Tea *(Camellia L. spp.):*

C. sinensis (L.) O. Kuntze - China type
C. assamica (Mast.) Wight ssp assamica - Assam or Indian type
C. assamica ssp lasiocalyx Planch ex Watt - Southern or Cambod type.

French: Thé; Spanish: Te; Italian: Te; German: Tee

Cultivated types are natural hybrids of the three major types or species and are referred to as China, Assam (Indian) or Cambod (Southern) hybrids according to their predominating character, particularly shoot size.

The China types are hardy and tolerant of extreme weather conditions; they have relatively small, erect, dark green leaves; they flower profusely and require more N than Assam types to sustain vegetative growth; their root cation exchange capacity is higher than that of Assam types and they require more K in the soil solution; they tolerate and respond to severe pruning and plucking. Assam types have supple, light green, long, flat or semi-erect, large leaves; they are high-yielding but require more care in handling; they are less tolerant of extreme weather conditions; they are more responsive to manuring and improved crop husbandry practices than other types. Cambod types are intermediate in character.

Crop data

Perennial. Harvested part: growing shoots (primarily 2 leaves and a bud; in some regions, up to 3 leaves and a bud).

Planting material: seedlings 10-18 months old raised from seed (hybrids, polyclonal and biclonal), single-leaf nodal cuttings from selected high-yielding bushes and grafted cuttings at the nursery stage; transplanted into the monsoon or rainy period.

Plants are trained into bushes by centring and plucking, and are harvested from the second year onwards at regular intervals of 7-20 days in the tropics and sub-tropics (all the year round between latitudes of up to 15-18 ° N and S, beyond which winter dormancy occurs at the rate of 30 days for every additional 3-5 ° from the equator) and at much longer intervals in temperate zones. The day length required for vegetative growth is 11 h 15 min. The economic life is believed to be around 40-60 years in many tea-growing regions; though, in South India, tea gardens over 100 years old are responding to manuring and good husbandry practices with productivity increasing every year.

Plant density: old plantings 6 400 plants/ha (1.2 m by 1.2 m, square), new plantings 10 000-20 000 plants/ha as single hedge (1.2 m by 0.6-0.8 m) or double hedge (1.20 - 1.35 m by 0.6-0.8 m by 0.6-0.8 m) along the contour.

Shade: tea is grown under shade (most commonly Grevillea - silver oak - and Albizzia) which allows 60-70 % penetration by sunlight. This reduces radiation damage at latitudes further from the equator, creates a favourable micro-climate during dry months and maintains a relatively much lower leaf temperature in summer, particularly in low latitudes.

Climate and soil

Tea is basically a rainfed crop cultivated commercially in humid zones of tropical, sub-tropical and temperate regions with alternating wet and dry periods, on well-drained soils preferably with pH 4.5-5.0 although in practice ranging from 3.0 to 6.5, and at altitudes from sea level to

2 300 metres. Its distribution extends from Georgia (USSR), 43 °N, to Corrientes in Argentina, 27 °S.

Major producers: India, China, Sri Lanka, USSR, Japan, Indonesia, Kenya.

Tea soils are managed by regular liming to pH 4.5 and 5.0; retaining prunings and litter from both tea and shade trees in the field itself; chemical methods of weed control, broadcasting of N and K fertilizers and placement of P at 15 - 25 cm depth to reduce soil erosion and leaving a buffer strip, where necessary, to avoid any direct loss of agricultural chemicals into waterways. Maintenance of soil organic matter is important for stabilizing soil structure. Soil conservation measures and "no-tillage" cultivation systems help to reduce erosion and to stabilize productivity in the long term.

Nutrient demand/uptake/removal

Only 8-13 % of the total dry matter produced, including roots, is harvested; this is about 13-17 % of the dry matter of the above-ground parts and 18-35 % of that of the parts formed after and above the level of pruning. The total amount of nutrients required to produce a given level of yield of marketable tea may be calculated from the chemical composition of the various plant parts and their relative proportions in the total dry matter (see Table).

