Module 4: Coffee Nutrition

Objectives

To impart knowledge on nutritional requirements of coffee for sustained soil fertility, coffee quality and yields.

Content

i) Introduction.
ii) Essential nutrients in coffee – Nitrogen, Phosphorus, Potassium, calcium, sulphur, magnesium, iron, zinc, manganese, copper, boron and molybdenum.
iii) Role of macro and micronutrients and deficiency symptoms – chlorotic/necrotic leaves, shortened internodes, reduced leaf size, overbearing dieback.
iv) Sources of macro and micronutrients - Inorganic fertilizers and their application schedules/rates, Foliar feeds, manures, mulches, compost and nutrient content.
v) Composting procedure – materials for use, use of EM, setting up the heap, monitoring the decomposition and renewing the mixture for regular supply of compost.
vi) Soil/leaf sampling and analysis - materials required, how to sample, when to sample and sample treatment before analysis.
vii) Liming – use of analysis report, nominal/minimal application rate and how to apply.
viii) Crop estimation – Importance of crop estimation, Timing, Methods used in crop estimation.

Methodology

i) Class lecture/field trainings sessions.
ii) Demonstrations of fertilizers/manure application, soil sampling and composting, foliar spray and liming.
iii) Group work/ practical sessions by participants.

Teaching aids/materials

i) Samples of various fertilizers, agricultural and dolomitic lime, soil auger and soil collection containers.
ii) Calibrated fertilizer applicator for large estates and cups for smallholder/lime measures
iii) Samples of decomposable and non - decomposable materials.
iv) Tools - jembes, shovels and pangas.
v) Illustrations of well - nourished coffee plants.
vi) Illustrations of deficiency symptoms on coffee plants.
vii) Cherry from well and poorly nourished coffee plants viii)pH meter, biological indicator of soil acidification (fern).
ix) Thermocouple for checking temperature of compost.

4.1 Introduction

For high yields and quality, there is need for adequate and timely supply of both macro and micro nutrients. The nutrients can be supplied from various sources such as fertilizers, manures or compost. Fertilizer programs are based on established inherent soil fertility characteristics and expected production level.

4.2 Essential nutrients in coffee

- Macronutrients – elements required in large quantities. They consist of the primary macronutrients required in relatively higher quantities such as Nitrogen (N), Phosphorous (P) and Potassium (K) and the secondary macronutrients required in moderately high quantities such as Calcium (Ca), Magnesium (Mg), and Sulphur (S).
- Micronutrients - elements required in very small quantities but are essential for plant growth. They include Zinc (Zn), Copper (Cu), Boron (B), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Chlorine (Cl).

4.3 Role of macro and micronutrients and deficiency symptoms

4.3.1 Importance of macronutrients

Nitrogen (N)

- Essential for vegetative growth.
- Increases tree bearing capacity.
- Enhances bean size.

Phosphorus (P)

- Essential for roots and bearing wood development.
- Promotes early berry maturity.
- Increases bean density.

Potassium (K)

- Crucial in glucose transportation from the chlorophyll to storage tissues – roots, stems and branches.
- Promotes healing of injured plant tissue especially after picking, pruning and hail storm damage.
- Essential for berry development – enhances bean size (berry length) hence raises the proportion AA and AB grades.
- Regulates evapotranspiration pull i.e. the opening and closing of stomata thus the loss of water through the stomata and the uptake from the soil.
- Enhances mucilage formation and ripening.

Magnesium (Mg)

- A major constituent of chlorophyll which facilitates the making of plant glucose which in turn makes all the biochemical constituent of the plant – starch, amino acids, vitamins and the plant tissues.
- Enhances bean colour (Bluish-Green colour).
- Initiates root formation.

Calcium (Ca)

- Facilitates growth of apical and root terminal points – intensifies flowering density.
- Essential for vegetal and floral bud formation – it's a constituent.
- Manages the lyophilic series - directs the overall ratios of nutrients uptake.
- Plays a key role in bark formation – its constituent of the bark tissue.

Deficiency symptoms

Nitrogen deficiency (yellowing of young leaves) overbearing die-back due to of N deficency.

Phosporous deficiency (yellowing of older leaves).

Phosporous deficiency (yellowing of older leaves).

