Coffee *[Coffea arabica L. (Arabica coffee); Coffea canephora Pierre ex Froehner (Robusta coffee); Coffea liberica Bull ex Hiern. (Liberica coffee); Coffea excelsa Chev. (Excelsa coffee)]*

French: Café; Spanish: Café; Italian: Caffee; German: Kaffee

Arabica accounts for 80 per cent of the world coffee trade, and robusta most of the remaining 20 per cent. Liberica and excelsa together supply less than 1 per cent.

Crop data

Small perennial tree. Arabica typically up to 5 m, robusta up to 12 m, liberica up to 18 m.

Harvested part : fruits ("cherry" or "berry"). Processing removes the skin (epicarp), pulp (mesocarp), "parchment" (endocarp) and "silverskin" (integument) to leave the marketed product, "green bean" (endosperm).
Seed pre-germinated (optional) between wet sacks or in sand beds. Sown in nursery beds or pots. Vegetative propagation by grafting, budding and rooted cuttings is sometimes practised, particularly with robusta, and recently micropropagation techniques have been developed for arabica and robusta.

After 6-12 months in nursery, seedlings are transplanted to the field, usually at the beginning of the main rains.

Temporary shade and/or windbreaks are often provided for the first one or two years by shrubs such as Crotalaria spp and Tephrosia spp. Permanent shade may be provided by such trees as Albizia spp, Inga spp and Leucaena spp. Robusta is often shaded, dwarf arabica cultivars are usually not shaded, and tall arabica varieties may or may not be shaded.

Arabica is largely self pollinating, but robusta is cross-fertilized. First flowers 9-18 months after planting, and first crop matures during second or third year in the field. Following initiation, flower buds enter a dormancy phase which often coincides with a dry period. This dormancy is broken by the onset of rain. Fruits ripen 7-9 months after flowering in arabica, 9-11 months in robusta, about 12 months in excelsa, and up to 14 months in liberica.

Tree frame can be modified by various pruning systems. Individual trees having either a single bearing upright, or several, most commonly 2-5, bearing uprights. Low input coffee is often rarely, if ever, pruned, and individual trees may have 10 or more bearing uprights.

Plant densities vary from less than 1 000 to 10 000 trees/ha. Dwarf arabica cultivars are planted at the highest densities, of most commonly 3 000-7 000 trees/ha. Tall arabica cultivars are typically planted at 1 200 - 2 500 trees/ha, and robusta, liberica and excelsa from less than 1 000 to 2 000 trees/ha. Particularly in Brazil, it is common to plant two or more seedlings per station ("cova") at a relatively low density.

Mulch is sometimes applied, particularly to newly planted coffee, and in areas with a pronounced dry season. Leaf fall and prunings from coffee and shade trees can provide a significant proportion of mulching requirements.

Arabica grows best in a subtropical climate, which is frost-free and without strong winds; ideal temperature range 15°-24 °C; rainfall 1 500-2 500 mm per year, well distributed, but

with a drier period of 6-12 weeks. In some locations (e.g. Kenya) rainfall is supplemented by irrigation. Commonest altitudes 600-2 000 m in the tropics, although at higher latitudes (e.g. Brazil) it is grown below 600 m. Robusta, liberica and excelsa are more tolerant to heat, and flourish in the tropics from sea level to 1 100 m.

Coffee prefers deep (1-3 m, depending on climate) well drained, loamy soil which is slightly acid, and rich in humus and exchangeable bases, particularly potassium. Volcanic soils are often very suitable, although the crop is grown on a wide variety of soils.

Nutrient demand/uptake/removal

Nutrient removal in green bean - Macronutrients								
Coffee type	**Country**	**Source**	**kg/1000 kg green bean**					
			N	**P2O5**	**K2O**	**MgO**	**CaO**	**S**
Arabica	Brazil	Malavolta, 1990	17.0	2.5	18.7	2.6	3.9	1.3
Arabica	Papua New Guinea	Hart, 1969	22.0	4.6	20.4	3.3	2.1	-
Robusta	Papua New Guinea	Hart, 1969	25.4	4.6	24.0	4.0	3.6	-
Liberica	Equ.Afr.	Ledreux, 1928	28.0	6.4	45.0	-	-	-
Excelsa	Equ.Afr.	Ledreux, 1928	26.0	6.2	31.0	-	-	-

Nutrient removal in green bean - Micronutrients								
Coffee type	**Country**	**Source**	**g/1000 kg green bean**					
			Fe	**Mn**	**Zn**	**Cu**	**B**	**Mo**
Arabica	Brazil	Malavolta, 1990	61.2	20.4	12.2	13.6	16.3	0.05