Nutrient contents (to produce 100 kg marketable tea) - Macro- and secondary nutrients

Plant part	Proportiona dry matter		Nutrient contents in the various parts							
			kg					g		
	kg	%	N	P2O5	K2O	MgO	CaO	Al***	Cl	Na
1. Plucks (marketable tea)**	100	12.5	4.0	1.15	2.4	0.42	0.8	100	6	8
2. Foliage on the bush	120	15.0	3.9	0.98	1.1	0.60	2.1	120	15	9
3. Fallen leaves (litters)	80	10.0	2.6	0.66	0.7	0.40	1.4	80	10	6
4. Stems/branches	320	40.0	3.2	1.90	0.7	0.80	1.1	160	10	24
5. Roots	180	22.5	3.2	0.98	3.8	0.71	1.3	411	NA	27
Total	800	100.0	16.9	5.68	8.8	2.92	6.7	871	-	74
Removed by 1 & 4*	420	45.0	7.2	3.05	3.1	1.21	2.0	260	16	32

* removed as crop (1) and for fuel at the time of pruning (4). - ** 12.5 % in high yielding fields under intensive cultivation systems; in low/moderate yielding fields it varies between 8 to 10 %. - *** Al content in mature foliage can go several times (up to 20 times) the figures shown above. - NA Not available

Sources : ¦Magambo and Othieno; 1977; Ranganathan and Natesan, 1988; Ling, Harding and Ranganathan, 1989; Natesan and Ranganathan, 1990; Annual Reports 1968 to 1989 UPASI Tea Research Institute, UPASI, Coonoor (India).

Nutrient contents (to produce 100 kg marketable tea) - Micronutrients

Plant part	Proportional dry matter		Nutrient contents in the various parts (g)				
	kg	%	Zn	B	Cu	Fe	Mn
1. Plucks (marketable tea)**	100	12.5	4	3	4	20	85
2. Foliage on the bush	120	15.0	4	9	12	40	180
3. Fallen leaves (litters)	80	10.0	3	6	8	27	120
4. Stems/branches	320	40.0	11	6	6	24	72
5. Roots	180	22.5	16	2	8	130	22
Total	800	100.0	38	26	38	241	479
Removed by 1 & 4*	420	45.0	15	9	10	64	157

* removed as crop (1) and for fuel at the time of pruning (4). - ** 12.5 % in high yielding fields under intensive cultivation systems; in low/moderate yielding fields it varies between 8-10 %.
Sources: Magambo and Othieno; 1977; Ranganathan and Natesan, 1988; Ling, Harding and Ranganathan, 1989; Natesan and Ranganathan, 1990; Annual Reports 1968-1989 UPASI Tea Research Institute, UPASI, Coonoor, India

Plant analysis data

Plant analysis is not very useful for predicting fertilizer needs, as the chemical composition of the tissues is little affected except in extreme cases of deficiency of long duration. However, comparison with the average figures shown in the table can prove useful in modifying current fertilizer schedules where the content of any particular nutrient(s) shows a decreasing trend over the years, and to correct imbalances.

For example, the ratio of K in growing shoots to that in older leaves gives an indication of withdrawal of that nutrient from mature foliage as a result of inadequate K supply; this was at one time used extensively in East Africa for correcting K imbalance.

The K content of mature leaves, and their ash, has been reported as a useful guide for identifying K deficiency in S. India, Indonesia, Taiwan and USSR. Healthy tissues contain > 0.8 % K and their ash > 8 % K.

The K index of living tea tissues expressed on a moisture basis, i.e. K % DM x (100 - % moisture)/ % moisture, varies little through the year. If it falls below 0.25 % at any time of the year, there is a need to increase the rates of K application in the fertilizer schedule. Succulent tissues are more sensitive in this respect than others.

The Ca content of the maintenance foliage should be kept between 0.6 % and 0.8 %. Crop depression occurs when it exceeds 0.8 %, and heavy metal toxicity (particularly of Mn) arises when it falls below 0.6 %. Ca, Zn and Fe can all accumulate in the roots, with restricted movement to the shoots. In soils high in Mn, availability in the soil should be kept low by heavy liming and by extra attention to the soil organic matter status.

