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ORGANIC FARMING GUIDE

VOLUME 1

Crop production

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1 Soil properties

The soil is a living system that requires proper maintenance and care. Fertile soils provide essential nutrients to plants and support a diverse and active biotic community.

1.1 Physical properties

A soil physical properties determine how well a plants root grow and proliferate. Plant roots grow well soils that haves good porosity, infiltration, drainage, water-holding capacity and resistance to crusting and compaction.

The soil physical properties depend on its texture. The soil texture is determined by the amounts of sand, clay and organic matter in the soil.

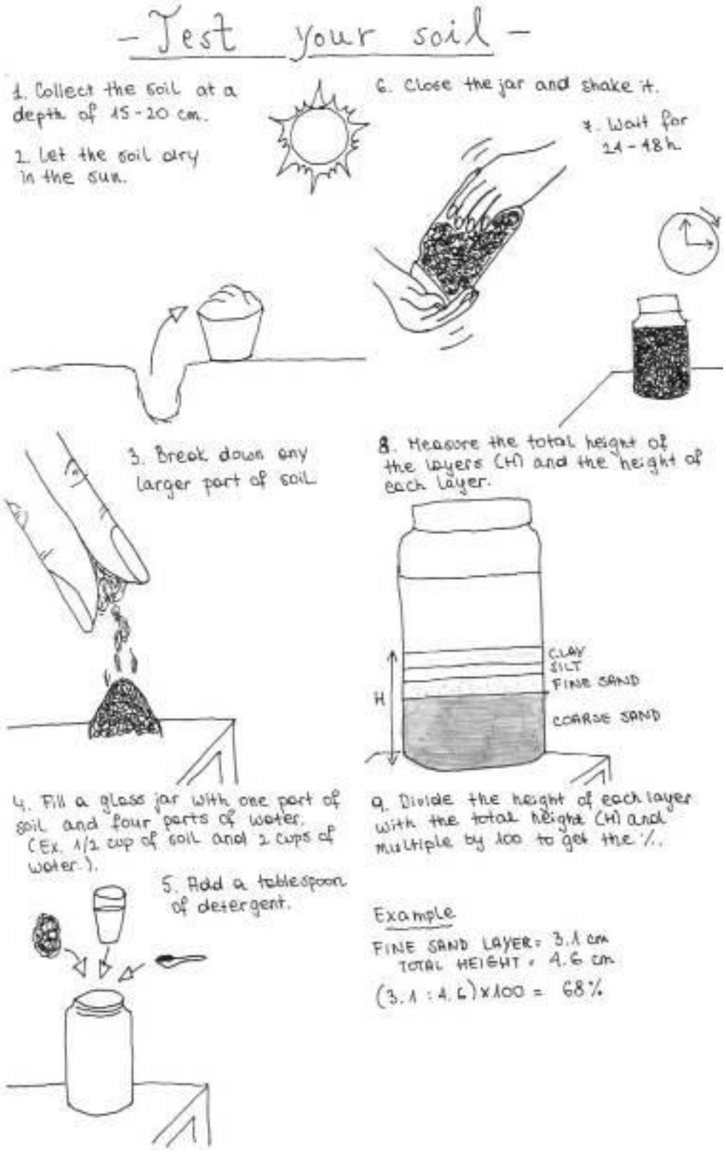


Figure 1. Experiment to examine your soil type

Sandy soils are easy to cultivate but they cannot hold much water. This happens because sand particles are large so there is a lot of empty space between them. Nutrients also tend to drain from the soil with the water before the plants are able to absorb them.

Clay soils, on the other side, are difficult to cultivate but they can store water and nutrients.
To determine the texture of your soil try the test shown in *Figure 1*.

The sand particles will settle first, at the bottom of the jar. The thinner silt particles will settle onto the sand. You will find the layers are slightly different colours, indicating various types of particles. Finally, the clay particles will settle on top.How to manage sandy soils

Sandy soils are relatively easy to manage: ploughing, planting and cultivating do not require too much effort. But, on the other hand, sandy soils are poor in nutrients.

Most sandy soils have a very small amount of clay which is essential for retaining nutrients. Sandy soils also do not retain water so they dry very quickly. The golden rule for managing sandy soil is: "LESS, MORE OFTEN".

Apply less water more often. Since sandy soils dry easily, if you give the plants big amounts of water most of it will be lost. Instead, provide the plants with less water more frequently. This way, the plants will be able to take up most of the water.

Do the same with fertilizers. Apply smaller amounts more frequently so that the plants can take up most of the nutrients before they are washed away.

Compost is very useful in sandy soils. It retains the nutrients you apply and releases them gradually as it decomposes. Mulch can also help because it cools down the soil.

Despite these difficulties, if you manage sandy soils in the right way they can be very productive and all types of vegetables can be grown.

1.2 Chemical properties

Soil chemical properties control the availability of nutrients to plants. Nutrients must be present in sufficient quantities, or yields will be limited.

Most farmers tend to "build the soil" through the increase of organic matter by using crop rotation, cover crops, animal and green manure. Increasing the soil organic matter is fundamental for an organic production system.

Macronutrients	Micronutrients
Nitrogen (N)	Iron (Fe)
Phosphorous (P)	Manganese (Mn)
Potassium (K)	Copper (Cu)
Calcium (Ca)	Zinc (Zn)
Magnesium (Mg)	Molybdenum (Mo)
Sulphur (S)	Boron (B)
	Chlorine (Cl)
	Nickel (Ni)

Table 1. Essential nutrients for plant growth.

