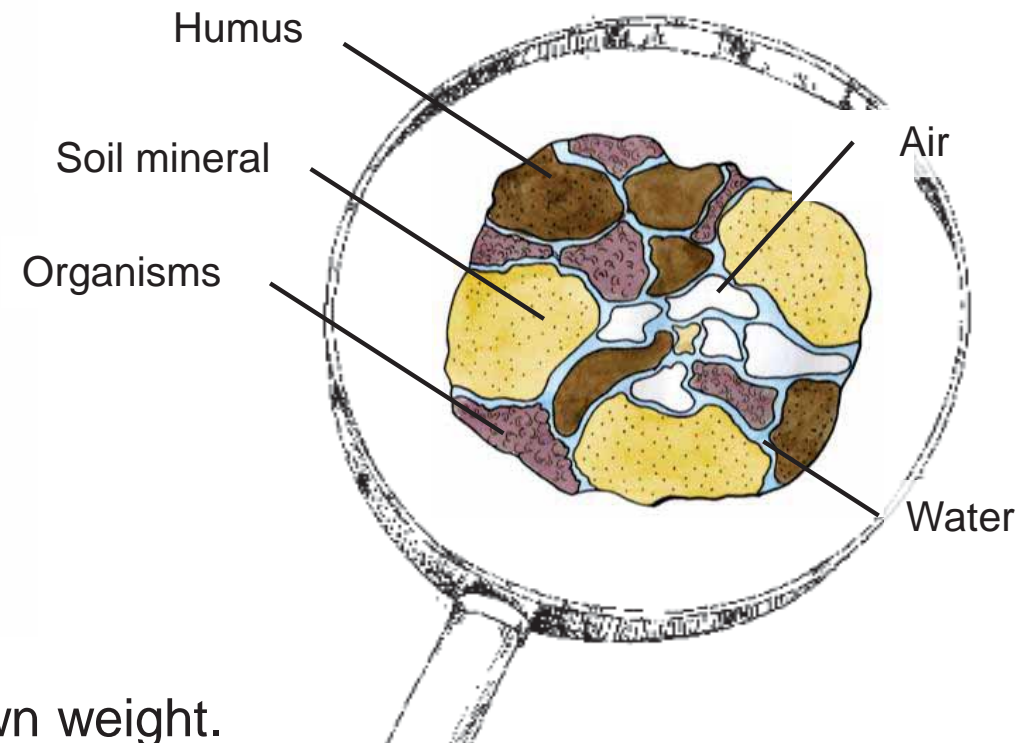


Why organic matter is so important



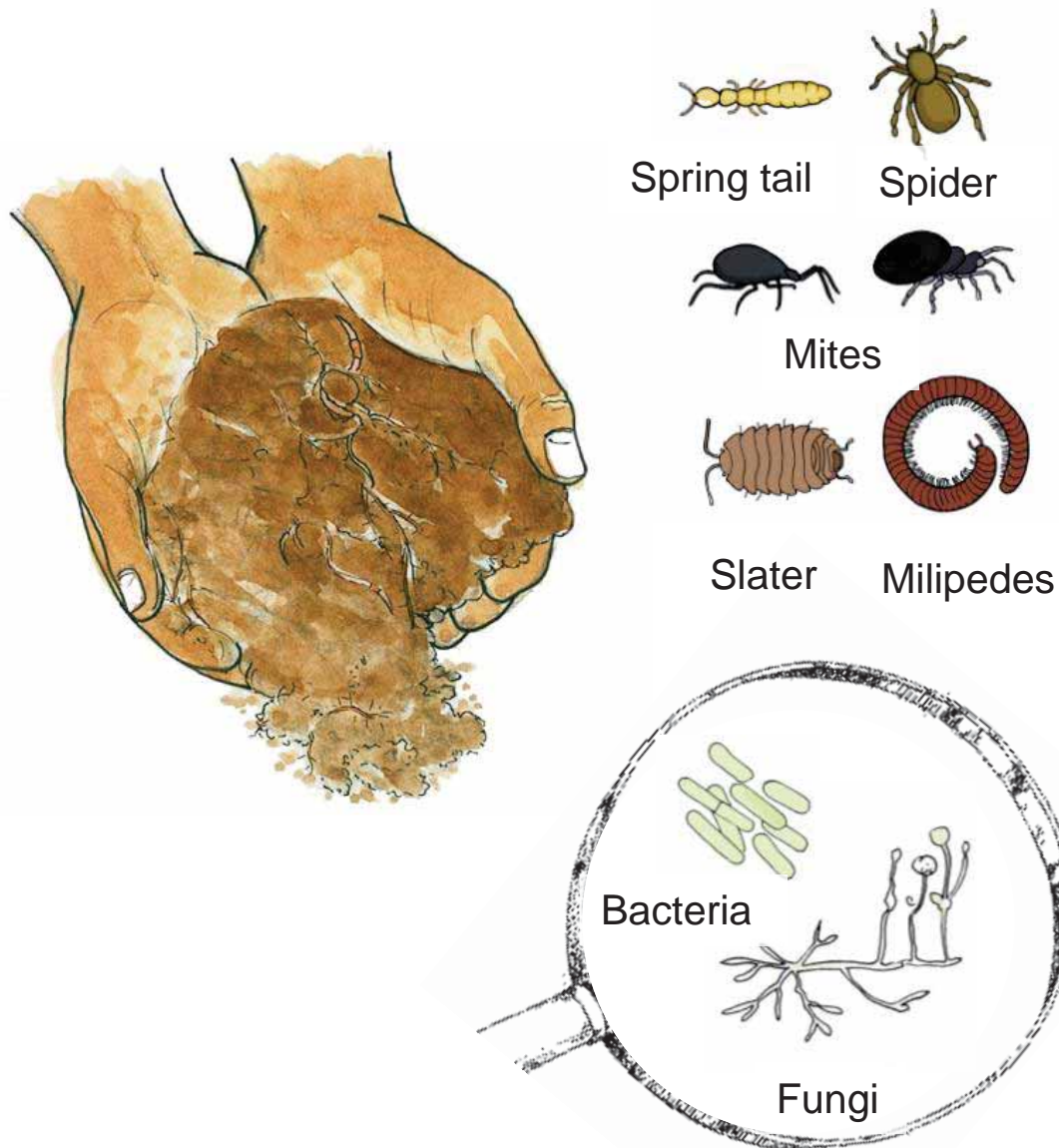
Microscopic view of a soil aggregate consisting of mineral particles, humus and soil organisms

Organic matter ...

- > gives the soil a good structure.
- > can hold water up to five times its own weight.
- > provides food and an environment for beneficial soil organisms.
- > has a great capacity to retain nutrients and release them continuously.
- > prevents soils from becoming too acidic.

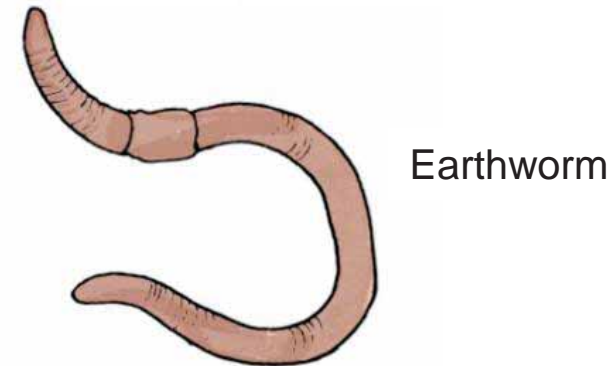


Soil organisms



Larger soil organisms:

- > Pull dead biomass into the soil
- > Feed on organic materials and mix them with the soil
- > Dig tunnels and facilitate aeration and drainage



Soil micro-organisms:

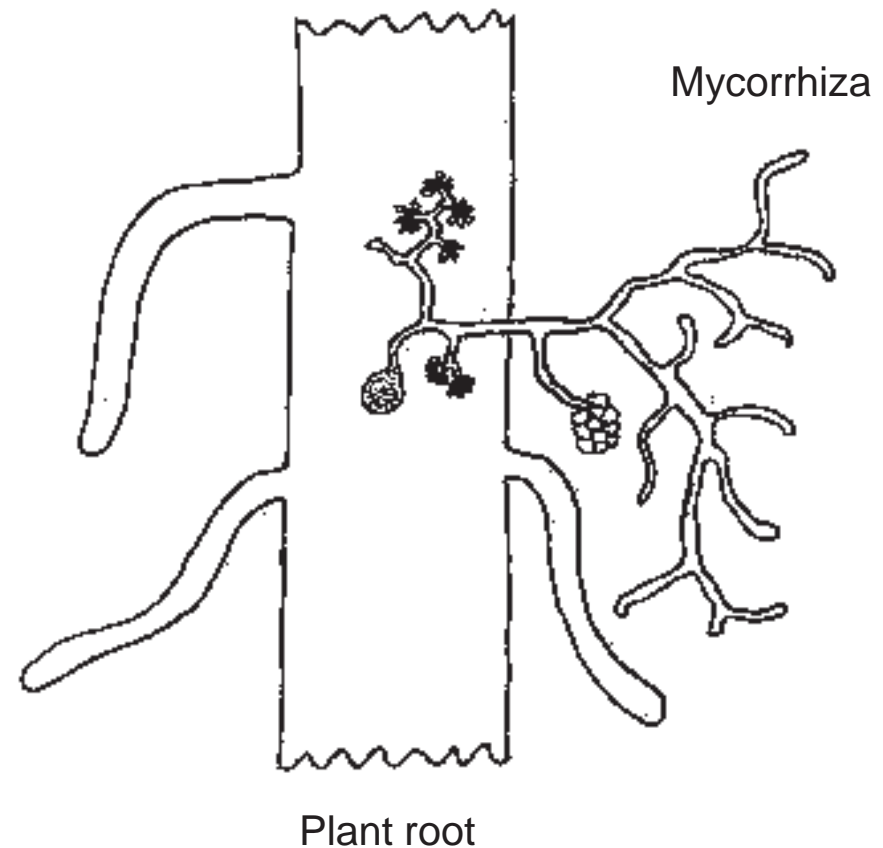
- > Decompose organic matter
- > Improve the soil structure
- > Make nutrients available for plants
- > Protect the plants from disease attack



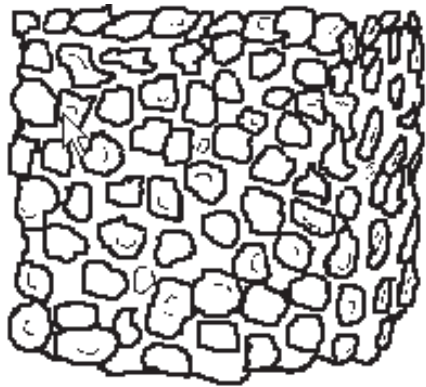
Mycorrhiza – a beneficial fungus

Mycorrhizae ...

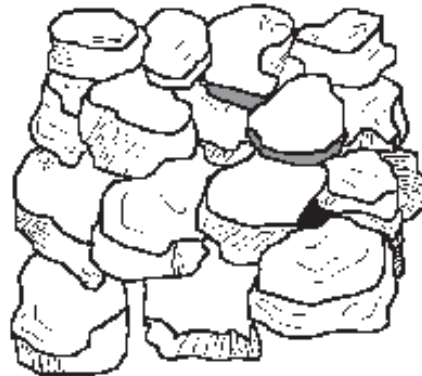
- > live in symbiosis with plant roots.
- > enlarge the surface of the roots and penetrate small soil pores.
- > support the plants in taking up nutrients and water.
- > improve the soil structure and preserve moisture.
- > are sensitive to chemical fertilizers and pesticides.



