



Booklet

Soil fertility and fertilizers

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About AfricaRice and Afrique-learning

AfricaRice:

AfricaRice is a leading pan-African rice research organization committed to improving livelihoods in Africa through solid science and effective partnerships. AfricaRice is a research center of CGIAR, which is part of a global research partnership on future food security. It is also an intergovernmental association of African member countries. Today, it has 30 member countries. The mission of AfricaRice is to contribute to poverty reduction and food security in Africa through research, development and partnership activities, aimed at increasing the productivity and profitability of the rice sector so as to guarantee the sustainability of the agricultural environment.

Afrique-Learning:

Afrique-learning is a Beninese cooperative which creates and manages vocational e-learning courses specially designed for African youth. Courses are tailor-made in collaboration with experts in the field with the aim of producing interactive, illustrated, interesting and easy-to-study courses that provide the student with important information in simple and appropriate language. Learning is done independently at the student's own pace, it is assessed and a course certificate is attained following a final test. Courses are available on computer, smartphone or android tablet. They only require a very modest bandwidth and are therefore within the reach of students. Registration and classes are free.

Acknowledgements

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Sources of images

- [1] Fairhurst, T. (ed) (2015) Handbook of Integrated Soil Fertility Management. African Consortium for Soil Health, Nairobi.
- [2] Illustration produced by EUDOX BÉATITUDES
- [3] Photos provided by AfricaRice
- [4] https://upload.wikimedia.org/wikipedia/commons/thumb/5/56/Calcium_oxide_powder.JPG/250px-Calcium_oxide_powder.JPG
- [5] https://fr.wikipedia.org/wiki/Soja#/media/Fichier:Plante_de_Soja_-_Feuilles_et_fruits.jpg
- [6] https://fr.wikipedia.org/wiki/Arachide#/media/Fichier:Peanut_9417.jpg
- [7] https://fr.wikipedia.org/wiki/Pois_d%27Angole#/media/Fichier:Cajanus_cajan.jpg
- [8] Photo provided by Hendrik Pöhl

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- Fairhurst, T. (ed) (2015) Handbook for Integrated Soil Fertility Management. African Consortium for Soil Health, Nairobi.
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Smart-Valleys inland valley fertilization

The longer the inland valley is exploited, the more the inland valley becomes impoverished. It is therefore important to fertilize the soil to provide it with the nutrients necessary for good long-term production.

This booklet goes deeper into the concept of fertilization and specifies the main fertilizers to use.

The role of soil as a nutrient provider for plants

Soil and the plant requirements

The soil comprises 4 elements: air, water, mineral components and organic components. For a plant to grow and produce, it needs nutrients that can only be found in the soil. The soil is therefore the reservoir of nutrients for plants.

The main sources of nutrients for the plant are of two kinds. The 3 basic nutrients: nitrogen (N), phosphorus (P) and potassium (K). Secondary elements such as calcium (Ca), sulfur (S), magnesium (Mg), iron (Fe), zinc (Zn) are also added in smaller quantities and trace elements in even more reduced quantities.

It is important to know them and to make sure that none of them are lacking, in order to guarantee good soil fertility and promote productivity.

But what is the soil?



Land use for agriculture [1]

Definition and role of the soil

The “soil” is the thin layer of material on the earth’s surface, above rocks, which serves as a natural medium for plant growth. It therefore includes mineral and organic matter found in this surface layer, and promotes plant growth. A soil is therefore said to be fertile when it contains enough material to nourish the crops from the phase of germination to that of maturity.

