WORLD COFFEE RESEARCH

PROMECAFE
Por el Desarrollo de la Caficultura Regional

# GOOD PRACTICE GUIDE

## COFFEE SEED PRODUCTION

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**WORLD COFFEE RESEARCH**

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# ABOUT THE GUIDE

Planting new coffee shrubs is a decision with long-term implications for coffee growers, in addition of facing them with high financial and opportunity costs. It is essential for them to not only select the right varieties but also to make sure that the seeds or seedlings they are planting are all from the selected variety, and present the best, with the best physical and phytosanitary quality for maximum yield.

World Coffee Research (WCR), together with a network of collaborators, has produced two guides: one on coffee seed production and another on nursery management, in order to help reduce coffee growers' risks when buying seeds or seedlings and encourage sowing of healthy plants to ensure future growth and yield. These guides are intended to attain two key goals:

**Plant Health** resulting from healthy, strong seedlings reaching their maximum potential yield with a minimum mortality rate of seedlings planted. In this regard, the guides focus on describing appropriate seed production and nursery management techniques with good agricultural practices at each stage.

**Genetic Purity** of the material, so that farmers may be confident that they are planting in their fields the variety they chose, with desirable genetic characteristics and no risk of cross-pollination. To do so, the guides include specific portions on traceability, ranging from the purchase of seeds or plants to produce mother plants to the sale or planting of the seeds or plants produced.

The guides complement the WCR Arabica Coffee Varieties catalog describing the characteristics of over 50 different varieties and allowing coffee farmers to select the optimum varieties for their farms. The catalog is available at https://varieties.worldcoffeeresearch.org

These guides and catalogues contribute to a broader effort to strengthen and professionalize the coffee nursery industry, born of a common desire to reduce the risks faced by coffee producers by improving the quality of plants available to them.

Such efforts must include technical support for the renewal and renovation of coffee plantations, training, improved access to credit, among other factors. In the long term, the professionalization process is expected to result in lower risk for all involved in the coffee value chain: from growers to buyers.

The Coffee Seed Production guide is intended to serve as a useful tool for nursery owners, helping them identify ways to improve their practices for a top-quality production. It highlights critical steps and factors applicable in most producing countries. It is not intended to serve as a comprehensive guide to seed production or a "coffee manual" as this requires much more detail and adjustment to context.

Some practices are shown under different levels of technical development as follows,

**Gold level stands for excellent practices.**

**Silver level stands for good practices.**

**Bronze level stands for basic practices. Generally, these involve basic compliance with good agricultural practices.**

# MODULE 1

## PURCHASE AND PLANTING OF SEEDS/SEEDLINGS

# MODULE 1 - CONTENTS

# A. PURCHASE AND GENETIC CONFORMITY

Factors to consider when purchasing seeds or seedlings to produce mother plants are as follows,

## LEGAL CRITERIA

**Essential legal requirements:**

1. Local registration of seeds or seedlings (mandatory)
2. Seeds or seedlings certification and traceability documents
3. Permit certification or variety breeder (coffee royalties). (Registered varieties are protected by breeder's rights. To use such varieties for commercial purposes, users must request the breeder's permission and/or pay coffee royalties or licensing fees. These can be paid for annually or on a per-unit basis.)

**Risks of non-compliance with legal requirements:**

1. Inability to sell certified seed, resulting in lower price.
2. Absence of permits and registration may result in cancellation of seed production by the local seed production agency.

### GENETIC PURITY

**Definition**

A population of plants with similar characteristics such as plant height, leaf tip color, size, or bean shape. These characteristics are specific to one cultivar and distinguish it from another. This population must be homogeneous (minimum variability) and stable (characteristics inherited with plant reproduction.)

As a matter of fact, at most nurseries in coffee producing countries, seeds and plants are marketed without traceability. There is not a reliable system to certify the origin and genetic purity of the varieties used.

In order to renew plantations or to establish new ones, growers invest heavily to purchase new plants available near their regions. Some growers engage in making their own seedbeds.

As a result, growers often plant adulterated genetic material. It also can lead to increased susceptibility of plants to diseases, to lower yields, to and shorter lifespan in the field.

It is recommendable that seeds from the selected coffee variety are obtained from certified, registered nurseries to make sure the variety comes from a renowned source with the required genetic stability and homogeneity.

**Risks from non-compliance with genetic purity standards:**

1. Plants that are susceptible to disease
2. Plants with low productivity or yield
3. Shorter lifespan in the field

### SAMPLING PROTOCOL TO MEASURE GENETIC CONFORMITY

1. Each sample corresponds to a coffee plant
2. Two to three leaves (neither too young nor too mature) are collected per plant.
3. Once collected, leaves must be packed in envelopes made of material allowing air circulation. Keep sample leaves fresh. Avoid contact of water drops with leaves.
4. Envelopes must be sealed and labeled with sample number. All relevant description and information about the sampled plant must be kept in record.
5. Envelopes must be sent to a lab for genetic analysis.

### RIGHTS OF VARIETY MARKETERS

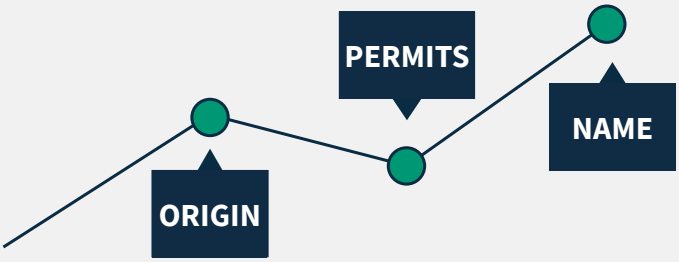
In order to sell seeds of varieties that are protected by breeder's rights, growers must obtain breeder permission to reproduce and market those varieties.

**NOTICE:** Producers willing to engage in seed production must review local legislation about the topic.

## AGRONOMIC CRITERIA

1. Resistance to local pests and diseases
2. Yield potential
3. Year of first harvest (production precocity)
4. Optimal production altitude
5. Cup quality potential
6. Bean size
7. Expected bean-to-parchment yield
8. Nutritional requirements
9. Shrub size and planting distance
10. Ripening season

## TRACEABILITY




From the time seeds or seedlings are purchased, every document helping track their origin/authenticity must be carefully kept. These include,

- Documents indicating the origin of seeds/seedlings
- Certificate of authenticity
- Permits to produce seeds in order to develop seedlings (respect breeders' rights)
- Invoice/purchase order
- Name of variety
- Proof that variety is registered locally
- Seed/seedling import documents (import must be legal)

## GENETIC CONFORMITY - LEVEL

### GOLD LEVEL

- Ensure genetic conformity of plants purchased. A control lot of purchased plants is planted, exclusively to check genetic conformity. To check plant genetics, a visual inspection of plants is conducted and samples are sent to lab.
- Only seedlings conforming to standard are kept. The entire production process for the control lot, genetic analysis and destruction of non-conforming plants, is documented and given traceability.

### SILVER LEVEL

- Purchase certified seeds/seedlings. Visually ensure quality of seeds/seedlings. Plants not conforming to phenotypic profile are destroyed.

If seeds, rather than seedlings, are purchased to develop a seed lot, a seedbed is first made and seedlings are transferred to the field later on for the establishment of the seedlot. The process of producing seedlings is not described in this guide. To review seedling production best practices, see *WCR's Good Practice Guide: Coffee Nursery Management*. This guide focuses on the process of establishing a seed lot once the seedlings for this purposed are acquired.

# B. PLANT SELECTION

Seedling selection is key to ensure the quality of seeds to reproduce from the very beginning.

## POINTS TO CONSIDER IN SELECTING SEEDLINGS

- Strong plants.
- No nutritional deficiencies.
- Pest-free.
- Straight primary root (not too small, bifurcated, or necrotic.).
- Seedling comes in a bag/tube.

### TUBE - ADVANTAGES

- No contact of root with soil. Splashing is avoided. Lower risk of impact from pathogen agents.
- Good root development.
- It avoids malformations of roots at the base of containers due to self-pruning by light. When light reaches the roots they stop growing and do not roll up.

### BAG - ADVANTAGES

- Plant can be in the nursery for a longer time and is, consequently, more robust, better developed and stronger to transplant to field.

**Risks derived from using bags**

- Soil is compacted.
- Curly, necrotic roots.
- Pests and *Phyllophaga spp*. larvae. Soil less sterile.
- Potential presence of nematodes in soil from the field.

# C. SELECTION OF AREA TO PLANT SEED LOT

## ISOLATION OF PLOT

It is critical to make sure that the lot chosen to plant mother plants is isolated from every type of potential cross-pollination to ensure that plants will produce seeds from the selected variety.

## GENETIC CONFORMITY - LEVEL

### GOLD LEVEL

- Isolate seed lot 500 meters away from any other variety in the farm.
- If coffee is to be planted near the control lot, only the same variety chosen to produce seed must be planted.

### SILVER LEVEL

- Distance to other varieties: between 500-200 meters.
- Two rows around the seed lot are not harvested for seed. They are left to produce commercial fruit.

### BRONZE LEVEL

- Distance to other varieties: between 200-50 meters.
- Four rows around the seed lot are not harvested for seed. They are left to produce commercial fruit.

**Risk of not having the isolation mentioned in gold level:**

1. Risk of cross-pollination and production of seeds with undesirable genetic features intended for reproduction.

# D. PREPARING THE LAND TO PLANT

Proper soil preparation prior to planting mother plants ensures appropriate seed production under the best possible circumstances.

## GOOD LAND PREPARATION PRACTICES

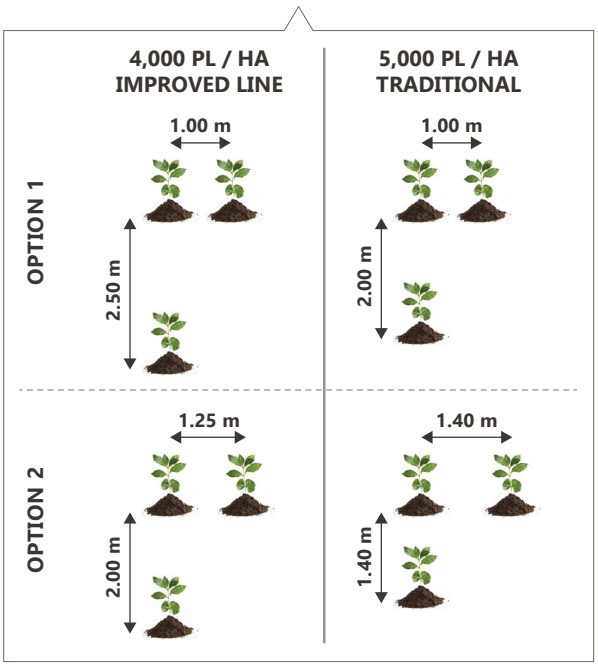
1. Terrace for slopes above 40%.
2. If plot is located where coffee was planted previously, allow at least one year before planting if possible (fallow).
3. Plot must be clean, without any weeds. Cut them off. If needed, apply herbicide at least two weeks after cutting weeds off and 20-30 days prior to planting.

**Avoid**

- Planting following the slope.
- Lack of permanent shade or permanent shade beyond 60%.
- Naked soil.
- Applying herbicide two-to-one week prior to planting.

## SOWING DENSITY AND DISTANCE

A 3,000-5,000-plant density is recommended per hectare (planting can be done in 1 or 2 rows, depending on variety and planting distance). Recommended distance between seedlings is as follows,




Distance may vary according to variety, weather conditions and pruning in the farm.

## LAND PREPARATION - LEVEL

### GOLD LEVEL

- Plant along contour lines.
- Permanent shade (15% - 40% shade).
- Temporary shade (if permanent shade is not available) established at the time of planting.
- Soil protected with vegetative ground cover (Brachiaria, Arachis pintoi or weed layer kept).
- Soil suitable to plant coffee (no pebbles, loam/ loam-clay soil).
- Annual soil analysis.

### SILVER LEVEL

- Plant along contour lines.
- Permanent shade (15% - 40% shade).
- Temporary shade (if permanent shade is not available) established at the time of planting.
- Soil suitable to plant coffee (no pebbles, loam/ loam-clay soil).
- Soil analysis performed less than 3 years ago.

**Risks of non-compliance with good practices in relation to plant density**

1. Very high plant-per-hectare density if planting distance is not corrected may increase the pest/ disease risk. Also, productivity may decrease because of poor lighting.
2. Lower-than-recommended plant density can result in lower yield per hectare and may increase production costs.

# E. PLANTING HOLES

Factors to consider when creating the hole to plant coffee plants:

- Depth will depend on soil type and plant bag/tube size. For a reference, consider a depth between 25 and 35 cm and a diameter between 20 and 30 cm.
- The hole must be at least 10 centimeters deeper than bag/tube bottom.

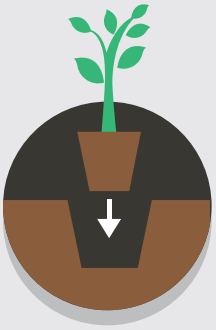
# F. STAGES IN PLANTING


## STEP 1:

Final field transplanting should preferably be done at the beginning of the rainy season.

## STEP 2:

The hole is made in line with the characteristics described above. Make sure no *Phyllophaga spp*. larvae are present. Otherwise, consider applying insecticide after planting. Also, a preventive application can be made in each hole. In some cases, holes can be made 4-8 months prior to planting, which will allow for natural pest and disease control through solarization.



## STEP 3:

If plants are transplanted from bags to field it is important to cut off the last 2 - 5 cm from the bag to eliminate the defects from the roots and foster lateral root growth. **(Picture 1)**

If the root is curled or rolled at the bottom of the bag, it should be pruned to eliminate that defect and encourage root growth. **(Picture 2)**

Disinfect tools before starting and every time the bottom of a bag is cut off to prevent diseases from spreading. This action is sometimes performed in the nursery prior to transplant.

**Picture 1**

**Picture 2**

## STEP 4:

Fill the hole around the plants with surface soil. This improves organic matter levels and allows for better aeration and drainage.

Incorporate 30 - 90 g (depending on soil analysis) of agricultural lime (Ca + Mg + S) in the soil used to fill the hole to reduce acidity levels, improve nutrient absorption capacity and increase root mass.

After applying lime, slow-release fertilizer can be applied. If a regular complete formula is to be used, wait two to three weeks for lime to alkalize the soil.


## STEP 5:

The upper part of the substrate (root mass) of the plant should be at gound level. If the root mass is below the ground surface, water can accumulate during rainy season and provide the neccesary conditions for fungi like *myrothecium* or *fusarium* to attack. Always compact the soil properly to avoid air pockets.

# G. ELIMINATING ATYPICAL PLANTS

Atypical plants must be eliminated as soon as possible, preferably at the nursery, to avoid setting them in the field, thus incurring unnecessary expenses and risks due to contamination from pollen. In case it has not been done before, it is key to do so in the field.

It is essential to preserve **genetic purity** at seed lots to replicate desirable characteristics in seeds and future plant generations. Thus, elimination is advisable in the following cases,

1. Genetically non-conforming plants detected through observation of phenotype (coloring of sprouts – apexes – or plant size different from the variety planted)
2. Plants with high disease levels (coffee rust, coffee-tree wilting, American leafspot, anthracnose, thread blight)
3. Plants suffering from nutritional deficiency or showing yellow/chlorotic leaves
4. Low-yield plants

## GENETIC CONFORMITY -LEVEL

### GOLD LEVEL

- DNA sampling not older than 5 years old is managed by a third party
- Atypical plants are taken out of the plantation before blooming and replaced.

### SILVER LEVEL

- No DNA samplings are managed by a third party.
- Atypical plants are taken out of the plantation before blooming and are replaced.

### BRONZE LEVEL

- Atypical plants are kept and identified. This practice entails the risk of potential cross pollination from surrounding atypical plants and reproduction of undesirable characteristics. Notice that neither these plants nor those around them are harvested for seeds. They are harvested only to sell beans.

