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African Organic Agriculture Training Manual

A Resource Manual for Trainers in Mali

9-25 ORGANIC MANGO SOIL FERTILITY MANAGEMENT

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Ready for field testing

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This is an interim version. Comments and recommendations for improvement are welcome.

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CONTENTS

9-25 SOIL FERTILITY MANAGEMENT IN ORGANIC MANGO

SET OF TRANSPARENCIES

SOIL FERTILITY CHALLENGES IN MALI

Learning targets for farmers:

- Understand the organic approach to soil fertility management
- Learn how to build and maintain a productive soil
- Learn how to rehabilitate degraded soil back to production

1. Introduction

Mango production in Mali is challenged by many factors starting from field to post-harvest and market access related problems. Besides pest and diseases, recurring droughts and limited access to water for production, the declining soil fertility is a major field-related production challenge for mango. Specifically, farmers in Mali are experiencing the following **soil fertility related bottlenecks**:

- **Low soil nutrients**. Commonly, soils are low in Calcium (Ca), Magnesium (Mg) and Potassium (K), and when acidic, plant available Phosphorus (P) is also limited. This is exacerbated by and a lack of or limited soil nutrient replenishment.
- **Soil loss**. Due to overgrazing, deforestation and over cultivation without efficient soil conservation methods, soil loss through erosion is a common problem.
- **Low soil pH**. Due to reducing land sizes with increasing population pressure, farmers are forced to cultivate continuously on the same pieces of land with limited fertilizer inputs. Coupled with loss of top soil through erosion, soil acidity (low soil pH) is a common problem in Mali.
- **Limited access and use of inorganic fertilizers**. Low fertilizer usage in Mali is attributed to lack of financial capability by most smallholders, limited access to inorganic fertilizers in most rural villages, and limited awareness on the use and application of these fertilizers.
- **Limited use of organic fertilizers**. Organic fertilizers are made from natural materials of either plant or animal matter and includes animal manure (cow dung and poultry manure), household wastes, crop residues and compost, all of which may be easier to access by most farmers. Aside from supplying nutrients, organic fertilizers also improve the physical structure and biochemical

activity level of the soil. Despite these benefits, farmers lack the quantities and proper awareness on how to produce, prepare, store and use organic fertilizers to maximize yields.

› **Limited knowledge of the farmers** on the status and needs of fertilization of mango trees.

Traditionally, farmers maintain soil fertility by fallowing the land in the slash and burn system. This is no longer possible due to reducing land sizes and growing population pressure. Instead of farmers having one plot under crops and another being fallowed, they can have fallow species right in their fields. That is, they can produce crops and fallow their land at the same time. Equally, farmers can increase rain water infiltration into the soil, reduce run off and protect the soil from water loss through evaporation.

This manual presents approaches that can help farmers to improve mango yields from new and existing mango orchards.

2. Soil requirements for mango production

Mango (*Mangifera indica* L.) grows well in high to medium fertile soils with good drainage rich in organic matter with a pH range of 5.5 to 7.5, but can thrive in a wide range of soil types with appropriate nutrient management.

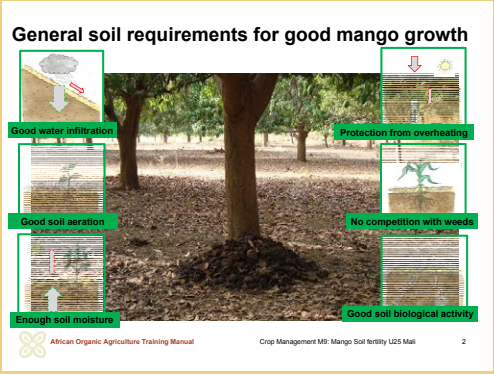
› However, mangoes are generally sensitive to excess nitrogen during the fruit development and ripening stages. This can result in poor quality and green fruit with poor storage characteristics.

› Calcium and potassium levels are also thought to influence fruit quality and storage.