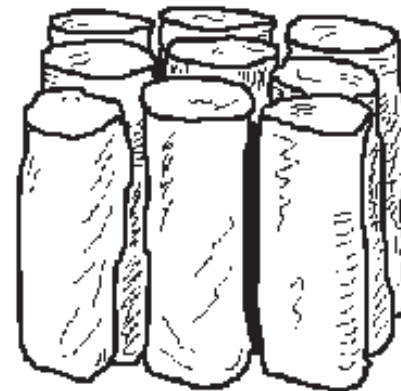
Types of soil structure



Granular structure



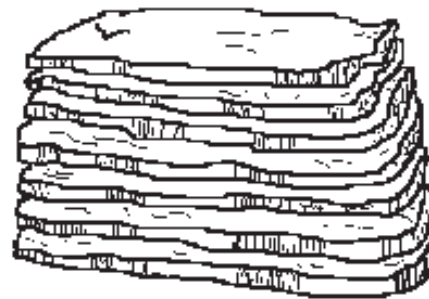
Blocky structure



Prismatic structure



Columnar structure



Platy structure



Single grained structure

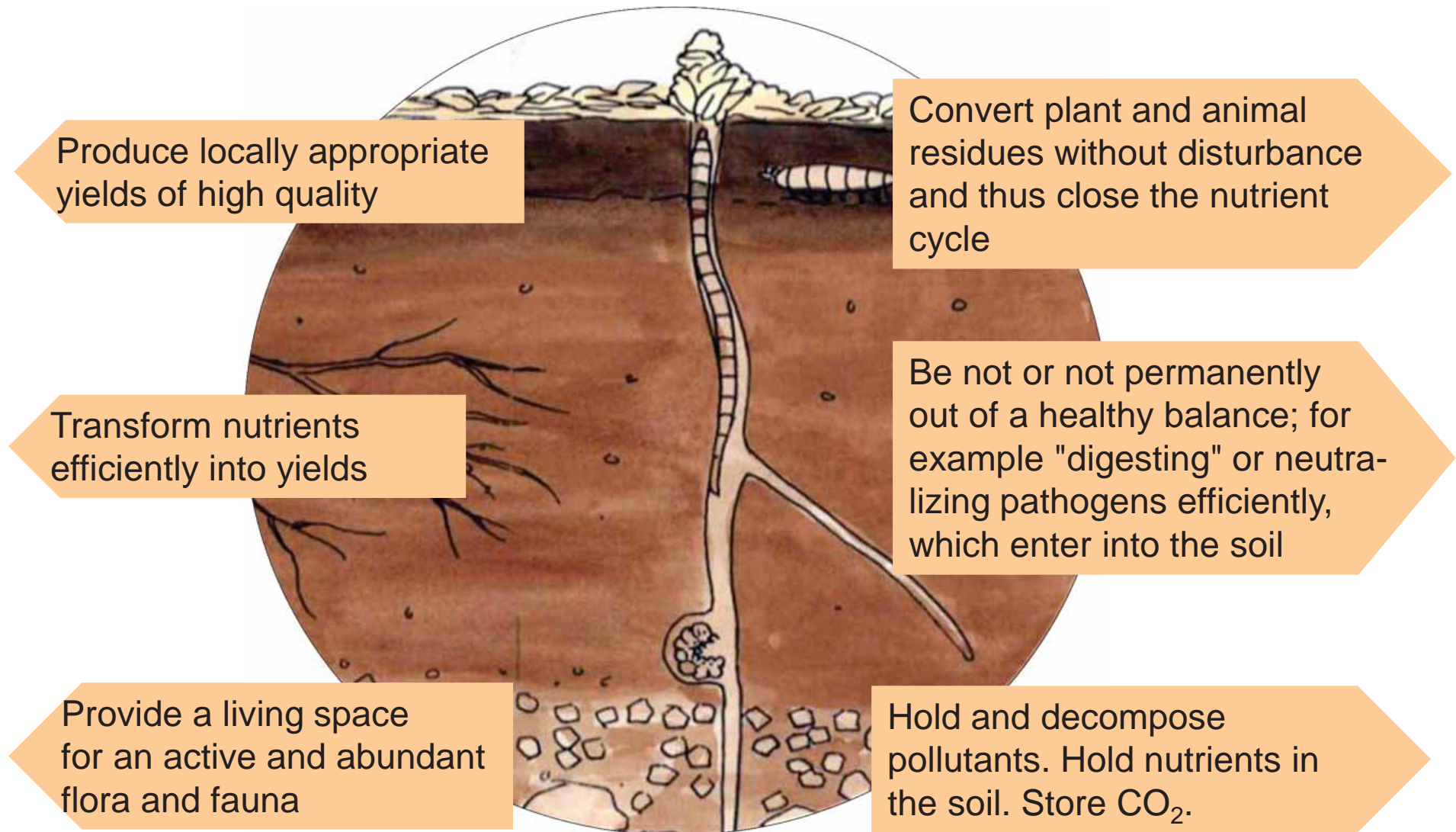


Soil assessment questionnaire

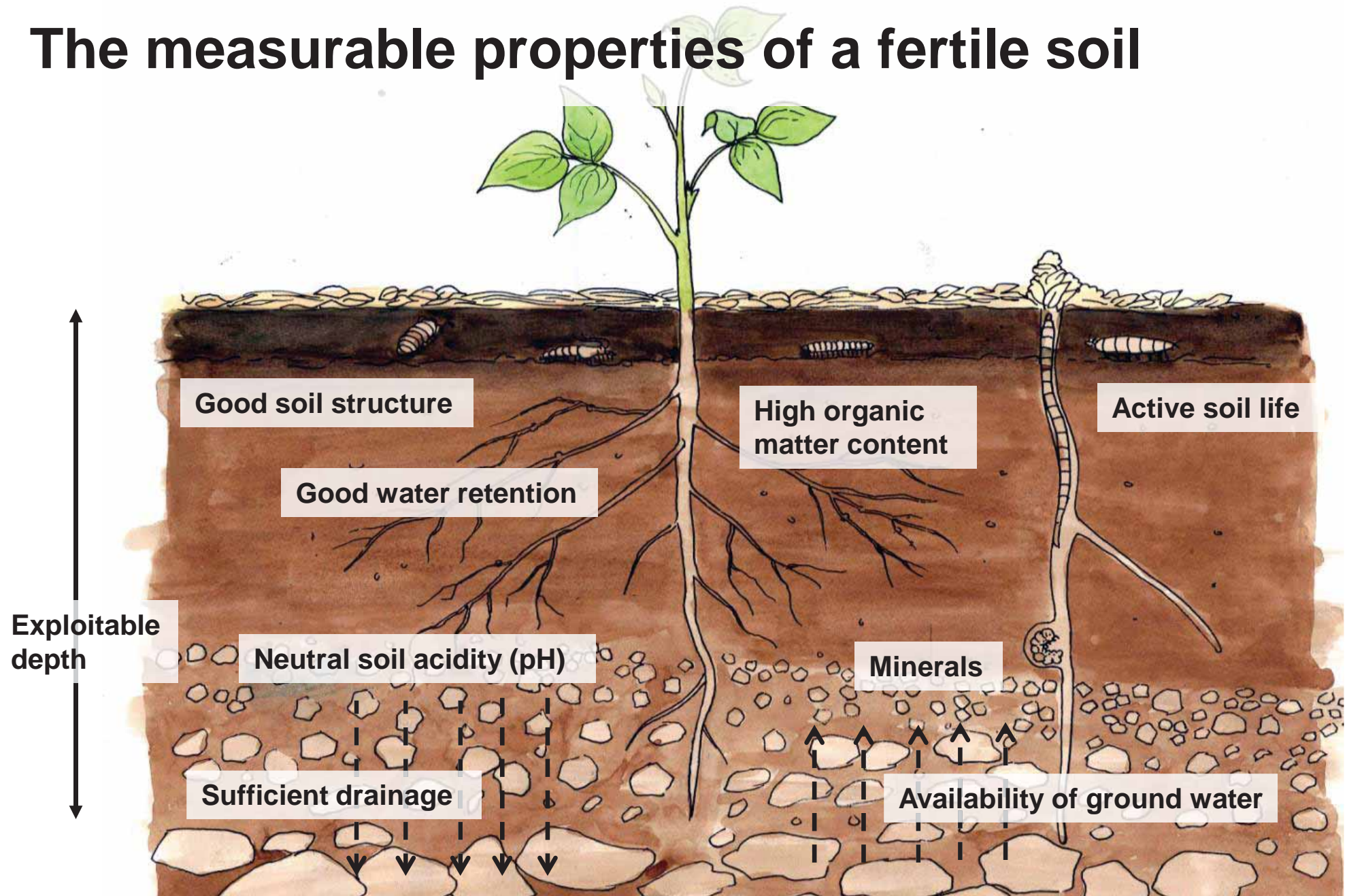
Tactile properties: Soil type	<i>How does the soil feel between the fingers? gritty? → rich in sand; smooth, but not very sticky? → rich in silt; smooth and sticky? → rich in clay</i>
	<i>Is the soil sticky enough to form a square and a roll? Try to make a firm square of soil. Next, try to roll up the square into a thin roll. roll is not possible → sand or sandy loam; thin roll is possible → loam or clay</i>
	<i>Is it possible to form a stable ring? If a roll was possible, try to bend the roll into a ring. ring not possible → loam; ring with cracks outside → light clay soil; firm ring without cracks → heavy clay soil</i>
Visual properties: Colour and structure	<i>What colour does the soil have? What might be the reason for the colour?</i>
	<i>Can you find structures of plant residues? Which?</i>
	<i>Do you find traces of soil organisms? Which?</i>
Smell	<i>Can you feel a smell of the soil? Which kind of smell?</i>
Site information	<i>On which kind of place the sample was collected, or on which sites usually this kind of soil is found?</i>
Suitability for agricultural use	<i>How are these sites usually used? What crops are grown?</i>
	<i>Is this type of soil suitable for agricultural use?</i>
	<i>Will it keep moisture well? Will water logging occur?</i>
	<i>Is it easy to till? Does it have a good structure?</i>
	<i>Do you suppose to find earthworms in this type of soil?</i>
<i>Is it rich in nutrients? Which crops would you grow on it?</i>	
Treatment for improvement of soil fertility	Soil cultivation, tillage:
	Fertilisation, manuring:
	Plant cover, mulching:
	Crop rotation, fallows:



Soil's natural functions



The measurable properties of a fertile soil



Major primary nutrients: functions and common deficiency symptoms

Nutrients	Functions	Deficiency symptoms	Comments
Nitrogen (N)	<ul style="list-style-type: none"> › Necessary for the formation of amino acids (the building blocks of protein) › Essential in plant cell division (vital for plant growth) › Aids production of carbohydrate (component of leaf chlorophyll) › Affects energy reactions in the plant 	<ul style="list-style-type: none"> › General yellowing of the plant starting with older leaves (bottom of plants) › Late and slow plant growth › Reduced flowering in severe cases 	<ul style="list-style-type: none"> › Common in plants grown on soils low in organic matter (<0.4 %) › Plants containing less than 1.0 % N are generally deficient
Phosphorus (P)	<ul style="list-style-type: none"> › Involved in photosynthesis, respiration, energy storage and transfer › Promotes early root formation › Stimulates growth and early maturity › Improves quality of fruits, vegetables and grain › Important in seed and fruit formation › Increases water use efficiency 	<ul style="list-style-type: none"> › Slow, weak and stunted growth › Leaf tips look burnt, followed by older leaves turning dark to blue green or reddish purple in severe cases › Delayed maturity and poor seed and fruit formation 	<ul style="list-style-type: none"> › Common in crops grown on acid soils, limy soils, coarse textured soils low in organic matter. › Best P-uptake at pH 6.5 to 7.5
Potassium (K)	<ul style="list-style-type: none"> › Increases photosynthesis › Increases water-use efficiency › Essential to protein synthesis › Important in fruit formation › Improves quality of seeds and fruit › Increases disease resistance › Activates enzymes and controls their reaction rates › Required for translocation of carbohydrates within the plant 	<ul style="list-style-type: none"> › Stunted growth (often) › Chlorosis along the margin or edge of leaves › Weakened stalks, causing toppling over and lodging 	<p>Common in:</p> <ul style="list-style-type: none"> › soils inherently low in total or non-exchangeable K › coarse textured leached soils › soils under intensive cultivation with N and P fertilizers alone



Characteristics of acid soils and suitable crops

Characteristics of acid soils

- › pH is less than 6.5
- › Open textured with high massive structure
- › Low in Ca and Mg with negligible amount of soluble salts
- › Brown or reddish brown, sandy loams or sands

Suitable crops

4.5	Citrus, pineapple
5.0	Apple, grapes, tobacco, watermelon
5.5	Cassava, cotton, cowpea, peas, tomato, sorghum, soybean
6.0	Cabbage, carrot, cassava, cashew nut, cauliflower, groundnut, mango, onion, peanut, radish, spinach
6.5	Alfalfa, groundnut, sugarbeet



Characteristics of alkaline soils and suitable crops

Characteristics of alkaline soils and symptoms in crops

- › pH more than 7
- › High exchangeable sodium decreases the availability of calcium and magnesium to plants
- › Toxicity due to excess hydroxyl and carbonate ions
- › Growth of plant affected mainly due to nutritional imbalance
- › There is restricted root system and delay in flowering in sensitive varieties
- › Leaf burn in annuals and woody plants due to excess of chloride and sodium

Suitable crops

7–8	Asparagus, banana, beetroot, cabbage, cauliflower, coconut, cotton, cucumber, date palm, grape, guava, maize, pumpkin, rice, sesame, sorghum, spinach, sugarcane, sunflower, tomato
-----	---



Resistance to soil erosion

Good soil structure:

- > Crumbly soil surface with stable soil aggregates
- > Many soil pores resulting in easy drainage
- > Good penetration and rooting of plant roots



Soil fertilized with compost and animal manure

Poor soil structure:

- > Crusty soil surface and poor structure
- > Few pores and compacted soil layers resulting in poor drainage
- > Poor root growth

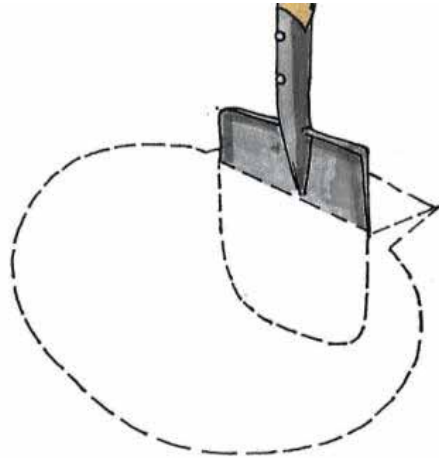


Soil fertilized with mineral fertilizers only

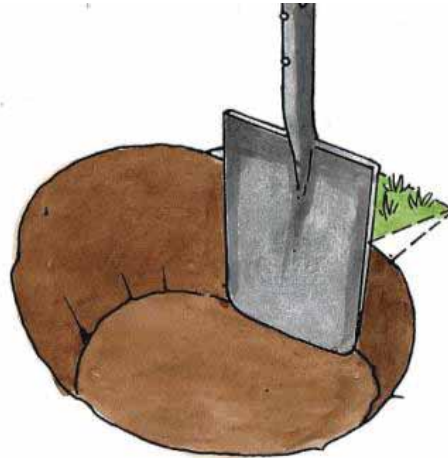
Pictures taken in FiBL's DOC Long Term Comparison Trial in Switzerland after the same rain incident.



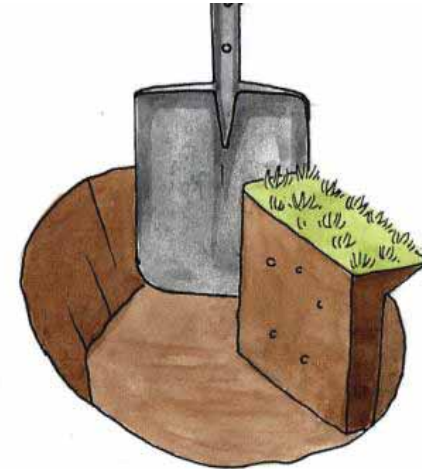
Spade examination of the soil (1)



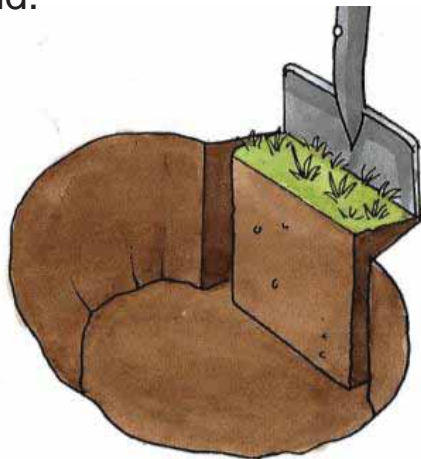
1. Choose a representative place within a (future) crop field.



2. With a flat spade, vertically dig out the soil in front of the soil face to be examined.



3. Carefully cut out a block of soil avoiding compaction or deformation.



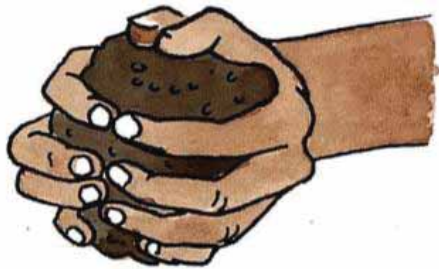
4. Remove the block of soil carefully.



5. Present the soil block in a way that the soil layers, the distribution of humus, soil pores, roots, etc. can be inspected.



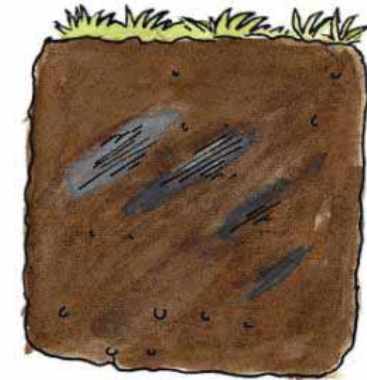
Spade examination of the soil (2)



1. How is the soil's humidity?



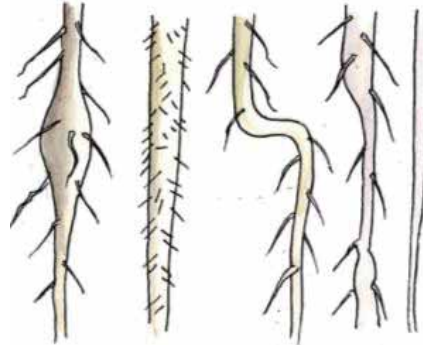
2. How does it smell?



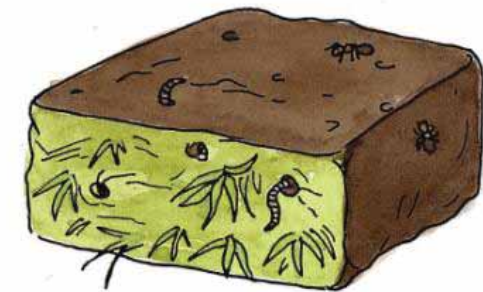
3. Does it have rust-coloured and blue-grey stains on the cut?