**Plant displaying leaves that are too broad for the variety being planted (abnormal)**

**Larger, “taller” plant**

**Leaf tips with different color**

**Plant displaying chlorotic points (variegated)**

**Plant with too narrow leaves**

# H. TRACEABILITY

Traceability of seedlings begins when they are received at the farm and includes,

1. Assigning a code to each seedling received.
2. Storing seedlings, separating them according to their variety, to avoid cross contamination.
3. Inventorying individual lots including code, variety, date it was received, storage location, date and place of planting, and quantity, among others.
4. Designing a map to identify individual lots and their codes.
5. Regularly updating map and inventory.

**See Annex 1 for sample traceability cards.**

It is recommended for each batch to have a GPS reference appearing in all the records where the batch is mentioned, this being a unique identification.

## CRITICAL POINTS IN MODULE 1

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Purchasing certified seeds/seedlings |
| | | Having breeder's rights to reproduce that variety (only for varieties not in the public domain in each country) |
| | | Maintain traceability of purchase and planting of seeds/seedlings |
| | | Meeting selection criteria for seed lot |
| | | Meeting isolation criteria for seed lot |
| | | Seeds/seedlings must come from certified nurseries which have complete traceability |
| | | Using strong, pest-free, well-fed plants without nutritional deficiencies, with straight root (not too small, bifurcated, or necrotic.) |
| | | Seed lot slope must not be above 40% |
| | | Eliminate genetically non-conforming plants in seed lot detected through observation of phenotype (coloring of sprouts – apexes – or plant size different from the variety planted, in addition to uniform ripening) |
| | | Keeping a record (Annex 1) |
| | | Designing a map to identify individual lots and their codes and updating it regularly. |

# ANNEX 1

Sample traceability cards for coffee seeds or seedling from purchase to planting.

## TABLE 1. SEED/SEEDLING CHECK-IN

| Date lot was received | Purchas order/in voice # | Seed/ seedling origin | Name of variety | Code given | Quantity | Storehouse location | Person in charge |
|---|---|---|---|---|---|---|---|
| 04-12-18 | 08736 | Farm Estrella, Nicaragua. | Marsellesa | 120418L1 | 1,000 plants | Bed 3 | Juan Pérez |

## TABLE 2. SEED/SEEDLING INVENTORY

| Code | Previous quantity at the storehouse | Date planted | Planting place | Quantity planted | Quantity currently at the storehouse | Person in charge |
|---|---|---|---|---|---|---|
| 120418L1 | 1000 | 05-05-18 | Lot 3 Bed 23 | 100 | 900 | Juan Pérez |

**DOWNLOAD EXCEL TABLE HERE**

# MODULE 2

## FIELD MAINTENANCE FOR SEED PRODUCTION

# MODULE 2 - CONTENTS

**Module 2 deals with general plantation management issues including fertilization, weed control, shade, pest and disease control, irrigation, and good practices for agrochemical purchase and handling.**

**Keep in mind that this module relates to managing a plantation intended to produce coffee seed, not beans for the traditional coffee market.**

# A. SOIL CONDITIONING

**Soil conditioning recommendations for a plantation intended to produce coffee seed for reproduction.**

**Soil conditioner requirements:**

- Analyze soil prior to planting seed lot; apply soil conditioners as needed to improve pH, neutralize exchangeable acidity (H + Al) and add organic matter (organic fertilizer).

**Risk from lack of soil conditioner:**

- If pH is not improved in acid soils, roots will not be able to absorb nutrients. Thus, fertilizing acid soil will lead to a waste of money.
- Acid soil (low pH) can negatively affect yield, resulting in lower amounts of seeds.

Most soils in coffee plantations contain high levels of iron. Also, they tend to be very acid. In addition, in the case of most fertilizers an acidic reaction occurs, so soil pH tends to decrease over time. Soil conditioning helps mitigate this problem, and provides sulfur (S), calcium (Ca) and magnesium (Mg) depending on individual fertilizers. However, there are alkaline soils that do not have low pH which do not require pH correction.

Nutritional deficiencies are not necessarily the result of chemical element deficit. They may result from low pH (acid) soil and a low organic matter percentage (< 3 %) preventing nutrient absorption. This problem can be corrected through the application of soil conditioner.

# B. FERTILIZATION

Fertilization supplies extra nutrients to enhance plant development as soils are not always able to meet plant requirements in terms of nutrients. In addition, it compensates the extraction of nutrient from the soil carried out by the plants.

## WHY IS GOOD FERTILIZATION NEEDED?

Strong, well-feed plants are needed to obtain top-quality seeds. Thus, fertilization based on soil analysis and nutritional requirements according to yield is key to achieve appropriate seed development.

**Recommendations in relation to applying fertilizer to a coffee plantation intended to produce seed to reproduce plants.**

**Requirements for effective fertilization:**

1. Fertilization based on annual/biannual soil analysis
2. Purchasing quality fertilizers from certified suppliers
3. Fertilization in line with nutritional requirements of coffee crop
4. Applying soil conditioner based on (corrective) soil analysis
5. Applying fertilizer according to harvest estimation

**Risks of non-compliance with appropriate nutrition:**

- Low yield of beans to be used as seeds.
- Higher risk of disease due to nutritional deficiency.
- Poor bean quality (small beans, snail-shaped beans, and so on).
- “Bi-annuality” (one good year and one bad year in terms of yield). Plantation exhausted.

Information for nutritional needs of Marsellesa coffee is shown below.

**Note: This is just one example for a specific variety in a specific location. There are several factors leading to different results, depending on plantation conditions, pH, acid soil type, climate, and so on.**

| Marsellesa | Dose Kg/Ha commercial product | | | | |
|---|---|---|---|---|---|
| **Efficiency** | **70%** | **50%** | **75%** | **85%** | **70%** |
| | **N** | **P205** | **K20** | **CaO** | **MgO** |
| 15-month-old plant | 77 | 12 | 54 | 33 | 10 |
| 27-month-old plant (8,345 kg/ha -est.-coffee cherries) | 240 | 35 | 205 | 99 | 30 |
| 39-month-old plant (12,620 kg/ ha- est.-coffee cherries.) | 261 | 65 | 238 | 141 | 37 |

Source Agrotico-ECOM CR

**"Fertilization band" (area to apply fertilizer)**

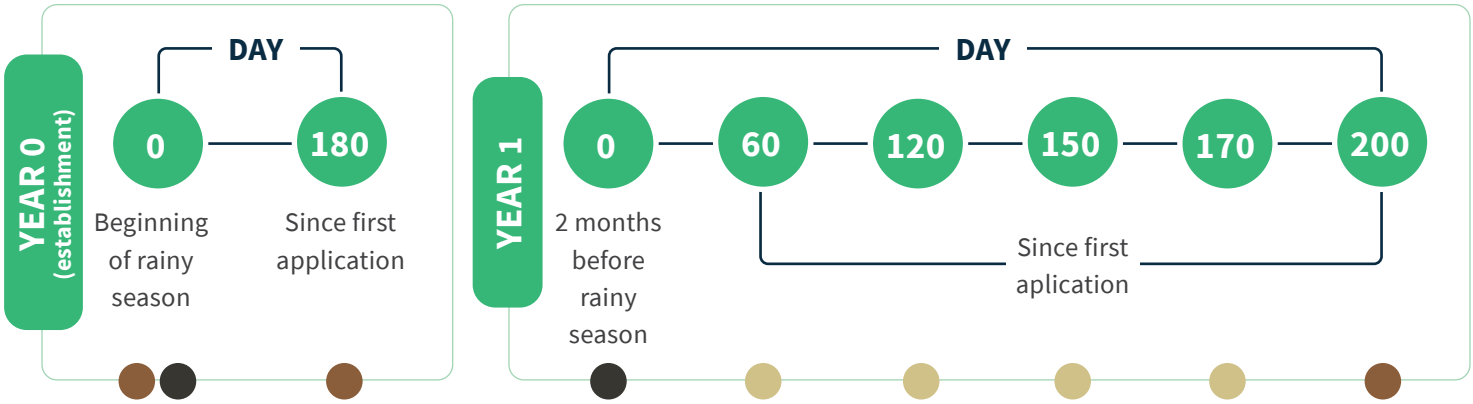
## EDAPHIC FERTILIZERS

### GOLD LEVEL: SLOW- RELEASE FERTILIZERS

- Slow-release fertilizer is recommended as it provides continuous nutrition in line with plant needs, thus preventing pollution and lixiviation. However, it is more expensive than traditional fertilizers, so not every producer can afford it. However, the investment brings excellent results in terms of increased yields.

**Recommended annual soil fertilization cycle:**

Color code ● ● ● indicates applications depending on day and year.




(50g – 70g) **slow-release** fertilizer placed in hole

(50g – 70g) fertilizer **in line with soil analysis**

**Soil conditioner**
(30g - 50g per plant) incorporated in the hole at planting and according to soil analysis

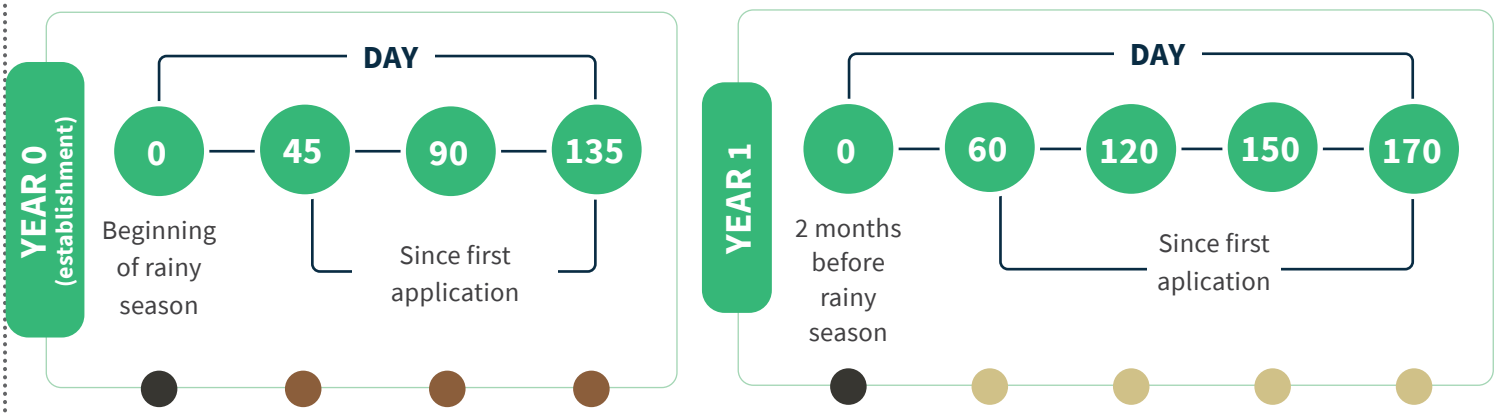
The dose must be appropriate for input type, soil-substrate, and soil moisture, among others. The first application of fertilizer when establishing the coffee plantation can be done fractionally from 25 g to 35 g in two applications. The chart recommends between 50 g and 70 g on day 0. This is done in some countries to save labor cost.

## SILVER LEVEL: TRADITIONAL FERTILIZERS, ABUNDANT NUTRITION

- If traditional fertilizers are used, break doses to make the most of plant nutrients and avoid loss from rain and poisoning from excess nutrients. An example of a traditional fertilization is attached. Perform soil analysis before applying fertilizer to correct deficiencies if needed.

**Recommended annual soil fertilization cycle:**

Color code ● ● ● indicates applications depending on day and year.




30 g of fertilizer **for new plantations** Ex.: 18-46-0, 12-42-0)

(50 g – 70g) appropriate fertilizer, **based on soil analysis**

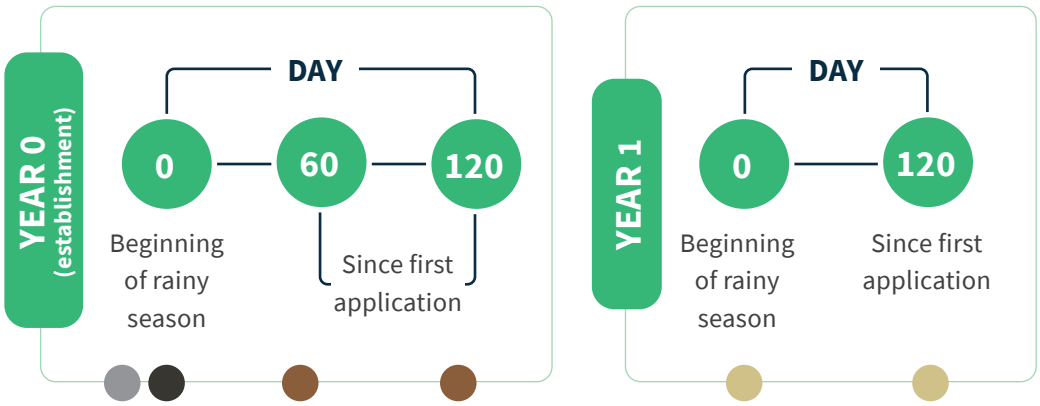
**Soil conditioner (30g - 50g per plant)** incorporated in the hole at planting and according to soil analysis

## BRONZE LEVEL: RECOMMENDED ANNUAL SOIL FERTILIZATION CYCLE

- This illustrates basic maintenance fertilization for plantations. Perform soil analysis before applying fertilizer to correct deficiencies if needed.

**Recommended annual soil fertilization cycle:**

Color code ● ● ● indicates applications depending on day and year.




**Soil conditioner (30g - 50g per plant)** incorporated in the hole at planting and according to soil analysis

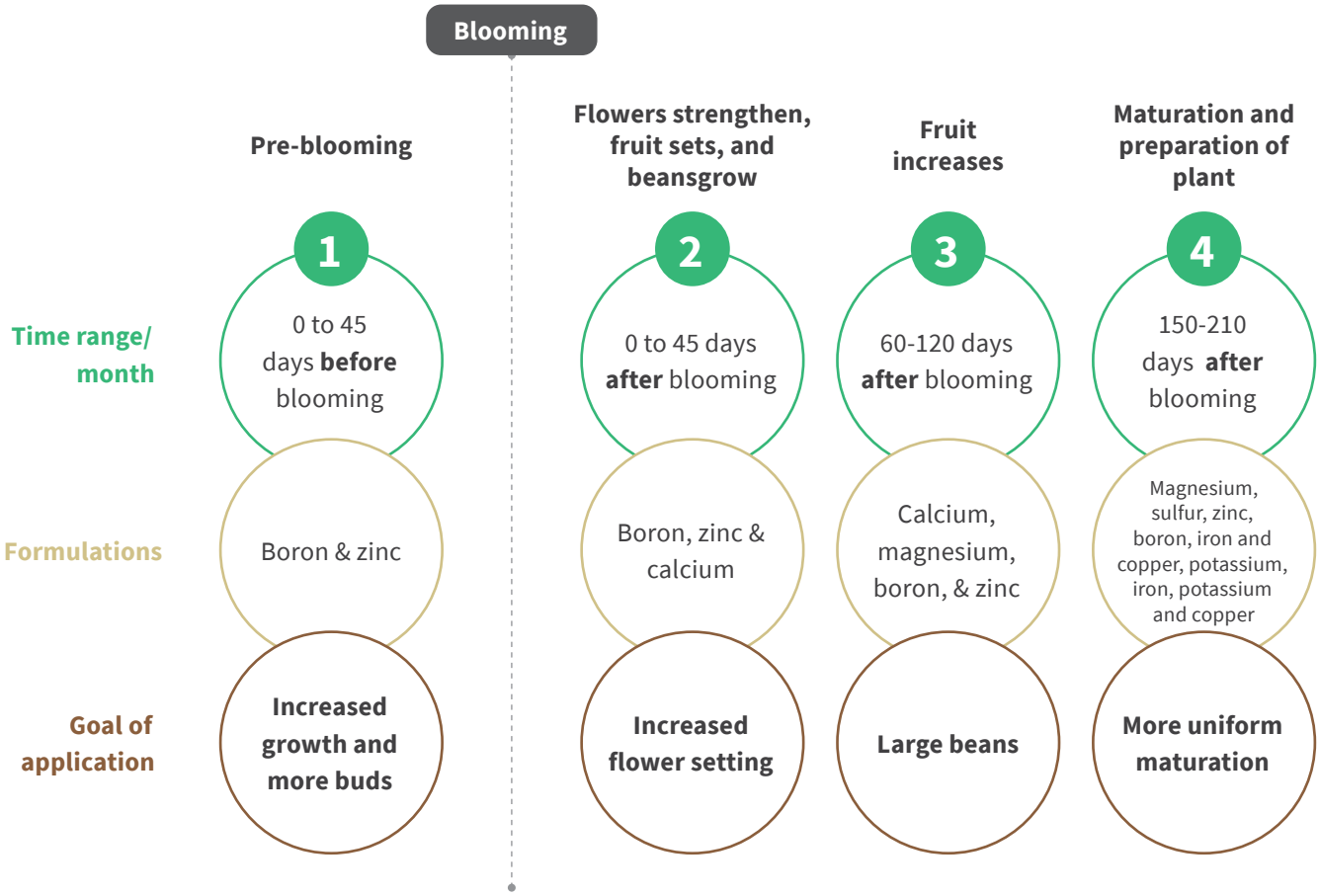
(50g – 70g) appropriate fertilizer, **based on soil analysis**

30 g of fertilizer **for new planting** (Ex.: 18-46-0, 12-42-

30 g of fertilizer placed **in soil new plant**

## FOLIAR FERTILIZERS

Foliar fertilizers are applied to provide minor elements missing during physiological stages of plants (blooming, appearance of grain, new sprouts) and to control pests and diseases. Fertilizer will be applied based on previous field monitoring. Under intensive management, four to six foliar fertilizer applications are made over one year.