› Trace elements like zinc, copper, boron and manganese are important. The role of boron in flowering and internal fruit quality is especially important. Mango is intolerant to saline conditions.

Routine application of organic manures in conjunction with appropriate soil conservation measures can reverse the unfavourable soil conditions. However, the availability, quality and accessibility of organic manures as well as the timing of their application to support nutrient release for crop growth is important.

GENERAL SOIL REQUIREMENTS FOR GOOD MANGO GROWTH



Discussion on local challenges related to soil fertility

Ask the farmers what challenges they see in relation to soil fertility management. Ask them, how relevant they think soil fertility is for mango production.

Perception of soil fertility

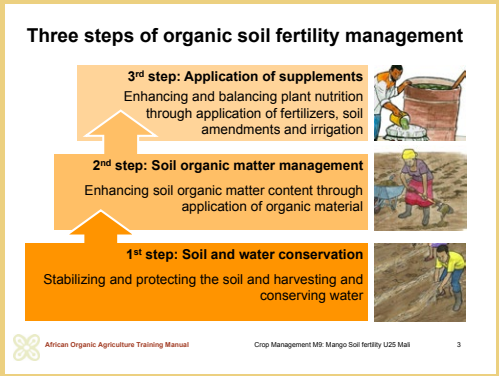
Provide a poster of the interior of the soil (soil profile; see the general soil fertility manual at www.organic-africa.net). Ask the participants:

› How do they understand soil fertility and the factors influencing fertility status of soils?

› How can they tell, if a soil is fertile?

› How do they identify soil fertility problems in the field?

THREE STEPS OF ORGANIC SOIL FERTILITY MANAGEMENT



3 The organic approach to soil fertility management

Organic crop production is based on the principle that "healthy plants grow from healthy soil". A healthy soil is a fertile soil which is able to provide all essential nutrients in adequate quantities and in the proper balance for the growth of plants – independent of external or direct application of nutrients – when other growth factors like light, temperature and water are favourable. A healthy soil is biologically active with diverse types and quantities of soil organisms, has adequate organic matter, is deep and well drained to support good root development.

Organic soil fertility management can be seen as a three-step approach, whereby each step builds the foundation for the next one. The aim is to optimise steps 1 and 2 that encourage natural conservation and rejuvenation of the soil and to minimize application of external fertilisers, soil amendments and irrigation water (step 3). Proper and efficient application of steps 1 and 2 saves on costs for fertilisers and other supplements and prevents possible negative impacts on the farm ecosystem that could arise from the use of step 3 supplements.

Step 1. The first step focuses on conserving the soil, soil organic matter and soil water from loss. Applied measures aim at protecting the soil surface from being exposed to the sun and drying out, and from being carried away by wind or washed down by rain. The aim is to establish a stable and less vulnerable soil as the foundation to managing its fertility. This first step requires an understanding and appreciation of the basic properties of soil and the prevailing type of soil within an area as this has implications on the management requirements and approaches. For better informed approaches, a soil test/analysis (for physical, chemical and biological properties) can be done to guide the decisions. Observe the trees and particularly the mango fruits. If you discover nutrition deficiency syndromes, you should think at possible deficits in the soil.

Step 2. The second step focuses on improving the organic matter content and enhancing biological activity in the soil. The aim here is to build an active soil with good structure which can hold water and supply plant nutrients.

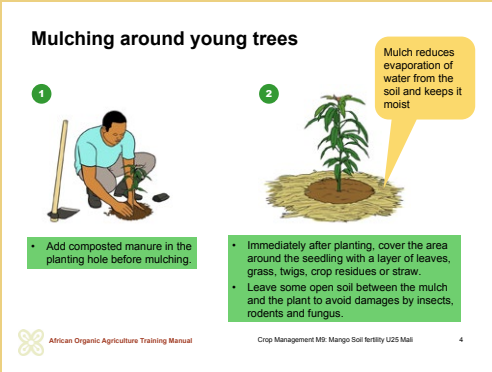
Step 3. The third step focuses on supplementing the nutrient requirements as well as improving the growing conditions by applying some soil amendments or supplements and fertilizers. For organic production, these fertilisers ought to be permitted as the use of synthetic fertilizers is prohibited.

