea aquatica	4.61-4.61		
Stafford (1976)			
Amaranthus hybridus	1.96-5.11		
Taylor (1982/83)			
Amaranthus caudatus		0.20-0.29	4.77-5.35

Reference Crop crop part	N min-max %	P min-max %	K min-max %
Tomato			
Aung (1983)			
fruits		0.06-0.07	1.49-3.03
Beeson (1941)			
fruits		0.29-0.84	
Besford (1979)			
fruits		0.17-?.??	
straw		0.05-?.??	
Besford (1978)			
fruits			0.98-4.83
Besford et al (1975)			
fruits	2.20-3.42	0.42-0.45	1.50-4.34
Cooper (1955)			
HI (incl leaves shed)	0.81 * HI (excl leaves shed)		
Author's interpretation			
Erickson (1982)			
DM % fruits	4.5		
Furr (1976)			
fruits			2.22-2.51
Graifenberg et al (1986)			
fruits	1.65-1.65		
straw	1.50-1.50		
HI	62.7		
Granges (1980)			
fruits	1.77-2.53	0.32-0.50	3.22-4.52
Greidanus et al (1971)			
fruits	2.71-3.20	0.40-0.42	3.45-6.00
Hartman (1986)			
fruits	2.61-?.??	0.58-?.??	1.95-?.??
straw	3.03-?.??	0.85-?.??	2.45-?.??
Hills (1983)			
fruits	2.30-2.30		
straw	1.74-1.74		
HI	62.4		
Ho (1984)			
DM % fruits	7.7		
Hurd, R.G. (1979)			
HI	79		
HI (incl shed leaves)	65		
DM % fruits	7		
Kaufmann et al (1968)			
fruits	2.59-2.71	0.43-0.61	4.38-4.82
straw	2.11-2.42	0.28-0.31	3.27-3.67
HI	44.2		
Kidson et al (1953)			
fruits	2.17-2.73	0.40-0.54	4.38-6.58
straw	(2.06-2.26)	(0.33-0.55)	(2.58-2.82)
HI	62.5		

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		