If skins, pulp and parchment are not returned to the field, nutrients removed in whole fruit (equivalent to 1 000 kg green bean) are:

Nutrient removal in whole fruit - Macronutrients - (equivalent to 1000 kg green bean)								
Coffee type	**Country**	**Source**	**kg**					
			N	**P2O5**	**K2O**	**MgO**	**CaO**	**S**
Arabica	Brazil	Malavolta, 1990	34.8	5.7	64.5	4.6	9.9	2.9
Arabica	Kenya	Cannell and Kimeu, 1971	31.4	5.5	47.4	4.5	5.0	-
Arabica	India	Tandon, 1988	34.0	5.0	48.0	-	-	-
Robusta	India	Tandon, 1988	35.0	7.0	39.0	-	-	-
Robusta	Cote d'Ivoire	Snoeck and Duceau, 1978	33.4	6.2	43.8	4.1	5.5	-
Robusta	Indonesia	Roelofsen and Coolhaas, 1940	35.0	6.0	50.0	4.0	4.0	-

Nutrient removal in whole fruit - Micronutrients - (equivalent to 1000 kg green bean)								
Coffee type	**Country**	**Source**	**g**					
			Fe	**Mn**	**Zn**	**Cu**	**B**	**Mo**
Arabica	Brazil	Malavolta, 1990	112	50	84	32	51	0,12

Often, pruned leaves and branches are left in the field, but stems are removed for firewood or fences. Even the stems, however, contain significant quantities of nutrients:

Coffee type	**Country**	**Source**	**kg/ha**					
			N	**P2O5**	**K2O**	**MgO**	**CaO**	**S**
Arabica (1)	PNG	Willson, 1985	14.8	2.8	11.9	-	-	-
Arabica (2)	Brazil	Malavolta, 1990	105	14	119	13	84	2

Arabica (3)	Brazil	Malavolta, 1990	40	5	41	3	18	1
Robusta (4)	Cote d'Ivoire	Snoeck, 1983	34.8	9.1	17.4	13.9	66.1	-

Coffee type	Country	Source	g/ha					
			Fe	Mn	Zn	Cu	B	Mo
Arabica (2)	Brazil	Malavolta, 1990	1039	114	54	84	120	-
Arabica (3)	Brazil	Malavolta, 1990	471	45	11	28	33	-

Notes
(1) 1350 trees/ha, one stem per tree removed each year.
(2) 1904 covas/ha, 3-4 stems/cova, all cut 0.4 m above ground after 7 years.
(3) 1904 covas/ha 3-4 stems/cova, all cut 1.5 m above ground after 7 years.
(4) 1333 trees/ha, 4 stems/tree, all removed after 5 years.

Nutrient uptake

Nutrient uptake includes nutrients lost in crop and prunings, and nutrients used for the growth, development and maintenance of the tree:

Nutrient uptake - Macronutrients								
Coffee type	Country	Source	kg/ha/year					
			N	P2O5	K2O	MgO	CaO	S
Arabica (1)	Brazil	Malavolta, 1990	167.4	17.9	164.0	54.1	90.6	13.7
Arabica (2)	Costa Rica	Carvajal et al., 1969	172	36	119	20	53	-
Arabica (3)	Kenya	Cannell and Kimeu, 1971	150	23	180	25	77	-
Robusta (4)	Cote d'Ivoire	Snoeck, 1983	85.2	17.6	82.1	20.5	54.8	-
Robusta (5)	Indonesia	Saleh, 1983	53.2	10.5	80.7	16.5	28.0	-

Nutrient uptake - Micronutrients								
Coffee type	Country	Source	g/ha/year					
			Fe	Mn	Zn	Cu	B	Mo
Arabica (1)	Brazil	Malavolta, 1990	2202	746	489	360	199	-

Notes:
(1) Mundo Novo and Catuai varieties, 5.5-6.5 years old, 1250 covas/ha, 2 stems/cova, yield 3 000 kg/ha green bean.
(2) Bourbon variety, 3-4 years old growing in nutrient solution, equivalent uptake by 1 500 trees.
(3) Five year old trees, 1 500 trees/ha, yield 1 100 kg/ha gb.
(4) Five year old trees, 1 333 trees/ha, yield 1 000 kg/ha gb.
(5) 1 200 - 1 600 trees/ha, shaded, yield 1 500 - 2 000 kg/ha gb.