Soil fertility is best improved through combined implementation of the different strategies. One practice alone may not be sufficient to maintain or even improve fertility of soils.

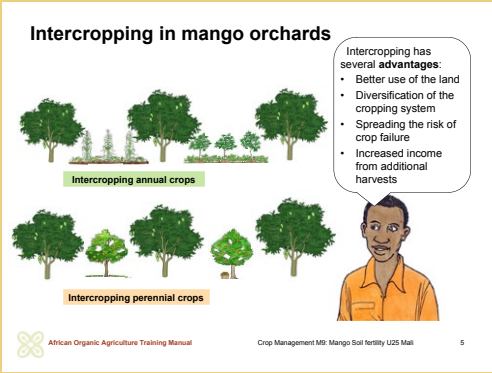
Discussion on measures for soil fertility improvement

Ask the participants to mention the measures the know to improve soil fertility. What measures to they apply in mango production?
Discuss the suitability and the difficulties related to application of the measures, based on their experiences. Identify potential improvements in soil fertility management in local mango production, including measures that are worthwhile to be tested.

MULCHING AROUND YOUNG TREES



INTERCROPPING IN MANGO ORCHARDS



3.1Soil and water conservation (1st step)

The soil conservation strategies to be adopted will depend on the location and slope of the mango field:

Mango production on gentle slopes

For a gently sloping garden or orchard (≤9%), soil conservation strategies will mainly focus on protecting the soil surface from being exposed to the sun and drying out, thereby losing water, reducing biological activity and facilitating quick loss of organic matter. The risk of water and wind erosion is quite low on gentle slopes. Such strategies to reduce soil exposure include:

› **Mulching.** Mulching is the process of covering the topsoil with plant materials such as leaves, grass, twigs, crop residues or straw. This protects the topsoil from being washed away by strong rain and from drying out by the sun. The mulch reduces evaporation of water and thus keeps the soil humid. As a result the plants need less irrigation and can use the available rain more efficiently. A moist soil also enhances the activity of soil organisms such as earthworms, and microorganisms as rhizobia and mycorrhiza. Organic mulch material is an excellent food source for soil organisms and provides suitable conditions for their growth. As the mulch material decomposes, it also releases its nutrients, while part of the mulch material is transformed to stable humus, contributing positively to the soil's organic matter content. A thick mulch layer further suppresses weed growth by inhibiting their germination. Mulching is especially useful during early stages of growth of mango trees, i.e. the first 3 years of establishment, by spreading the mulch materials around the growing trees..

› **Use of cover crops or intercrops.** Mango trees grow slowly, taking 3 to 5 years depending on the variety before the trees cover the space in-between the trees. Besides the exposure of the soil to erosion and water loss, normally weeds will grow in this space requiring regular ploughing or digging to remove them.

Cover crops are low-growing perennial plant species, which can be sown in the alley spaces between the mango trees with the main intention to protect the soil, prevent weed growth and improve soil fertility. They therefore require regular slashing, mowing to avoid competition with the growing mangoes. The slashed materials are left in the field where they contribute

Sharing of experiences with mulching

Ask the participants, what their experiences are with mulching.

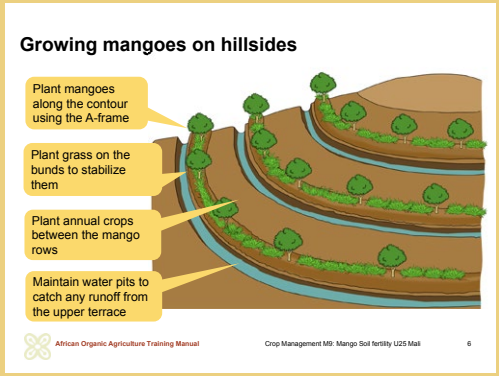
› Which crops do they mulch?
› Why and which materials do they use for mulching?
› What are the main pros and cons of mulching which they know, have experienced, have heard about, or foresee?