4. When breaking the clod, does it fall into small, crumbly bits or into bigger, egged parts?



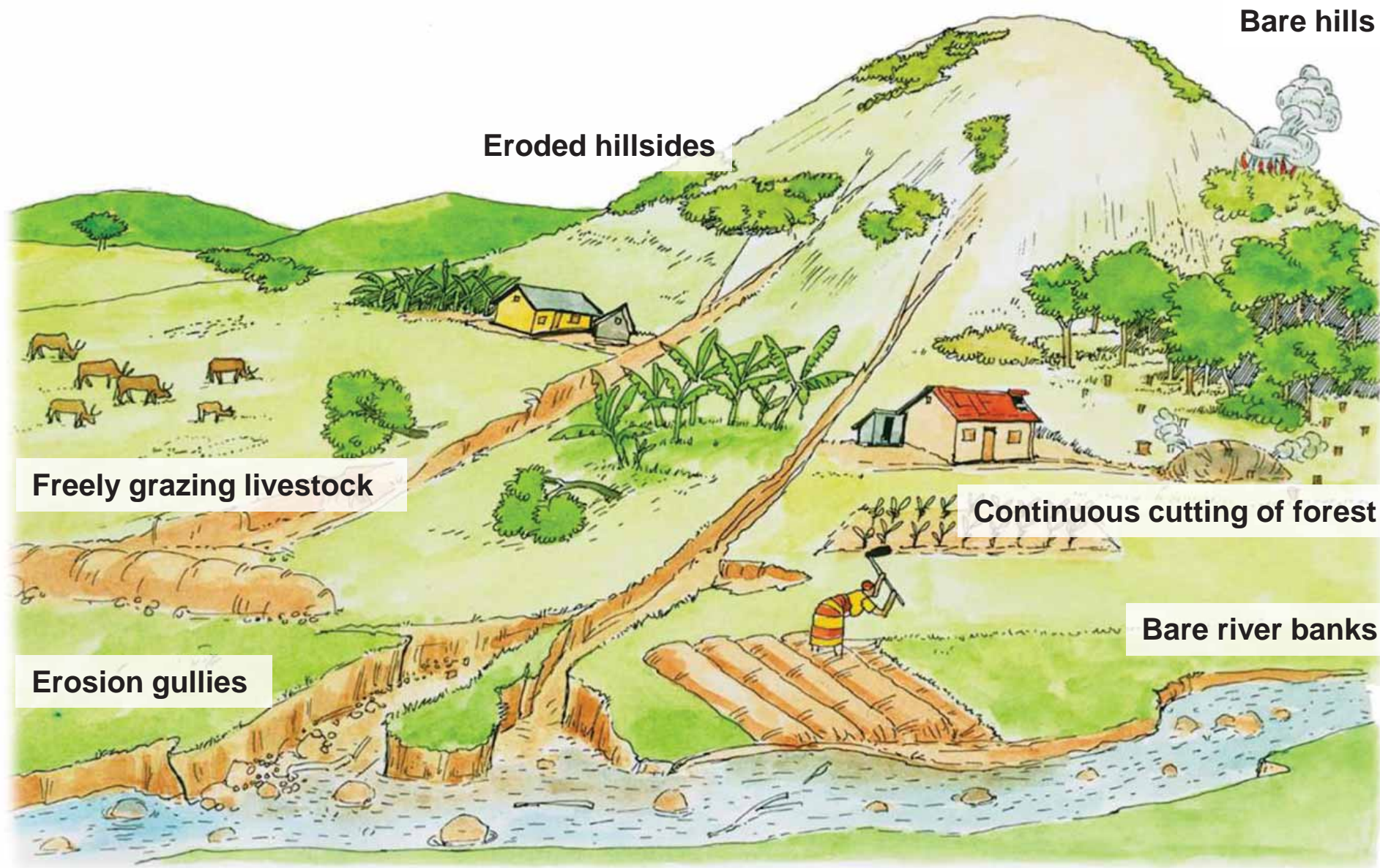
5. Do the roots show any signs of disturbance?



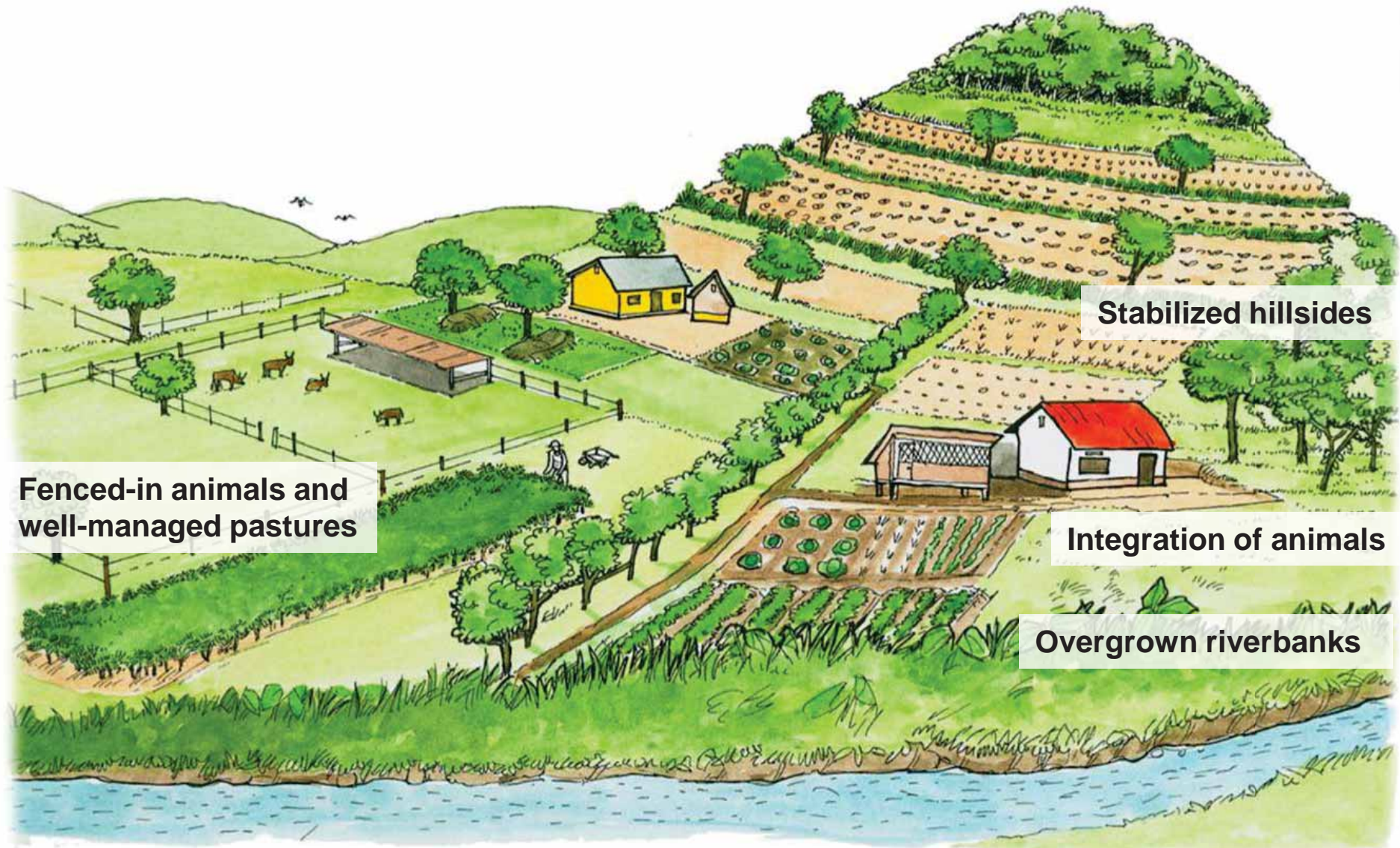
6. Are there any signs of biological activity?



A degraded landscape



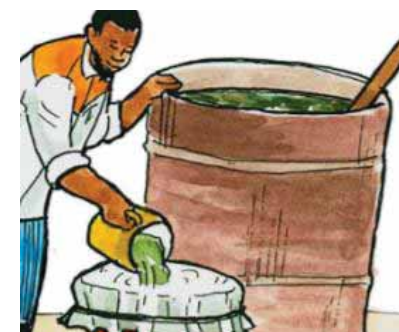
A well-managed landscape



Three steps of organic soil fertility management

3rd step: Application of supplements

Enhancing and balancing plant nutrition through application of fertilizers, soil amendments and irrigation



2nd step: Soil organic matter management

Enhancing soil organic matter content through application of organic material

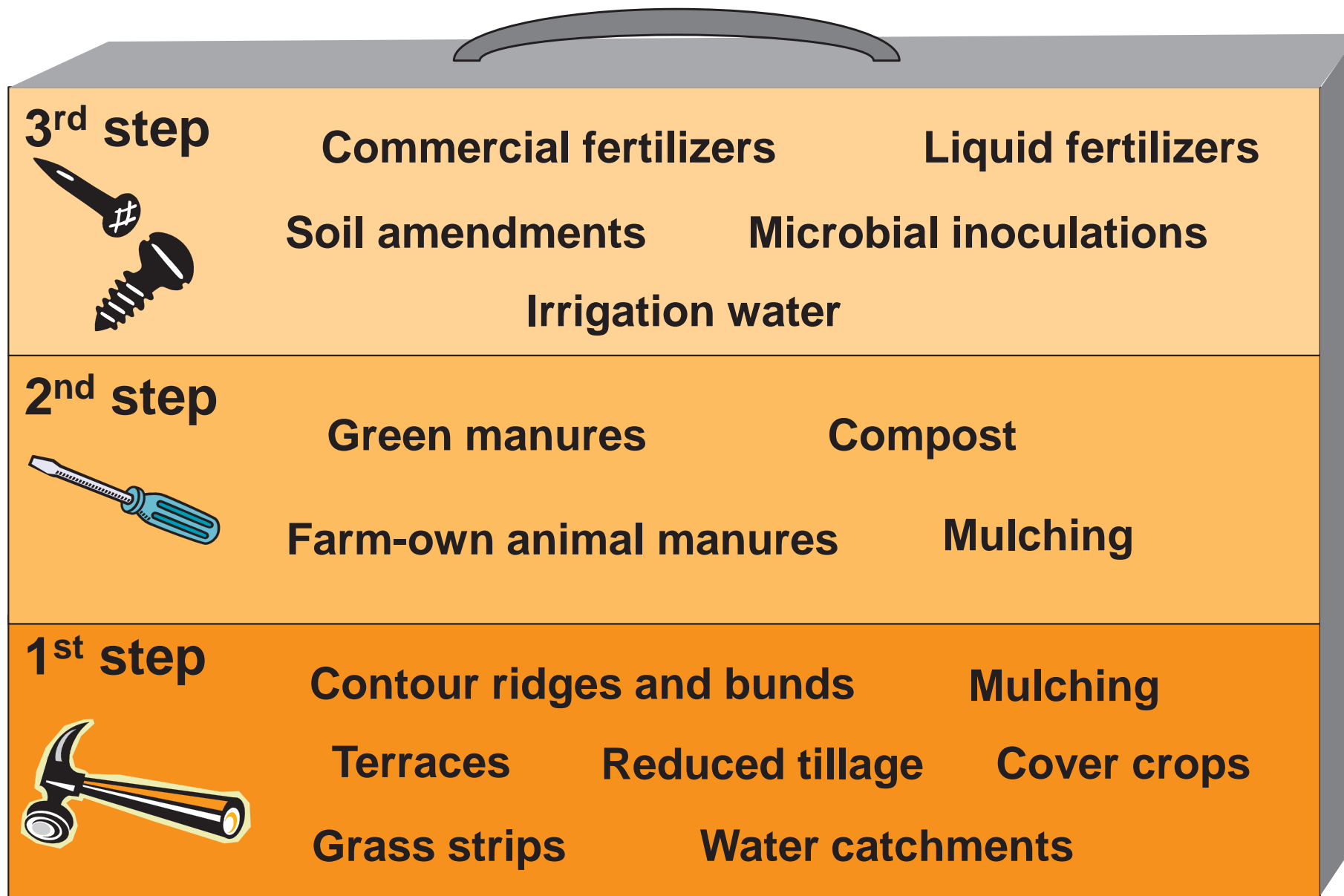


1st step: Soil and water conservation

Stabilizing and protecting the soil and harvesting and conserving water

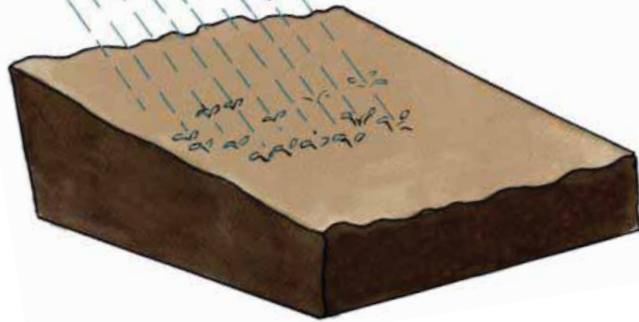


The soil fertility management tools

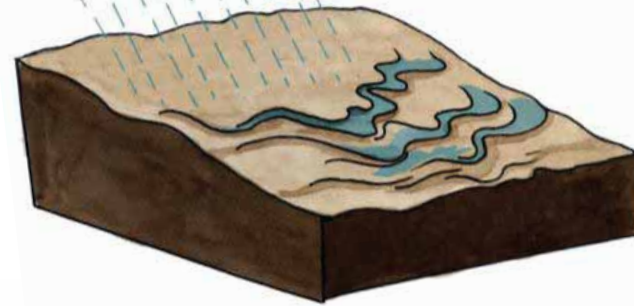


Common forms of erosion

Splash erosion



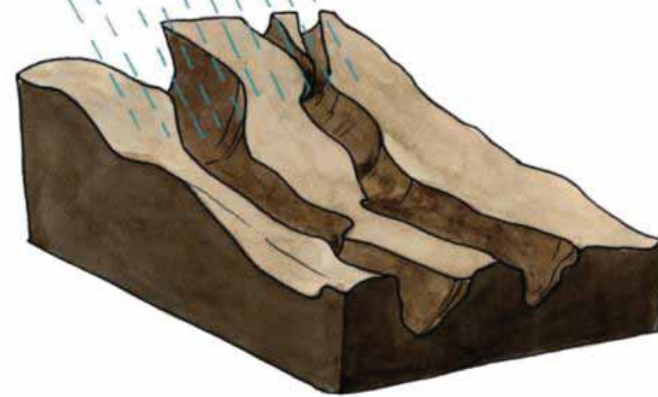
Sheet erosion



Rill erosion



Gully erosion



Different possibilities of covering the soil



Covering the land with a cover crop



Covering the land with mulch



Covering the land with crop residues



Growing crops in a multistorey system



Cover crops for erosion control

Species	Characteristics	Additional/alternative uses	Integration into the farm
Wild groundnut (<i>Arachis pintoi</i>)	<ul style="list-style-type: none"> › Grows well in humid climates; tolerates waterlogging, and survives dry seasons of 4 months › Low-growing, but excellent weed control once established › Tolerates low grazing 	<ul style="list-style-type: none"> › Forage: pasture crop for grazing; combines well with competitive sward grasses 	<ul style="list-style-type: none"> › Ground cover under tree crops like avocado, banana, cassava, cocoa, coffee, citrus, mango or pineapples › Permanent pasture for intensive grazing systems
Stylo (<i>Stylosanthes guianensis</i>)	<ul style="list-style-type: none"> › Herbaceous perennial legume › Grows in humid climates, but can survive long dry periods › Grows 30 to 120 cm high › Has a low P requirement 	<ul style="list-style-type: none"> › Forage: pastures, cut-and-carry forage systems or production of conserved feed; combination with grasses possible 	<ul style="list-style-type: none"> › Used primarily as a pasture legume › Cover crop in plantations and orchard crops › Fallow crop
Siratro (<i>Macroptilium atropurpureum</i>)	<ul style="list-style-type: none"> › Perennial twining legume › Grows in humid climates, but persists well under dry conditions › High P requirement 	<ul style="list-style-type: none"> › Forage: can be grazed, but not heavily; combines with tall grasses 	<ul style="list-style-type: none"> › Pasture legume › Cover crop in plantations › Fallow crop
Cucurbits (e.g. Watermelon)	<ul style="list-style-type: none"> › Creeping › No nitrogen fixation 	<ul style="list-style-type: none"> › Food: Marketable flowers and fruits 	<ul style="list-style-type: none"> › Intercropping with cereal crops › Rotation with veget. and root crops
Grasses (e.g. Elephant grass or Tropic Lalo Paspalum)	<ul style="list-style-type: none"> › Low or medium high growing, stoloniferous perennial grasses › No nitrogen fixation › Combines well with leguminous forage plants 	<ul style="list-style-type: none"> › Forage: pastures, cut-and-carry forage systems or prod. of conserved feed 	<ul style="list-style-type: none"> › Soil cover in permanent crops › Full ground cover as permanent grazing pasture or for fodder prod. › Alley cropping with fodder legumes such as <i>Leucena</i> sp and <i>Sabania</i> sp.