Nutrients recycled

Significant quantities of nutrients may be recycled in coffee leaf litter, prunings, pulp and parchment, and in shade tree leaf litter and prunings:

Nutrients recycled - Macronutrients								
Component	Country	Source	kg/ha/year					
			N	P2O5	K2O	MgO	CaO	S
Arabica (1) leaves	Brazil	Malavolta, 1990	37.5	6.0	46.4	29.0	43.7	3.1
Arabica (2) pulp + parchment	Brazil	Malavolta, 1990	17.8	3.2	45.8	2.0	6.0	1.6
Arabica (3) prunings	Brazil	Malavolta, 1990	322	41	341	50	207	11
Arabica (4)	Kenya	Cannell & Kimeu,	97.5	12.0	90.0	17.9	60.9	-

prunings + leaves		1971						
Robusta (5) leaves	Cote d'Ivoire	Snoeck, 1983	28.7	4.8	21.8	6.6	18.8	-
Erythrina (6) leaf litter + prunings	Costa Rica	Glover and Beer, 1986	182	48	187	45	183	-
Arabica + Erythrina leaf litter + prunings	Costa Rica	Glover and beer, 1986	366	69	317	80	340	-

Notes:
(1) Mundo Novo and Catuai varieties, 5.5-6.5 years old, 1 250 covas/ha, each with two trees.
(2) Pulp and parchment produced during processing of 1 000 kg green bean
(3) Mundo Novo variety, 1 904 covas/ha, with 3 or 4 stems per cova. Nutrients from leaves, branches and stems when pruned 0.4 m from the ground after 7 years growth.
(4) Ten year old, single stem coffee, 1 500 trees/ha. Nutrients from annual pruning and fallen leaves.
(5) Five year old trees with 4 stems/tree and 1 333 trees/ha.
(6) Erythrina poeppigiana pruned three times/year, 238 trees/ha.
(7) Erythrina poeppigiana, 238 trees/ha, pruned three times/year, and arabica coffee, 3 700 trees/ha, pruned once.

Nutrients recycled - Micronutrients								
Component	**Country**	**Source**	**g/ha/year**					
			Fe	**Mn**	**Zn**	**Cu**	**B**	**Mo**
Arabica (1) leaves	Brazil	Malavolta, 1990	751	78.7	160	200	97.5	-
Arabica (2) pulp + parchment	Brazil	Malavolta, 1990	51.0	29.5	71.4	18.4	34.7	-
Arabica (3) prunings	Brazil	Malavolta, 1990	2805	438	154	232	351	-

Notes:
(1) Mundo Novo and Catuai varieties, 5.5-6.5 years old, 1 250 covas/ha, each two trees.
(2) Pulp and parchment produced during processing of 1 000 kg green bean
(3) Mundo Novo variety, 1 904 covas/ha, with 3 or 4 stems per cova. Nutrients from leaves, branches and stems when pruned 0.4 m from the ground after 7 years growth.

Leaf analytical data

Sample 3rd or 4th pairs of leaves from tips of fruit-bearing branches, at mid-height of tree, on four quadrants; total of at least 40 leaves from 10 or more representative trees. Nutrient contents vary with season; it is often recommended that samples be taken at the end of the season when the crop matures, when nutrient levels are generally low. Differing critical levels from country to country are often attributable to differences in nutrient supply and/or retention capacities of soils:

Nutrient analysis data - Macronutrients							
Source	**Level**	**% of dry matter (60° C)**					
		N	**P**	**K**	**Mg**	**Ca**	**S**
Malavolta, 1990 Brazil (Arabica)	Deficient	<2.2	<0.10	<1.4	<0.26	<0.5	<0.10
	Marginal	2.2-2.6	0.10-0.14	1.4-1.8	0.26-0.30	0.5-0.9	0.10-0.14
	Adequate	2.7-3.2	0.15-0.20	1.9-2.4	0.31-0.36	1.0-1.4	0.15-0.20
	High	3.3-3.5	0.21-0.23	2.5-2.7	0.37-0.39	1.5-1.7	0.21-0.25
	Excess	>3.5	>0.23	>2.7	>0.39	>1.7	>0.25
Carvajal, 1984 Costa Rica (Arabica)	Deficient	<2.0	<0.09	<1.0	<0.10	<0.8	-