### MIXING ORDER FOR FORMULATIONS

1. Regulate hydrogen potential (pH) and water hardness.
2. Add surfactant.
3. Add wettable powder (WP) (pre-mix).
4. Add dry concentrated solutions or dispersible granules (FW, DF, or WG) (pre-mix).
5. Add emulsionable concentrate (EC, EW).
6. Add soluble liquids (SL).
7. Add foliar fertilizers.

**In the case of foliar fertilization, it is important to:**

1. Fix hydrogen potential (pH) of solution between 5 and 5.5
2. Pour products in order: first, add half the volume of water, fix pH (5-5.5), add surfactant, add mineral (foliar) components, add bio stimulants, check pH again, and finally add the remaining water volume. This will prevent negatively affecting the mix for effective absorption. (Implement Good Practices in Product Preparation.)

Source: ECOM

## ORGANIC FERTILIZATION

Fertilization either from organic sources (manure, compost, etc.) or inorganic (phosphate rock, potassium sulphate) is an important source for coffee shrubs. It can serve as the only source of nutrients or combined with traditional fertilization methods.

Organic fertilizers result from decomposition of different organic materials including animal manure, plant remains, and food waste and coal performed by microorganisms. It improves physical, biological and chemical properties of the soil.

**Organic fertilization - advantages**

- Lower economic cost; use of natural resources available in the environment to produce fertilizers.
- Environmental balance in plantation; reduction of pests.
- Provides organic matter and helps preserve soils.
- Provides hormones contributing to root and plant growth.

**Organic fertilization - Risks**

- Mismanagement of organic fertilizer resulting in poisoning of plantation
- Insufficiency of nutrients to meet plant needs
- Pathogens that can infect the soil due to poor management of organic fertilizer

It is key to analyze organic fertilizer or demand an analysis of the fertilizers purchased to know their contribution in detail. Analyze moisture content, pH, electric conductivity, total organic matter, total nitrogen, phosphorus, potassium, calcium, magnesium, iron, copper, manganese, zinc, sodium, boron, sulfur, ash percentage and carbon:nitrogen ratio.

**Organic fertilization – recommended annual cycle:**

| Applications | Time range / month | Organic fertilizer |
|---|---|---|
| 1 | Beginning of rainy season | Compost, bocashi, chicken manure, lombricompost |
| 2 | 50 days after the beginning of the rainy season | Compost, bokashi, chicken manure, vermicompost |
| 3 | 100 days after the beginning of the rainy season | Compost, bokashi, chicken manure, vermicompost |
| 4 | 150 days after the beginning of the rainy season | Compost, bokashi, chicken manure, vermicompost |

**Organic foliar fertilization- recommended annual cycle:**

At this link you can find how to manufacture bio inputs from mountain micro-organisms (MM), fermented grass, bio-ferment of dung, phosphorus, and bio-ferment. There are also recipes for organic pesticides (document in Spanish).

| Applications | Time range/month |
|---|---|
| 1 | **Pre-blooming:** 0-45 days before blooming |
| 2 | **Flowers strengthen, fruit sets, and beans grow:** 0-45 days after blooming |
| 3 | **Fruit multiplies:** 60-120 days after blooming |
| 4 | **Maturation and preparation of plant:** 150-210 days after blooming |

## NUTRITIONAL DEFICIENCIES

As mentioned previously, inadequate fertilization results in low yield and increased likelihood of disease. A guide to major deficiencies is shown below. It is important to always check well the plantation. Remember that yellow, deformed, or different leaves do not always indicate nutritional deficiency; a comprehensive assessment of causes must always be made.

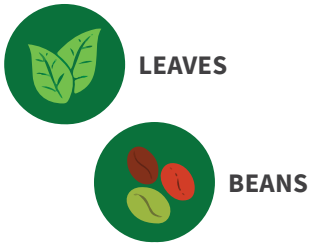
**Nutritional deficiencies of plants are mainly seen in the parts of plants shown in the circles.**

### NITROGEN DEFICIENCY

**Symptoms:**

- Chlorosis/yellow mature leaf
- Lower vegetative growth
- Potential defoliation
- Lower chlorophyll content

Source: ECOM

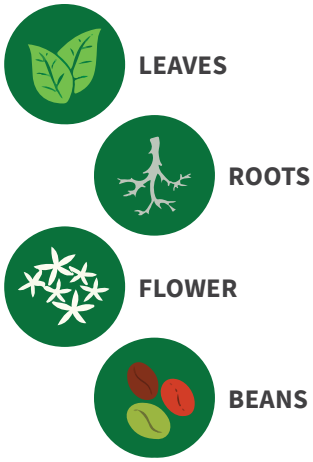



### PHOSPHORUS DEFICIENCY

**Symptoms:**

- Slow plant growth
- Little root
- Small leaves
- Decreased blooming
- Delayed ripening
- Smaller beans
- Reddish mature leaves

Source: ECOM

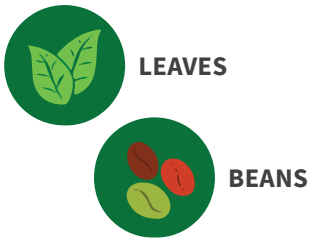



### POTASSIUM DEFICIENCY

**Symptoms:**

- Chlorosis or necrosis of leaf edges and points
- Defoliation
- Small beans with little mucilage
- Less dry weight
- Smaller size of coffee beans
- Unequal ripening
- Cup quality loss due to low amount of sugar in beans

Source: ECOM

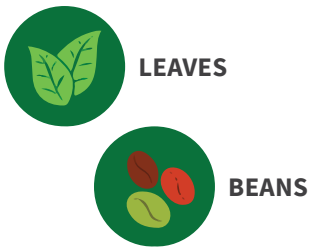


## MAGNESIUM DEFICIENCY

**Symptoms:**

- Lower vegetative growth/fewer beans
- Acceleration of premature ripening
- Fall of fruit during harvest
- Yellow spots between leaf veins
- Small beans and fruit with lower percentage of Brix degree beans

Source: ECOM

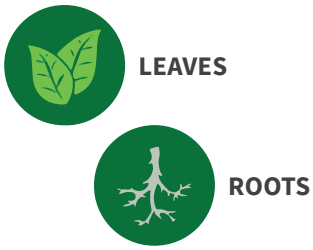



## CALCIUM DEFICIENCY

**Symptoms:**

- Marginal chlorosis at the edges of young leaves
- Corrugated leaves
- Necrosis and deformation of tips
- Generalized pale green color

Source: ECOM




## CRITICAL POINTS IN FERTILIZATION

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Annual/biannual soil analysis |
| | | Fertilization based on soil analysis, variety requirements and coffee plantation yield |
| | | Correction of soil acidity (pH) of plantation, if needed, to facilitate absorption of nutrients |
| | | Fertilize several times to ensure improved nutrient absorption |
| | | Disseminate fertilizer homogeneously over root area; do not pile up fertilizer at plant base or at one single specific point |
| | | Fertilize under adequate soil moisture conditions |
| | | Check fertilizer origin to ensure quality |

# C. WEED CONTROL

## REASONS FOR WEED CONTROL

Weed control is done mainly to prevent weeds from competing with crops for nutrients and lighting and to facilitate work for field staff. However, weed control must be adequate, not overapplying chemicals to maintain ecosystem balance. Sustainable weed control results in improved soil health and pest control.

Control weeds preferably through the use of covers, mechanical control and, as a last resort, chemicals. Herbicides may be advisable when planting for the first time. However, for annual plantation management the use of covers and mechanical control is preferred.

**Weed control recommendations for a plantation intended to produce coffee seed.**

**Requirements for appropriate weed control**

- Use of ground cover
- Mechanical control using weed whackers, machetes
- Appropriate use of herbicide (doses and application)

**Risks of naked soil management**

- Soil compactation
- Soil erosion and loss from runoff
- Loss of nutrients

**Beans cover**

**Brachiaria cover**

### GOLD LEVEL: GROUND COVER

- Use ground cover. Incorporate organic materials from the plantation into soil (waste from shade trees and pruning).
- Weeds can be used as ground covers, just control them continuously by trimming to prevent them from growing and competing with coffee.

### SILVER LEVEL: MECHANICAL CONTROL

- Control weeds or ground covers from seed lot through mechanical control. This can be done manually, with machetes or with a weed whacker.

### BRONZE LEVEL: HERBICIDES

- Herbicides can be used when weed control is not done using coverage or mechanical control.

Use only herbicides allowed in your country and follow safety sheet guidelines for each product, a.k.a. MSDS (Material Safety Data Sheet)

See UTZ “Banned plaguicide/plaguicide under monitoring list” accessible here. Also consider Rainforest Alliance certification list “OMS/FAO exceptional use of highly hazardous plaguicides” available here.

## CRITICAL POINTS TO CONTROL WEEDS APPROPRIATELY

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Use of ground covers |
| | | Mechanical weed control with machete or weed whacker |
| | | Use an agroforestry system at the farm (helping bring in organic matter and reducing weed growth) |
| | | Conduct early weed control prior to the appearance of new weed seeds |
| | | Adequate management of herbicide doses |
| | | Use of personal protective equipment to apply herbicide |

# D. SHADE

**Shade management recommendations for a plantation intended to produce coffee seed.**

### WHY IS SHADE IMPORTANT IN COFFEE PLANTATIONS?

- Shade regulates microclimates. Coffee shrubs are sensitive to dramatic temperature changes.
- Shade reduces radiation, improves water balance and increases relative moisture levels.
- Shade improves soil fertility through organic materials. When trees from the *Fabaceae* or *Leguminosae* family are used, they supply nitrogen to plantations.
- Erosion control. Leaves and branches resulting from pruning protect the soil against runoff and erosion.
- Shade improves ecosystems by providing food and shelter to birds, insects, and reptiles, which results in ecological balance in plantations.

**Risks associated to lack of shade**

- Coffee shrub burning from high radiation
- Nutritional issues in case of both low nutritional levels and lack of shade
- Increased risk of anthracnose in beans
- Increased soil erosion
- Production peaks and bi-annuality increase
- Soil cracking, leading to root tearing
- Loss of water in soil during the dry season
- Increased incidence of pests and diseases

Shade type depends on different factors including rain, cloudiness, altitude, and wind at plantation site. Growers must take these factors into account to select the most suitable shade for their plantations. Generally, between 15% and 40% shade levels are recommended, in line with factors above. Shade trees must be planted between coffee shrubs, not on alleys, so they do not hinder plantation management.

### WINDBREAK TREES

It is important to include barriers to protect plantations intended for seeds against strong winds. These barriers can also serve another purpose: to mark the borders of the seed lot.

Common plants used as windbreak barriers include:

**(This list will vary depending on the region).**

- Cornstalk dracaena *(Dracaena fragrans)*
- Spineless yucca *(Yucca guatemalensis)*
- Plantain *(Musa sp.)*
- Silk oak *(Grevillea robusta)*
- Pigeon pea *(Cajanus cajan)*
- Colpachí (*Croton niveus*)

## TEMPORARY SHADE/TEMPORARY CULTIVATION

Temporary shade can be used mainly early in plantation life to take advantage of land, bring in additional income, protect the new plantation against pests and solar radiation and to combine coffee with other short-term crops.

**Advantages from temporary shade**

1. Protection against sun and wind
2. Addition of organic materials
3. Maintain moisture levels
4. Additional income to coffee growers
5. Improve physical properties of soil

**Plants mentioned below are recommended**
(List will vary depending on region.)

- Corn *(Zea mays)*
- Beans *(Phaseolus vulgaris)*
- Chili pepper *(Capsicum annuum)*
- Tomato *(Solanum lycopersicum)*
- String beans *(Phaseolus spp.)*
- Cassava *(Manihot esculenta)*
- Pigeon pea *(Cajanus cajan)*
- Tephrosia *(Tephrosia candida L.)*
- Castor oil plant *(Ricinus communis)*

**Temporary shade - sample**
***Ricinus communis***

## PERMANENT SHADE

**Shade recommendations will vary depending on region.**

Trees are commonly used to provide permanent shade. In addition, these can provide fruit or timber, resulting in extra income for coffee growers. Also, they can provide nitrogen sequestration, adding value to coffee plantations.

**Fruit trees and plants** (see list below) are recommended to provide shade.

- Citrus trees *(Citrus sp.)*
- Avocado *(Persea americana)*
- Red mombin *(Spondias purpurea)*
- Banana, plantain *(Musa sp.)*
- Cas *(Psidium friedrichsthalianum)*
- Mango *(Mangifera indica)*

**Timber trees:**

- Mahogany *(Swietenia sp)*
- Coyote *(Platymiscium sp.)*
- Guayabón *(Terminalia sp.)*
- Laurel *(Cordia sp.)*
- Cedro real *(Cedrela sp.)*
- Rosy trumpet tree *(Tabebuia rosea)*

**Nitrogen fixers:**

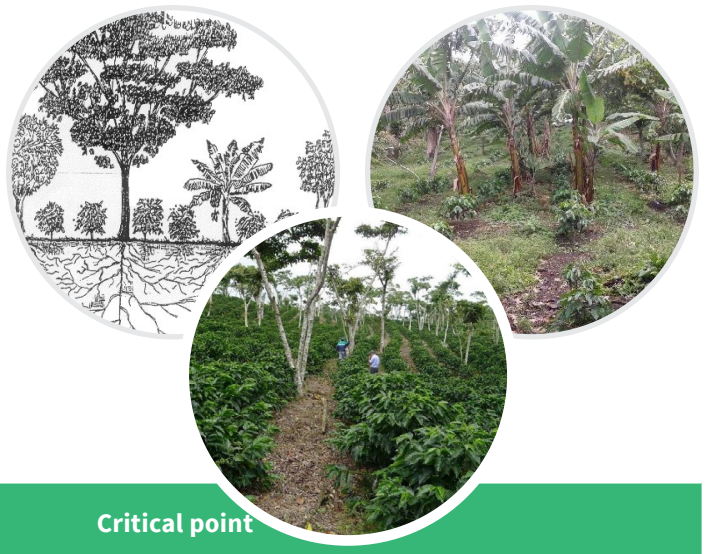
- Poró *(Erythrina poeppiggiana)*
- Guaba *(Inga edulis)*
- Quickstick *(Gliricidia sepium)*

**Permanent shade- sample**

## SHADE REGULATION

As stated previously, shade management depends on individual plantation circumstances. However, it is advisable to,

- Prune shade trees at the beginning of the rainy season to allow for light.
- Prune tree center and let horizontal branches grow.
- Allow at least two meters between coffee plants top and the shade canopy.



