HomeBiogas

HomeBiogas Biofertilizer

User guide

HomeBiogas

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01 Biofertilizer- overview

Biofertilizer is an organic liquid fertilizer, which is made by breaking down organic matter, such as food waste and animal manure, in an anaerobic process (digestion without oxygen). Biofertilizer contains organic compounds of low molecular weight, with a high recycling and absorption speed. Easily mineralized by microorganisms, it enhances crop productivity by producing readily available nutrients and minerals for plant roots and/or leaves. It also boosts sustainability in crop production helping to improve both the environment and consumer health.

Composition

The composition of biofertilizer varies according to the type of organic matter used. For example, where organic waste (animal manure or food waste) is used, it may depend on factors such as feeding rate, breeds, ages of the animals, and water composition.

The HomeBiogas biodigester creates biofertilizers with a wide range of macroelements, microelements, microorganisms, biostimulants, and dissolved organic matter (DOM). See Table 1. These elements contribute to improved soil structure and fertilization, helping to grow and to develop much healthier and more productive plants.

Table 1 Nutrients present in the biofertilizer

Macronutrients present	Micronutrients present
N, P, K, Ca, Mg, S	B, Cu, Fe, Mn, Zn, Cl-, Mo, Na, Ni

The importance of micronutrients

For all plants, micronutrients are as crucial as macronutrients, albeit in smaller quantities. Micronutrients help plant absorb macronutrients at a pace that is consistent with nature. Yet, the high-quality NPK fertilizers typically used today in place of traditional fertilizers, do not contain high quantities of micronutrients. The low of minimum illustrated below, states that crop growth is dictated not by the total resources available, but by the availability of the resource that is most scarce in relation to need. In the illustration, we see how if any stave of the barrel is missing, the water will drain to the level of the lowest stave. Similarly, insufficient levels of micronutrients will prevent crops reaching their full potential, even if all other elements are present in the correct quantities.

Biofertilizer can be used for:

- Seed and root treatment
- Soil preparation
- Crop fertilization
- Pest and disease management
- Animal feed supplement

In this guide, we focus on soil preparation and crop fertilization. The biofertilizer can be used to fertilize crops directly or added when composting other organic materials.

The table below shows an example of the macroelements and microelements of a Kenyan system fed with farmyard cow manure. Since biofertilizers vary according to the organic waste used and have different demographics, the example below is only representative of the system where the samples were taken.

Law of the minimum illustration representing how lack of nutrients is the bottleneck of yield.

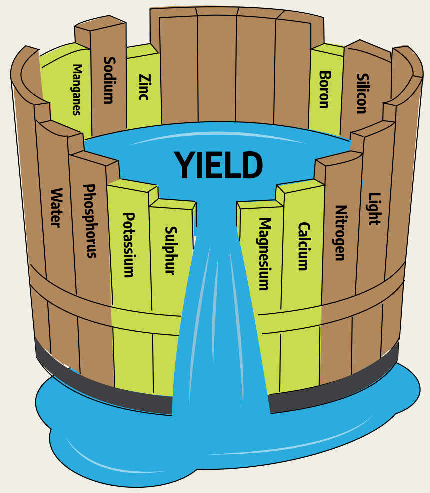

Table 2 Laboratory test example of macro and microelements from a farm system fed with cow manure in Kenya

Biofertilizer composition from a farmyard cow manure

Marcoelements								
Sample	Ph	Electrical conductivity (ms cm-1)	Nitrate (ppm)	Phosphorus (ppm)	Potassium (ppm)	Calcium (ppm)	Magnesium (ppm)	Sulphr (ppm)
Cow manure	6.7	4.55	175	40.2	857	63.4	14.2	9.92

Microelements								
Sample	Boron (ppm)	Copper (ppm)	Iron (ppm)	Manganese (ppm)	Molybdenum (ppm)	Zinc (ppm)	Sodium (ppm)	Chloride (ppm)
Cow manure	0.16	0.039	3.01	0.76	<0.01	0.17	70.1	187

Biofertilizer production in the HomeBiogas system

The HomeBiogas system works in continuous flow-organic waste fed into one end equals the fertilizer output from overflow.Table 3 below shows the amount of liquid fertilizer produced per system per day (assuming maximum input).

Table 3 Amount of biofertilizer produced (in liters) per system per day

Type of system/ Feeding type	Daily input of	Daily input of animal manure (ratio 1:2 - animal manure:water)	Total food waste and slurry (animal manure after dilution)
HBG 2	6 liters	16 liters animal manure + 32 liters water= 48 liters slurry	54 liters
HBG 4	12 liters	28 liters animal manure + 56 liters water= 84 liters slurry	96 liters
HBG 6	18 liters	43 liters animal manure + 86 liters water= 129 liters slurry	147 liters

As the organic matter is processes, flammable gas is created. A month after this starts to happen, the biofertilizer is ready to use.

Before that, during the first 30 days it is recommended to reuse the liquid that is released from the HomeBiogas system to dilute the animal manure being input into the system. This will increase the quantity of nutrients and bacteria within the digester.

02 Soil and biofertilizer analysis

Watch video >

In order to accurately calculate the application rate for the biofertilizer, both a soil analysis and a biofertilizer analysis must be carried out. The protocol for how to do this can be found in Annexes I and II to this document.

Once the relevant laboratory results have been obtained, next stepis to carry out a nutritional balance analysis - comparing the nutrients in the soil to the nutrients required by the crop, to ensure that the biofertilizer and chemical fertilizer provide the missing components.

See Section 3 below for details of how to do this:

- Check your soil type
- On what crops the biofertilizer will be applied
- Compare the soil analysis, and complement the needs of the crop with the biofertilizer and chemical fertilizer- this is called “nutritional balance”, which is explained in the next section (Biofertilizer application methods)

03 How much biofertilizer to apply

Once you have the results of the soil and biofertilizer laboratory analysis, you must adapt the usage of the biofertilizer to the specific needs of your soil and crops.