	Low	2.0-2.3	0.09-0.12	1.0-1.7	0.10-0.20	0.8-1.1	<0.2
	Adequate	2.3-2.8	0.12-0.20	1.7-2.7	0.20-0.35	1.1-1.7	0.2
	High	>2.8	>0.20	>2.7	>0.35	>1.7	-
CRF (undated) Kenya (Arabica)	Deficient	<2.5	<0.15	<2.2	<0.25	<1	<0.10
	Adequate	2.5-3.0	0.15-0.30	2.2-3.0	0.25-0.40	1.0-2.0	0.10-0.30
	Excessive	>3.0	>0.30	>3.0	>0.40	>2.0	>0.30
Krishnamurthy Rao, 1990 India (Arabica)	Low	<2.5	<0.10	<1.5	<0.30	<0.69	-
	Medium	2.5-3.5	0.10-0.15	1.5-3.5	0.30-0.40	0.69-1.11	0.10-0.18
	High	>3.5	>0.15	>3.5	>0.40	>2.0	>0.18
Willson, 1985 ,Compilation (Robusta)	Deficient	<1.8	<0.10	<1.2	<0.20	<0.4	<0.12
	Low	1.8-2.7	0.10-0.13	1.2-1.8	0.20-0.30	0.4-0.8	0.12-0.18
	Adequate	2.7-3.3	0.13-0.15	1.8-2.2	0.30-0.36	0.8-1.5	0.18-0.26
	High	>3.3	>0.15	>2.2	>0.36	>1.5	>0.26
Loué, 1957 Cote d'Ivoire (Robusta)	Very Low	<1.8	<0.11	<0.8	<0.30	<0.8	-
	Low	1.8-2.8	0.11-0.12	0.8-1.5	-	0.8-0.9	-
	Medium	2.8-3.3	0.12-0.15	1.5-2.5	0.30-1.10	0.9-1.2	-
	High	>3.3	>0.15	>2.5	>1.10	>1.2	-
Colonna, 1964 Central Africa Rep. (Excelsa)	Low	<1.59	<0.09	<0.73	<0.23	<1.92	-
	Medium	1.59-1.70	0.09	0.73-1.60	0.23-0.39	1.92-2.28	-
	High	>1.70	>0.09	>1.60	>0.39	>2.28	-

Nutrient analysis data - Micronutrients							
Source	**Level**	**ppm dry matter (60° C)**					
		Fe	**Mn**	**Cu**	**Zn**	**B**	**Mo**
Malavolta, 1990 Brazil (Arabica)	Deficient	<50	<40	<5	<4	<20	<0.10
	Marginal	50- 89	40-119	5- 7	4- 7	20-58	0.10-0.14
	Adequate	90-180	120-210	8-16	8-16	59-80	0.15-0.20
	High	181-220	211-300	17-25	17-30	81-90	0.21-0.30
	Excessive	>220	>300	>25	>30	>90	>0.30
Carvajal, 1984 Costa Rica (Arabica)	Deficient	-	<25	-	<10	<40	-
	Low	<75	25- 50	<6	10-15	40- 60	-
	Adequate	75-275	50-150	6-12	15-20	60-100	-
	High	-	>150	-	>20	>100	-
CRF (undated) Kenya (Arabica)	Deficient	<50	<50	<20	<10	<40	-
	Adequate	50-200	50-200	20-?	10-30	40-100	-
	Excessive	>200	>200	-	>30	>100	-
Krishnamurthy Rao, 1990, India (Arabica)	Low	-	-	-	<8	-	-
	Medium	100-300	80-200	10-15	10-15	40-45	0.10-0.15
	High	-	-	-	>15	-	-
Willson (1985) Compilation	Deficient	<40	<20	<13	<10	<20	<0.30

(Robusta)							
	Low	40- 70	20-35	13-20	10-15	20-35	0.30-0.50
	Adequate	70-200	35-70	20-40	15-30	35-90	>0.50
	High	>200	>70	>40	>30	>90	-
Loué, 1957 Côte D'Ivoire (Robusta)	Very Low	<75	<35	<3	<7	<25	-
	Low	75- 80	35-40	3-14	7-10	25- 40	-
	Medium	80-100	40-60	14-27	>10	40-150	-
	High	>100	>60	>27	-	>150	-
Note: Critical levels for molybdenum are tentative.							

Excessive levels of N, P or K, or low levels of Fe, have been shown to be detrimental to the cup quality of the beans. High levels of N also result in production of excessive foliage at the expense of flowers and hence cherries. Inadequate N or K leads to "dieback" and, in extreme cases, may even result in death of the tree. Inadequate potassium may also increase the proportion of "floaters", or empty cherries.

Several nutrient interactions are important. Excessive N can induce S deficiency. The leaf N : S ratio should be less than 35; if above 40, S is likely to be deficient. The N/P interaction is also important; generally the leaf N : P ratio should be between 7 and 35, or ideally between 18 and 22. High P can also induce Fe and Zn deficiencies. Deficiencies of Mn or S are often associated with high K. K/Mg antagonism is well established; generally, the leaf K : Mg ratio should be below 10. Other antagonisms include Fe/Mn and Ca/B.