The decomposition of plant residue leads to the formation of humic substances which constitute 70 to 80 % of the organic matter. During the formation of soil organic matter various nutrients, such as nitrogen (N), phosphorous (P) and sulphur (S), are incorporated in the soil.

Usually 2 to 5 percent of organic matter decomposes annually. There are six macronutrients and eight micro-nutrients which are essential for plant growth (*Table 1*).

Water, hydrogen and oxygen, which account for 95% of plant biomass, are provided with water and carbon dioxide.

pH (Acidity or Alkalinity)

One of the crucial factors in nutrient management is maintaining an optimal soil pH level as it influences the nutrient solubility, microbial activity and root growth.

High pH levels favour the release of cations but reduce the solubility of salts such as phosphates and carbonates. Low pH levels favour fungi while high pH levels favour bacteria.

Usually, an **optimal pH level stands between 6.0 and 7.0**. (*Figure 2*).

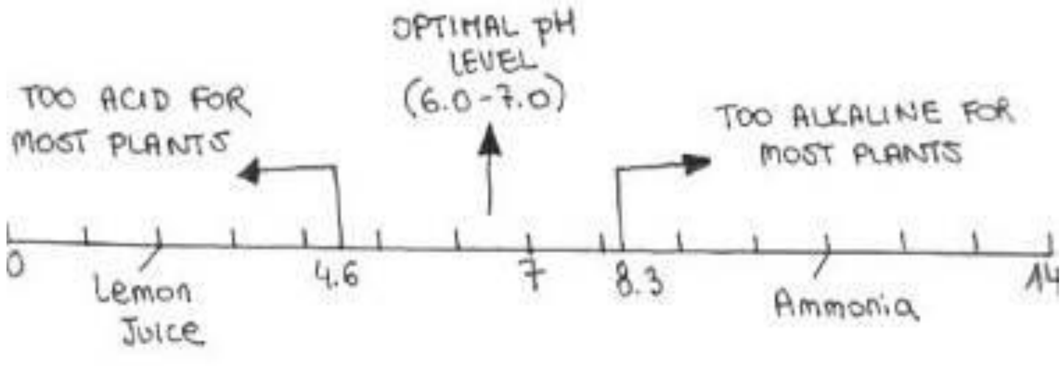


Figure 2. pH ranges and influence on plant growth.

To raise the pH of an acid soil, lime can be applied.

Lowering the pH of a soil tends to be more complicated; sulphur can be applied but it is a temporary and expensive solution.

Nitrogen

Organic farms enhance the soil availability of nitrogen by using legume cover crops, green manures and legumes. To ensure a sufficient amount of nitrogen, organic farmers also use animal manure and more concentrated substances such as blood meal, fish emulsion and seaweed.

Organic nitrogen must be mineralized before being available to the plants. Mineralization is the process in which the organic nitrogen contained in soil organic matter is converted into plant-useable inorganic forms as a result of the activities of soil microorganisms.

Phosphorous

The amount of phosphorous in the soil should be monitored on a yearly basis. Excessive amounts of phosphorous lead to the contamination of surface waters through field runoff.

Good sources of phosphorous include compost, certain organic fertilizers, manure, bone meal, fish meal and rock phosphate.

Potassium

Potassium is abundant in soils with a high amount of illictic clays. In general, if the soil potassium concentration is greater than 200 ppm adding more potassium will not result in a yield increase.

The goal of nutrient management is to provide the crops with the ideal amount of nutrients. Adding too much fertilizer will not result in a yield increase. As shown in *Figure 3*, adding too much fertilizer can cause a decrease in the crop growth and yield.

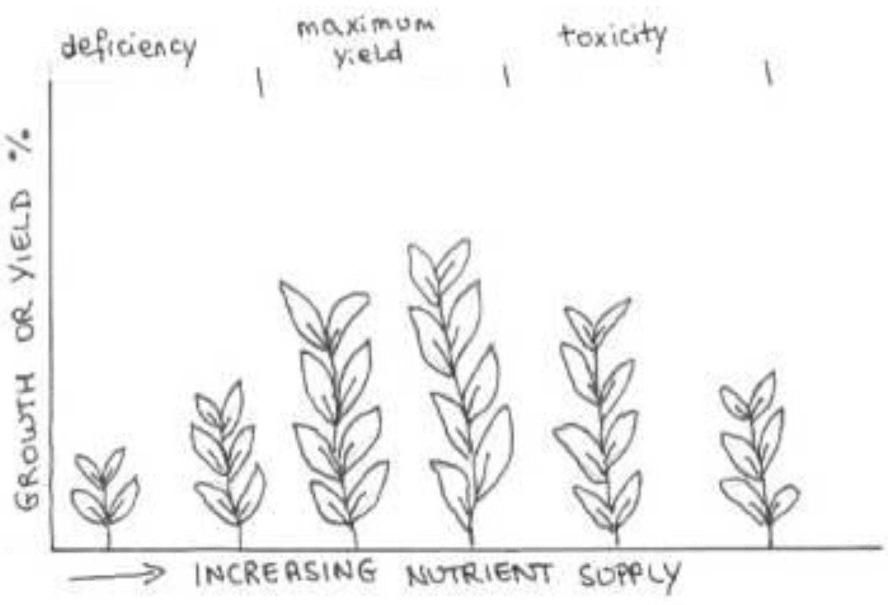


Figure 3. The effect of increasing nutrient supply on the plant growth and yield.