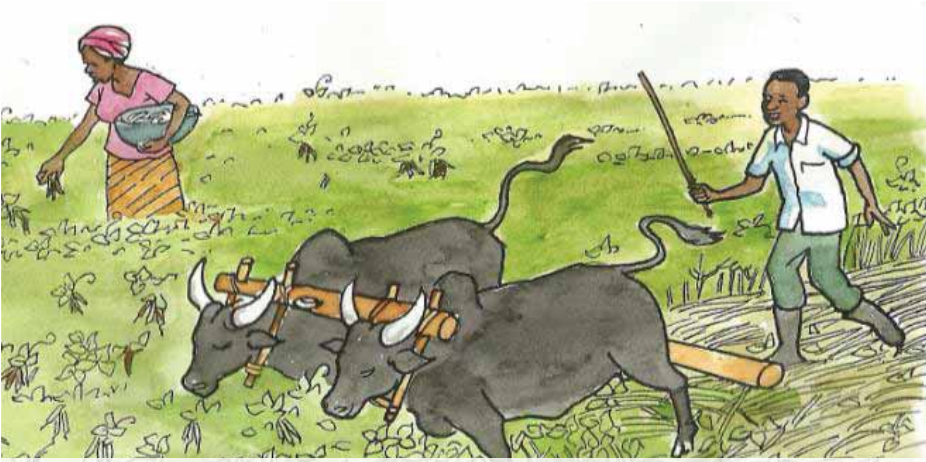
Possibilities of growing cover crops



Intercropping in annual crops



Relay cropping



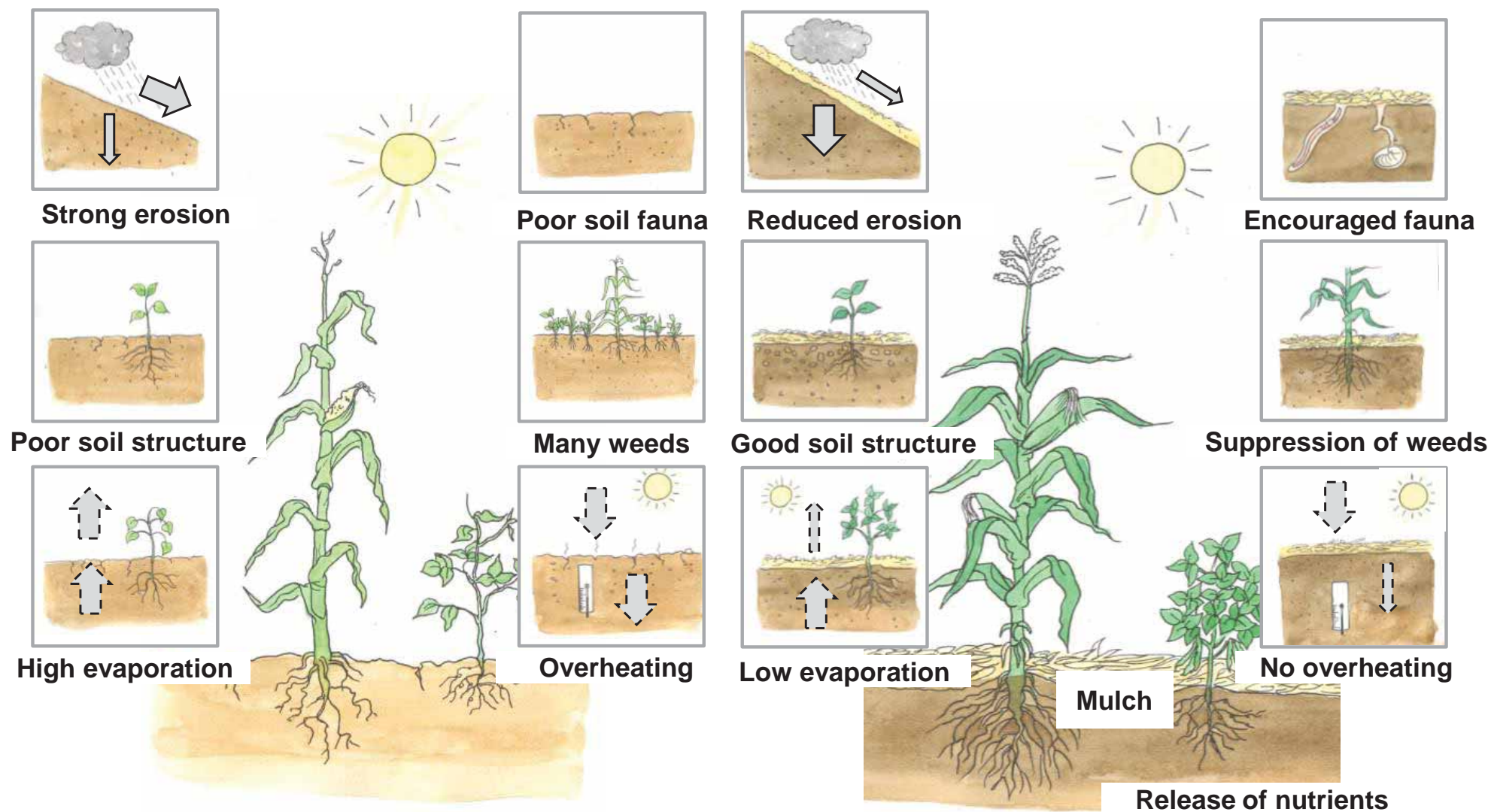
Rotation / improved fallow



In permanent crops



Why use mulch?



How to apply mulch

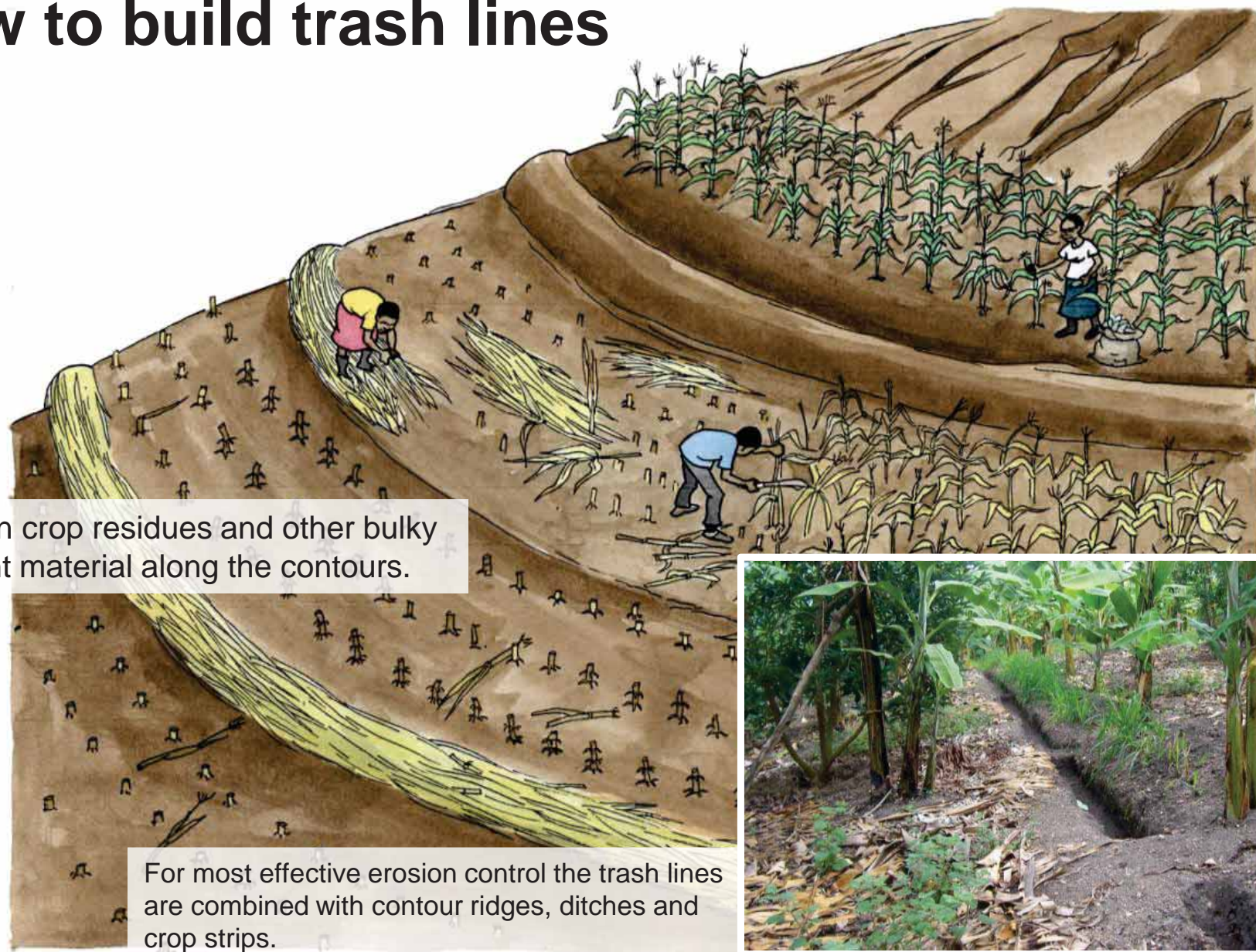


When applying mulch:

- > Apply before the rainy season.
- > Not a too thick layer.
- > Apply in rows or around single plants avoiding direct contact with the plant stems.
- > Or evenly spread the mulch on the field.



How to build trash lines



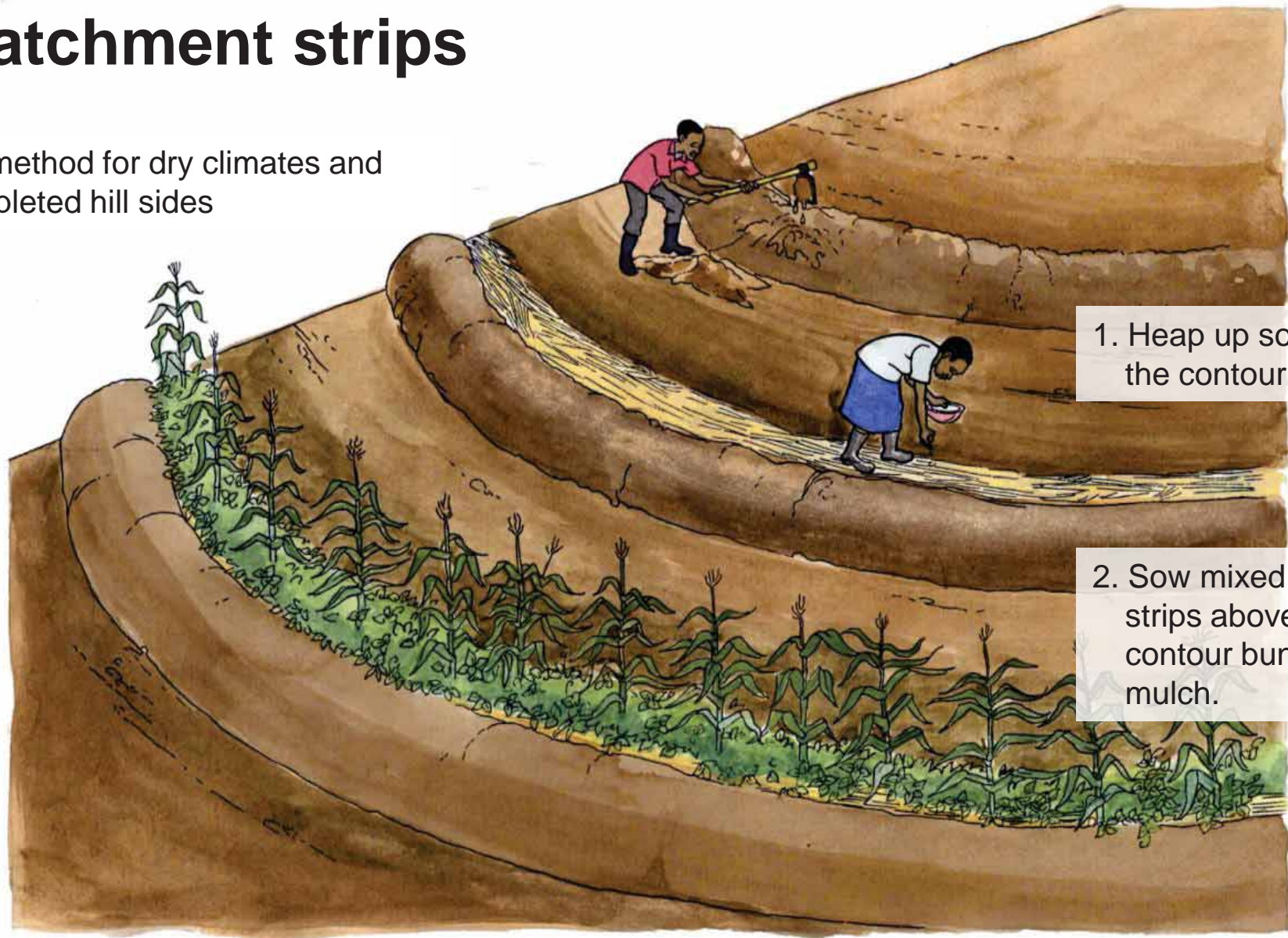
Align crop residues and other bulky plant material along the contours.

For most effective erosion control the trash lines are combined with contour ridges, ditches and crop strips.