The biofertilizer produced by the HomeBiogas biodigester contains many nutrients, making them available to the crops to support growth.
Other advantages include enhancing the structure of the soil, providing organic matter and microorganisms that will help retain humidity (soil moisture) and nutrients, and decomposing the chemical nutrients that are in the soil and making them available to the crops.
With the soil and biofertilizer test results ready, you can use the “nutritional balance” method to estimate the gap between the number of nutrients that the crop requires and the amount the soil can provide, and calculate the necessary dose to apply to correct any deficiency. Note: according to the 'efficiency factor', plants can only recover a fraction of the fertilizer applied, and therefore, the dose will necessarily be higher than the estimated deficit.

Follow the guidelines for nutritional balance in the **Balance Excel** and use the Excel Calculator to calculate the correct application rates for your crop and soil types
This will guarantee that the soil and crop will receive exactly what is missing and required.
It is recommended to use the services of an agronomist to make the calculations.

Calculating the correct amount of biofertilizer for your crop

Step 1 Gather information

- Define the crop needs (crop area, days of production between sowing and harvest, sowing depth, sowing density, variety, etc.)
- Soil nutritional contribution (laboratory analysis)
- Biofertilizer nutritional contribution (laboratory analysis).

Step 2 Calculate crop needs

- Enter the gathered information gathered in **Step 1** into the green spaces on the Nutritional Balance Excel.
- Double-check that the information entered in the correct cells.
- Consult a local agronomist to interpret the results.

The information generated in the Excel will give you a better basis for making a decision on how to apply your biofertilizer and any possible reduction in the use of chemical fertilizer, which can increase savings.

In the even that there is no agronomist available to make the calculation above, the table below provides general guidelines on how much biofertilizer to apply per crop. publication: num 1

Table 4 Amount of biofertilizer to be applied per crop2 (by Hivos)

Group	Crop	Tons/Ha	Liter/m²
Basic staplerops	Banana	50-60	5-6
	Barley	10-20	1-2
	Cassava	10-40	1-4
	Corn	10-25	1-2.5
	Millets	6-20	0.6-2
	Potato	10	1
	Rice	40	4
	Sorghum	15-25	1.5-2.5
	Teff	5-20	0.5-2
	Wheat	15	1.5

Group	Crop	Tons/Ha	Liter/m²
Vegetables	Alfalfa	5-10	0.5-1
	Cabbage	10-20	1-2
	Carrot	5-10	0.5-1
	Chillies	10	1
	Sweetcorn	5-10	0.5-1
	Cucumber	15	1.5
	Eggplant	10	1
	Kohlrabi	20	2
	Komatsuna	10-20	1-2
	Lettuce	10	1
	Okra	10	1
	Onion	10-25	1-2.5
	Radish	10-20	1-2
	Spinach	30	3
	Tomato	10-25	1-2.5
	Turmeric	10-20	1-2

Group	Crop	Tons/Ha	Liter/m²
Fruits	Grapes	10-20	1-2
	Blueberry	10-20	1-2
	Mulberry	10-20	1-2
	Mango	10-20	1-2
	Papaya	5-10	0.5-1
	Watermelon	5-10	0.5-1

Group	Crop	Tons/Ha	Liter/m²
Pulses	Castor bean	10-20	1-2
	Gram	10	1
	Guar	10-20	1-2
	Peas	10-20	1-2
	Pigeon pea	10-20	1-2
	Soybeans	10	1
	Tabe bean	10-20	1-2
	Groundnut	10	1

Group	Crop	Tons/Ha	Liter/m²
Other crops	Cotton	0-15	0.015
	Coffee	20-50	2-5
	Deccan hemp	10-20	1-2
	Elephant grass	10-20	1-2
	Mustard	10-20	1-2
	Red Pepper	10-20	1-2
	Tea	10-20	1-2
	Tobacco	15	1.5
	Sugar cane	10	1
	Sunflower	15	1.5

1 Reference - Bioslurry: a Supreme Fertiliser, by Hivos.
https://www.ourenergypolicy.org/wp-content/uploads/2014/05/bioslurry.pdf

The table below presents an example of the amount of biofertilizer to be applied per crop, per stage in the crop lifecycle The figures have been calculated according to biofertilizers sampled in Kenya.

Table 5 Biofertilizer application per crop per stage (using 100% biofertilizer)

Crop	Amounts required at each stage in l/ha/period					Period
	Pre-treatment[2]	Plant e	Vegetative[3]	Flowering [4]	Before fall [5]	
Vegetables	2000 l/ha	4500 l/ha	6750 l/ha	—	—	Per season
Short-term vegetables	2000 l/ha	1,028 l/ha	4,500 l/ha	—	—	Per season
Corn	2000 l/ha	2,250 l/ha	9,000 l/ha	6,750 l/ha	4,500 l/ha	Per season
Tomatoes	2000 l/ha	2,250 l/ha	9,000 l/ha	6,750 l/ha	4,500 l/ha	Per season
Onions	2000 l/ha	2,250 l/ha	9,000 l/ha	6,750 l/ha	4,500 l/ha	Per season
Coffee	2000 l/ha	4,500 l/ha	18,000 l/ha	13,500 l/ha	9,000 l/ha	Per year

The biofertilizer requires dilution. In order to maintain healthy soil, it is important to follow the dilution guidelines in Table 6.