2 Methods to enhance soil fertility and suppress weeds

Nutrient management in organic farming is not simply avoiding chemical fertilizers. In fact, organic farmers should nourish the soil as management by neglect cannot be certified.

The most important methods to build soil fertility and manage weeds and pests are shown in *Table 2*.

METHOD	BENEFITS
Cover crops	Improved soil structure and fertility, reduced soil erosion, weed suppression.
Composting	Improved soil structure and fertility, reduced nutrient leaching, improved soil water capacity.
Crop rotation	Improved soil fertility, weed suppression.
Mulching	Reduced soil erosion, weed suppression, maintenance of soil temperature and moisture.
Conservation tillage	Improved soil structure, increased soil organic matter.

Table 2. Methods used in organic farming to improve the soil and manage weeds.

2.1 Cover crops

Cover crops are used to cover the soil during those months in which the field is not used to grow other crops. Cover crops have multiple benefits for the soil: they prevent soil erosion and nutrient runoff, they help loosen compact soils and they fix nutrients and organic matter to the soil.

Cover crops are generally distinguished according to their botanical classification in two main groups: grasses and legumes.

However, there are many other excellent crops that do not fall into either of these groups including: buckwheat (*Fagopyrum esculentum*), sunflower (*Helianthus* spp.), and a wide variety of mustards (*Brassica* spp.) and forage radishes (*Raphanus sativus*).

The **grass family** (*Poaceae*) of cover crops include grains and forage grasses such as cereal rye (*Secale cereale* L.), sorghum (*Sorghum bicolor* spp. bicolor), sorghum-sudangrass hybrids (*Sorghum bicolor* X *S. bicolor var. sudanense*), and wheat (*Triticum aestivum*).

These crops, besides producing income, make good cover crops. They establish easily, they grow a dense root system and they trap the nutrients that would otherwise be lost by leaching and/or runoff. Therefore, they eliminate the environmental risks associated to soil erosion and nitrogen leaching.

Some grasses (rye, sorghum, sorghum-sudangrass) are also beneficial for the suppression of weeds as they release allelopathic substances that inhibit the growth of other plants.

Legumes are a large group of plants in the bean family (*Fabaceae*) that includes vetch (*Vicia* spp.), clover (*Trifolium* spp.), field peas (*Pisum sativum*), cowpea (*Vigna unguiculata*), and soybean (*Glycine max*).

Legumes are used in soils with a low nitrogen concentration since the bacteria that inhabit their roots convert N_2 gas to plant- available nitrate (nitrogen fixation).

Legumes provide a net release of nitrogen for the subsequent vegetable crop while the use of grasses can result in a deficit of nitrogen availability.

However, in the long- term, grasses are fundamental for building soil organic matter and soil fertility. A detailed list of possible cover crops and their use is shown in *Table 3*.

<table>
<tr><th colspan="2">Winter species</th><th colspan="4">Use</th></tr>
<tr><td rowspan="7">legumes</td><td>Serradella</td><td rowspan="12">Cover</td><td rowspan="7">Nitrogen fixing</td><td colspan="2" rowspan="3"></td></tr>
<tr><td>Hairy vetch</td></tr>
<tr><td>Common vetch</td></tr>
<tr><td>Faba beans</td><td rowspan="3">Human & animal food</td><td rowspan="3"></td></tr>
<tr><td>White lupin</td></tr>
<tr><td>Blue lupin</td></tr>
<tr><td>Field pea</td><td rowspan="3"></td><td>Grain</td></tr>
<tr><td rowspan="5">grasses</td><td>Black oat</td><td rowspan="5">Forage</td><td rowspan="5"></td></tr>
<tr><td>Annual ryegrass</td></tr>
<tr><td>Triticale</td><td rowspan="3">Grain</td></tr>
<tr><td>Stooling rye</td></tr>
<tr><td>White oat</td></tr>
<tr><th colspan="2">Summer species</th><th colspan="4">Use</th></tr>
<tr><td rowspan="3">legumes</td><td>Cowpea</td><td rowspan="6">Cover</td><td rowspan="3">Nitrogen fixing</td><td></td><td rowspan="6"></td></tr>
<tr><td>Sunnhemp</td><td rowspan="2">Potentially toxic</td></tr>
<tr><td>Indigofera spicata</td></tr>
<tr><td rowspan="3">grasses</td><td>Italian millet</td><td rowspan="2">Forage</td><td rowspan="3"></td></tr>
<tr><td>Pearl millet</td></tr>
<tr><td>Finger millet</td><td>Human & animal food</td></tr>
</table>

Table 3 - List of possible cover crops

COVER CROPS

PRACTICAL SHEET 1

2.1.1. Choose the right cover crop

• if you want to provide readily available nitrogen to your cash crops, choose legume cover crops;

• if you want to suppress weeds or improve the soil quality choose a grass cover crop such as cereal rye or a sorghum-sudangrass mix.

A third option is to choose a mixture of grasses and legumes (bicultures) which offers several advantages.

2.1.2. Cover crop strategies

1. fallow crops;
2. winter cover crops;
3. interseeded cover crops;
4. smother crops.

Fallow crops are used to add biomass to the soil and rest the land from cultivation. They are integrated in the crop rotation plan and they are grown instead of a cash crop. For this reason they can be expensive in terms of lost production.

Winter cover crops are used to cover the soil that would otherwise be left bare during winter months. Usually they are sown in autumn and destroyed after 4 to 5 months. They must be sown soon after the cash crop has been harvested.

Interseeded cover crops are cover crops that are grown simultaneously with the cash crop. They must be sown after the cash crop but early enough to survive the competition with the cash crop.