Fertilizer recommendations

Nurseries: A well prepared bed or potting mixture, consisting of topsoil, sand, organic material and a P fertilizer, will provide adequate nutrition for the 6-12 months the seedlings spend in the nursery. Other nutrients may however be added to the potting mixture, and often small quantities of fertilizers are also applied as the seedlings develop. Foliar fertilizers are particularly effective.

Planting holes: should be filled with a mixture of topsoil, organic material and a P fertilizer. Other nutrients may be added in the planting hole, including limestone, dolomite or kieserite if appropriate. Some very acid soils are limed with a top dressing before planting.

Young coffee: for the first 2 or 3 years in the field it is usual to follow a standard fertilizer programme which provides relatively small, but frequent applications of N, P and K. Rates are calculated on a per tree basis, and increase as the trees develop. Particularly during the first year, foliar fertilizers provide a valuable supplement to ground-applied fertilizers, and can be used to supply the necessary micronutrients, especially Zn and B. Containing macro- and micronutrients, they are often beneficial during the dry season.
Ground-applied fertilizers are distributed in a gradually widening band around the tree, which extends from about 7 cm from the stem to slightly beyond the edge of the drip circle.

Mature coffee: When the trees are in bearing, fertilizer rates are calculated on the basis of soil and leaf analysis, expected yield, stage in the production cycle, and general condition of the crop: usually 150-300 kg/ha/year N and K2O and 0-150 kg/ha/year P2O5, split into three or four dressings. K is particularly necessary during the period of fruit expansion and ripening. Mg and S are also important and are usually provided as components of compound or other straight fertilizers.

Micronutrients are usually given in foliar fertilizers, which are often best applied as routine applications during the dry season. Serious deficiencies, however, are best treated with immediate foliar application in conjunction with a more concentrated ground-applied fertilizer.

Robusta coffee generally requires less nutrients than arabica.

Preferred nutrient forms

In most countries, at least some of the required nutrients are usually applied in the form of a compound fertilizer. Typically, one or two applications of an appropriate compound will provide adequate P, Mg and possibly S, and a proportion of the required N and K of which the balance is then provided by straight fertilizers.

Commonly used N fertilizers include urea, ammonium sulphate, ammonium sulphate nitrate, ammonium nitrate and calcium ammonium nitrate. In particularly acid soils urea and ammonium sulphate should be avoided if possible, and calcium ammonium nitrate be used. Urea should be mixed with the topsoil, particularly in drier weather, to reduce volatilization losses. Urea is commonly used in foliar sprays at concentrations of 1.0-1.5 % (over 2 % may produce leaf scorch).

K is provided as muriate or sulphate. If there is enough S in the compound and nitrogenous fertilizers, then muriate is preferred. If adequate S is not provided by the other fertilizers, then sulphate of potash should be considered. If muriate is used near the coast, it is important to monitor Cl leaf levels in order to avoid possible toxicity.

The most commonly used straight **P** fertilizers are single or triple superphosphate, diammonium phosphate and rock phosphate. Rock phosphate is best used in acid soils. Single superphosphate is also useful on acid soils, particularly those low in S and Ca. If diammonium phosphate is used, it also supplies some of the N requirement.

If additional **Mg** is needed, Kieserite, magnesium sulphate (as Epsom salts) or magnesium nitrate are usually recommended for soil application. Epsom salts or magnesium nitrate can also be used as 0.5-0.75 % foliar spray. Often, Mg and liming are both needed, in which case dolomite or dolomitic limestones are preferred.

B and **Zn** are the most commonly encountered micronutrient deficiencies. They may be treated respectively with Solubor, or Borax (foliar or soil-applied), and with zinc sulphate, zinc sulphate monohydrate, zinc oxide (foliar or soil-applied) or zinc chelates (foliar). **Fe** or **Mn** deficiencies may occur, particularly with robusta, and are usually treated with foliar sprays of Fe or Mn chelates or sulphates.

Present fertilizer practices

Brazil (Source: Malavolta, 1990)

Traditionally, coffee was planted at 1 400-1 900 covas/ha and 2-4 plants per cova. Recently higher densities (up to 5 000) have been used with one plant per hole. No shade is used. National average yields are around 600 kg/ha gb, but well managed low-density plantations achieve 1 200-1 500 kg/ha gb, and recently planted high-density plantations 1 800-2 400 kg/ha gb. The following practices refer to arabica.

Nurseries: Potting mixture = 1 000 litres topsoil plus 200 litres stable manure (or 50 litres chicken manure), 5 kg single superphosphate, 1 kg dolomitic limestone, 500 g muriate of potash, 5 g borax, 5 g zinc oxide (50 % Zn) and 5 g copper sulphate.