Table 6 Biofertilizer dilution rate (meaning 1:x = 1 liter biofertilizer per x liters of biomass)

Feeding type	System age	Dilution rate
Food waste	1–6 months	1:1
	6 months and beyond	1:2
Animal manure	1–6 months	1:2
	6 months and beyond	1:3
Food waste + animal manure	1–6 months	1:2
	6 months and beyond	1:3

2) Pre-Treatment - soil preparation before planting
3) Plant establishment
4) Vegetatitive stage - the stage between the first leaf production and before flowering
5) Flowering - The formation of the flower
6) Before fall - the process of the flower falling off due to the formation of the seed from pollination through the flower.

04 How crops absorb biofertilizer

The Biofertilizer can be absorbed by plants through two main mechanisms:

Soil and roots   Foliar

Biofertilizer absorption through soil & roots

The most common and effective method for plants to take up essential nutrients from the soil is through their roots. The essential organ for the uptake of the nutrients on the root is their root hair. This nutrient uptake can be altered by the structure of the root. Nutrient ions are transported to the stele at the center of the root, in order for the nutrients to reach the conducting tissues, xylem and phloem, that will then distribute these nutrients where the plant needs them the most.

Plants also absorb water and nutrients through their root system, and carbon dioxide from the environment. The combination of nutrients that come from biofertilizer or mineral fertilizer, with water, carbon dioxide, and sunlight produces the energy that enables plants to grow and reproduce.

Biofertilizer can be applied to the soil by five fertigation technologies:

1. manual
2. surface
3. drip
4. sprinklers
5. sprayers

Foliar absorption of Biofertilizer

Foliar fertilization is the process where the nutrients are absorbed through stomata in the plants leavs. While the soil application method is more common and most effective for nutrients that are required in greater quantities, this can also be an effective method of absorbing nutrients, potentially achieving a larger crop yield.

Foliar application is achieved by applying the fertilizer onto the surface of the leaves, where it can penetrate more readily via cuticular cracks, stomata, trichomes, or lenticels, and reach the target cells where the nutrients are required. Biofertilizer can be applied to the foliage in two fertigation technologies: (1) sprinklers or (2) sprayers.

Sprinkler or spray irrigation works similarly to natural rainfall. Water is pumped through pipe systems before being sprayed into the air through a sprayer or sprinkler nozzles that send out tiny droplets towards the ground.. The difference between a sprinkler and a sprayer is that a sprayer breaks water into tiny droplets and gives a much more precise calculation of water.

*When applying the biofertilizer by foliar irrigation, make sure to use personal protective equipment (PPE): breathing mask and eye protector.

05 Soil Treatment

Watch video >

Pre-treatment

The soil requires a minimum two-week pre-treatment before seed sowing. This process is called the resting period, which allows the soil to restructure and increase microbial activity.

Pre-treatment process:

Planting

01 Pot or seed tray preparation
- Mix 1 part biofertilizer (1 L) with 3 parts soil (3 kg)
- Put the mixture into small seed pots
- Add water
- Plant seeds

02 Seedbed preparation
- Remove topsoil (1 x 1 x 0.10 m)
- Return topsoil mixed with biofertilizer
- Add wate
- Plant seeds

Perennial crops
(no need to replant; these crops keep growing year after year)

Planting
- Dig a hole 1 m3 (1 x 1 x 1 m). Soil preparation requires a pit before planting
- Return topsoil mixed with biofertilizer
- Add water
- Plant seeds

Annual crops
(need to be sown annually; these plants complete their life cycle in one year)

01 Poor soil quality
- Plough an area of 1 m x 1 m x 0.25 m
- Return topsoil mixed with biofertilizer
- Add water
- Plant seeds

02 Maintaining soil structure
- Plough an area of 1m x 1m x 0.10 m
- Mix 1 L. of biofertilizer with the removed topsoil
- Add water
- Plant seeds

03 Planting pits
- Spread 1 L biofertilizer or 1 kg compost onto 1 m of soil (1 L or 1 kg/1 m2)
- Mix 2 parts water with 1 part biofertilizer or 1 part compost and 1 part removed topsoil
- Add water
- Plant seeds

Fodder crops
(used to feed livestock)

- Spread 1 L of biofertilizer or 1 kg of compost on 1 m of soil (1 L or 1 kg / 1 m²)
- return topsoil mixed with biofertilizer
- Add water
- Plant seeds
- Continue feeding as plants become established

Basal treatment

This is the process where fertilization takes place after planting the crop. Fertilization is carried out according to the explanation in Table 2 above (Biofertilizer application per crop per stage).

Perennial crops
(no need to replant; these crops keep growing year after year)

01 Basin
- Dig a 60 cm circle around the plant
- Add biofertilizer diluted 1:2 with water or as advised by your local agronomist
- Cover and add water

02 Covered trenches
- Dig a trench to the side of the plant (0.60 m x 0.60 m)
- Add biofertilizer diluted 1:2 with water or as advised by the agronomist
- Cover and add water

Annual crops
(need to be sown annually; these plants complete their life cycle in one year)

01 Covered trenches
- Dig between rows (0.10 x 0.10 m)
- Add biofertilizer diluted 1:2 with water or as advised by the agronomist
- cover and water

02 Top dressing
- Use 0.5 L biofertilizer solution per week, diluted 1:2 with water, for every meter cultivated
- Add wate

03 Applying with a watering can
- Mix water and biofertilizer 2:1
- Add water

Fodder crops
(used to feed livestock)

- Dig between planting rows
- Add biofertilizer diluted 1:2 with water as advised by the agronomist
- Add wate

All crops
(annual and perennial)

Dilute biofertilizer 1:2 with water:
- Filter
- Irrigate
- Stop irrigation during flowering or 2 weeks before harvesting

*** Biofertilizer can be applied to the soil with a bucket or through surface irrigation, drip irrigation, sprinkler irrigation, or sprayer irrigation systems. Sprinkler irrigation or sprayer irrigation system can be used for foliage application.**

Aerobic compost

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In aerobic compost, organic material decomposes with the help of bacteria and microorganisms, and the use of oxygen. The process provides a rich source of organic matter and enhances soil fertility by increasing its humus content. In addition, the physicochemical and biological properties of the soil are improved.