Smother crops are crops that are grown during a spring, summer or fall period window between cash crops.

2.1.3. What to do with the cover crops residue?

Cover crops residue can be incorporated in the soil by tillage, mowing or rolling.

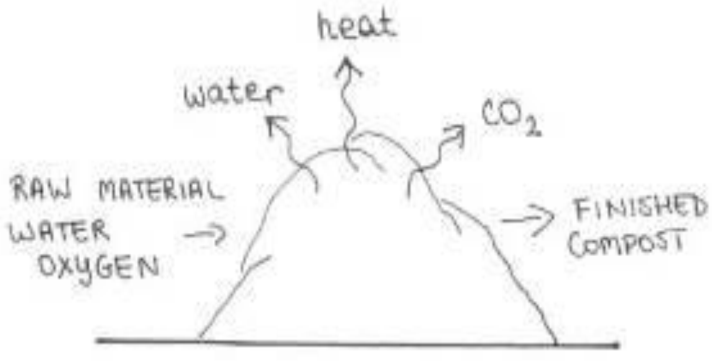
In no- tillage systems, cover crops residue is left on the soil surface as mulch.

During the wet season, incorporating legumes in the soil will increase the yields of the cash crops that follow.

During dry season the best option is to leave the cover crop residue on the soil surface to maintain the moisture in the soil.

2.2 Composting

Composting is a strongly recommended procedure in organic farming as compost reduces pathogens and weed seeds in organic matter, makes nutrients available to plants, stimulates root growth, prevents erosion and builds soil structure, increases the water holding capacity and prevents nutrient leaching.



Composting is the aerobic decomposition of organic matter (*Figure 4 above*).

Aerobic means that the material decomposes in presence of oxygen. In anaerobic conditions, anaerobic organism take over the process and the result is putrefied organic matter that cannot be called compost.

The process of composting consists of two phases (*Figure 5.*): the **active phase** which is characterized by an intense microbial activity and rapid decomposition of organic matter which results in a temperature increase to 55-65 ^{0}C.

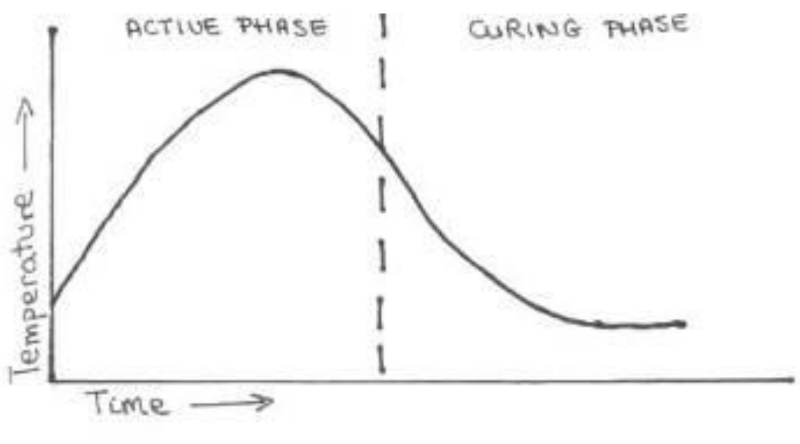


Figure 5. The process of composting.

After the readily available organic matter is consumed, the microbial activity slows down and the temperature decreases to around 37 ^{0}C. The volume of the pile, at this point, will be reduced by 25 to 50 percent.

Adding water and turning the pile in this phase will not result in a temperature increase in the pile. When the compost pile reaches the temperature of ambient air the **curing phase** begins. This phase lasts for about 30 days in which the pile rests undisturbed.

In the composting process, three factors are critical: **temperature**, **moisture**, **aeration**.

Temperature. A decrease in temperature may suggest a low microbial activity. In this case, the pile should be turned to increase the amount of available oxygen and thus reactivate the organisms.

The turning can be done by hand or with other specialized equipment. Another option is to use perforated pipes under the pile which allow the flow of oxygen through the pile.

Turning the pile also insures the moving of the outer, cooler, material to the inner layers of the pile where it will be subjected to higher temperatures.

The temperature in the pile must be kept under 65 ^{0}C because if the pile becomes too hot, organisms begin to die and the process slows down. In dry areas, too hot piles can result in the combustion of the material.

Moisture. Moisture should be kept, inside the pile, in a range between 40 and 50 percent. As the temperature in the pile rises some water will evaporate so it will be necessary to add water to the pile. Be careful not to add too much water; if the moisture content exceeds 65 to 70 percent, the water will occupy most of the pore spaces in the pile limiting the oxygen availability.

Aeration. It is very important to maintain aerobic conditions inside the pile. For that reason, it is essential to turn the pile regularly and to prepare the pile with different sized material so to create empty spaces inside the pile.

For good compost another very important factor is the **carbon- nitrogen ratio (C: N)**. Usually, the organisms in the pile require a carbon quantity which is 20 times bigger than the nitrogen quantity.

- If the C: N ratio is lower than 20 (too much nitrogen), the organisms will consume all the carbon before stabilizing the nitrogen. The result will be the release of ammonia (NH_3) in the atmosphere.
- if the pile has too much carbon (C: N> 40), the composting process will be prolonged because of the excess of carbon.

To create an ideal C: N ratio in the pile it is important to know the C: N ratio of the various materials (*Table 4*):

- ❖ C: N= 10:1 to 20:1 (material rich in N): legumes, fresh manure, seed germ and first- cut grass.
- ❖ C: N= 30:1: food waste, end-of-season crop residues, decomposed tree leaves.
- ❖ C: N > 100 (material rich in C): sawdust, wood chips, fresh fall leaves, straw.