## CRITICAL POINTS IN SHADE MANAGEMENT

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Plot has windbreak shade both at lot borders and farm borders |
| | | Plot has permanent shade |
| | | Shade trees are pruned annually |
| | | Conduct shade regulation at the right time, before the rainy season starts |

# E. PEST AND DISEASE CONTROL

**Pest and disease control recommendations for a plantation intended to produce coffee seed for reproduction purpose.**

### WHY IS PEST CONTROL AND MANAGEMENT ESSENTIAL AT COFFEE PLANTATIONS?

Pest control ensures quick pest management and ensures productivity and income to growers. Pest and disease control are needed at every coffee plantation to protect coffee production.

**Risks from failing to conduct pest and disease management**

- Low productivity
- Financial loss
- Risk of partial/total loss of plantation
- Non-compliance with the standard results in loss of seed certification
- Risk of impacting surrounding farms due to poor pest management

**Pests impacting coffee seed development and quality will be dealt with next. We are focusing on coffee seed since this is a guide to produce coffee seeds.**

## INSECTS HARMFUL TO COFFEE SEEDS

### COFFEE BERRY BORER

**Coffee berry borer – What is it?**

Coffee berry borer *(Hypothenemus hampei)* is a small insect whose adult female attacks coffee beans between week 8 and week 32 after blooming (until harvest is done).

**Damage**

Female coffee berry borers pierce coffee beans, making tunnels to lay their eggs in green, brown, or grain bunches resulting in damaged beans. Once they hatch, eggs release larvae feeding on the bean and making it useless to plant.

### COMPREHENSIVE MANAGEMENT OF COFFEE BERRY BORER

#### GOLD LEVEL: CULTURAL AND BIOLOGICAL CONTROL

**Cultural Control**

- Uniformity of varieties
- Pruning
- Thinning
- Weed control
- Collecting beans from the ground and removing all remaining fruit on the plant after harvest
- Traps: Place 20 traps/ha, for 3 months at the beginning of the rainy season. Recommended for montoring.

**Biological Control**

- Apply fungus Beauveria bassiana, 1 kg/ha, when borer starts to drill beans.

#### BRONZE LEVEL: CHEMICAL CONTROL

- Chemical control recommended only if monitoring reveals attack levels surpassing 2% - 3% and the insect is just beginning to penetrate the fruit.
- Apply insecticide allowed in your country and follow safety sheet guidelines for each product, a.k.a. MSDS (Material Safety Data Sheet).

### BORER SAMPLING

1. Divide the farm in homogeneous lots (1 ha - 5 ha)
2. Randomly select 100 beans per plant in 20 shrubs at each lot
3. Count drilled beans in each 100-bean sample
4. Establish damage percentage

When controlling borers through insecticide, consider borer location in beans. Insecticide must be applied when borer is penetrating the fruit. Carry out chemical control for incidence percentages above 2%-3%.

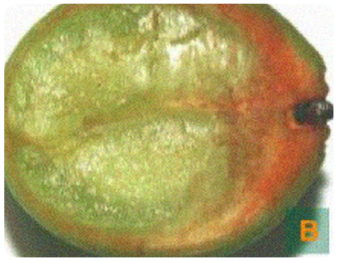
## BERRY BORER CONTROL PRACTICES

**What you can expect to find when monitoring the berry borer**


**A. Outside the bean.**

**Recommended control:**

Either biological or chemical control to contact the insect.

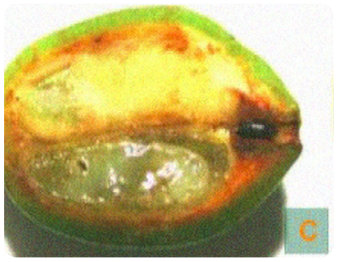



**B. Starting to drill, has not reached parchment yet.**

**Recommended control:**

Use either biological or chemical control to contact the insect.

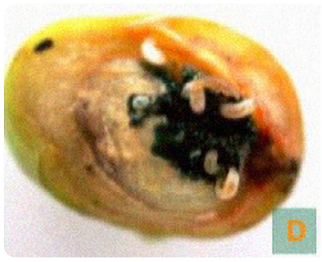
Effectiveness at this stage will be lower than at the previous one.




**C. Already reached bean parchment.**

**Recommended control:**

No chemical control as it will be ineffective.
**Conduct health harvest.**




**D. Within the bean. Has built tunnel. There are either eggs or larvae.**

**Recommended control:**

No chemical control.

**Collect beans early or late in the harvest process, depending on crop stage.**

Source: ECOM, 2019

Photos: ICAFE, 2019

# FUNGI HARMFUL TO SEEDS

## AMERICAN LEAFSPOT

**What is it?**

American leafspot *(Mycena citricolor)* is a disease resulting from a fungus, more common in highlands and favored by constant rain, high humidity levels, and low temperature.

**Symptoms**

Grayish-brown circular spots on leaves, tender stems, and beans. It appears especially during the rainy season.

**Damage**

The main damage consists of leaf fall, resulting in weakening of shrubs and lower yields the following year. It also causes fruit fall, reducing harvest.

Plantations without disease management can experience defoliation up to 95%, and harvest reduction can reach up to 80%.

## COFFEE LEAF RUST

**What is it?**

Coffee rust epidemics devastate coffee plantations. This disease *(Hemileia vastatrix)* is caused by a fungus and is particularly serious in mid- and low-altitude plantations. High temperature, and humid, rainy environment help it thrive.

**Symptoms**

The first symptoms of the disease appear on the underside of leaves, with pale yellow spots growing over time and coming together to form larger yellow-orange spots with the appearance of fine dust. That is where spores are produced.

**Damage**

In case of severe attack, the main damage results from the fall of a large amount of leaves, which weakens the plant, as well as from very irregular ripening of beans, lower yield, and even death of the shrub.

## ANTHRACNOSE

**What is it?**

Anthracnose is caused by the fungus *Colletotrichum spp.* and impacts leaves, branches, flowers and fruits of coffee. It occurs in different conditions and at different altitudes and affects coffee plantations with different technology levels -from traditional to technified- as well as different coffee varieties. It occurs in all coffee areas, both low and dry and high and humid.

**Symptoms**

It infects mainly malnourished plants or plants that suffer from stress resulting from climate factors, management factors, or other pests. Both fruits and leaves dry up.

**Damage**

High incidence results in leaves and fruit fall and the shrub gradually dries up. Yield is reduced, and shrub may even die.

To control anthracnose, it is important to prune sick plants or branches to eliminate it. It is recommended to prune 4 inches below the point where the disease appears. (Pruning scissors must be disinfected for each plant.)

## RECOMMENDATIONS TO CONTROL FUNGAL INFECTIONS

Since these fungi (American leafspot, coffee leaf rust, and anthracnose) behave similarly, similar agricultural practices can be followed to manage each of them.

### GOLD LEVEL

- Establish planting density not above 5,000 plants/ha, depending on variety, temperature, altitude, and so on
- Replace varieties highly susceptible to disease if applicable (there are no varieties resistant to *Mycena citricolor* or anthracnose)
- Prune plants exhausted or badly hurt by disease
- Thin twice per year; leave two axes per planting point
- Conduct effective weed control
- Regulate shade from trees/plants
- Fertilize appropriately based on soil analyses
- Do monthly samplings and apply fungicide to control American leafspot, coffee rust, or anthracnose whenever incidence is above 5%
- Apply early before sporulation takes place

### SILVER LEVEL:

- Prune plants exhausted or badly hurt by disease
- Thin twice per year; leave two axes per planting point
- Conduct effective weed control
- Regulate shade from trees/plants
- Fertilize appropriately based on soil analyses
- Apply fungicide to control American leafspot, coffee rust, or anthracnose whenever incidence is above 5%

### BRONZE LEVEL:

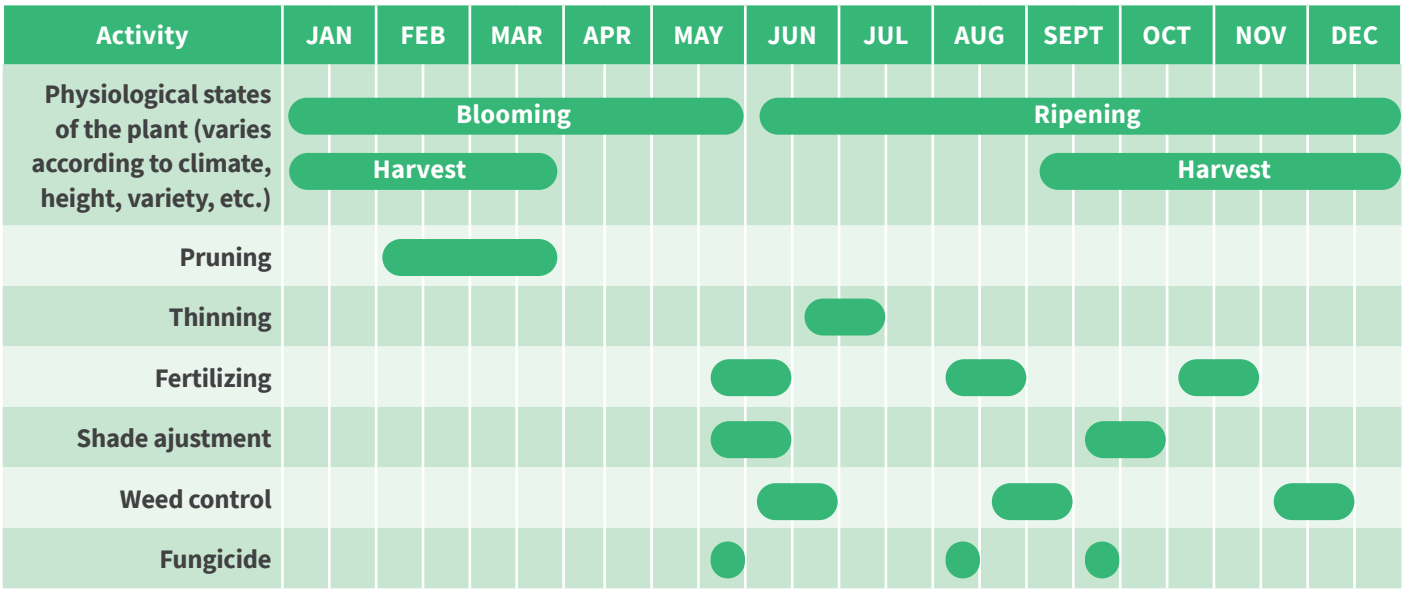
- Prune plants exhausted or badly hurt by disease
- Thin twice per year; leave two axes per planting point
- Regulate shade from trees/late shade plants
- Fertilize 2-3 times per year using a
- coffee fertilizing formula
- Apply fungicide to control twice per year

Integrated pest management is key to control American leafspot, coffee leaf rust, and anthracnose. An appropriate way to do so is illustrated in the table on the next page.

## RECOMMENDED ACTIVITIES IN CENTRAL AMERICAN CALENDAR YEAR TO COMPREHENSIVELY HANDLE AMERICAN LEAFSPOT (*Mycena citricolor*), COFFEE RUST (*Hemileia vastatrix*) AND ANTHRACNOSE (*Colletotrichum spp*):

There are several cultural practices helping prevent the appearance of these fungi, which behave similarly.

Integrated pest management is key to controlling American leafspot, coffee rust, and anthracnose. The table below is an example for Central America, where the rainy season begins in May. This calendar can be adapted to different regions, adjusting for the different timing of rains. Some specific activities are recommended.

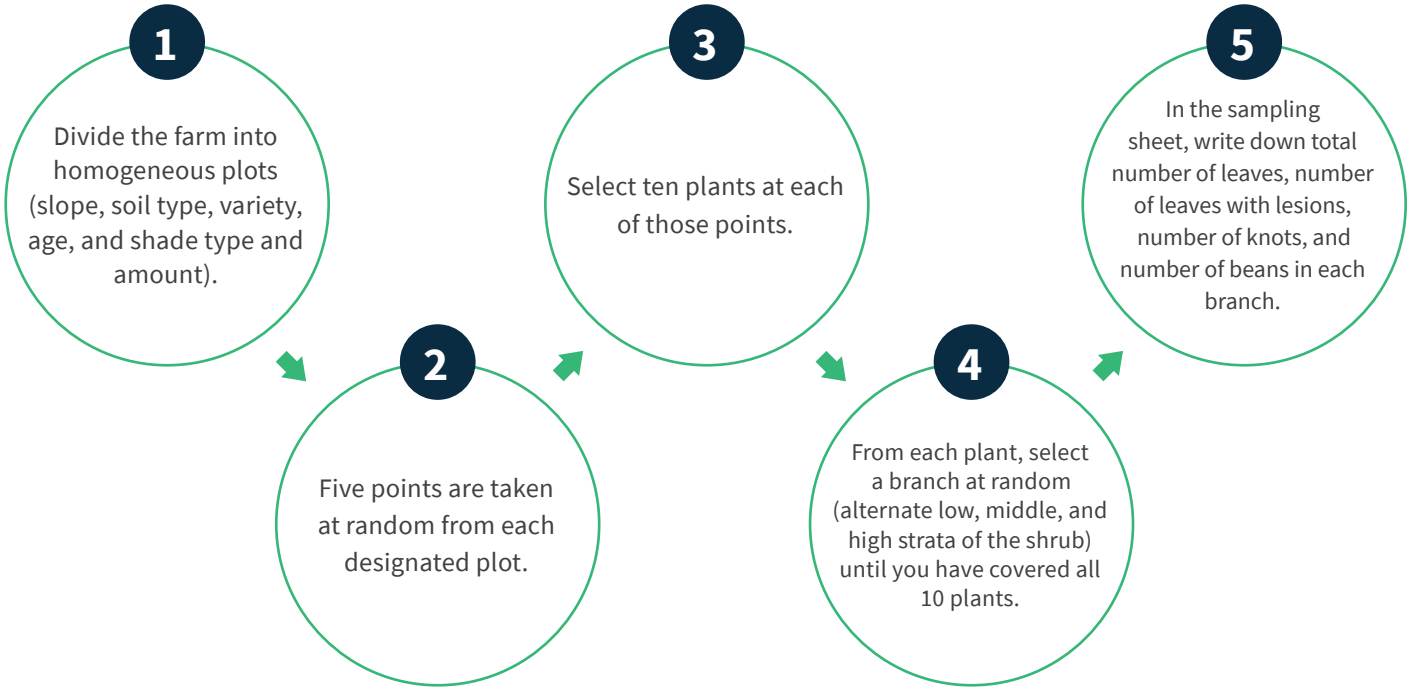



Physiological stage of the plant (varies according to climate, altitude, variety, and so on.)

Major activities to be conducted and optimal months are detailed above.

## MEASURING INCIDENCE FOR AMERICAN LEAFSPOT *(Mycena citricolor)*, COFFEE LEAF RUST *(Hemileia vastatrix)*:

Incidence is measured very similarly as these are all fungi.




## FORMULA TO MEASURE INCIDENCE:

$$\text{Incidence} = \frac{\text{Number of leaves with coffee rust or American leafspot}}{\text{Total number of leaves evaluated}} \times 100$$

In general, chemical control is indicated when sampling for coffee rust *(Hemileia vastatrix)*, American leafspot *(Mycena citricolor)*, and anthracnose *(Colletotrichum coffeanum)* show the disease's incidence reached **5%.**

## CRITICAL POINTS IN DISEASE MANAGEMENT

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Annual pruning of coffee bushes |
| | | Thinning |
| | | Timely fertilization based on soil analysis |
| | | Regulation of shade – pruning of shade trees at plantation |
| | | Weed control |
| | | Fungicide if needed |
| | | Collection of fallen beans from ground after harvest to prevent coffee berry borer |
| | | Frequent sampling |

# F. IRRIGATION

**This section offers recommendations to irrigate a plantation intended to obtain coffee seed for reproduction.**

## WHY IS RAIN IMPORTANT FOR FLOWER OPENING?

**Abundant rain**

Allows roots to absorb the water and send message for floral buds to open.