Humus, a byproduct of aerobic compost, helps the soil retain water and nutrients (especially sandy soil). Furthermore, the composted soil can loosen the tightly bound particles in clay or silt, allowing roots to spread, water to drain and air to penetrate. By, altering the soil structure, in this way it makes erosion and the spread of disease in the soil less likely.

There are two main types of compost: homemade, and mechanically produced. To read more on this, please refer to ANNEX IV

01

Organic waste should be separated as follows

- Leftover food waste and animal manure should be placed in the HomeBiogas system
- Garden waste/farming leftovers, citrus peels & eggshells should be left to compost aerobically

02

A successful aerobic compost process requires

- Humid environment of 55% moisture
- Carbon-nitrogen ratio of 30:1 (C:N)
- Aeration of the compost heap

03

The standard method is to mix biofertilizer into compost containing:

- Dry matter—dry organic waste (garden clippings, leaves)
- Green matter—fresh organic waste (weeds)
- Soil

To enrich your compost heap with the liquid biofertilizer produced by the HomeBiogas biodigester, follow these steps:

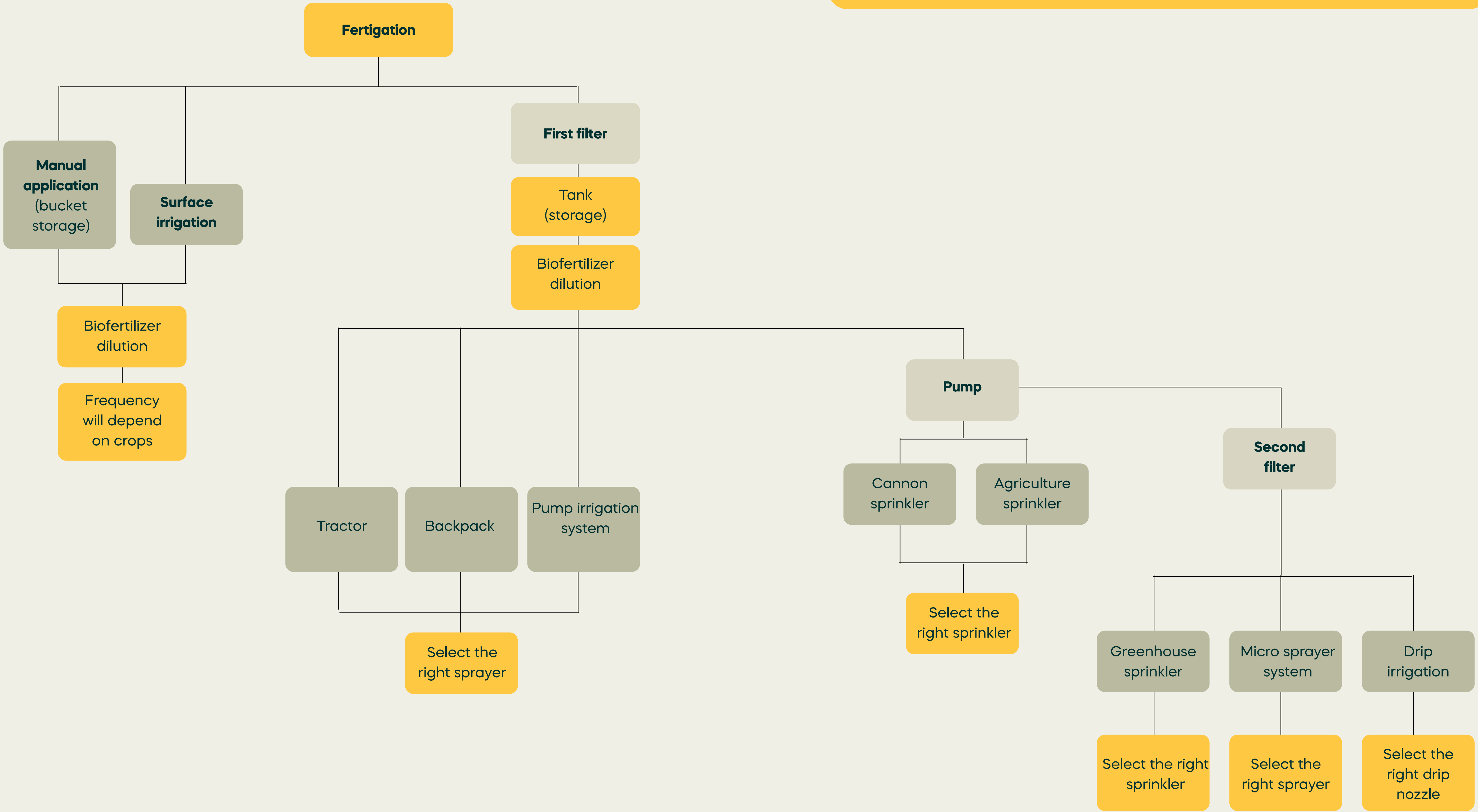
1. Instead of sprinkling water, sprinkle the biofertilizer on the top layers. Apply only enough to percolate to all layers; - 1 L of biofertilizer per 1 m2 on a 0.15 cm layer, too much biofertilizer will affect the proper decomposition of the heap.
2. Apply biofertilizer every time you mix the compost heap.

Tip If biofertilizer needs to be stored for an extended period of time, adding it to your compost heap is a perfect solution. Compost that contains added fertilizer will boost crop production and improve the quality of the soil when applied.

06 Methods of fertilization

*Check the biofertilizer dilution in **Table 6** above

Importent Fertilization is only carried out between pre-planting and the emergence of the first fruit (before the fall stage).