Let the participants discuss among each other, how they can implement mulching in mangos. Highlight the challenges they are likely to encounter with mulching, and how they will solve them.

to improving the physical properties of the soil, reduce runoff and erosion, suppress weeds and, if the cover crop is a legume, transfer nitrogen to the main crop, when left as mulch in the garden. There are different plant species that can be used as cover crops. However a good cover crop should be low-growing and not climbing; grows fast and covers the soil in a short time; resistant against common pests and diseases, and does not transmit any to the main crop (mango); tolerant to drought; nitrogen-fixing; and easy to sow and to manage, slash, and or cut for fodder.

Besides cover crops, an economic crop may be grown in alley spaces of the mango trees, a practice referred to as **intercropping**. Intercropping with seasonal crops like beans, maize, peanuts, vegetables is preferable, however upon harvest all crop residues should be left in the garden to protect the soil. Use of intercrops or cover crops increases biodiversity and thus assist in pest and disease management. Maintaining biological diversity within and around the orchard is an important feature of organic systems. Areas of remnant vegetation can also be protected on the garden peripheries as shelterbelts providing an important habitat for natural predators of insect pests, which reduce harm to crops and the need for direct pest control measures.

GROWING MANGOES ON HILLSIDES



Mango production on moderately steep slopes

For a moderately sloping field (10 to 15 %), the biggest challenge for the farmer is to protect the soil from loss from erosion. Therefore, a lot of investment will go into construction of water catchment structures like contour ridges and bunds, combined with grass strips planted on the contour ridges, and water pits/catchments to reduce the movement of water along the slope. Water pits/ditches may be dug along the contour to trap the running water and encourage infiltration into the soil. Mangoes can then be planted on the contour ridges.

Fodder grasses may be planted as grass strips, such as vetiver grass (*Vetiver zizanioides*), napier grass (*Pennisetum purpureum*) and guinea grass (*Panicum maximum*), Bahia grass (*Paspulum notatum*) can be planted in strips at intervals across the slope to slow down water runoff. In addition to reducing soil erosion, the grasses provide feed for the animals. The grass strips can be mixed or replaced with a hedge row of **leguminous fodder trees** such as *Leucaena diversifola, Calliandra calothyrsus, Sesbania sesban, Gliricidia sepium*. Then manure from the animals can be used to add organic matter to the soil.

The **A-frame** is a simple, cheap and easy-to-construct tool for marking contour

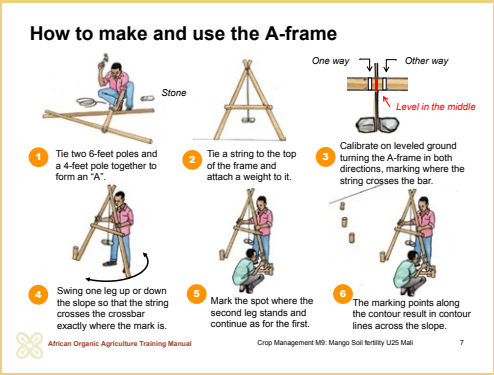
Sharing of experiences with planting of grasses and fodder trees on contour ridges

Mention the different types of grasses or trees grown in your area that help to protect the soil. Discuss the potential role of indigenous grasses and trees.

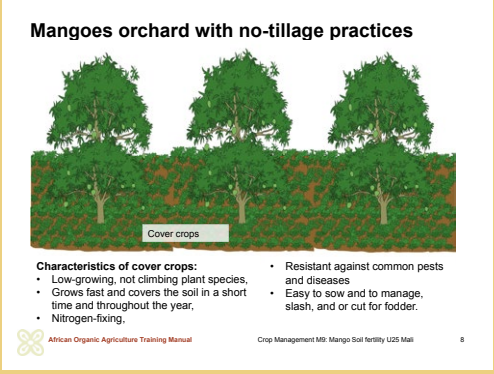
- What are the main challenges which are experienced, known or envisaged related to the species?
- What are the sources of planting materials?