MATERIAL	% N	% C
High in carbon		
non– legume hay	1.3	42
macadamia husk	1.3	50
tree pruning	1.0	50
straw	0.7	56
sawdust	0.1	50
High in nitrogen		
blood and bone	13	42
vegetable wastes	3	30
grass clippings	3.4	58
cattle manure	2.7	48

The finished compost has the following characteristics:

- Nice earthy smell.
- Not wet nor too dry and powdery.
- Dark soil sized particles.
- Ambient air temperature.

Table 4. Carbon and nitrogen content of common waste material

COMPOSTING

PRACTICAL SHEET 2

How to compost

1. Find a suitable area for the compost pile. The area should be relatively flat, free of stones, weeds and tree stumps.

2. Mix all the materials and construct a pile. The pile should be between 1.5 and 2 metres high and 2 to 3 metres wide. It can be as long as you want (*Figure 6*).

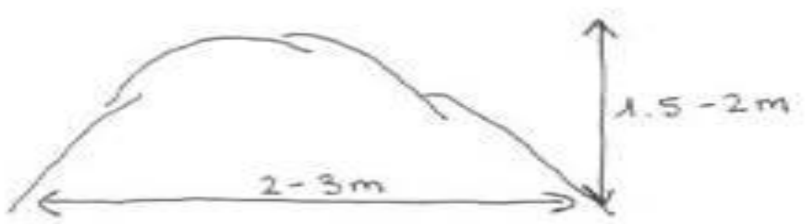


Figure 6. Compost pile ideal height and width.

With this dimensions, every 1 metre in length of the pile will make about 3 cubic metres of compost.

3. Add water to the pile and cover the pile in case of excessive rainfall (*Figure 7*).

Figure 7.Water the pile regularly (right) and in case of rainfall cover the pile (left).

4. After 7 days check the temperature of the pile. Dig a hole in the middle of the pile; steam should come out and the compost should feel uncomfortably hot.

If the temperature is right, turn your pile after 7 days or when the temperature declines. If the temperature is above 70 ^{0}C turn the pile immediately and reduce the pile height to 1.5 metres.

5. Keep checking the temperature every 7 days and turn the pile after the correct temperature has been achieved.

6. Once the pile has stopped heating, let it rest for at least 2 weeks (curing phase).

7. The whole process will take around **8 weeks** depending on the starting material.

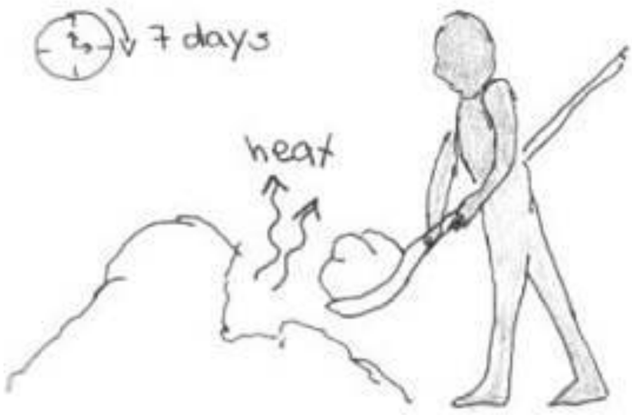


Figure 8. Check the pile temperature and turn the pile regularly.

Method to check the moisture in the pile

1. Dig into your pile at least a foot or until it gets too hot to touch.

2. Pick up a handful of compost and squeeze hard.

3. If you feel liquid between your fingers, or if one or two drops of water come out, the compost is in the ideal moisture range, between 40% and 50%.

PROBLEM	CAUSE	SOLUTION
Water running off and/ or clumping	Too wet	Add dry material.
Bad smell	Anaerobic conditions	Add larger material and turn the pile frequently.
Ammonia smell	Excess of nitrogen	Add material rich in carbon.
The temperature does not increase	Too much carbon Incorrect moisture Too little oxygen	Add material rich in nitrogen. Adjust. Turn pile.

Table 5. Common problems that occur during composting

2.3 Crop rotation

Crop rotation is the subsequent cultivation of different crops on the same land.

This practice has numerous benefits. It improves the soil fertility (especially if you include legumes in the cycle), it helps suppress weeds, it reduces pests and diseases and it conserves the soil.

Continuous cultivation of the same crop allows the increase of the pest population that feeds on that crop. By planting a different crop you reduce the food availability for the pest causing a decrease of its population. Some crops have common pests so you must avoid planting those crops in succession.

When deciding which crops to include in the rotation, you must keep in mind which crops require high quantity of nutrients in the soil (the heavy feeders). Heavy feeders produce more when rotated with light feeders and nitrogen- fixing crops (legumes).

To make a good crop rotation plan, the most important thing is to know the family where your crops belong so to avoid planting crops from the same family (*Table 6*).

FAMILY	COMMON NAMES
Allium	Chive, garlic, leek, onion, shallot.
Cucurbit	Bitter gourd, bottle gourd, chayote, cucumber, ivy gourd, luffa gourd, melons, pumpkins, snake gourd, squash, wax gourd.
Crucifer	Bok choy (petchay), broccoli, Brussels sprouts, cabbage, Chinese cabbage, cauliflower, collard, kale, kohlrabi, mustard, radish, turnip, watercress.
Legume	Common beans, black bean, broad bean (Fava), clover, cowpea, garbanzo, hyacinth bean, kidney bean, Lima bean, lintel, mungbean, peanut, pigeon pea, pinto bean, runner bean, snap pea, snow pea, soybean, string bean, white bean.
Aster	Lettuce, artichoke.
Solanaceous	Potato, tomato, pepper, eggplant.
Grains and cereals	Corn, rice, sorghum, wheat, oat, barley, millet.
Carrot family	Carrot, celery, dill, parsnip, parsley.
Root crops	Potato, cassava, sweet potato, taro, yam, water chestnut.
Mallow family	Cotton, okra.