Getting the biofertilizer from the biodigester to the crop


Kenya

Manual fertilization

(Bucket/pitcher/watering can)

In this method, fertilizer is applied is directly to the soil. Apply fertilizer, to one side of the plant stem, or near the ends of the roots. The application rates and quantity of liquid fertilizer to be applied directly to the soil will vary according to the crop and plant development stage.

Watch video >


India

Surface irrigation (flood irrigation)

With the surface irrigation method, water is distributed over the soil surface by gravity. There are three types of surface irrigation: level basin, furrow, and border strip. Biofertilizer can be mixed with running water across the field. To avoid leaching of nutrients from the biofertilizer, pleaseTable 6 above for dilution rates.

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Sprinkler, sprayer, drip irrigation

Sprinkler, sprayer, and drip irrigation systems enable better control of the quantity, quality, and efficiency of the irrigation. Sprinkler and sprayer irrigation systems irrigates the soil and/or foliage through sprinkler/sprayer guns or nozzles. Each sprinkler/sprayer covers a circular area, reaching several plants. The difference between a sprinkler and a sprayer is that the sprayer will irrigate by pulverizing the water flow. Drip irrigation only irrigates the soil through nozzles, and provides the soil with the right amount of nutrients. Every irrigation system is different and has different needs. Ask your local agronomist which types of nozzle, sprinkler, and sprayer are right for your system requirements.

After the biofertilizer is produced, the first step is to filter it. All irrigation systems benefit from having filters. Filters remove any suspended impurities in the irrigation solution, and they are the cheapest way of guarding against suspended matter entering and blocking your irrigation system. Filters keep the pipes, drip nozzles, sprinklers, and sprayers free of obstructions. They ensure that your irrigation system is protected from blockage damage and they protect crop health, reduce costly maintenance and extend the life expectancy of your irrigation system.

For all these irrigation systems a first filter is needed. The first filter should be fitted after the biodigester exit and before the tank entrance. Its purpose is to stop large suspended particles from accumulating in the tank, preventing malfunction and clogging up of the pump, pipes, and nozzles. Plastic mesh or cloth can be used as the filtration media.


Drip irrigation


Sprinkler irrigation


Sprayer irrigation

First filter

After the biofertilizer is produced, it must be filtered before it is applied to the crop, regardless of the fertilization method used. As the cheapest way of removing any suspended impurities in the irrigation solution and keeping pipes, drip nozzles, sprinklers, and sprayers free of obstructions, filters ensure that your irrigation system is protected from blockage damage, protect crop health, reduce costly maintenance and extend the life expectancy of your irrigation system. Fitted after the biodigester exit and before the tank entrance. The first filter can be inline or made with a DIY cloth. After dilution, the biofertilizer is ready to be used.

01

Mesh filter (inline)

Mesh filter requirements:

- material: plastic
- mesh size: holes should not be larger than 2 mm

02

Cloth filter (DIY)

If plastic filters are unavailable, a DIY method can be used by applying cloth, such as an old T-shirt, to the filter to remove large particles.

Types of fertilization that require only a first filter:

Backpack sprayer:

After dilution and filtration, the biofertilizer is ready to be used with the backpack.

- Add the fertilizer to the backpack
- **Tip:** apply the fertilizer when the weather is not too hot and sunny to avoid evaporation
- Spray all over your crops or trees
- Backpack sprayer: ≥ 3 mm sprayer

Watch video >

Tractor Sprayer:

After dilution, the biofertilizer is ready to be used with the tractor sprayer system.

- Add the fertilizer to the tractor tank
- **Tip:** apply the fertilizer when the weather is not too hot & sunny to avoid evaporation
- Spray all over your crops.
- Tractor sprayer: ≥ 3 mm sprayer

Watch video >

Pump/Venturi:

Certain irrigation methods need to be connected to a pump after the biofertilizer has been filtered and diluted.

It is recommended to use an INOX pump - the size will depend on the irrigation system selected.

Types of fertilization that require a first filter and connection to a pump/venturi:

After the pump, these two irrigation systems will only require the selection of the suitable nozzle.

Cannon/gun sprinkler:

Nozzle size will depend on the length ratio for watering, and the timing and flow planned for the irrigation system

Agricultural/garden sprinkler:

(Nozzle size will depend on the planning of the irrigation system).

Second filter

(Nozzle size will depend on the planning of the irrigation system). After the pump, the irrigation methods set out below will require a second filter, to prevent particles from accumulating inside the piping system and blocking the nozzles. If nozzles become obstructed, the pressure within the irrigation system increases, risking malfunction and disruption to the dilution rate, fertilization timing, and application.

Types of filters:

Disc

llow disk filter
(80 mesh/200 microns)

Mash

- 80 mesh for drip, and some micro sprayer, irrigation systems
- 50 mesh for agricultural / garden, greenhouse, and some micro sprayer irrigation systems

Types of fertilization that require a first filter, connection to a pump/venturi and second filter:

Greenhouse sprinkler

For standard sprinkler/sprayer systems:
2.3 mm to 3 mm sprinkler

Drip irrigation

A drip irrigation system irrigates a more accurately calculated amount of water through drip nozzles and delivers water to the soil, directly to the crop roots.

Suggestions:

- Make sure drip holes are located on the upper part of the pipe, to avoid accumulated organic matter obstructing the drip holes.
- Use nozzles of at least 2 L/hour (0.5 gph). The best ones are above 4 L/hour (1 gph).
- The best dripper to prevent clogging is a heavy wall pipe, high quality with a non-compensated, flow rate.

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Micro-sprayer

For standard sprinkler/sprayer systems:
1.5 mm to 2.33 mm sprayer

System maintenance

All irrigation systems require maintenance.
The procedure is set out in the following steps:

01 Clean the filters as frequently as possible after using the system, preferably after each use. Accumulation of organic matter may occur and could cause future problems with system functionality.