Find out, what training, if any, will be required by the participants.

HOW TO MAKE AND USE THE A-FRAME



MANGO ORCHARD WITH NO-TILLAGE PRACTICES



lines along a slope, making it readily accessible to farmers. The A-frame is made from three poles, some rope, a stone and a supply of stakes.

How to build and use an A-frame:

(i) Fix three poles of about 2.5 meters long each in a position forming an even 'A'. If rope is not sufficient to tie the ends, use nails.

(ii) Tie one end of a piece of cord to the top of the A and fi x a stone tied to the other end so that the stone is at some distance from both the ground and the crossbar.

(iii) Put the A-frame upright and mark the position of both legs. Then, mark the point where the string passes the crossbar of the A.

(iv) Turn the A-frame so that the placement of the legs is reversed. Again mark the point where the string passes the crossbar. If the two marks are not at the same point, mark a third point with a knife exactly halfway between the first two.

(v) Drive the first stake at the edge at the top of the field. Place one leg of the A-frame above and touching the stake. Place the other leg in such a position that the string passes the level position point on the crossbar.

(vi) Drive another stake into the ground just below the second leg. Move the A-frame and continue in the same way across the field.

(vii) The next contour line is placed 3 to 6 meters below the first line. The steeper the slope, the closer the lines should be.

Mango production on steep slopes

On steep slopes (>15 %), reduced or no tillage should be applied to minimize soil disturbance. Due to the very high risk of erosion, soil disturbance should be minimized. Bush clearing/slashing followed by direct digging of planting holes for the mangoes is highly recommended.

MATERIALS USED FOR COMPOSTING

HOW TO MAKE GOOD COMPOST: 'HEAP' METHOD

3.2Improvement of soil organic matter (2nd step)

These practices aim at enhancing the organic matter content of the soil as the basis for efficient management of plant nutrients and water. They can be applied wherever mango is grown irrespective of the slope of the garden or orchard.

Soil organic matter benefits can be grouped into three categories:

- **Physical benefits:** Soil organic matter enhances aggregate stability, improves water infiltration and soil aeration, reduces runoff; improves water holding capacity; reduces the stickiness of clay soils making them easier to till; reduces surface crusting, and facilitates seedbed preparation.
- **Chemical benefits:** Soil organic matter increases the ability of the soil to hold onto and supply over time essential nutrients such as calcium, magnesium and potassium – also known as Cation Exchange Capacity (CEC); it improves the ability of a soil to resist pH change – this is also known as buffering effect capacity; accelerates decomposition of soil minerals over time, making the nutrients in the minerals available for plant uptake.
- **Biological benefits:** Soil organic matter provides food for living organisms in the soil; it enhances soil microbial biodiversity and activity, which can help in the suppression of crop diseases and pests; and enhances pore space through the actions of soil microorganisms. This helps to increase infiltration and reduce runoff.

In addition to mulching and cover cropping (described in step 1) which also contribute to soil organic matter to some extent, **farm yard manures** or **compost** from within or outside the farm can be used. These materials are a good source of humus substances to the soil and thus improve its structure and water holding capacity of the soil.

Well-decomposed manure or compost can be applied directly in the planting holes of mangoes, to aid quick root development. Additional quantities of manure can be top dressed directly around the growing plants if well decomposed or composted, or spread in shallow trenches in between the mango planting lines.

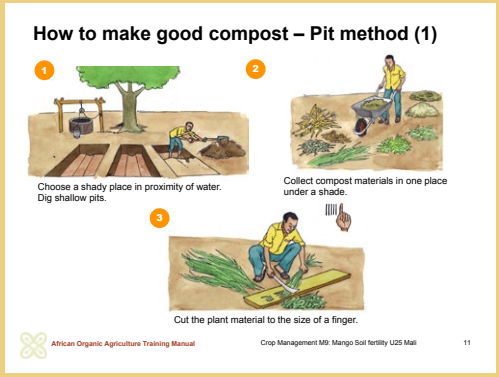
Sharing of experiences with compost production

Ask each participant to discuss their experiences with compost making.