Sensitive tissues for P are: flush in Indonesia and S. India, mature foliage in Sri Lanka, and second, third and fourth internodes in S. India. P in these tissues varies between 0.22 % and 0.50 % and declines with age.

Crop yield is reduced if the Na content of leaf tissues exceeds 150 ppm. In soils containing more than 60 ppm exchangeable Na, large quantities of K should be used to reduce the uptake of Na.

Al is accumulated passively by tea; its exact role is not yet understood. Aluminium - tea tannin complexes impart brightness and redness to black tea liquors, for which they are valued, and they affect the valuation of green tea liquors for the same reason.

Fertilizer recommendations

Fertilizer recommendations - Southern India			
Stage	**Nutrients**	**Nutrient kg/ha/year**	**Remarks**
1. Nursery	N:P2O5:K2O:MgO: Zn	30:30:30:10:3	Per 100 000 cuttings in 16 to 20 applications (once in 15 days)
2. Young tea			P in one blanket application
- 1st year	N:P2O5:K2O:MgO	90+180:270:30	placed at 15-25 cm depth.
- 2nd year	N:P2O5:K2O:MgO	90+240:360:40	N, K and Mg for soils with pH
- 3rd year	N:P2O5:K2O:MgO	90+300:450:50	below 4.5 and N

- 4th year	N:P2O5:K2O:MgO	90+300:300:50	and K for soils with pH above 4.5 in 4 dressings in the first year and 4-6 dressings (broadcast) thereafter; foliar application of Zinc sulphate at 6-10 kg/ha in 3-5 sprays as required.
3. Pruned fields			P in one blanket application placed at 15-25 cm depth.
- Rejuvenation pruning	P2O5 + N:K2O	90+180:360	N and K in 4-6 dressings in lighter forms of pruning and
- Hard pruning	P2O5 + N:K2O	90+210:315	2-3 in harder forms of pruning, 3-5 foliar sprays of in total 6-10 kg/ha Zinc sulphate.
- Medium, light, cut-across and skiffing	P2O5 + N:K2O	90+240:360	
4. Mature tea (low yielding less than 3000 kg/ha			P once in two years placed at 15-25 cm depth. N and K broadcast in 4-6 dressings; 6 kg/ha Zinc sulphate in 3 foliar sprays every year or 11.25 kg/ha in 5 foliar sprays in alternate years.
- 1 000 kg/ha	P2O5 + N:K2O	90+120:100	
- 2 000 kg/ha	P2O5 + N:K2O	90+120:170	
- 3 000 kg/ha	P2O5 + N:K2O	90+250:190	
5. Mature tea high yielding (above 3 000 kg/ha)			P once every year placed at15-25 cm depth. N and K broadcast in 4-6 dressings. 6-10 kg/ha Zinc sulphate every year in 3-5 foliar sprays.
- 3 000 kg/ha	P2O5 + N:K2O	70+250:250	For fields yielding below
- 4 000 kg/ha	P2O5 + N:K2O	70+350:350	4 000 kg/ha 20-25 kg/ha year
- 5 000 kg/ha	P2O5 + N:K2O	90+450:450	Mg as Magnesite and 75-125 kg/ha as magnesium silicate; for fields yielding above 4 000 kg/ha 40-50 kg/ha Mg as Magnesite and 125-150 kg/ha Mg as magnesium silicate.
- Liming to pH 4.5-5.0 recommended in year of pruning at rate based on soil pH, yield level, annual rainfall and length of pruning cycle.			
- N rates adjusted to yield of marketable tea. 10 kg N per 100 kg yield up to yield of 2 000 kg/ha (minimum 120 kg/ha N), plus 5 kg N per 100 kg additional yield over 2 000 kg/ha up to 3 000 kg/ha, and 10 kg N per 100 kg additional yield thereafter.			