02 Check drip nozzle, sprinkler, and sprayer functionality. If the irrigation system is not working correctly, remove and clean the drip nozzles, sprinklers, or sprayers, and clean.

03 To clean the piping system, let the system run 1.5 times longer than it would normally take for the pipe to fill.

04 To keep the irrigation system clean, use only water at the beginning, followed by fertilizer, followed by just water at the end.

05 Clean the system with water, and occasionally use a cleaning solution of your choice (acid/chlorine/hydrogen peroxide H2O2). Piping and laterals should be flushed through every few weeks.

How to store the biofertilizer

Watch video >

After filtration, it is recommended to store the biofertilizer in a tank. Storage will allow use of the fertilizer when necessary .

The fertilizer should be diluted in the tank, please refer to **Table 6**

- In the shade
- Store for up to 6 months
- Do not use a transparent receptacle
- To allow gases to escape, use a breathable cap and do not close the cap too tightly.

Storage cans in Ecuador

Pesticide reduction by using biofertilizer

Biofertilizer supplies plants with nutrients, which increases plant vigor and boosts the physiological processes that give them the ability to naturally resist attack from pests and diseases. It also improves the soil structure, so the plants can take up antioxidants present in the biofertilizer, reducing the free radicals that cause stunted growth and disease.

The anti-pest properties of biofertilizer (based on sensitivity testing) reduce and prevent attack from fungal, bacterial, and viral diseases. Using biofertilizer therefore reduces the need to use bactericides, fungicides, or nematicides.

Biofertilizers can also disrupt the reproductive cycle of pests, reducing the pest population and thus further reducing the need for pesticide application.

Annex I - soil analysis

Watch video >

Introduction:

Soil sampling is essential for building sustainable soil fertility and devising an optimal fertilization program. However, it depends on the protocol used in sampling soil for analysis. Previously, a sample was a representation of 2 hectares; however, human activities, fertilization programs utilized, and continuous use of the land had an impact on soil sampling representation. Because of this, there is a growing need to characterize the variability in nutrients across the field. Each sample should represent 1 hectare or less for the best characterization of nutrient variability within the field to serve as a guide for the variable-rate application of crop nutrients. Where field variability is low, larger sample areas are acceptable, but where variability is high, more samples are needed to adequately represent the field adequately.

How to select soil samples:

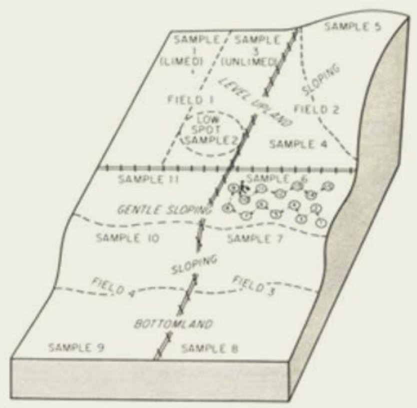
Soil samples are collected to take account of the following factors:

- Soil type
- Previous cropping history
- Slope
- Soil color
- Drainage
- Previous fertilization applications

If the land where you intend to collect your samples has any of the above variations, each variation will need its own sample representation. Areas that differ from the above MUST be sampled separately.

Example:

In this image, there are **11 sampling areas** based on ground topography (slopes, steep and gentle; and lowland), soil types, soil color, and drainage



Determination of soil sampling

Topsoil samples → from 0–25 cm, for:

- tree crops and deep-rooted crops
- shallow-rooted crops
- Subsoil samples → from 25–50 cm, for:
- Crops—tree crops and deep-rooted crops

Cultivation practices. In areas where heavy machinery is used, soil tends to be harder, so it is difficult to obtain a soil sample at the correct depth. This may lead to erroneous sample results. In this case, watering the area where samples are to be collected is recommended.

How to collect samples

Equipment needed:

01

Shovel

02

Bucket

03

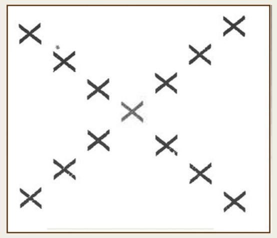
Sample bags

04

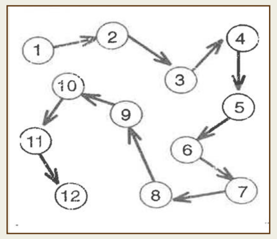
Labels/marker pens

Procedure:

1. Select core points (soil collection points). It is recommended that the cores are collected in a zigzag pattern, as shown in the image titled ZigZag Method.
2. Put the cores in a bucket and mix thoroughly.
3. Label each sample bag and fill it with 500g of thoroughly mixed soil as a representative sample.
4. Take the sample to the lab for analysis within 24 hours.



Traverse mathod



Zig zag mathod

Always remember to remove any surface debris before sampling, This may be

1. Dead or back furrows
2. Fence rows, old or new
3. Old roadbeds, or proximity to limestone gravel roads
4. Terrace channels
5. Windbreaks or snow fence lines
6. Turn rows
7. Spill areas
8. Added fertilizer brands, including anhydrous
9. Unusual or abnormal clods

Parameters to consider

1. Macro and micronutrients
2. Electrical conductivity
3. pH
4. Soil density
5. FDA (Fluorescein Diacetate) – Tests microorganism activity in the soil
6. OM (Organic Material)
7. C-N ratio

Annex II - Biofertilizer analysis

Watch video >

Introduction:

Biofertilizer sampling is essential for building a sustainable fertilization program. Results obtained from the biofertilizer analysis help in guiding the application rate, according to the soil state (from the soil analysis results) and crop type. Because the fertilizer is organic, the degradation (loss of nutrients) rate tends to be higher than with synthetic fertilizer, due to environmental factors. Therefore, it is crucial to understand the degradation rate of the fertilizer after considering possible conducive environmental factors for storage (it is important to prevent exposure to sunlight).