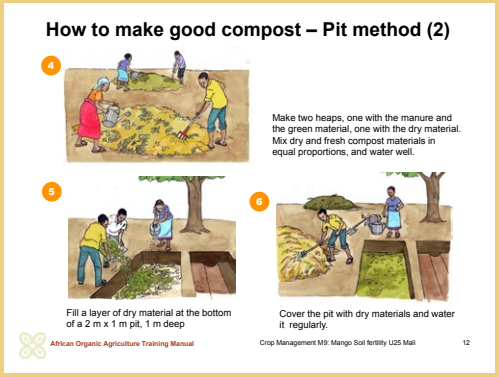
- What are the reasons that they make compost?
- How do they make the compost?
- What materials are commonly available for use?
- Which materials do they use and why?
- When do they make compost, and how long does it take before the compost matures?
- How do they know that the compost is ready for use?
- Are they satisfied with the compost that they make? If so, why, and if no, why?

Discuss the general challenges encountered in compost making, and draw conclusions for further training activities.

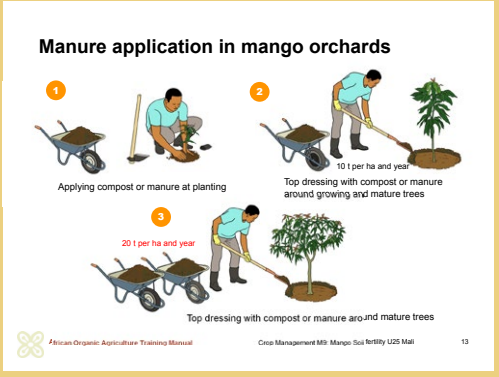
HOW TO MAKE GOOD COMPOST: PIT METHOD (1)



HOW TO MAKE GOOD COMPOST: PIT METHOD (2)



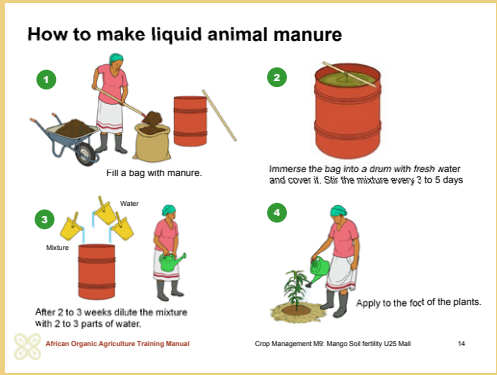
MANURE APPLICATION



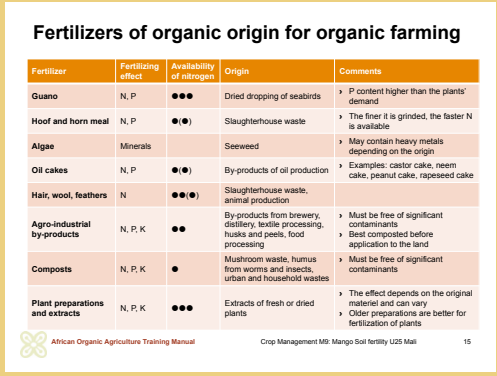
Sharing of experiences on the use of compost

Discuss with the participants the question, how the amount of compost/ manure to produce and apply to the trees is determined.