Fertilizer recommendations - Northern India			
Stage	**Nutrient condition**	**Nutrient kg/ha/year**	**Remarks**
1. Nursery	N:P2O5:K2O	10:5:10, 2g/m^2, nursery bed	One part of fertilizer is mixed with 9 parts of sand and evenly broadcast (minimum of 8 fortnightly bed applications recommended).
2. Young tea			
- 1st year	N:P2O5:K2O	10:5:10 (8 :4 :8 - 12 :6 :12)	5 g in 3-4 applications per plant and application.
- 2nd year	N:P2O5:K2O	10:5:10 (16 :8 :16 - 24 :12 :24)	10 g in 3-4 applications per plant and application.
- 3rd year	N:P2O5:K2O	10:5:10 (32 :16 :32 - 48 :24 :24)	20 g in 3-4 applications per plant and application
- 4th year	N:P2O5:K2O	120:60:120 - 135 :67 :5 :135	as 10:5:10 in 3-4 split dressings.
3. Mature tea	N	90-135	A higher level of N up to 250 kg/ha and year is recently adopted in many

			commercial gardens (applied in several split dressings).
	P2O5	6.7	In 3 split dressings once in 3 years.
	K2O	100-120	A higher level of K2O up to 250 kg/ha and year is recently adopted in commercial gardens (applied in several split dressings).

Source: Tea Research Asociation - Tocklai Experimental Station, Jorkat, Assam (India) - Encyclopaedia on tea culture

Fertilizer recommendations - Sri Lanka			
Yield level kg/ha	**kg/ha per 100 kg marketable tea**	**kg/ha**	
	N*	**P2O5**	**K2O****
below 1 600	10	60	60- 80
above 1 600	10	60	90-120
* See footnote to table of fertilizer recommendations for S. India concerning N - ** N : K2O ratio of 2:1 recently introduced.			
Source: Kemmler, G., 1986			

Rates of N recommended for mature tea - Central Africa			
Age of bushes- years after planting	**kg/ha N**		
	High fertility	**Low fertility and replanted areas**	**All**
10	120	150	
15	155	160	
20	165	165	
21-30			170-185
31-40			200-215
41-50			230
Down pruned			90-110
N:P2O5:K2O ratio of 5:1:1 extensively used with supplementary P2O5 and K2O each at 150 kg/ha before pruning if required. Sources: Kemmler, G., 1986; Tolhurst, 1978.			

Fertilizer recommendations - Indonesia		
Age of bushes/yield level/type of soil	**Nutrients/Rate of application**	**Remarks**
Young tea		
- 1st year	8 g N + 2 g P2O5 + 2 g K2O/plant	MgO at 2 g/plant in podzols only
- 2nd year	12 g N + 3 g P2O5 + 3 g K2O/plant	
- 3rd year	12 g N + 2 g P2O5 + 4 g K2O/plant	
Mature tea in plucking		
- up to 1 200 kg/ha	N at 12 % pro rata on yield	N:P2O5:K2O ratio 4:1:2 in the year of pruning; from second year onwards 5:1:2 in wet months and 5:1:3 in dry months
- 1 200- 2 500 kg/ha	N at 10 % pro rata on yield	
- above 2 500 kg/ha	N at 8 % pro rata on yield	
= andosols	120 kg/ha N, 20 kg/ha P2O5, 40 kg/ha K2O	
= podzols	120 kg/ha N, 30 kg/ha P2O5, 30 kg/ha K2O, 30 kg/ha MgO	For every 1 000 kg of made tea
= latosols	120 kg/ha N, 30 kg/ha P2O5, 24 -72 kg/ha K2O	

- N:P2O5:K2O = 6:1:2 in andosols; 5:1:1 - 5:1:3 with a mean of 5:1:2 in latosols.
- N:P2O5:K2O:MgO ratio = 5:1:1:1 - 6:1.5:1.5:1.5 in podzols.
- Placement of fertilizers at 10 cm depth between tea rows.
- Leaf tissue analysis is used to monitor the health of bushes under the recommended manuring schedules.

Source: Isa Darmawijaya, 1985.