How to collect samples

Equipment needed:

01

Glass/polythene bottle

02

Bucket

03

Labels/marker pens

Procedure:

NOTE: It is recommended that sample collection be carried out by a laboratory technician

1. Add at least 5L of water into the system. Drain off the first 5L of biofertilizer before obtaining fertilizer from the system.
2. (OPTIONAL) In the event that your container is not wide enough, to access samples directly drain the fertilizer into a clean bucket.
3. Pour a sample into your glass/polythene bottle.
4. Label samples accordingly.
5. Keep samples in the shade. Refrigeration is recommended in areas with very high temperatures. Please follow the storing instructions on PAGE 26.
6. Deliver the sample to the lab within 12 hours.

If the fertilizer is to be stored and you wish to check the degradation rate:

7. Follow steps 1-6 above to collect samples of two-day-old fertilizer from the stored biofertilizer.
8. Repeat the process as on day seven ascertain the degradation rate.

Recommended parameters

The recommended test parameters for laboratory testing include:

1. Macronutrients—nitrate, ammonium, phosphorous, potassium, calcium, magnesium, sulfur
2. Micronutrients—boron, copper, iron, manganese, zinc, molybdenum, sodium, chloride
3. pH
4. Organic material
5. C-N ratio
6. Electrical conductivity

Annex III - Nutritional balance

The following information represents an example of how the Nutritional Balance Excel was calculated. The nutritional balance is expressed by the following equation:

Fertilization dose = Crop demand – (soil supply + biofertilizer supply) / fertilizer recovery efficiency

To apply the formula, we need to determine:

Crop demand: This requirement includes the extraction coefficient of nutrients obtained and the expected yield. As the coefficient of extraction is calculated on a weight basis (kg/ton nutrient), it is important to project a unit weight per crop to be harvested, normally in grams and multiplied by the number of plants per hectare and convert them to tons (divide by 1000).

Let's take as an example a production yield of lettuce established in Finca Lolita located on Santa Lucía Milpas Altas, Guatemala, that has a theoretical need of 100 kg /ha of nitrogen.

To estimate the contribution of the soil is complex since it varies depending on many factors which are very important to determine the nutrient content in the soil. The demand has a direct relationship with the biomass produced, and can be finally expressed as a function of the expected performance.

Crop demand
190 kg/ha N

Soil and biofertilizer contribution
This value is obtained from the total mineral nitrogen content present in the soil (ammonium + nitrates) and the biofertilizer, as determines by the soil and biofertilizer analysis.

Nitrogen as biofertilizer input
4.61 kg/ha available, corresponding to the result obtained by soil analysis that determined 6.8 ppm (mg/kg), assuming an apparent density of 1.0 and an approximate weight of soil per hectare of 3,000 tons. 0.12 kg/ha available, corresponding to the result obtained by biofertilizer analysis that determined 0.04 p/p %, assuming an apparent density of 1.0 and an approximate weight of soil per hectare of 3,000 tons.

Balance to cover
Crop demand - soil contribution = 190 kg/ha N – 4.61 kg = 185.39 kg/ha N.

Fertilizer recovery efficiency
An estimated 80% of recovery (80/100=0.8)

Fertilization dose: 185.39 kg/ha n / 0.8 =231.39 kg/han

To know how many liters of biofertilizer is needed to cover the nitrogen needs, we need to know:

1 kilogram	1.2 Liter of biofertilizer
0.12 kg/ha N X 1.2	0.144 L/ha N of biofertilizer
231.39 kg/ha N	231.39 L/ha N

Meaning that

231.39 / 0.144	1606.88 L/ha of biofertilizer is needed to cover the N needs
231.39 X 0.20 (20%)	46.28 L/ha N

Meaning that we need

46.28 / 0.144	321.38 L/ha of biofertilizer to cover the 20% of the crop N (nitrogen) needs. * But we also need to cover the other 80% of the crop needs with chemical fertilizers. So we need to take 80% of the 231.39 Kg/Ha
231.39 X 0.80 (80%)	**185.12 Kg/ha of N using chemical fertilizer**

To find out how much biofertilizer and chemical fertilizer you need for a specific area (for example 3,000 m2)

Hectare	10,000
Biofertilizer	321.38/10,000 = 0.032138 X 3000 = 96.414 L/area N of biofertilizer
Chemical Fertilizer	185.12/10,000 = 0.018512 X 3000 = 55.536 kg/area N of Chemical Fertilizer

The nutritional balance can also be determined with other required macroelements and microelements.

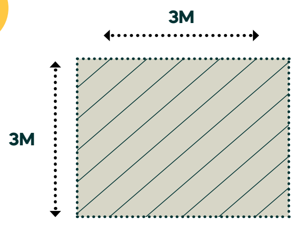
Once you have the specific nutrient that needs to be incorporated, you can consult your local agronomist about the best fertilizer formula. It is very important to keep in mind that these are REFERENTIAL ESTIMATES that can be modified according to the type of soil, antecedent of the property, considering previous rotations, fertilization level applied to the crop above, use of organic amendments (compost, plant residues, animal manure), percentage of organic matter and nitrogen supply systems already present either through irrigation or manual application.

Annex IV - Compost

Composting is the biological decomposition of organic material by microorganisms under controlled, aerobic (oxygenated) conditions to a relatively stable, humus-like material - compost. Composting can happen in many different ways using a variety of materials, methods, equipment, and scales of operation. For agricultural operations, the common materials or feedstocks that are composted are livestock manure and bedding, and various residual plant materials (straw, culls, on-farm processing of waste, etc).