HOW TO MAKE LIQUID ANIMAL MANURE



FERTILIZERS OF ORGANIC ORIGIN



Fertilizer	Fertilizing effect	Availability of nitrogen	Origin	Comments
Guano	N, P	●●●	Dried dropping of seabirds	› P content higher than the plants' demand
Hoof and horn meal	N, P	●(●)	Slaughterhouse waste	› The finer it is grinded, the faster N is available
Algae	Minerals		Seeweed	› May contain heavy metals depending on the origin
Oil cakes	N, P	●(●)	By-products of oil production	› Examples: castor cake, neem cake, peanut cake, rapeseed cake
Hair, wool, feathers	N	●●(●)	Slaughterhouse waste, animal production	
Agro-industrial by-products	N, P, K	●●	By-products from brewery, distillery, textile processing, husks and peels, food processing	› Must be free of significant contaminants › Best composted before application to the land
Composts	N, P, K	●	Mushroom waste, humus from worms and insects, urban and household wastes	› Must be free of significant contaminants
Plant preparations and extracts	N, P, K	●●●	Extracts of fresh or dried plants	› The effect depends on the original materiel and can vary › Older preparations are better for fertilization of plants

3.3 Soil fertility and water supplements (3rd step)

In situations of heavy nutrient depletion or unfavourable growing conditions such as extreme pH levels, based on soil or leaf test results, soil supplements of macro- and micronutrients may be used. These supplementary measures include:

- Use of **self-made liquid manures** that are easily available to plants.
- Use of **soil amendments** such as lime to correct soil pH, and microbial inoculations to enhance biological activity of the soil and nitrogen fixation in the soil.
- Use of **fertigation water** to supplement both water and nutrient requirements. Fertigation water must be adequately managed, scheduled and monitored to reduce problems with contamination of the water table, leaching of nutrients and salinity inducement.
- Use of **commercial organic and selected mineral fertilizers** (Tables 1 and 2) to satisfy specific nutrient needs. In organic production, mineral fertilizers shall be used as a supplement to methods described in Steps 1 and 2. The use of mineral fertilizers shall be justified by appropriate soil and or leaf analysis. However only naturally occurring mineral fertilizers are allowed by most organic standards and certification schemes.

FERTILIZERS OF MINERAL ORIGIN (1)

Fertilizers of mineral origin for organic farming (1)

Fertilizer	Origin	Characteristics	Application
Plant ashes	Burned organic material	› Mineral composition similar to plants › Easy uptake of the minerals › Wood ashes rich in K and Ca	› To compost (best) › Around the base of the plants
Limestone	Ground limestone Algae	› Buffers low pH (content of Ca and Mg secondary) › Algae: rich in trace elements	› Every two to three years when soil-pH is low (avoid excessive use, as it reduces availability of P and increases deficiencies in micro-nutrients)
Stone powder	Pulverised rock	› Trace elements (depending on the composition of the source) › The finer the grinding, the better the adsorbance	› To farmyard manure (reduces volatilisation of N and encourages the transformation process)

FERTILIZERS OF MINERAL ORIGIN (2)

Fertilizers of mineral origin for organic farming (2)

Fertilizer	Origin	Characteristics	Application
Mineral potassium	Natural potassium salts (e.g. sulfate of potash, muriate of potash, kainite, sylvanite, patenkali)	› Sulphate of potash is easily available › Patentkali: high contents of Mg and S; easily available › In rock form slow reaction	› Only in case of demonstrated deficiency
Rock phosphate	Pulverised rock containing P	› Easily adsorbed to soil-minerals › Weakly adsorbed to organic matter › Slow reaction	› To compost › Not to reddish soils (as irreversibly adsorbed) and to soils with high pH
Clay	Natural	› Good nutrient and water binding capacity	› Large amounts required for soil improvement
Sulfur	Volcanic	› Sulphate of potash is easily available, but can be washed out › Elemental sulfur: slow reaction	
Trace elements	Anorganic or complexed salts	› Complexed salts are more easiliy available to plants than anorganic salts, but are more expensive	› Spraying onto plants where soil/plant nutrient deficiency is documented by soil or tissue testing or diagnosed

Sources and further reading

Infonet Biovision: https://www.infonet-biovision.org/PlantHealth/Crops/Mango

Organic mango production: strategies and methods. Government of Western Australia. Department of Primary Industries and Regional Development. Agriculture and Food. 15th March. 2018. https://www.agric.wa.gov.au/mangoes/organic-mango-production-strategies-and-methods