Soil constituents

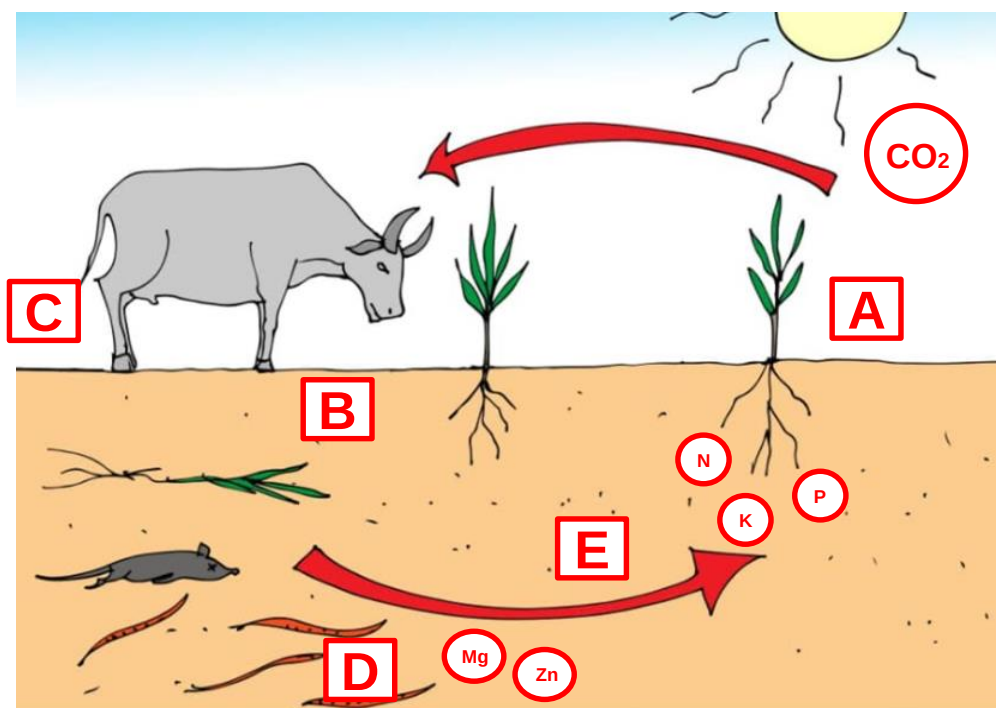
Soil comprises 4 elements: air, water, mineral material (which supports the roots) and humus which is organic matter (composed by materials of animal and plant origin).

Nutrient cycle

Plants draw mineral salts from fertile soil to grow (A). Then some of the plants are eaten by herbivorous animals (B).

The cycle is such that dead animals and plants return to the soil (C), forming the litter, where they are decomposed by earthworms, fungi and other organisms. They also become nutrients for the soil (D).

These are obviously a source of fertility (E) and therefore represent enormous agricultural potential.



Nutrient cycle [2]



Fertile soil allows a good crop growth [3]

Soil fertilization

Nutrients supplied by the soil are essential for crop growth. But they are generally present in insufficient quantities to achieve the production objectives that farmers aim for.

Because, by dint of harvests, the soil becomes depleted and becomes incapable of supplying the necessary quantities and proportions of nutrients to the plants. Erosion is also a cause of soil infertility because it removes nutrients from it. The gap between nutrient inputs to soils and their level of loss in Africa is still very large.

To assess soil fertility, we can use indicators such as: the dominance of vegetation, the presence of a particular fauna, the color and appearance of crops in times of drought and throughout their life cycle, the texture of the soil to the touch, the suitability of the soil to be worked, yield levels, etc.



Assessment of soil texture [1]

How to fertilize the soil?

Fertilizers are the main method of fertilizing the soil. They substantially improve the amount of nutrients contained in the soil and consequently the yields.

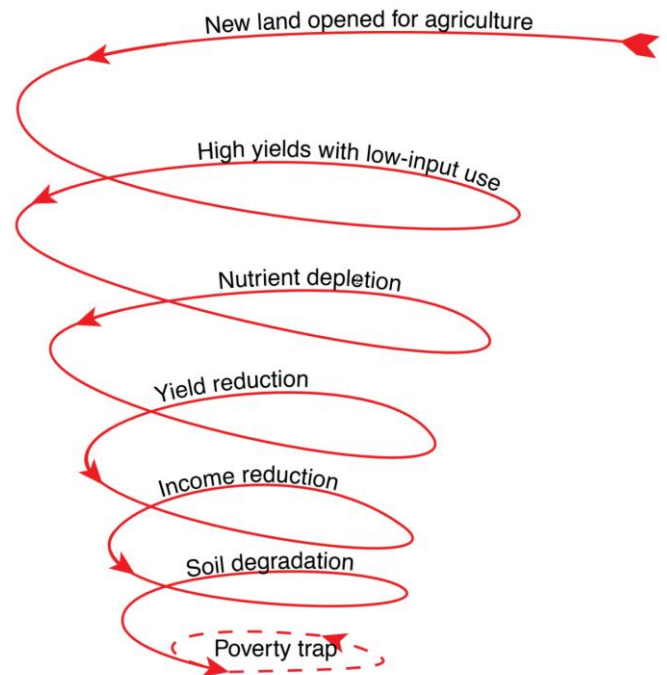
Produced by various processes, they come in the form of a concentrate of nutrients that crops readily absorb.

The use of fertilizers

The benefits of using fertilizers

The use of fertilizers has both direct (increase in agricultural yields) and indirect (increase in the amount of residue and therefore organic matter) benefits.

Thus, not using fertilizers or using little of them exposes the producer to: a decrease and depletion of soil nutrients, a drop in yield, soil degradation. And as a result, there is a decline in farmers' income and an increase in poverty.