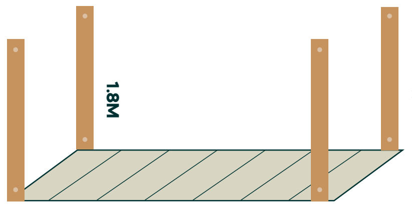
How to make DIY compost:

01



Select an area 3m x 3m

02



Add pegs at each corner of your 3m x 3m area.
The height of the pegs should be 1.8 meters. The purpose of the pegs is to help guide the farmer during preparation, and to define the area during shuffling of the heaps.

03

Add a layer of dry grass or leaves, 10 - 15 cm thick

04

Add a layer of waste/green matter-prepared and mixed - 15 cm thick

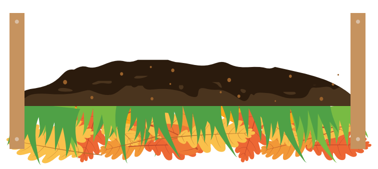
05

Add a2cm-thick layer or 18 L of biofertilizer to the pit.

06

Recomnded Add a layer of ash - 2 cm thick Adding ash introduces potassium and calcium, which will help in the decomposition process and regulate the pH in the pit.

07

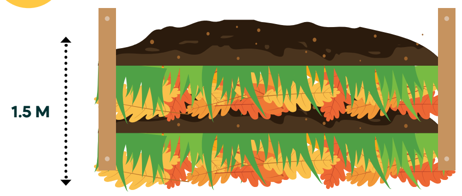


Add a 2 cm-thick layer of soil (top layer).

08

Sprinkle water on the upper layers. The amount should be only enough to percolate to all layers; too much water will affect the proper decomposition of the heap.

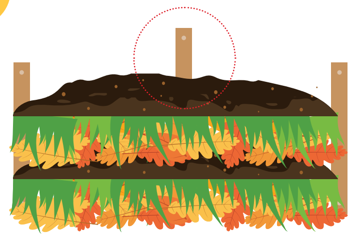
09



Repeat steps 4 to 8, until the heap attains a height of 1.5 meters; higher than this will make the heap too heavy, resulting in three problems:

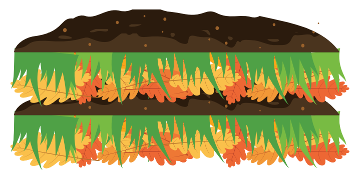
1. too much heat, which micro-organisms will not withstand
2. impeded air circulation
3. difficulty in mixing the heap, especially in the absence of special equipment.

10



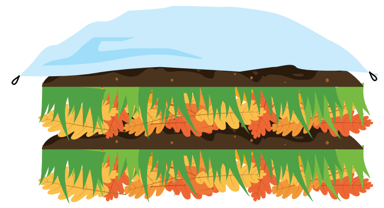
During shuffling, erect a peg in the middle of the heap, ensuring that it sinks in adequately.

11



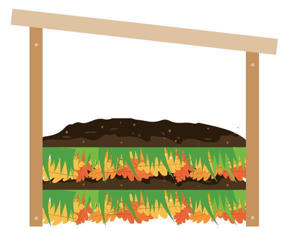
Remove the pegs from the heap. At times the middle peg can be left in place to serve as a gauge of the temperature and heap height. The resultant hole will also aid air circulation.

12



Cover the heap (any cover can be used). The cover will prevent rainwater from getting in and accelerate the composting process by maintaining the temperature inside.

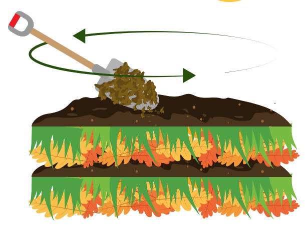
13



(Recommended in places with heavy rainfall) Place or construct a roof (outer cover), a raised platform or shed above the heap and wait for maturation of compost to take place before using it on the farm.

14

Why we shuffle the heap?
Aerating and turning the compost promotes microbial activity by increasing the levels of oxygen and temperature. This will happen within a few hours and slowly decline, stabilizing within 1–2 hours. The first turning should be carried out fourteen (14) days following the completion of the heap structure. The second turning should be carried out 14 days after that. The 14-day period may be extended, depending on the rate of decomposition. During turning, ensure that the layers that were at the top, sides, and base of the heap are put in the middle to enable them to decompose properly.



How to make DIY compost

If you have a large amount of organic material, Due to the size of a windrow, mechanical equipment may be required to turn the compost. to do this.

Advantages of the windrow:

- Uniform mixing of the organic material, reducing accumulation of high moisture and overheating of hotspots in the material, which reduce microbial activity.
- Moisture and temperature control. Temperatures must remain above 55°C for the first 15 days of the process, during which most pathogens and seeds will be killed.

The windrow's dimensions will determine the size of the equipment needed for the turning. A recommended windrow size should not be higher than 2.5 m or wider than 3.6 m.

Three different equipment systems may be used for turning the compost in a windrow:

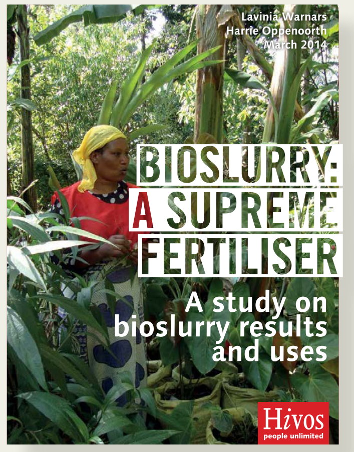
Tractor-loader
used to lift and turn the compost in the into the space beside the existing windrow.

Manure spreader
Using a tractor loader plus a second tractor with a manure spreader will result in better mixing and aeration of the compost

Windrow turner
A tractor plus windrow turner is the most efficient and best system, where the equipment is designed to turn the compost from the outer edge of the windrow to the center of the new windrow.

Annex V- bioslurry: A supreme fertiliser

Read more >



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