How to build contour bunds with catchment strips

A method for dry climates and depleted hill sides

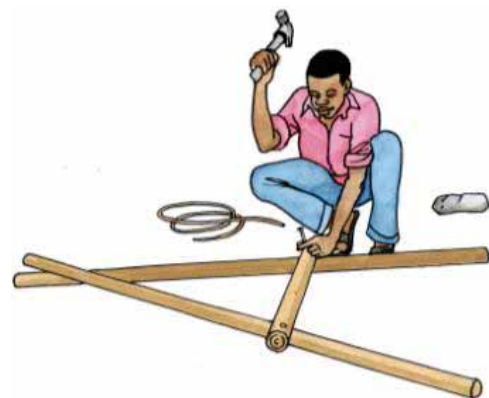


1. Heap up soil along the contour lines.

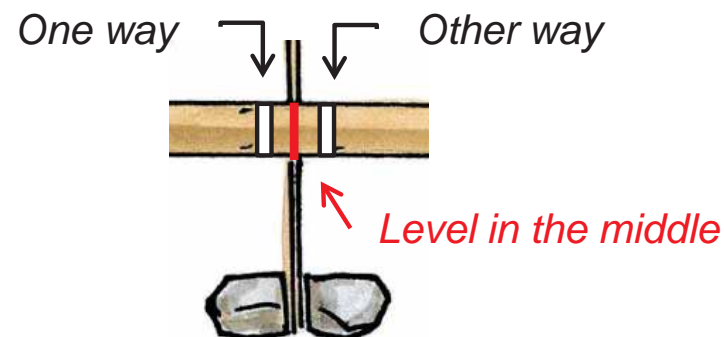
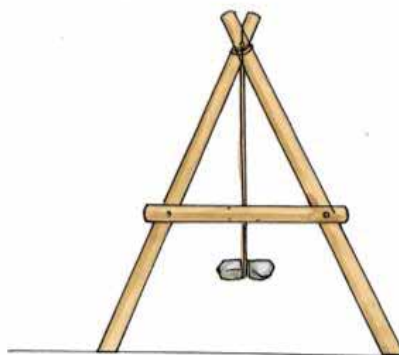
2. Sow mixed crops in strips above the contour bunds into mulch.



How to make and use the A-frame



Stone



1. Tie two 6-foot poles and a 4-foot pole together to form an "A".

2. Tie a string to the top of the frame and attach a weight to it.

3. Calibrate on leveled ground turning the A-frame in both directions, marking where the string crosses the bar.



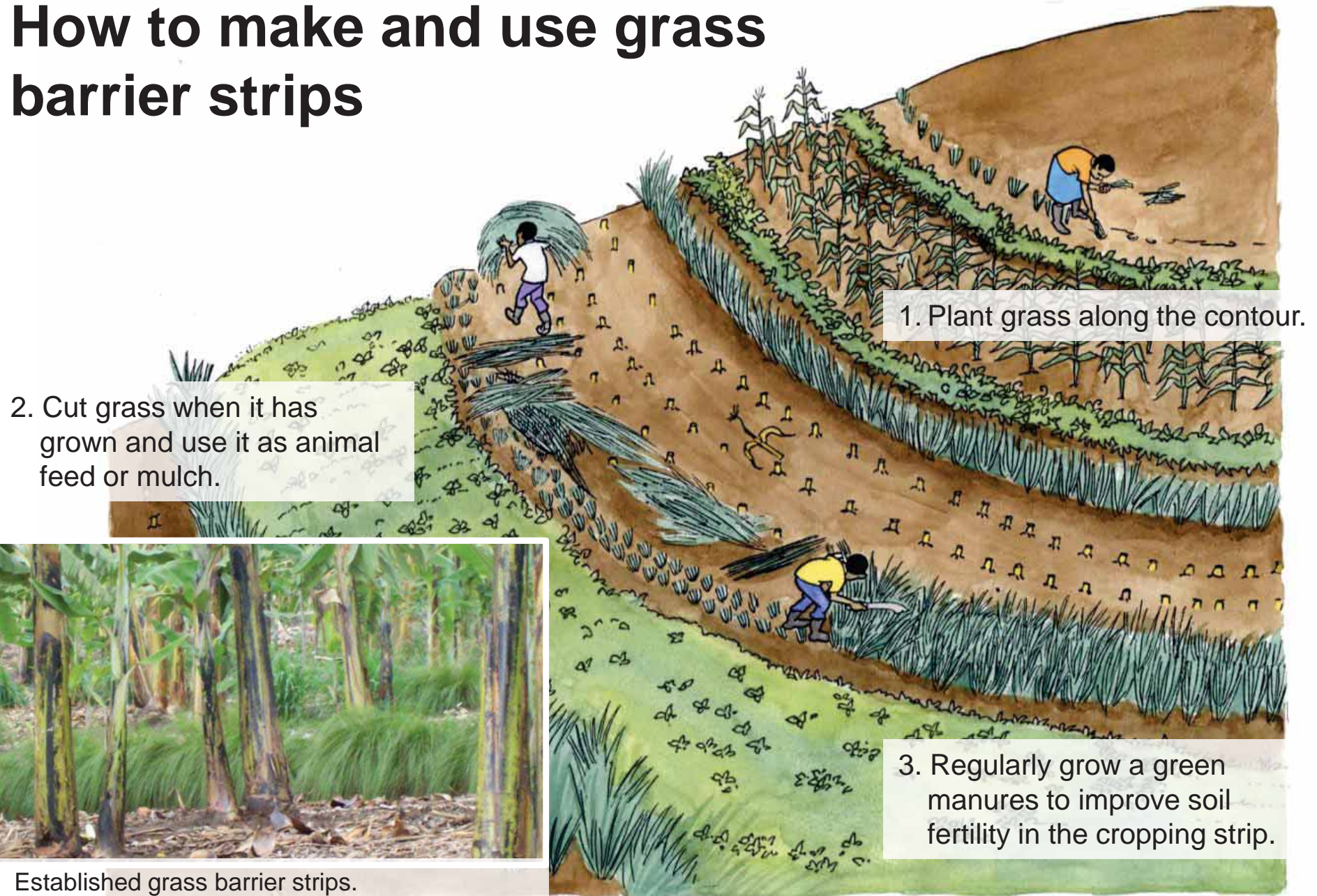
4. Swing one leg up or down the slope so that the string crosses the crossbar exactly where the mark is.

5. Mark the spot where the second leg stands and continue as for the first.

6. Marking points along the contour results in contour lines across the slope.

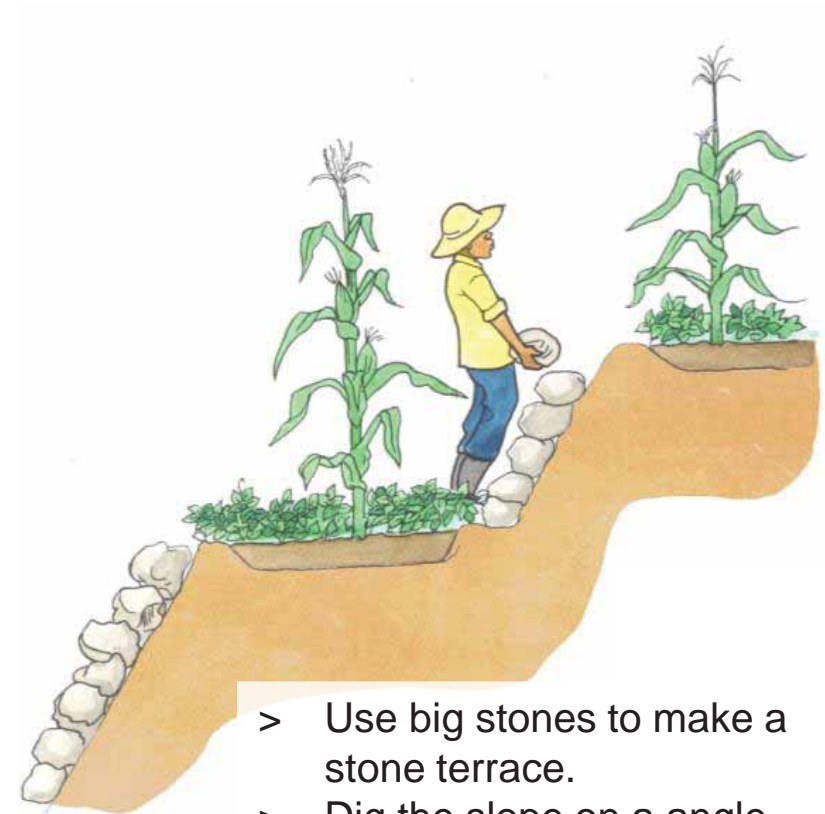
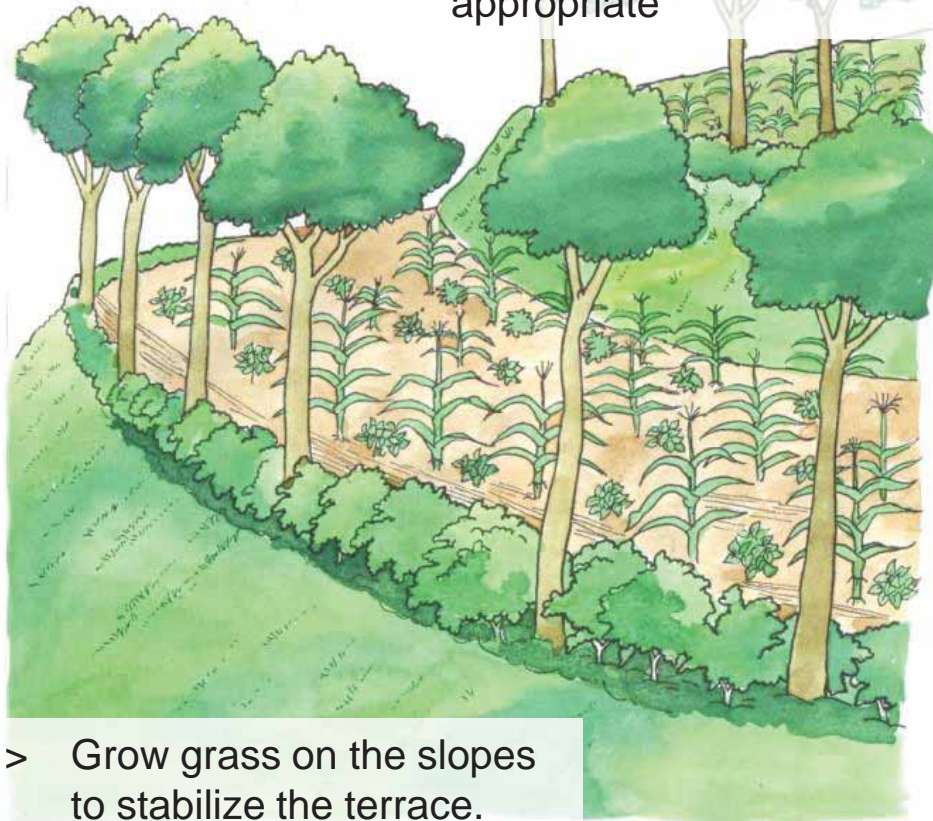


How to make and use grass barrier strips



Building a bench and a stone terrace

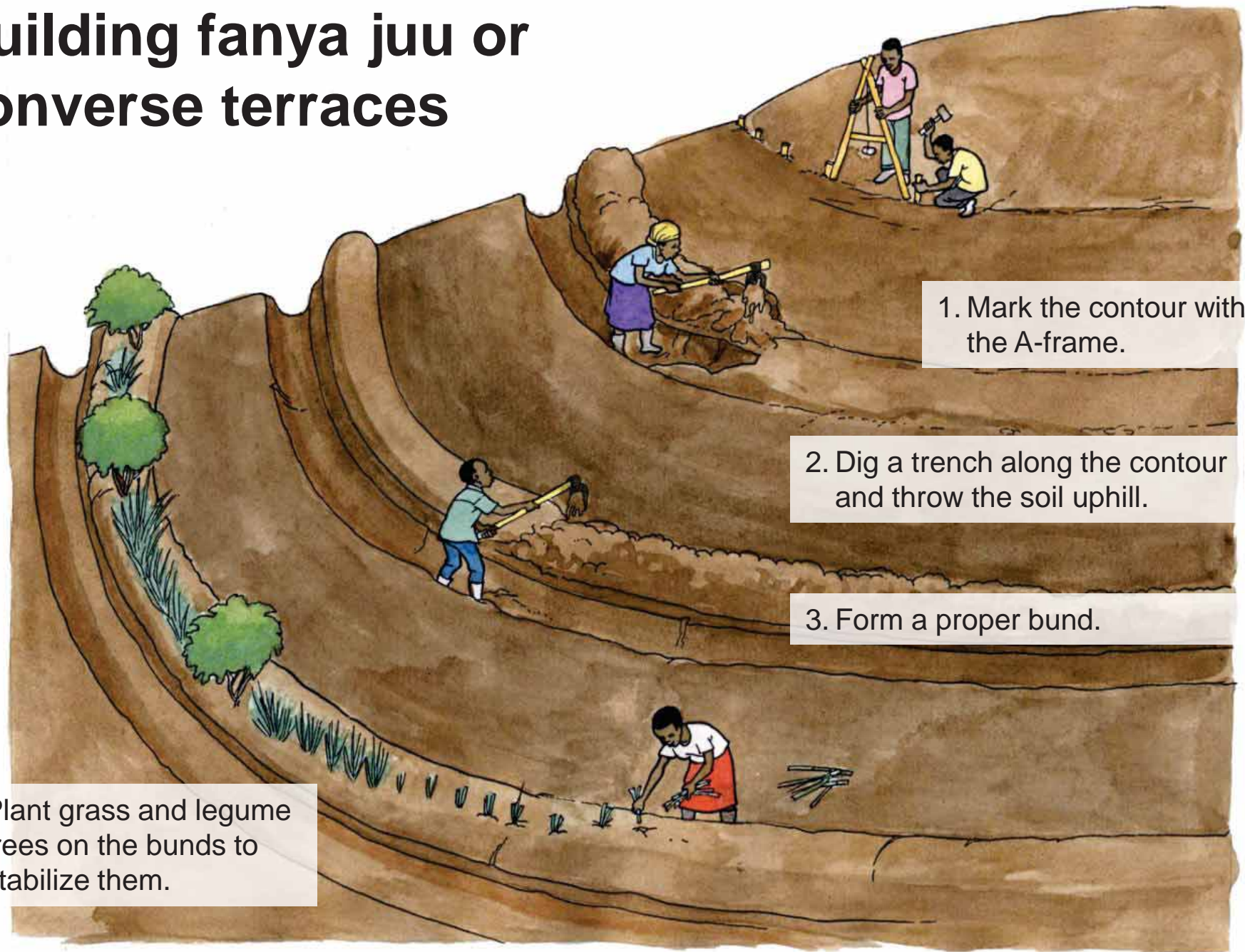
- > Grow leguminous trees or shrubs or fruit trees on the edges of the terrace, if appropriate



- > Use big stones to make a stone terrace.
- > Dig the slope on a angle and place the stones against the slope.



Building fanya juu or converse terraces



1. Mark the contour with the A-frame.

2. Dig a trench along the contour and throw the soil uphill.

3. Form a proper bund.

4. Plant grass and legume trees on the bunds to stabilize them.



Digging planting pits



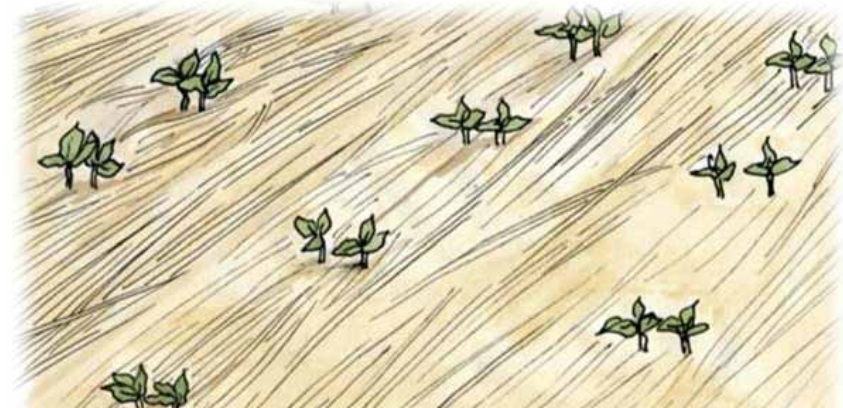
1. Dig small holes along the rope.