Planting holes: Before planting, acid soils are limed (topdressed and incorporated into top 30 cm at least) at rates necessary to increase base saturation to 70 %. Sometimes phosphogypsum is also topdressed to overcome subsoil acidity. Planting holes are prepared (40 x 40 x 40 cm), and refilled with soil plus 60-80 g P2O5 (as single superphosphate), 12-15

g K_2O (as muriate of potash), 200-500 g dolomitic limestone, 0.2 g boron, 0.2 g copper, 1 g zinc and organic fertilizers if available. If planting furrows are used, equivalent quantities of the above fertilizers are applied.

Young coffee: During the first year in the field each plant receives 4 dressings of 5 g N, and 2 dressings of 5-10 g K_2O. In the second year four times as much N and K_2O are applied, split into 3 dressings. In the third year, the application rates are double those of the second year, and 0-40 g P_2O_5 are added (depending on soil analysis).

Mature coffee: When the trees are in full bearing, fertilizer rates are based on soil and leaf analyses, and on expected yield: 200-300 kg/ha/year N and K_2O; 0-50 kg/ha/year P_2O_5 in 3-4 dressings (Sept. - Apr.). Micronutrients are controlled by 3-4 foliar sprays containing boric acid (0.3 %) and zinc sulphate (0.6-0.8 %). Copper is supplied as oxychloride used in coffee leaf rust control.

Kenya (Source: CRF, 1983 and CRF, 1990)

Traditionally most coffee was planted at 1 329 trees/ha, although more recent plantings, particularly if irrigated, have been at densities of 3 000-4 000 trees/ha. Traditional farmers average about 600 kg/ha green bean, while non-irrigated plantations average about 800 kg/ha green bean and irrigated plantations 1 300 kg/ha green bean. The better plantations exceed 2 000 kg/ha green bean. Most plantations are not shaded. The following practices are for arabica which represents the great majority of production.

Nurseries: Recommended potting mixture = 300 litres well sieved topsoil, 200 litres coarse sand, 100 litres farmyard manure, 250 g single superphosphate plus a soil insecticide. This is sufficient to fill about 220 polypots (30 x 17 cm when flat, volume 2.75 litres). Very little additional fertilizer is required although weekly applications of foliar feeds are considered beneficial during the final 6 months.

Planting holes: (60 x 60 cm dia) are dug during the dry season, and allowed to "weather" for 3 months before refilling with topsoil, 20 litres cattle manure (or well rotted coffee pulp), 100 g double superphosphate, 100 g dolomitic limestone (where necessary) and a soil insecticide. In acid soils 200 g single superphosphate are used in place of double superphosphate. If the Ca:Mg ratio is very low, ground limestone is used in place of dolomitic limestone. Holes are refilled one month before planting, in order to allow the soil to settle. When planting, a small hole just sufficient to accommodate the nursery seedling, is opened in the centre of the refilled hole.

Young coffee: During the first two years in the field 40 kg/ha/year N are applied, split into 3 dressings per year (March/April, May/June, November). Calcium ammonium nitrate is recommended if the soil pH is below 5.4; above pH 5.4, ammonium sulphate, ammonium sulphate nitrate, or urea are recommended. Fertilizer is applied in a broad band extending from about 30 cm from the stem to about 30 cm beyond the drip circle.

Mature coffee: 80, 100, 100-150 or up to 200 kg/ha/year N for expected yields of below 1 000, 1 000-1 500, 1 500-2 000, and over 2 000 kg/ha green bean respectively. More than 200 kg/ha/year N is not recommended. Annual amounts are split into 4 dressings in high rainfall or irrigated areas, or 3 dressings in moderate rainfall areas. If the soil pH (in water) is below 5.4, calcium ammonium nitrate (CAN) is recommended, twice for every one application of ammonium sulphate nitrate (ASN) or urea. If the pH is between 5.4 and 6.5, alternating applications of CAN and ASN are recommended, or urea; above pH 6.5, ammonium sulphate or ASN.

If the soil pH is below 5.4, P is given as 350 g single superphosphate/tree. Above pH 5.4, 150 g diammonium phosphate or 150 g double or triple superphosphate/tree are recommended before or during the main rains.

Soil exchangeable K level should be at least 0.5 me%, and K:Mg:Ca ratio 1:(2-3):(4-6). If additional K is required, 100-190 g muriate or sulphate/tree (135-250 kg/ha) are recommended once every 3-4 years at the beginning of the main rains. If Mg is needed 170 g calcined magnesite/tree are recommended every 3-4 years, supplemented by 0.5 % solution of Epsom salts as foliar feed. Ca is supplied as 340 g dolomitic limestone/tree (460 kg/ha) every 4-5 years.