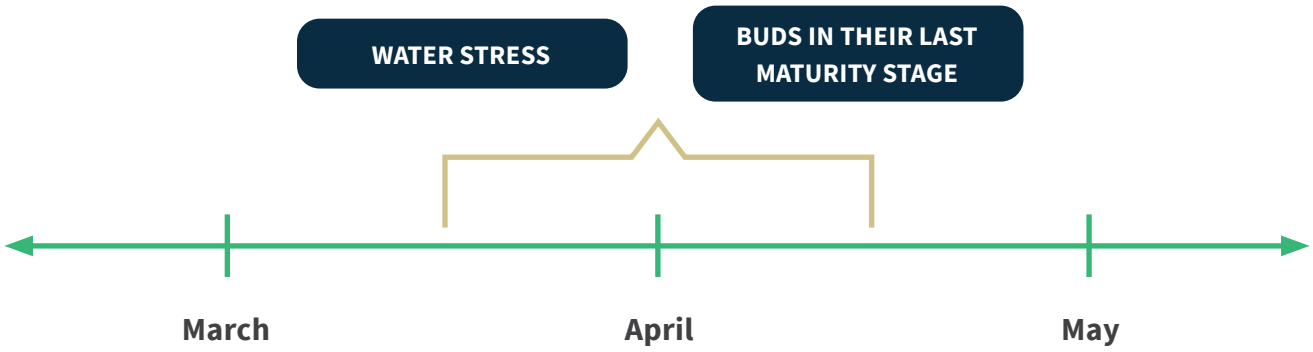
**Scarce rain**

Many buds may open only partially, which leads many of them to fall.

**Late rain**

Many buds may lose their viability.

## WHEN IS IRRIGATION RECOMMENDED? EXAMPLE FOR CENTRAL AMERICA




Irrigation is recommended during the dry season, after planting takes place in the fields. Clearly, coffee endures short periods of drought, and most coffee farmers do not have a water source or an irrigation system. However, irrigation can reduce the effects of a long drought may have on blossoming and on the production.

## RECOMMENDATIONS CONCERNING IRRIGATION

- Use water from sources authorized for agricultural use which have a permit.
- Have a watershed management plan.

## TIME AND AMOUNT OF WATER REQUIRED

| | Amount of water | Time |
|---|---|---|
| Rain | 20 mm | |
| Sprinkling | 30-35 mm | 3 hours ((8 l/s & 24 m cover) |
| Irrigation | 30 liters/plant | Depending on nozzle discharge |

# G. GOOD PRACTICES IN PURCHASING AND HANDLING CHEMICAL OR ORGANIC PRODUCTS

## WHY ARE GOOD PRACTICES IN PURCHASING AND HANDLING CHEMICAL AND ORGANIC PRODUCTS IMPORTANT?

The reason is it allows farmers to maintain workers' health and to minimize the environmental impact from coffee production activities.

**Risks from inadequate agrochemical handling**

- Poisoning, health issues, even death
- Pollution of soil and nearby water bodies; potential death of animals and plants; environmental degradation
- Poisoning of coffee plantation due to overdosing

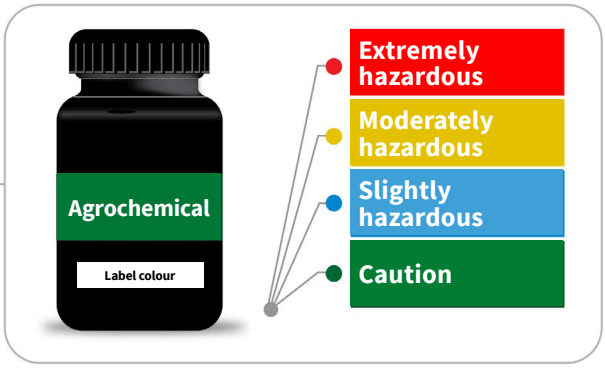
Agrochemicals must be purchased from duly authorized suppliers. It is important to keep all purchase documents for each agrochemical products. The same good practices must be followed to purchase and apply organic products.

To avoid potential damage to human health, as well as environmental pollution, it is essential to take **5 steps in handling agrochemicals** and organic products:

### STEP 1:

**RECOMMENDATIONS TO SELECT AGROCHEMICALS**

- First, use every cultural/biological measures.
- Identify the pest.
- Find out useful product to fight it.




### STEP 2:

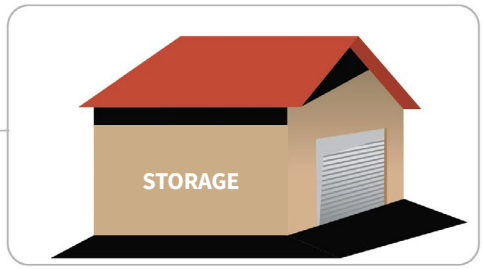
**APPROPRIATE AGROCHEMICAL HANDLING**

#### TRANSPORTATION

- Do not bring agrochemicals together with foodstuffs
- Do not carry agrochemicals at the driver's cabin

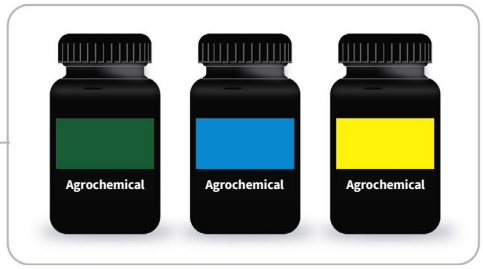
#### STORING

- Keep home/office and storage far from each other
- Restrict access to children and strangers
- Provide adequate access and ventilation for storage
- Products (herbicides, insecticides, fungicides, fertilizers)




#### HANDLING

- Keep products in their original packaging, with their own labels
- Do not use beverage bottles to carry agrochemicals



## STEP 3:

### SECURITY MEASURES WHEN USING AGROCHEMICAL

#### MEASURING OR WEIGHTING

- Use graduated measuring devices (test tubes, scales)
- Use the appropriate doses

#### PROTECTION EQUIPMENT REQUIRED

Prior to handling agrochemicals use, as indicated in the label:

- Safety glasses
- Face mask
- Gloves
- Appropriate clothes

#### REVIEWING APPLICATION EQUIPMENT

- Make sure the equipment has no leaks
- Fill half the hand pump with water
- Place each product separately in the water in the pump
- Do not combine agrochemicals prior to placing them in the water in the pump

## STEP 4:

### APPROPRIATE WAY TO APPLY AGROCHEMICALS

#### MEASURING OR WEIGHTING

- Use appropriate doses to achieve your goal (ask a technician)
- Use personal protection equipment
- Stir the mix with a rod
- Wash empty containers thoroughly prior to discarding
- Do not apply agrochemicals for more than four hours
- Do not smoke, eat, or drink while applying agrochemicals
- Do not apply in case of wind or high temperature

## STEP 5:

### AFTER APPLYING AGROCHEMICALS

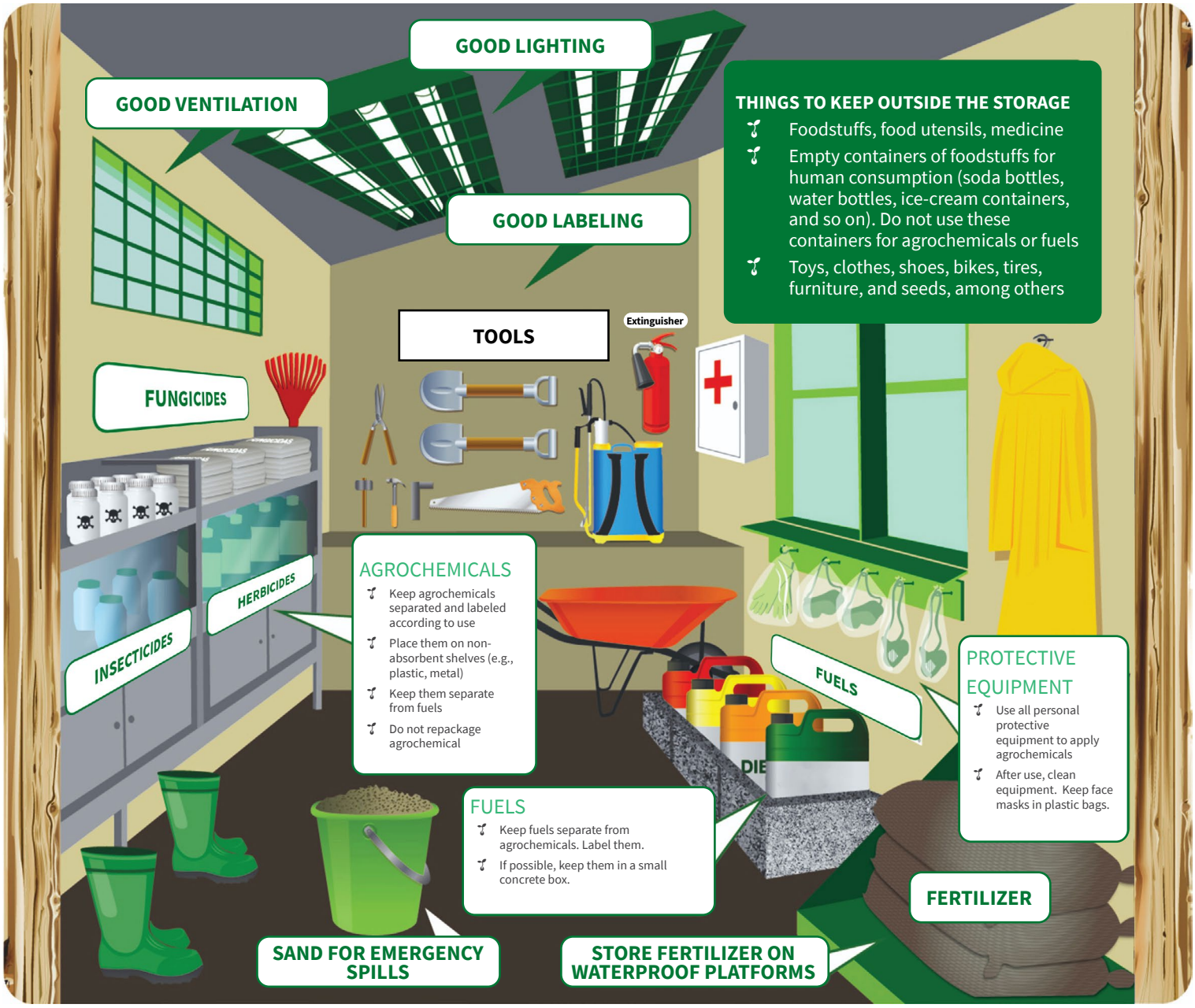
#### MEASURING OR WEIGHTING

- Wash the equipment far from water bodies, people, or animals
- Shower using soap and water
- Wash your clothes separately from other clothes
- Collect empty agrochemical containers and bring them to recycling or place them at an appropriate place

## REQUIREMENTS TO STORE THE PRODUCTS

- Space exclusively intended to store these goods
- Labels
- Closed, well ventilated site
- Concrete floor
- No children, unauthorized personnel, or animals allowed
- Keep fungicides, insecticides, herbicides, granular fertilizers and foliar fertilizers separated.
- No smoking, no fire sources (matches, lighters)

**Example of an agrochemicals and organic products storage**




In case of emergency, keep emergency numbers at hand, together with product safety sheet and instructions with steps to take.

**Safe agrochemical handling**

- Preserve and follow Safety Sheet information as well as Manipulation and Application Instructions for each agrochemical.
- Training plan for staff allowing them to understand the reasons for certain actions and how to take them properly.

### CRITICAL POINTS IN AGROCHEMICAL/ORGANIC PRODUCTS MANAGEMENT

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Products must be purchased form authorized suppliers |
| | | Agrochemical purchase documents must be carefully kept |
| | | Product application records are kept including date, product name, dose, plot, amount of water per hectare used, and observations) |
| | | Purchase products locally authorized to use in coffee plantations |
| | | Follow all agrochemical storing requirements |

# H. TRACEABILITY

It is important to record all field activities to have a better control over production practices, ensure that they are effective, meeting the needs of the plantation and in line with **Good Agricultural Practices.**

### TRACEABILITY LEVEL AT THE FARM

#### GOLD LEVEL:

- Having written procedure and planning for each activity, including individual plant growth and health check, application of fertilizers, herbicides and pesticides, irrigation, and shade management.
- Conducting and documenting periodic monitoring of plant growth and health, and adjust field activities and applications to optimize plant growth.
- Having a written record of each application comprising at least date of application, product used, quantity applied, and place.
- Having a written record of each activity comprising at least date, activity, & place.

#### SILVER LEVEL:

- Having a written record of each application comprising at least date of application, product used, quantity applied, and place.
- Having a written record of each activity comprising at least date, activity, & place.

#### BRONZE LEVEL:

- Having a written record of each application comprising at least date of application, product used, quantity applied, and place.

# MODULE 3

## SEED HARVEST

## MODULE 3 - CONTENTS

### WHY ARE GOOD PRACTICES IN HARVESTING IMPORTANT TO SELECT COFFEE SEEDS?

Coffee beans need a careful harvesting process. A good harvesting process ensures optimum quality of the seeds you want to reproduce. It discards imperfect, undesirable beans that may result in weak, sick plants.

**Basic good harvest requirements:**

1. Harvest ripe beans only (no green or overripe beans).
2. Harvest beans from plants without imperfections or disease

**Risks of non-compliance with appropriate harvesting practices:**

1. Low percentage of seed germination.
2. Plants prone to suffering from diseases.
3. Poor-quality plants can lead to years of loss for coffee growers.
4. Loss of traceability and, consequently, of genetic purity.

## SELECTION OF PLANTS TO HARVEST

Seed selection is intended to ensure seed viability to obtain high-quality plants to guarantee the success of future coffee plantations.

## A. DEFINITION OF SUITABLE PLANTS TO HARVEST

1. Productive coffee bushes, preferably young plants (3 to 15 years).
2. Strong plants with healthy leaves, stems, and branches, with well-shaped, firm and healthy roots.
3. Plants with size characteristics and the phenotype of the chosen variety.
4. Plants with stable productivity.
5. Seed lot located within the isolation limits mentioned in Module 1.
6. It is advisable to eliminate atypical plants not meeting the size and phenotype requirements of the selected variety as mentioned in Module 1.

# B. HARVESTING

CLEAN BASKETS

**Baskets must be clean to avoid cross contamination with seeds from different varieties.**

QUALIFIED STAFF

**Staff must be trained and qualified prior to harvesting.**

OPTIMAL BERRIES

**Collect ripe beans only, not half-ripe or overripe beans.**

COLLECTION AT PEAK HARVEST TIME

**Collect at the peak of harvest season (not before, not later). No beans from the earliest harvest or those collected after harvest are used. These can be sold as cherries, but not as coffee seeds. See harvest season picture below.**

Module 1, subsection G. **"Eliminating Atypical Plants"** explains the importance of eliminating atypical plants from seed lots to prevent cross pollination resulting in seedlings with undesirable characteristics for that variety.

# C. TYPE OF FRUIT TO HARVEST

## TYPE OF FRUIT TO BE HARVESTED

1. Optimally ripe beans (red or yellow, depending on variety)
2. Larger, healthy beans
3. Free from damage resulting from disease/pests
4. Beans carefully collected to protect coffee bushes

A post-selection process can be conducted to ensure top quality.

## AVOID

1. Green, half-ripe, and overripe beans. Half-ripe beans have a lower germination percentage.
2. Beans damaged by coffee berry borer, mold, anthracnose or any other visible damage.
3. Harvesting plants located at the borders of seed lot due to potential cross pollination. See Module 1, subsection G.

## APPROPRIATE SEASON TO HARVEST COFFEE SEEDS


# D. TRANSPORTING BEANS TO COFFEE MILL

- Beans must be brought to plant the same day they are harvested.
- Pack beans in bag and keep a record indicating at least variety, plot where they were collected, date, weight, number of bags, license plate number of trucks bringing them, departure time, arrival time, name of truck driver, signature of harvest supervisor, and signature of coffee mill manager. See examples of traceability card below.

# E. TRACEABILITY - FROM HARVEST TO COFFEE MILL

To ensure seed traceability from farm to coffee mill, coffee bags must be labeled indicating at least weight, lot, variety, date and signature of harvest supervisor.

### TABLE 3. LABEL FOR COFFEE BAGS (WHICH ARE BROUGHT FRESHLY HARVESTED FROM THE FIELD TO THE MILL)

| Date | Lot | Variety | Weight | Bag number | Signature of harvest supervisor |
|---|---|---|---|---|---|
| 2-12-18 | Lot 3 | Caturra | 50Kg. | Bag 5 | José López |

Also, a record is kept by lot of harvested coffee bags with information for each of them.