Consequences of non-fertilization:
progressive reduction of soil fertility [1]



A fertilizer seller who offers NPK [1]

Which fertilizer to use?

Fertilizer can be used in its simple form to provide a specific nutrient to the plant, or as a mixture to provide two or more nutrients. An example of the most widely used fertilizer is NPK fertilizer.

But in all things, the farmer must take into account the type of crop, the current and past use of manure, the properties of the soil as well as the climatic conditions, in making his choice of fertilizer.

Fertilizer application

The dosage and time of application

It is very important to know the requirements of crops in order to adapt a specific amount of fertilizer to them. When the amount of fertilizer is greater than the plant's requirements, nutrients are wasted and contaminate the environment.

When this quantity is lower, the quality of crops is poor, the rate of yield drops and the quantity of crop residues drops. The operating system, as well as the location of the operation, must be taken into consideration.

Regarding the spreading of fertilizers, it must be done only when crops require it. Usually the fertilizer is applied when sowing or immediately after transplanting. For rice cultivation, in addition to one of these times, the farmer will add two extra fertilizers at tillering and then at panicle initiation.

Then the cover doses are adjusted according to the growth rate of the crop.



Fertilizer dosed using a capsule [1]

Method of application

It is a function of the workforce, the crop and the soil.

- 1st principle: The farmer makes sure to weed to eliminate all weeds.
- 2nd principle: The fertilizer is applied to a slightly wet soil. This facilitates the absorption of nutrients for the plant and prevents nitrogen from volatilizing as a gas.

Broadcast application: Before sowing or when the crop is in place, the farmer applies the fertilizer evenly to the soil surface.

Band spreading: The farmer spreads the fertilizer in a pre-dug 5 to 8 cm deep band, then plants the seeds over the covered fertilizer.

Spot application: When sowing, the farmer applies a small amount of fertilizer in each pocket with the seed. Or, in the growth phase, applies it close to the plant.

Deep placement: The farmer places slow release nitrogen fertilizers in the soil of flooded fields.



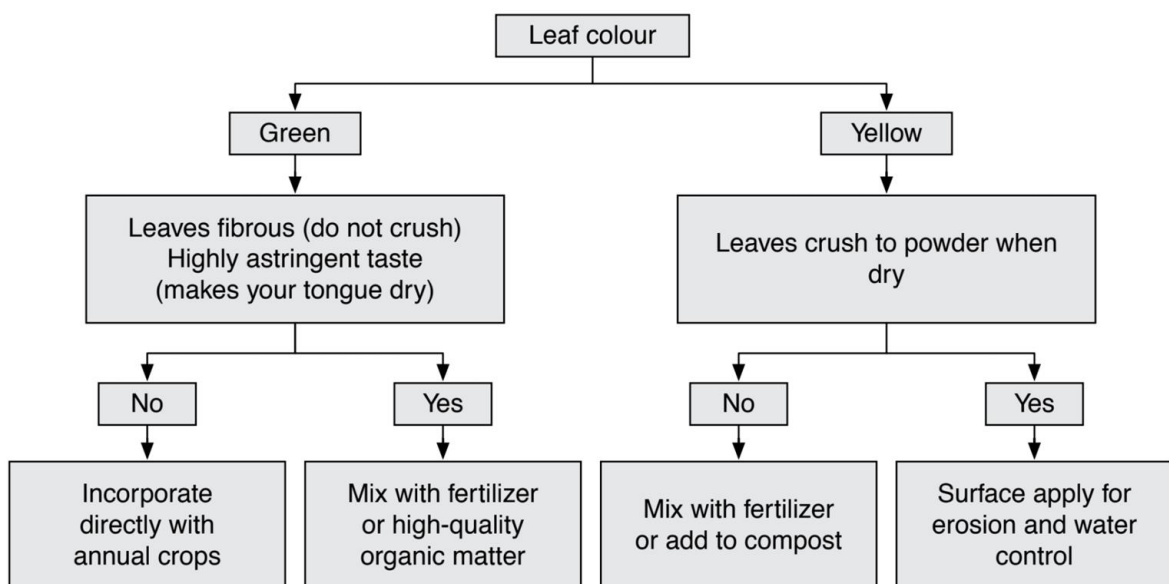
Band spreading [1]

Organic inputs

Poultry manure, biochar and cow dung are organic inputs rich in nutrients essential for plants. Once in contact with the soil, they are broken down by bacteria and fungi, which release nutrients. It is important to know how to sort and choose the materials because the rate at which nutrients are released depends on it.

Because leaves decompose faster than wood, for example, and the decomposition time can differ from one leaf to another, you have to be careful about which material to exploit directly, which to compost and which to use as a ground cover to counteract erosion.