Appropriate compound fertilizers (based on soil available P, and exchangeable cation levels) often replace one of the N applications 6 months before the main flowering. Foliar feeds are used to supplement soil applications during dry weather or times of stress.

Farmyard manure (20 litres/tree), cattle manure (40 litres/tree every 2-3 years), coffee pulp (25 t/ha dry material every 2-3 years) and Napier grass mulch (16-28 t/ha dry material for 2 years followed by 2-3 years without) are also recommended if available.

Lime is applied to acid soils at a rate of 500 g/tree for every 1 me% of exchangeable acidity.

Papua New Guinea (Source: CRI, 1990)

Coffee in Papua New Guinea is often shallow rooting (<50 cm) due to soil conditions, and annual rainfall totals range from 1 500-3 000 mm with no dry season, but a drier period July - Sept. Traditional low input, heavily shaded, coffee gardens produce up to 1 000 kg green bean/ha, although typically less than half of this is harvested. Rehabilitated, lightly shaded, coffee gardens can produce up to 1 500 kg/ha green bean, and unshaded commercial plantations average about 2 000 kg/ha green bean, with the better plantations exceeding 3 000 kg/ha green bean in good years. The following practices refer to arabica, which accounts for 95 % of production.

Nurseries: Recommended potting mixture = 300 litres sieved topsoil, 200 litres washed coarse river sand, 100 litres well-rotted coffee pulp, 250 g triple superphosphate and a granulated soil insecticide. This is sufficient for 125 polypots (30 x 15 cm , volume 4.8 litres). A complete foliar feed, containing macro- and micronutrients, is given monthly, and 5 g of high-P compound fertilizer is applied to each polypot after 6 months.

Planting holes (45 x 45 cm dia) are dug 1 - 2 weeks before planting, and immediately refilled (to avoid filling with rain) with a 4:1 mixture of topsoil and well rotted coffee pulp, plus 60 g diammonium phosphate or triple superphosphate (or 240 g rock phosphate). Seedlings are later planted in the centre of the refilled planting hole.

Young coffee: Tall varieties (e.g. Arusha, Mundo Novo, Blue Mountain) are typically planted at 2 500 trees/ha. During the first year in the field, they receive a complete foliar feed on the day of planting, and monthly thereafter. At 6 weeks, 70kg/ha ammonium sulphate and after 14 weeks, 100 kg/ha 15:15:6 (or similar) compound fertilizer are applied. Compact varieties (e.g. Caturra, Catimor) are typically planted at 3 000 - 5 000 trees/ha, and grow particularly rapidly in their early years. Application rates of soil-applied fertilizers are therefore increased to 140 kg/ha ammonium sulphate and 200 kg/ha 15:15:6.

During the second year in the field, tall varieties receive 100 kg/ha 15:15:6 in October and February, and 70 kg/ha ammonium sulphate in December and May. Complete foliar feeds are applied during the drier season in July, August and September. Compact varieties are fertilized according to expected yield.

Mature coffee in bearing (from year 3 for tall varieties, and from year 2 for compact varieties): Generally, recommended N:P2O5:K2O:MgO ratios are 4:1:4:1, and for expected yields of under 500, 1 000, 1 500, 2 000, 2 500 and over 2 500 kg/ha/year green bean respectively 60, 100, 140, 200, 300 and 400 kg/ha/year N are recommended. These rates are modified where necessary on the basis of the condition of the trees, and on soil and leaf analysis.

Fertilizer is not recommended for heavily shaded, unrehabilitated, traditional coffee gardens producing less than 500 kg/ha green bean. Rehabilitated coffee gardens are best fertilized with 2 dressings (October, April) of a compound fertilizer as close as possible to the recommended N: P2O5:K2O:MgO ratio of 4:1:4:1. Well managed rehabilitated coffee gardens and commercial plantations, producing more than 1 000 kg/ha green bean should be given a low-P/low-K compound in October and April/May, and straight N and K in December/January and February/March. Foliar sprays containing macro- and micronutrients should be given in July, August and September.

Urea and ammonium sulphate are the most commonly used N fertilizers, K is usually applied as muriate. If additional P is required, diammonium phosphate, triple superphosphate or rock phosphate is given. Supplementary Mg is provided in locally mined dolomite, kieserite or nitromagnesia at 50 kg/ha/MgO.