4.3.2 Importance of micronutrients Zinc (Zn)

It is the only known metallic plant hormone which:

- Boosts flower initiation and formation.
- Enhances fruit set and leaf size.
- Sets the inter-nodal spacing on the branch and the stem.
- Enhances phosphorus uptake and utilization.
- Determines the leaf symmetry.

Boron (B)

- Enables flower fertilization by facilitating pollen germination through the stigma to the ovary. Consequently, optimal flowering and fruit set are realized i.e. it minimizes flower abortion.
- Manages the utilization of water in the plant together with potassium. Consequently, it regulates the uptake of water from the soil together with potassium.
- Promotes shoot and root growth.
- Facilitates protein and sugar synthesis from glucose.

Iron (Fe) and Sulphur (S)

- Helps in the production of chlorophyll which is required in glucose formation.
- Promotes bean colour (lack of iron leads to amber beans).
- Together with copper, iron facilitates energy transfer processes during photosynthesis.

Molybdenum (Mo)

- Facilitates translation of pinheads to expanding berries without abscission i.e. abnormal drop of the pinheads

Deficiency symptoms

Zinc deficiency

Boron deficiency

Iron deficiency

4.4 Sources of macro and micronutrients

4.4.1 Inorganic Compound Fertilizers (NPK)

- These are granular, mechanically mixed homogeneous fertilizers with multiple nutrients. Examples of compound fertilizers are 17:17:17 and 20:10:10.
- If two or more nutrients are limiting in the soil, it's economical to apply a compound fertilizer. One of the annual N-fertilizer applications should be replaced with a compound fertilizer at a rate sufficient to supply the same quantity of Nitrogen.

Nitrogenous Fertilizers

- Sources include Ammonium Sulphate (AS), Calcium Ammonium Nitrate (CAN) and Urea.
- The choice of Nitrogen fertilizer depends on the soil reaction (pH).

Phosphate Fertilizers

- Common sources include Single Super Phosphate (SSP), Di-Ammonium Phosphate (DAP), Triple Super Phosphate (TSP) and Phosphoric/phosphorous acid.
- The choice of a Phosphatic fertilizer depends on the soil reaction (pH).
- DAP contains both Phosphorous and Nitrogen but has an acidifying effect. It is only recommended for use in soils with high pH and high levels of potassium. Continuous use of DAP without soil analysis can lead to big cherries without beans. Avoid using DAP unless recommended after soil analysis.

Potassium Fertilizers

- Sources include Muriate of Potash, Sulphate of Potash and organic manure (coffee pulp, napier grass and cattle manure).

Foliar Fertilizers

- These are formulations of soluble fertilizers usually applied on the foliage of the coffee tree to supplement soil applied fertilizers with the aim of:

  - Correcting nutrient deficiency.
  - Supplementing nutrient availability where soil nutrient uptake is impeded during dry weather or cold spells.
  - Apply when evaporation is low, preferably mornings or evenings, when it is not hot.

4.4.2 Organic fertilizers

Consist of manures, mulches and composts

- Boma manures are livestock organic waste made from accumulated dung from cattle pens and bomas.
- Farmyard manure (FYM) is made from a mixture of farm plant residues and daily accumulation of dung. Periodic turning of the boma and FYM leads to a fine livestock manure. The latter is often richer in potassium.
- Compost is made from decomposed organic materials derived from plant residue.

- Mulches are plant materials applied directly on the soil surface.

The benefits of all these include:

  - » Improvement of soil structure.
  - » Improvement of soil porosity/aeration - ability of the soil to hold optimal water and air.
  - » Lowered soil bulk density hence improved uptake.
  - » Moderation of top soil temperatures.
  - » Minimization of top soil moisture loss.
  - » Increment of microbial activity.
  - » Suppression of weed/insect pests.
  - » Soil erosion control.

- To avoid inducing nutrient imbalances, the mulching material to be used should be guided by the soil nutrient status. Examples of manures and the nutrients they supply:

  - » Cattle manure - rich in Nitrogen and Potassium.
  - » Poultry manure - rich in Phosphorus and Nitrogen.
  - » Coffee pulp - rich in Potassium and Nitrogen.
  - » Sisal waste - rich in Calcium.

- The amount of nutrients released to crops depends on:

  - » Nature and origin of materials.
  - » Level of decomposition.
  - » Weather conditions.
  - » Storage condition - exposing the manure to direct sun or rain leads to loss of Nitrogen.