This diagram will guide you in this regard:



Categorization and use of leaves as organic inputs [1]

Benefits of organic inputs

They promote the absorption of mineral fertilizers by crops as well as the retention of moisture by the soil. They provide the soil with organic components in addition to the nutrients from mineral fertilizers, and help reduce soil acidity.

But the wrong methodology can cause fertilizers to lose their nutrients. It is recommended that you incorporate crop residues into the field and then use others as fodder for livestock. It is also important to make compost to sustain the crops. But in general, it is necessary to favor a mixture of mineral and organic materials for better yields.

Mineral fertilizers

These are products containing at least 5% nitrogen, phosphorus or potassium, the 3 main plant nutrients. Mineral fertilizers are usually either produced by the chemical industry or mined from the soil. They are very effective and often necessary in addition to organic inputs. Another example of a mineral fertilizer is ash.

However, we must take care to maintain or even proportionally increase the amount of organic matter in a soil when applying mineral fertilizers, to avoid increasing soil acidity and decreasing productivity.

Advantages of mineral fertilizers

They serve to replenish nutrients in already impoverished soils in several regions of the African continent, in particular. With the obvious insufficiency and difficulty of managing large amounts of organic inputs, the addition of mineral fertilizers serves to strengthen the soil.

The crops thus regain the balance necessary for their good growth.

However, be careful not to overdose and avoid exclusive application of mineral fertilizers, as this can make the soil acidic (low pH) and therefore infertile. Indeed, an acidified soil handicaps the decomposition of organic matter, destroys phosphorus in particular and therefore reduces the soil's organic and nutrient content.

To reduce the acidity of the soil, lime is very useful, although it is expensive and not very readily available.

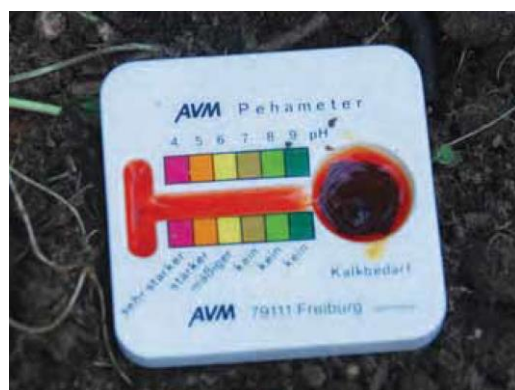
How to apply lime?

The amount of lime to apply depends on the degree of acidity of the soil. This is why sandy soils only need small amounts of lime, unlike clay soils which are by nature very acidic.

Lime should be applied at the time of soil preparation, between 0 and 15 cm deep.



Lime [4]



A pH meter® is a useful low cost tool for measuring soil pH in the field [1]

Application examples for rice production

The case of NPK fertilizer

When sowing, apply NPK rice fertilizer at the rate of 200 kg / ha.

NPK cotton respects the same dosage. But it is not recommended that you use NPK fertilizer when leveling. You could induce the proliferation of weeds, which are very harmful to the nutrients.



The application of NPK [2]

The case of urea

Rich in nitrogen, its application requires the evacuation of water from plots when water depth exceeds 5 cm. Urea can be applied in two ways depending on the length of the rice growing cycle:

- once between 30 and 35 days, then a second time between 45 and 50 days for varieties with a short cycle (90 - 100 days)
- once between 45 and 50 days then a second time between 60 and 65 days for varieties with a long cycle (110 - 120 days)

Regardless of the cycle, it is important to take into account the amount of water in the inland valley. Urea is applied by band when the water has been evacuated, and by broadcasting when it has not been evacuated.



The application of urea [2]

Keeping the soil fertile: other approaches

Harnessing legumes

Legumes are special in that they enrich the soil with nitrogen, thus nourishing the crop that will follow. They are grown in poor soils and require little or no manure, which reduces the needs of these crops and therefore the work of the farmer. In addition, they prevent soil erosion when used as a cover crop.

Examples of legumes: peas, Mucuna, soybeans, cowpeas, peanuts, beans, pigeon peas, ...

This is why a rotating legumes and cereals is recommended. Mineral fertilizers are therefore no longer essential.



Soybeans [5]



Peanuts [6]



Pigeon pea [7]

Farming practices to respect

We must take care to properly prepare the soil to properly establish the crops. The date of sowing depends on the start of the rainy season. The distances between the seed rows, then between the plants and the number of plants per pocket must be appropriate.

The depth of planting must also be observed and the weeds removed in time. It is important to weed just before applying the cover fertilizer. Otherwise, the weeds absorb the fertilizers to the detriment of the crops.

Crop rotation must be practiced, especially for intensive rice cultivation.



Crop rotation with soybeans [8]