### TABLE 4. RECORD OF COFFEE HARVEST BY BATCH (WHICH ARE BROUGHT FRESHLY HARVESTED FROM THE FIELD TO THE MILL)

| Lot | Date | Variety | Number of bags | Signature of harvest supervisor |
|---|---|---|---|---|
| Lot 3 | 2-12-18 | Caturra | 5 | José López |
| Lot 3 | 2-13-18 | Caturra | 6 | José López |
| Lot 3 | 2-14-18 | Caturra | 5 | José López |

In addition, a record of bag transportation must be kept including information such as truck data, location of bag in truck (optional), date and time of departure, name of coffee mill, truck arrival time, name of driver and name of person receiving bags in the mill.

### TABLE 5. RECORD OF TRANSPORTATION OF COFFEE BY BATCH (WHICH IS BROUGHT FRESHLY HARVESTED FROM THE FIELD TO THE MILL)

| Truck license plate number | Date | Truck departure time | Truck arrival time | Name of driver | Name of person responsible for receiving coffee at the mill |
|---|---|---|---|---|---|
| BYN 234 | 2-12-18 | 3:40 p.m. | 5:10 p.m. | Mateo Fernández | Flor Pérez |

**DOWNLOAD EXCEL TABLE** HERE

## CRITICAL POINTS IN HARVESTING COFFEE BERRIES FOR SEED

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Only ripe (not green or over-ripe) beans must be harvested for seed. Green or over-ripe beans harvested by mistake are selected and separated to be marketed as fruit. |
| | | Only healthy, perfect beans must be harvested. Imperfect beans are also harvested but they are marketed as fruit. |
| | | For seed, only beans at harvest peak must be harvested. Beans collected at the beginning and the end of the harvest season are collected but they are sold as fruit. |
| | | Only beans from the seed plot located within the isolation limits mentioned in Module 1 must be harvested for seed. |
| | | Beans must be harvested only from plants with the size and phenotypical characteristics of the selected variety. |
| | | Baskets must be clean. |
| | | Coffee beans must be brought to the mill the same day they are harvested. |
| | | Beans must be packed in bags indicating variety name, harvest plot, date, and truck carrying them. |
| | | Traceability records from harvest to coffee mill must be kept. |

# MODULE 4

## WET PROCESSING OF COFFEE SEEDS

# MODULE 4 - CONTENTS

After careful harvesting, coffee beans are processed to serve as seed for reproduction. To do so, a rigorous process consisting of depulping, fermenting, demucilaginating, washing and drying is carried out to preserve seed quality.

**Requirements for proper seed processing:**

1. In-depth cleaning of coffee mill prior to receiving coffee fruit
2. Good adjustment of pulper to avoid broken beans

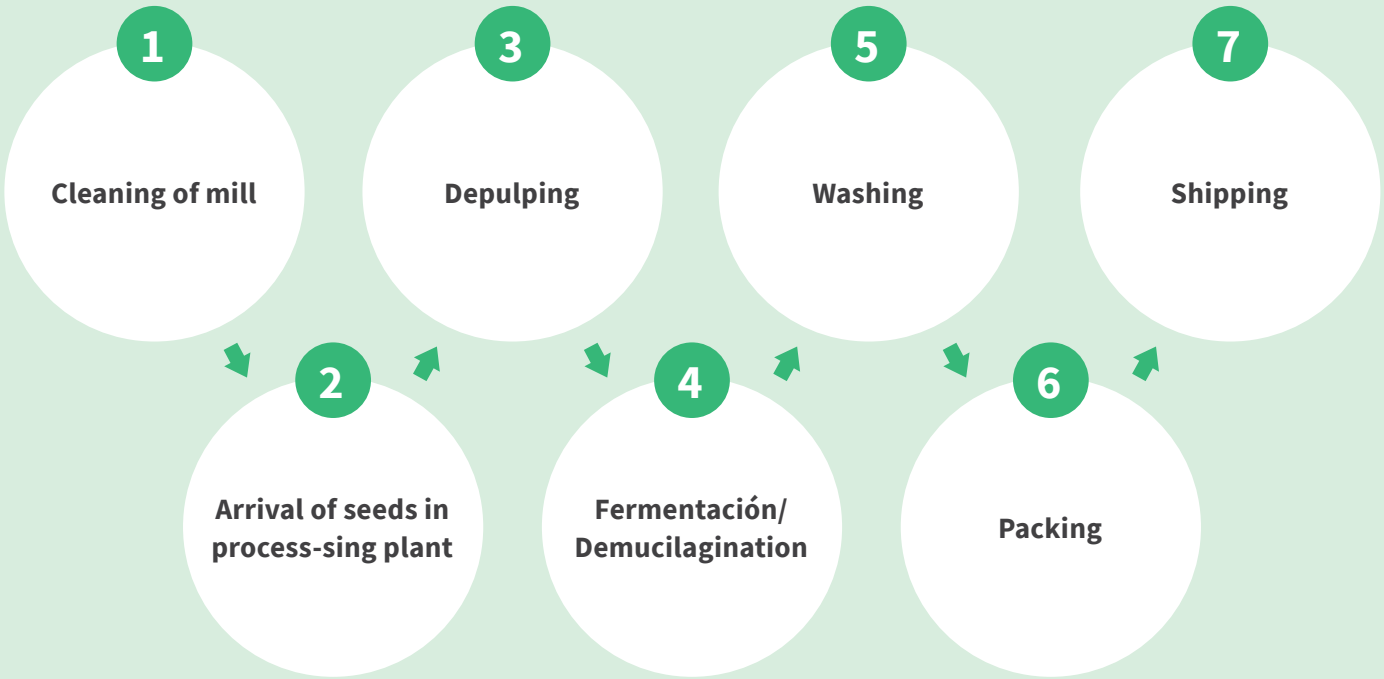
**Risks from non-compliance with rigorous processing:**

1. Over-fermentation; loss of seed viability
2. Low germination percentage
3. Poor washing may result in pathogens in stored seeds
4. Risk of losing traceability and genetic purity

# A. WET PROCESSING FLOW

Seed processing is a priority and must be done first and exclusively in a single day. Coffee beans intended for seed should be processed separately from beans intended for commercial use.

WET PROCESSING STAGES



# B. PROCEDURE TO RECEIVE FRUIT AT THE COFFEE MILL

This stage of process is key to achieve uniform quality of coffee beans, making them suitable to serve as seed.

Requirements to process cherries to turn them into seed include

1. In-depth cleaning of site where beans will be received as well as all equipment to be involved in the depulping, fermentation, demucilagination, washing and drying process, to avoid contamination from beans belonging to other varieties.
2. Receive only ripe, optimum coffee cherries. **See picture.**
3. Sorting out unripe, green, overripe, or dry cherries. To achieve this, collectors are asked to sort coffee cherries prior to measuring.
4. Cherries free from debris (leaves, sticks, soil, pebbles, etc.)
5. Coffee bags must be clearly identified (weight, lot number, variety, date, signature of harvest manager).

## CLEANING THE COFFEE MILL

One day before milling, the areas of the mill where coffee cherries will circulate should be cleaned:

- Coffee cherry scale (kg)
- Receiving tank
- Pulper
- Piping bringing cherries to float siphon
- Float siphon
- All machines and pieces involved in the process

## RECEIVING THE RIPE FRUIT

- Cherries are received in bags cearly labeled with weight, lot number, variety, date, and signature of harvest manager.

All cherries collected are weighed in electronic scales. These are calibrated annually by specialized companies which provide a certificate.

- Cherries are placed in coffee receiving tanks.

## FRUIT SUITABLE TO BE USED AS SEED (ONLY TOP QUALITY)

Not all coffee cherries entering wet processing are appropriate to serve as seeds. To ensure seed viability, a strict process must be followed.

1. First, cherries should be separated by density. Fruit are placed in water to separate out any floating cherries, which are of lower quality. This first stage allows the elimination of any fruits damaged by coffee berry borer, seedless fruits, and peaberries. Only those that sink should proceed to depulping.
2. After depulping, the seeds should be sent through a mechanical sieve to remove any beans which have pulp remaining. These go to seconds.

**These two selection processes help choose only the first-line suitable beans to serve as seed.**

### CRITICAL POINTS IN RECEIVING COFFEE:

| Complies | Does not comply | Critical point |
|---|---|---|
| | | In-depth cleaning of site where ripe fruits will be received |
| | | Receive only optimal, ripe coffee |
| | | Not mixing coffee (unripe, green, overripe, dry) |
| | | Pure coffee (free from leaves, sticks, soil, pebbles, or any other thing) |

# C. DEPULPING

## WHAT IS IT?

Depulping is the process to remove the husk of ripe coffee fruit. At this stage the lubrication of the mucilage is used to separate the husk from the beans without damaging them.

## DEPULPING PROCESS

1. Coffee cherries that do not float (the first ones) go to pulpers, where the pulp is separated from the parchment coffee
2. Screen separating pulp with parchment to eliminate unfit beans
3. Goosenecks, to remove stones, sticks or impurities that may be present in coffee bags
4. Washing channels
5. Clean water is used in the process, recycled through recirculating pump
6. After depulping it is recommended to screen coffee to eliminate pulp or husks as these negatively affect fermentation

**Risks from poor depulping process:**

- Poor calibration of equipment can result in broken/peeled beans
- Damaged beans can lead to fermentation and drying problems
- Broken beans hinder germination
- Broken beans can facilitate the appearance of diseases, mainly fungi, so that seeds will not be suitable for planting

### CRITICAL POINTS IN DEPULPING

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Depulp coffee the day it is collected to avoid overfermentation |
| | | Install a device to remove pebbles to avoid deterioration of depulping equipment |
| | | Check depulping equipment continuously |
| | | Sort decupled coffee as follows:<br>1. Depulped coffee<br>2. Pulp |
| | | After depulping it is advisable to screen depulped coffee to remove beans still with their peel or pulp, as this negatively affects fermentation. |

## DEPULPING TYPES

There is a trend to work with pulpers using little water and producing higher yields. Some depulping methods include,

### HORIZONTAL CYLINDER PULPER

It is a cylinder made of iron or aluminum. When rotating, it presses the ripe fruit against a concave plate with channels through which loose beans are forced to move. See illustration.

### DISC PULPER

Pulping is carried out by the surface of discs, which have buttons dragging the cherries and depulping them by forcing them over the pulper crest.

### VERTICAL CONE PULPER

This pulper reduces water in pulping, minimizes energy, and it has more capacity than other pulpers, among other things. The conical structure is arranged in such a way that it performs its rotation vertically. This way a larger number of pulping devices can be installed around it.

# D. FERMENTATION – DEMUCILAGINATING MACHINE

## WHAT IS FERMENTATION/ DEMUCILAGINATION?

The purpose of fermentation/mechanical demucilagination is to eliminate the mucilage covering coffee beans. These are two different methods with the same function.

**Fermentation:** it consists of transforming mucilage into a substance soluble in water through the action of microorganisms (fungi, yeasts) and subsequent washing.

**Mechanical demucilagination:** it consists of eliminating mucilage by physical or mechanical means and its subsequent washing. In this process, the consumption of water is reduced. In addition, a continuous flow of the process is established, and yields are increased without negatively affecting quality.

**Risks from poor fermentation/demucilagination**

- Overfermentation of beans can kill the embryo and disable germination.
- The demucilaginating machine must be calibrated daily. If it does not work properly it can damage or break the beans allowing pathogens to entry and negatively affect seed viability
- Poor fermentation can leave to an excessive amount of mucilage on the beans, which in turn may result in issues during the drying process and to the appearance of pathogens in storage.

## FERMENTATION

Depulped coffee is placed in fermentation tanks designed to remove mucilage during the process. Seed under fermentation is properly identified with cards allowing to trace information in the process. Fermentation can take 12 to 24 hours, depending on weather conditions. In some cases it can last up to 36 hours under very cold conditions. Variety can also prolong the fermentation process.

**Fermentation tank**

## MECHANICAL DEMUCILAGINATION

A process by which coffee seeds pass through a rotating machine that causes friction between them to loosen the mucilage.

**Mechanical demucilagination**

Important factors to consider with mechanical demucilage:

- Rotor speed
- Ratio between rotor and housing diameters
- Rotor diameter, shape, and type

## IMPORTANCE OF GOOD FERMENTATION

Fermentation is intended to separate mucilage from beans (the sugar layer protecting the grain). Poor fermentation may result in mucilage residues, leading to the appearance of fungi during storage.

## FERMENTATION TIME

Recommended fermentation time can vary between 12 and 24 hours, depending on climate conditions at individual wet mill sites as well as on variety, due to mucilage amounts in fruit.

Overfermentation and high temperature can kill the embryo; therefore, seeds would not suitable for reproduction. Thus, especially care is needed during this process.

Mechanical demucilage requires immediate drying, which results in an investment in equipment and drying infrastructure. If not properly dried, residues of mucilage will restart the fermentation process, which may negatively affect seed viability.

**Factors related to quality control in fermentation:**

1. Start fermentation in the afternoon (recommended time: between 4 and 5 p.m.)
2. Weigh the mass of mucilaginous coffee deposited (you can add water or keep it dry, both ways are O.K.)
3. Measure initial pH with pH-meter
4. Stop the fermentation the next day, when pH is between 3.7 - 3.9
5. Drain mucilage
6. Dispose of and treat mucilage and wastewater

## SYSTEMS ADVANTAGES/DISADVANTAGES

### MECHANICAL DEMUCILAGINATION

**Advantages**

- The process is carried out continuously.
- Large quantities of coffee can be processed in less time.
- Water consumption is reduced thanks to the recirculation system.
- Mucilage is recovered virtually pure for potential later use.
- With immediate drying, yields between 1% - 2% can be obtained.
- It requires less space as compared to fermentation tanks.

**Disadvantages**

- Mucilage residues remain in the beans groove.
- Drying equipment is required to avoid overfermentation.
- Trained personnel is required to manage the process.
- There is more peeled coffee.
- Higher energy consumption.
- Higher initial investment.

### FERMENTATION

**Advantages**

- Low initial investment.
- Beans do not suffer mechanical damage
- Lower energy consumption
- If performed correctly, mucilage comes off easily

**Disadvantages**

- More water wasted
- Requires continuous control and qualified staff
- Requires additional space
- Requires more time. Lower yield
- Mucilage is wasted due to washing. More wastewater

## WASHING COFFEE BEANS

What is it?

1. After fermentation, beans are washed with clean water to remove mucilage residues adhered to parchment. This procedure can be done through immersion and passing of a stream of water.
2. Fermented beans are placed in a container, tank, or washing channel and mucilage adhering to them is removed by rubbing them with each other. Four successive rinses are recommended, as follows,
   - Add 30% of water, shake, remove impurities and eliminate
   - Add 20% of water, shake, and discard
   - Add 20% of water, shake, and discard
   - Add 30% of water, shake, discard, and remove impurities
3. This procedure must be performed at least four times or more until a rough sound between beans is heard. At the beginning of the washing, beans slip from the hand due to residues; when well washed they remain in the hand with a rough consistency, like sandpaper. This activity is used also to eliminate seedless beans that remain and float on the surface of water during washing.

### WASHING PROCESS-SUMMARY

- Beans are washed to remove the remains of mucilage from beans
- Clean water is used
- Pre-cleaning of decanter (water recirculation pump).
- Washing parchment coffee allows discarding pulp, mucilage, seeds with less weight, and diseased seeds.

# E. PACKING

After washing and sorting coffee, it is placed in polyethylene bags of specific color (with color depending on seed variety), duly labeled SEED and indicating variety name. Labeling bags is essential to maintain traceability of seed. It is recommendable to add a label to each bag, for instance: **Sample label for coffee bags going to the drying yard.**

## WEIGHING

- Once coffee is place in bags duly labeled SEED and indicating variety namely, it is weighed on properly calibrated electronic scales (Kg).
- The weight in kilograms of wet parchment coffee is obtained and recorded.

# F. SHIPPING AND RECEPTION

At the time coffee leaves the mill, it is ready for the drying process detailed in Module 5. However, to dispatch the coffee, it is important to count with records proving its origin.