4.4.3 Fertilizer Application

Appropriate fertilizer types and rates depend on overall fertility status of the soil and can be determined by undertaking soil analysis.

N.P.K application

- Apply 6 months before the main flowering (April for October/November flowering and October for March/April flowering) at the rate of 250g/tree to allow the plant to absorb adequate amount of P. P absorption is a slow process for dicots.
- Apply 2 weeks after the onset of rains to allow the feeder roots to develop.
- Apply on at most 20cm wide ring along the drip line and incorporate shallowly in the soil. Alternatively, scoop some soil, apply then cover shallowly (1 – 2 inches) with soil. The latter is more efficient.

Boron/Zinc application

- Apply a foliar mixture of Zinc and Boron at the rate of 2 - 3kg of each per Ha (40 - 60 g of each/20 litres of water) 2 – 3 months before the main flowering.

Nitrogen application

- Apply Nitrogen fertilizer (e.g. CAN/AS) after the main flowering, two weeks after the onset of rains at the rate of 300g/tree per year.
- For East of Rift Valley, apply in 2 equal splits at 3 - 4 weeks interval (150g per application).
- In West of Rift Valley, apply in 3 equal splits at 3 - 4 weeks interval (100g per application).
- Apply the fertilizer in at least a 30cm wide ring starting from the drip line towards the stem.
- If trees are carrying a heavy crop, apply a foliar fertilizer rich in Nitrogen during the dry or cold spell. For example, apply Urea 46% N at the rate of 10kgs/ha (10kgs in 1000 lts of water or 200g per 20lts of water) or other foliar formulations rich in Nitrogen. A better practice will be to use a foliar rich in NPK.
- Additional application of Nitrogen should be based on expected production. Trees carrying a heavy crop should be supplied with adequate nitrogen.

The table below gives a guideline on the amount of nitrogenous fertilizer to be applied for various levels of production.

Fertilizer application rates based on production per unit.

Amount of crop estimated in the current season	Kg N/ha per year	Grams of fertilizer/ tree		Kg of fertilizer/ha	
		21% N	26% N	21% N	26% N
Less than 1000 kg clean coffee per hectare (5 kg of cherry per tree)	80	330	260	390	310
1000-1500 kg clean coffee per hectare (5 – 7 kg of cherry/tree)	100	358	290	476	385
1500–2000 kg clean coffee per	100 – 150	358 - 538	290- 434	476 -	385- 577
hectare (7– 10 kg of cherry/tree)				715	
Over 2000 kg clean coffee per hectare (over 10 kg of cherry /tree	Up to 200	716	578	952	769

Note: Nutrition rates are dependent on prevailing crop. To determine the amount of N per hectare for Ruiru 11 and Batian, a multiplication factor can be used bearing in mind the table above is based on SL variety at 1330 trees / hac.

Fertilizer application schedule for late main crop areas

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
					Main flowering		Initial expansion		Final expansion/ maturation		
Final expansion/ maturation					CAN						
			Zinc sulphate								
			Solubor								
			Lime							Lime	
			Manure							Manure	

The key areas for the late main crop are – Central region, Upper Embu and West of Rift.

Note: NPK application in West of Rift valley should be done in August or September depending on the start of rains.

Fertilizer application schedule for early main crop areas

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Main flowering		Initial Crop Expansion			Final expansion/ maturation						
	CAN				NPK						
								Zinc sulphate			
								Solubor			
			Lime							Lime	
			Manure							Manure	

The key areas for the early main crop are – Meru, Machakos, Taita, and Oloitoktok regions.