Table 6. Crop groups

CROP ROTATION

PRACTICAL SHEET 3

How to rotate crops

The easiest way to plan a crop rotation is to divide the crops in 4 groups:

- **LEAF CROPS**: crops that need high amounts of nitrogen. For this reason they should be planted after legumes.

Leaf crops include: lettuce, greens, herbs, spinach, and the brassicas (cabbage, broccoli, cauliflower, brussel sprouts, and kale);

- **FRUIT CROPS**: crops that need phosphorous to develop fruits. These crops don't need a lot of nitrogen. If too much nitrogen is present fruits won't develop.

Fruit crops include: tomato, eggplant, courgette, peppers, corn;

- **ROOT CROPS**: crops that need potassium and barely any nitrogen. They are planted after the fruit crops when the amount of nitrogen in the soil is very low.

Root crops include: onion, carrot, garlic, beet and radishes.

- **LEGUMES**: crops that are nitrogen– fixing. They increase the amount of nitrogen in the soil and ensure there will be enough nitrogen for the subsequent plantation of leaf crops (see *Table 6*.).

In this system, the leaf plants go where legumes were last year, because legumes fix nitrogen in the soil, and leaf plants need large amounts of nitrogen.

The fruits follow the leaf plants because they need phosphorus, and too much nitrogen causes them not to have fruits.

The roots follow the fruits because they need potassium and need nitrogen less than the fruits.

Finally, the legumes follow the roots to put nitrogen back into the soil (*Figure 9*).

Crops in the same family should not follow one another in the field. At a minimum, crops from a particular family should be separated by at least two years of crops from other families.

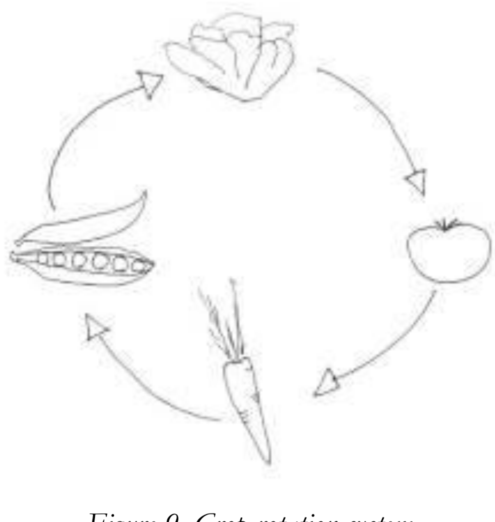


Figure 9. Crop rotation system.

Make a crop rotation plan

To plan your crop rotation:

1. draw a map of your fields;

2. divide each field in several smaller units of equal size;

1st YEAR	Area 1 LEAVES	Area 2 FRUITS	Area 3 ROOTS	Area 4 LEGUMES
2nd YEAR	Area 1 FRUITS	Area 2 ROOTS	Area 3 LEGUMES	Area 4 LEAVES
3rd YEAR	Area 1 ROOTS	Area 2 LEGUMES	Area 3 LEAVES	Area 4 FRUITS
4th YEAR	Area 1 LEGUMES	Area 2 LEAVES	Area 3 FRUITS	Area 4 ROOTS

Table 7. Example of a four years rotation plan

3. in every unit you will plant one crop and then move the crops from one unit to the other over the years, according to what group they belong (*Table 7*).

2.4 Mulching

Mulch is a protective layer of material spread on top of the soil. The material used can be organic, like straw, or inorganic like plastic and stones.

Mulching offers numerous benefits: it helps suppress weeds, it prevents soil erosion, and it maintains the soil temperature and moisture (*Figure 10*).

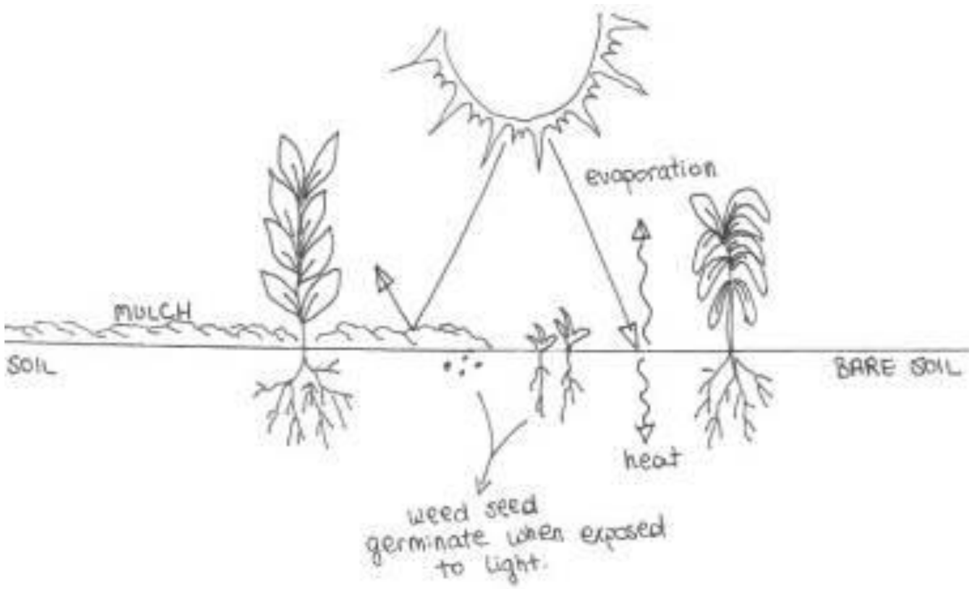


Figure 10. Advantages of applying mulch on the soil surface.