TABLE 6. SAMPLE CARD TO DISPATCH COFFEE AT MILL TO THE DRYING AREA

| | |
|---|---|
| **Name of farm:** | |
| **Date:** | |
| **Seed lot:** | |
| **Driver's name and surname:** | |
| **Type of vehicle:** | |
| **Truck license plate number:** | |
| **Number of bags received:** | |
| **Kilograms of parchment coffee received:** | |
| **Humidity level:** | |
| **Sender's signature:** | |

**DOWNLOAD EXCEL TABLE** HERE

## WET PROCESSING – MAINTENANCE

Maintenance of coffee mill is of the utmost importance, since it directly influences the quality of coffee to be processed. This work is divided into two parts:

- Plant cleaning
- Equipment checking and control

**In relation to plant cleaning, it is key,**

- Daily wash/clean all equipment involved in the process.
- Not allow beans left behind to ferment and mix with the coffee to be processed. It is important to make sure that all fruit and parchment coffee are completely removed before beginning again the milling process.
- Implement strict cleaning controls (preferably appoint a cleaner).
- Maintain permanent cleaning in wet processing.
- Keep a record showing when the plant was cleaned, signed by the person in charge and the main supervisor.

**In relation to equipment checking/control, it is key,**

- Have a certified company review and calibrate all equipment before the harvest.
- Ensure all facilities are in good shape.
- Keep a record showing the date when the mill was reviewed and calibrated, signed by the person in charge and by the main supervisor.

## WASTE-WATER TREATMENT (MUCILAGE)

**Local legislation**

The first step in wastewater treatment is checking local and national legislation on the topic and requirements in relation to COD, BOD, pH and maximum suspended solids for the discharge of water into natural water bodies.

### PRIMARY TREATMENT OF WASTE WATER

The first step in wastewater treatment, usually called the primary/initial step, is intended to achieve two goals regarding water from wet processing, namely,

1. Separate/eliminate solid particles from water.
2. Eliminate water acidity until neutral values are achieved.

**1 Separate/eliminate solid particles**

To separate the solids in a simple, economical way, filters are placed. These are metal meshes with very small holes allowing water to pass through and larger particles to be trapped.

Normally the right sites to place these meshes are at the end of washing spouts and/or at the entrance of treatment systems, specifically before entering the storage tank. The solids collected are deposited with coffee residue to make organic fertilizer.

**2 Bring water acidity to neutral values**

Coffee wastewater is acidic, causing the death of microorganisms and plants that are responsible for eliminating and absorbing the pollution present in water from wet processing. To neutralize them different chemicals such as lime, dolomite lime, hydrated lime, and sodium hydroxide/caustic soda can be used.

**Adding product to enhance pH in coffee wastewater**

**Process:**

1. Store wastewater in storing tank and stir with the wooden shovel.
2. Put on complete personal protection equipment.
3. Using a clean container, take a sample of wastewater. Insert measuring tape to measure initial pH.
4. In a separate bucket mix lime and wastewater; stir.
5. Pour the mixture from the bucket into the storage tank. Mix well using the wooden shovel until fully dissolved. Wait for 5 minutes.
6. Repeat step 3. If result approaches 7 that would be the final pH.
7. End process.


After these two preliminary steps, wastewater must be treated. Some systems are mentioned below:

**Tubular biodigester**

It is a bag made of a resistant plastic, where pig or cattle manure (bacteria) is introduced to clean coffee wastewater and at the same time produce and store biogas.

**Fixed-dome mini reactor**

A plastic tank where pre-treated wastewater (without solids and with pH 7) enters from top to bottom, passing upwards a bed of bacteria (manure) deposited at the bottom. The water is evacuated from one side of the tank and bio gas comes out from the top.

**Wetland by biofiltration**

Systems using plants as an active part of the treatment. Plants grow on a long, shallow bed (artificial wetland), filled with gravel and / or sand. Wastewater enters at one end and filters between the gravel and plant roots, collecting at the end of the bed.

**Controlled surface runoff**

It consists of providing enough moisture in an area with plants for optimum growth. Plants absorb water and eliminate contamination by evaporation or transpiration.

**Anaerobic lagoon**

They work based on aerobic and anaerobic degradation. The efficiency of the main treatment determines lagoon size. They should be built with little depth to achieve oxygenation of the entire volume without requiring forced aeration.

## PROTECTING WATER SOURCES

All growers/companies with coffee mills must comply with the national standard on use of water and natural sources. In addition, they must have all required permits for water use, whether from well, spring, river or pipe.

### CHARACTERISTICS OF WASTEWATER

Typical wastewater contains high concentrations of organic matter. This is significant for two reasons:

- **Ecologically**, by discharging this water in a receiving body such as a lake or river, organic matter is degraded by microorganisms and causes oxygen consumption, thus killing aquatic fauna.
- **From a sanitation standpoint**, organic matter favors proliferation of pathogenic organisms usually present in wastewater, so the more polluted the water, the longer the time and the danger it represents as a source of infection.

### BOD - ANALYSIS

Biochemical Oxygen Demand (BOD) is the most traditional method to measure the amount of oxygen consumed by microorganisms as they proliferate in wastewater and feed on organic matter. It evaluates impact on aquatic fauna and can be determined when water becomes a focus of infection, as each carbon compounds has different value as a substrate for microorganisms' growth.

### COD- ANALYSIS

Chemical Oxygen Demand (COD) is the traditional method replacing microorganisms with a strong oxidant reagent (Dichromate). Dichromate reacts with the amount of oxygen needed to consume organic matter, allowing for estimating the oxygen that would be consumed together with organic matter. COD can be obtained in 90 minutes while BOD measurement can take up to 5 days.

**Why keep measuring BOD?**

The reason to do so is that there are substances such as nitrites, sulfites, and ferrous ions that also react with dichromate and are recorded as oxygen consumption by organic matter. The chloride ion, present in a large amount of natural water, can interfere and requires adding reagents such as silver and mercury salts to suppress it, which implies handling and disposal of toxic waste. In addition, there is a group of organic substances such as pyridine and benzene that do not react with potassium dichromate, although they can be consumed by microorganisms. In practice, joint BOD and COD evaluations should be made for each specific discharge to establish a useful correlation.

So far, BOD and COD have served as the two routine parameters to evaluate oxygen consumption and organic load. Source: Aguasresiduales.info, 2015

## TREATMENT OF COFFEE PULP

When processing coffee pulp from the mill, it is recommendable to make organic fertilizer to use in coffee plantations.

**Pulp recycling**

**Pulp**

Coffee Processing Good Practice Manual: http://www.mag.go.cr/biblioteca_virtual/bibliotecavirtual/a00205.pdf

Comparative Analysis and Relationship between BOD, COD, and COT: https://www.aguasresiduales.info/revista/blog/analisis-comparativas-y-relaciones-entre-la-dbo-dqo-cot

# G. TRACEABILITY

**Records to ensure seed traceability at wet processing:**

- Record the process to allow for seed traceability from harvest in the field to reception at the wet coffee mill. This procedure must, as a minimum, identify/label harvested fruits by lot or variety lot, method of transportation from field to collection area prior to the beginning of wet milling, and careful maintenance of records. Coffee bags must indicate weight, number of lot of origin, variety, date, and signature of harvest manager. Transportation records must include at least a copy of the harvest data, location of fruits in the transportation truck, time and date of departure from the field, mill the product is being sent to, date and time of arrival, name of driver and authorized signature of who receives the cargo. See sample records in Module 3 -Harvest.
- Records at the wet processing area must indicate total number of bags of beans harvested, initial weight, weight of wet parchment coffee, variety, lot, time of reception at coffee mill, and time of departure from coffee mill.

TABLE 7. SAMPLE RECORD OF ENTRIES IN THE MILL

| | |
|---|---|
| Farm of origin | |
| Lot | |
| Variety | |
| Harvest date | |
| Arrival time | |
| Number of bags received | |
| Kilograms of cherry coffee | |
| Signature of plant manager | |

TABLE 8. SAMPLE RECORD OF DEPARTURES FROM THE MILL

| | |
|---|---|
| Farm of origin | |
| Seed lot | |
| Variety | |
| Harvest date | |
| Departure time | |
| Number of bags | |
| Kilograms of wet parchment coffee | |
| Signature of plant manager | |

**DOWNLOAD EXCEL TABLE HERE**

TABLE 9. SAMPLE RECORD OF TRANSPORTATION FROM MILL TO DRYING YARDS

| | |
|---|---|
| **Farm name:** | |
| **Date of transportation:** | |
| **Seed lot name:** | |
| **Harvest date** | |
| **Variety** | |
| **Driver name and surname:** | |
| **Truck type:** | |
| **Truck license plate number:** | |
| **Number of bags received:** | |
| **Kilograms of coffee received:** | |
| **Percentage humidity:** | |
| **Signature of sender:** | |
| **Name of individual entering the drying lot:** | |
| **Observations:** | |

**DOWNLOAD EXCEL TABLE HERE**

## CRITICAL POINTS IN PACKING

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Pack washed coffee in bags labeled seed. Include name of variety. |
| | | Record wet parchment coffee weight in kilograms |

## CRITICAL POINTS IN MAINTENANCE OF WET PROCESSING

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Daily clean/wash all equipment involved in the process. |
| | | Do not allow beans left behind to ferment and get mixed with coffee to be processed. |
| | | Keep a record of cleaning of coffee mill, signed by plant manager and the head supervisor. |
| | | Review and calibrate, with a certified company, all equipment prior to harvest. |
| | | Make sure facilities are in good shape |
| | | Keep a record showing the date when the mill was reviewed and calibrated, signed by plant manager and head supervisor. |

## CRITICAL POINTS IN SOLID WASTE TREATMENT

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Transformation of coffee husks into organic fertilizer through compost, vermicompost, and so on. |

## CRITICAL POINTS IN WASTEWATER TREATMENT

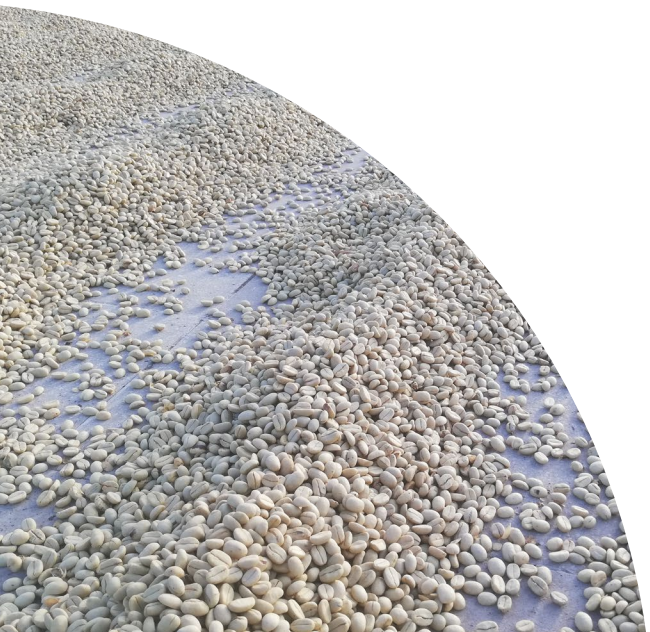
| Complies | Does not comply | Critical point |
|---|---|---|
| | | Separate and remove solid particles from water, treat solid particles with solid waste. |
| | | Eliminate water acidity up to neutral values by regulating pH. |
| | | Subsequently, separate solid particles and regulate pH, carry out deeper water treatment choosing between tubular biodigester, anaerobic lagoon, controlled surface runoff, wet-land by bio-filtration, fixed dome mini reactor, and so on |

## CRITICAL POINTS IN TRACEABILITY

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Carry all records and controls for each process: reception, depulping, demucilagination/ fermentation, washing, packing, maintenance of coffee mill, waste treatment, and so on. |

# MODULE 5

## SEED DRYING



# MODULE 5 - CONTENTS

### WHY IS DRYING IMPORTANT?

Good drying helps diminish the possibility of fungi or disease proliferation in seeds and to ensure their viability.

### WHAT DOES THE DRYING PROCESS CONSIST OF?

Drying consists of reducing the humidity of wet parchment grain (50%) to a figure between 25% and 30%. The goal is to lower humidity levels preserving the viability of the seed embryo but decreasing the possibility of pathogen proliferation. Seed drying is an important transition point between wet processing and the storehouse where the seed will be preserved (cold room or another).

**Good drying requirements:**

1. Drying yards or tables under shade to reduce direct radiation
2. Immediate transfer from coffee mill to drying yard to avoid bean viability issues (overfermentation)
3. Immediate transfer from drying yard to storage once humidity levels of 25%-30% are reached to avoid bean dehydration
4. Slow, homogeneous drying

**Risks from non-compliance with appropriate drying:**

1. Fungi/diseases may proliferate if humidity goes beyond 30%.
2. Temperatures above 40°C during drying may kill the embryo, resulting in no germination.

**Keep in mind that coffee seeds are living beings and must be kept alive during the drying and storage processes. Thus, drying must not endanger the embryo. Procedures to ensure seed drying quality follow.**

# A. PREPARATION OF SITE

The drying area for germination seeds must be isolated from areas where other varieties of coffee are treated to avoid bean mixing during the process.

## SEED DRYING - SUITABLE STRUCTURES

Drying coffee beans for seed is slightly different from drying regular coffee for sale. The goal in the first case is protecting the embryo.

Main differences include:

1. Drying must be done in an area with no direct sunlight to favor slow drying.
2. Temperature must not surpass 40°C as high temperature will kill the embryo, thus negatively affecting seed viability.

### CHARACTERISTICS OF THE STRUCTURE REQUIRED FOR THE DRYING AREA

**Roof:**

- Preferably an open area with shade net roof (60% - 80% shade) or under a high metal warehouse, always looking for good ventilation. Brightness can range between 7000 lux and 20000 lux.
- Minimum height between floor and roof: 2.5 meters

**Floor-Support:**

- The floor must be level to facilitate turning, with slight slope (0.3% to 0.5%) for draining.
- The floor may be made of concrete. However, if the floor is of earth, it must be covered with a geo-textile - geo-membrane. Wash before each drying cycle. Seed must not be in contact with the ground.
- Tables 1.5 m wide and 0.9 m high can be used. Their base should be made of mesh, shade net or fine sieve to allow for continuous air flow for faster drying faster than on ground.
- Maintain ditches/gutters around the drying yard to prevent water entry, negatively affecting drying.

**Sides:**

- Walls are not recommended to allow for free circulation of wind and prevent temperatures from rising.
- The infrastructure can be made with galvanized iron, structural pipes, or wood, that is, materials able to withstand wind and weather.

**Seed density:**

- Extend 10 kilograms of coffee per square meter is recommended.
- Minimum layer thickness: 1-2 cm without surpassing 5 cm.

## CRITICAL POINTS IN DRYING STRUCTURE

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Good ventilation, walls not recommended |
| | | High roofs, over 2.5 m |
| | | Shade. Shade net between 60% - 80% |
| | | Keep temperature below 35°C |
| | | Concrete or earth floor covered with geotextile or tables with a base of shade net, sieve or mesh for free circulation of air |

# B. HANDLING OF SEED DRYING

Once the drying area manager receives the wet parchment coffee from the mill he/she must take several steps to ensure the seed quality and traceability:

1. Coffee must be labeled with information of seed origin (lot), date of collection and number of kilograms of wet coffee received. The record sheet must be signed by the person responsible for wet processing. For further detail see Traceability in Module 4.
2. Make sure coffee is well washed (free of mucilage, foreign bodies and odors).
3. Next, extend coffee at the drying yard on a 10Kg. layer per square meter. The seed layer must be minimal (1-2cm) to avoid excess humidity.
4. Turn seeds every 30 minutes to homogenize drying and avoid sudden changes of humidity and temperature.
5. Measure humidity continuously with a hydrometer until the desired percentage of humidity is reached (25% -30%). However, once the aired point is reached (30% -40%), the thickness of the layer is increased (+ 30% height) to avoid a sharp drop in humidity.