4.4.4 Manure application

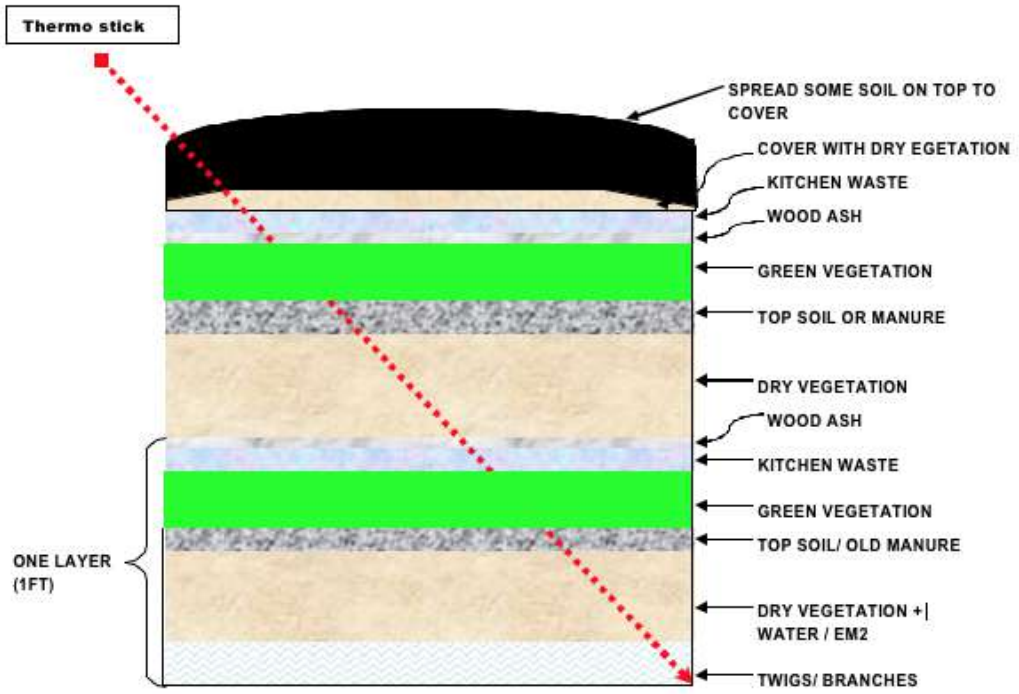
- Apply 1 - 2 debes of well decomposed manure/coffee pulp once a year during the dry weather, a month before the rains.
- Dig a shallow furrow ring (4 – 6" deep), 30cm wide, starting from the drip line towards the stem. Apply the manure and mix with soil.
- Manure may also be applied in the water basins - 45 cm deep. Leave a depression not exceeding 4" from the ground and cover with a thin layer of soil. However, this is not be the best practice.

4.5 Composting procedure

Compost is made from on-farm plant residues such as postharvest remains, weeds, tree litter fall, fodder/forage crops, coffee pulp, kitchen waste and other biodegradable materials. To assist in composting, EM (Effective Micro-organisms) can be used. This is a culture of micro-organisms that aids rapid breakdown of organic materials to release nutrients. The stock culture is termed as EM1 and is used to generate the working culture - EM2 as follows:

- Mix 1 litre of EM1 with 1 litre of Molasses and 20 litres of water. Let the mixture ferment for 7 days.
- 2 litres of EM2 can be mixed with 100 litres of water for use in compost making.
- For large scale compost, prepare ground of 100ft by 4ft wide. This should be done in areas free from flooding and run-offs.
- Line the composting depression with a strong polythene sheeting
- Stack the materials into 2ft thick layers.
- Apply the diluted EM2 solution and repeat the layering until approx. 4ft high.
- Wet each layer with adequate amount of water.
- Compress the layers and cover with polythene sheet and apply a thin layer of soil on top.
- Incubate for 3 weeks. After 3 weeks, start and continue turning and rewetting biweekly to aerate the mixture evenly.
- Poke in a thermocouple regularly to monitor the compost temperatures or use a stick to feel the temperatures.
- The decomposition process is complete when the mixture no longer feels hot.
- The compost will be fluffy and dark in colour when fully decomposed. This takes approximately two months.
- The end point is determined by a 66% reduction from the original volume.
- Apply 5 -10kg of the compost per tree depending on the canopy size.
- For small scale compost, make a hole 5ft by 5ft but the horizontal length depends on the availability of the composting materials and undertake the process above.
- Apply the compost from the first hole after two months and restart filling all over gain
- To ensure a continuous supply, undertake the procedure repeatedly.
- EM is readily available at Agrochemical shops.

Compost



NB. All the above steps must be carried out within 24 hours.

Well decomposed manure.