Fertilizer recommendations - Bangladesh		
Age of bushes	**Ratio of nutrients (N :P2O5 :K2O)**	**Rates kg/ha and year**
1. Young tea	1:1:1	9, 18, 36, 54 and 72 kg/ha N in the first five years from planting.
2. Mature tea		
- skiffing	1:0:0	90 kg/ha N plus foliar application of 1-2 % urea spray at 15 days interval
- light pruning	4:1:3	90 kg/ha N, 22 kg/ha P2O5, 68 kg/ha K2O
- medium pruning	1:1:1	90 kg/ha N, 90 kg/ha P2O5, 90 kg/ha K2O
Source: Rashid, 1985		

Present fertilizer practices

In South India and Sri Lanka, nursery plants receive a soluble 10:10:10:4 (N:P2O5:K2O:Mgo) nursery mixture which in South India also includes Zn. This is applied in 0.3 % solution at 10 litres per 4 m2 at fortnightly intervals after rooting commences, by means of a watering can fitted with a fine rose. In North India, NPK mixture diluted with sand is broadcast on the nursery beds. In some other regions, only straight N is applied in the nursery.

No fertilizer or organic manure is applied in South India at the time of planting; regular fertilizer applications begin 2 months later. In some other regions, organic manure (compost, bone meal, etc.) and rock phosphate or superphosphate are applied to planting holes at planting.

P is applied straight in South India, as rock phosphate placed at 15-25 cm depth once a year up to the first prune and once every 1-2 years thereafter, depending on yield level, at rates varying from 40 to 100 kg/ha P2O5. P is also applied as rock phosphate in most other tea-growing areas, except that superphosphate is used extensively in Africa, broadcast in mixtures or compounds.

N and K are broadcast in NK mixtures in South India, and, in other countries, in NPK mixtures supplemented by separate applications of straight N. Aerial application is favoured in Africa. Placement at 10 cm depth between the rows is recommended in Indonesia.

Urea is the major source of N, but ammonium sulphate is always used to provide part (15-20 %) of the total annual N requirement in South India. Ammonium sulphate is also used once every 3-4 years as a source of S as well as of N in North India.

In South India, calcium ammonium nitrate is used for pre-winter application.

The amount of N applied varies pro rate with yield in Sri Lanka, South India and Indonesia, the rates being slightly lower in South India due to the higher soil organic matter status. In Africa it is based on the age of the bushes and on the region and responses obtained in field trials.

The **N:K2O** ratio varies in South India with the stage in the pruning cycle, yield level and source of N : 1:2 or 2:3 in the pruned year and, in other years, 2:1 with ammonium sulphate, 1:1 with urea, 4:3 with calcium ammonium nitrate or 1:1 for yields over 3 000 kg/ha

irrespective of the source of N. K is applied as muriate. In Indonesia the N:K2O ratio varies with soil group and growth stage (young tea, pruned tea or mature tea). In other countries it is based mainly on regional trials. In Sri Lanka, K is used at rates of 60-80 kg/ha K2O for yields of up to 1 600 kg/ha or 90-180 kg/ha K2O for higher yields; a 2:1 N:K2O ratio has recently been introduced.

An **N:P2O5:K2O** ratio of 5:1:1 is widely used in Africa with a balancing application of P and K before prune if required.

Zn is widely applied, mainly as foliar application, in most tea-growing countries: as the sulphate in India and Sri Lanka, and as the oxide in African countries. **Mg** is given as magnesite or magnesium sulphate, or as magnesium silicate if Si is also needed.

Liming to maintain pH between 4.5 and 5.0 is done in South India once in 3-5 years in the year of prune, rates being based on factors determining loss of Ca from the soil (e.g. rainfall, yield and fertilizer use). Elsewhere liming is done on an ad hoc basis related either to soil testing or field trials, rates varying from 250 to 1 000 kg/ha/year through the pruning cycle.

Soil testing has been standardized in South India for pH, soil organic matter status, P, K, Mg, Ca, Na and Cu. Limiting nutrients are identified at critical growth stages and included in the fertilizer schedule as needed: Zn for yields over 1 000 kg/ha, Mg, Si and B for yields over 3 000 kg/ha, and Mo for yields over 4 500 kg/ha (Tandon & Ranganathan 1988).

Further reading

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