2. Fill a bit of compost or rotten manure into every hole and cover it with topsoil.



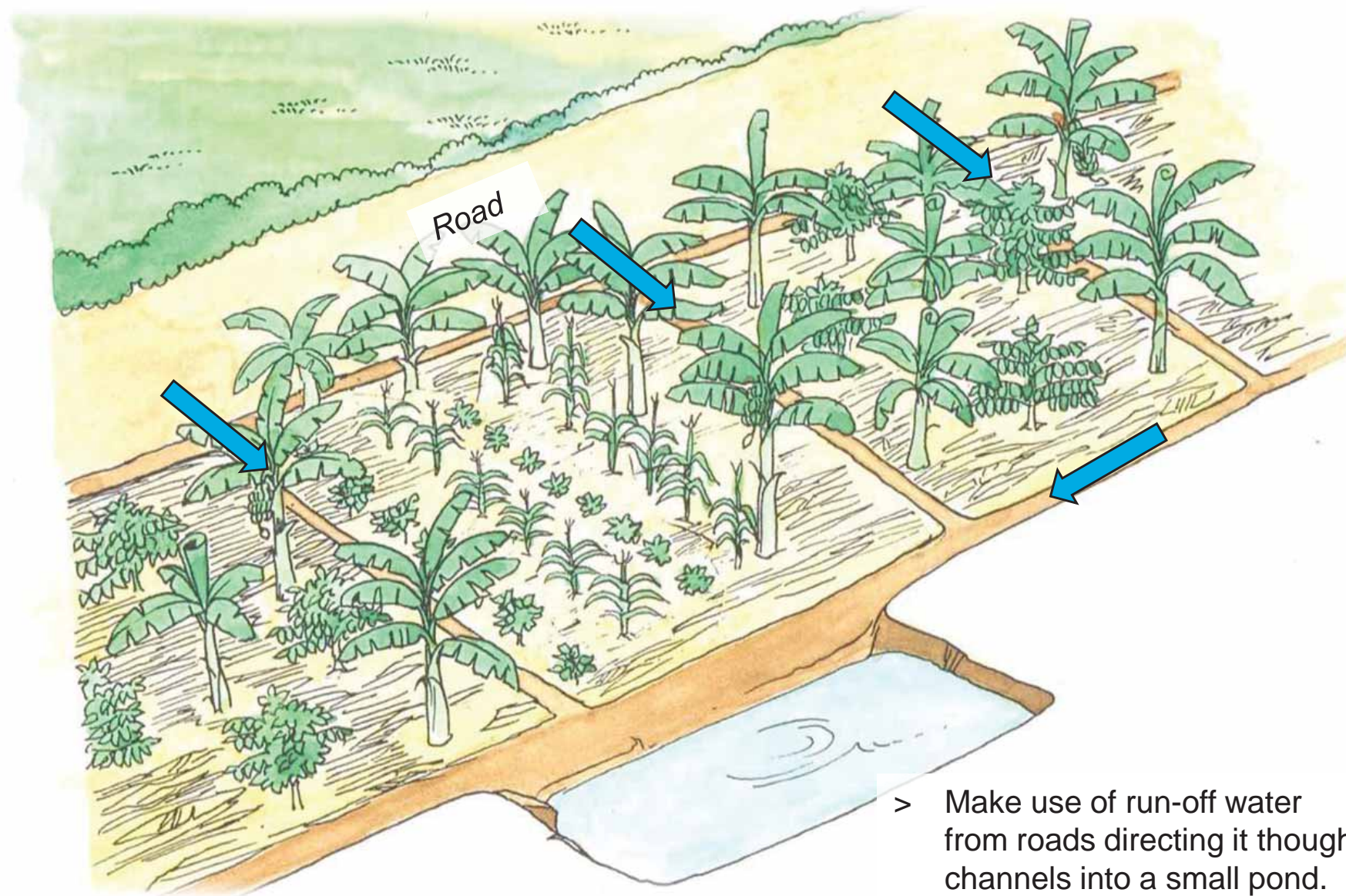
3. Place the seeds into the refilled holes.



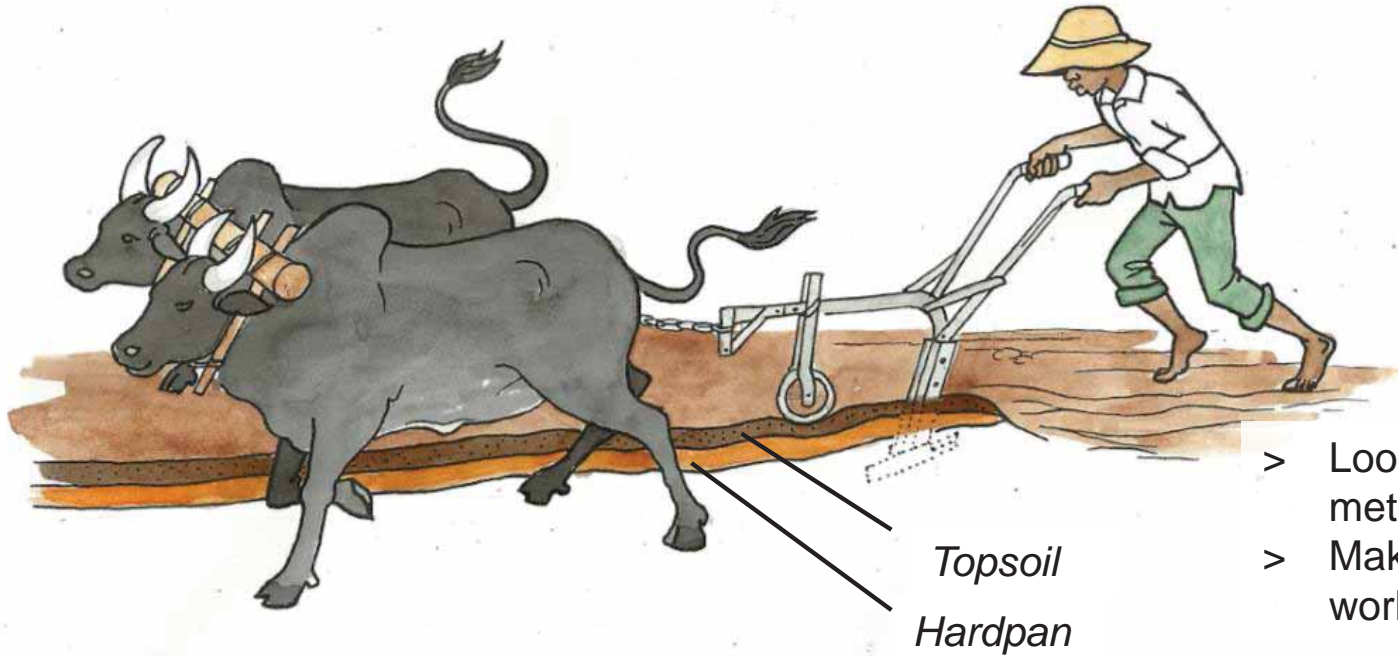
4. Cover the planting lines with dry mulch.



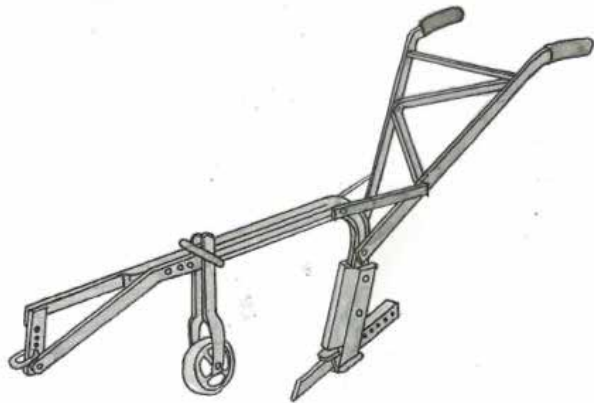
Water catchments



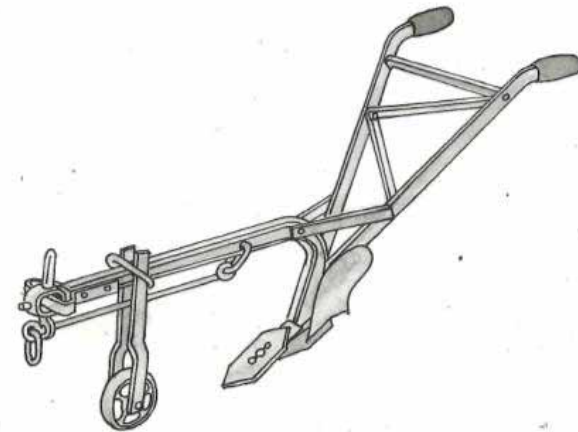
Reduced tillage



- > Loosen the soil at 0.5 to 1 meter intervals.
- > Make sure the subsoiler works under the hardpan.



Subsoiler used for breaking a hardpan



Ripper used for reduced soil tillage



Recultivation of land with old fallow



1. Slash the thick grass and weed mulch.



2. Sow velvet beans into the dry mulch.



3. Flatten the velvet stems with a beam.



4. Rip the land through the dry mulch cover before sowing the next regular crop.



Farm-own sources of organic matter



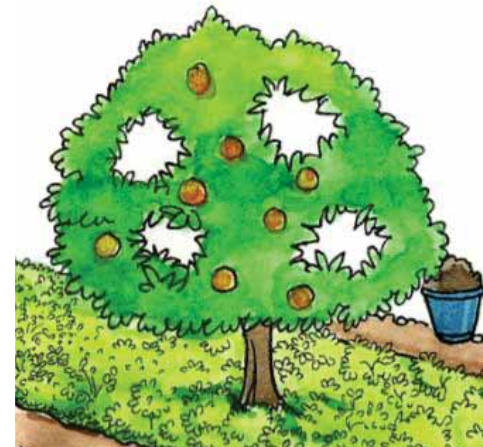
Balanced crop rotation



Crop residues



Mulch



Cover crops



Cuttings



Green manures



Organic manures



Compost



Benefits of green manures

Green manures prevent nutrients from loss.

Green manures cover the soil preventing erosion.

Green manures supply organic material to the soil.

Green manures suppress weeds.

Leguminous green manures fix nitrogen from the air.

Some green manures provide high quality fodder.



Green manure in rotation or as improved fallow



1. Let animals feed on the crop residues or cut the residues and leave them as mulch.



2. If possible, rip the land with oxen to facilitate growth of the following green manure.



3. Sow the green manure with early rains.



4. Let the green manure grow until flowering or longer in case of improved fallow.



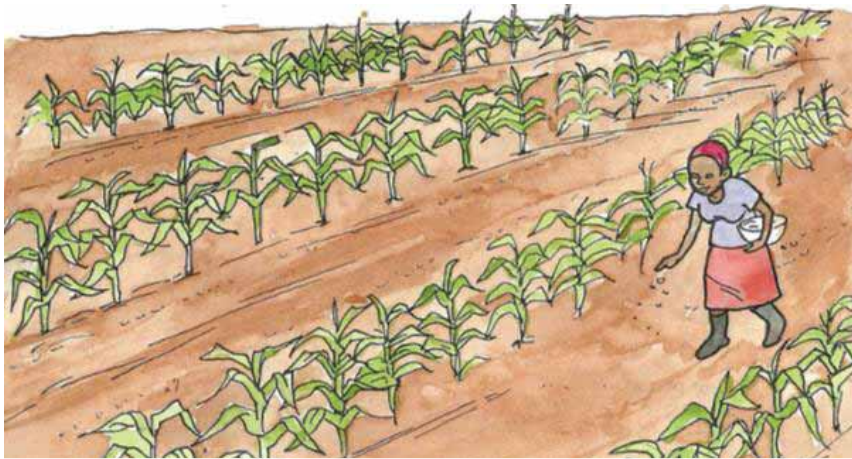
5. Slash the green manure and leave it as mulch or work it into the soil.



6. Sow the following regular crop.



Relay cropped green manures



1. Sow 1 or 2 rows of green manure between the rows of the established main crop.



2. After harvest of the main crop leave the green manure cover the entire soil surface.



3. Slash and dig the green manure crop into the topsoil.

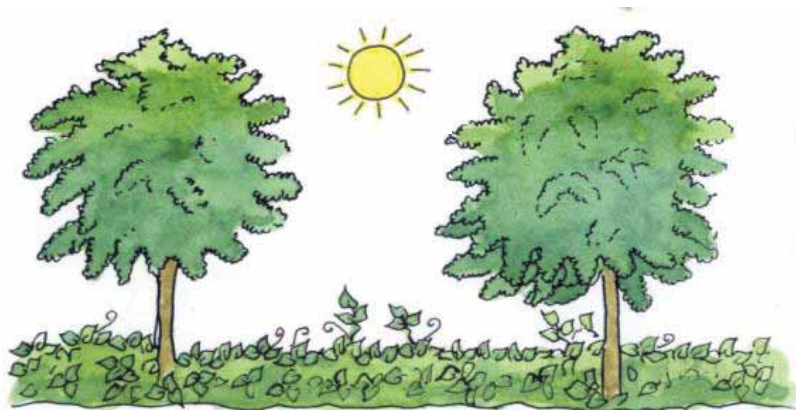


4. Sow the following crop.



Alley cropping

Growing trees in rows between annual crops creates a favourable micro-climate for crop growth.



1. In the dry season the trees form a dense shade over the avenues.



2. At the beginning of the rain season the trees are lopped and annual crops are sown.



3. During the growing season the trees are periodically lopped to avoid competition for light, and the leaves are used for top dressing mulch.



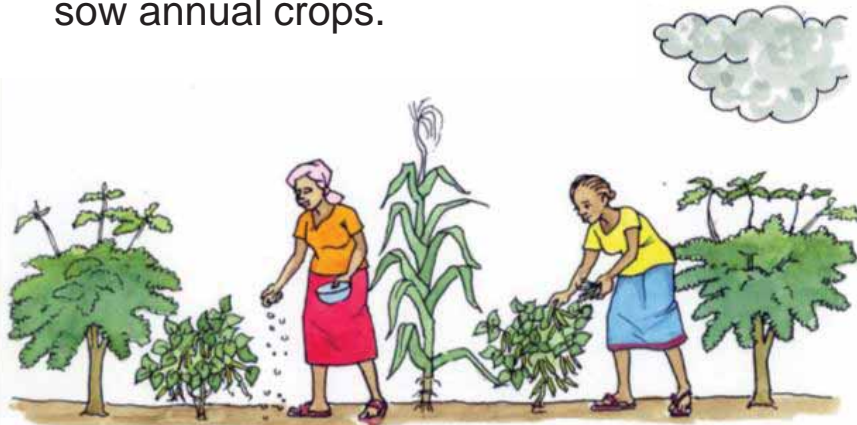
Combining alley cropping and green manuring



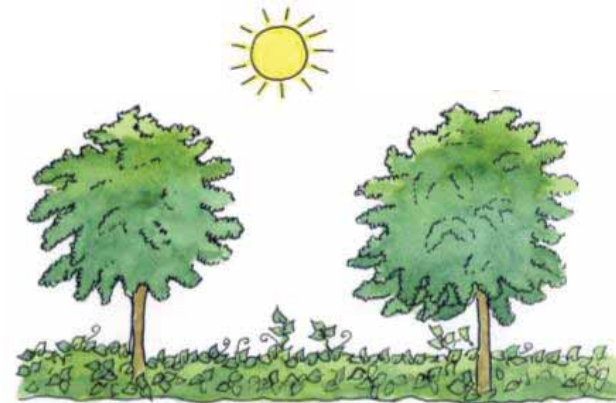
1. Before rains prune the legume trees and sow annual crops.