4.6 Soil and leaf sampling for analysis

4.6.1 Soil sampling

Soil sampling entails collecting representative samples (random sampling) from the whole farm for the purpose of analysis. It should be done during the dry season

- When sampling, ensure you have two containers, a fork jembe or a panga and packaging bags (for the sample).
- Take samples from the various parts of the farm. Collect samples outside the tree canopy between 4 trees.
- At the sampled point, dig out and place the top soil (first 6") separately from the sub soil (6 - 18"). Mix the top soil and the sub soil separately and take 1 or 2 handfuls from each and put in separate containers. Repeat this at the other sampled points.
- Thoroughly mix the soil in each of the containers and take a sample of about 1kg of top soil and 1kg of subsoil.
- Put the topsoil and subsoil in separate packages and label appropriately giving your name, location and address (Postal and email). Send the samples to CRI.
- At least 5 sampling holes (cores) should be dug for a small farm of 1 acre and below. For larger farms add 2 - 3 cores per every additional acre.
- Undertake soil analysis every 2 - 3 years in order to determine the type and quantities of fertilizers to apply.

Soil sampling tools and process.

4.6.2 Leaf sampling

Soil sampling tools and process.

- A sample should represent not more than 8 hectares. However, irrespective of plot size, samples may be taken to diagnose problems in specific areas.
- Use the fourth leaf pair counting from the first fully open leaf at the tip of a primary branch from the mid canopy of the cropping region of the tree. Where the fourth leaf pair is not available, sample the third pair.
- Take a sample from at least 25 trees selected randomly from the plot. The selected trees should be representative of the field.
- Pick four leaves from the four compass points of a tree. A single leaf from the fourth leaf pair should be picked.
- A complete sample should therefore consist of four leaves from each of the 25 trees thus making a total of 100 leaves per sample.
- Sample either from the uniform - cropping or non - cropping branches but not from both
- Sample before the onset of rains.
- Pack the 100 leaves in a khaki paper bag and put a label. The label should indicate the name of the farmer, block number/size and the date of sampling.
- Submit to CRI within 48 hours of sampling.
- Soil sampling should be done every two to three years.

4.7 Liming

- Apply lime as advised in the soil analysis report.
- Where soil analysis has not been done and there is an indication of high acidity (e.g. presence of fern and poverty grass), apply lime at 250g/tree each year in order to attain a suitable soil pH (4.4 - 5.4).
- Broadcast the lime along the rows during the dry weather.

Lime application

4.8 Crop estimation

- Crop estimation is the approximation/determination of the expected yield. It is expressed as the number of Kg of cherry per unit area (acre/ha/tree).

Importance of crop estimation

- Activity planning - It helps in planning for inputs purchase (particularly N), coffee picking and processing i.e. fermentation, drying and storage area.
- Budgeting and sourcing of financing required for critical farm operations like additional fertilizers and picking/processing expenses.
- Can be used to calculate the expected incomes.

Timing

- The best time is during the rapid expansion stage which is 7 – 17 weeks after flowering.
- At this stage, there are minimal chances of physical damage since the berries fairly developed. The timing also helps in giving the farmer adequate time to meet additional nutrient requirements based on production in addition to preparing for processing budgetary requirements.

Crop in rapid expansion stage.

4.6.2 Crop Estimation Process

Methods used in crop estimation

- Visual observation method
  - » Visual assessment of the bearing canopy at every stage of crop growth.
  - » Used in conjunction with past record/production trends.
  - » Requires on farm experience to achieve significant level of reliability and is less costly/tedious.

- Actual count method which is a reliable but costly exercise and involves the following steps;
  - » Randomly select a sample area of about 10% of total production unit.
  - » On the selected tree samples, count and record the number of bearing branches (at lower/middle/high canopy levels).
  - » Select randomly from the sampled tree (s) 2 or more bearing branches - should be representative of the rest of the branches.
  - » Count and record the berries on each selected branch for every tree sample (in the sample unit area).
  - » Sum up the total number of berries on the sampled branches, record and then take the mean (average).
  - » Multiply the mean number of berries by the number of bearing branches on the sampled tree(s).
  - » Sum up the total number of berries for all trees in the sample unit.
  - » Calculate the mean (average) number of berries in the sample unit.
  - » Multiply the mean (average) from sample unit by total number of trees in the production unit.
  - » Convert the number of berries to kg of cherry/Clean coffee; assumptions – 500 to 600 berries (good coffee) is equivalent to 1Kg Cherry. 6 to 7kg of cherry is equivalent 1Kg of clean coffee.