Since organic mulches offer more benefits then the inorganic ones (improving soil fertility) we will limit this chapter to the use of organic mulches.

We can distinguish two types of mulching:

- **summer mulching**: the goal of summer mulching is to keep the soil moisturized and cool during the hot summer months. Summer mulches do not need to be removed as they will slowly decompose adding organic matter to the soil.
- **winter mulching**: the goal of winter mulching is to protect the roots from freezing. It is usually applied in late fall and removed in early spring.

There are several materials that can be used as mulch and each one has its own benefits and disadvantages:

Hay

Hay is the most used material since it's available in most farms. If you are using hay from other farms be careful because the hay can contain herbicide residue and viable weeds which can harm your crops.

The best solution is to grow your own mulch crop taking care you cut it before viable seeds are formed. Mulch hay can be derived from perennial forages and annual crops (rye, sorghum- sudangrass, etc.).

Do not grow mulch crops repeatedly on the same field as they impoverish the soil. Include them in your crop rotation plan and alternate them with vegetable crops that receive the mulch.

Straw

Straw is an agricultural by-product, which consists of dry stalks and other residues left after the harvest of cereal plants.

Some farmers prefer using straw instead of hay since straw is less likely to carry weed seeds. Straw decomposes more slowly than hay and reflects more light (since it is lighter than hay) so it cools more the soil.

Straw is also a highly inflammable material and should not be used in high traffic areas.

Because of its cooling potential, applying straw can delay the crops growth. Thus it is recommended to use it for cool weather crops (ex. potato) and during hot summer weather.

Tree leaves

Leaves are mostly used in areas where trees are abundant. They are the less expensive mulch material but give the best results when composted.

In rainy areas, leaves tend to compact creating airless soil conditions. In dry areas the leaves can be blown away from the soil surface. So, the best solution is to include them in the compost pile.

Chipped Brush, Wood Shavings, Bark, Sawdust

These materials are mostly used on perennial crops. Although they have several advantages, they are far more expensive than hay or straw. Sawdust tends to compact creating airless conditions in the soil, it can be washed away with the rain and it can tie up the soil nitrogen.

Compost

Compost can be used as mulch, but it is a very expensive practice since the suppression of weeds may require the application of large amounts of compost.

Other residues (peanut hulls, buckwheat hulls)

These residue materials can also be used as mulches. Avoid using residues that may carry pathogens, seed weeds and herbicide residue.

Living mulch

Living mulch consists of annual or perennial cover crops that are grown in the rows between the crops.

Living mulch crops will compete for water and nutrients with the other crops. For that reason you should avoid growing the living mulch too close to your crops. Living mulches give the best results in large plantations where a row without crops can be left as a boundary between the mulch and the other crops.

MULCHING

PRACTICAL SHEET 4

Always apply mulches on wet, warm soil. If you apply the mulch on a dry soil it will keep the soil dry.

Apply the mulch after the crops are well established.

At the beginning of a sunny day cultivate the field. Wait 12 to 36 hours and then apply the mulch.

Pay attention to the thickness of mulches. A too thick layer will create airless conditions in the soil.

The mulch thickness depends on the material used but usually it should have a thickness of less than 10 cm. If you want to get rid of persistent weeds you can apply a thicker layer of mulch (more than 10 cm).

Do not apply the mulch too close to the plant crown and/or tree base. If too close the mulch will cause plant to rot.

How to water the plants once the mulch is applied?

Before applying the mulch water well the soil. This way the mulch will retain the moisture in the soil.

To evaluate how much to water, stick a finger in the mulch to check the moisture level.

2.5 Tillage

Tillage is the mechanical modification of soil structure in order to prepare it for growing crops. Tilling methods include shovelling, picking, raking, ploughing, rototilling, etc.

We can distinguish 3 main types of mechanical tillage:

1. **conventional tillage**: intensive tillage done prior to and/or during planting. The soil disturbance is generally more than 15 cm deep. Essentially no residue is left on the surface after conventional tillage is completed.
2. **cultivation**: shallow tillage intended to manage weeds.
3. **conservation tillage**: tillage that maintains at least 30% of the soil surface covered with residue.

Tillage has several negative effects on the soil since it destroys the soil organic matter. For this reasons a "no-till agriculture organic system" is starting to be used. However, if tillage is done properly- like conservation tillage, the negative consequences can be minimised.

Conservation tillage includes non-turning or superficial tillage while at the same time simply opening of planting rows with a chisel or ripper tine (furrow). Ripping, planting and fertilizer application can be combined in one single operation.

This method is an option for situations where full ground cover can be achieved (e.g. semi-arid and arid regions). This method is frequently applied in south-eastern Africa.

The residue left on the soil surface after conservation tilling has numerous benefits. During the growing season, the residue retains moisture and prevents erosion. It has been shown, that the residue can reduce soil erosion by 10 to 90%.