2. During the rainy season the soil is covered and annual crops can grow.



3. At the end of the rainy season when annual crops are ready for harvest, sow green manure.



4. In the dry season the green manure grows and covers the soil. Before new rains the green manure is cut down and mixed into the soil.



Green manures providing dense soil cover

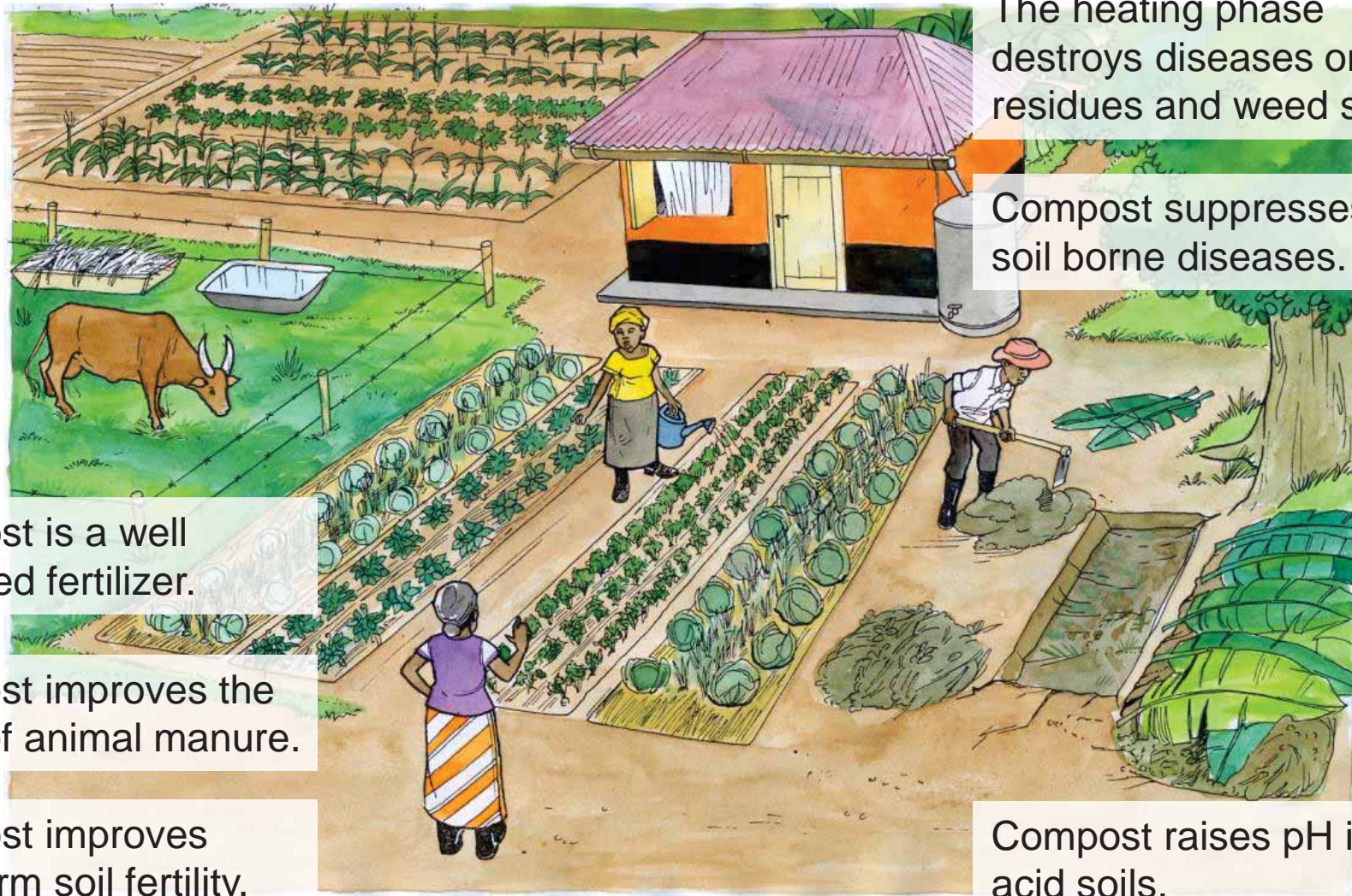
Species	Characteristics	Additional/alternative uses	Integration into the farm
Greenleaf Desmodium <i>(Desmodium intortum)</i>	<ul style="list-style-type: none"> › Grows on a wide range of soils, but has no tolerance to salinity › Low drought tolerance › Perennial; long trailing and climbing › High biomass production › High N fixation rate › Tolerates shade, but no constant or repeated defoliation (grazing) 	<ul style="list-style-type: none"> › Forage: in pastures and irrigated pastures, for conservation as hay and silage, for cut-and-carry systems 	<ul style="list-style-type: none"> › Intercrop with maize and sorghum in the humid tropics to repel stem borer grass moth (<i>Chilo partellus</i>) and witch weeds › Ground cover under permanent crops › In mixed stands with other legumes or grasses
Lablab <i>(Dolichos lablab, Lablab purpureus)</i>	<ul style="list-style-type: none"> › High drought tolerance when established; may stay green throughout the dry season › Climbing › High biomass production › Medium to high N fixation rate 	<ul style="list-style-type: none"> › Food: leaves, flower buds and green pods edible › Forage: green or dried leaves and dried seeds; green plants for silage 	<ul style="list-style-type: none"> › Improved fallow after maize during the dry season › Nurse crop for plantation crops › Mixed forage crop with summer grass crops (high forage quality)
Velvet bean <i>(Mucuna pruriens)</i>	<ul style="list-style-type: none"> › Can grow on very poor soils also › Prefers humid climates (but no waterlogging); tolerates some drought; dies during the dry season › Climbing › High biomass production › Fixes up to 150 kg per ha of N › Suppresses nematodes 	<ul style="list-style-type: none"> › Food: young leaves as vegetables, cooked beans › Forage: leaves mixed with 4 times Napier grass; grains only if boiled; residues can be used as forage, silage or hay; the seeds can be used to make concentrate feed 	<ul style="list-style-type: none"> › Improved fallow on severely degraded soils (planted at the onset of the rainy season) › Relay cropping in cereal crops with repeated pruning (and subsequent Mucuna fallow); sowing of the following crop into dead mulch › Soil cover in citrus or coffee



Green manures with erect growth

Species	Characteristics	Additional/alternative uses	Integration into the farm
Cowpea (<i>Vigna unguiculata</i>)	<ul style="list-style-type: none"> › Climbing, bushy and erect forms › Moderate drought tolerance; not tolerant to excessive soil moisture › Moderate biomass production › N fixation 50 to 100 kg per ha 	<ul style="list-style-type: none"> › Food: young leaves, green pods and dried beans › Forage: fresh cut and carry forage, hay and silage (mixed with forage sorghum or millet) 	<ul style="list-style-type: none"> › Intercropping with maize, sorghum, millet or cassava
Jackbean (<i>Canavalia ensiformis</i>)	<ul style="list-style-type: none"> › For humid and sub-humid climates; but high drought tolerance › Grows on poor or degraded soils › Moderate biomass production › N fixation up to 230 kg per ha › Mature crop provides good mulch 	<ul style="list-style-type: none"> › Food: young leaves, tender pods › Forage: as fodder in small proportions of the diet; mature seeds ground 	<ul style="list-style-type: none"> › Intercropping in young banana, cocoa or coffee, cassava or sweet potatoes › Relay cropping in cereal crops
Black Sunnhemp (<i>Crotalaria juncea</i>)	<ul style="list-style-type: none"> › Grows on poor or degraded soils also › Drought tolerant › Annual; growth to 3 m › Moderate biomass production › N fixation 100 to 200 kg per ha › Controls nematodes › Regrows when cut before flowering › Mature crop provides good mulch 	<ul style="list-style-type: none"> › Food: young leaves only › Forage: no more than 10 % of the diet of cattle, not to be fed to pigs › Insect repellent › Production of bast fibres 	<ul style="list-style-type: none"> › Sole crop in rotation for green manuring › Intercropping with taller grain or forage crops › Intercropping or relay cropping with vegetables, beans, sweet potatoes, cassava or pineapples
Red Sunnhemp (<i>Crotalaria ochroleuca</i>)	<ul style="list-style-type: none"> › High drought tolerance › Grows to 2 m; regrows, if not cut too low › Suppresses nematodes › Can be used as mulch also 	<ul style="list-style-type: none"> › Food: young leaves, pods and flowers › Forage: leaves reported to be non-toxic before flowering › Insecticide: seeds used in storage to keep weevils away 	<ul style="list-style-type: none"> › Intercropping with food or cash crops

Why invest in compost production?



The heating phase destroys diseases on crop residues and weed seeds.

Compost suppresses soil borne diseases.

Compost is a well balanced fertilizer.

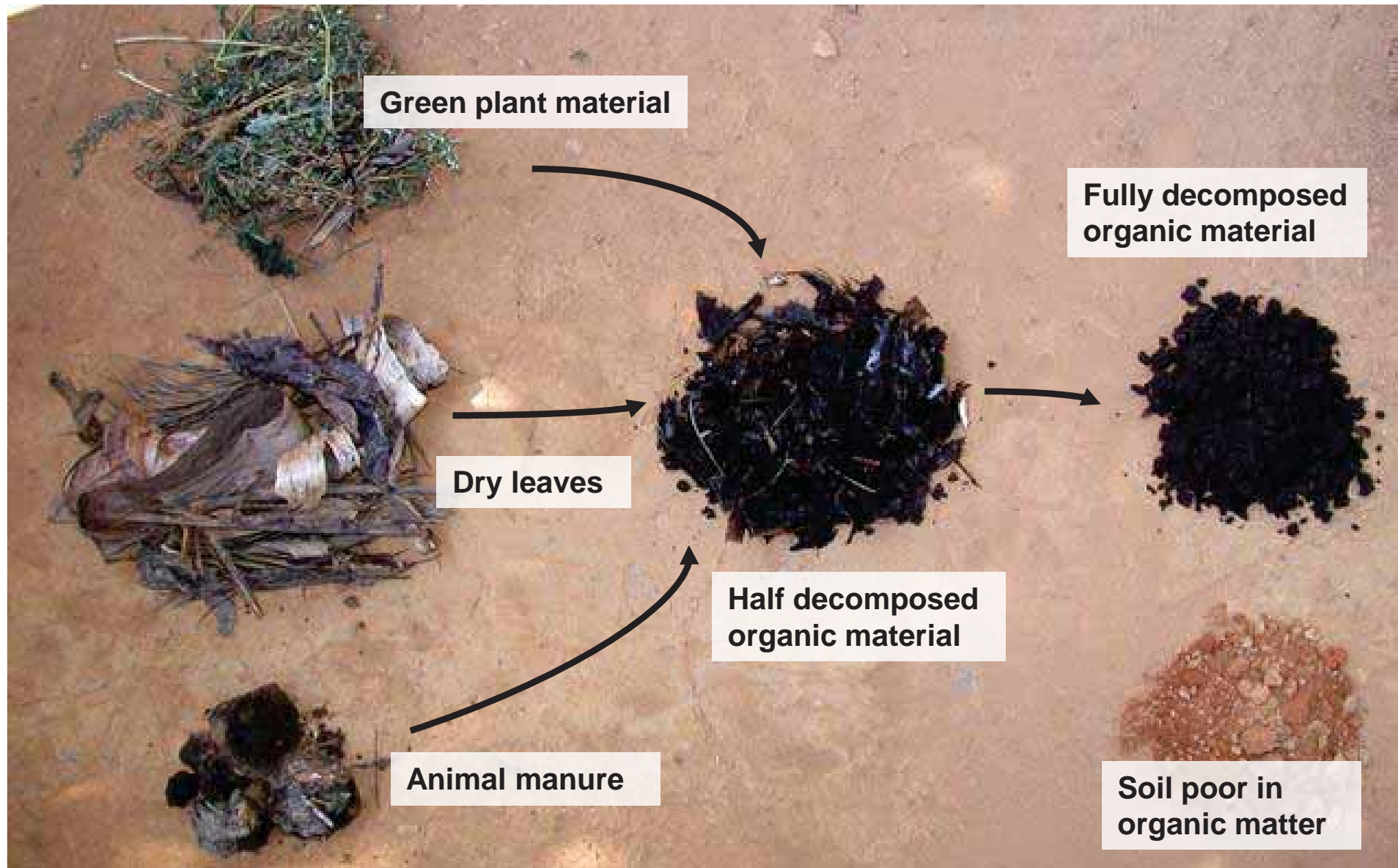
Compost improves the value of animal manure.

Compost improves long-term soil fertility.

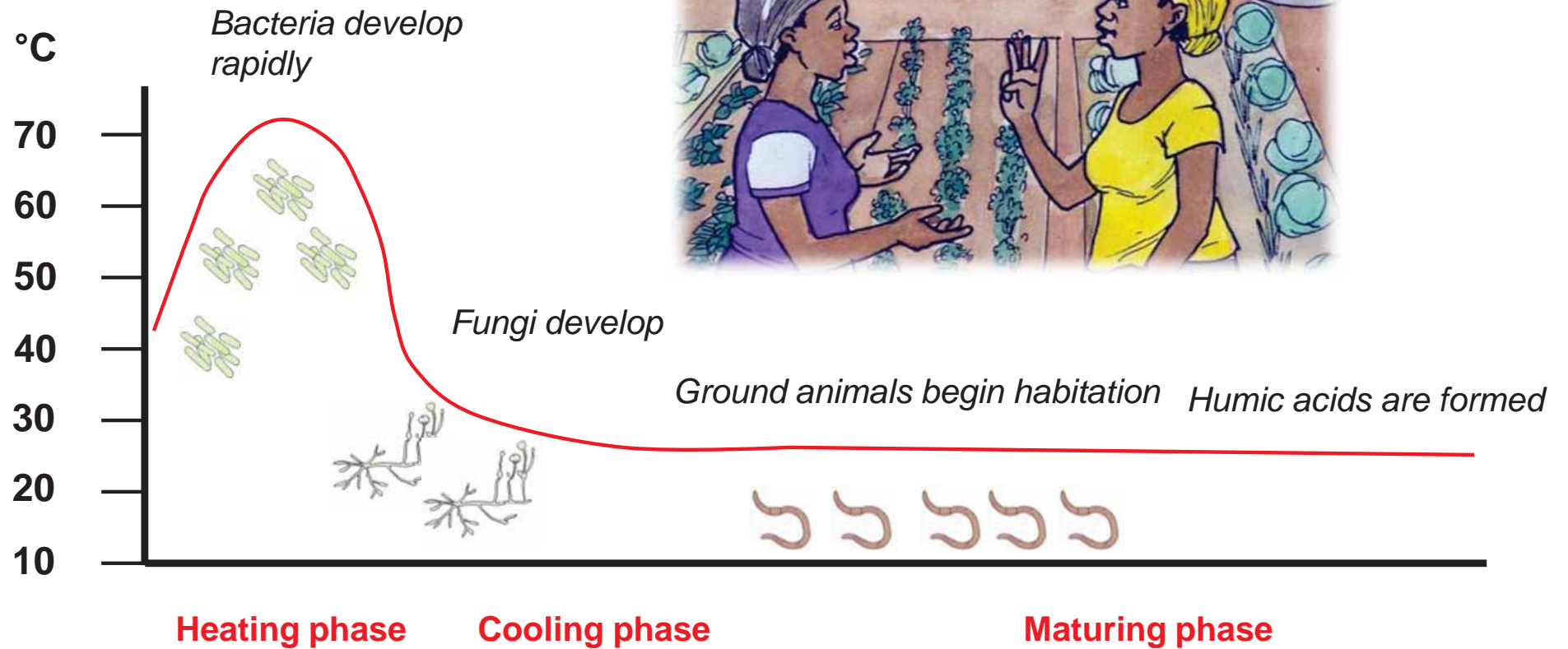
Compost raises pH in acid soils.