**Don’ts at the drying yard**

- To preserve genetic purity, never leave scattered beans at the borders of drying yards
- To preserve genetic purity do not mix lots from different origins
- Do not mix lots with different drying levels in order to maintain homogeneous drying of coffee
- Always avoid contact of beans with soil to prevent humidity and reproduction of pathogens from occurring
- Do not walk unnecessarily on coffee extended on yards to prevent parchment from peeling as well as cross-contamination

The main tool to turn coffee is the wooden rake (see picture below). First, drying beds are made with a North-South direction and next they are made with an East-West direction. This is repeated over and over.

A light wood rake with thick bristles is recommended to allow for constant flow of beans.

When drying on tables, seeds can be moved by hand or with a smaller rake, trying to make drying beds for uniform drying.

Staff must wear clean shoes with smooth soles worn for this activity to avoid contamination of seeds and development of pathogens.

**Stirring rake**

**Drying beds**

## DRYING TIME

- Be especially careful the first day, when coffee beans have higher moisture content. Stir them more often, every 30 minutes. In the following days stir them frequently, the more it is stirred the faster it dries.
- Coffee beans spend 3-7 days at the drying yard, depending on humidity percentage at the time it arrives as well as on temperature, external lighting, drying layer thickness, and frequency of turning.
- Continuous monitoring of seed humidity is required to store it at the time it reaches the optimal humidity level.
- It is advisable to keep coffee beans piled for the night, covered with a piece of canvas (or thick, black plastic) to protect it against early morning dew.

**Preparing seed for the night**

If high temperatures (40°C or above) is used to accelerate drying, it will cause irreversible damage to seed quality and embryo, resulting in death of the bean. This damage is easily recognizable due to the black spot in the embryo. Over time, the bean turns grayish. If the embryo dies, the plant cannot germinate to establish a seedbed.

## HUMIDITY TO PRESERVE SEEDS

| Mill | Drying |
|---|---|
| Coffee comes out with a 50% humidity level | Slow drying (3-7 days). Humidity level must reach 25% - 30% |

A hydrometer for grain is needed to measure humidity. There are different models and prices in the market, from most basic and accessible to those more sophisticated and expensive. Hydrometers require constant calibration.

Daily samples must be taken to measure humidity. It is key for each sample to divide into subsamples from different points of the drying yard to have representative data.

A humidity measurement protocol and germination tests must be established. (For details of germination tests refer to WCR Nursery Manual.) The following humidity measurement protocol is attached as a guide:

1. Take 3 subsamples from 10 different points of the drying yard. Sample weight will depend on your humidity meter.
2. Connect the meter in an enclosed area protected from the wind.
3. Measure.
4. Keep a daily record of humidity measurement. When desired humidity level is reached, remove coffee from the drying yard.

**Seed damaged because of high temperature**

## QUALITY SAMPLING

Quality sampling on a per-lot basis prior to storing seeds in the storeroom/cold room allows to know the seed quality this is being stored. Sampling steps include,

1. Taking two 500 g- samples per lot.
2. Classifying beans in the sample per category as good and defective beans (peaberries, broken/seedless, triangled, drilled, abnormally sized and black/pulped beans)
3. Counting and weigh beans per category to have an estimate of the amount of good beans per lot. Finding percentage and quantity of good beans per kilogram.
4. For sampling purposes, count all defective beans and take them out of the seed lot.

**Peaberry sample**

**Broken-seedless bean sample**

**Triangled bean sample**

**Drilled bean sample**

**Abnormal size bean sample**

**Black/pulped bean sample**

Individual sample records must include lot, variety, origin, stock, sample number, sample weight, humidity level, quantity of beans, and weight by category.

**Illustrative quality sampling record:**

| Date | Lot | Variety | Origin | Sample number | Sample weight | Sample beans |
|---|---|---|---|---|---|---|
| 12-3-17 | 1407 | Caturra | Aserrí | 3 | 200g | 600 |

## SEED SELECTION

**Screen to sift coffee**

Careful seed selection must take place prior to seed storage or sale to keep only good beans. Screens can be used for effective selection. They are tables with mesh or sieve of a given size to separate smaller beans and peaberries.

Subsequently manual selection of beans that passed the first filter of the screen is made to separate peaberries, broken/seedless, triangled, drilled, abnormally sized and black/pulped beans.

**Note: Peaberries are not defective beans but the result of low setting of flowers (due to different reasons), where only one egg of the two in the fruit is filled. Peaberries produce plant identical to normal beans. Although they can be used for seed, most growers consider them defective, so they are separated and sold as green coffee or gold coffee.**

Seed selection is a critical step to ensure homogeneous germination and plants with desirable genetic characteristics.

## SEED PACKING

Once seeds are selected and optimal humidity is reached (25%-30%), they must be packed in thick polyethylene bags (thick plastic bags), closed tightly, and brought to storage at either storeroom or cold room. See Module 6 (Storage) for additional details. Labeling bags is essential to maintain traceability of seed. It is recommendable to add a label to each bag, for instance:

**Sample card for coffee bags going into storage**

| | | | | | | |
|---|---|---|---|---|---|---|
| 2-12-18 | Lote 3 | Caturra | 50kg | Saco 5 | 25% | Juan Chaverría |

## CRITICAL POINTS IN DRYING YARD MANAGEMENT

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Drying density: 10Kg. per $m^2$; 1-2 cm. layer. Once 30%-40% humidity is attained, a thicker layer may be left to avoid fast dehydration |
| | | Turn coffee every 30 minutes at the drying yard |
| | | Constantly monitor seed humidity to store it when optimal level is reached |
| | | Keep coffee beans piled for the night, covered with a piece of canvas to protect it against early morning dew |
| | | Pack seeds in thick polyethylene bags to prevent moisture loss, with different colors assigned to each variety. Store immediately |
| | | Keep traceability records |

# C. TRACEABILITY

## LABELING

Labeling of bags is essential to preserve seed traceability to assure seed quality and authenticity.

Traceability must be rigorous. Each bag must be labeled with tracking information including date bag was received at drying yard, harvest day, variety, plot of origin, weight in kilograms of wet parchment, storage date, weight in kilograms of stored product, moisture percentage at storage time, observations, and name of person who entered the lot.

Also, in case transportation from the drying yard to the storehouse or cold storage room is needed, a record showing date and time of transportation, name of coffee mill from which the product left, name of driver, place of storage, and name of receiver, with signatures, must be included.

Sample card:

TABLE 10. SAMPLE LABELING OF BAGS FOR STORAGE (DIRECTED FROM DRYING TO STORAGE OR SALE)

| | |
|---|---|
| **Farm name:** | |
| **Transportation date (if needed):** | |
| **Seed lot name:** | |
| **Harvest day:** | |
| **Variety:** | |
| **Driver name and surname (if needed):** | |
| **Vehicle type (if needed):** | |
| **License plate number (if needed):** | |
| **Number of bags received:** | |
| **Kilograms of coffee received:** | |
| **Percentage moisture:** | |
| **Sender's signature:** | |
| **Name of staff member entering the lot to storehouse:** | |
| **Notes:** | |

**DOWNLOAD EXCEL TABLE HERE**

## SHIPMENTS AND RECORDS

All seed entries/exits to and from the drying yard must be recorded. To do so, a detailed entries/exits inventory commonly known as Kardex® must be kept. (Kardex® is a system for orderly registration of products and movement control.) Each movement is backed by a record entry of seed information (batch, moisture, and weight, among others) as well as complete client information (client name or business name, farm, address, and quantity received, among others), signed by both parties.

# MODULE 6

## SEED STORAGE

# MODULE 6 - CONTENTS

## WHY IS APPROPRIATE STORAGE IMPORTANT?

Storage meeting lighting, temperature, and humidity requirements ensure longer seed life and helps preserve germination percentage.

**Storage requirements:**

1. Temperature: 20°C (+/-2°C)
2. Relative humidity 65%-90%
3. Closed, dark environment to meet temperature and humidity requirements

**Risks from inadequate storage:**

- Low-to-null germination percentage
- Lower seed strength and viability
- Proliferation of pests/diseases polluting the entire lot (e.g., (borer, fungi)

# A. SEED STORAGE FACILITIES

### GOLD LEVEL. COLD ROOM

**Requirements:**

- Four-inch thick polyester walls
- AC connected to a temperature sensor to keep a 20°C (+/-2°C) temp.
- Relative humidity: 65%-90%
- Daily temperature and humidity check
- Plastic pallets to place coffee bags (never place them directly on the floor or on wooden pallets as these may house bugs).

### SILVER LEVEL. STOREROOM

**Requirements:**

- Concrete walls and floor to isolate heat. Totally sealed.
- Ceiling at the storeroom to isolate heat.
- Plastic pallets to place coffee bags (never place them directly on the floor or on wooden pallets as these may house bugs).
- Daily temperature and humidity check
- Storeroom built at a cool site with temperatures not beyond 25° C

It is important to maintain traceability of stored seeds, separate seeds by variety, use bags of different colors or marked with colored ribbons, and place them on different pallets in the storeroom/cold room. Bags must be properly labeled for traceability purposes.

### COLD ROOM - ADVANTAGES

If temperature and humidity are within recommended ranges, seeds will be preserved, allowing for greater germination up to a year after storage; it can even be more than 18 months.

### COLD ROOM - DISADVANTAGES

- High initial investment
- Eergy cost

### STOREROOM - ADVANTAGES

Much lower costs make it accessible to small and medium-sized growers. They only need to monitor the requirements mentioned above.

### STOREROOM - DISADVANTAGES

- Lower seed viability (6 -10 months)
- Increase proliferation of pests/diseases
- Inability to control external climate conditions
- Germination rate decreases after storage for 6 months to a degree that varies in line with control levels of management and storeroom conditions.

# B. TEMPERATURE AND HUMIDITY CHECK

To ensure optimal conditions for seed viability, daily control of both temperature and moisture is required.

| Date | Min. Temperature | Max. Temperature | Min. relative moisture | Max. relative moisture |
|---|---|---|---|---|
| 12-12-17 | 16°C | 20°C | 65% | 68% |

Electronic meters can be used to store continuous data.

Immediate remedial action must be taken in case of inappropriate levels of moisture/temperature.

**In case of increased moisture in stored seeds,**

- Place a dehumidifier in the cold room/storeroom and constantly monitor moisture.
- Bring seeds again to drying yard and monitor moisture until it reaches the level desired.

**In case of high temperature in storage,**

- Check AC operation. Install fans temporarily while AC issues are fixed.
- Isolate storeroom/cold room from inside.
- Move seeds to a cooler place.

## MOISTURE MONITORING

**First month**

**Weekly monitoring**

**Following months**

**Monthly monitoring**

**Monthly germination monitoring must be carried out.**

## TREATMENT OF SEEDS

The hardest pest to deal with at storeroom/cold rooms is coffee berry borer *(Hypothenemus hampei).* It is key to eliminate every single bean damaged by the borer through manual selection. In addition to their potential to contaminate the lot as borers leave them, damaged beans will not germinate due to internal damage.

Recommendations to control berry borer in stored coffee berries.

1. Apply insecticide to seeds before packing them in polyethylene bags.
2. Install a berry borer trap in the storeroom/cold room to measure borer population and take corrective action if needed. Organic or chemical insecticide can be applied (check local legislation to see if this is allowed).
3. A very effective method is packing seeds under vacuum in an airtight bag, which causes berry borer death due to lack of oxygen. Treatment time and seed moisture must be previously evaluated.

## MONTHLY GERMINATION SAMPLE

Whether seeds are stored in cold rooms or a store rooms, seed producers must always conduct monthly germination samplings to monitor seed viability.

1. A sample is taken per lot of counted grains (it can be 500)
2. They are planted at germination beds
3. Follow-up is given for 45 days until germination takes place
4. Seedlings are counted, and percentage germination is obtained

Detailed follow-up of germination percentages per lot must be kept, including at least the data below:

| Lot # | Amount of seeds | Number of good seedlings | Number of discarded seedlings | Germination percentage | % discarded |
|---|---|---|---|---|---|
| 1407 | 1500 | 1323 | 177 | 88,2% | 11,8% |

Usually, local seed bureau from the country (not always available, check for your country) conducts an annual sampling after disinfection takes place.

For further information on how to prepare germination beds, see Module 2 in WCR Coffee Nursery Management Manual.

## CRITICAL STORAGE POINTS

| Complies | Does not comply | Critical point |
|---|---|---|
| | | Temperature: 20°C (+/-2°C) degrees Celsius |
| | | Relative moisture: 65%-90% |
| | | Closed, dark environment to maintain moisture and temperature |
| | | Daily moisture and temperature inspection and record |
| | | Plastic pallets to place coffee bags (never place them directly on the floor or on wooden pallets as these may house bugs). |
| | | Keep seed traceability, separate varieties in storage; use bags with different colors or identify them with color tapes and place them on different pallets |
| | | Place a coffee berry borer trap in the storeroom/cold storage room to measure popula-tion level and make remedial applications if needed. |
| | | Conduct monthly germination sample for each seed lot to assess viability. |

# C. SALE

## EXPORT

Coffee seeds may be exported to other countries. Major steps for this type of sale are outlined below, although they vary depending on individual countries.

1. Visit the local export agency to check on export requirements.
2. Find out about import/export regulations for each country.
   - Some countries require exporters to register as seed producer and meet some country-specific standards.
3. Register the variety to export in both countries.
4. Importers must register themselves with country authorities.
5. Seeds are commonly required to be free from pests and diseases. Some countries also require a given germination percentage.
6. Seeds can be packed in different types of containers according to customer and country requirements (polypropylene bag, plastic boxes, and so on.) Take into consideration maximum volumes and weights authorized by carriers. Weight is limited for occupational health reasons.
7. Seeds must be carried in refrigerated trucks to ensure viability until their destination.
8. A sample of each lot must be kept to conduct germination studies as a reference to customers.
9. In all cases, it is important to maintain traceability as well as document and record all seed-related information (variety, lot, weight, date, client, and so on.) All documents must go with the seed must (including phytosanitary certificate, and any other document required.)

## LOCAL SALE

To sell seeds locally, sellers must check local legal requirements. Usually, both sellers and varieties must be registered with local seed authorities. It is important to document and record all the information related to seeds themselves (variety, lot, weight, moisture level, date, and customer's name). Detailed records will be entered for each exit.

### LOCAL SALE PROOF - SAMPLE

**Date:**

**Owner's name:**

**Buyer:**

**Driver:** **Car license plate #**

| Unit | Quantity | Variety | Lot | % moisture | Unit price | Price |
|---|---|---|---|---|---|---|
| Kg. | 86 | Marsellesa | 180502 | 25% | 200 | 17200 |
| | | | | Taxes 13% | | 2236 |
| | | | | Total | | 19436 |

Seller's signature

Buyer's signature

Driver's signature

# D. TRACEABILITY

For seed traceability purposes, fingerprinting DNA is the safest way to learn the level of coffee purity. This service is available at WCR. For further information, go to WCR Web site https://worldcoffeeresearch.org/.

Bag receipt must be duly registered to ensure individual bag traceability. The transportation record sheet must include, as a minimum, lot data, shipment date and time, name of coffee mill of origin, name of truck driver, storage location, and name of receiver, complete with signatures. These same data must be shown in the receipt record sheet as well as storage location. In the storeroom inventory records indicate sale including lot data, sale date, quantity, and purchaser. Invoice must include all data related to seed.

Below please find a sample card. (Sample cards are intended to serve just as examples. Individual farms can adapt them as needed.)

TABLE 11. SAMPLE RECORD FOR SALE OF SEED

| | |
|---|---|
| **Buyer name:** | |
| **Date seed was purchased:** | |
| **Date seed was taken to storage:** | |
| **Name of seed lot:** | |
| **Harvest date:** | |
| **Variety:** | |
| **Driver name and surname:** | |
| **Type of vehicle:** | |
| **Vehicle license plate number:** | |
| **Number of bags received:** | |
| **Kilograms of coffee received:** | |
| **Percentage moisture:** | |
| **Signature of sender:** | |
| **Name of person in charge of preparing exit card for sale:** | |
| **Comments:** | |

**DOWNLOAD EXCEL TABLE** HERE

If you have additional doubts about the good practices to manage coffee seedbeds, please contact the local personnel of World Coffee Research

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