CONSERVATION TILLAGE

PRACTICAL SHEET 5

There are 3 main types of conservation tillage:

- no-till;
- ridge-till;
- strip-till.

No-till is a method of planting crops that requires no seedbed preparation other than opening the soil so that the seed can be placed at the intended depth. Planting is done in a narrow (usually 15 cm or less) seedbed or slot.

The operation consists in slicing through the surface residue and the top 7 to 10 cm of soil, drop the seeds and cover them again with the soil and residue.

Ridge-till is a method of preparing the seedbed and planting on a pre-formed ridge remaining from the previous year's crop. Ridge tillage differs from no-till planting in that some cultivation is required during the current growing season to form the ridge for next year's crop.

Ridge-till systems leave residues on the surface between ridges.

Ridge-till works best on nearly level, poorly drained soils. The ridges speed up drainage and soil warm-up.

Strip-till is a method of preparing a seedbed on a strip 5 to 10 cm wide and 5 to 20 cm deep. The seedbed is mechanically tilled to optimize the soil and micro-climate environment for germination and seedling establishment.

The interrow zone is left undisturbed and protected by mulch. Of the three systems, this one produces the most soil disturbance.

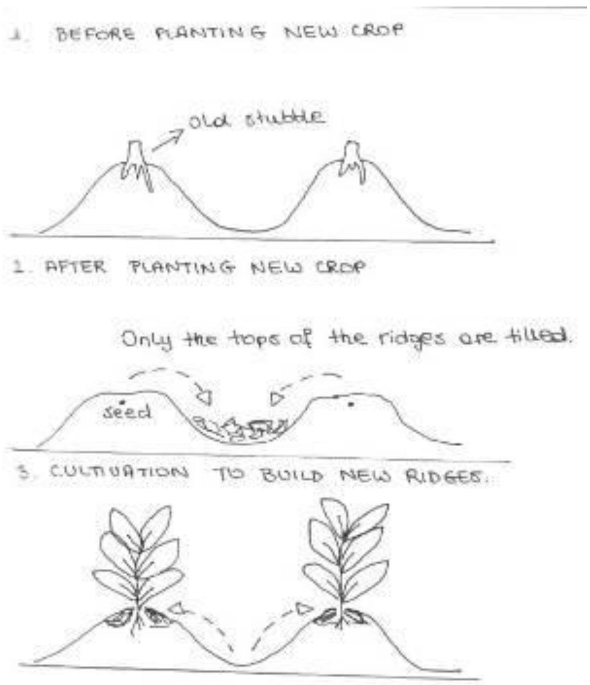


Figure 11. Ridge tillage: (1) Crop residue is being removed and put aside. The seeds are planted on the ridge (2). After the new crops emerge, the residue is moved on the ridges (3).

HOW TO BUILD A SMALL VEGETABLE GARDEN

PRACTICAL SHEET 6

Overview

Building a small vegetable garden requires only as much effort as you wish to put into it. Raised beds are a handy way to make the most of a small space but are not necessary. Choose smaller varieties of plants to make the most of your small space. Cherry or grape tomatoes are just as lovely in salads as big beefsteak slicing tomatoes. Growing vertical vegetables, such as peas, beans and cucumbers can also help make the most of your space.

Step 1

Plan your full season of growing before you start. Consider strategies such as succession gardening, in which you constantly have seedlings growing in a flat indoors. You can then transplant them outdoors when the current crop is past its prime.

Interplanting, interspersing vegetables that take different amounts of time to mature, is another good use of small space. Write your plans on paper, and do not be afraid to revise as you learn new things.

Step 2

Start tomatoes, cucumbers, peppers and other hot-weather-loving vegetables in a flat about six to eight weeks before the date of the last frost in your area. Use a small amount of starter mix in each cell and sow the seeds according to packet instructions.

Use a mister to water so you do not disturb seeds or soil.

Step 3

Consider raised bed gardening. Raised beds consist of soil mixed with organic matter to a minimum height of 8 to 12 inches above ground level. At their simplest, they are mounds of soil where gardens are planted. They have better aeration and drainage than other gardens, as well as larger yields in a smaller space. Borders of wood frames or stones may be added.

Step 4

Sow cool-weather-loving vegetables such as lettuce and spinach in your garden in the spring. Pay careful attention to packet instructions. Some seeds, such as lettuces, need to be covered by a very scant amount of soil. Lettuces require some sunlight to germinate.

Step 5

Transplant hot-weather seedlings to your garden after all danger of frost has passed. Squeeze the cells of the flat to loosen the root balls and plant in holes twice as wide as each root ball. When planting vertical plants that you will train onto trellises, plant a couple of inches closer together than packet instructions suggest.

Step 6

Securely mount trellises near the seedlings of vertical plants after you have transplanted them. Pound the trellises into the ground with a mallet. Use strips of pantyhose to tie tender seedlings of vining and climbing vegetables to your trellises. Pantyhose is strong and sturdy, yet will not bruise tender seedlings.

Step 7

Monitor your garden's watering needs closely. Raised bed gardens are more convenient for weeding and harvesting, but they dry out more quickly than traditional gardens. All vegetable gardens, regardless of whether they are raised bed or traditional, require consistent watering. Water deeply once every few days or whenever the top couple inches of soil look dry. During the hottest days of summer, water at least once a day. Do not water during midday because you might burn the leaves and fruit of your plants.

Things You'll Need

- Pencil
- Paper
- Vegetable seeds
- Flat
- Starter mix
- Mister
- Trowel
- Compost
- Shovel
- Fertilizer
- Trellises
- Mallet
- Used pantyhose