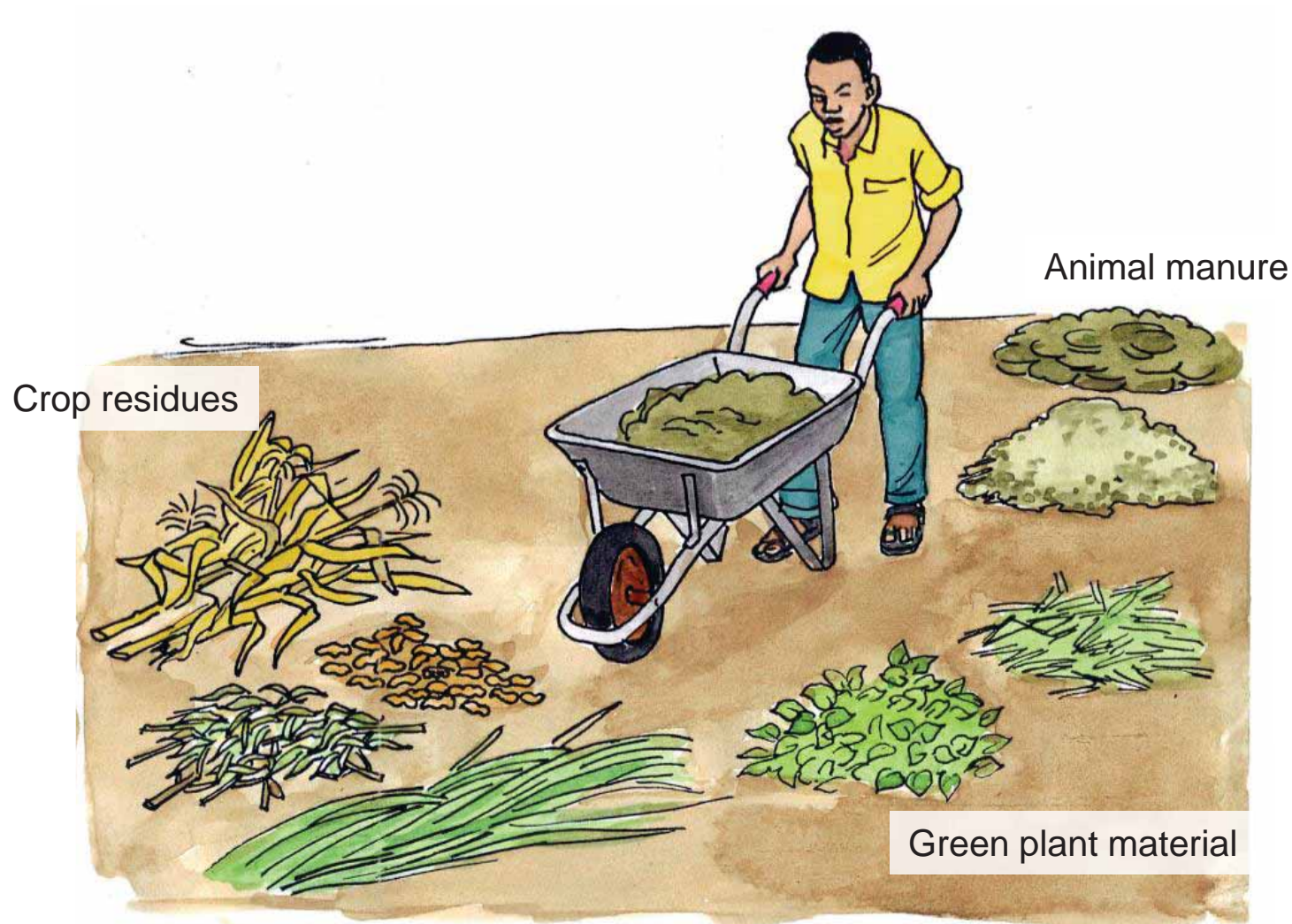
The formation of soil organic matter



Composting process



Materials used for composting

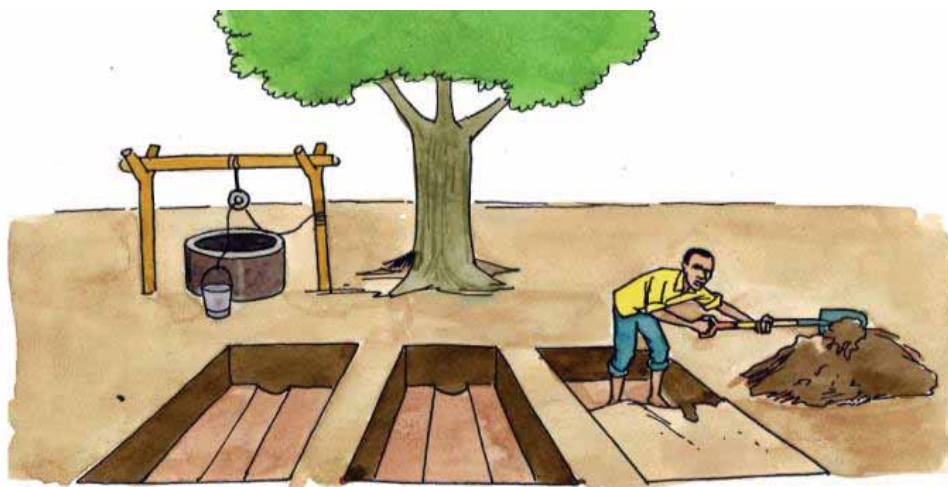


In addition following materials may also be used:

- > Ashes
- > Saw dust
- > Algae
- > Some top soil or old compost



How to make good compost (1)



1. Choose a shady place in proximity of water. Dig shallow pits.



3. Cut the plant material to the size of a finger.



2. Collect materials.



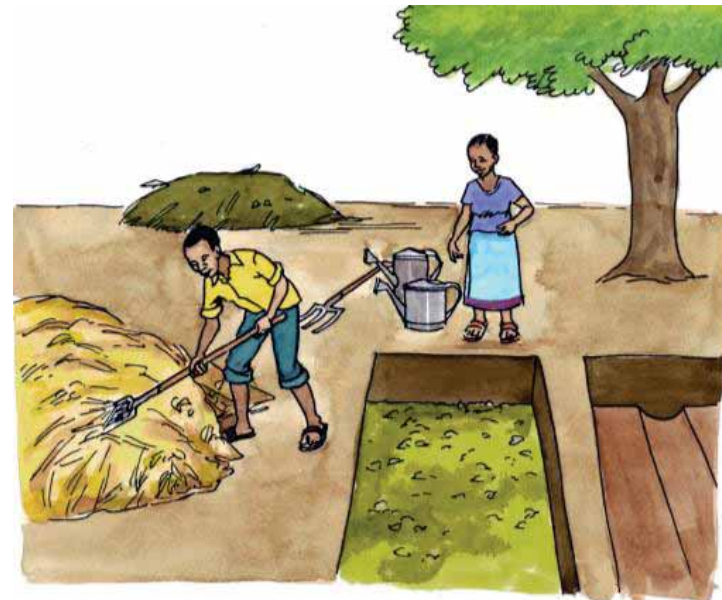
4. Make two heaps, one with the manure and the green material, one with the dry material. Mix and water both well.



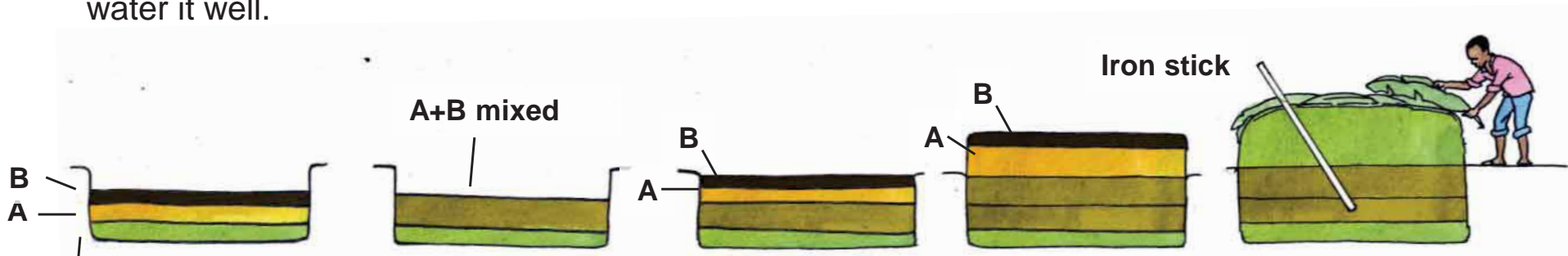
How to make good compost (2)



1. Fill-in bottom layer of dry material and water it well.



2. Then, fill-in a layer of dry material.



3. Fill-in layer by layer, always mixing the layers of dry and green material and watering them well.

4. Cover the compost with grass or banana leaves.



How to make good compost (3)

- > Warm stick = Decomposition process in full action
- > Cold stick = Decomposition cannot start; or it has declined and the heap can be turned



1. Check the temperature of the metal stick regularly.



3. Turn the compost twice, when the temperature in the heap has declined.



Compost keeps its form without dripping = ideal moisture content



Compost falls apart = too dry



Compost smears or drips = too wet

2. Check the moisture regularly.



4. 3 to 6 weeks after the second turning the compost should be ready for use. Sieving is useful when it is used for nursery beds and to fill planting holes.



How to make plant tea



1. Collect and chop green sappy leaves.



2. Immerse the plant material into fresh water and cover the drum. Stir every three days.



3. After 15 days sieve the mixture and dilute it with two parts of water.



4. Apply to the plants in the early morning.



How to make liquid animal manure



1. Fill a bag with manure.



2. Immerse the bag into a drum with fresh water and cover it. Stir the mixture every 3 to 5 days

3. After 2 to 3 weeks dilute the mixture with 2 to 3 parts of water.

4. Apply to the foot of the plants.



Fertilizers of organic origin for organic farming

Fertilizer	Fertilizing effect	Availability of nitrogen	Origin	Comments
Guano	N, P	●●●	Dried dropping of seabirds	<ul style="list-style-type: none"> › P content higher than the plants' demand
Hoof and horn meal	N, P	●(●)	Slaughterhouse waste	<ul style="list-style-type: none"> › The finer it is grinded, the faster N is available
Algae	Minerals		Seaweed	<ul style="list-style-type: none"> › May contain heavy metals depending on the origin
Oil cakes	N, P	●(●)	By-products of oil production	<ul style="list-style-type: none"> › 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	<ul style="list-style-type: none"> › 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	<ul style="list-style-type: none"> › Must be free of significant contaminants
Plant preparations and extracts	N, P, K	●●●	Extracts of fresh or dried plants	<ul style="list-style-type: none"> › The effect depends on the original material and can vary › Older preparations are better for fertilization of plants



Fertilizers of mineral origin for organic farming (1)

Fertilizer	Origin	Characteristics	Application
Plant ashes	Burned organic material	<ul style="list-style-type: none"> › Mineral composition similar to plants › Easy uptake of the minerals › Wood ashes rich in K and Ca 	<ul style="list-style-type: none"> › To compost (best) › Around the base of the plants
Limestone	Ground limestone Algae	<ul style="list-style-type: none"> › Buffers low pH (content of Ca and Mg secondary) › Algae: rich in trace elements 	<ul style="list-style-type: none"> › 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	<ul style="list-style-type: none"> › Trace elements (depending on the composition of the source) › The finer the grinding, the better the adsorbance 	<ul style="list-style-type: none"> › To farmyard manure (reduces volatilisation of N and encourages the transformation process)



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)	<ul style="list-style-type: none"> › Sulphate of potash is easily available › Patentkali: high contents of Mg and S; easily available › In rock form slow reaction 	<ul style="list-style-type: none"> › Only in case of demonstrated deficiency
Rock phosphate	Pulverised rock containing P	<ul style="list-style-type: none"> › Easily adsorbed to soil-minerals › Weakly adsorbed to organic matter › Slow reaction 	<ul style="list-style-type: none"> › To compost › Not to reddish soils (as irreversibly adsorbed) and to soils with high pH
Clay	Natural	<ul style="list-style-type: none"> › Good nutrient and water binding capacity 	<ul style="list-style-type: none"> › Large amounts required for soil improvement
Sulfur	Volcanic	<ul style="list-style-type: none"> › Sulphate of potash is easily available, but can be washed out › Elemental sulfur: slow reaction 	
Trace elements	Anorganic or complexed salts	<ul style="list-style-type: none"> › Complexed salts are more easily available to plants than anorganic salts, but are more expensive 	<ul style="list-style-type: none"> › Spraying onto plants where soil/plant nutrient deficiency is documented by soil or tissue testing or diagnosed

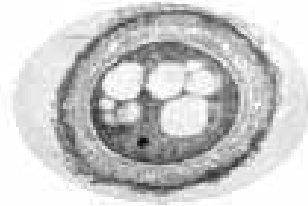


Some active ingredients of microbial fertilizers



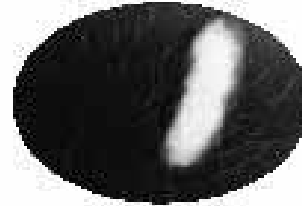
Rhizobium

- › A bacterium
- › Lives in soil, around and inside of the roots of legumes
- › Forms a symbiosis with leguminous plants
- › Fixes atmospheric nitrogen



Azotobacter

- › A bacterium
- › Lives free in the soil
- › Can fix nitrogen



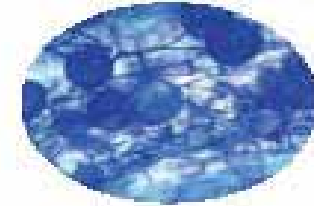
Azospirillum

- › A bacterium
- › Lives in soil
- › Is able to live on its own in soil, or in close associations with plant roots
- › A brasilense is able to fix nitrogen



Pseudomonas

- › A diverse group of bacteria
- › Can use a wide range of compounds that plants give off when their roots leak or die
- › Various functions: e.g. Solubilizing phosphorus and making it available



Mycorrhiza

- › A fungus-root symbiosis. Lives with the roots of nearly all plants
- › Lives in the root and extends itself into the soil
- › Helps the plant by gathering water and nutrients
- › Improves soil structure