If, despite the routine foliar feeds, Zn deficiency is still a problem, one ground application of 30-60 kg/ha zinc sulphate or 15-30 kg/ha zinc sulphate monohydrate or 3 foliar sprays at four-week intervals of 1.2 kg zinc sulphate or 600 g zinc sulphate monohydrate in 300 litres water/ha, are recommended. Boron deficiencies are similarly treated with one ground application of 37.5 kg/ha Solubor (or 75 kg/ha borax, or 3 foliar sprays at four-week intervals of 900 g Solubor or 1.8 kg borax in 300 litres water/ha. Mo deficiency is treated by 3 applications of 150 g ammonium molybdate in 300 litres water/ha.

India (Source: Krishnamurthy Rao and Ramaiah, 1985)

India produces both arabica and robusta. The following practices refer to robusta, which is typically planted at 1 075 trees/ha, under a regulated mixed shade.

Nurseries: When seedlings have 4-5 pairs of leaves, each seedling receives 3-5 g diammonium phosphate and a pinch of urea.

Planting holes should receive triple superphosphate and coffee pulp.

Young coffee: During the first year in the field 45 kg/ha N, 30 kg/ha P2O5 and 45 kg/ha K2O are applied in three equal dressings. In the second and third years, these amounts are increased to 60 kg/ha/year N, 45 kg/ha/year P2O5 and 60 kg/ha/year K2O.

Mature coffee: For robusta producing up to 1 000 kg/ha/year green bean, 80 kg/ha/year N, 60 kg/ha/year P2O5 and 80 kg/ha/year K2O in two equal dressings in March (pre-blossom) and October (post-monsoon). For robusta producing over 1 000 kg/ha/year green bean, 120 kg/ha/year N, 90 kg/ha/year P2O5 and 120 kg/ha/year K2O in 3 equal dressings in March (pre-blossom), May (post-blossom/pre-monsoon) and October (post-monsoon).

Urea, ammonium sulphate and calcium ammonium nitrate are commonly used N fertilizers. P is given on acid soils as rock phosphate or basic slag, and on less acid soils as nitrophosphates. Both muriate and sulphate of potash are used as K fertilizers. Various compounds are also in use, and commercial plantations apply supplementary foliar sprays.

Côte d'Ivoire (Source: Snoeck, 1988)

The Ivory Coast is a major producer of robusta, typically grown without shade at about 1 333 trees/ha. Current recommendations are to plant 1 961 trees/ha. Yields range from less than 500 kg green bean/ha to about 2 000 kg/ha green bean, although well managed, elite clones can produce yields in excess of 3 000 kg/ha green bean.

Nurseries: Polypot nurseries are used occasionally for growing seedlings propagataed from seed but most commonly for rooted cuttings which are obtained from clonal cuttings gardens and initially raised in propagators until roots are 5-10 cm long. The potting mixture consists of sifted humus and rich topsoil, and the polypots are 25 cm x 12 cm diameter. Fertilizers applied depend on the topsoil used. Often no fertilizers are used, or only urea as a foliar feed (10 g urea/10 litres water) every 2 weeks. If necessary 3 g 15:15:15 compound fertilizer can be applied to each pot every 2 weeks from the 2nd to the 6th month.

Planting holes (40 x 40 x 40 cm) are dug at the beginning of the rainy season, and refilled the next day with topsoil, mixed if possible with compost or manure.

Young and mature coffee: Emphasis is placed on soil analysis, and to a much lesser extent, leaf analysis. On moderately leached soils (base saturation > 40 %), only urea is recommended during the first production cycle. During the first year in the field 43 kg/ha urea are recommended, split into 2 dressings in July and September. In the 2nd, 3rd and 4th years, rates are increased to 109, 174 and 196 kg/ha/year urea respectively, applied in March and September (i.e. at the onset of the two rainy seasons). In the 5th, 6th and 7th years the recommended rate is 217 kg/ha/year urea, applied in March and September. The coffee is stumped back during the 8th year and so the fertilizer rate is reduced to 109 kg/ha urea, applied in July and September. 500 kg 20:10:5 compound fertilizer ha/year are recommended throughout the second and subsequent production cycles.

On very leached soils (base saturation < 40 %), or soils with low cation exchange capacity (CEC < 5 me%), 12:6:20:4 compound is recommended: In the first year in the field, at 333 kg/ha split into 2 dressings in July and September, and in the 2nd and 3rd years at 666 and 1 000 kg/ha/year respectively, applied in March and September. This latter rate continues to the 7th year. The coffee is stumped-back in the 8th year and so the rate is reduced to 250 kg/ha/year, applied in July and September. 1 000 kg/ha/year 12:6:20:4 are recommended from the 9th year onwards.

Leaf analytical data are used to identify micronutrient deficiencies.

Further reading

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